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COOPERATION FOR CLIMATE AND GREEN DEAL BOOK

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Cooperation for Climate and Green Deal Book

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Introduction

In this book, it is aimed to reinforce the knowledge with studies on climate change and the subjects related to climate change from different disciplines.

The book contains 16 chapters containing theoretical and practical information.

The sections are; climate change and carbon footprint, climate change and adaptation, climate change design-tourism, climate change and education, climate change and energy, climate change and health, climate change and hemp, climate change and migration, climate change and monitoring, climate change and philosophy, smart transportation, safe food supply, climate change and sustainability, climate change and water pollution, green technology, climate change monitoring in wetlands, zero pollution and non toxic environment, zero waste, recycling and waste management.

We would like to thank Ondokuz Mayıs University, Ondokuz Mayıs University Technology Transfer Office, Ondokuz Mayıs University Environmental Problems Research and Application Center, participants and sponsors for their support and contributions in the publication of this book.

PREFACE

Human-induced climate change causes widespread degradation of nature and affects the lives of billions of people worldwide. In the Climate Change report of the Intergovernmental Panel on Climate Change (IPCC), published in 2022, it is clearly emphasized that it is not possible for both humans and the ecosystem to combat these negative effects by addressing the effects, risks and adaptations of climate change. European Green Deal prepared by the European Commission, a series of policies have been developed that aim to make climate neutral, turn climate and environmental challenges into opportunities in all policy areas, and enable the transition to a competitive economy by using resources efficiently. Within the scope of harmonization with the European Green Agreement, Turkey accepted the Paris Agreement and set a net zero emission target for 2050. A Green Deal Action Plan was prepared by the Ministry of Trade in order to contribute to Turkey's transition to a sustainable and resource-efficient economy and to address the effects on industry, agriculture, energy and transportation policies. Main actions under the Action Plan to reach the related goals have been determined as limiting carbon emissions, a green and circular economy, green financing, a clean, economic and safe energy supply, sustainable agriculture, sustainable smart travels, combating against climate change, establishing diplomacy principles and raising awareness regarding the European Green Deal.

Cooperation for Climate and the Green Deal Book, addresses key environmental issues such as wastewater, solid waste and air pollution, as well as energy, health, carbon footprint, smart transportation, cannabis, safe food and other climate compatible issues. Written by academics and experts in the field, the book aims to provide a roadmap for all members of society to adopt the concepts of green technology and green transformation and adapt them to their lifestyles.

Prof. Dr. Yuksel ARDALI
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Table of Contents

CHAPTER 12:

Green Technology

CHAPTER 13:

Monitoring of Climate Change in Wetlands

CHAPTER 14:

Zero Pollution And Non-Toxic Environment

CHAPTER 15:

Zero Waste, Recycling and Waste Management

CHAPTER 1

Carbon Exchange and Carbon Footprint

SUSTAINABLE POSTHARVEST TECHNOLOGIES OF HORTICULTURAL PRODUCTS TO REDUCE CARBON FOOTPRINT

Fisun G. Çelikel[1*], Ernst J. Woltering[2], Leo J.S. Lukasse[3]

ABSTRACT

Unfortunately, we lose a significant part of produced horticultural crops after harvest. The lost product has a huge carbon footprint. The most important postharvest factor in maintaining quality and preventing losses of perishable products is temperature. The cut flowers, fruits and vegetables that are not sensitive to chilling injury should be stored close to 0°C. This, however, requires more energy for cooling and thus needs the use and development of sustainable cooling principles. One obvious solution for storage facilities is the use of solar power. Various systems have been developed to store surplus energy during the daytime in the form of an ice buffer that can be used during the night to keep the product cool. Other smart cooling principles such as the Quest technology runs on reefer containers. These aid in saving energy and lowering the carbon footprint during refrigerated transport. Cut flowers and other horticultural products should be transported at low temperatures to keep them fresh from grower to consumer. However, refrigerated trucks use about 25% more fuel than non-refrigerated ones. Shipping containers by sea is a more sustainable alternative to conventional airfreight and overland transport with significantly less CO_2 emission. Eco-friendly treatments are another important issue in sustainability of horticultural industry. After harvest, cut flowers and some other horticultural crops are commonly treated with a range of compounds with the aim to improve the storage performance and to prolong the vase or shelf life. Eco-friendly and sustainable treatments should be preferred to maintain the postharvest quality of horticultural products. Plastics are being replaced by biodegradable packaging, ecofriendly renewable and recyclable materials, new heat-sealable, fiber-based materials from sustainably managed or certified forests, and other sustainable coatings. Novel procedures based on temperature treatments under controlled atmospheres (CATT) can replace the use of harmful chemicals in insect disinfection. Finally, advanced control of the distribution chain can minimize the postharvest losses contributing to the sustainability for horticultural and even all agricultural products.

Keywords: Temperature, Cooling, Transport, Storage, Packaging

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1. INTRODUCTION

A workshop titled 'How to make the transition to sustainable postharvest quality management of ornamental products? (https://www.ishs.org/news/ihc2022-workshop-03-how-make-transition-sustainable-postharvest-quality-management-ornamental) during IHC2022 (International Horticultural Congress) was held in Angers France on 14-20 August 2022 by workgroup Quality of Ornamentals (https://www.ishs.org/quality-ornamentals) of ISHS (International Society for Horticultural Science [1] (Acta Horticulturae in press).

The intention of the workshop was to express and highlight the most recent developments and innovations regarding sustainable postharvest handling issues of cut flowers and ornamental plants as follows: sustainability of ornamental chain; transition to sustainable transporting flowers by sea and rail for environmental and energy saving purposes; sustainable temperature management, cooling methods and storage; transition to sustainable postharvest care products (biocides, pulsing) and eco-friendly treatments (spray, pulsing, vase solutions); biodegradable packaging materials; sustainable solutions alleviating postharvest losses in cut flowers/greens and other ornamental products (pot plants, flower bulbs, etc.) to maintain their quality during postharvest handling, storage and transport, as well as to extend their vase/shelf life. Our aim was to discuss the new developments on sustainable issues with respect to postharvest performance of ornamental plants, to encourage future studies on the sustainable and environment friendly concepts. Following our introductory talks, we encouraged the participants to share their ideas and experiences. We had interesting fruitful discussions among participants and speakers (moderators).

In addition, an oral presentation titled 'Towards sustainable postharvest technologies' was presented during IHC2022 in symposium 'Innovation in ornamentals: from breeding to market' [2] (Acta Horticulturae in press).

Therefore, this keynote talk of Cooperation for Climate and Green Deal Symposium which was held in Atatürk Congress Center of Ondokuz Mayıs University (OMU) on 24-26 October 2022 is an updated combination of these two significant related scientific activities on sustainable postharvest technologies for all horticultural crops including fruits and vegetables.

As an outcome of the workshop in Angers, we identified 4 main opportunities to reduce carbon footprint during sustainable postharvest quality management of horticultural products (fresh fruits, vegetables and cut flowers):

1. Reducing / preventing postharvest losses
2. Reducing energy for cooling, storage and transportation
3. Reducing or avoiding harmful postharvest chemicals
4. Reducing waste of packaging materials

2. POSTHARVEST LOSSES

2.1. Preventing

Unfortunately, we lose a significant part of produced horticultural crops including ornamental products after harvest. They are living perishable crops with a high percentage of water that need care during handling and marketing. Depending on the commodity as well as the technology used and care taken during and after harvest, the postharvest losses can be up to 50% of production: 20% - 50% in developing countries and 5% - 25% for developed countries [3]. Preventing, or at least minimizing, these high postharvest losses contributes most to sustainability by reducing the greenhouse gas emissions and carbon footprint, considering all forms of energy including labor and human efforts, plant nutrition, pesticides and all natural resources (water, soil, etc.) used to produce them. The lost product has a huge carbon footprint.

2.2. Preharvest Factors

Before starting to discuss postharvest factors, we should be aware of the significant effect of preharvest factors on postharvest quality. First of all, we know that genetics is important in the degree of perishability of horticultural crops including fresh fruits, vegetables and cut flowers/greens. Therefore, other than consumer preferences, postharvest quality and longevity should be considered during cultivar selection avoiding the necessity to use harmful chemicals or technology to improve their life after harvest. Cultivar resistance to pest, disease and varied stress conditions is of importance in terms of sustainability of the horticultural sector. Therefore resistance to non-optimal conditions should be taken into consideration in breeding studies to develop new cultivars. Other than genetic factor, we know all cultural practices and environmental conditions during growth may greatly determine the postharvest quality and longevity of products as shown before for cut carnations [4, 5]. We know that we are only able to maintain the high quality of horticultural products obtained by proper cultivation and growing techniques.

2.3. Postharvest Factors

The important question is how to maintain postharvest quality or how to prevent postharvest losses for horticultural products? Then, of course we should consider the main factors in postharvest quality of fruits, vegetables and flowers. Temperature and care are the most important ones.

TEMPERATURE is the most important factor in harvested horticultural crops that continue to respire after detachment from the plants. The detailed research studies [6-10] in University of California at Davis clearly showed how temperature significantly affected the quality and longevity of crops via their respiration rates. As storage or transportation temperatures were lowered down to 0°C (except tropical chilling sensitive flowers), respiration rates were reduced significantly and thus postharvest quality of cut flowers was maintained (Figure 1). Therefore, lower temperature after harvest and during the whole supply chain to consumers means longer postharvest life and less postharvest losses. However, lower temperature at the same time means more energy to be used.

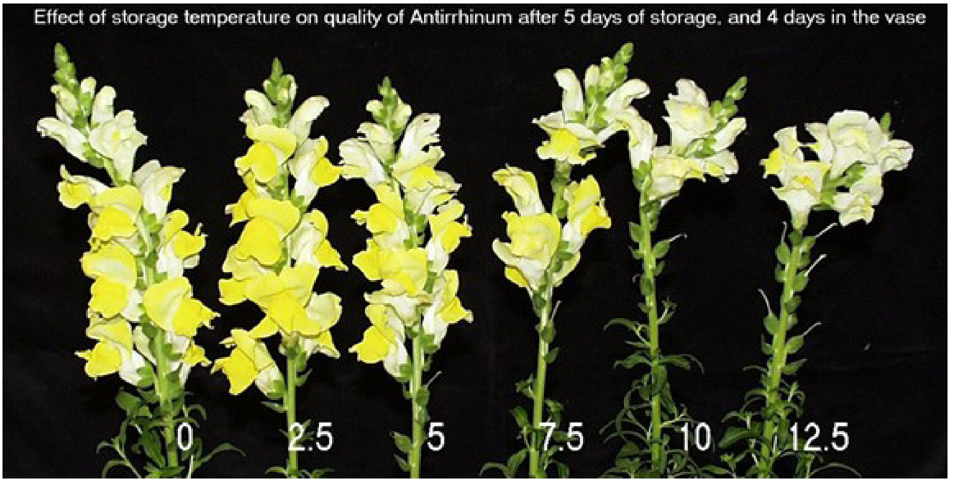

Figure 1. Effect of storage temperatures on quality of Snapdragon flowers (cv. 'Rocket Mix') after 5 days of dry storage and 4 days in the vase [10].

CARE is another important factor in postharvest quality and longevity, and thus sustainability. Careful harvesting and handling may reduce the waste (postharvest losses) significantly by minimizing or eliminating any wounding on crop surface which may cause decay and fungal development during storage and transport. Care is the most important sustainable tool in preventing postharvest losses, needs no energy to use, just care for products. Thus, training of workers and all people involved during and after harvest is important to be aware of living crops and significant effects of any kind of wounding on crop surfaces. Any deterioration or wounding not only reduces the quality and value of products, but also increases postharvest losses by causing water loss, pathogen infection and many more adverse effects.

3. SUSTAINABLE COOLING AND TRANSPORTATION

3.1. Sustainable Cooling

Therefore, we should use sustainable cooling systems using environmentally friendly renewable energy resources such as solar energy. One obvious solution for storage facilities is the use of solar power. Various systems have been developed to store surplus energy during the daytime in the form of an ice buffer that can be used during the night to keep the product cool. In addition, it is important to develop sustainable cooling technology such as the Quest technology developed at Wageningen Food and Biobased Research, Wageningen University and Research, the Netherlands [11]. It runs on reefer containers to save energy and lower the carbon footprint during refrigerated transport.

Quest stands for **QU**ality and **E**nergy in **S**torage and **T**ransport. Quest II has been developed by Wageningen UR Food & Biobased Research, shipping line Maersk Line and reefer unit manufacturer Carrier Transicold. The original idea dates back to 2002 and resulted in Quest I. In 2007 Maersk started to use the Quest I Software to reduce the energy consumption. In parallel the development of Quest II started. The main energy savers in Quest II are a balanced internal air circulation and a no part-load compressor operation. The effect of

Quest II temperature control on product quality was thoroughly investigated for a range of products, both in labscale tests and in hundreds of field trial shipments. Neither the labscale tests nor the field trials have ever revealed any adverse effect of Quest II on produce quality. Since completion of the development project in 2011, Maersk Line has started to introduce Quest II in its fleet [11] (Figure 2).

CO_2 Emission reduction by Quest technology

Quest II reduces Maersk Line's yearly CO_2 emission with 350,000 tons. Such savings are comparable to the CO_2 emission of cars driving 2 billion kilometers. Two natural areas of activity are the re-use of the Quest II knowledge in adjacent fields of use, like cold storage and further control improvements in reefer containers [11].

Figure 2. The new Quest II (patent pending) control methodology for container refrigeration units reduces the energy consumption of reefer containers by 65%. This saving comes without any adverse effect on produce quality [11].

3.2. Sustainable Transport

Those big volume exports are today still for 90 ~ 95% air freighted, while sea transport in reefer containers would cut the carbon footprint more than 65% [11]. Therefore, sea transport is a big opportunity to reduce carbon emission. The industry should first of all focus on converting the large volume exports from Ecuador, Colombia, Kenya and Ethiopia from air freight to sea freight.

However, the trade of the current system is organized such that receivers are used to order 1 or 2 days in advance, also the whole current supply chain infrastructure is tailored to air freight. Thus, the locations of precooling facilities and consolidation centers should be reconsidered and adapted for such a transformation.

Therefore, other than long or short term storage facilities, we should find out and use sustainable cooling principles also for transportation. Although air transport is the most expensive way, it is still commonly used for perishables. Transporting flowers by rail or sea is an environmentally friendly alternative to air to reduce carbon footprint. Other than much lower cost, there are many advantages of container transport by sea or rail. Compared to rail or sea transportation, air transportation is fast. In the trade of perishable products this is an advantage. However, conditions in air transport are often poorly controlled. Reefer containers can maintain quality for a long time as both temperature and gaseous conditions can be optimized.

4. ECO FRIENDLY POSTHARVEST CHEMICALS

Fruits, vegetables, cut flowers and greens are commonly treated with a range of compounds to improve the storage performance and to prolong their postharvest life. These compounds are either applied through the feeding solution for cut flowers in vase or are used as sprays or dips after harvest. Some of the compounds affect biological processes (such as ethylene sensitivity or chlorophyll breakdown), some tackle postharvest fungal infections and some such as biocides, organic acids and detergents improve water uptake of cut flowers.

Eco-friendly treatments (spray, pulsing, and vase solutions) should be used for sustainability of the flower industry. For instance, natural extracts and essential oils from medicinal plants should be preferred as a biocide in pulsing or vase solutions to maintain the postharvest quality of cut flowers and greens.

However, most of essential oils were obtained from native plants. Therefore, collecting of flowers or other plant parts should not be a threat to their populations. There must be some other concerns in using natural extracts as biocide commercially. In spite of many publications on significant effects of essential oils as biocide, there is no commercial product yet.

Other than bactericides, natural sources such as lemon juice could be used as acidifying agent.

Ethylene is a problem for many sensitive horticultural crops such as apple, mango, avocado, several types of vegetables and many cut flowers. 1-Methylcyclopropene (1-MCP) can be applied to these food products and is an ecofriendly alternative to the commonly used silver thiosulphate (STS) in cut flowers and pot plants (Figure 3). Unfortunately, STS, an environment pollutant with heavy metal, is still commonly used in the flower industry. A good waste management is essential to prevent or at least reduce its harmful effect to natural resources.

Figure 3. Treatment of snapdragon flowers with environment friendly ethylene inhibitor 1-MCP (+M) on prevention of ethylene-mediated (+E) abscission (FG Çelikel).

Novel procedures based on temperature treatments under controlled atmospheres (CATT) can replace the use of harmful chemicals in insect disinfection. Postharvest insect control such as

hot air treatments under CATT can provide an alternative eco-friendly method to replace methyl bromide, a potent ozone-depleting gas.

5. SUSTAINABLE BIODEGRADABLE PACKAGING

Increasing the plastic waste is a big concern in the world. Plastics are now being replaced by biodegradable packaging, ecofriendly renewable and recyclable materials, new heat-sealable, fiber-based materials from sustainably managed or certified forests, and other sustainable coatings. Forest certification is an important and powerful tool to ensure positive environmental, social, and economic benefits for forest management and wood supply. All materials used can be traced back to their origin. With Forest Stewardship Council (FSC) forest management certification all important environmental, ecological, social, and economic aspects are considered throughout the value chain, including respecting human (both worker and consumer) rights.

Biopolymers obtained by beneficial microorganisms and fresh fruit waste [12, 13] are important opportunity to reduce waste and carbon footprint. This kind of ecofriendly packaging materials and coatings should be preferred to use in flower industry similar as food packing. Other than plastics, cardboard waste of flower packaging is a big concern in terms of environment, because of commonly used plastic coatings. Thus, sustainable recyclable coatings are suggested to be used by flower industry. In addition, considering the sustainability pyramid related to packaging materials (Reduce, Reuse, Recycle), the use of reusable plastic boxes could be a solution in fruit, vegetable and flower transport where currently disposable cardboard boxes are used.

6. CONCLUSION

There are ample possibilities for improvement of sustainability in the horticultural (fresh fruit, vegetable, cut flower) industry. Breeding cultivars and development of cultivation techniques to achieve more resistance to adverse postharvest conditions should have high priority. Improvement of sustainability of storage and transportations can be achieved through the transition from air to sea or train transportation and by the development of more sustainable cooling systems. Postharvest chemical treatments for improvement of storability and for pest control may be reduced or replaced by more environmentally friendly alternatives (natural compounds, heat and CO_2 treatments). The use of fossil-based plastics in packaging can be reduced by using biodegradable and recyclable alternatives. Finally, advanced control of the distribution chain from grower till consumer can assure that product losses are minimized, contributing to the sustainability of the value chain for horticultural and agricultural products.

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ECO-FRIENDLY AGRICULTURE AUAVs (AGRICULTURAL UNMANNED AERIAL VEHICLES) APPLICATIONS

Derya Özücan[1*], Mehmet Cem Elik[2]

ABSTRACT

As the world population increases, the need for food increases day by day as well. Agriculture is one of the keystones for national economies. The use of traditional methods in agriculture is no longer sufficient to bring the production amount to an adequate level. They are of no use because most of the time the crop is over-treated with pesticides or used when there is no need. While such wrong agricultural practices disrupt the balance of the ecosystem, they also negatively affect agriculture to agreat extent. After adverse climatic conditions, the most important factors affecting production in agriculture are pests, diseases, insufficient soil conditions and damage to beneficial organisms. The use of advenced technology unmanned aerial vehicles in agriculture allows us to keep these negative factors to a minimum. The use of digital measurement Technologies provides the opportunity to collect instant data from the field and to monitor and intervene at every stage of production.This study was carried out as MCEM Informatics and Nanotechnologies company. It is a compilation of applications and other scientific studies, the benefits provided by the use of unmanned aerial vehicles are discussed.

Keywords: Agricultural Technologies, AUAV, Pesticides

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1. INTRODUCTION

The use of traditional methods in agriculture, which has a special importance for national economies is not sufficient in today's conditions. For this reason, it has become necessary to apply more modern methods such as "Precision Agriculture (PA)". Precision Agriculture relys on the use of data sources together with advanced analytical tools in order to support farmers to take more data based decisions and manage them correctly in order to reach their goals [1,2]. Recently there has been a increasing interest in precision agriculture on a global basis as a promising step towards producing more high quality food in a more sustainable way by optimizing externalities [3]. The report, Published by the Intergovernmental Panel on Climate Change (IPCC), noted that sustainable land management could be key to reversing the negative impact of climate change on land [4]. It is crucial for farmers to change the way they work, not only to mitigate the effects of climate change, but also to protect themselves against economic losses.

Top factors that negatively affect production:

- adverse climate conditions
- damage to beneficial organisms
- pests
- plant diseases
- inadequate soil conditions

In agriculture, one field is considered a heterogeneous entity with variable topography, soil characteristics, weed infestation and yield potential, thus adapting practices spatially and temporally. Unmanned aerial vehicles (UAA) are gaining a relatively more important role in precision agriculture. They help agricultural professionals implement sustainable farming practices, while also increasing profitability. It allows tracking and mapping of crop parameter data in the field in combination with GPS and geographic information system tools. These enable farmers to prepare pesticide and fertilizer prescriptions, or to identify diseases and pests seen in the product early, to intervene, and thus to obtain higher yields [4].

For example, UAVs with multi-spectral cameras have been used for the assessment of crop yields, for monitoring of crop height and biomass and for mapping of crop and weed [5,6]. Various studies have been conducted on the advantages and disadvantages of UAVs compared to traditional methods. A brief comparison of the technical characteristics of the most commonly used RS platforms in agriculture is presented in Table-1. UAVs can replace or complement most of these platforms [3].

Table-1. Technical comparison of common RG platforms used in precision agriculture (3).

Specification	**Ground-Based**	**Satellite**	**Manned Aircraft**	**UAV**s
Cost	Low	Highest	High	Lowest
Operating Environment	Indoor/outdoor	Outdoor	Outdoors	Indoor/outdoor
Time-Consuming	Long	Shortest	Short	Short

Labor-Intensity	Highest	Low	High	Medium
Trained pilot requirement	No	No	Yes	No
Automatic crop spraying	No	No	No	Yes
Spatial resolution	Highest	Low	Moderate	Highest
Operational risk	Low	Moderate	High	Low
Spatial accuracy	Moderate	Low	High	High
Temporal advantage	No	No	No	Yes
Specification	**Ground-Based**	**Satellite**	**Manned Aircraft**	**UAVs**
Adaptability	Low	Low	Low	High
Maneuverability	Limited	Limited	Moderate	High
Deployability	Moderate	Difficult	Complex	Easy
Susceptibility to weather	Yes	Yes	Yes	No
Repeatability rate	Minutes	Day	Hours	Minutes
Feasibility for small areas	Yes	No	No	Yes
Autonomy and sociability	Low	Low	Low	High
Real-time data availability	No	No	Yes	Yes
Limited to specific hours	No	Yes	No	No
Running at low altitude	No	No	No	Yes
Ground coverage	Smallest	Large	Medium	Small
Observation range	Local	Worldwide	Regional	Local
Operational complexity	Simple	Complex	Complex	Simplest

UAVs have several technical problems and limitations as well as advantages. Short flight time, difficulties in maintaining flight altitude, stability, sensitivity to weather conditions and legal problems related to application permits in Turkey are experienced.

A study was also conducted measuring droplet accumulation after spraying. This work was done on a 1.2 meter high citrus tree. The trees were divided into 6 parts, and droplets were found in the front, back, middle, left and center parts, but there was a deviation in the distribution in the right part. This deviation may be due to manual actuation or speed, or due to a right-hand wind [7]. Since there is no licensed pesticide in its formulation suitable for spraying with drones, our Ministry of Agriculture and Forestry is cautious about spraying with drones and does not allow every pesticide in every cultivated plant. In addition, the fact that the purchased agricultural drones are subject to many procedures creates extra difficulties [8]. In this study, it is aimed to draw attention to the many benefits of the use of AUAVs in agriculture and to provide some benefit in eliminating the difficulties encountered.

2. PESTICIDE AND FERTILIZER APPLICATION WITH AGRICULTURAL UNMANNED AERIAL VEHICLES

The first unmanned aerial vehicle was born with the dream of a flying torpedo during World War I. During World War I, several attempts were made to make the flying equivalent of the torpedo. The first of these is the Aerial Target missile, which Archibald Montgomery Low started to develop in 1914. Also known for his television design, which he called TeleVista, Low was actually a British researcher who is called the “father of radio-guided systems”. Like many firsts, the Aerial Target failed its test flight in 1917 and crashed on landing. The R50 and RMax models of the Japanese Yamaha company are the first to combat pests in agriculture [9-11]. However, Yamaha stopped production in 2007 [12]. Pesticide and fertilizer application in agricultural areas is of primary importance as they increase the quality and quantity of crop yields. However, some problems in traditional methods affect these processes. For example, chemical exposure of operators, uneven spread of pesticides and fertilizers, skipping or overlapping of some crop areas during spraying, crop crushing during application, chemical drift by wind. In Picture-1, you can see the DJI Agras T20 model, one of the agricultural unmanned aerial vehicles.

Picture 1. DJI Agras T20 model Agricultural Unmanned Aerial Vehicles

Global climate change, which triggers many problems such as melting glaciers and rising sea levels, affects the whole world. One way to combat the climate crisis is to reduce carbon emissions. Carbon emissions can be reduced by 51.45kg CO_2e (carbon dioxide equivalent) per hectare through the use of drones in plant protection operations [21]. UAVs’ ability to modulate ground clearance as topography and geography changes, generate high-resolution field maps, allowing spraying of the right amount of fluid in real time for even coverage, which in turn offers site-specific management opportunity in precision agriculture. Using a low or ultra low volume spray, UAVs can reduce the application of pesticides and fertilizers by about 10-20% and reduce the amount of chemicals penetrating groundwater [16,2]). Pesticide application with the UAV is at least 5 times faster than conventional machines. UAVs significantly reduce chemical drift due to its capability to work significantly close to crops without causing to any harm. The use of drones enables the elimination of operator exposure to chemicals. In addition, pesticides are applied directly to the plant, not to the soil.

Despite the advantage of drones in pesticide and fertilizer application, the operation effectiveness still relies on several factors. The level of droplet deposition onto target crops is a critical index for assessing the spray performance. Unfortunately, droplet accumulation is still a major concern in spray application while using drones. Flight parameters also influence the effectiveness of spraying by drones. The variability in flight parameters during drone operation influence the average droplet deposition. The efficiency of spraying also depends on environments temperature during pesticide application. Land size, may appear challenging for drones as transpassing all areas with a single flight for spraying may not be possible. Recharging the batteries and refilling the spray tanks may be necessary several times while pesticide and/or fertilizer application.

Crop growth is generally not even across fields, resulting in significant variability in crop yield within the field. Such differences in plant growth may be due to biotic (pests) or abiotic (soil, water, etc.) factors. Conventional crop monitoring methods are known to be the collection and assessment of tedious crop growth data and crop yield data of previous years / seasons. The comparison of NDVI data and images of disease / pest spots taken by UAVs at different stages of crop growth with yield data can be given as an example (3). In this way it would be easily possible to determine and evaluate the highest and lowest yield obtained from the same area of the field for each season and each crop.

The transformation of UAV based image to a Digital Surface Model (DSM) or Crop Surface Model will enable the assessment of crop health, growth rate, and yield forecast topography (18). Thes use of such a model is needed for the estimation of biomass accumulation and plant height. Model combinations in addition to spectral data may accelerate the estimation of yields. The observed maps generally provide good details of variations in vegetative growth and yield potential [19].

The main challenge of UAV images in monitoring plant health and yield potential may be evaluation every temporal data at high resolution. It is very important to relate the observed crop characteristics with observed crop yield. Another advantage of UAVs' is their close flight capability to crops which enables higher resolution images due to reduced influence from cloud cover and low light conditions when compared with satellite imagery. UAV imaging has the ability to produce a map of whole field at millimeter detail, for which a beforehand flight schedule is not needed. Drones with multispectral cameras allow farmers to monitor crops to better observe crops and respond quickly. You can see the Phantom 4 model with DJI multispectral camera in Picture-2 and the field view taken with this drone in Picture-3.

Picture 2. DJI Phantom-4 UAV with multispectral camera (24)

Picture 3. Field image taken by UAV with multispectral camera (24)

With the use of spesific sensors UAVs can predict biomass, monitor crop plant health and stress, detect pest or pathogen invasions, monitor soil fertility, and target patches of high weed or invasive plant pressure, resulting in precision management practices that enable lower use of agrochemicals [7].

Sensor selection for drones are very significant. The selection of drone sensors mainly relys on applications such as disease detection, nutrient detection and water status detection. Researchers are continuously working on the improvement of drones and developed mission-specific drones for crop monitoring. However, the UAV system made its breakthrough in the agriculture industry around 2011, as drone technology and payload devices became affordable and easy to use [14].

Finding the most important spectral channel for a proper detection of symptoms in different crops is extremely important for pest managements with UAVs, A good result of disease detection with UAV is best observed when textural and spectral data is combined (20). The combination of hyperspectral and thermal sensors provided promising data forin disease detection during the early stage [21,22]. Though, the evaluation of data from different sensor types may become challanging during data processing.

Besides UAV flight parameters, high spatial and temporal resolution of UAVs imagery is required for proper crop and pest discrimination. One of the challenges in image processesing is the spectral similarity of pest symptoms and abiotic stresses on crops, which causes to deteriorations in early detection due to similarities in appearance reflecting analogous spectral patterns for crops with pest symptoms and healthy crops. Other factors influencing UAV-based aerial detection of pests are image collection time and spectral characteristics of field background [23].

For analysing and interpreting the data, software packages of various complexity and cost are used, requiring installation and configuration after purchase, These will require periodic maintenance, advanced coding, or advanced data training. The non-expert users utilizing UAVs will require investment in time and money for learning new skills with UAV. UAVs technologies don't require a trained human pilot, however, a private pilot license is required for flight operations. Unmanned aerial vehicles are in the UAV-2 class. According to the regulation of the General Directorate of Civil Aviation in Turkey on UAV systems, the maximum take-off weight of UAV-2s should be between 25 and 150 kilograms. Users of these drones must have a UAV-2 pilot license.

For the adaptation of agricultural producers to UAV operations, clear information on economic benefit of precision agricultural technologies is additionally required. Some other technical factors affecting the adoption of these technologies are [3]:

• Socioeconomic characteristics (e.g., farm size, farming experience, education, age, and access to the information)
• Physical attributes of the farm (e.g., variability of soil types, productivity)
• Location of the farm (ex, broadband connectivity)
• Initial financial investment
• Interest in learning new skills and the learning curve
• Compatibility of new technologies with the current practice
• Potential benefits (reducing production costs, increasing yields, protecting the environment, providing massive amounts of information to help manage farms)
• Complexity of the technology and ease of use
• Complexity of data interpretation and decision making
• Data transfer speed
• Data privacy
• Safety.

UAVs are easily adopted by farmers, related to a small farm. An effort is always needed for making these technologies more user-friendly and available to all level of users covering different interests for precise crop management. More research is needed, including remote crop monitoring and interpretation, and data processing.

3. CONCLUSION

In this article, the usage areas of UAVs in agricultural areas are mentioned and a compilation is made from the studies on this subject. There are a wide variety of factors associated with the use of drones in precision agriculture. To exploit the full potential of drone-based applications, sensing technologies, measurement protocols, post-processing techniques, evaluation techniques must be combined. It is foreseen that there is a need for the development of experimental platforms to determine the most appropriate methodology, especially in different environmental conditions.

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HOW CARBON FOOTPRINT MATTER IN TURKSTAT: A CASE STUDY OF SAMSUN REGIONAL OFFICE

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EXTENDED SUMMARY

BACKGROUND

Climate change is a serious global problem and there are essential international efforts to provide standards, control and reduce the impacts of climate change.Greenhouse gas emission (GHG) has been further examined in the last two decades due to the fact that it has been one of the main results of climate change. Therefore, estimation of carbon emission is of vital importance to introduce carbon footprint. Carbon footprint is total amount of GHG emission, expressed as carbon dioxide equivalent (CO2e),caused by activities of an individual or organization.

PURPOSE

The aim of this study was to calculate total carbonemission and carbon footprint for Samsun Regional Office of Turkish Statistical Institute (TurkStat) from the period 2017 to 2021.

METHOD

The material of this studyincluded activities which are responsible for GHG emission and they were identified and classified into three groups: i) direct emissions (scope 1) ii) energy indirect (scope 2) iii) other indirect (scope 3). In this context, natural gas consumption and fugitive emissions were included in Scope 1 whereas electricity consumption and transport-related activities and fuels were included in Scope 2 and Scope, respectively. The activity data of Samsun Regional Office was calculated by quantity of consumption whereas netcalorific value and carbon emission factor was used from international documents.

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FINDINGS

The results of the study revealed that total carbon emission was calculated 136.87 tCO2e in 2017 and decreased until 2020. Nevertheless, it has started to increase by 2021 and was measured as 117.79 tCO2e. On the other hand, total carbon emission per capita was computed 1.4 tCO2e in 2017, perpetually decreased until 2020 but started to increase by 2021 and reached 1.2 tCO2e. Therefore, emission per capita decreased by 13.97% in five-years period.

The results highlighted that distribution of carbon emission was changed with respect to scope in years. The rate of natural gas consumption and fugitive emissions was 11% in 2017, sharply increased and almost doubled in 2020 (21%) but started to decrease by 2021 (16%). On the other hand, the rate of electricity consumption was 24% in 2017, slightly fluctuated in time but decreased from 25% to 21% in 2020-2021 period. Lastly, transport related activities and fuels did not significantly change in 2017-2018 period but it has started to decrease by 2019 and continued in 2020. Nevertheless, transport related activities and fuels increased in 2021 and measured as 63%. The results revealed that transport related activities and fuels was the major source of carbon dioxide emission.

The model results revealed that the amount of carbon emission has changed in terms of scope in five years-period; natural gas consumption and fugitive emissions has increased by 28.74% whereas electricity consumption and transport related activities and fuels has decreased by 22.75% and 17.77%, respectively. Fluctuation of natural gas, electricity and fuel consumption and total carbon emission could be explained by some reasons. First of all, natural gas consumption increased in 2020-2021 period with respect to previous three years. On the other hand, electricity consumption considerably decreased in the same period. Until 2020, average temperature of service building was not enough in winters and alternative heating methods such as air conditioning and electric heater were used. Since 2020, service building was adequately heated and there was no need for alternative heating methods. Therefore, natural gas consumption increased and electricity consumption decreased. There were two important reasons for fluctuations of carbon emission in transport related activities and fuels. i) The number of vehicles (rental, not owned) decreased in the beginning of 2019 and therefore fuel consumption and carbon emission has also decreased. ii) In 2020, pandemic has severe impacts on statistical process. Some surveys were postponed whereas data collection method of some surveys were shifted from Computer Assisted Personal Interviewing (CAPI)to Computer Assisted Telephone Interviewing (CATI) method. Therefore, fuel consumption and carbon emission has substantially decreased. In 2021, postponed surveys with new ones were applied and CATI method ceased to be used in some surveys. Therefore, carbon emission started to increase.

CONCLUSION

Although computation of carbon footprint is not main task of TurkStat, climate change is an essential global problem regardless of any task and institutional precautions should be identified. Therefore, three targets could be introduced to lessen total carbon emission of Samsun Regional Office. i) Central heating and cooling systems could be used and service building could be insulated for leaking heat. ii) Some surveys should be continued to be collected with CATI method. iii) The results of this study would be shared with all employee in order to rise institutional awareness on climate change and carbon footprint.

Keywords: Climate Change, Carbon Footprint, Greenhouse Gas Emission

CALCULATION OF INDIVIDUAL ECOLOGICAL FOOTPRINT

Sevde Üstün Odabaşı[1*]

ABSTRACT

Individuals meet their basic needs such as food, heating, and shelter from nature to maintain their lives.As a result of these actions, they cause serious damage to nature. While our natural resources are consumed unsustainably, many wastes are generated, and the ecosystem balance is disturbed. To calculate how much the ecological carrying capacity of the world has been exceeded, the concept of ecological footprint has been created. The ecological footprint is the measure of the self-renewal capacity of our world, and the ecological footprint determines the pressure exerted by the living thing on the world. For this purpose, in this study, an individual's ecological footprint was calculated with a web calculator. As a result of the study, the ecological carbon footprint of an individual was calculated as 9.4 gha.It has been determined that an individual living in this way need 5.8 Earths.In terms of equivalent CO2, an ecological footprint of 9.7 tons was calculated.

Keywords: Ecological Footprint, World Overshoot Day, Biological Capacity, Carbon Footprint, Offsetting

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1. INTRODUCTION

With the development of industry and technology, the pressure on our world has increased even more.As a result of the limited natural resources and their use as if they will never be exhausted, there have been environmental effects.Therefore, the concept of sustainability has emerged.Sustainability aims to transfer the resources used today to future generations without loss.Another concept that has come to the fore with sustainable life has been the ecological footprint.While we live, we consume resources and produce waste until the end of our lives.Each substance consumed and each waste produced require a certain amount of fertile soil and water.The fertile land and water area required to produce the resources we consume and absorb the wastes we create is expressed as the ecological footprint[1].In short, the ecological footprint is a key sustainability indicator to measure our impact on the planet.It is a method developed to calculate the ecosystem balances that are deteriorated as a result of human activities and to determine the amount that needs to be restored to the ecosystem.In other words, it calculates the "number of worlds" that will be required for a sustainable future, with the earth overshoot day, in the face of both the resources that people demand from nature and the deterioration of the natural balance.The "earth overshoot day" has emerged, which means the day when one year of natural resources offered by the world is consumed.In other words, it is understood that the resources offered by the world are consumed in 209 days[2].Currently, 1.7 earths are needed to support human activities.As a result, our resources are depleted, and biodiversity is decreasing.Accordingly, the planet is getting warmer, climate change is occurring, and the living spaces of living things do not restrict.

Ecological footprint can be calculated separately and holistically for an individual, community, institution, company, city, or country.Its ecological footprint calculates how much land should be obtained from 365 liters of water per year for a person who consumes 1 liter of water per day[3].Likewise, the ecological footprint of a person who eats vegan and a person who eats meat is also different.In short, the ecological footprint can be calculated by multiplying consumption, production area, and population on a national scale; It can also be calculated to cover different fields of activity such as consumption, production, import, and export[4].The ecological footprint is measured in hectares of global area (gha).Considering the variables in the formula, consumption; refers to the extent of use of goods.On the other hand, the production area refers to the productive biological area required to meet the consumption area in a sustainable way.Finally, population refers to the number of people consuming natural resources in a given area [5].

Ecological footprint components are divided into six.These; are carbon footprint, agricultural land footprint, grassland footprint, built area footprint, and fishing field footprint. Among these components, the carbon footprint is the fastest growing factor, more than the sum of the effects of all other components.The carbon footprint accounts for 60% of the global ecological footprint. For this reason, scientists primarily draw attention to the carbon footprint to reduce the ecological footprint[6].

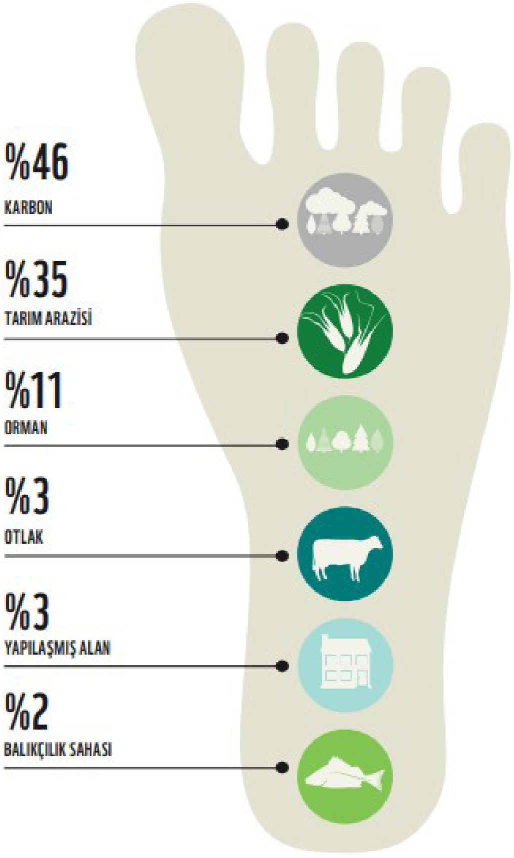

Figure 1. Turkey's Ecological Footprint components [6].

The productivity of productive areas in Turkey is above the world average.On the other hand, the per capita biocapacity is less than the world average due to the high population density.The Ecological Footprint of the consumption, which was 2.7 gha in 2007 in Turkey (Figure 1), is equal to the world average and lower than the average of Mediterranean countries.The Ecological Footprint of consumption in Turkey is 50% above the global bio-capacity per capita[6].

The gap between the amount of natural resources that the world provides sustainably and the amount demanded is increasing day by day.The ecological footprint must be calculated to leave a sustainable environment for future generations.For this purpose, the individual ecological footprint of a person living in Turkey was calculated using a web-based footprint calculator.The categories with the most impact were determined by determining the individual ecological footprints, and the measures that could be taken to reduce these impacts were discussed.

2. MATERIAL AND METHODS

In this study, the ecological footprint was calculated by using the calculators prepared by the World Wide Fund for Nature (WWF) and the Global Carbon Footprint Network [7, 8].The calculator created by WWF gives the results in tons, while the global carbon footprint gives the results in gha.In addition, the WWF calculator evaluates food (4 questions), travel (7 questions), home (8 questions) and stuff (7 questions), while the global carbon footprint calculator evaluates food (2 questions), home (6 questions) and travel (5 questions).The reason for using two different calculators is to detect changes in ecological footprint from different sources.Individual measurement; It is based on the biologically productive area that will meet the individual's consumption and considers different types of consumption such as the amount of biologically productive area, climatic conditions, and population of the country.The questions of two different calculators are given in the Table 1 below.

Table 1. Ecological footprint calculation questions prepared by WWF and Global Carbon Footprint

WWF Questions	**Global Carbon Footprint Questions**
Food	**Food**
How would you best describe your diet? -Meat in every meal -Meat in some meal -No beef -Meat very rarely -Vegetarian -Vegan	How often do you eat animal-based products?(beef, pork, chicken, fish, eggs, dairy products) -Never -Infrequently -Occasionally -Often -Very often
In a week, how much do you spend on food from restaurants, canteens and takeaways? -**£** 0 -£ 1-10 -£ 10-60 -More than £ 60	How much of the food that you eat is unprocessed, unpackaged or locally grown? (less than 320 kilometers/200 miles away) -None 0%-----------------All 100%
Of the food you buy how much is wasted and thrown away? -None -0-10 % -10-30% -More than 30%	
How often do you buy locally produced food that is not imported to the UK? -A lot of the food I buy is locally sourced -Some of the food I buy is locally sourced -I don't worry about where my food comes from	
Travel	**Travel**
What kind of vehicle do you travel in most often as driver or passenger? (if any) -Car -Motorbike -Neither- I walk, cycle or use public transport for all my journeys	How far do you travel by car or motorcycle each week? Car: zero km---------very far (800 km) Motorbike: zero km---------very far (800 km)
How many hours a week do you spend on the train for personal use including commuting? -I don't travel by train -Under 2 hours - 2 to 5 hours - 5 to 15 hours -15 to 25 hours - Over 25 hours	What is the average fuel economy of the vehicles you use most often? -Car: Inefficient …………………. Effıcıent or Electrıc -Motorbike:Inefficient …………………. Effıcıent or Electrıc

How many hours a week do you spend on the bus for personal use including commuting? -I don't travel by bus -Under 1 hours - 1 to 3 hours - 3 to 6 hours -6 to 10 hours - Over 10 hours	When you travel by car, how often do you carpool? -Never -Infrequently -Occasionally -Often -Always
In the last year, how many return flights have you made in total to the following locations? -domestic ---- -to/from Europe ---- -to/from outside Europe ----	How far do you travel on public transportation each week? (bus, train, etc.) Not far 0km--------------------Very far 800 km
What percentage of your flights do you offset? -None of them -25% -50% -75% -All of them - Not applicable	How many hours do you fly each year? None (0 hours)---------many (200 hours)
Home	**Home**
What kind of house do you live in? - Detached - Semi deached - Terrace - Flat	Which housing type best describes your home? -Freestanding, no running water - Freestanding, running water -Multi-storey apartment -Duplex, row house or building with 2-4 housing units - Luxury condominium
How many bedrooms does your house have? -1 -2 -3 -4 or more	What material is your house constructed with? -Straw/bamboo -Brick/concrete -Steel/other -Wood -Adobe
How many people (aged 17 and over) live in your house? -1 -2 -3 -4 -5 or more	How many people live in your household? -Just me1 ……….10 or more What is the size of your home? -Tiny -Large -Huge
How do you heat your home? -Gas -Oil -Electricity -Wood - Heatpump	Do you have electricity in your home? -No -Yes How energy efficient is your home? -Hardly (Very inefficient) -Below average -Average -Above average - Very (Efficiency-centered design)
Is your electricity on a green tariff? -I don't know -No -Yes but the tariff is less than 100% renewables -Yes 100%	What percentage of your home's electricity comes from renewable sources? Low %0-----High %100
Do you regularly turn off lights and not leave your appliances on standby? -Yes -No	Compared to your neighbors, how much trash do you generate? -Much less -Less -Same - More -Much more

How warm do you keep your home in winter? -below 14°C -14-17 °C -18-21 °C -over 21°C	
Which of these home energy efficiency improvements are installed in your home? -Energy saving lightbulbs -Loft insulation -Cavity or solid wall insulation -Condensing boiler -Double glazing -Low flow fittings to taps and showers -Solar panels -Solar water heater	
Stuff	
In the last 12 months, have you bought any of these new household items? -TV, laptop or PC -Large item more furniture -Washing machine, dishwasher, tumble dryer or fridge freezer -Mobile phone or tablet	
In a typical month, how much do you spend on clothes and footwear? -£0 -£ 1-60 -£ 60-180 -£ 180+	
In a typical month, how much do you spend on your pets and pet food? -I don't have pet - £ 1-10 - £ 10-35 -£ 35+	
In a typical month, how much do you spend on health, beauty and grooming products? -£ 0-10 -£ 10-60 -£ 60+	
In a typical month, how much do you spend on phone, internet and TV contracts? -£ 0 -£ 1-35 -£ 35-70 -£ 70+	
In a typical month, how much do you spend on entertainment and hobbies (sports/gym, cinema, books, newspapers, gardening, computer games) -£ 0- 25 -£ 25-50 -£ 50-75 -£ 75+	
Which of these types of waste do you recycle and/or compost? -Food -Paper -Tin cans -Plastic -Glass	

3. RESULT AND DISCUSSION

First, the calculation was made with the calculation method prepared by WWF.The first category is the food category and includes four questions.The first question was about how often meat is preferred at meals, and the answer was “meat in some meals.”The second question was about how much money was spent on eating out.In this question, the currency was not in “Turkish Lira” but was available in the calculation module as “Pound Sterling.”Therefore, the calculations were made by converting from sterling to Turkish lira. The answer to this question was chosen as £1-10.The third question was about how much of the purchased food was wasted, and the answer was 0-10%.The other question was about how often food was chosen from abroad.The answer to this question was given as “some of the food I buy locally sourced.”After the food category was completed, it was the travel category.The first question in this category was which vehicle type was preferred most frequently.The answer to this question was “car.”The second question was about the fuel type of the vehicle used.The answer to this question was “medium petrol or diesel car”.The third question was how many hours a week were spent commuting to work.The answer to this question was chosen as “2 to 5 hours”.The fourth question was how many hours per week were spent commuting on the train.The answer to this question was, “I don’t travel by train.”The fifth question was how many hours per week were spent commuting by bus.The answer to this question was, “I don’t travel by bus.”The sixth question was about the number of annual air travels.This question was answered only 2 in the country. The seventh question was about what percentage of flights were offset.The answer to this question was “non of them.” After the travel category, it was switched to the home category.The first question in this category was about how to live in a house. The answer to this question was “flat.”The other question was about the number of bathrooms in the house. Two answers were given to this question. The third question was about how many people lived in the house.Two answers were given to this question. The fourth question was about the heating system of the house.The answer to this question was “gas.” The fifth question was whether the electricity was in the green tariff.The answer to this question was, “I don’t know.” The sixth question was whether the lights were regularly turned off or whether the devices were put into standby mode.The answer to this question was “yes.” The seventh question was about the home temperature in winter. The answer to this question was “over 21°C”.The eighth question was about energy improvements installed at home. The answers to this question were “energy-saving light bulbs” and lost isolation.The last category was the stuff category. The first question in this category was about electronic goods purchased last year.This question was not answered because new items were not purchased. The second question was about the money spent on clothing and shoes in a year.The answer to this question was “£60-180” by converting the pound to the Turkish lira.The third question was about how much money you spend on your pet monthly. The answer to this question was, “I don’t have a pet.”The fourth question was about how much money is spent monthly on beauty products. The answer to this question was “£0-10” by converting the pound to the Turkish lira.The fifth question was about the amount of bills such as monthly telephone and internet. The answer to this question was “£35-70” by converting the pound to the Turkish lira.The sixth question was about the amount spent monthly on entertainment and hobbies. The answer to this question was “£0-25”.The last question was about which types of waste he sent for recycling. The answer to this question was “plastic.”After all, categories were answered, an ecological footprint of 9.7 tons (of CO_2 equivalent) was determined when the calculation was made according to the data entered in the calculation module.It was determined that 32% of this footprint belongs to the house category, 24% to the food category, 27% to the travel category, and 17% to the stuff category.According to the WWF calculator, it has been determined that the ecological footprint is less than the footprint of an average person living in England. However, this value is still quite high for the world.

Secondly, the calculation was made with the calculation module prepared by Global Carbon Footprint. The first category is the food category, and two questions were asked to be answered in this category.The first question was about how often meat is consumed, similar to the WWF module. The answer to this question was “often.”The second question was how much food was packaged or locally sourced. The answer to this question was “50%”.The second category after the food category is the home category. There are six questions in this category.The first question of the Home category was about the type of residence. The answer to this question was “Multi-storey apartment.”The second question was about the material the house was built with. “Brick/concrete” is given as an answer to this question.The third question was about how many people lived in the household and the size of the household. For this question, the number of people living in the household was chosen as two and the household size as “Large.”The fourth question was about electricity use at home. The answer to this question has been chosen as “above average”.The fifth question is what percent of the electricity in the house comes from renewable sources. According to the Presidential Annual Program data, Turkey met 42.3% of its electricity production from renewable sources in 2020 [8].Therefore, the answer to this question was given as 42%. The fifth question asked about the amount of garbage compared to your neighbors. The answer to this question was given as “more.”The sixth question was about how many kilometers traveled by car or motorcycle each week. The answer to this question was “125 km by car”.The seventh question was about the fuel consumption of the vehicle used. This question was answered as “5 liters/100 km by car”.The eighth question was about using shared vehicles while traveling by car. The answer to this question was given as “10%”.The ninth question was about how far traveled by public transport. This question was answered 0 because public transportation is not used.The tenth question was about how many hours in a year. This question was answered with “5 hours”.After all, categories were answered; when the calculation was made according to the data entered in the calculation module, an average of 5.8 earth, i.e., 9.4 gha ecological footprints, was determined.Looking at the ecological footprint components, the carbon footprint was calculated as 5.2 gha, built-up land 0.4 gha, forest products 1.5 gha, cropland two gha, grazing land 0.2 gha, and fishing grounds 0.2 gha. 55% of the ecological footprint consists of a carbon footprint. Figure 2 shows the components of the environmental footprint.

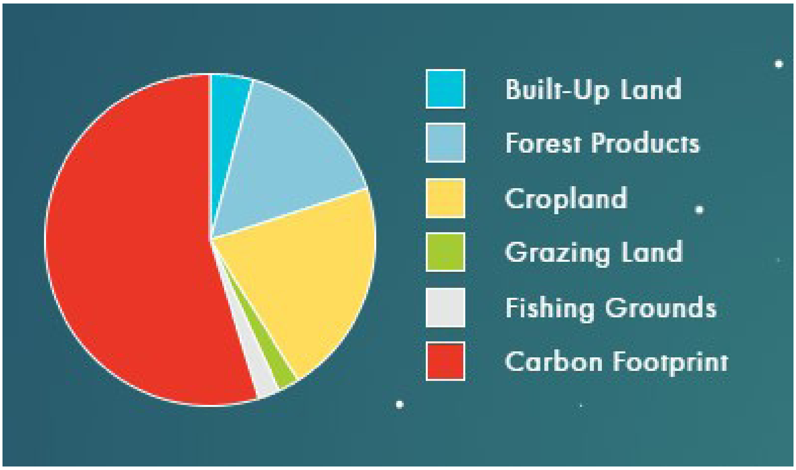

Figure 2. Ecological footprint distributions at the end of individual ecological footprint calculation

4. CONCLUSION

This study aims to calculate individual ecological footprints using WWF and Global Carbon Footprint, two separate web-based calculators.Two different calculation methods are preferred in the study because they vary according to countries and criteria.In this way, it was possible to compare the results obtained.At the end of the study, an ecological footprint of 9.7 tons was calculated with the calculation created by WWF and 9.4 gha with the calculation module created with Global Carbon Footprint.At the same time, the effects of ecological footprint components are given in the calculation module created with Global Carbon Footprint.Accordingly, among the ecological footprint components, the environmental impact was the carbon footprint with 55%.The ecological footprint in the world is 2.8, and Turkey's ecological footprint in 2015 is determined as 3.4 gha.When the results are examined, each 9.4 gha ecological footprint is well above the determined values.Accordingly, it is necessary to take some small but effective measures to reduce our ecological footprint before it is too late.We can list these measures as follows; Reducing dependence on fossil fuels, using water areas and usable water economically, using grasslands, forests, wetlands, and seas knowing that they are limited, making population planning and keeping it under control, urban planning, dissemination and support of recycling and finally ecological awareness. It needs to be disseminated. It is possible to leave a sustainable environment for future generations by taking these small precautions.

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CALCULATION OF WASTE-SOURCED GREENHOUSE GAS EMISSION (CARBON FOOTPRINT) IN DENIM INDUSTRY

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ABSTRACT

Global warming and climate change issues take an important place in the world agenda and studies on these subjects are increasing day by day. Turkey also signed the Paris Agreement to reduce carbon emissions which are the triggers of global warming and climate change and prepared an action plan for the European Green Agreement. Therefore, in recent years, the concept of "carbon footprint" has started to come to the fore more and more in order to calculate emissions that cause greenhouse gasses. Especially in sectors with high greenhouse gas emissions such as textiles, carbon footprint calculation is of great importance in order to reduce carbon emissions and the negative effects of climate change. The aim of this study is to determine the waste-derived carbon footprint of the textile industry, which carried out 1 237 500 kg denim washing in 2021. All the data required for the calculation were taken from the textile company where the study will be conducted. Emission factors were obtained using standards published by Department for Environment Food & Rural Affairs (DEFRA). The equivalent CO2 calculated as a result of the waste generated in the denim washing company in 2021 was found to be 54.26 tons. This study, which has an important role in the carbon footprint assessment of textile factories, clearly shows the effect of carbon footprint resulting from waste.

Keywords: Carbon Footprint, Textile, Greenhouse Gas, Waste

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1. INTRODUCTION

Considering the areas it encompasses, the textile industry is one of the biggest and most varied sector. By 2030, global clothing consumption is predicted to increase by 63%, which is calculated to be equivalent to 500 billion new t-shirts [1]. In our country, the textile industry has a very important place in production and export. However, the use of natural resources and the possibility of causing global environmental problems in the textile industry has become an important issue that needs to be emphasized more than other industries [2].

The textile industry has always been considered a sector that uses more water. In addition, air emissions, energy consumption, and solid wastes, which are other important problems, appear as environmental problems in the textile industry. A large number of different solid wastes are produced in the Textile Industry, so their disposal is on the agenda. Some of these wastes can be recycled or reused, while others are incinerated or buried. Some wastes are also rarely processed in anaerobic digesters. Therefore, it is very important to create an inventory of solid wastes in the textile industry and to evaluate their environmental effects[3]. At this point, it is possible to understand the reasons for the potential effects of the carbon footprint and the production of solid waste in the textile industry. The carbon footprint expresses the size of the impact on the environment as a result of consumption activities. In other words, it includes the greenhouse gas emissions released as a result of the product becoming waste and is also defined as the equivalent amount of carbon dioxide released per unit product [4-5].

The concept and name of carbon footprint is derived from the concept of ecological footprint developed by William E. Rees and Mathis Wackernagel at the University of British Columbia in the 1990s [6]. Carbon footprint is part of ecological footprint and Carbon footprints are usually reported as tons of emissions (CO_2 equivalent) per year. Carbon footprints are more focused than ecological footprints as they only measure the release of climate change-causing gases into the atmosphere. The carbon footprint of an organization can be measured by performing computational activities. There is a calculation method of GHG emissions provided by the Intergovernmental Panel on Climate Change (IPCC). This calculation method can be found by multiplying the emission sources' data with the relevant emission factors. Emission factors may differ in each country and may change over time. Sources such as IPCC guideline, GHG Protocol, Ecoinvent, IEA and DEFRA are used for emission factors. The literature on the evaluation of carbon footprint in the textile industry has been reviewed and the carbon footprint and carbon footprint evaluation methods in the textile industry were explained for different product groups in different countries. Kirchain et al. presented the carbon footprint for a t-shirt made of polyester was calculated as 7.1 kg-CO_2e/t-shirt, which corresponds to an approximate value of 35 kg CO_2e/kg-t-shirt [7]. Hasanbeigi et al. performed the energy footprint value for woolen knitted fabrics was calculated between 73 and 132 kWh/kg fabric in Iran's textile industry [8]. Yan et al. conducted carbon footprints of fabrics produced from pure wool and wool-polyester blend were calculated as 14 kg-CO_2e/kg-fabric and 13.5 kg CO2e/kg-fabric, respectively [9].

In this study, a research was conducted on the carbon footprint in the textile sector, which is one of the most important processes that generate waste. First, an inventory study was carried out for different categories of waste produced in the selected textile company in 2021. Then, by multiplying the emission factors with the data obtained, the emissions from each source were calculated separately and carbon footprint values were obtained.

2. MATERIAL AND METHODS

2.1. Waste Data of Textile Facility

The textile company selected for the study carries out only Denim Washing activities in the "Denim (Jeans) or Apparel Products Washing Facility". The annual maximum production amount within the scope of the activity is 15136 pieces/year (2724 kg/year). The facility has 34 employees and is open 300 days a year. Batteries and accumulators, packaging wastes, hazardous wastes, domestic solid wastes, and treatment sludge are the waste categories that contribute to the textile factory's carbon footprint. The detailed classification of the waste data generated by the production line on an annual basis is shown in Table 1. The data was collected in 2021 by the textile factory, which put in an average of 300 days of labour.

Table 1. Type and amount of waste generated from the activities of the industry

Type of Waste	Amount of Waste (tons)
Domestic Waste	40.193
Sludges from on-site wastewater treatment (combustion)	20.25
Sludges from on-site wastewater treatment (landfill)	69.8
Processed textile fiber waste	0.339
Waste print toners containing hazardous materials	0.007
Engine, gearbox and lubricating oils	0.025
Paper and cardboard packaging	0.08
Plastic packaging	4.88
Wooden packaging	0.04
Metallic packaging	0.47
Packaging containing residues of hazardous substances or contaminated with hazardous substances	2.319
Absorbers contaminated with hazardous substances, filter materials, cleaning cloths, protective clothing	4.02
Gases in pressure tanks	0.005
Laboratory chemicals consisting of or containing hazardous substances, including mixtures of laboratory chemicals	0.004
Permanganate (e.g. potassium permanganate)	0.04
Wastes whose collection and disposal are subject to special treatment in order to prevent infection	0.004
Fluorescent lamps and other mercury-containing waste	0.02
Oils and fats	0.1
Batteries and accumulators	0.001

2.2. Calculation of Carbon Footprint

Waste data generated in 2021 were gathered from the relevant departments of the organization in order to assess the carbon footprint of waste. Emissions from each waste were calculated separately by multiplying the relevant data and emission factors. Emission factors were obtained from the "UK greenhouse gas conversion factors report" published by the UK Ministry of Environment, Food and Rural Affairs (DEFRA) in 2021. Calculations were made based on the multiplication of each type of waste generated by the respective emission factors (Equation 1).

$$CF = \text{Amount of waste generated [ton-waste]} * \text{Emission Factor[kg-}CO_2\text{e]} \quad (1)$$

The emission data calculated for each waste were then combined to form the total carbon footprint from the waste of the facility.

3. RESULT AND DISCUSSION

Table 2 displays the distribution of the IPCC-calculated carbon footprint values for the factory that performs the denim washing process in 2021 resulting from waste production

Table 2. Waste-sourced greenhouse gas emission (carbon footprint) in industry

Type of Waste	**Amount of Waste**	**Emissions of Carbon Dioxide**
	tons	**ton CO_2e**
Domestic Waste	40.193	17.93578
Sludges from on-site wastewater treatment (combustion)	20.25	0.43119
Sludges from on-site wastewater treatment (landfill)	69.8	32.59980
Processed textile fiber waste	0.339	0.15833
Waste print toners containing hazardous materials	0.007	0.00327
Engine, gearbox and lubricating oils	0.025	0.00053
Paper and cardboard packaging	0.08	0.00170
Plastic packaging	4.88	0.10391
Wooden packaging	0.04	0.00085
Metalic packaging	0.47	0.01001
Packaging containing residues of hazardous substances or contaminated with hazardous substances	2.319	1.08308
Absorbers contaminated with hazardous substances, filter materials, cleaning cloths, protective clothing	4.02	1.87752
Gases in pressure tanks	0.005	0.00011
Laboratory chemicals consisting of or containing hazardous substances, including mixtures of laboratory chemicals	0.004	0.00009
Permanganate (e.g. potassium permanganate)	0.04	0,00085

Wastes whose collection and disposal are subject to special treatment in order to prevent infection	0.004	0.00009
Fluorescent lamps and other mercury-containing waste	0.02	0.00934
Oils and fats	0.1	0.04670
Batteries and accumulators	0.001	0.00002

Sludge from wastewater treatment has been identified as the plant's main source of waste when waste data for the denim washing facility selected as the research area for the year 2021 are investigated. The sludge that settles to the bottom after flocculation after Biological Treatment and the dye flocks formed after Chemical Treatment are pumped into the sludge tank. The sludge coming into the sludge tank is dewatered in the filter press. A total of 90.05 tons of dewatered sludge produced by the filter pres in 2021. The domestic waste produced by the facility comes in second. Domestic solid waste is produced as a result of the facility's staff's requirements. Within the plant, recyclable wastes such paper/cardboard, glass, plastic, and metals are also collected separately. Plastic garbage is one of them, and its annual production for 2021 is 4.88 tons, making it a waste type that should be considered at the facility.

Chemical substances spilled and scattered in environmental accidents that may occur in the facility and absorbent materials to be used for cleaning them, contaminated cloths; personal protective equipment such as contaminated gloves, masks, clothing; Contaminated packaging of products are hazardous wastes that may originate from the facility. Among these wastes, Packaging containing residues of hazardous substances or contaminated with hazardous substances and Absorbers contaminated with hazardous substances, filter materials, cleaning cloths, protective clothing are among the hazardous wastes that should be considered in terms of quantity. The category with the least amount of waste leaving the facility is batteries and accumulators with 0.001 tons.

As can be seen from the Table 2, the total carbon footprint value of all wastes generated as a result of the activity of the denim washing facility in 2021 was found to be 54.26 tons-CO_2e. Sludges from on-site wastewater treatment (landfill) has the highest carbon footprint among different types of waste. This value is followed by household waste, Absorbers contaminated with hazardous substances, filter materials, cleaning cloths, protective clothing and Packaging containing residues of hazardous substances or contaminated with hazardous substances, respectively. Batteries and accumulators have the lowest carbon footprint with 0.00002 tons-CO_2e.

4. CONCLUSION

In this study, a research was conducted on the carbon footprint in the textile sector, which is one of the most important processes that generate waste. An inventory study was carried out for different categories of waste produced in 2021 by the selected textile company. Then, the emissions from each source were calculated separately by multiplying the emission factors with the data obtained, and the carbon footprint values were reached. The total carbon footprint resulting from denim washing has been calculated as 54.26 tons-CO_2e for 2021. When the CO2 equivalent emissions for different waste types at the facility are examined, the waste type that contributes the highest to the carbon footprint is Sludges from on-site wastewater treatment (landfill), and the waste that contributes the least is Batteries and accumulators. In order to reduce the amount of carbon footprint, recycling of materials left over from production and encouraging the reuse of unsuitable products for different purposes by the consumer will reduce the amount of waste in the textile industry and thus, it will be inevitable to reduce the carbon footprint. Targeting a “zero carbon footprint” in the textile sector will be attainable now that zero waste management has become more important. Therefore, waste generation should be reduced, wastes should be reused, and if this is not technically or economically feasible, wastes should be disposed of in a way that does not harm the environment. This would help the textile industry reduce its carbon footprint.

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CHAPTER 2

Climate Change and Adaptation

GM CROPS AND CLIMATE

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ABSTRACT

The cultivation area of genetically modified (GM) crops has exceeded 190 million hectares worldwide. In most of this cultivation area, herbicide-tolerant soybean and rapeseed, and insect-resistant cotton and corn are produced. In addition to these main GM plants, transgenic sugar beet, alfalfa, potato, squash, papaya, apple, pineapple and eggplant species have also been commercially produced in many countries. With the production of transgenic plants, an increase in yield is achieved and significant returns are obtained in terms of environment and health. As a result of the production of plants tolerant to herbicides, soil cultivation can be reduced as well as obtaining optimal yield. Less tillage reduces greenhouse gas emissions and erosion, and gives less damage to the soil structure. By producing insect-resistant GM crops, farmers can control insects without using chemical pesticides. With this production, greenhouse gas emissions can be reduced as a result of not using agricultural machinery for insecticide spray. In addition, the increase in yield obtained by the cultivation of transgenic plants will reduce the need for new agricultural areas, thus helping to reduce CO_2 emissions. The increase in temperature, drought and floods that occur with global warming not only causes yield loss, but also reduces the seed setting rate of plants, grain quality and weight, and germination and growth. Moreover, these changes disrupt the physiological and metabolic functions of plants from planting to maturation. In recent years, important studies have also been carried out to develop GM crop plants that are tolerant to environmental stress conditions such as drought and high temperature in many plant species such as wheat, corn, rice, tobacco, soybean, sugarcane, cotton and potato, and significant results have been obtained. With the introduction of these plants into production, the negative effects of drought and high temperature can also be reduced.

Keywords: Transgenic Plants, Stress Tolerance, Global Warming, CO_2 Emission

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1. INTRODUCTION

Two important periods stand out in the studies on the improvement of plants for use in human and animal nutrition. The first of these is the period in which the development of traditional plant breeding and commercial fertilizers and other agronomic techniques, called the 'Green Revolution', took place from 1960 to 1970. During this period, significant increases were observed in the yield and quality of the plant products. However, plant cultivars with high yield and quality were often susceptible to diseases caused by fungi, bacteria, nematodes and viruses, and insects. Compared to wild plant species, this susceptibility to insects and diseases in cultivated plants is due to the generally applied breeding methods. Since plant characteristics such as yield quality and quantity are kept in the foreground while selection is made in breeding programs, resistance to diseases and pests has always remained in the background. In addition, in classical plant breeding, important limitations are encountered in improving many other agricultural characteristics of plants, especially in resistance to diseases and pests. Among these, the low number of species that can be hybridized between them and the inability to prevent the crossing of undesirable traits together with the desired characters in these hybridizations between species. It takes a long time to eliminate these undesirable characters by backcross breeding, which is one of the major disadvantages of classical plant breeding [1]. In addition, it is rather slow to achieve desired results with hybridization and selection techniques in classical plant breeding methods. Especially in perennial plants such as fruit trees, it may take years to complete the breeding work [2]. Since it has not been possible to develop resistant varieties against diseases and harmful insects, especially in important plants such as corn, wheat, rice and potatoes with classical breeding methods, plants have been protected against these factors by using chemical pesticides for years. On the other hand, these chemical can remain in the food chain for a long time without decomposition and can often be dangerous for human and animal health. This situation is also a growing concern in terms of environmental health. While 4.1 million tons of chemical pesticides were used worldwide in 2017, its value was 54.2 billion dollars. In Turkey, 55 thousand tons of pesticides were used in 2017, and 93 million dollars were spent (FAO, Agribusiness intelligence, Food and Business knowledge platform).

The second period in crop production is the 'Biotechnology Revolution'. Using very effective and new techniques developed in the biotechnology revolution, one or a few genes can be easily transferred to plant varieties with high yield and quality in order to gain new characteristics. As a result of this process, there is no change in other characteristics of plant cultivars. In other words, with the use of biotechnological techniques, besides shortening the breeding period; Obstacles encountered in crossbreeding, genetic dependence problems and limitations in benefiting from gene pools can be easily eliminated [2].

2. GM CROPS

Obtaining new plants from single cells using in vitro techniques and the discovery of the natural gene transfer mechanism from *Agrobacterium tumefaciens*, which causes crown gall disease (the formation of tumors) in plants, to plant cells formed the basis of plant biotechnology and genetically modified GM plants [3]. With the use of these two discoveries together, gene transfer has been made to almost all cultivated plant species in the last 40 years.

2.1. Gene Transfer to Crop Plants

It has been known for the last 60 years to obtain new plants in the laboratory from single plant cells, and the ability of *Agrobacterium tumefaciens* to transfer genes to plants was discovered in the 1980s. After this discovery, there have been very important developments in plant biotechnology and genes copied from different sources (such as plants, bacteria, animals and viruses) could easily be transferred to plants by *A. tumefaciens.A. tumefaciens* bacterium has become the most widely used tool for gene transfer to plants since 1983. Therefore, this bacterium has been called the natural genetic engineer of plants [1].

When a soil-bacterium *A. tumefaciens* infects the plant from the wounded areas, it causes tumor formation by excessive and irregular division of the infected cells [2]. *A. tumefaciens* contains chromosomal DNA as well as a small plasmid DNA called Ti plasmid (Figure 1). Studies have revealed that as a result of infection, a DNA fragment called T-DNA (transferred-DNA) region on plasmid DNA passes from bacteria to plant cell and combines with plant chromosomes [4]. After this integration, with the activation of auxin, cytokinin and opine genes in the T-DNA region, an excessive hormone production occurs in the plant cell and the plant cell turns into a tumor with rapid and irregular division [1, 3]. This tumor also synthesizes sugar derivatives known as opines, which are the energy source of the bacterium.

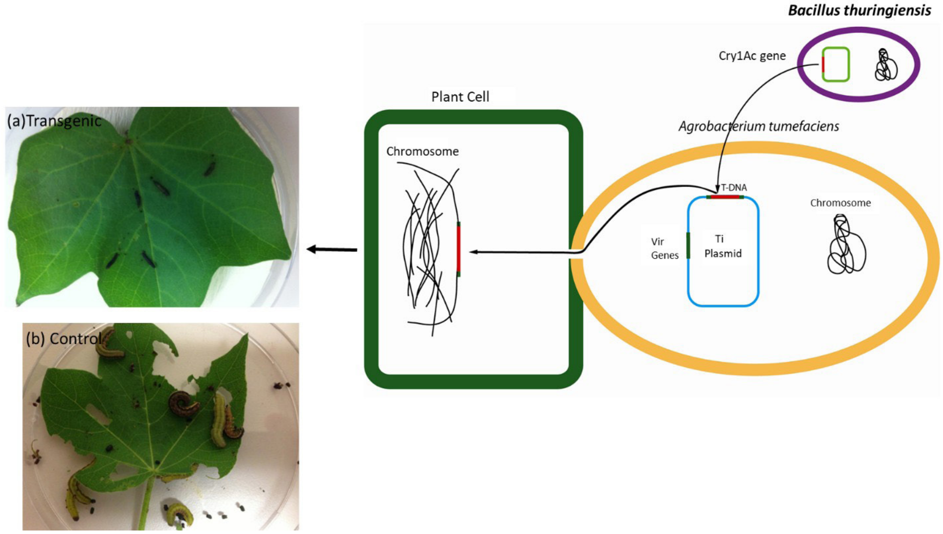

Figure 1. Structure of *Agrobacterium tumefaciens* and transfer of the insect-resistant Cry1Ac gene from *Bacillus thuringiensis* to cotton plant by *A. tumefaciens*. a) Leaf biotoxicity assays of transgenic plants carrying Cry1Ac gene with *Spodoptera exigua*. b) Control plant leaf [1, 5].

The T-DNA region is limited from the right and left with certain DNA sequences of 24 base pairs, and the integration with plant chromosomes occurs via the right border [4]. When the tumor and opine genes in the T-DNA are removed by restriction enzymes and the genes that we want to transfer to plants are placed in their place, the bacteria can transfer these genes to plant cells by their nature [6, Figure 1]. In the last 40 years, thousands of genes have been copied from different organisms and transferred to plants by cloning them into the T-DNA region. On the other hand, since the gene transfer frequency from *A. tumefaciens* to plant cells is extremely low, marker genes that provide resistance to antibiotics or herbicides are used in the selection of the transformed cells and ultimately plants [7]. Marker genes are cloned into the T-DNA region together with the genes encoding the agricultural characteristics we want to bring to the plants, and then they are transferred to the plant cells by routine gene transfer methods. With the addition of herbicides or antibiotics to the in vitro nutrient media where gene transfer is carried out, only cells with gene transfer develop from a large number of plant cells, and GM plants can be obtained from them by tissue culture methods [3, 4]. In addition to *A. tumefaciens*, other methods such as gene gun, microinjection and transformation of protoplasts have also been developed for gene transfer to plants. However, in these methods, the transmission of many unwanted genes along with the genes we want to transfer to plants cannot be prevented and significant irregularities are observed in the transferred genes. On the other hand, the gene transfer technique with *A. tumefaciens* is easier and cheaper, and transferring only the desired genes to plants brings an important advantage in terms of biosecurity. Therefore, *A. tumefaciens* is preferred as a gene transfer method in the commercial production of GM plants. With the development of more efficient transformation vectors, it has become possible to transfer genes to almost all crop plant species, including monocots by *A. tumefaciens.*

2.2. Herbicide-Tolerant GM Crops

Development of GM crops tolerant to herbicides was one of the first successful applications of plant biotechnology. It was possible to easily produce GM plant cultivars tolerant to broad-spectrum herbicides such as glyphosate and glufosinate that are the most extensively used herbicides. Glyphosate causes the death of plants by specifically inhibiting the production of the 5-enolpyruvyl shikimate 3-phosphate synthase (EPSPS) enzyme, which is involved in the shikimate pathway of aromatic amino acid synthesis [8]. As a result of transfer of *epsps* gene, which is insensitive to glyphosate, from *A. tumefaciens* CP4 strain to plants and its heterologous expression, GM plants tolerant to glyphosate (Raoundup Ready) herbicide were developed [9]. The other herbicide glufosinate (or phosphinothricin) completely inhibits the enzyme glutamine synthase, which is involved in the conversion of glutamate and ammonia to glutamine in plants. This results in accumulation of ammonia and plant death [10]. For the development of tolerant crops to this herbicide *pat* and *bar* genes from *Streptomyces* spp. were transferred to plants. In GM plants, both genes encode phosphinothricin acetyl transferase (PAT) enzyme which detoxifies phosphinothricin herbicide applied to crop plants by acetylation [8]. The vast majority of GM crops cultivated today carry *epsps. bar or pat* genes.

2.3. Insect-Resistant GM Crops

Many different methods have been developed to obtain GM plants resistant to insect pests. In almost all of these methods, genes encoding insecticidal proteins that have a toxic effect on insects have been isolated from different organisms and transferred to plants. By transferring the *cry* (crystal) genes, which are responsible for the synthesis of delta-endotoxin proteins *of Bacillus thuringiensis* (*Bt*), to plants GM cultivars that are fully resistant to harmful insects were developed [Figure 1 and 2]. When insects eat GM plants, *Bt* delta-endotoxins produced by *cry* genes turn into active forms in the midgut of insects, then bind to the receptor sites in the intestinal epithelial cells, causing the cells to explode and ultimately to the death of the insects [3, 11, 12]. Almost all of the insect-resistant GM plants produced today harbor the different forms of *cry* genes and these plants are the most produced plants in terms of cultivation area after the herbicide-tolerant plants.

2.4. Abiotic Stress-Tolerant GM Crops

The increase in temperature, drought and floods that occur with global warming not only causes yield loss, but also reduces the seed setting rate of plants, grain quality and weight, and germination and growth [13]. Moreover, these changes disrupt the physiological and metabolic functions of plants from planting to maturation. In recent years, important studies have been carried out to develop GM crop plants that are tolerant to environmental stress conditions such as drought and high temperature in many plant species such as wheat, corn, rice, tobacco, soybean, sugarcane, cotton and potato, and significant results have been obtained. However, due to the complexity of the response of plants to abiotic stress factors, commercial production of GM crops tolerant to abiotic stress conditions has been much less compared to herbicide- and insect-resistant plants [14]. Currently, corn, soybean and sugar cane cultivars resistant to abiotic stress conditions have been developed and started to be commercially produced, albeit limited. However, it is reported that the production areas of these plants will gradually expand in the coming years. In recent years, promising technologies such as CRISPR-Cas9, which make precise changes in the genome, have also been used effectively to obtain plants tolerant to stress conditions.

Figure 2. Leaf biotoxicity assays of GM potato carrying hybrid *SN19 cry* gene against Colorado potato beetle (CPB). **a)** GM plant carrying *SN19 cry* gene subjected to larvae of CPB, **b)** non-GM control plant subjected to larvae of CPB, **c)** GM plant carrying *SN19 cry* gene subjected to adult of CPB, **c)** non-GM control plant subjected to adult of CPB [15].

3. GLOBAL PRODUCTION OF GM CROPS

The production adventure of GM plants, which started in 1996, reached a very large cultivation area of 190.4 million hectares in 2019, after a period of 23 years [14, Table 1]. Most of these GM crops consist of insect-resistant and herbicide-tolerant plants. In the areas where these plants are planted, yield increases have been achieved, as well as significant savings in the use of chemical and labor. These important advantages have aroused the desire of farmers in both developed and developing countries to produce more GM plants each year. While GM crops were planted more in developed countries, they were also widely available in developing countries. Among the GM crops produced in the world, herbicide-tolerant soybean is the leading one with a planting area of 91.9 million hectares (48.2%). Soybean is followed by 60.9 million hectares (32%) of insect-resistant maize and 25.7 million hectares (13.5%) of insect-resistant cotton. Herbicide-tolerant canola cultivation worldwide is 10.1 million hectares (5.3%) [14].

Table 1. Global planting area of GM crops from 1996 to 2019 [14].

Year	Area (million hectares)	% Increase	Year	Area (million hectares)	% Increase
1996	1.7		2008	125.0	9
1997	11.0	547	2009	134.0	7
1998	27.8	153	2010	148,0	10
1999	39.9	44	2011	160.0	8
2000	44.2	11	2012	170.0	6
2001	52.6	19	2013	174.2	2.5
2002	58.7	12	2014	181.0	6.8
2003	67.7	13	2015	179.7	-0.7
2004	81.0	16	2016	185.1	3.0
2005	90.0	11	2017	189.8	2.5
2006	102.0	13	2018	191.7	1.0
2007	114.3	12	2019	190.4	-0.7

The number of countries producing GM crop plants reached 29 in 2019 [14, Table 2] and an additional 42 countries imported GM crops for food, feed and processing. These plants have been rapidly adopted by small and large farmers in developed and developing countries; have achieved significant economic, environmental, health and social gains. The USA, Brazil, Argentina, Canada, India, Paraguay and China continued to lead the production of GM plants in 2019 [Table 2]. The USA is one of the largest producers of GM crops, with a plantation area of 71.5 million hectares. A large number of GM field and horticultural crops, especially corn, soybean and cotton, are produced in the USA [Table 2].More than 95% of the total soybean, corn, rapeseed and sugar beet planted in this country consists of GM crops. Brazil and Argentina, which are among the largest soybean producers in the world, export their GM soybean products to the whole world. Almost all of the total soybean planting area in these two countries consists of GM soybean. India, which started to plant GM cotton in 2002, has increased its production amount approximately three times and has become an important cotton fiber exporter. South Africa is the country with the highest production of GM plants in the African continent and is the 8th country with the highest GM plant production in the world with 2.7 million hectares. In this country, GM corn, soybean and cotton are planted [Table 2].

Table 2. Planting area and species of GM crops by countries in 2019 [14]

Country	Area (Mhas)	GM crops	Country	Area (Mhas)	GM crops	Country	Area (Mhas)	GM crops
USA	71.5	Maize, soybeans, cotton, alfalfa, canola, sugar beets, potatoes, papaya, squash, apples	Uruguay	1.2	Soybeans, maize	Chile	<0.1	Maize, canola
Brazil	52.8	Soybeans, maize, cotton, sugarcane	Philippines	0.9	Maize	Malawi	<0.1	Cotton
Argentina	24.0	Soybean, maize, cotton, alfalfa	Australia	0.6	Cotton, canola, safflower	Portugal	<0.1	Maize
Canada	12.5	Canola, soybeans, maize sugar beets, alfalfa, potatoes	Myanmar	0.3	Cotton	Indonesia	<0.1	Sugarcane
India	11.9	Cotton	Sudan	0.2	Cotton	Bangladesh	<0.1	Eggplant
Paraguay	4.1	Soybeans, maize, cotton	Mexico	0.2	Cotton	Nigeria	<0.1	Cotton
China	3.2	Cotton, papaya	Spain	0.1	Maize	Eswatini	<0.1	Cotton
South Africa	2.7	Maize, soybeans, cotton	Colombia	0.1	Maize, cotton	Ethiopia	<0.1	Cotton
Pakistan	2.5	Cotton	Vietnam	0.1	Maize	Costa Rica	<0.1	Cotton, pineapple
Bolivia	1.4	Soybeans	Honduras	<0.1	Maize			

4. IMPACT OF GM CROPS ON THE ECONOMY, ENVIRONMENT AND CLIMATE

Farmers generally accept new technologies and applications because they think they will benefit from them. While this benefit is mostly related to the money they will earn; ease of application, saving time, using less chemicals and inputs and some other factors are also important. The rapid production increases of GM crops since 1996 show that they provide significant benefits to farmers and therefore are highly adopted by them [16, Table 3]. While GM plants facilitate agricultural production, they increase yield per unit area and make a significant contribution to sustainable agriculture by reducing the tillage and use of insecticide.

Table 3. Extra profit from yield increase in cultivation of GM crops between 1996-2018 [16].

Country	Billion Dollars	
	(Between 1996-2018)	2018
USA	95.9	7.8
Argentina	28.1	2.4
Brazil	24.3	3.8
India	21.1	1.5
China	23.2	1.5
Canada	9.7	0.9
Others	23.2	1.0
Total	**224.9**	**18.9**

Weeds are extremely invasive and their control is very difficult especially in fields where intensive agriculture is applied. In areas where weed control is not done, this damage can reach 60-70% levels. In addition, weed seeds affect the quality by mixing with grain products. Despite the fight against weeds, weeds reduce the yield by 15% in agricultural areas. In the areas where herbicide-tolerant GM crops are produced, 100% weed control can be eachieved with a less herbicide application according to the weed density in the stages after the plants emerge to the soil surface. Since GM crops are fully tolerant to herbicides, there is no slowdown in plant development, and there can be a wide time interval for herbicide application. With an effective weed control, harvesting costs are reduced and cleaner and higher quality products can be obtained. In this case, significant savings in labor can be achieved, as well as significant increases in yield as a result of complete weed control. In addition, as a result of reducing soil cultivation, soil micro flora and fauna can be protected as well as erosion can be reduced. More importantly, there will be a reduction in carbon emissions to the environment by reducing tillage.

With the effect of global warming, insect pests have developed into the biggest factor threatening crop production today. Significant increases are observed in the insect density and the mobility of insects between regions. Insects also play an important role in the spread and development of many diseases. When harmful insects are not combated, many plants may experience very high losses. Despite the intensive insecticide applications against harmful insects, it is estimated that the product losses caused by insects are around 15-20% worldwide (Food and Business Knowledge Platform).

Today, thousands of chemicals as insecticides are licensed in many countries. Especially in years when insect epidemics are intense, the number of chemical spraying in many crop plants such as corn and cotton production can increase up to 4-5 and significant yield losses can be experienced despite the insecticide use. In addition, chemical application against insect larvae that develop in the root, stem and fruit of the plant can often be ineffective. On the other hand, among pesticides, insecticides are considered as the group that threatens the environment, human and animal health the most. Insecticides can cause irreversible biological and genetic damage when taken by humans during spraying and in the form of residues on products. Many farmers lose their lives during the struggle with pesticides. Intensive insecticide use in agriculture can cause great economic losses and significant environmental pollution, especially soil and water, as well as cause great damage to the natural ecological balance. Beneficial insects, which are necessary for ecological balance and plant production, are also damaged by the use of chemicals. In addition, as a result of the widespread use of insecticides, target insects can gain resistance to the chemical used over time and the resistance is transferred to the next generations [17]. Therefore, more effective chemicals are used against resistant insects. On the other hand, as a result of the widespread production of insect-resistant GM corn and cotton in countries such as the USA, China, India, Brazil and Argentina, yield increases up to 35% have been achieved, while very significant decreases have been observed in the use of insecticides [18,19]. Farmers have also minimized the fuel cost they spend for insecticides with the resistant cultivars. The use of GM plants has increased the product quality along with the increase in yield. Insect damage, which directly affects the quality, and the production of mycotoxins, which occur in the ear and stem, can be prevented. In addition, as a result of not using insecticides, significant improvements have been made in the health of the farmers.

5. CONCLUSION

GM crop plants have made very important contributions in terms of agricultural production, environment and climate. With the production of GM crops, a total of 824 million tons extra yield and a value of 225 billion dollars were obtained between 1996 and 2018. In 2018, these values were 86.9 million tons and 19 billion dollars, respectively [16]. With the increase in yield, a total of 231 million hectares of land was saved between 1996 and 2018. In addition, with the production of GM plants, a total of 776 thousand tons of pesticides were prevented from being used between 1996 and 2018, while less spraying and soil cultivation was carried out [16]. Again, a reduction of 27 billion kg in CO_2 emissions was recorded in 2016 alone with the production of GM plants. This equated to the withdrawal of 16 million vehicles from traffic in one year [16]. In recent years, important studies have also been carried out to develop GM and CRISPR-Cas9 crop plants that are tolerant to environmental stress conditions such as drought and high temperature in many plant species such as wheat, corn, rice, tobacco, soybean, sugarcane, cotton and potato, and significant results have been obtained. With the introduction of these plants into production, the negative effects of drought and high temperature can also be reduced.

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TRANS-DISCIPLINARY APPROACH TO THE IMPACT OF STRONG WINDS AND STORMS ON CULTURAL HERITAGE

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ABSTRACT

Due to the triggering effect of climate change, meteorological issues such as strong winds, storms and tornadoes have become visible also in Turkey in the 2000s. The negative environmental impacts and service disruptions caused by weather events, including the deadly consequences in nature, have increased and have become frightening. There seems to be no issue that is not affected by the phenomenon of strong winds and storms that have spread throughout the country. When the records taken from the General Directorate of Meteorology are evaluated, it is seen that the speeds of winds around Turkey have reached the limit that causes them to be categorized as storms. In addition to the winds, the phenomenon of fire has put the issues of human-induced accidents and terrorism on the agenda. Although to this date, the author accepted the" safeguarding from people "approach on which the principles of "safeguarding cultural assets" are based, this article focuses on the connection of the "storm phenomenon" and "effects on cultural assets" in Turkey in its entirety. Problem solving methodology involves an interdisciplinary approach.

Keywords: Storm, Disaster Administration, Cultural Sssets, Trans-Disciplinary, Interdisciplinarity

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1. INTRODUCTION

In 2000s, strong winds, storms and tornadoes have become more important with the triggering effect of climate change and these meteorological events have spread throughout Turkey which in turn negatively affected many industries, starting from the agriculture industry. The winds have also turned human-induced safety issues, especially forest fires into network of multi-faceted relations. In short, as in the whole world, natural disasters with a meteorological character have affected different regions of Turkey in different dimensions. This article is about storms and it is based on legal regulations and the data gathered in our study on storms. The aforementioned study's preparations were completed on February 17, 2020 and its application was submitted under the field of "multidisciplinarity-guided projects" through our Dean's Office addressed to the Rector of Dokuz Eylul University [2]. I would like to highlight that at the time of application process, in the beginning of 2020, this issue was not present yet in the academic study agendas, publications and even projects of organizations and institutions directly related to the issue and there were no correlations found to this topic in relation to "strategically prioritizing it".

In the statistics prepared by the Disaster and Emergency Management Presidency (AFAD) on the Overlook at 2019 and Statistics on Natural Events, earthquake, landslide/rockfalls, floods and avalanches are stated under the title on nature-based events in 2019 but storm-related disasters are not present there (AFAD, 2020). Therefore, it won't be wrong to say about 2019 that disasters related to strong winds did not get sufficient attention. All the more, despite all the damage and losses created by the storms, the Turkish Disaster Risk Reduction Plan through Presidential Decree (TARAP) (2022-2030) numbered 5787 published on the Official Gazette dated July 7, 2022 and numbered 31890 includes "Drought, Hurricane, Storm and etc." under the category of "Other Disasters" (page 10) but the full text does not offer any data analysis on the phenomenon of storms. According to me the word "other" can only may be used for "volcanoes" in Turkey as of today. And the status quo clearly shows the importance of this study on storms and how it plays a guiding role for Public Administration.

2. DEFINITION OF STORM

According to the data of the Centre for Research on the Epidemiology of Disasters (CRED), [1] the primary disaster between 2001 and 2020 is flood and the secondary one is storm. In 2021 EM-DAT (the Emergency Events Database) has recorded 121 incidents of storms. The number of reported storms between 2001 and 2020 is 102 on average.

Explanatory Dictionary of Disaster Management Terms prepared by the Disaster and Emergency Management Presidency defines storm as follows:

[2] *BAP Project based on the Philosophy of Interdisciplinary and Transdisciplinary Studies in Holistic Disaster Administration: An Approach for Storms, Project No: 2020 KB.MLT.010 - Team Members: Zerrin Toprak Karaman, Ozlem Cakır, Meric Aziz Berge, OguzSancakdar, Ergun Lafli, Gözde Emekli, Mehmet Dogan, EminKoc, Aytac Duran, Orcun Cobangil, Yakup Ozkaya, Kıvanc Demirci.*

"*Storm: The wind that blows at a speed of 23 to 26 meters per second (82.8 -93.6 km/h) which harms the nature and people"* (AFAD, 2014). The definition continues with saying, *"as the speed and intensity of the wind increases the damage it causes to the nature and people also increase. When used alone, the word storm means a wind storm. Since strong winds bring rain, snow, hail, sand, and etc, they could also be called snow storm, sand storm or dust storm."* According to the definition of a storm, the wind's speed must be defined in order for strong winds to be evaluated within the scope of a storm.

While Beaufort wind scale [2] allows defining winds depending on their intensities, thanks to the development of sensitive tools (anemometer) that can accurately measure the speed of the winds, Beaufort scale can also categorize the winds regarding their speeds. According to this scale, when the wind speed is between 17.2 and 20.7 m/sec. (61.9-74.5 km/h)[3] and above, it is defined as a storm [2]. It should be added immediately that we are proceeding from a philosophical approach based on the storm remaining within the borders of the country and on reducing its negative effects. Currently, there is no record of migration in Turkey, occurring due to storms, strong winds, and other climatic reasons. In terms of climate migrations, residents generally tend to move to cities that are conveniently located in their own countries which create an internal climate migration. However, they can also move out of the country. And this negatively effects the life quality indicators, especially the infrastructure indicator in the destination which in turn creates pressure over resources.

Extreme weather events caused by climate changes trigger disasters such as extreme droughts, floods, rises in sea levels, extreme rainfall, storms, forest fires, and etc. and these disasters cause nature to change which makes it uninhabitable. The region or country of which the critical infrastructure got damaged and which lost its livelihoods creates temporary or permanent population mobility which in turn increases the burden on the administration related to climate migration. According to the author, mobility within the country, "internal climate migration", entry from a country that has become threatening to another or escape from one country that has "threat conditions" causes concepts such as "external climate migration" and "climate refugees". If we were to give an example from Turkey since this directly affects the country, the great migration waves coming from Syria and Afghanistan caused by political reasons and experiences occurred during the migration that is expected to be analyzed under human rights underlines the importance of migration governance for public administration. Even though the migrant has not burnt all bridges between them and their country, climate-related population mobility has also[3] [4] similar features when the threat-like properties of the situation, not being able to return to that country and helplessness are taken into account. Since on a global scale, climate migrations are more "threatening" than political migrations due to greater population mobility, they require global and strategic tactics. Even though the country from which people migrate and the destination country could have similar or different development

[3] Climate-induced forceful displacement is when people are forced to leave their homes permanently or temporarily, mainly due to sudden onset of climate-related disaster event(s). Climate-induced migration is often more complex when we take into consideration the decision to move based on multiple factors (including climate risk and slow-onset climate events) or moving somehow voluntarily as well. Because of the hardship when it comes to defining the line between migration and forceful displacement, the term "climate migration" is used to refer to both https://www.ipcc.ch/2022/02/28/pr-wgii-ar6/ . [4]

levels, the humanitarian threats that arise are always similar. The pressure of excessive population can negatively affect the location decisions and encourage illegal settlements.

3. STORM RESEARCH SAMPLE AND RISK ANALYSIS OF THE STORM PHENOMENON

Key stakeholders in our study on storms which is conducted within the DEU-BAP project are the city directorates of Meteorology, AFAD, Red Crescent, Municipality, GAMER, Environmental Urbanism and Climate Change, and Culture and Tourism. Their professional opinions were evaluated for the purpose of this study. An interview form consisting of 19 closed-ended questions was prepared using the “qualitative research method” to measure the perceptions and awareness of institutions about the storm issues and to see how much they consider themselves to be a key stakeholder in this matter. The prepared form was utilized while interviewing a total of 75 institution representatives in 4 cities. City visits happened in Izmir (September 29 - October 20, 2021), Canakkale (February 15-16, 2022), Antalya (March 2-4, 2022) and Elazig (May 20, 2022). The obtained data were transferred to the MAXQDA 2022 Qualitative Data Analysis Program. The basic reliability indicators sought in qualitative studies, especially “credibility, transferability, reliability, confirmability”, were complied with. In addition, it was possible to collect the lessons learned in the basic setup of trans-disciplinary studies at the Workshop on “Strong Winds and Storms, Multifaceted Social-Institutional Resistance Analysis”, held on March 31, 2022. Governorship of Izmir provided participation of representatives from public institutions and organizations and non-governmental organizations to the workshop. And the results were published as the Strategy Guide [5]

This study of which the official application was done and which focuses on questions like, “Are there any overlooked issues related to the phenomenon of storms caused by climate changes in Turkey?” or “Is the issue of strong winds and storms a change that poses a danger to public safety in Izmir and in Turkey” actually also serves as an early warning for the central and local administrations.

The issue requires its direct relation to society to be revealed and due its characteristics, the boundaries of a sole discipline should be surmounted. This status of the matter creates the need to be solved with either an interdisciplinary or transdisciplinary approach [6].

We shared the Google forms on August 30, 2021 and within a month 70 people that we had reached through social media completed the form. Regarding the collected answers we see that people do not have information about their responsibility on this matter and that they are getting anxious about it[4]. As a matter of fact, when asked to get the public’s thoughts on the storm, 67.1% of the participants said they were worried, 20% said they are not worried and 12.9% had no idea about the matter. 92.9% of the participants

[4] The trial survey was conducted between August 30, 2021 and September 30, 2021 and 70 participants replied to the survey. 42.9% of them was male and 57.1% was female. Their age distribution is as follows: 34.3% (15-25 y.o.) , 31.4% (26-35 y.o.) , 12.9% (36-45 y.o.) and 10% (55-65 y.o.) 48.6% of the participants has undergraduate degrees, 22.9% has master’s degrees and 17.9% has doctoral degrees. The cities of participants are as follows: Izmir, Afyonkarahisar, Artvin, Gaziantep, Konya, Manisa, Mugla, Trabzon, Kocaeli, Corum and Istanbul. The disasters the participants reported to have happened are earthquake (87.5% of the participants), storm, strong winds and hurricane (28.6%) ,tornadoe (3.6%) and tsunami (1.8%). According to these participants, in terms of danger priority, the storm comes last.

claim that they are not prepared for any storm-related disasters and only 7.1% said that they were prepared. In terms of urban safety, the question asking about the preparation against “dashboards and roofs flying” revealed that 75.5% of the participants does not have any preparations for such instances, 12.9% is prepared and 11.4% does not have an idea about it.

Although these stated values are not the main basis of the study, social approaches have also revealed some hints that it would be appropriate to conduct a study on storms.

Winds, especially the Lodos wind blowing from the southwest in Turkey have been on the agenda for a long time. The matter of winds has been more present in Turkish news about disasters happening in the country during 2022. Here are some examples:

> *The Lodos storm, which was effective in the Marmara and Black Sea Regions in the beginning of April 2022, especially in Istanbul, and which led to the loss of 7 people’s lives raised curiosity about the safety of buildings especially of the roofs. According to sector representatives, one of every 4 roofs in our country is ’problematic’, that is, in need of maintenance” [7]. Besides the people who lost their lives as a result of flying rooftops, materials used for building these roofs that were dislodged because of the Lodos damaged houses and cars. News reports showed that the balconies of the houses collapsed and their outer coating exploded (Esenyurt, Istanbul) . Various News examples are included below.*
>
> *A storm of 40-60 km/h- speed is expected to blow like a strong storm of 50-80 km/h. Istanbul Metropolitan Municipality stated that there may be disruptions in the air, sea and land transportation. And the public was asked to be cautious against dangers such as flying rooftops, crashing trees and utility poles, and flue gas poisoning. Although these issues are constantly on the news, they keep happening.* [8]
>
> *The warning of the governor’s office on June 2, 2022 stated that Gaziantep was buried in a dust cloud. And in the news, people were told not to go out because it was impossible to see anything with dust everywhere. Considering the high frequency of trees and utility poles crashing, local authorities must keep this issue on their agenda and it is of utmost importance that they make sure these items are not hazardous by reconsidering the types of trees used on the streets and their relation with water.*

Our research is interdisciplinary and trans-disciplinary. Therefore, the notes gathered during the workshop are also merged with learned lessons from non-experts and evaluations were developed based on all of these. The figure below represents the topics and science areas that make the storm a holistic phenomenon. Due to the nature of this article, cultural assets are highlighted.

Below is a Figure 1 that reveals the damage and loss created by storms taking into account the fact that storms have increased impact in unplanned areas, especially because of the selection of wrong locations. Figure 1 also emphasizes the importance of interdisciplinary examination of cases.

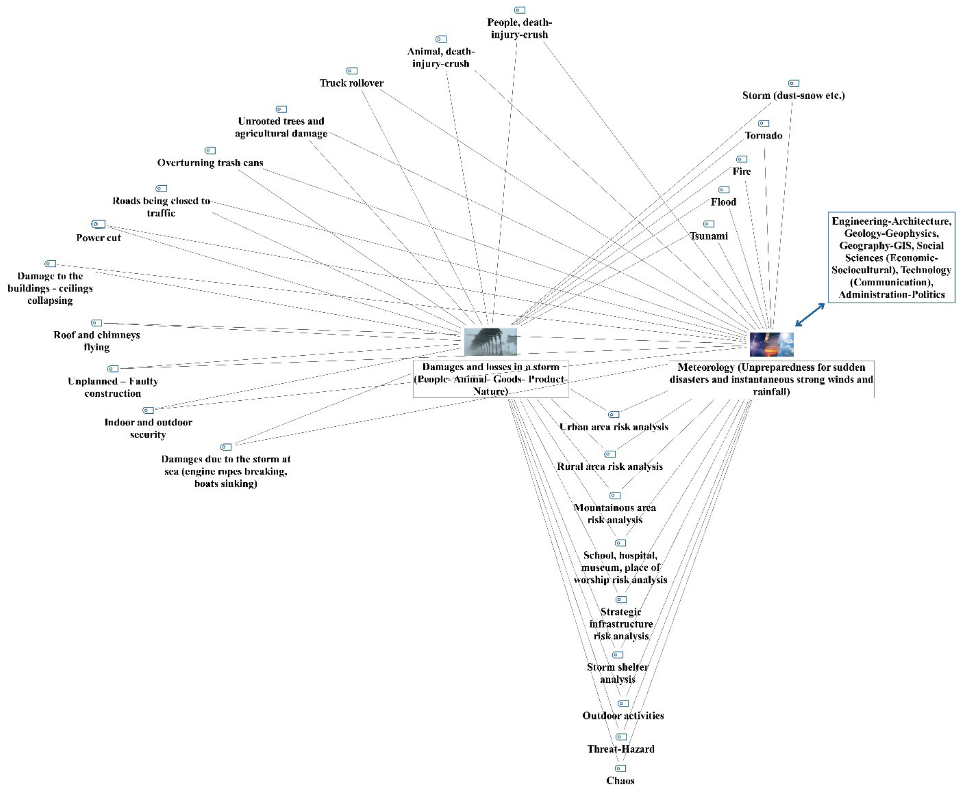

Figure 1. Storm and its Interdisciplinary, Cost-Damage Relations Network

Source: Developed by the author (2022)

4. STORM EXPERIENCE IN TURKEY

The highest wind speed recorded in Turkey in 2021 was measured as 176.0 km/h on January 27, 2021 at the Mountain Bolkar in Ulukısla province of the city Nigde. On the same date, the wind's speed was recorded to be 175.0 km/h at the Cambası Ski Center in Kabaduz, Ordu and in the Dereli Kumbet Plateau situated in Giresun the wind's speed was at 161.6 km/h. The highest wind speed at a city center was recorded to be 122.2 km/h on March 12, 2021 in Kahramanmaras. Characters such as the Storm God (Teshub) which is the typical god of the Hittites and the well-known mythological figure Zeus also points to the natural events that turned into threats in the past.

Turkey experiences stormy days. Data collected from the General Directorate of Meteorology (MGM) shows that between January 1, 2020 and February 28, 2021 there have been winds of blowing at a speed of 10.8 m/s (38.8 km/h) and more. When this data is analyzed these speeds can be evaluated as storms (Figure 1). According to these data, the highest speed record that can be evaluated within the scope of the storm is 48.9 m/s at Afyonkarahisar-Regional station, (176 km/h) 33.4 meters / s (120.24 km /h) at Hakkari and Manisa stations and 32.9 m /s (118.4 km /h) at Zonguldak station. According to the Beaufort wind scale, these values are considered to be evaluated as within the definition of hurricanes [5]. On the other hand, during the same observation period, wind speeds of 17.2-20.7 m/s (61.9-74.5 km/h) (defined as a storm by the Beaufort wind scale) and above were recorded at stations all around the country at a total of 378 times.

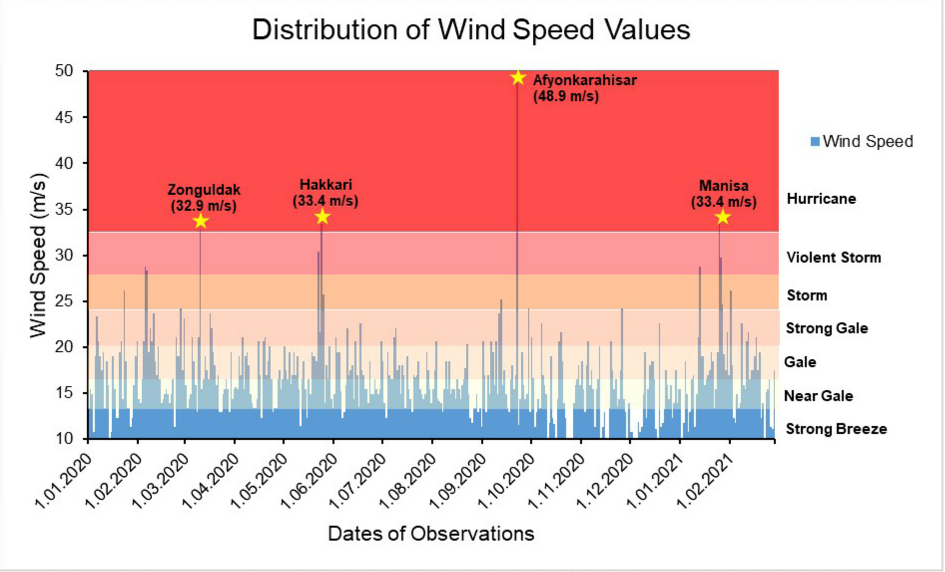

Figure 2. Distribution of Wind Speed Values

Source: Wind speed data collected from the General Directorate of Meteorology (MGM) between January 1, 2020 and February 28, 2021 when the winds were blowing at a speed of 10.8 m/s (38.8 km/h) and more. Wind speed classification was made according to the Beaufort scale by Meric Aziz Berge within the scope of the Project.

It is observed that the distribution of the stations where the wind speed values falling into the storm category and above is not concentrated in a single region in particular, but rather has a distribution throughout Turkey. When the results of these records which include a period of about 13 months are examined, it is clear that wind speed reach to the extent where they could cause storm-like disasters throughout Turkey [9]. Based on the information gathered this article highlights the relation between the storms and the cultural assets in Turkey.

4.1. Protective Approach in the Relationship between Cultural Assets And Storm

The Law on the Safeguarding and Natural Assets dated 1983 and numbered 2863, has a protective approach to cultural assets and contains many basic regulations. The objective of this law is “to make the definitions of movable and immovable cultural and natural assets that need safeguarding, to organize activities and actions in this regard, to determine the foundation and duties of the organization that will make the necessary principle-based

[5] Hurricaneis a very strong tropical cyclonic storm in which the Beaufort scale shows 12 and the vision range gets very short where the wind blowing at a speed of 64 miles or more than 11 km/h meets the water on the North Atlantic Ocean. Hurricanes are stronger storms.

and implementation-related decisions (2863, Article 1). Definitions have been developed for historical places such as protected areas and archeological sites.

When the basic components of the definitions are evaluated the "cultural assets" are all the movables and immovables on or under the ground or below the sea that have a genuine value in terms of science and culture and which has been subject of social life during historical times or prehistoric times or the things that are found to be related to science, culture, religion or fine arts during these times[6]. Especially those above the ground are affected by various disasters, and especially by storms. Studies regarding the assets underwater can be considered new.

"Natural assets" are values that are found on or under the ground or underwater that belong to geological periods, prehistoric and historical periods and which must be protected due to their rarity, beauty or due to their properties. The common point of emphasis for the activities specified in this terminology, creating the balance between "usage and safeguarding", shows the need for an field research that includes archeological, historical, natural, architectural, demographic, cultural, socio-economic, property and settlement-related data. This kind of a research is an interdisciplinary study, in the narrow sense and when the public views are taken into account it becomes a transdisciplinary study.

In addition, issues such as protection, in the place where the asset is located and its "preservation, maintenance and repair" can be evaluated in terms of the conditions brought by the day. Although it is not the direct subject of this article, the author thinks that "on-site safeguarding" will be more crucial especially when we think about the recent fact that the real historical artifacts are not being protected on site but "kept secret" in some place and their imitations are being displayed in museums could cause[7] multifaceted questioning that will be brought to the public in the future, especially in terms of functionality. Perhaps the digital exhibition of the originals is much more rational. Although this method ensures the safety of the works it also changes the definition of tourism[8]. When it comes to keeping artifacts secret in different buildings, it would be appropriate to pay more attention to building quality and location selection, anticipating that cultural assets detained in buildings may face more destruction if the buildings are exposed to security vulnerabilities due to disasters, perhaps more than they would have been exposed in nature.

Floods and other types of disasters are a problematic area not only for local residents, but also for visitors. In addition, the chaotic environments created by the disaster can open

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6 Some examples of immovable cultural assets include, immovables such as castles, fortresses, towers, ramparts, historic barracks, forts and strongholds and fixed weapons within, ruins, caravanserais, hotels, Turkish baths and madrasas, domes, tombs and epitaphs, bridges, aqueducts, water ways, cistern and wells; historic road remains, churches, monasteries, social complexes, old remains of monuments and walls, frescoes, reliefs, mosaics and tent rocks.

7 Nicola Salvi's fountain dated 1732, the Trevi Fountain, one of the most famous monuments in Rome has been repaired, relocated and restored by the Vatican. I was very surprised when I saw that the location of the monument I had seen in 1982-1983 was changed in 2017 and it was taken to another place in the square where the statues were installed in their places in a brand new fashion.

8 World Tourism Organization (UNWTO) defines tourism as "activities which entail the movement of people to countries or places outside their usual environment for personal or business/professional purposes. and for periods no longer than a year." This definition emphasizes that tourism is different from travel. And Safe Tourism *covers tourism activities in which the safety of the environment that the tourist is planning to visit is ensured by making the environment safe with the help of necessary facilities and tools (*the definition belongs to the author*)*

up a suitable door for terrorist attacks. Other examples could be given. As we know, on January 3, 2017, Louvre Museum became the target of human-induced terrorist attack and no one from the public visitors or enforcement staff was hurt. [10] Although a place with more than 1,000 visitors were seen as a suitable environment for terrorist attacks, security staff managed the tackled the incidence with great success. Other disasters do not only negatively affect cultural assets in that place but tourists are also exposed to a similar threat. In summary, natural disasters also disrupt tourism activities [11]. When the Seine river overflowed 6 meters on January 29, 2018, the areas on both sides were flooded and the relocation of historical monuments in the Louvre museum to the upper floors also made the news [12]. The multifaceted methods of and need for protection of cultural assets are present in legal regulations. In Turkey, the Ministry of Culture and Tourism is responsible for taking all the precautions, making sure all the measures are taken, supervising these measures or appointing government institutions and organizations, municipalities and governorships to do this job to ensure the safeguarding of immovable cultural and natural assets regardless of their owner or administrator. (Law No: 2863, Article 10). The safeguarding of cultural and natural assets under the administration and control of the Presidency and the Grand National Assembly of Turkey shall be carried out by them. In ensuring this protection, if necessary, technical assistance and cooperation of the Ministry of Culture and Tourism can be provided.

The safeguarding and valorization of cultural and natural assets located under the administration and supervision of the Ministry of National Defense or along the border and in prohibited areas are carried out by the Ministry of National Defense. This protection is carried out according to the protocol principles to be arranged between the Ministry of National Defense and the Ministry of Culture and Tourism.

Municipalities are authorized within municipal borders and adjacent areas, and governors are authorized outside these borders. Metropolitan municipalities and governorates, are establishing conservation, implementation and audit offices where experts from professional fields such as art history, architecture, urban planning, engineering, and archeology will work together to carry out operations and implementations related to cultural assets under the roofs of municipalities which are authorized by the Ministry. These works require an interdisciplinary approach.

Regarding the aforementioned information, we understand that public organizations and institutions will make the necessary effort to safeguard cultural assets through interdisciplinary work. In relation to the article 10 mentioned above, some cultural assets are safeguarded by two institutions, by both the Presidency and the Parliament (Topkapı Palace and Dolmabahce Palace are mere examples). Detecting the responsible authority to preserve the cultural assets located in military zones is defined by Ministry of National Defense making official correspondence with relevant organizations and asking whether they have the authority to protect the area to be discovered and analyzed. In the example of the city of Izmir, the status of Sancakkale area in the district Inciraltı and the Uzunada in the district of Urla was determined by the first and second regional councils responsible for conserving cultural assets in Izmir making the necessary correspondence with relevant authorities. However, institutions must cooperate with the Ministry of Culture and Tourism for the conservation of cultural assets in their areas of responsibility. They are unable to carry out conservation and restoration projects on their own.

What is the position of damages related to extreme hot or cold weathers caused by climatic changes such as in the instances of storms in relation to these works? The message derived from the information is that the current perception is more based on the threatening effect of "human-induced" disasters on cultural assets. As a matter of fact, the following lines from the minutes of the Parliament of 1987 summarize the issue:

"The safeguarding, maintenance and transfer of natural and cultural assets to the next generations has become an important problem in our country, just like in all countries of the world. Rapidly changing living conditions, rapid urbanization, population growth, increasing destruction of natural resources, industrialization and technical progress, necessitates "taking quick and effective measures" for the safeguarding of cultural values of our ancestors [13]. The subject of climate-related effects is not included in this statement. Although the law does not explicitly include climatic effects,

"*Taking all the precautions, making sure all the measures are taken, supervising these measures to ensure the safeguarding of immovable cultural and natural assets regardless of their owner or administrator"* is defined as one of the responsibilities of public administration. The Convention for the Safeguarding of the Intangible Cultural Heritage links the serious threats to the intangible cultural heritage, such as deterioration, perishment or destruction, with humans [14].

The term "safeguarding" means guaranteeing the viability of intangible cultural heritage. This encompasses not only the identification, documentation, research, conservation, protection, development and fortification of heritage elements and transferring the knowledge thereof through generations by education in our out of school but also revitalization of various aspects of the cultural heritage (Convention, Article 2/3).

They discuss measures of "legal, technical, administrative and financial" safeguarding by using the terminology of solidarity with words like education, sensitivity, participation, national and international collaboration. (Article 11-15). Although the issue of "climate" is not directly involved, time-related and human-related threats are stipulated in this Convention.

For a long while, the main themes when it comes to safeguarding and conservation of cultural and natural assets has been about finding the responsible and figuring out the kind of plans and projects that need to be done. The general approach remains the same while the content of these plans and projects evolve depending on the conditions brought by the day. Why are cultural assets important? Because they are the tools to transmit all material and spiritual values created and accumulated in the process of historical and social development to subsequent generations which in turn reveal the story of civilization and existence. The increase of socio-cultural diversity in societies with different types of migration seems to have made the subject a priority for research at the educational level.

In a study conducted at the level of secondary education, the initial indicators used when analyzing students are selected to be the culture, social structure and political mechanisms that they have [15]. Owning and sharing their social and cultural history, gender, ethnicity, socio-economic classes, religion, being or not being an exception (nationality), socio-cultural behaviors, reactions to events, food taboos, having a transnational family or not, youth volunteering, openness to innovation, adopting or rejecting critical approach, appreciating values, being curious and the desire to discover are also factors that are being analyzed in this study.

This approach has been associated with the definitions of culture. In the perspectives of anthropology and sociology, the integrity of culture-society defines cultures as a value that one learns and shares as a united and complex entity composed of an individual's "beliefs, applications, values, attitudes, laws, norms, artifacts, symbols, information and everything a human possesses".

Cultural assets are being categorized depending on the following criteria: Dynamic, flexible and adaptable, Shared and Opposed (social differentiation from the reality), Learned through socializing or cultural influence/culturing, Requiring language and other forms for communication, Ethnocentrism (other cultures being evaluated according to the prejudices caused by one's own culture's standards and traditions), Cultural Relativity and the Inclination to understand other cultures. Some issues such as "safeguarding the cultural heritage" requires to be supported with a cultural accumulation background that is explained through "cultural reciprocity".

Picture 1. Image of the Mount Nemrut Image and Destruction of its Cultural Assets

(Source: Mountain Nemrut, taken in September, 2021: T Kaan Erge)

It is understood from various research that there are challenges in the safeguarding of cultural and natural assets. Sculptures on Mount Nemrut can be good examples to protection and conservation works against natural destruction especially through storms and strong winds.

There are cultural and historical assets on mountains and shores because they were the first places of settlements. These assets on the shorelines are affected by external factors such as winds, waves, currents and water resources that feed that shoreline. Both the deterioration of the coastal balance by humans and the effects of the wind are important factors that require consideration in the protective approach.

The fact that the wind is effective for a long time and that it increases its intensity makes it easier to remove the roofs from their place. It is expected that it will be useful to make risk plans for disasters, micro-zoning maps depending on the disaster types. It is expected that data gathered from such studies will contribute to the reliability of larger-scale plans in the spatial forecasting of problems that may arise in earthquakes and other disasters [16].The same report highlights the need for taking storms and strong winds and other disaster types into account while renovating the worn out and old buildings in areas that went through socio-economic changes and construction developments. Generally, in our country, buildings are built against Lodos in order for them to be exposed to sun. And this makes the buildings even more vulnerable to the negative effects of the winds. On one hand, through extreme temperatures, houses are more exposed to heat, and on the other hand, they become open to wind effects.

In the risk analyses of the provinces, disaster issues come to the fore in among the problems they face and the public's concern can be seen in the action reports. Taking into account the multiplying effect of wind in cases of floods, firstly, the improvement of stream beds, zoning and settlement planning issues should be carefully observed. Construction and settlement on the shores, near the stream and river beds should not be allowed. It is important to review the coastal law and related regulations. Especially when the strong flows of streams and rivers coincide with rises in sea level due to storms or earthquakes, it is known that significant floods occur on the zones next to shores and this concept has been repeatedly underlined [16]

The protective approach in terms of historical monuments is generally structured in a "human-centered" way. Historical monuments are affected by strong wind depending on their geographical location. In addition to the civil architecture that is being conserved and renovated by the Conservation Councils, artifacts with religious aspect, some historical schools and buildings should also be renovated by taking the wind effects into consideration as well. This approach will increase the functionality of these works. Conducting area-based risk analyses with data gathered from meteorology within the context of effect matching should also be considered starting from the important cultural assets. Corporate cooperation and interdisciplinary projects can be developed for these purposes. For example, repairs are being carried out in Harput castle against falling roofs due to wind and on Mountain Nemrut against various damages (field observation of the year 2022).

News about the damage and destruction of cultural assets in Turkey due to strong winds can be accessed through news channels. In the case of Izmir; news stated that the Seferihisar castle in the Sığacık region, the lower floors of the castle were damaged because of the flood caused by a tornado and excessive rainfall on February 12, 2021. Buildings on the coast of Izmir were damaged by storm and floods. Academic studies are needed to work on the extent of the effects of strong winds on cultural assets.

Individuals question the possibility of worst case scenarios when they do not see the results with their bare eyes. However, news such as the one on December 19, 2021 talking about the storm causing a tree in Bornova and Cesme districts of Izmir to be unrooted created a certain amount of public awareness. Recent problems in specific places intensifies the interest on the matter but if the effects and results of these disasters are not so strong, they are quickly forgotten. The provincial risk perception gathered from the date of our BAP project studies [16] can be seen below: As you can see from the table, there is a directly proportional relation between the risk perception and the events that happened during 2021- May, 2022 which is the period that the study was conducted.

Table 1. Risk Perception of Provincials According to Their Natural Disaster History **(Source:** Storm DEU BAP project, June 2022)

Natural Disaster History/ Provincial	**Antalya**	Çanakkale	**Elazığ**	İzmir	**Toplam**
Storm	7	8	9	11	35
Flood	5	7	12	21	45
Earthquake	2	15	13	26	56
Tsunami	-	-	-	5	5
Forest Fire	9	6	2	7	24
Avalanche	-	-	3	2	5
Drought	-	-	-	2	2
Landslide	-	2	1	4	7
∑TOTAL	23	38	40	78	179
N: Documents/ Speakers	11(14.7 %)	18(24.0%)	17(22.7%)	29(38.7 %)	75(100,0%)

Table 1 shows that fires are highlighted in Antalya and Izmir, the cities which experienced dangerous "forest fires" respectively on October 13, 2021 and August 3, 2021. The value for Antalya is 9 and for Izmir is 7. Canakkale had fires (last ones in July and August 2022) after we gathered the data and the value on the table is 6. Elazıg on the other hand is at 2 with very little-scaled fire news and a last forest fire on August 21, 2022. The fact that the disaster cases are recent has also put emphasis on strong winds and storms. Izmir received the highest value with 22, while Çanakkale entered the evaluation with 17, Elazığ with 13 and Antalya with 9 points.

Below is the relationship between the safeguarding of cultural property and the phenomenon of storms.

4.2. Safeguarding of Cultural and Natural Assets and the Impacts of Storms

Some of the items listed on the SWOT (strengths, weaknesses, opportunities and threats) chart of "cultural and natural assets" created through the coordination of Izmir Governorship and various organizations and institutions during the all-day Workshop on Storm Project[9]conducted on March 31, 2022 are listed below with some of the action plans developed that day.

Strengths: Having a strong database of Geographical Information Systems, maps being digitalized and sustainable, having a legislation for safeguarding cultural assets, having rich cultural assets of historical and natural character all around the country, rising number of scientific excavation works, artifact restoration being done more consciously, teams for fighting against smuggling being active, inventory and security systems of museums being developed, finding more and more archeological data underwater.

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9 The author would especially like to thank the Izmir Governorship and the Izmir Chamber of Commerce Administration for their facilitation of this workshop, which was held within the scope of the project in question.

Weaknesses: Deficiencies in terms of the safeguarding, display maintenance and repair of cultural and natural assets; the fact that cultural assets are extremely sensitive to physical erosion created by win and the changes in temperature; lack of knowledge in terms of the extent of the damage to cultural and natural assets/lack of reporting; lack of a sufficient number of archaeologists being employed; failure to benefit from sciences such as geography sociology, and public administration in order to do an interdisciplinary study; insufficient number of staff; increases in forest fires because of the summer drought, and winds hence creating a higher risk; lack or absence of joint working culture between organizations agencies; complicated legislation, scope of authorities being mixed since they are distributed between different organizations.

Threats : The loss of cultural and natural assets cannot be measured accurately, cultural assets that are located outdoors get damaged with the increasing frequency of intense storms; the negative effect of forest fires increased in number and intensity due to storms; metaverse tourism market could increase the enthusiasm to travel virtually while promoting the safeguarding of cultural heritage but this could decrease socializing; cultural assets are open to risks arised by air pollution and they get very negatively affected by dust storms; extreme heats are negatively affecting the summer tourism and the tourists visiting the historical sites; loss of income due to storms and excessive winds damaging the tourism facilities and touristic attractions, unhealthy procedures for restoration activities; restoration tenders are not based on competency; protected areas and the areas which were damaged during natural disasters are being open to construction; cultural and natural assets being transferred to different locations after a disaster; the effects of natural disasters and storms are not on the agenda of related institutions; the preparations are either insufficient or nonexistent; lack of inventory due to illegal excavations and post-disaster uncertainty that benefits smugglers; having no strategy of taking pictures of natural or human-induced damages on protected areas in order to create social awareness; the extent of damage to underwater archeological artifacts due to storms is unknown.

Opportunities: Historic structures that were in the zones of terrorism and natural disasters have been transferred to safe areas thanks to developments in technology; possibility to keep the topic of cultural and natural asset preservation on the agenda through public service announcements; creation and development of awareness around the preservation of cultural and natural assets among NGOs and citizens/community; the estimation that historic artifact potential both on an under the ground waiting to be discovered is huge; Turkey's geographical location is suitable to benefit tourism in terms of its cultural assets.

In addition, on December 11, 2019, the World Mountain Day workshop was held in Izmir with the participation of 135 people around 8 tables. In this workshop, the weaknesses in the field of "cultural assets in mountainous areas" were evaluated[10]. Some of the issues discussed during that workshop are listed below.

The weaknesses observed regarding the mountains and their cultural assets

NGOs not being as effective in mountainous areas; • Not being rational when it comes to resource consumption; • Not protecting the local architecture; • Illegal settlements that

[10] The author would like to special thank the Governorship of Izmir for the coordination and facilitation of the Workshop on Mountainous Areas. Full text at https://afetyonetimi.deu.edu.tr/connected to, https://disk.yandex.com.tr/d/fZahppTW3Qzybk [20].

do not abide by the official construction and development plans; •Illegal archeological excavations being conducted due to the fact that mountainous areas are hard to reach and far away and the resulting damages; • Lack of a tip line or a communication system for illegal archeological excavations and stolen objects; • Locals of the mountainous areas not being able to create a force of pressure against unnecessary public investments such as HES; • Metropolitan municipalities remaining insufficient when it comes to planning mountainous areas because the municipal development plans of a 1/25,000 and 1/1,000 scale do not take mountainous areas into consideration. These issues require individual consideration and evaluation of action plans. The lack of a public policy directly related to mountainous areas is also a point that could be criticized. The principles developed in the evaluation of the concept of public service are important in terms of social peace and security [18]. Children, young people and women are the disadvantaged groups in the mountainous areas [19] and they should be in the center of capacity building and social development policies. Disasters have a much more devastating effect in mountainous areas and negatively affect disadvantaged groups.

Besides, it is not just the duty and responsibility of administration but also of the public and institutions to complete the main framework of by rehighlighting the public safety through focusing on "wind shelters" and things to be done in cases of dangers. This could be done by drawing wind risk maps for mountainous areas due to the fact that first settlements were constructed in these areas and therefore cultural assets are also very present. It should also be noticed that most university campuses are in mountainous zones as well.

In Turkey, since 2009, significant administrative mechanisms have been formed such as AFAD (Ministry of Interior Disaster and Emergency Management Presidency) and GAMER (Security and Emergency Coordination Center) for proactive disaster administration studies and other mechanisms are being strengthened. As there are common problematic areas and distinct issues within the field of disaster administration process, among public administration's essential responsibilities before during and after disasters are creating strategic action plans for the cities that encompass planning, timely and appropriate intervention, management and improvement, reconstruction; keeping these action plans up-to-date and publicly sharing them.

5. CONCLUSION AND EVALUATION

The information gathered for this study shows us that there is an ever-increasing risk for people finding themselves stuck in a supermarket because of an unexpected storm on an ordinary day, just like in Germany on February 17 and May 16, 2022.

Referring to the presentation of the architect Oktay Ekinci (1952-2013) , [21] "Victor Hugo wrote the very first law to protect assets in France... The name of the law was "Law for Memories" and was based on the theme of keeping the memories of people alive and carrying them into the future". In addition, the regulation prepared in 1850 for monumental structures was also named the "Regulation for the Grand Products of the Mind". The European Urban Charter (1992) also presents an example for the essence of asset preservation with the following words: "these assets are not the heritage of the past. They ensure that people feel prepared for the future with a sense of permanence in their mortal life." [21] The Statement of Conclusion at the back of the book touches upon issues such as "raising public awareness, big responsibility on the shoulders of local administrations, demolishing historic artifacts rather than preserving them comes from a mentality based solely on personal interests, the need for organizational coordination, closer collaboration with non-governmental organizations, training more informed and talented staff, the fact that cultural and historic artifacts are pieces of world heritage, making a place in the school curriculum for these topics, and placing this topic among the lessons offered in the course for becoming a district governor" [11] which are all topics related to human-induced damages.

Today, we cannot ignore the negative effects on cultural and natural assets of phenomena such as "strong winds and storms" caused by climate changes that were not taken into account in the past but are prominent today. There are no comprehensive studies developed for the storms that include the features specified in the administrative stages above. For this reason, these studies conducted on the storm are among the first, and further recommendations should be developed upon the essential preliminary information gathered from these studies.

It is crucial to know the effects of strong winds and storms on sectoral integration especially on agriculture, to review the agricultural activities and settlement plans, to use the new Environmental Impact Assessment (EIA) and its revised version in order to integrate them into Strategic Environmental Assessment (SEA) studies as risk analysis, and to support the works that could increase both sectoral and social resilience. EIA and SEA studies are important disaster risk analyses. Therefore, it is beneficial to conduct risk analyses for storms by taking into account the areas around the shores.

The crises that arise due to storms, tornadoes and floods have now begun to precede the perception of earthquakes. The priority of these studies is the restructuring of existing legal regulations in accordance with the circumstances imposed by the day. For example, while factors such as air quality and etc. are included in the Environmental Impact Assessment, nowadays, wind speeds can also be determined from meteorology and wind warning signs can be placed on highways, on the routes deemed appropriate with signs such as "risk of slipping".

In order to ensure the conservation balance of cultural and natural assets, risk maps of areas with wind risk can be created based on the data taken from meteorology. Expert organizations can be used in the projects to be created for this purpose.

It is important to build awareness around winds and the way to behave on windy days, as well as to work on measures such as banning public from going out on the street and prohibiting to go into traffic on days when the winds could turn into storms. Because according to our studies, the public prefers the use of a "commanding" authority.

In urban and rural areas, it is critical for local governments to be aware of their responsibilities for reviewing the status of trees in public areas in a way that does not pose a danger, as well as taking necessary measures against "roofs and antennas flying", "use of balconies" for buildings which could be affected by the storm. The significant issue of determining the existence of a relationship between sand/dust and dams in cities is of interest to researchers as an important issue. Regarding the recent climate-related events it is not enough to only underline the "fire and storm" relation. The integrated disaster

[11] Op.cit. p. 149-150

relations between "floods and storms" need evaluation as well. Looking at human history, storms that were related to almost "divine" powers which were so intense have always existed in the past. These kinds of storms also occur in our era and it would not be some sort of a fortune telling to predict that the effects of climate change will continue to impact our future in an ever-increasing fashion.

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THE ROLE OF GENOME EDITING IN RESPONSE TOCLIMATE CHANGE

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ABSTRACT

Climate change is a global threat to crop growth and productivity and almost every aspect of our life in the present times.Changes in global temperature, population growth and water scarcity are increasing at an alarming rate and are likely to get worse in the future. The overall impact of climate change on agricultural productivity appears negative ascrop respiration and evapotranspiration are temperature-reliant, insect infestation and disease have become more common in plants than ever.As reported bytheIntergovernmental Panel on Climate Change (IPCC),major commodity crops' productivity was negatively affecteddue to theirsusceptibilityto weather variables, resulting insignificant economic losses.Climate change will also harm livestock.Therefore, improving agricultural productivity and sustainability is critical for the entire planet.Recently, the urgency of harnessingcrop and livestock genome editing technologyto tackle some of our biggest global challenges has grown exponentially.Genome-editingsystems are set to enable precise modifications to the DNA in a cell or organism, which creates opportunities for rapid development of elite cultivars with desired traits. Therefore, genome editing provides a suitable approach for either boosting organisms in adapting to climate change or limiting the consequences of climate change on agriculture.Transcription activator-like effector nucleases (TALENs), Zinc Finger Nucleases(ZFNs), and CRISPR/Cas systems have paved the way toenhance performance across a variety of traits.The use of CRISPR/Cas systems has dramatically increased the precision and efficiency of generating appreciablepromise for producing crops and animals that can better deal with the effects of climate change.Here,the current efforts ofapplicationsof genome-editing techniques in plants and livestock are highlighted,which canhelp secure the global food supply. Furthermore,we recap a comprehensive overview of the CRISPR-Cas9 tool and talk through their abilities to resist the daunting threat of climate change.

Keywords: Climate Change, Genome editing, CRISPR, Agriculture

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1. INTRODUCTION

Climate change is a possible change in the average weather patterns of a region over a long period of time resulting in the overall heating of the Earth's surface (global warming) due to an increase in gaseous emissions[1].These days, climate change and its effect isunanimously one of the biggest challenges faced by the world.The industrial revolution is the beginning of the problem,which leads to an increase in population. In addition, technological advancement increased the need for energy sources and their exploitation, despite any harmful side consequences[2].Scientists have compared this phenomenon to a cosmic catastrophe because it will affect all sectors directly or indirectly**.**Since 1850, these emissions produced especially due to human activities have caused the planet's average temperature to rise by almost 1°C. Droughts, floods, frequent heatwaves, rising seas, ultimately global temperature is likely to increase, and their magnitude is directly associated with the emission[3]. Climate change will play an essential role in the global agricultural system. Unfortunately, most climate change scenarios eventually negatively impact the agricultural system and substantially decreasein productivity for most crops is resulted if with slight temperature increase (2 °C– 4°C[4]. Accordingly, with significant increase in emissions both natural ecosystems and agricultural settings will be harmed. High air temperatures increase the soil's temperature, affecting the germination of the seeds of different crops.Rise in temperature also affects the activity and effectiveness of the micro-revival of the soil. On the other side, rising temperatures may lead to an increase in evaporation and sufferlack of irrigation water. This may lead to a decrease in the productivity of many crops.In fact, many of these effects are already being observed. In an annual United Nations study in 2019, findings indicated that an estimated two billion people worldwide did not have regular access to safe, nutritious and adequate food during the year. Therefore, plants and animals must adapt to new environments that are changing faster than their pace of adaptation.Risingtemperatures and shifting precipitation regimes will drastically alter the biological landscape,resulting in species migration, invasion, and extinction[2].Consequently, innovation and non-traditional solutions in agriculture have become very important to maintain the agricultural system in all its aspects and achieve food security and safety simultaneously.For many scientists, gene editing represents an ideal solution to the food crises that are expected to exacerbate in the future.Genome editing techniques have introducedprecise and predictable genome modifications into DNA toobtain desired traits[5].These modifications can resultin the knockout or knockdown of one or multiple genes withoutthe permanent insertion of any foreign DNA. On second thoughts, genes from otherorganisms can be inserted into precise locations within thegenome to knock-in a new trait.Through the years, many promising tools for achievingspecific gene edits have been developed, including zinc-finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and CRISPR-associated protein 9 (Cas9)[6]. Although CRISPR/Cas systems have significantly increased the accuracy and effectiveness of making modifications, there is undoubtedly still a role for other gene editing technologies.Besides modern breeding methods, CRISPR-Cas technologies will playan essential rolein crop improvement programs.Gene editing techniques have created enormous possibilities for developing crops and animals that can better deal with the effects of climate change. This review highlights the current efforts and status of CRISPR/Cas technique for plant and livestock improvement.

Effects of Climate Change on Crops and Livestock

Agriculture is susceptibletoclimate change and thus very vulnerable to climate change[1]. Climate change could impact agriculture in severalaspects, including crop yield, growth rates, photosynthesis and transpiration rates, moisture availability, etc.Recently, the concentration of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and Sulfur Hexafluoride (SF_6) have rapidly increased. Figure 1illustrates the increase in CO_2 emissions (1960–2020). Increased carbon dioxide(CO_2) concentrations in the atmosphere have a positive impact on vegetation productivity[7]. By contrast, a rise in the average seasonal temperature can limit the growing season of many crops, reducing their yield[4].Besides, the productivity of agriculture will be affected by changes in land and water regimes due to changes in temperature and precipitation.

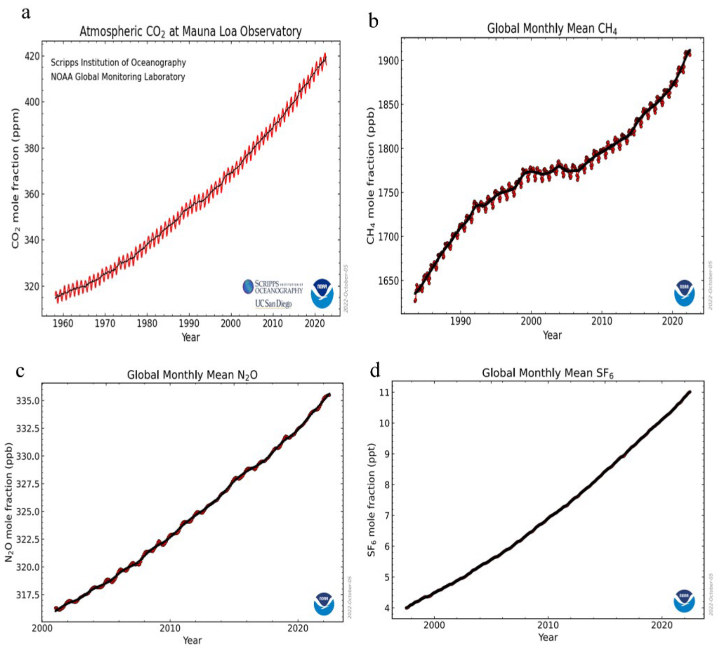

Figure 1. The CO_2 (a), CH_4 (b), N_2O (c), and SF_6 (d) concentrations are increasing in the atmosphere[8].

Climate change will also have a negative impact on livestock.Changing precipitation patternsand rising temperatures have a direct impact on animals, their feed, andthe diseases that infect them. High temperature has proved to increase death rates in many livestock species as it directly affects feed intake, ultimately limiting their weight gain and causing numerous health problems [8].

The Role of Genome-Wide Association Study (GWAS) on Climate Change

Under both natural and artificial selection, wild ancestor plants produce natural variations in crops.The ability of different crops to adapt to various environmental conditions is a significant resource for agricultural improvement to fulfill the rising food demand of the human population[9].There is a substantial desire in the possibility of using GWAS to identify genes responsible for natural variation.Recent progress in sequencing technology andmethodology developmenthave made it possible to carry outGenome-wide association studies (GWAS), in which numerous genetic variants are examined to find statistical links between genotype and phenotype.With the help of these studies, it is now possible to identify genomic variations linked to either typical agronomic phenotypes or biochemical and molecular phenotypes.These relationships allow for gene cloning and rapid crop breeding applications using genetic engineering or marker-assisted selection.Numerous agronomic, physiological, and physicaltraits, including flowering time, plant height, kernel quantity, stress tolerance, and grain production have been linked to specific genomics by genome-wide association studies (Table 1).

Table1. Summary of Plant genes that resist climate change

Plant Species	Trait Category	Trait Targeted	Transcription Factor	Ref.
Common bean	Abiotic stress	Regulates various aspects	DUF221 domain-containing genes	[10]
Oat	Abiotic stress	drought, ageing, and H2O2 stress	Glutathione reductase (GR)	[11]
Rice	Abiotic stress	drought and salinity stress	Polycomb Group (PcG) genes	[12]
Maize	Abiotic stress	Cd and drought stress	SWEET gene family	[13]
Common bean and jujube	Abiotic stress	drought stress and Low temperature	BURP domain-containing genes	[14], [15]
Potato	Flowering time	Flowering response	SBP genes	[16]
Common bean	Abiotic stress	Salt stress	bHLH transcription factors	[17]
Common bean	Abiotic stress	Salt stress	AP2-ERF gen	[18]

Application of Gene Editing for Climate Change in Agriculture

It is important to emphasize how GWAS and genome editing work in harmony.While GWASis a powerful tool for identifying genes underlying complex traits, gene editing simultaneously verifies gene function in vivo conditions.Here, we summarize the currentstatus and efforts of applications of genome-editing techniques for climate change inagriculture. CRISPR-Cas technologies have the upper hand in crop improvement programs Figure 2.

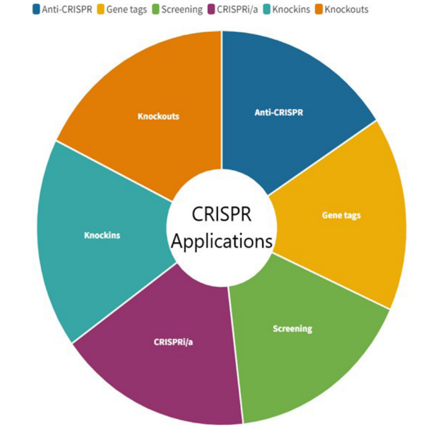

Figure 2. Applications of CRISPR technology for crop improvements.

CRISPR Increases Tolerance to Abiotic Stress

Abiotic stress is the term used to describe how non-living factors negatively affect living organisms in a particular environment. Abiotic stresses include drought, salinity, low or high temperatures, and other environmental extremes.. Zhang, Liu [19] illustrates the improvement of the rice salinity tolerance by engineering a Cas9-OsRR22-gRNA expressing vector, targeting the OsRR22 gene in rice. İn addition, the Cas9-free dst mutant showed significant levels of salt stress and moderate osmotic stress tolerance, which increases the tolerance to salt, drought, and grain production in India rice cultivars [20] (Figure 1). Furthermore, Tran, Doan [21] reported that the precise elimination of *SlHyPRP1* negative-response domain(s) lead to high salinity tolerance at the germination and vegetative stages (Figure 3). Table 2 recaps CRISPR/Cas9-mediated genome editing is applied to examine genes involved in response to temperature, drought, and salinity stresses.

Table 2. Summary of CRISPR/Cas9 application for responding to temperature, drought, and salinity stresses[22].

Plant Species	Target Genes	Gene Function	Phenotype	Mode of Application	Ref.
Rice	*OsPRP1*	Proline-rich protein	Cold sensitive	*OsPRP1* enhances cold tolerance by modulating antioxidants	[23]
Tomato	*SlCPK28*	Protein kinase, Ca^{2+} sensing	Heat sensitive, accumulation of ROS	Mutants exhibited sensitive phenotype and higher H_2O_2 content after treatment at 45 °C for 12 h.	[24]
Tomato	*SlMAPK3*	MAP kinase upregulating HSPs'/HSFs' genes' expression	Heat tolerance, reduction of ROS accumulation	SlMAPK3 mutants exhibited less severe wilting and less membrane damage, showed lower ROS contents, and presented higher both activities and transcript levels of antioxidant enzymes.	[25]
Tomato	*SlLBD40*	Plant-specific transcription factors	Enhanced drought tolerance and reduced stomatal conductance	Mutants showed drought-tolerant phenotype under the 10-day watering cessation treatment.	[26]
Maize	*ARGOS8*	Negative regulator of ethylene responses	Enhanced drought tolerance, increased grain yield	Mutants sown on soil with only normal 15% moisture showed drought-tolerant phenotype.	[27]
Soybean	*GmMYB118*	MYB transcription factor family	Reduced drought and salinity tolerance	Mutants showed drought-sensitive phenotype after 14-day no water treatment.	[28]
Wheat	*TaHAG1*	Histone acetyltransferase	Reduced salinity tolerance, more chlorotic leaves and higher Na^+ content in the mutants	Mutants showed salinity-sensitive phenotype at 200 mM NaCl application.	[29]
Potato	*Coilin*	A main structural protein controlling the formation, composition, and activity of subnuclear Cajal bodies	Enhanced salinity tolerance, slower yellowing and leaf fall	Mutants showed salinity-tolerant phenotype at 300 mM NaCl application.	[30]

Table 3. CRISPR/Cas9-mediated genome editing is applied to examine genes involved in disease tolerance.

Species	Trait Targeted	Gene(s) Edited*	References
Banana	Banana streak virus	eBSV	[31]

Figure 3. Applications of CRISPR technology in crop against abiotic stresses. Salt stress (a, c, f), drought stress (b, c, e), heat stress (d)

CRISPR Increases Tolerance to Disease

Climate change may strongly affect diseases depending on the geographic and temporal scales.In plants, there are several identified genes that increase diseaseresistance when knocked out, Knocked in, or overexpressed. Some plants have been modified to develop simultaneous resistance to many diseases.The primary method of disease prevention using gene editing techniques has been to change the genetic factors involved in vulnerability in the plant.Tripathi, Ntui [31] described a method for inactivating the(banana streak virus) eBSV by altering the sequences of the virusFigure 4. In addition, Zhang, Ge [32] illustrated that CRISPR/Cas9 system was developed in *G. hirsutum* through editing the Gh14-3-3d gene. The two transgene-clean editing plants with homozygous mutations, ce1 and ce2 showed higher resistance to *Verticillium dahliae* infestation than wild-type plants. Furthermore, Sljaz2Δjas mutants have been identified asmore resistant to PtoDC3000 when surface inoculated.Gene editing techniques have also increased tomato tolerance to bacterial speck virus [33]. In conclusion, various recent gene editing initiatives have demonstrated promising results in promoting disease resistance.

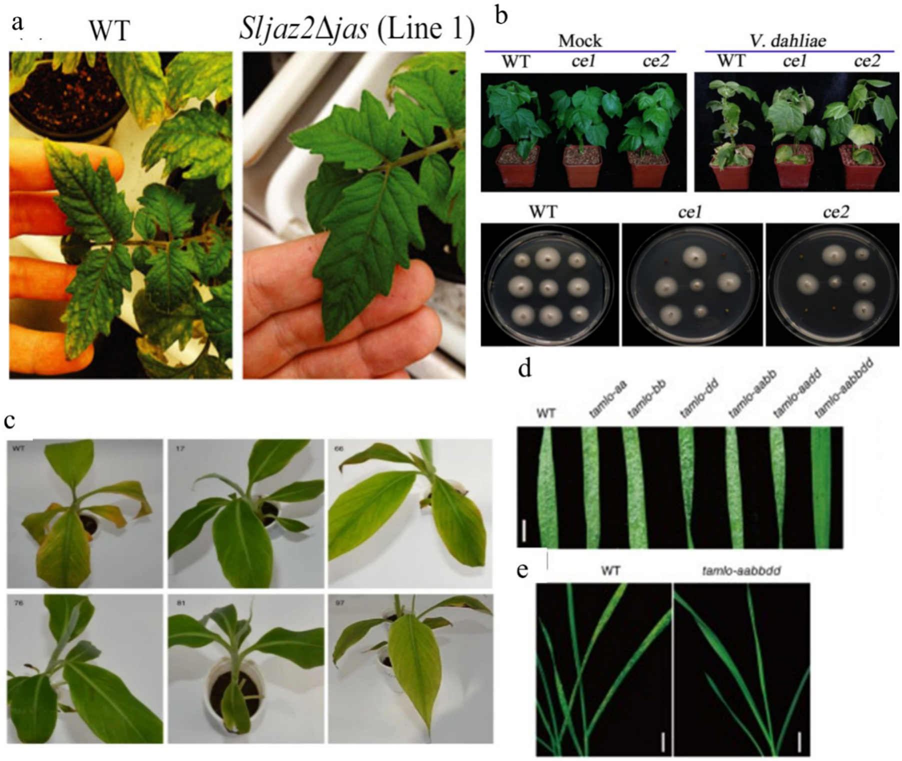

Figure 4. CRISPR technology can be applied to create resistant crop against biotic agents. Tomato plant inoculated with *P. syringae* (a), tomato plant inoculated with *V.dahliae* (b),banana plant inoculated with *bananastreak virus* (c), wheat plant inoculated with *P. Mildew* (d, e)

CRISPR Increases Yields

Crops and livestockyields will continue to lose a lot of productivity due to climate change[34].The Intergovernmental Panel on Climate Change (IPCC) predicts that extreme weather events would disrupt the world's food supply, reduce it, and raise food prices. Many different gene modifications have been developed for crop plants to boost yields. In rice, targeting various gene combinations linked to yield has led to lines with 11–68% higher yields.CRISPR/Cas9 system was used in this study to edit two yield genes:*Gn1a* and *DEP1*[35].These genes have a significant role in yield attributes that were characterized before. In wheat GW2, LPX-1, and MLO were simultaneously knocked out to increase yield and disease resistance[36]. Tomato architecture has been improved by CRISPR/Cas9 system, which enabled increasing fruit size and altered plant morphology Figure 5. [37].

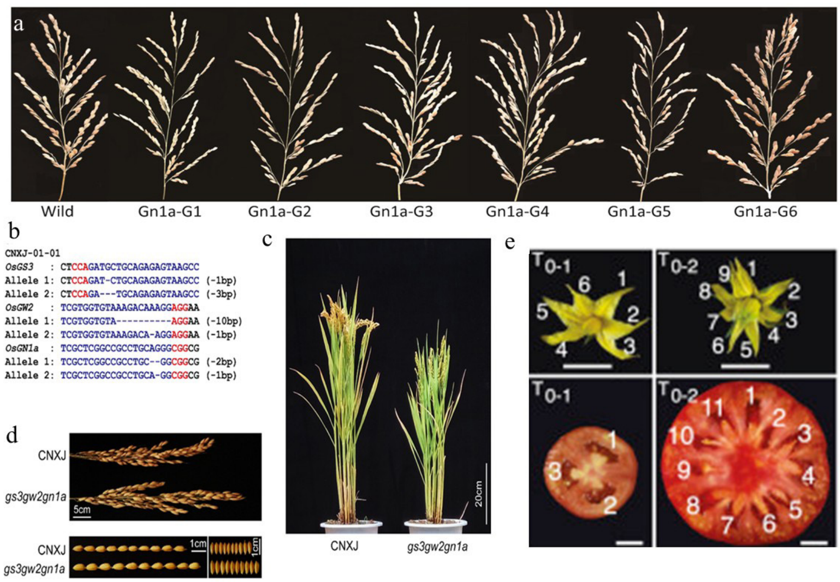

Figure 5. Applications of CRISPR technology for higher yield in crops. (a, b, c, d) rice, (e) tomatoes**.**

Transgenic Plants and World Agriculture

Even though many countries are working on the development of genome-edited crops for several years, only a few of countries clarified their opinion towards genome editing. In countries like Canada and USA, and developing countries such as Pakistan and India, genome edited crops can easily be passed through their regulatory procedures. However, New Zealand and Europe are strict with their old GMO regulatory procedures. In our country, the GMO regulation procedures are same as Europe. With the prediction that genome-edited products will no longer be recognized as GMOs soon United Kingdom UK, after it leaves the European union is planning to change current rules so that gene-edited plants using CRISPR system are treated differently to GMOs.

Since nematodes cause significant crop production losses in our country and throughout the world, the tomato line to be developed as a result of this project will be very important both economically and nutritionally. Due to the GMO regulations in our country, even if our genome edited tomato variety is not commercially available inside our country, we expect it to be commercially sell in the near future, just like in the UK. Considering the export potential, our genome-edited tomato variety can also be exported to countriesw-here genome-edited crop is not restricted such as USA, Pakistan, India etc.

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EFFECT OF NDVI ON LST, EVALUATION IN TERMS OF CLIMATE CHANGE

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ABSTRACT

The quality, continuity, and integrity of green spaces in cities play a critical role in mitigating land surface temperatures. In this study, the effect of green areas, which is one of the environmental parameters, on the Land Surface Temperature (LST) was investigated. The reason for the increase in LST is unplanned urbanization, unplanned development, decrease or fragmentation of green (permeable) areas, increase in impermeable surface coatings and high construction. LST increases causes the temperature in the city to increase gradually, and the warming of the cities is one of the main causes of climate change. Surface-based solutions can help mitigate and adapt to climate change. In the study, the change between the years 2000-2020 was determined using both remote sensing and statistical techniques to analyze the dynamics between environmental variables. As a result of the analyzes made, the amount of green space decreased by 14.1% between 2000- 2020 in the study area, which includes the central districts of Samsun, İlkadım, and Atakum, and the rural areas of Bafra. It has been observed that this rate is shared as 7.1% in built-up areas and 7.33% in bare soil areas. Considering the effect of the decrease in green areas on LST values, it is seen that while LST was 41.75 °C in 2000, it increased to 43.44 °C in 2020. LST affects the distribution of energy between soil and vegetation and determines the surface air temperature. To demonstrate this effect, algorithms have been applied to the raw data of Landsat 8 and Landsat 7 satellite images by using remote sensing technologies, using Arc Gis 10.2 and Q Gis 3.16 utilities. NDVI and LST obtained from satellite images were compared and evaluated in terms of climate change.

Keywords: Climate Change, Land Surface Temperature, NDVI, Remote Sensing

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1. INTRODUCTION

Apart from the factors of global warming such as droughts, big forest fires, soil erosion, warming of the oceans, rising sea level, and the opening of agricultural areas to construction, which accelerates this change with human activities, are the factors that create green space unqualified, disrupt the ecosystem and reduce biodiversity, thus harming the urban green infrastructure [1]. At the United Nations Climate Change Conference (COP 21) held in Paris in 2015, an agreement was made among the leaders of 195 countries that they will work nationally and globally to keep the global average temperature rise 2°C above pre-industrial temperature averages [2]. According to [3], it is predicted that temperatures will exceed 2.6-3.1C at the beginning of the next century. Unless precautionary measures are taken in cities and rural areas, climate change will continue to show its devastating effects on a global scale.

Urban population growth is one of the factors affecting climate change. It is estimated that the world population will reach 9.7 billion by 2050 [4]. Industrialization and irregular urbanization continue to harm human life by triggering climate change. Irregular urbanization becomes a major environmental problem with the destruction of open and green spaces [5,6,7]. The urban environment is under the influence of the Urban Heat Island (UHI), which is a factor in climate change and a negative effect of unplanned urbanization [8].

Urban land cover absorbs radiation from the Sun during the day and surface coverings, so surface UHIs need to be measured against the LST. [9] developed a new method that uses Surface Urban Heat Island density (SUHI) for image-based analysis of satellite data to reveal the relationship between LST and impermeable surface areas. For better management of land and water resources in urban areas, urban thermal environment dynamics should be studied using satellite images [10,11,12] reported that the effect of greening in rural areas is an important and widespread driver for increased daytime surface urban heat island density (SUHII = urban LST - rural LST).

Nature-based solutions and complementary urban approach proposals aim to expand 'blue', and 'green' areas, thereby reducing heat island effects, and improving human health. Effective implementation of appropriate Nature Based Solutions to improve the sustainability of urban systems primarily requires evaluating and understanding green space change.

This study aims to evaluate the effect of green space change on LST in urban and rural districts on the Samsun coastline for the period 2000-2020. To achieve this goal: (i) identify land use/land cover change related to urbanization, (ii) identify the change in LST related to green space change. The study findings will be useful for local and regional planners and city administration units.

2. MATERIAL AND METHODS

2.1. Study Area

The study area starts from the rural town of Bafra in the west that limited to the E70 ring road from the east and the Black Sea to the north. The area of Bafra district is 175000 ha and its distance from Samsun is 51 km. It is located at the junction of the Kızılırmak river with the Black Sea coast. Bafra plain covers an area of approximately 75800 ha. While agricultural activities are carried out in the plain, the upper lands with a high slope are forest and pasture areas. Bafra Plain, which covers the Kızılırmak delta, is surrounded by mountains in the south. The highest of these is the Nebiyan mountain with 1224 m. Kızılırmak, Bafra's largest and Turkey's longest river, crosses these mountains through a deep valley and reaches the plain. The length of Kızılırmak is 1151 km. Bafra plain was formed entirely by the effects of Kızılırmak. Many lakes were formed in the parts of the river close to the sea [13].

Landscape pattern of the study area, impervious surfaces (settlement areas, squares, roads, parking lots, etc.), fields, green areas, forested areas, mountainous areas, nature protection areas (Kızilirmak Bird Sanctuary, Galeriç Forests), water areas (Black Sea) for Bafra district. , Kızılırmak, Derbent Dam, Lakes), for Samsun urban, impermeable surfaces (Settlements, Industry, Squares, roads, parking lots, etc.), water areas (the Black Sea, rivers, lakes), green areas (City forest, Golf club, etc.) The stadium consists of grass and bush landscape areas made in the areas formed by the filling of the sea, and the coastline (sand area).

Samsun province is located in the middle part of the Black Sea coastline and constitutes approximately 1.2% of Turkey with its surface area. In terms of landforms, Samsun consists of the mountainous part in the south, the plateaus between the mountainous part and the coastline, and the Bafra and Çarşamba plains, which have a very high agricultural potential between the plateaus and the Black Sea. Samsun has an important role in the commercial and agricultural structure of the region. The fact that it is surrounded by the Kızılırmak and Yeşilırmak deltas and its vegetation is suitable, and that it is connected to all parts of Turkey by air, sea, and road, has made Samsun a favorite province of the Black Sea Region over time. The total area of Samsun, including the lakes and the water bodies of the dams, is approximately 9579 km². Samsun city center has started to develop towards the west and south in the direction of the extension of the coastline over time, due to the extremely dense urbanization. Between 1998 and 2014, the urban settlement area in Samsun increased by 96.32% and grew to approximately 32 km², and this growth generally developed towards agricultural areas [14].

2.2. Satellite and Meteorological Data Used

To make sense of the correlation between LST and air temperature change in terms of local climate change, ground station data and satellite image data were collected from reliable sources. August average temperature, total precipitation, and wind speed data of stations 17030 (Samsun Regional Station) and 17622 (Bafra Station) located in the study area for the years 2000, 2010, and 2020, obtained from Samsun General Directorate of Meteorology, were used. The meteorology data used are shown in Table 1.

Table 1. Samsun Meteorology General Directorate Data for August

	August mean air temp. (C°)		August average precipitation (kg/m²)		August Avg. Wind speed (m/sn)	
İst. No.	Bafra Station (17622)	Samsun District Sta. (17030)	Bafra Station (17622)	Samsun District Sta. (17030)	Bafra Station (17622)	Samsun District Sta. (17030)
2000	23.1	23.8			1.8	2.5
2010	25.7	26.8	19.4	4.4	2.0	1.8
2020	23.3	24.3	26.4	21.0	1.9	2.2

Landsat 7 ETM+ operational satellite data dated August 2000, August 2010 and Landsat 8 OLI data dated August 2020 were downloaded from the US Geological Survey [15] Global Visualization Viewer. Detailed information on bands, wavelengths, and resolution is given in Table 2. Landsat satellite images have a resolution of 30 m. The thermal band to be used in surface temperature calculations has a resolution of 60 m in Landsat 7, while it has a resolution of 100 m in Landsat 8. The satellite images used in the study are Landsat 7 ETM+ (Collection 1, level 1), and Landsat 8 OLI/TIRS (Collection 1, Level 1) satellite data belonging to the summer months of 2000, 2010, and 2020. Images max. It is masked to have a cloud rate below 10%. Atmospherically corrected images were obtained geometrically ready.

2.3. Image Classification

Change in land use causes a change in land cover and hence LU/LC. This change can be detected as a result of urbanization through the analysis of remote sensing images and the use of field surveys. The marginal loss of land around cities, seen as a result of urbanization, is becoming a global concern. [16] applied the LULC classification scheme in his research. In the literature, a supervised classification algorithm has been used in many studies [17,18]. In this research, the maximum likelihood checked algorithm was used. According to [19], the maximum likelihood algorithm is robust and easy to use. LULC patterns were mapped using the 2000 and 2020 supervised classification, and four classes were considered to suit the targets: water areas, built areas, green areas, and bare areas.

2.4. Accuracy Assessment

In this investigation, MLC-controlled classification was performed with the original satellite data bands (LANDSAT) that produced LU/LC maps for the years 2000 and 2020. Then, the LU/LC maps were evaluated using the cross-classification method. Statistically, the confusion matrix obtained from LU/LC maps and field data (signature file) was used for accuracy assessment [20]. The accuracy of the LU/LC classes was determined by the kappa statistical coefficient. The classes within the study area were determined as (i) Water (River, Lake, Sea), (ii) Built (Urban, Roads), (iii) Vegetation (Forest, Cropland, Delta, (iv) Open Land (Bare Soil) [21]. The kappa accuracy coefficient was found to be 0.87 for the year 2000 LU/LC maps, and 0.96 for the year 2020 LU/LC.

2.5. Normalized Difference Vegetation Index (NDVI)

The Normalized Difference Vegetation Index (NDVI) is used as an indicator and measures green vegetation from distant satellite images [6]. It's calculated as in Equal 1.

$$NDVI=(NIR- RED)/(NIR+ RED) \qquad (1)$$

2.6. Land Surface Temperature (LST)

1. TOA (Top of Atmospheric) calculation of spectral radiation

$$TOA (L) = M L * Q kal + A L \qquad (2)$$

ML = Band-specific multiplicative rescaling factor obtained from the metadata file (RADIANCE_MULT_BAND_ x ,where x is the band number).

Q cal = thermal band value

AL = Band-specific additive rescaling factor obtained from the metadata file (RADIANCE_ADD_BAND_ x ,where x is the band number).

2. Converting from SSO to Luminosity Temperature (BT)

$$BT = (K 2 / (\ln (K 1 / L) + 1)) - 273,15 \qquad (3)$$

K1 = Band-specific thermal conversion constant from metadata (K1_CONSTANT_BAND_ x ,where x is the thermal band number).

K2 = Band-specific thermal conversion constant from metadata (K2_CONSTANT_BAND_ x ,where x is the thermal band number).

L = TOA

3. NDVI calculation

$$NDVI = (Nır – Red) / (Nır + Red) \qquad (4)$$

4. Vegetation Pv rate calculation

$$P v = ((NDVI – NDVI min) / (NDVI maks – NDVI min))^2 \qquad (5)$$

5. Emissivity calculation ε

$$\varepsilon = 0.004, * P v + 0.986 \qquad (6)$$

6. Calculating Land Surface Temperature

AYS = (BT / (1 + (0.00115 * BT / 1.4388) * Ln(ε)))   (7)   [23]

3. RESULT AND DISCUSSION

According to the results of the LU/LC maps in the study, water areas decreased by 0.34%, built areas increased by 7.1%, green areas decreased by 14.1%, and bare areas increased by 7.33 in 20 years (2000-2020).

While the mean LST in the study area was 28.61 °C in 2000, it was found to be 27.93 °C in 2020. LST's max. While its value was 41.75 ° C in 2000, it increased to 43.44 ° C in 2020. However, when the mean LST values are examined, it is seen that 0.68 C° is low. In order to find out which land cover caused the decrease in the mean LST value, four types of land cover were masked in each LST map and their average temperatures were obtained. Accordingly, as shown in Table 2, the LST value shows a decreasing trend in water areas, vegetation areas, and bare soil areas. On the other hand, the temperature increased in the built-up areas.

Table 2. LST distribution for LU/LC classes

31/07/2000				
	LST (C°)			
	Min	**Max**	**Mean**	**StD**
Water	19.97	32.11	22.89	0.70
Builtup	19.68	41.51	31.44	2.85
Vegetation	19.09	40.02	29.26	2.56
Open Land	24.52	41.75	33.05	1.89
31.08.2020				
	LST (C°)			
	Min	**Max**	**Mean**	**StD**
Water	18.16	32.33	21.62	0.84
Builtup	19.17	43.44	32.04	3.75
Vegetation	19.55	40.49	27.43	2.74
Open Land	19.69	43.23	31.84	3.93

Although the mean NDVI was 0.17 in 2000, it is seen to increase to 0.22 in 2020. The NDVI value ranges from -1 to +1. Negative NDVI indicates areas of water. O and values close to 0 indicate the existence of built-up areas. Values up to 1 indicate the presence of green areas and the green quality of these areas. It should be mentioned that the closer the NDVI value is to 1, the more healthy vegetation exists [23]. In our study area, while the amount of green space decreases in urban areas, it is seen that the quality and amount of vegetation increase in rural areas. As a result, while the max LST value increased in urban areas, the overall LST value showed a decreasing trend with the effect of lowering the temperature of green areas.

The air temperature change taken from the meteorology stations was seen as a 0.5C° increase according to the Samsun regional station data. Since the data received from the satellite belongs to August, air temperature, precipitation, and wind speed data were obtained for August. However, while the working area boundary of the satellite images is a sharp line, the meteorological data represent a general region. In addition, the increase in precipitation and wind speed affects the air temperature value. Therefore, it is not possible to interpret meteorological data with the results obtained from satellite data.

4. CONCLUSION

In this study, LST, NDVI, and LU/LC change and Meteorology Station data were investigated for 20 years in the area covering the central districts Ilkadım and Atakum along the coastline of Samsun and the rural district Bafra. The data of Landsat 7 ETM+ and Landsat 8 OLI –TIRS satellite images for the years 2000, and 2020, coinciding with August, were used. The results show that the green area has decreased in 20 years and the bare soil and residential area have increased. Accordingly, Max. LST value dropped. However, while the amount of green space decreases in urban areas, it increases in rural areas. It has been observed that the dense and fertile lands in the rural areas of Bafra have been cultivated and processed regularly in the last 20 years. The NDVI value was high in this area. LST max. Although the value increased, the average LST value decreased by 0.68 C° with the cooling in the countryside. [12] stated in his study that the decrease in LST in rural areas affects the whole city. However, the decrease in LST experienced in three lands (Vegetation, Water, Openland) classes could not prevent the increase in the Built-up class. The negative impact of the density of construction on LST is great and it is seen that the fragmented green areas in cities with low NDVI value do not have the power to reduce this negative impact. Instead of this planning approach, it is thought that protecting the productive and valuable green areas in rural areas, increasing their quality (NDVI) and area, and reducing the heating in urban areas will be beneficial.

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CHAPTER 3

Climate Change and Design-Tourism

EFFECT OF CLIMATE CHANGE ON WAVE OVERTOPPING SAFETY OF COASTAL STRUCTURES

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ABSTRACT

Significant consequences of climate change are observed in particular on coastal structures. Two problems due to climate change are considered, which are defined as the rise of the mean sea level and the increase in the magnitude of environmental effects, namely the wave height and wave period. Besides permanent inundation risk for low elevation areas, the latter change also introduces the risk of functional incapability for existing coastal structures in terms of wave overtopping under storm conditions. In this paper, a general analysis for existing coastal structures has been carried out, which are supposed to be designed according to two different limit overtopping rates. A mean water level rise range of 0-1.0 m, changes in overtopping rates are calculated and plotted as diagrams. It can be seen that a significant amount of increase in mean overtopping rates can take place in case of mean sea level rise, which becomes more visible for low crested structures subject to milder wave climates. Furthermore, advanced armor block types with small friction coefficients are more sensitive to mean sea level rise in terms of overtopping.

Keywords: Sea Level Rise, Wave Overtopping, Breakwaters, Overtopping Rate, Coastal Flooding.

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1. INTRODUCTION

Coasts comprise an important habitat for people since early centuries. It has been stated that 40% of the world population lives in a region less than 100 km away to coasts [1]. A significant amount of world trade and logistics take place over oceans and seas, boosting the importance of coastal cities. Due to the importance of coastal cities and navigation from various points of view such as national security, strategical issues, marine trade, sea sources, tourism etc., protection of coastal cities and facilities from sea-based effects such as storms, tidal changes and currents has become one of the pioneering challenges in coastal and marine engineering. Thus, design of shore protection structures evaluated for centuries with the primary concern being structural stability. Starting from 1980s research intensified on wave runup and overtopping in order to mitigate coastal flooding and increase the serviceability of coastal structures with the primary parameter used in describing overtopping safety defined as the mean overtopping rate, defined as the volume of seawater passing the unit width of the structures crest in unit time and some empirical equations for the prediction are recommended by various researchers [2-6]. Criteria for safe limits of wave overtopping are also described [7]. Since storm waves are of random nature, the mean overtopping rates are however not satisfying to describe maximum overtopping volumes and their effects. By considering this fact and also by taking the increase in storm magnitudes, the threat of mean sea level rise into account, studies and research projects about overtopping did intensify on overtopping volumes and velocities during the last two decades in order to improve the functionality, safety and stability of coastal structures [8-10]. The most recent knowledge about wave overtopping has been summarized in EurOtop (2018) design manual [11].

Climate change introduces two different forms of risks in coastal cities and installations: First, the rise of sea level threatens coastal installations with inundation. Second, marine-based environmental effects in case of extreme weather, i.e. waves and storm surge, endanger the stability and functionality of shore protection structures.

Based on the sea level rise estimations for different climate change scenarios presented by IPCC [12] studies have been carried out in order to predict coastal areas subject to inundation. Recent studies deal with the mean sea level rise problems in case of waves and storm surge [13-15]. Though one may consider the case of a permanent inundation more serious, coastal flooding due to waves and storm surge, though temporary, can lead to disastrous effects in coastal regions such as residential areas, wastewater treatment, transportation, industrial installations and hence can affect public safety, health and life quality. Excessive amounts of coastal flooding can even trigger industrial disasters for some heavy facilities such as power plants.

Overtopping takes place if the wave runup height exceeds the crest height of the structure. Thus, the dictating parameter in overtopping control is the crest height, whereas a secondary parameter can be given as the roughness of the structure surface, which dissipates the energy of the water “climbing” on the structure and hence reduces runup. The process is also affected by the slope of the structure, which defines the type of wave breaking and hence the following runup behavior of waves. Consequently, wave runup has been used as a design parameter for long decades and various formulations have been developed for its prediction. For steep structures such as breakwaters and mound seawalls the effect of slope disappears and the maximum runup value approaches to three times of the wave height. Since crest heights designed according to "No overtopping" principle significantly increase construction costs and lead to aesthetical problems, it is a common procedure to permit some amount of overtopping. Some of these limits presented in EurOtop (2018) [11] are summarized in Table 1.

Table 1. Allowable mean overtopping rates [11].

Functional Criteria	**EUROTOP Limits**	
	q_{max} (lt/s/m)	**Notes**
Vehicle traffic	<5	H_{m0} = 3m
	10-20	H_{m0} = 2m
	<75	H_{m0} = 1m
Pedestrian traffic	0.3	H_{m0} = 3m
	1	H_{m0} = 2m
	10-20	H_{m0} = 1m
Small boats safety set 5-10m from the wall	1	3m – 5m
Large yachts safety	5	>5m
Equipment damage set back 5-10m	1	1-3m

The effect of mean sea level rise is considered in modern design guidelines for coastal structures. However, the service life of coastal structures is fairly long, and most of the existing structures are designed according to older guidelines, hence the mean sea level rise is not considered in the design. Thus, sea level rise threatens these structures with loss of performance or stability. This study aims to investigate the consequence of the mean sea level rise in terms of overtopping rates for such coastal structures. For this purpose, variation of mean overtopping rates with mean sea level rise have been calculated for some typical coastal structures which are designed according to preceding guidelines, and the effects of structure type and properties are assessed as explained below.

2. MATERIAL AND METHODS

2.1. Structure Properties

For the study, structure types commonly applied along the coasts of Turkey are selected. These comprise of rubble mound breakwaters with different types of armor units and vertical seawalls in locations with milder wave climate. It has been assumed that the crest height of these structures are evaluated by considering the overtopping limits. In this study, two limit overtopping rates corresponding to risk levels given in Table 1 are taken into account, which are q_{max} = 1 lt/s/m and q_{max} = 5 lt/s/m, respectively. Crest height values for the structures are calculated by using Eq. 1 and Eq. 2 for spectral wave heights in the range of 3m ≤ H_{m0} ≤. 6m. Rounded to a 0.1 m precision, calculated "design" crest height values are given in Table 2 for q_{max} = 1 lt/s/m and in Table 3 for q_{max} = 5 lt/s/m, respectively.

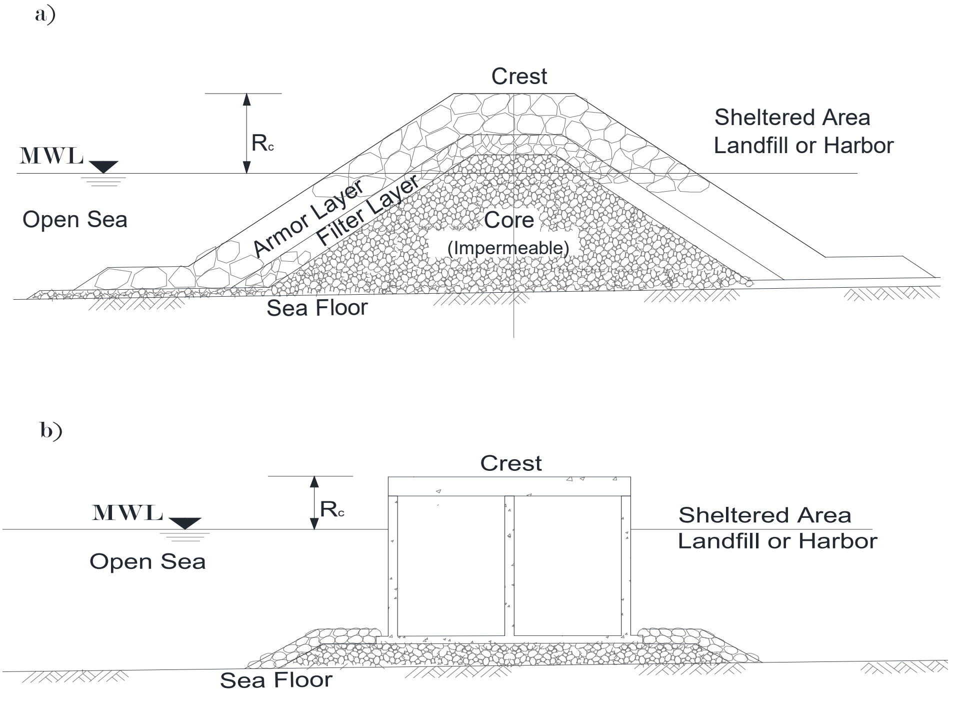

Figure 1. Cross sections of shore protection structures used in this study

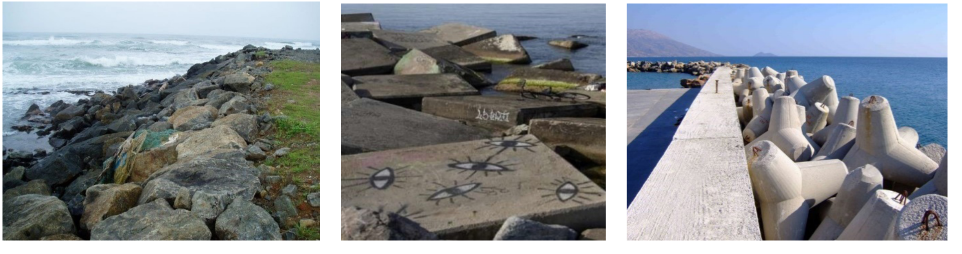

Figure 2. Armor blocks covered in the study (a) Quarrystone (b) Cubes (c) Tetrapods.

Three different types of armor units have been used in the study, which are quarrystone (rock), concrete cubes and tetrapods. The latter two are artificial units made from concrete, used when no suitable size of rock is available (Figure 2).

Table 2. Crest heights for q_{max} = 1 lt/s/m overtopping limit.

No	Type and Armor Material		Design Wave H_{m0} (m)					
			3.00	3.50	4.00	4.50	5.00	6.00
1	Mound	Quarrystone	6.20	7.40	8.60	9.80	11.10	13.60
2	Mound	Cubes	4.90	5.80	6.70	7.70	8.70	10.70
3	Mound	Tetrapods	3.90	4.70	5.50	6.30	7.00	8.70
4	Monolithic	Vertical	5.50	6.60	7.70	8.80	10.00	12.30

Table 3. Crest heights for q_{max} = 5 lt/s/m overtopping limit.

No	Type and Armor Material		Design Wave H_{m0} (m)					
			3.00	3.50	4.00	4.50	5.00	6.00
1	Mound	Quarrystone	5.10	6.10	7.20	8.30	9.40	11.60
2	Mound	Cubes	4.00	4.80	5.70	6.50	7.30	9.10
3	Mound	Tetrapods	3.30	3.90	4.50	5.30	6.00	7.40
4	Monolithic	Vertical	4.50	5.40	6.30	7.30	8.30	10.30

2.2. Assumptions and Limitations

In the conventional design of coastal structures the crest height is calculated as the sum of the static level changes such as the highest astronomical tide level, baromethric water level rise and storm surge, and dynamic level changes, i.e. wave runup. To simplify the problem, it has been assumed that the effect of sea level rise on static components is negligible and only wave runup is affected.

Only head-on wave attack has been considered. Water depth in front of the structure does not lead to depth-limited wave breaking, and the sea bottom has a smooth slope in front of the structure. The effect of a parapet wall or crown wall has been omitted.

2.3. Methodology Used

In order to predict the crest heights of existing structures, two different allowable overtopping rates are used with respect to Table 1, which are q_{max} = 1 lt/s/m and q_{max} = 5 lt/s/m, respectively.

The "existing" crest heights are calculated according to Eq. 1 for sloped structures and Eq. 2 for vertical structures, which are recommended by EurOtop (2018). Roughness coefficients γ_f for mound structures are taken as 0.60 for quarrystone, 0.47 for cube and 0.38 for tetrapod armed slopes, respectively. The mean overtopping rate equations used are given below:

For simple sloped (i.e. mound) structures:

$$\frac{q}{\sqrt{gH_{mo}^3}} = 0.09 * exp\left(-\left(1.35\frac{R_c}{H_{mo}\gamma_f\gamma_\beta}\right)^{1.3}\right) \quad (1)$$

For vertical structures:

$$\frac{q}{\sqrt{gH_{mo}^3}} = 0.47 * exp\left(-\left(2.35\frac{R_c}{H_{mo}}\right)^{1.3}\right) \quad (2)$$

Here, q (m^3/s) is the overtopping rate, g (m/s^2) is the gravitational acceleration, H_{m0} (m) is the spectral offshore wave height, R_c (m) is the crest height of the structure (Figure 1) and γ_f and γ_β are coefficients including the effects of surface roughness and wave angle of attack, respectively. Calculated "existing" crest level heights are presented in Table 2 and Table 3.

The effect of mean sea level rise Δh is simulated on these structures by increasing the water level gradually and calculating the corresponding mean overtopping rates by using Eq. 1 and Eq. 2. The variation of overtopping rates with the mean sea level rise are plotted and shown in Figures 3-10. The mean sea level rise in the diagrams covers a region of 0 ≤ Δh ≤ 1m, covering the IPCC scenarios 2.6 and 8.5.

3.RESULT AND DISCUSSION

3.1. Sloped Structures

For rock-armoured mound structures, the variation of mean overtopping rates with the mean sea level rise is shown in Figs. 3 and 4 for the design overtopping rates of q_{max} = 1 lt/s/m and q_{max} = 5 lt/s/m, respectively. It can be observed that overtopping rates increase with increasing water level, reaching a maximum value of 4.2 lt/s/m for a 3m spectral wave height and 2.1 lt/s/m for a 6m spectral wave height for q_{max} = 1 lt/s/m design overtopping limit. For the q_{max} = 5 lt/s/m design limit, these values increase to 22.5 lt/s/m and 10.5 lt/s/m, respectively.

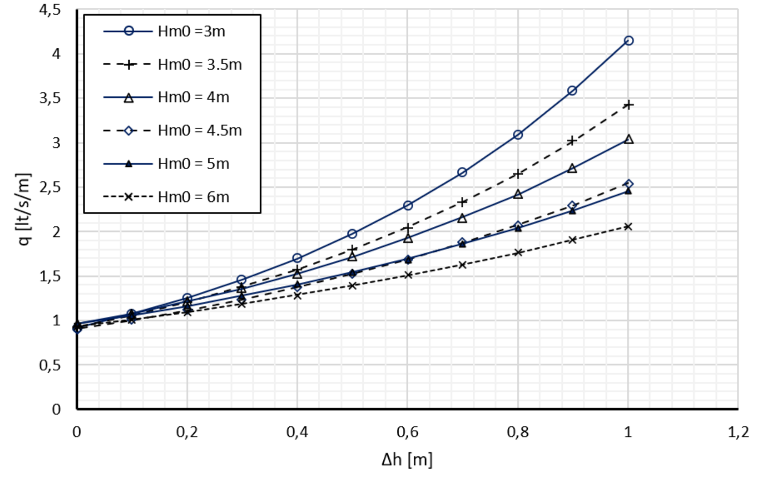

Figure 3. Overtopping rates due to mean sea level rise for rock armored slopes, q_{max} = 1lt/s/m

The fact that the increase in a smaller design wave is greater than the increase in larger design waves is directly related to the smaller crest height of the former case and hence the smaller value of R_c/H_{m0} parameter. This behavior is observed for all configurations.

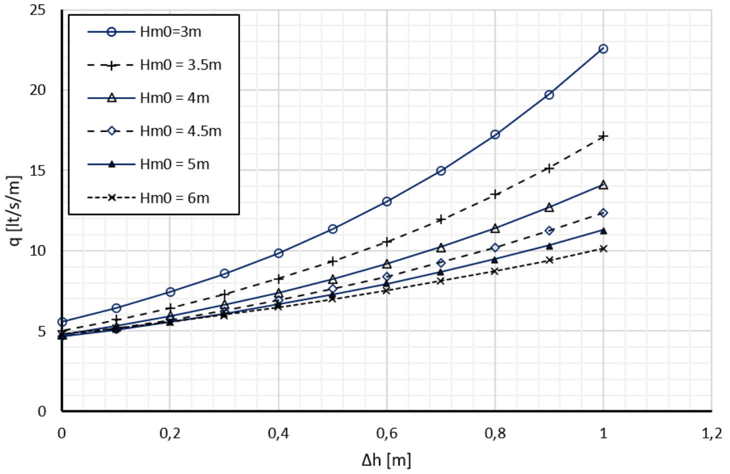

Figure 4. Overtopping rates due to mean sea level rise for rock armored slopes, q_{max} = 5lt/s/m

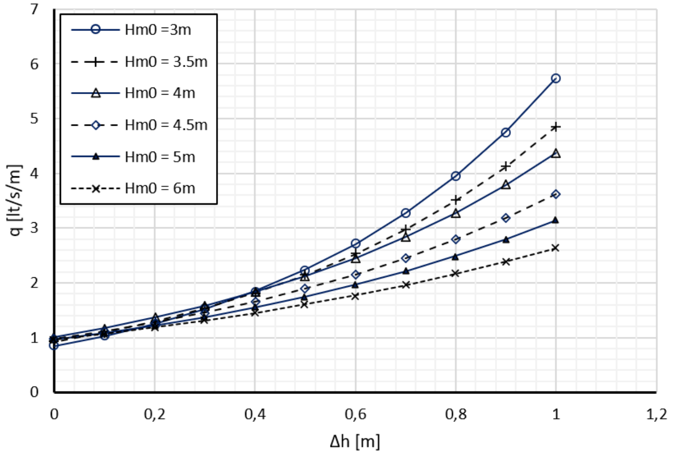

Figure 5. Overtopping rates due to mean sea level rise for cube armored slopes, q_{max} = 1lt/s/m

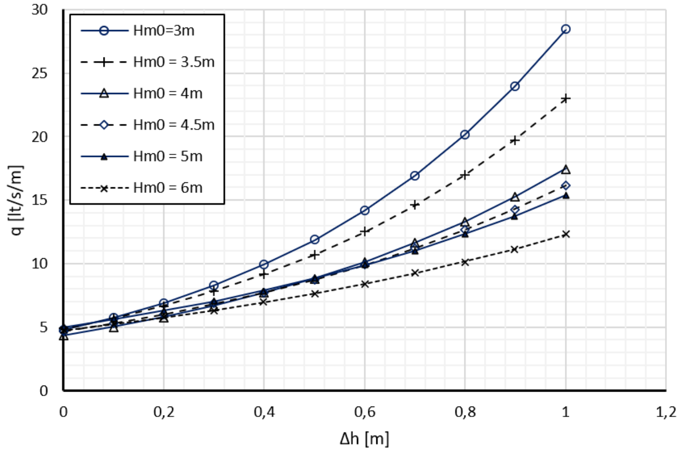

Figure 6. Overtopping rates due to mean sea level rise for cube armored slopes, q_{max} = 5lt/s/m

The variation of overtopping rates with the mean sea level rise for cube armored slopes is plotted in Figs. 5 and 6. For a 1m rise of mean sea level, the maximum values of mean overtopping rates can be seen as 5.75 lt/s/m and 28.4 lt/s/m for for q_{max} = 1 lt/s/m and for q_{max} = 5 lt/s/m design overtopping rates, respectively.

All mean overtopping rate values in Figures 5 and 6 are clearly greater than those achieved for rubble mound structures. The main reason of this increase is the friction coefficient, which is less than quarrystone armor. This outcome becomes more evident for tetrapod-armored slopes shown in Figures 7 and 8, where the maximum overtopping rates increase to 10.5 lt/s/m and 37 lt/s/m for for q_{max} = 1 lt/s/m and for q_{max} = 5 lt/s/m, respectively. Thus, it can be concluded that high performance armor units are more sensitive to mean sea level rise in terms of "expected" increase in wave overtopping rates.

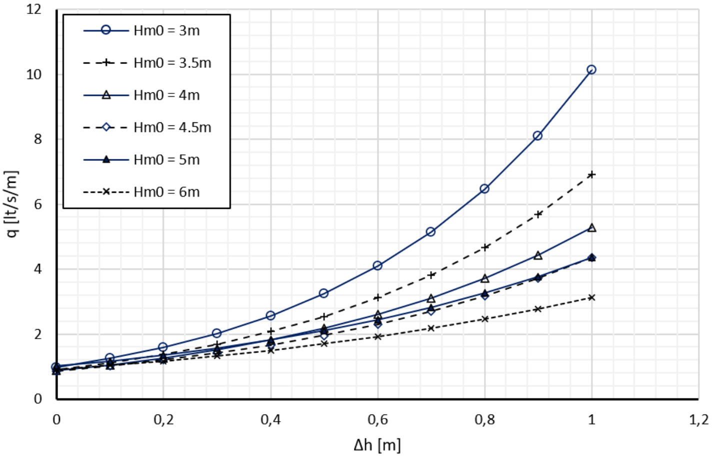

Figure 7. Overtopping rates due to mean sea level rise for tetrapod armored slopes, q_{max} = 1lt/s/m

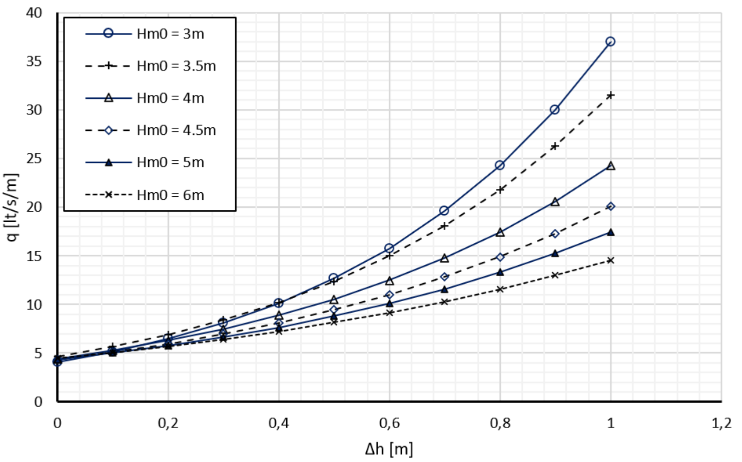

Figure 8. Overtopping rates due to mean sea level rise for tetrapod armored slopes, q_{max} = 5lt/s/m

3.2. Vertical Structures

The variation of overtopping rates with the mean sea level rise for vertical structures is shown in Figures 9 and 10. It can be observed that the mean overtopping rate values for vertical structures are slightly greater than those calculated for rubble mound structures.

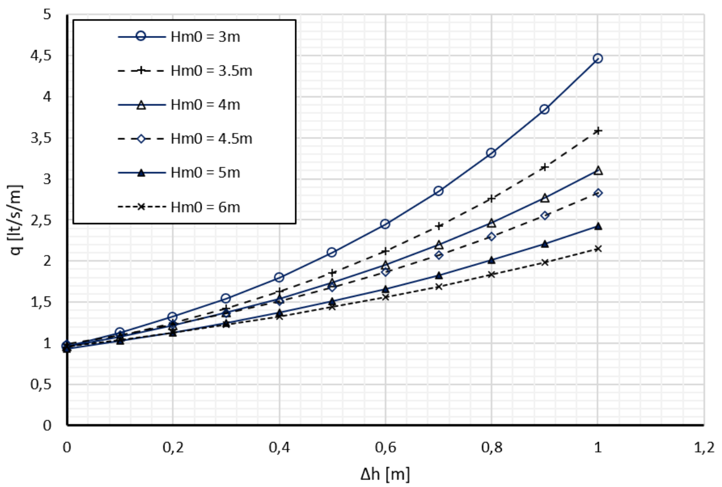

Figure 9. Overtopping rates due to mean sea level rise for vertical structure, q_{max} = 1lt/s/m

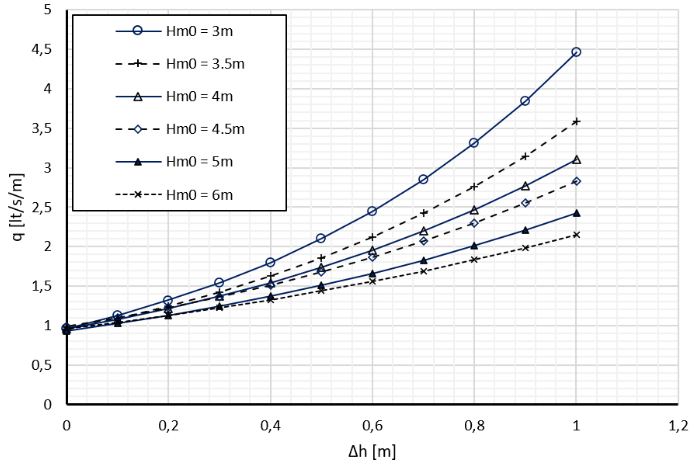

Figure 10. Overtopping rates due to mean sea level rise for vertical structure, q_{max} = 5lt/s/m

4. CONCLUSION

A simple study has been carried out in order to inspect the effect of mean sea level rise on wave overtopping over existing coastal structures. Structures inspected are assumed to be designed for two different maximum allowable overtopping rate thresholds of 1 lt/s/m and 5 lt/s/m. Mound structures with rock, cube and tetrapod armor layers and vertical structures are inspected by using the mean overtopping rate estimation equations presented in EurOtop manual. It can be concluded from Figures 3-10 that a significant increase in wave overtopping rates should be expected due to mean sea level rise, reaching limits disrupting the functionality of these structures. An interesting outcome is that the increase in overtopping rates is more sensitive to crest height rather than the design wave height, thus, the effect will be greater for structures located in milder wave climates. Furthermore, structures covered with high-friction armor units such as cubes and tetrapods introduce greater overtopping rates, hence these carry a greater risk in terms of shore protection and structural stability.

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EVALUATION OF PLATEAU TOURISM ACCORDING TO THE THERMAL COMFORT CONDITIONS; ÇAMICI PLATEAU, NIKSAR/TOKAT

Savaş ÇAĞLAK[1*]

ABSTRACT

The tourism potential of a region is influenced by various factors such as landscape, flora, fauna, geographical location, topography, culture, leisure opportunities, weather and climate. The happy, peaceful and healthy time of individuals participating in tourism depends primarily on climatic conditions. Therefore, people who will participate in tourism and recreational activities today also consider climatic conditions in their destination selection. Thermal comfort can be defined as the state of people feeling comfortable or happy in their thermal environment (mainly temperature, humidity, wind climatology). In the absence of such comfort, many social, economic and physical problems are observed, such as a decrease in welfare and happiness, health problems and an increase in energy use, and a decrease in work efficiency. In this study, it is aimed to determine the suitable tourism periods according to the thermal comfort conditions of Çamiçi plateau of Niksar district of Tokat province. In the study, the number 19045 located in Çamiçi plateau meteorology of the station between 2017 and 2021 (5 years) hourly; air temperature (˚C), relative humidity (%), wind speed (m/s) and cloudiness (octa) data were used. As a method, the Physiological Equivalent Temperature obtained from the RayMan model (Physiological equivalent Temperature- PET) index was used. As a result of the study, it has been determined as the most ideal period for tourism activities, during which comfortable conditions are experienced during 5 months of the year (150 days) from May to the end of September. It is recommended that tourism planners and people who will participate in tourism take into account the specified periods in order to ensure that the tourism activities to be done are healthy and of high quality.

Keywords: Thermal Comfort, Plateau Tourism, Çamiçi/Niksar, PET (Physiological equivalent temperature)

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1. INTRODUCTION

The climatic features, which are expressed as the average of long-year weather conditions observed in a region, are the reasons why people use agriculture, transportation, trade, etc. It also affects the quality and sustainability of tourism activities. Sustainable tourism activities depend on the participants to feel fit and happy and to spend quality time. In the provision of these conditions, climatic conditions are an important factor in terms of natural environment characteristics. Therefore, individuals who will participate in tourism today also consider climatic conditions in the selection of tourism destinations [1]. Thermal comfort is the state of people feeling comfortable, happy and comfortable in the thermal environment they are in [2, 3]. In other words, it can be expressed as the situations in which the heat taken and the heat given off are equal in the interaction of the human body with the thermal environment [4]. Uncomfortable conditions; It causes many social, economic and physical negativities such as a decrease in people's welfare happiness, health problems, decrease in work efficiency and increase in death rates [5-14].

Thermal comfort conditions were initially calculated for indoor environments in order to determine the work efficiency of the employees, and later they were developed and started to be used for outdoor activities. In particular, many studies have been conducted on the relationship between outdoor thermal comfort conditions and tourism activities and tourism periods. 15] He explained the quantitative characteristics of climate zones by making monthly maps for the whole world. [16] determined the comfort periods suitable for Greece, [17] determined the comfort conditions for tourism purposes at Sun Moon Lake in Taiwan. [18] They determined the thermal comfort conditions in Tbilisi, the capital of Georgia, in terms of tourism. [19] explained the suitable thermal comfort periods of the tourist center of Lake Balaton, the largest freshwater lake in Europe and Hungary. [20] determined the climate comfort periods for coastal tourism in Turkey. [1] He evaluated the climate and lively climate of Nevşehir in terms of tourism. [21] examined thermal comfort conditions in terms of tourism activities in Artvin province. [22] They examined the thermal comfort conditions of Amasya in terms of tourism. [23] They discussed the thermal comfort features of Antalya in terms of tourism. [24] examined the Muğla-Karabağlar plateau in terms of landscape planning. Studies dealing with the relationship between plateau tourism and thermal comfort have been limited. People who want to escape from the noisy, suffocating and stressful conditions of city life prefer springs for destinations where they will feel peaceful and happy and be alone with nature. Therefore, studies examining the relationship between highland tourism and thermal comfort conditions are needed. Therefore, in this study, it is aimed to determine the suitable tourism periods in terms of thermal comfort conditions of Çamiçi plateau, which is an important highland tourism attraction center.

Çamiçi plateau is located in Niksar district of Tokat province in the Central Black Sea Region of the Black Sea Region. The plateau is located in the north of Niksar district center, at an altitude of approximately 1350 meters (Figure 1). Çamiçi Plateau, which is 17 km away from the town center, is on the Niksar Unye road. The natural beauties and cool air of the plateau are a natural therapy and attract thousands of tourists for health and sightseeing purposes. There are shops where needs such as restaurants and markets can be met on the plateau, and it has an area that can be used by approximately 10 thousand people with its large area [25].

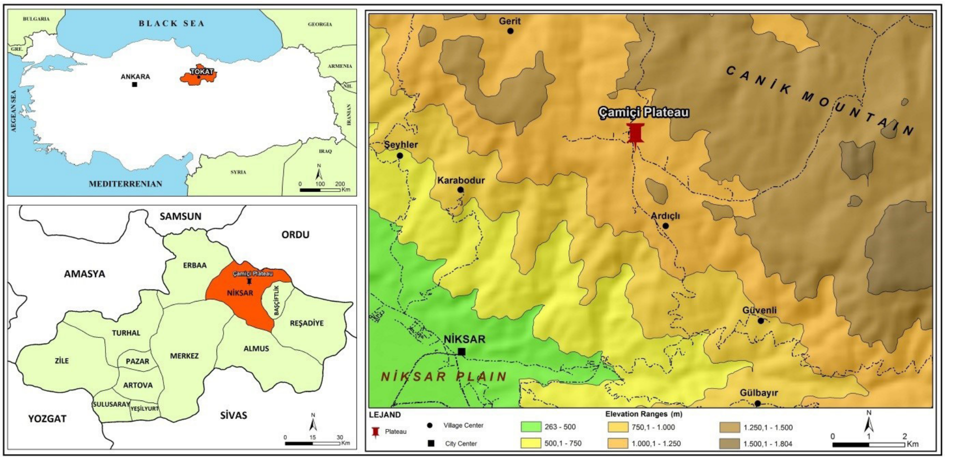

Figure 1. Location map of Çamiçi plateau (Niksar/Tokat)

2. MATERIAL AND METHODS

In the study, the meteorology station numbered 19045, located in Çamiçi plateau and started to measure in 2017, between 2017 and 2021 (5 years) hourly; air temperature (˚C), relative humidity (%), wind speed (m/s) and cloudiness (octa) data were used. As a method, the Physiological Equivalent Temperature (PET) index was used through the RayMan software, which calculates both personal factors and atmospheric conditions. The index calculates all the effects of the thermal environment on humans and the thermo-physiological conditions of the human body [26, 27,28]. In the PET index, the thermal stress levels of a healthy male individual aged 35 years, 175 cm tall, weighing 75 kg, carrying 0.9 clo clothing load and 80W workload were taken into account (Table 1). Obtained PET values were announced at 10-day intervals from the first day of the year to the last day of the year as a percentage.

Table 1. Human thermal sensation and stress ranges for PET [28].

PET (°C)	Thermal Sensation	Level of Thermal Stress
< -4.0	Extreme cold	Freezing cold stress
-3.9–4.0	Very cold	Extreme cold stress
4.1–8.0	Cold	Strong cold stress
8.1–13.0	Cool	Moderate cold stress
13.1–18.0	Slightly cool	Slightly cold stress
18.1–23.0	**Comfortable**	**No thermal stress**
23.1–29.0	Slightly warm	Slightly heat stress
29.1–35.0	Warm	Moderate heat stress
35.1–41.0	Hot	Strong heat stress
>41.0	Very Hot	Extreme heat stress

3. RESULT AND DISCUSSION

As a result of the analysis, according to the average values, in Çamiçi plateau; From November to the end of February, ‘very cold’ and ‘cold’ stresses are experienced. ‘Cool’ stress is perceived in March and October, and ‘slightly cool’ stress is perceived in April and May. ‘Comfortable’ conditions prevail from June to late September (approximately 120 days) (Figure 2).

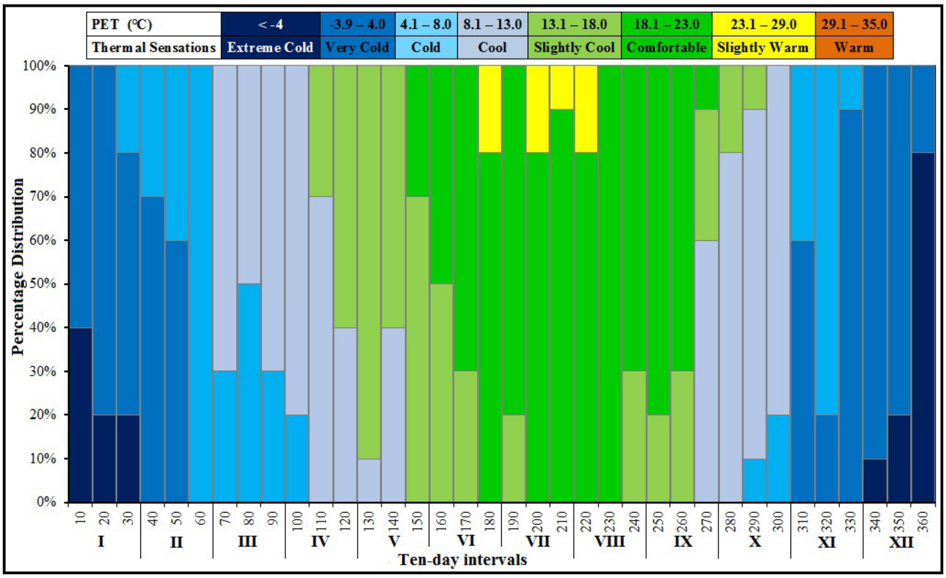

Figure 2. Distribution of mean thermal comfort conditions of Çamiçi plateau (2017 - 2021)

According to the maximum PET values, in Çamiçi plateau; ‘Very cold’ and ‘cold’ stresses are effective from the last 10 days of November to the 20th day of February. In October, November and March, ‘cool’ and ‘slightly cool’ stresses are experienced. While ‘comfortable’ conditions are perceived from May to mid-June and in September, ‘slightly warm’ stress is perceived in July and August (Figure 3).

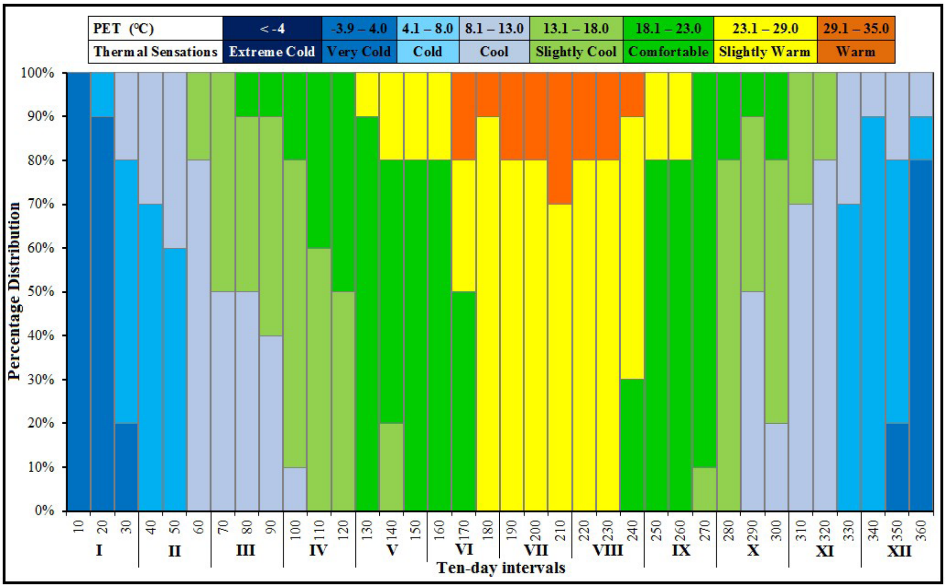

Figure 3. Distribution of maksimum thermal comfort conditions of Çamiçi plateau (2017 - 2021)

According to the minimum values, in Çamiçi plateau; From the 20th day of October to the 10th day of April, 'extreme cold' and 'very cold' stresses are experienced. From the 10th day of April to the end of May, and in the last days of September and the first days of October, 'cold' and 'cool' stresses are effective. While 'slightly cool' stress is perceived in June and September, 'comfortable' conditions are perceived in July and August (Figure 4).

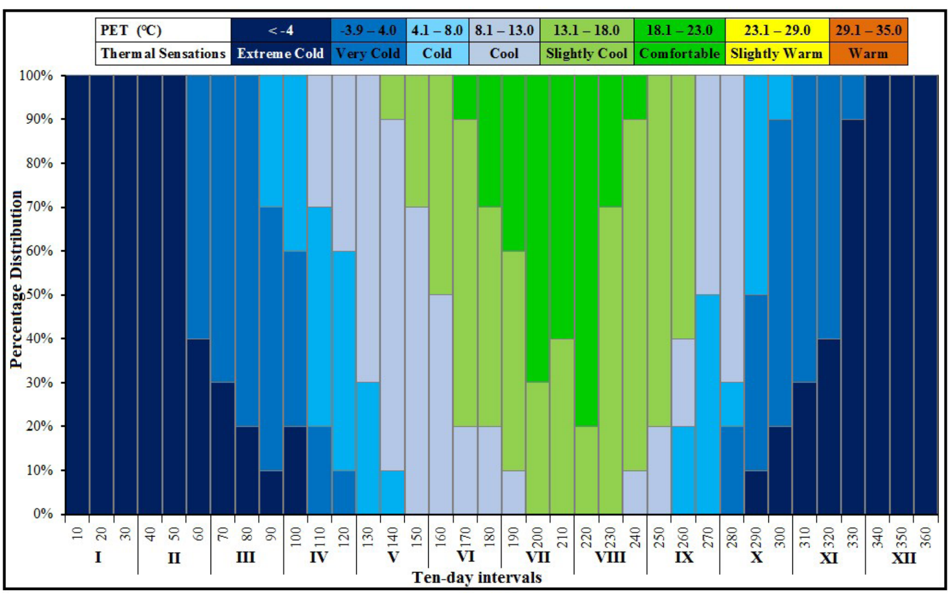

Figure 4. Distribution of minimum thermal comfort conditions of Çamiçi plateau (2017 - 2021)

In Turkey, located in the middle zone of the northern hemisphere, the plateaus are important as places where people can have fun, relax and spend quality time during the warm period of the year, from May to September. In the study, while heat stresses are experienced in the cities during the hottest times of the year, 'comfortable' conditions are experienced in the Çamiçi plateau.

4. CONCLUSION

Tourism activities play an important role in the development of countries and regions. However, the tourism activities to be carried out are under the control of climatic conditions. Therefore, climatic conditions should be taken into account in the planning of tourism activities to be carried out. For this purpose, suitable tourism periods in terms of thermal comfort conditions of Çamiçi plateau, which is an ecotourism area, were examined. As a result of the study, it has been determined that comfortable conditions are experienced during 5 months of the year (150 days) from May to the end of September for tourism activities to be carried out in Çamiçi plateau. It is recommended that tourism planners and people who will participate in tourism take into account the periods determined for the healthy and high quality of the tourism activities to be carried out. In Çamiçi Plateau, which has a relaxing atmosphere and meets the green and blue, it is recommended to make plans for the construction and increasing human pressure in order to ensure that the tourism activities are sustainable and the ecological and natural environment characteristics are not deteriorated.

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DETERMINATION OF IDEAL PERIODS FOR BEACH TOURISM IN TERMS OF THERMAL COMFORT CONDITIONS IN SAMSUN AND PREDICTIONS FOR THE FUTURE

Muhammet BAHADIR[1], Savaş ÇAĞLAK[2*]

ABSTRACT

The happy, peaceful and healthy time of individuals participating in tourism depends primarily on climatic conditions. Therefore, people who will participate in tourism and recreational activities today also consider climatic conditions in their destination selection. Because of its coast to the Black Sea, Samsun has important beaches in terms of sea-sand-sun (3S) tourism. There are a total of 7 beaches in Samsun, 6 of which are in the Atakum district and one in the İlkadım district. Thermal comfort can be defined as the state of people feeling comfortable or happy in their thermal environment. In this study, suitable periods in terms of beach tourism in Samsun in terms of thermal comfort conditions have been examined at present and predictions for the future have been made. In the study, the measurement data of the Samsun regional meteorology station numbered 17030 between 1991 and 2020 and the future climate prediction (projection) data based on the climate scenarios of the Representational Concentration Paths (RCPs) scenario set, which can be described as moderate (RCP4.5) and pessimistic (RCP8.5) were used. As a method, the Physiological Equivalent Temperature obtained from the RayMan model (Physiological equivalent Temperature- PET) index was used. As a result of the study, in terms of thermal comfort conditions, 180 days at present (1991- 2020) for beach tourism in Samsun, 210 days in the near future (2021- 2050), and 240 days in the far future (2069- 2098) are ideal has been determined. It should be taken into account that the duration and seasons of tourism activities, types, and types will change with the change in thermal comfort conditions. In this case, it is recommended that tourism investors, planners, and tour organizers make decisions considering the changing conditions for tourism activities.

Keywords: Thermal Comfort, Beach Tourism, PET (Physiological equivalent temperature), Climate Change, Samsun

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1. INTRODUCTION

Climatic conditions are effective from people's health conditions their economic activities. Especially many activities to be done outdoors are directly under the influence of climatic conditions. Tourism activities that people carry out for the purpose of traveling, having fun, seeing, and resting are undoubtedly under the control of climatic conditions. In other words, climatic conditions not only provide quality and efficient tourism activities in a region but also have limiting effects. For this reason, suitable periods should be preferred in terms of climatic conditions in order for tourism activities to be sustainable and of high quality.

Being able to make beach tourism depends on the warm seas as well as suitable climatic conditions. Ideal climatic conditions are required for people to swim, sunbathe and have fun. Due to such factors, individuals who will participate in tourism activities prefer tourism destinations that are suitable for their tourism activities. Today, with the development of transportation and communication technologies, people have access to information about more places and can have information about the tourism destinations they can choose.

In order for tourism activities in a region to be sustainable, thermal comfort conditions should be determined and appropriate periods should be taken into account. Thermal comfort can be defined as the state of people feeling comfortable, happy, and comfortable in their thermal environment (especially temperature, humidity, wind, etc.). It has been stated in many studies that uncomfortable conditions cause many social, economic, and physical negativities such as a decrease in people's well-being, health problems, a decrease in work efficiency, and an increase in death rates [1-10]. The climatic conditions, which have a natural tendency to change in all time scales, have gained a different dimension with the increasing human pressure since the 19th century [11]. It is stated that the effects of climate change will cause even more adverse conditions in the coming years [12]. Changing climatic conditions will affect all sectors and all activities [13, 14]. These changes in the climate will also affect tourism activities by causing the thermal comfort conditions to change. In studies conducted in Turkey, it has been stated that beach tourism will be adversely affected due to the increased temperature in the Mediterranean region due to climate change [15, 16].

This study, it is aimed to determine suitable tourism periods in terms of thermal comfort conditions and to develop projections for the future in Samsun, which was established on the coast of the Black Sea and where beach tourism developed. Samsun is a port and tourism city located on the coast of the Black Sea in the Central Black Sea Section of the Black Sea Region. Samsun, the most developed city of the Black Sea Region, is administratively a metropolitan city and consists of four metropolitan districts, namely Atakum, İlkadım, Canik, and Tekkeköy [17, 18, Figure 1]. There are a total of 7 beaches, 6 in Atakum and one in Ilkadım, in Samsun, where sea tourism develops [Figure 1]. With these opportunities, sea-sand-sun (3S) tourism has developed in Samsun. Both residents of Samsun and many people from the surrounding provinces come to the beaches to swim and cool off.

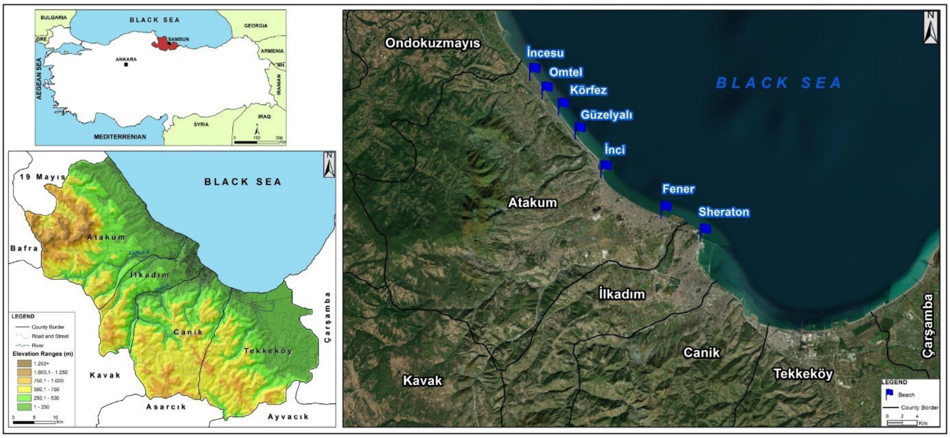

Figure 1. Location map of Samsun

In Samsun, where maritime climatic conditions are observed, the annual average temperature is 14.6 °C according to the long annual averages [19]. As extreme values, the highest temperature was 39.0 °C in August and the lowest temperature was -9.8 °C in February. In Samsun with total annual precipitation of 716.7 mm, precipitation increases in autumn and decreases in summer. The annual average relative humidity was 72.2% and the annual average wind speed was 2.2 m/s. Some mean and extreme values for Samsun are given in Table 1.

Table 1. Mean and extreme values for Samsun (1929 – 2020)

17030- Samsun Regional Meteorology Station		
Parameters	Value	Date/Period
Mean temperature	14,6 °C	Annual
Mean relative humidity	% 72,2	Annual
Mean wind velocity	2,2 m/s	Annual
Total precipitation	716,7 mm	Annual
Rainy days	154 days	Annual
Maximum temperature	39,0 °C	August
Maximum temperature	-9,8 °C	February
Highest rainfall in a day	238,2 mm	09.11.1967
The highest snow thickness	76 cm	03.02.1960
Fastest wind velocity	34,5 m/s	15.12.1978

2. MATERIAL AND METHODS

In the study, to determine today's thermal comfort conditions, hourly; air temperature (ºC), relative humidity (%), wind (m/sec), and cloudiness (octa) measurement data were used. The thermal comfort conditions foreseen in the near and far future periods are calculated from the daily data of the most widely used RCP4.5 and RCP8.5 scenarios of the IPCC's most recently effective Representative Concentration Pathways (RCP: Representative

Concentration Pathways). In daily data; air temperature (ºC), relative humidity (%), wind (m/sec), and solar radiation (w/m^2) data were evaluated. More than 100 indices have been developed to determine thermal comfort conditions, and bibliographic studies have been conducted on them [20, 21, 23]. Among these indices, PET (Physiological Equivalent Temperature) index is the most widely used in determining outdoor conditions and tourism activities. Therefore, the PET index was used in the study through the RayMan model, which is a widely used radiation model that calculates both personal and environmental factors together. In the calculation of PET (Physiological Equivalent Temperature; [24, 25] index; 35 years old, 175 cm tall, 75 kg, male, healthy individual with 0.9 clo clothing load and 80W workload were taken into account [25]. The values obtained in Table 2' it has been classified taking into account the comfort ranges in.

Table 2. Human thermal sensation and stress ranges for PET [edit from 24, 25].

PET (°C)	Thermal sensation	Level of thermal stress	Colors
< -4.0	Extreme cold	Freezing cold stress	
-3.9–4.0	Very cold	Extreme cold stress	
4.1–8.0	Cold	Strong cold stress	
8.1–13.0	Cool	Moderate cold stress	
13.1–18.0	Slightly cool	Slightly cold stress	
18.1–23.0	**Comfortable**	**No thermal stress**	
23.1–29.0	Slightly warm	Slightly heat stress	
29.1–35.0	Warm	Moderate heat stress	
35.1–41.0	Hot	Strong heat stress	
>41.0	Very Hot	Extreme heat stress	

While many tourism activities are carried out in "comfortable" conditions in terms of thermal comfort conditions, in terms of beach tourism, it can be done in "slightly warm", "warm" and "hot" conditions along with "comfortable" conditions. But together with cold conditions such as "very cold", "cold", "cool" and "slightly cool", "very hot" conditions can also be dangerous.

3. RESULT AND DISCUSSION

The findings were divided into periods and explained at ten-day intervals. Today's (1991 - 2020) thermal comfort conditions have been determined, and predictions have been made for thermal comfort conditions in the near (2021 -2050) and far future (2069 -2098).

3.1. At Present (1991 – 2020)

Today, "cold" stress from the last 20 days of December to the 10th day of February (60 days) in Samsun, from the 10th day of February to the 20th day of March, and from the 20th day of November to the 10th day of December (60 days).) "cool" stress, "slightly cool" stress is experienced from the 20th day of March to the 20th day of April and from the 20th day of October to the 20th day of November (60 days). "Comfortable" conditions are perceived from the 20th day of April to the 20th day of May and the first 20 days of October (50 days). "Slightly warm" stress was determined from the 20th day of May to the 20th day of June and the last 20 days of September (50 days), and "warm" stress was determined in the last 10 days of June, July and August and the first 10 days of September [Table 3].

Table 3. Distribution of current (1991 - 2020) thermal comfort conditions of Samsun

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Days of the Year	10	40	70	100	130	160	190	220	250	280	310	340
	20	50	80	110	140	170	200	230	260	290	320	350
	30	60	90	120	150	180	210	240	270	300	330	360

Thermal Sensations					
Cold	Cool	Slightly Cool	Comfortable	Slightly Warm	Warm

In today's climatic conditions, it has been determined that Samsun is suitable for beach tourism from the last 10 days of April to the 20th day of October.

3.2. Near Future (2021 – 2050)

In Samsun in the near future; "cold" stress 40 days a year according to the RCP4.5 scenario, 20 days according to the RCP8.5 scenario, 60 days of the year according to the RCP4.5 scenario, 80 days according to the RCP8.5 scenario, both "cool" stress and "slightly cool" stress In the scenario, it is predicted that it will be effective for 60 days. "Comfortable" perceptions are expected to be experienced for 50 days in both scenarios. It has been determined that "slightly warm" stress will be perceived as 60 days according to the RCP4.5 scenario and 50 days according to the RCP8.5 scenario. It is predicted that "Warm" stress will be experienced for 60 days according to the RCP4.5 scenario, 50 days according to the RCP8.5 scenario, and "hot" very hot stress for 30 days according to the RCP4.5 scenario, and 50 days according to the RCP8.5 scenario [Table 4; Table 5].

Table 4. Distribution of predicted near future (2021 - 2050) thermal comfort conditions according to Samsun's RCP4.5 scenario

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Days of the Year	10	40	70	100	130	160	190	220	250	280	310	340
	20	50	80	110	140	170	200	230	260	290	320	350
	30	60	90	120	150	180	210	240	270	300	330	360

Thermal Sensations						
Cold	Cool	Slightly Cool	Comfortable	Slightly Warm	Warm	Hot

Table 5. Distribution of predicted near future (2021 - 2050) thermal comfort conditions according to Samsun's RCP8.5 scenario

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Days of the Year	10	40	70	100	130	160	190	220	250	280	310	340
	20	50	80	110	140	170	200	230	260	290	320	350
	30	60	90	120	150	180	210	240	270	300	330	360

Thermal Sensations						
Cold	Cool	Slightly Cool	Comfortable	Slightly Warm	Warm	Hot

In the near future, it is expected that Samsun will be suitable for beach tourism from April to the end of September.

3.3. Distant Future (2021 – 2050)

In Samsun, which is a coastal city, it is predicted that cold stress will not be experienced in the distant future for only 10 days according to the RCP4.5 scenario and not at all according to the RCP8.5 scenario. While the "cool" stress is expected to be effective for 80 days in the RCP4.5 scenario and 90 days according to the RCP8.5 scenario, the "slightly cool" stress is expected to be effective for 30 days according to both scenarios. It is predicted that "comfortable" perceptions will be experienced for 70 days in the RCP4.5 scenario, 60 days according to the RCP8.5 scenario, and "slightly warm" stress will be experienced for 60 days according to both scenarios. "Warm" stress is expected to be experienced for 40 days in the RCP4.5 scenario, 30 days in the RCP8.5 scenario, and "hot" stress for 70 days in the RCP4.5 scenario and 90 days in the RCP8.5 scenario [Table 6; Table 7].

Table 6. Distribution of predicted distant future (2069 - 2098) thermal comfort conditions according to Samsun's RCP4.5 scenario

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Days of the Year	10	40	70	100	130	160	190	220	250	280	310	340
	20	50	80	110	140	170	200	230	260	290	320	350
	30	60	90	120	150	180	210	240	270	300	330	360
Thermal Sensations												
Cold	Cool	Slightly Cool	Comfortable	Slightly Warm	Warm	Hot						

Table 7. Distribution of predicted distant future (2069 - 2098) thermal comfort conditions according to Samsun's RCP8.5 scenario

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Days of the Year	10	40	70	100	130	160	190	220	250	280	310	340
	20	50	80	110	140	170	200	230	260	290	320	350
	30	60	90	120	150	180	210	240	270	300	330	360
Thermal Sensations												
Cold	Cool	Slightly Cool	Comfortable	Slightly Warm	Warm	Hot						

According to both scenarios, it is foreseen that beach tourism can be done in Samsun in the distant future from the last 10 days of March to the 20th day of October. As a result of the analyzes made, 180 days of the year have been determined as suitable for beach tourism in Samsun. It is predicted that 210 days of the year in the near future and 240 days in the distant future will be suitable for beach tourism in terms of thermal comfort conditions [Table 8].

Table 8. Suitable periods for beach tourism in Samsun at present, in the near future and in the distant future

Periods		Present (1991 – 2020)			Near Future (2021 – 2050)			Distant Future (2069 -2098)		
Months	Ten days ranges	10	20	30	10	20	30	10	20	30
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
Total		180 days			210 days			240 days		

	Not suitable		Suitable

4. CONCLUSION

Expressed as a flueless industry, tourism plays an important role in the development of countries and regions. For the sustainability of tourism activities, climatic conditions should be taken into account in the planning. Climate change is closely related to all sectors. For this purpose, suitable tourism periods for beach tourism in Samsun in terms of thermal comfort conditions were examined and predictions for the future were made. As a result of the study, in terms of thermal comfort conditions, it has been determined that Samsun is suitable for beach tourism 180 days a year today, 210 days in the near future, and 240 days in the distant future. Thus, due to climate change, suitable days for beach tourism will increase in Samsun and beach tourism will be possible for longer periods throughout the year. While beach tourism in the Mediterranean region is adversely affected due to climate change, it is expected that beach tourism will increase in importance in Samsun. It is recommended that tourism planners and investors, tour organizers, and individuals who will participate in tourism take these results into account.

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CHAPTER 4

Climate Change and Education

A REVIEW OF GLOBAL CLIMATE CHANGE IN SCIENCE EDUCATION CURRICULUM OF TURKIYE

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ABSTRACT

Global climate change is a fact that poses a great danger to our world today and its effects are more clearly observed day by day. Turkiye is located between the temperate zone and the subtropical zone. Due to its geographical location, many different climate types such as continental climate, mediterranean climate, black sea climate, transitional climate are seen in Turkiye. Related to this diversity, Turkiye is one of the countries where the effects of climate change can be observed clearly. It is known that climate change has many negative effects and perhaps children will be exposed to these effects the most. Schools are where children spend the most time after home. For this reason, many countries have started studies within the scope of formal education on climate change awareness, starting from the first stages of education. The main purpose of this study is to critically examine how the concept of global climate change is handled in Turkish Science Education curriculum. In this research, document analysis technique used and the obtained data analyzed with descriptive content analysis. As a data source, science teaching achievements in primary and secondary education programs (from 1st to 8th grade) are used which prepared by the Turkiye Ministry of National Education. Analyzes carried out by two researchers simultaneously. In the findings obtained from this study, the achievements related to global climate change were examined and tabulated as direct, indirect and possible to be related. At the end of this study, it has been seen that the concepts of climate and climate change are included in a limited number of curriculum outcomes. It has been suggested that these concepts should be addressed in curricula starting from smaller grade levels.

Keywords: Climate change, science curriculum, primary education, secondary education, document review

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1. INTRODUCTION

In its most basic definition, climate can be defined as the average course of long-term weather conditions and related factors in certain regions on the globe [1]. Based on this definition, climate change can be expressed as deviations on the average course of the climate. Climate should not be considered just as a weather change or natural phenomenon. Considering that life on earth is shaped according to the suitable climatic conditions of the world, it is possible to say that the slightest change in the climate will affect all life. The increase or decrease in average temperature values with climate change brings with it extreme natural events. The number of natural events such as major forest fires, floods, storms and tsunamis that have occurred in recent years, causing serious loss of life and property, has been increasing due to climate change, and on a global scale, the ecosystem pays a price that is very difficult to return.

There are many factors that cause climate change. While some of these have occurred in certain periods since the existence of the world independently of humans (such as glacial periods, natural greenhouse effect), the majority of them are due to reasons such as artificial greenhouse effect and ozone layer destruction, especially after the industrial revolution, on the earth's atmosphere [2]. The destruction that will occur with factors such as the expected melting of glaciers, rising waters, warming of the atmosphere, and changes in precipitation regimes with the global climate change is a common problem for all humanity. The first steps to combat this problem were expressed at the Human and Environment Conference held in Stockholm, Switzerland in 1972. With this conference, it was decided that a global fight against the problem of climate change is required. Then, preparatory work continued with the Vienna Convention and the Montreal Protocol in 87, the Intergovernmental Panel on Climate Change in 89, and the United Nations Framework Convention on Climate Change in 94, and the Kyoto Protocol, which is considered one of the most important steps in the fight against climate change, was signed by the parties in 1997. Countries that signed this protocol in 2005, have committed to reducing their human-induced greenhouse gas emissions [3].

In addition to the steps taken on a global scale, countries also continue their individual studies on global climate change. For example, Turkey has started an important movement against global climate change with the Zero Waste project it has been carrying out since 2017 [4]. In addition, important scientific institutions and universities of our country also open calls for grants that support efforts to prevent and combat climate change. It is known that climate change has many negative effects and perhaps children will be exposed to these effects the most. Schools are where children spend the most time after home. For this reason, many countries have started studies within the scope of formal education on climate change awareness, starting from the first stages of education.The main purpose of this study is to critically examine how the concept of global climate change is handled in Turkish Science Education curriculum. As it is known, the main purpose of science education is to raise science literate individuals. This means individuals who are interested in research, questioning understanding and interpreting research results and even produce new information. In this study, it will be examined what kind of concepts and subjects are included in the Turkish science curriculum on a subject such as climate change. Education aims to bring about deliberate and desired behavioral changes in individuals [5]. It is an undeniable fact that education will play a major role in changing people's behaviors and attitudes in order to reduce the human-induced effects of global climate change. In this context, education can be planned at all levels, starting from primary education to higher education and even non-formal education.

The main purpose of this study is to determine global climate change and the topics that may be related to this concept within the scope of primary school science education, and to examine the course times and contents allocated to these topics at each level. In this context, it is aimed to make a summary about the situation of our curriculum in the fight against global climate change, to make a general evaluation and to make suggestions. It is thought that this evaluation is important in terms of laying the groundwork for further research.

2. MATERIAL AND METHODS

2.1.Method

In this research, document analysis method, one of the qualitative research methods, will be used. Document analysis is carried out to produce empirical information, to make sense of, or to reveal an understanding by analyzing the documents examined [6].

2.2. Data Collection Tool

As a data collection tool, Science Curriculum, Life Studies Curriculum, Social Studies Curriculum and Environmental Education and Climate Change curriculum prepared by the Ministry of National Education of Turkey examined.

2.3. Data Analysis Procedure

Descriptive content analysis technique was used in the analysis of the data. The analysis was carried out by two researchers simultaneously, common views were noted and opposing views were discussed and consensus was reached. In this context, Miles and Huberman's rater reliability formula was used for the reliability of the research. The reliability value obtained from the formula was found as 95%. The analyzed content was classified according to various categories and then interpreted. The findings obtained as a result of the analyzes are presented below.

3. RESULT AND DISCUSSION

Within the scope of the research, the concept of global climate change in primary school curricula and the courses containing this concept were examined. The results obtained are given in the table below.

Table 1. Acquisitions related to benefiting from primary school benefit programs

Curriculum	Grade	Concept of climate (achievement frequencies)	Achievement(s) **directly** related to climate climate change	Achievement(s) **indirectly** related to climate climate change	Achievement(s) **possible to be** related to climate change
Life Science	1	-	HB.1.2.5.Uses the resources in the house efficiently. HB.1.6.4. Be sensitive about keeping nature and environment clean HB.1.6.5. Distinguish the materials that can be recycled HB.1.6.7. Researches the seasons and their characteristics HB.1.6.8. Understands the changes in nature according to the seasons	HB.1.3.2. Realizes the precautions he should take to protect their health. HB.1.3.3. Chooses foods and drinks that are beneficial for their health HB.1.5.2. Recognizes historical, natural and touristic places in the immediate vicinity HB.1.6.1. Observes animals in the immediate vicinity. HB.1.6.2. Observes the plants in the immediate vicinity. HB.1.6.3. Takes care to protect the animals and plants in immediate vicinity.	HB.1.1.11. Participates in the process of determining the classroom rules. HB.1.1.12. Follows school rules. HB.1.3.1. Regularly takes care of themselves. HB.1.4.7. Distinguish between safe and unsafe areas for themselves.
	2	Climate	HB.2.6.3. Gives examples of the effects of natural elements in the immediate environment on human life. HB.2.6.4. Contributes to the recycling of consumed materials.	HB.2.1.6. Takes care when using school resources and belongings. HB.2.2.6. Researches the contribution of economical use of resources at home to the family budget. HB.2.3.6. Realizes the effects of seasonal fruit and vegetable consumption on human health. HB.2.5.8. Observes the production activities in the immediate vicinity. HB.2.6.1. Compares the conditions necessary for the survival of plants and animals. HB.2.6.5. Recognizes natural events. HB.2.6.6. Gives examples of natural disasters.	HB.2.1.3. Prepares course tools and materials according to the daily course schedule. HB.2.1.11. At school, he/she spends his/her money consciously in line with his/her needs. HB.2.2.9. List their wants and needs in order of priority. HB.2.3.2. Prepares a list of meals suitable for a balanced diet. HB.2.3.4. Explain the necessity of cleaning for a healthy life. HB.2.3.7. Chooses clothes suitable for seasonal conditions. HB.2.6.7. Explains natural events and measures that can be taken against natural disasters.
	3	-	HB.3.2.6. Makes original suggestions for the effective and efficient use of resources at home. HB.3.3.1. Uses resources efficiently while doing personal care. HB.3.3.2. Demonstrates conscious consumer behavior when purchasing food and beverages HB.3.6.4 Gives examples of the influence of people on natural elements from their immediate surroundings. HB.3.6.5. Takes responsibility for protecting nature and the environment. HB.3.6.6. Gives examples of the contribution of recycling to him/herself and the environment he/she lives in.	B.3.3.3.He/she is fed seasonal foods to maintain his/her health. HB.3.3.4. Adequate and balanced nutrition is required to maintain health. HB.3.6.1. Understands the importance of plants and animals in terms of human life. HB.3.6.2. Researches the growing conditions of fruits and vegetables.	HB.3.1.7. Will be willing to participate in activities related to social assistance and solidarity at school HB.3.2.1. Compares the characteristics of the childhood periods of family elders with the characteristics of their own childhood. HB.3.1.10. He/she researches the professions he/she is interested in and their characteristics. HB.3.2.8. While meeting his wishes and needs, he takes care to protect his own and his family's budget. HB.3.3.5. Cleaning and hygiene in common areas to protect the health of himself and the community obeys the rules. HB.3.5.3. It introduces the characteristics of historical, natural and touristic places in the immediate vicinity. HB.3.5.4. He/she establishes a relationship between the development of his/her country and the fulfillment of his duties and responsibilities. HB.3.5.5. Protects common areas and vehicles.

Science	3	-	F.3.7.2.2. Discusses the harms of battery wastes to the environment and what needs to be done in this regard.	F.3.1.2.1. Understands that there are lands and waters on the surface of the Earth. F.3.1.2.2. Explains that there is a layer of air that surrounds us on Earth. F.3.1.2.3. Compares the areas covered by land and water on the earth's surface on the model. F.3.6.2.1. Recognizes the environment in which he/she lives. F.3.6.2.2. He/she takes an active role in the cleaning of the environment he/she lives in. F.3.6.2.3. Explain the differences between natural and artificial environment. F.3.6.2.4. Designs an artificial environment. F.3.6.2.5. Realizes the importance of the natural environment for living things.	F.3.6.1.1. Classifies the living and non-living things by using the examples around him/her.
	4	-	F.4.6.1.1. Takes care to be economical in the use of resources. F.4.6.1.2. Realizes the importance of resources and recycling necessary for life.	F.4.5.1.2. Makes designs for lighting tools that can be used in the future. F.4.5.2.1. Conducts research on appropriate lighting. F.4.5.2.2. Discusses the importance of economical use of lighting tools in terms of family and national economy. F.4.5.3.1. Questions the causes of light pollution. F.4.5.3.2. Explains the negative effects of light pollution on natural life and observation of celestial bodies. F.4.5.3.3. Produces solutions to reduce light pollution. F.4.5.5.1. Questions the causes of sound pollution. F.4.5.5.2. Explain the negative effects of sound pollution on human health and the environment. F.4.5.5.3. Produces solutions to reduce sound pollution.	F.4.2.1.4. Relates a balanced diet with human health F.4.4.4.1. Designs experiments for heating and cooling of materials. F.4.4.4.2. Designs experiments to show that substances can change state under the influence of heat.
	5	-	F.5.6.1.2. Discusses the factors that threaten biodiversity based on research data. F.5.6.2.1. Express the importance of interaction between human and environment F.5.6.2.2. Offers suggestions for the solution of an environmental problem in his/her immediate surroundings or in our country. F.5.6.2.3. Makes inferences about environmental problems that may occur in the future as a result of human activities. F.5.6.2.4. Discusses the benefits and harm situations in human-environment interaction on examples.	F.5.6.1.1. Questions the importance of biodiversity for natural life. F.5.6.3.2. Express the ways of protection from destructive natural events.	F.5.2.1.1. Classifies living things according to their similarities and differences by giving examples. F.5.4.2.1. As a result of his experiments, he/she determines the melting, freezing and boiling points of pure substances. F.5.4.3.2. Interprets the results by making experiments on heat exchange as a result of mixing liquids with different temperatures.

Social Sciences	4	-	SB.4.4.5. Uses technological products without harming himself, others and nature. SB.4.5.5. It uses the resources around it without wasting it.	SB.4.3.3. Distinguish the natural and human elements in the living environment. SB.4.3.4. Observing the weather events occurring around him, he transfers his/her findings to illustrated graphics. SB.4.5.3. Exhibits conscious consumer behavior as a responsible individual. SB.4.5.1. Makes conscious choices between the two by distinguishing between wants and needs.	SB.4.3.6. Makes necessary preparations for natural disasters. SB.4.4.1. Classifies the technological products around it according to their usage areas. SB.4.4.2. Compares past and present uses of technological products SB.4.4.3. Researches the inventors of the technological products it uses and the development of these products over time. SB.4.4.4. Develops ideas for designing unique products based on the needs around them.
	5	1	SB.5.3.2. Making explanations of the effects of the climate seen in the environment on human activities from his/her daily life by giving examples . SB.5.3.4. Question the causes of disasters and environmental problems in the environment they live in.	SB.5.3.5. Explains the effects of natural disasters on social life with examples. SB.5.5.4. Analyzes the production, distribution and consumption network of products to meet basic needs. SB.5.5.5. Collaboratively develops new ideas based on production, distribution and consumption.	SB.5.2.2. Introduces the natural assets and historical places, objects and artifacts around. SB.5.5.2. Recognize the professions that develop depending on the economic activities in and around the place of residence. SB.5.5.3. Analyzes the impact of economic activities around people's social lives. SB.5.5.6.Uses his/her rights as a conscious consumer. SB.5.7.2. Discusses the impact of communication and transportation technology on economic relations between countries.

As seen in Table 1, the concepts of climate and climate change among the achievements of the life studies curriculum are only seen at the 2nd grade level and in one achievement. Likewise, it was only seen once at the 5th grade level in the social studies curriculum. In the science curriculum, climate and climate-related concepts are not directly included in any of the primary school learning outcomes. Despite this, although the if concept of climate is not included in it or not, 13 achievements in the life studies program (1st grade f:5, 2nd grade f.2, 3rd grade f:6) directly related to climate change, 8 acquisitions in the science curriculum (3th grade f:1, 4th grade f:2, 5th grade f:5), and 4 achievements (4th grade f:2, 5th grade f:2) are included in the social sciences curriculum. When the achievements that are indirectly related to climate and climate change are examined, the number of achievements in the life studies curriculum is 17 (1st grade f:6, 2nd grade f: 7, 3rd grade f: 4), the number of science achievements is 20 (3rd grade f:8, 4th grade f:9, 5th grade f:3), and the number of achievements in the social sciences curriculum was 7 (4th grade f:4, 5th grade f:3). In addition to these, although not directly or indirectly related, it was one of the findings determined by the researchers that there are possible gains with the activities to be associated with some achievements. The distribution of these achievements is 19 in the life studies program (1st grade f:4, 2nd grade f:7, 3rd grade f:8), 8 in the science program (3rd grade f:1, 4th grade f:4, 5th grade f: 3), in the social sciences program it was determined as 10 (4th grade f:5, 5th grade f: 5). [*f: frequency]

Table 2. Examining the concept of global climate change in secondary school curricula

Curriculum	Grade	Concept of climate (achievement frequencies)	Achievement(s) **directly** related to climate climate change	Achievement(s) **indirectly** related to climate climate change	Achievement(s) **possible to be** related to climate change
Science	6	-	F.6.4.4.1. Classifies fuels as solid, liquid and gaseous fuels and gives examples of commonly used fuels. *It is stated that fossil fuels are limited and one of the non-renewable energy sources, and the importance of renewable energy sources is emphasized by giving examples.* F.6.4.4.2. Discusses the effects of the use of different types of fuels for heating purposes on humans and the environment.	F.6.4.2.4. Compares the densities of the solid and liquid states of water and discusses the importance of this situation for living things.	F.6.4.3.4. Discusses the importance of thermal insulation in buildings in terms of family and country economy and effective use of resources. F.6.4.4.3. Researches and reports the precautions to be taken regarding stove and natural gas poisoning F.6.6.1.4. Discusses what can be done to pass the adolescence period in a healthy way, based on research data. F.6.6.2.4. Discusses the measures to be taken to protect the health of the sense organs. F.6.6.3.1. Discusses what needs to be done for the health of systems based on research data.
	7	-	F.7.4.5.1. Distinguish between recyclable and non-recyclable materials in household waste. F.7.4.5.2. Designs a project for the recycling of domestic solid and liquid wastes. F.7.4.5.3. Questions recycling in terms of effective use of resources. F.7.4.5.4. Pays attention to waste control in its immediate vicinity F.7.4.5.5. Develops a project to deliver reusable items to those in need. F.7.5.1.4. Gives examples of innovative applications of solar energy in daily life and technology.	F.7.1.1.2. Expresses the causes of space pollution and predicts the possible consequences of this pollution. F.7.5.1.5. He/she discusses his/her ideas about how to benefit from solar energy in the future.	F.7.6.1.3. Based on research data, the precautions to be taken for the healthy development of the embryo discusses. F.7.6.2.3. Explain the basic factors affecting the growth and development of plants and animals. F.7.7.1.6. Designs a unique lighting tool.
	8	6 Climate, climate science, climate scientist, global climate change	F.8.1.2.1. Explains the difference between climate and weather events. F.8.1.2.2. Climate science (climatology) is a science and experts working in this field are climatologists (climatology). tolog) says. F.8.6.3.3. Discusses the causes and possible consequences of global climate changes. F.8.6.4.1. Takes care to be economical in the use of resources. F.8.6.4.2. Designs projects for the efficient use of resources. F.8.6.4.3. Explains the importance of separating solid wastes for recycling. F.8.6.4.4. Offers solutions by using research data on the contribution of recycling to the country's economy. F.8.6.4.5. Offers solutions by specifying the problems that may be encountered in the future if the resources are not used sparingly.	F.8.1.1.1. Makes predictions about the formation of the seasons. F.8.4.4.7. Offers solutions for the prevention of acid rain. F.8.6.3.1. Explains the item loops by showing them on the diagram. F.8.6.3.2. Questions the importance of matter cycles in terms of life. F.8.7.3.5. Discusses the importance of conscious and efficient use of electrical energy in terms of family and national economy. F.8.7.3.6. Takes care to use electricity economically at home.	F.8.2.3.3. Makes inferences about the differences between mutation and modification. F.8.4.4.2. Gives examples of acids and bases from daily life F.8.4.5.4. Relates heat exchange with state changes in daily life F.8.6.1.1. Gives examples of producers, consumers and decomposers in the food chain. F.8.6.2.3. Indicates the importance of respiration in living things F.8.6.2.1. Realizes the importance of photosynthesis in food production in plants. F.8.6.2.2. Makes inferences about the factors affecting the rate of photosynthesis. F.8.7.3.3. Explains how electrical energy is produced in power plants. F.8.7.3.4. Generates ideas about the advantages and disadvantages of power plants.

Social Sciences	6	5: climate, mediterranean climate, monsoon climate, arctic climate, equatoriall climate	SB.6.4.2. Proposes ideas about the effects of scientific and technological developments on future life. SB.6.5.2. Analyzes the effects of unconscious consumption of resources on living life.	SB.6.3.4. Makes inferences about climate characteristics based on human experiences in different natural environments of the world.	SB.6.3.1. Defines the geographical position of continents, oceans and our country by using the concepts related to location. SB.6.3.2. Examines the main physical geography features of Turkey, landforms, climatic features and vegetation on the relevant maps. SB.6.4.3. Conducts research using scientific research steps.
	7	1: Küresel iklim değişikliği	SB.7.7.4. Together with his/her friends, he/she develops ideas for the solution of global problems.	SB.7.5.1. Explains the importance of soil in production and management with examples from the past and present. SB.7.5.2. Evaluates the effects of developments in production technology on social and economic life.	SB.7.1.3. Discusses the role of media in social change and interaction. SB.7.3.1. Makes inferences about the factors affecting the settlement from the past to the present through case studies. SB.7.5.5. Taking into account the new professions that have emerged depending on the developments in the world, plans for their preferences. SB.7.5.6. Analyzes the changes brought about by digital technologies in production, distribution and consumption networks. SB.7.7.1. Gives examples of international organizations of which Turkey is a member.

As seen in Table 2, the concept of climate is not included in the 6th and 7th grade achievements in the science curriculum. At the 8^{th} grade level, it is seen that the concepts of climate, climate science, climate scientist and global climate change are used in learning outcomes. In the social sciences curriculum, the concept of climate and climate types took place at the 6th grade level. In the 7th grade, it was seen that the expression "global climate change" took place in the learning outcome. In addition whether the concept of climate is included or not, 16 achievements in the science curriculum which are directly related to climate change (6^{th} grade f:2, 7^{th} grade f:6, 8th grade f:8), and social sciences curriculum (6^{th} grade f:2, 7^{th} grade f:1). When the achievements that are indirectly related to climate and climate change are examined, the number of science achievements is 9 (6th grade f:1, 7th grade f:2, 8th grade f:6), and the number of achievements in social sciences curriculum is 3 (6^{th} grade f:1, 7^{th} grade f:2). In addition to these, although not directly or indirectly related, the achievements that can be possible with the activities to be associated are 17 (6^{th} grade f:5, 7^{th} grade f:3, 8^{th} grade f:9) in the social sciences program. and 8 (6^{th} grade f:3, 7^{th} grade f: 5).

Table 3. Examining the concept of global climate change inEnvironmental Education and Climate Change Curriculum (2022)

	Human and Nature	Circular Nature	Environmental Issues	Global Climate Change	Climate Change and Turkey	Sustainable Development and Environmentally Friendly Technologies
Environental Education and Climate Change	ÇEID.1.1. Realizes that he/she/ she/she is a part of the environment he/she lives in, based on his observations. ÇEID.1.2. Discusses the positive and negative aspects of the interaction between man and nature. ÇEID.1.3. he/ she gives examples of the continuous interaction between living and non-living things in the environment he/she lives in. ÇEİD.1.5. Designs a project that will create social awareness for the protection of natural balance. ÇEID.1.6. Up-to-date behaviors that will negatively affect the natural balance	ÇED.2.1. He/ she gives examples to the natural resources in his/her vicinity by making use of the observation results. ÇED.2.2. Groups the natural resources on earth based on the results of his research. ÇED.2.3. Realizes that natural resources gain continuity with matter cycle and energy flow. ÇED.2.4. Makes inferences about the effect of disruption in matter cycle and energy flow on natural life.	ÇEID.3.1. Realizes the importance of the balance between production and consumption in daily life. ÇEID.3.2. Distinguish the concepts of waste, garbage and pollution. ÇED.3.3. Realizes that waste and garbage cause air, water, soil pollution and radioactive pollution. ÇEİD.3.4. Explain the concept of ecological footprint with examples. ÇEID.3.5. Explains local and global environmental problems with examples. ÇED.3.6. Explain the problems that arise due to environmental pollution and the effects of these problems on human life.	ÇEID.4.1. Questions the events that cause the increase of greenhouse gases. ÇEID.4.2. Realizes that global warming occurs as a result of the greenhouse effect. ÇEID.4.3. Explain the relationship between global climate change and global warming. ÇEID.4.4. Interpret the effects of global climate change through case studies. ÇEID.4.5. Explain the disasters caused directly or indirectly by global climate change with their effects.	ÇEID.5.1. Realizes the current and possible effects of climate change in Turkey. ÇEID.5.2. Discusses the importance of national and international studies on combating climate change in Turkey. ÇED.5.3. He/ she gives examples of measures to reduce the effects of climate change in Turkey. ÇEİD.5.4. Be aware of their responsibilities in the process of informing their immediate surroundings about combating climate change in Turkey. ÇED.5.5. He/ she designs project(s) that will create social awareness to reduce the effects of climate change in Turkey.	ÇEID.6.1. He/she realizes that while meeting his/her wishes and needs in his/her daily life, he/she must act by taking into account the needs of future generations. ÇEID.6.2. Realizes the importance of sustainable use of water resources. ÇEID.6.3. Discusses the effect of sustainable use of resources on development based on research data. ÇEID.6.4. Explain the importance of recycling and recovery in terms of sustainable development. ÇEID.6.5. Designs an upcycle product using waste materials. ÇEID.6.6. He/ she presents examples that support sustainable development in Turkey and the world. ÇEİD.6.7. He/she designs a project that includes a solution based on the awareness of sustainable development for the real life problem. ÇEID.6.8. He/she gives examples of different career fields related to environment, climate and sustainable development.

Since 2022, the Environmental Education and Climate Change curriculum has been started to be implemented as an elective course at the secondary school level. There are 6 units in this curriculum. While 2 of these units are directly related to climate change (Global climate change, Global Climate change and Turkey), the other four units are planned on environmental issues. The total number of achievements built on climate change is 10 (global climate change f:5, global climate change and Turkey f:5).

CONCLUSION

Global climate change is one of the common problems of humanity that directly affects the whole world and ecosystem. One of the most important ways to combat this problem is education. Even if there is no direct change in the solution of problems, thanks to the consciousness and awareness that will be created through education, significant success can be achieved in preventing problems before they occur. The results obtained from this study draw attention to how low the number of achievements directly related to climate change in the primary and secondary school curriculum is. Despite this, it has been concluded that the number of achievements related to the environment and indirectly associated with climate change is relatively higher. When curriculums are examined, it is seen that the expression of global climate change is handled only at the 8th grade level in the science curriculum and at the 7th grade level in the social sciences curriculum. It is thought that it should be used from smaller grade levels in order to increase knowledge and awareness about this concept. Since 2022, an elective course called "Environmental Education and Climate Change" has been introduced in order to increase knowledge and awareness about global climate change and environmental problems in addition to life sciences, social sciences and science curriculums. Although this situation is considered a positive development, fact that this course is planned to be taught in 6-7-8th grade is seen as a disadvantage. At the same time, it is thought that it is important for the teachers who will teach this course to receive in-service training on related subjects. In this context, it is thought that voicing an important problem such as climate change as many times as possible in the lessons and including examples in situations that can be associated with the achievements will have an important effect on raising awareness from an early age.

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AN EXAMINATION OF GLOBAL CLIMATE CHANGE AND ENVIRONMENTAL PROBLEMS IN SECONDARY SCHOOL SCIENCE TEXTBOOKS ACCORDING TO THE DIDACTIC TRANSPOSITION THEORY

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ABSTRACT

The theoretical framework that explains all the elements that scientific knowledge is affected by until it becomes learnt knowledge by students is called didactic transposition. The external didactic transposition, which is the first step of this transposition, deals with the transformation of scientific knowledge into knowledge to be taught. The textbook, which is used to convey the students' targeted acquisitions, is an important material that enables students to acquire the objectives, qualifications and content aimed in the curriculum. Textbooks are of great importance for effective science teaching. The aim of this study is to examine and evaluate the subject of global climate change and environmental problems in the secondary school science 5th, 6th, 7th and 8th grade textbooks in terms of external didactic transposition. In line with the purpose of the study, the document analysis method, which is one of the qualitative research designs, was used. Textbooks were examined under three headings: scientific content, visual elements and design principles related to the field of science. As a result of the analysis of the textbooks examined in the research, it was seen that the information related to global climate change and environmental problems was not given information about global warming, which is the main cause of global climate change, in which environmental problems were extensively covered in the 5th grade science book. In the 6th grade science textbook, global warming and greenhouse gases are mentioned in the form of a reading text without using any visuals. In the 7th grade science textbook, it has been seen that superficial information about global warming, which is the main cause of global climate change, is generally treated as recycling. It has been observed that the subject of global climate change and environmental problems is extensively covered in the 8th grade science textbook. On the other hand, it has been concluded that the possible economic, social and psychological effects of global climate change in the near future are not explained superficially in the books. In addition, it has been observed that there is very limited information on the measures to be taken to minimize the possible future effects of global climate change and environmental problems. Considering the results of the research, some suggestions were presented for the science textbooks and the science course curriculum.

Keywords: Science Education, Didactic Transposition Theory, Global Climate Change, Environmental Problem, Textbook

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1. INTRODUCTION

Textbooks are among the most important educational tools that guide teachers in the provision of education and the realization of the objectives of the curriculum and have a great importance in the learning of students. As textbooks act as a guide and resource for teachers, they have the potential to significantly affect the quality of education[1]. Textbooks, which are one of the basic tools of education and training, are important in schools in terms of contributing to the social, economic, social and personal development of students. In addition, textbooks are also effective in reaching the achievements in the curriculum. For widespread use of a textbook; the book should be prepared in accordance with the objectives of the curriculum in terms of content, contain rich elements that will motivate students visually, have measurement-evaluation sections, and should be prepared in accordance with student levels. It is also important that the prepared textbooks are compatible with the student workbooks. In short, the fact that textbooks are still an indispensable teaching tool for teachers and students. On the other hand, textbooks are the most criticized educational tools and it is known that there are problems associated with textbooks[2].

One of the most important theories about the transposition of knowledge in the educational process is the theory of didactic transposition. The theory of didactic transformation was first used by Chevallard[3]in mathematics education and later studied in other scientific fields. Chevallard defined this theory as "all the transpositions of a knowledge until it becomes a taught knowledge". According to the theory of didactic transposition, scholarly knowledge obtained by scientists undergoes some changes until they turn into learnt knowledge by students. In this case, the first type of knowledge, scholarly knowledge, goes through various transpositions and turns into knowledge to be taught, the second type of knowledge. According to Chevallard, curricula and textbooks constitute the scope of knowledge to be taught. Textbooks, which are a reflection of the education and training program, are an important part of the transposition of scholarly knowledge into knowledge to be taught to students. According to theory of didactic transposition, the next type of knowledge is taught knowledge. In other words, it is the teacher's interpretation of the scientific information in the curricula and textbooks and transferring them to the students. The last type of information is learnt knowledge. The learntknowledge is the structured form of the information conveyed by the teacher in the minds of the students. The transposition of scientific knowledge to knowledge to be taught is called external didactic transformation.The transposition of the knowledge to be taught to the learnt knowledge is called internal didactic transformation.The stages and steps of the theory of didactic transposition are shown in Figure 1[4].

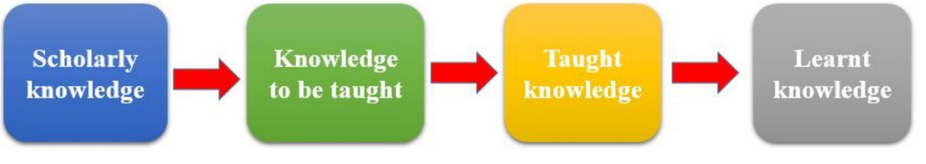

Figure 1. Stages and Steps of the Theory of Didactic Transposition (Bosch, Chevallard, & Gascon, 2005)

The theoretical framework that explains all the elements that scientific knowledge is affected by until it becomes learnt knowledge by students is called didactic transposition. The external didactic transposition, which is the first step of this transposition, deals with the transformation of scientific knowledge into knowledge to be taught. The textbook, which is used to convey the students' targeted acquisitions, is an important material that enables students to acquire the objectives, qualifications and content aimed in the curriculum. Textbooks are of great importance for effective science teaching.

Human, who is an essential element of the environment, is naturally affected by the increasing environmental problems. The basis of environmental problems is the low level of knowledge, attitudes, values and awareness of individuals about the environment. Most of the environmental problems are caused by the behavior of people who do not give enough importance to these issues. In order for the interaction between people and the environment to be carried out in a healthy way, it is necessary to raise individuals who are environmentally conscious and sensitive to the environment. Raising individuals with this awareness, consciousness, attitude and sensitive behavior can only be achieved with an effective environmental education.

Increasing environmental problems make us think that there are some problems in the implementation of environmental education. As a matter of fact, studies in the literature stating that students at different levels do not have enough knowledge about the environment, do not show enough interest in environmental problems, do not participate enough in activities related to the environment, and are less sensitive to environmental problems [5-7] support this idea.It should be known that it is not possible to fight against climate change without raising individuals who have the right information about the causes, possible effects, activities carried out and our individual duties and responsibilities.

The aim of this study is to examine and evaluate the subject of global climate change and environmental problems in the secondary school science 5th, 6th, 7th and 8th grade textbooks in terms of external didactic transposition.

2. METHOD

In line with the purpose of the study, the document analysis method[8], which is one of the qualitative research designs, was used. Secondary school science textbooks were examined under three headings: scientific content, visual elements and design principles related to the field of science.

Table 1. Information on Science Textbooks

Grade	Publishing	Year	Page	Code
5	Minister of National Education	2021	288	B5
6	Minister of National Education	2021	246	B6
7	Minister of National Education	2021	246	B7
8	Matbaa Publishing	2019	240	B8

3. RESULT AND DISCUSSION

The findings of the research were presented by analyzing according to sub-objectives.

In Table 2, general characteristics of Global Warning and Climate Change in 5th, 6th, 7th and 8th grade books are given. In the book, the subject of Global Climate Change and Environmental Problems is covered in 12 pages in the book B5, 1 page in the book B6, 7 in the book B7, 9 pages in the 8th grade book, together with the end-of-unit questions. The subject is divided into 5 different sub-topics in the B5 book and 4 outcomes. In the B6 and B7 books, 1 learning outcome is processed in a single topic. In total, 10 visuals and 27 different concepts were used in B5, 18 concepts were used without using images in B6, 6 visual 19 concepts were used in B7, 13 images and 30 concepts were used in B8. It can be said that the subject of Global Climate Change and Environmental Problems is covered briefly in the units.

Table 2. General Characteristics of Books B5, B6, B7 and B8 on Global Warming and Climate Change

Unit Features	B5	B6	B7	B8
Number of Pages Processed	12	1	7	9
Number of Images Used	10	0	6	13
Number of Concepts	27	18	19	30
Number of Subjects	5	1	1	3
Number of Outcomes	4	1	1	2

Table 3 shows the subtopics covered under the title of Global Warming and Climate Change in books B5, B6, B7 and B8. Environment, water, air and soil pollution in the book B5, Global Warming-Climate Change and its Effects on Turkey in the book B6, Domestic Waste and Recycling in the book B7, Causes and Possible Consequences of the Global Climate Changes in the book B8, Depletion of the Ozone Layer.

Table 3. Topics Covered under the Human and Environment Relations Unit

Topics
B5
5.1 Environmental Pollution
5.2 Water Pollution
5.3 Soil Pollution
5.4 Air Pollution
B6
6.1 Global Warming - Climate Change and Its Effects on Turkey
B7
7.1 Domestic Waste and Recycling
B8
8.1 Causes and Possible Consequences of Global Climate Changes
8.2 Depletion of the Ozone Layer

In Table 4, the outcomes related to Environmental Problems and Global Climate Change in the B5, B6, B7 and B8 are shown. In the B5, 4 gains, 1 gain in the B6, 4 gains in the B7, and 4 outcomes in the B8. Analysis, synthesis and evaluation steps, which require high-level skills, were not used in the acquisitions and activities used in the unit.

Table 4. Outcomes

B5	B6	B7	B8
F.5.6.2.1. Express the importance of interaction between human and environment.	F.6.4.4.2. Discusses the effects of the use of different types of fuels for heating purposes on humans and the environment.	F.7.4.5.1. Distinguish between recyclable and non-recyclable materials in household waste.	F.8.6.3.3. Discusses the causes and possible consequences of global climate changes.
F.5.6.2.2. It offers suggestions for the solution of an environmental problem in its immediate surroundings or in our country.		F.7.4.5.2. Designs a project for the recycling of domestic solid and liquid wastes.	F.8.6.4.3. Explain the importance of separating solid wastes for recycling.
F.5.6.2.3. It makes inferences about environmental problems that may occur in the future as a result of human activities.		F.7.4.5.3. It questions recycling in terms of effective use of resources.	F.8.6.4.4. It offers solutions by using research data on the contribution of recycling to the country's economy.
F.5.6.2.4. Discusses the benefits and harm situations in human-environment interaction on examples.		F.7.4.5.4. Pays attention to waste control in its immediate surroundings.	F.8.6.4.5. It offers solutions by specifying the problems that may be encountered in the future if the resources are not used sparingly

In Table 5, the sub-topics of the subject selected from scholarly knowledge are shown. The didactic transposition between scientific knowledge and the knowledge to be taught was examined the subject headings.

Table 5. Transposition of Scholarly Knowledge into Knowledge to be Taught

Scholarly Knowledge	B5	B6	B7	B8
Global Climate Change		√		√
Global Warming	√	√		√
Greenhouse Effect		√		√
Greenhouse Gases		√		√
Environmental Pollution	√		√	
Air Pollution	√			√
Water Pollution	√			
Soil Pollution	√			
Medical Wastes	√			
Nuclear Pollution	√			
Pine	√		√	
Plastic	√		√	
Heat	√			√

Recycle			√	
Paper	√		√	
Metal	√		√	
Environmental Awareness	√			
Non-Planned Urbanization	√			
Industrial Waste	√			
Cancer	√			
Filter	√			
TEMA	√			
ÇEVKO	√		√	
AGED			√	
TAP			√	
Waste Oil				
Renewable Energy				
Kyoto Protocol		√		
Technology		√		
Waste of Resources		√		
UN Report			√	
CFC Gases		√		√
UV-B Rays				√
Sustainable Development				
Ecological Footprint				√
Carbon Dioxide				
Methane		√		√
Water Vapor		√		
Photosynthesis				√
Glacier				
Nitrogen Dioxide		√		
Sulfur Dioxide		√		
Sunlight				
Season				
Climate				√
Environmental Problems				√
Industrialization	√			
Natural Resource			√	
Precipitation-Humidity				√
Atmosphere		√		√
Fossil Fuels		√		√
Human Activities		√		√
Surface Temperature		√		√
Waste Materials			√	
Zero Waste Project			√	

Domestic Liquid Waste			√	
Energy Saving			√	
Acid Rains				√
IPCC				√

Table 6 shows the concepts and terms in the books on Global Climate Change and Environmental Problems. In the B5, B6, B7 and B8, a total of 40 different terms were used on the subject. When the concepts are examined, it is seen that they are quite up-to-date and that students can encounter in their daily lives and social media. The scientific concepts that are suitable for the students' level are included in the textbook as information to be taught by undergoing a didactic transposition.

Table 6. Concepts on Global Climate Change and Environmental Problems in B5, B6, B7 and B8

Concepts Cited in Textbooks				
1. Environment	9. Water	17. Atmosphere	25. Fuel	33. Industrialization
2. Global	10. Natural Resource	18. Power Plant	26. TEMA	34. Natural Resource
3. Climate	11. Nuclear	19. Glaciers	27. ÇEVKO	35. Zero Waste
4. Greenhouse	12. Acid Rain	20. Industry	28. Waste	36. Recycling
5. Gas	13. Ozone Layer	21. Chimney	29. Climate	37. Precipitation
6. Pollution	14. Chemical Matter	22. Filter	30. Season	38. Waste of Resources
7. Earth	15. Ray	23. Energy	31. Temperature	39. Kyoto
8. Air	16. Sun	24. Wind	32. Fossil Fuels	40. Ecological Footprint

In Table 7, the frequency of the 9 most used concepts in B5, B6, B7 and B8 textbooks on Global Climate Change and Environmental Problems is given. According to this table, the subject of Global Climate Change and Environmental Problems is handled from a different perspective every year. It is usual for these concepts, which form the basis of the unit, to be used frequently.

Table 7. Concepts in B5, B6, B7 and B8

Concepts	**B5**	**B6**	**B7**	**B8**
Global warming	2	4	-	10
Climate Change	-	5	-	9
Recycling	1	-	20	-
Greenhouse effect	1	5	-	6
Environmental pollution	8	-	-	10
Ozone Layer	2	-	-	22
Biodiversity	3	-	-	-
Waste	10	-	46	-
Ecological Footprint	-	-	-	9

In Table 8, the types and numbers of images used on the subject of Global Climate Change and Environmental Problems are given. Number of images used in the unit B5 is 10. Considering that the unit is processed on 12 pages in total, excluding the end-of-unit questions, it can be said that the rate of using images is at an average level and there is approximately 1 image per page. Number of images used in the unit B7 is 6, considering that the unit is processed on 7 pages in total, excluding the end-of-unit questions. Number of images used in the unit B8 is 13. Considering that the unit is processed on a total of 9 pages, except for the end-of-unit questions, it can be said that the rate of image use is at an average level and there are approximately 2 image per page. It is thought that enriching the textbook with visuals will help students learn concepts. When image types are examined, they are more than other image types as pictures. After photography, the most used image types are picture, model and table. While explaining most of the concepts or terms in the unit, the picture of the concept is used.

Table 8. Number of Images Used in Textbooks

Image Types	Number of Images Used in B5	Number of Images Used in B6	Number of Images Used in B7	Number of Images Used in B8
Picture	8	-	5	10
Diagram	-	-	-	1
Model	1	-	-	1
Table	-	-	-	-
Photograph	1	-	1	3

Figure 2. Images Used on Global Climate Change and Environmental Problems in Textbooks

In Figure 2, it is seen that there are images showing the result of environmental problems in textbooks (B5, B7 and B8).

Figure 8 shows one page of the textbook.When we examine the page in terms of integrity, it is observed that the texts, images and spaces provide integrity and create a regular image.The text to be used on the page is located at the bottom left of the visual elements and is placed on the page in harmony with each other.The visual used on the page has created a meaningful integrity with the subject described.

Figure 3. Image in B5

4. CONCLUSION

In the research, it was concluded that the textbook in which information about Global Climate Change and Environmental Problems is presented directly and most intensively is the 8th grade science textbook. It has been observed that only superficial information about global warming, which is the main cause of Global Climate Change and Environmental Problems, is included in the 5th grade science textbook. In the 6th grade science textbook, the subject of Global Climate Change and Environmental Problems is given at the end of the unit in the form of only one page of lecture, associating with greenhouse gases. It is thought that the main reason why the information on Global Climate Change and Environmental Problems is presented in more detail only in the 8th grade science textbook is that it supports the substance cycles in nature. The information that could be related to Global Climate Change and Environmental Problems was also given in the 7th grade Science textbook, but when these findings were examined, it was seen that the information included mostly focused on recycling. In general, it has been concluded that sufficient information is not given about global warming, which is the main reason for such an important event for our country and the Earth. In the research, it was seen that the information about the causes and formation of Global Climate Change and Environmental Problems was presented in a superficial way. It is mentioned that Global Climate Change and Environmental Problems are only caused by the excessive emission of greenhouse gases in the 8th grade textbook, but it is not associated with unconscious consumerism and unconscious use of forests. In addition, it was seen that this information was not supported by visuals in the 6th gradescience book. However, considering the developmental periods of the students, who are the target audience of the secondary school science course, it is recommended to use appropriate visuals as much as possible for the effective teaching of subjects containing abstract concepts and information such as Global Climate Change and Environmental Problems. In this respect, it can be said that supporting the causes and formation of Global Climate Change and Environmental Problems with information and visuals is insufficient, especially in the 6th grade textbook. In our study, it is seen that the subject of Global Climate Change and Environmental Problems, which is included in school science books, is handled from a different perspective and as a sub-topic under a unit, not as a unit on its own. In the solution of environmental problems such as global climate change, it is very important to create a conscious society that can be possible by raising individuals who are sensitive to the environment, conscious and actively participate in the solution of problems. Educational institutions have important duties to increase social awareness. It is recommended that such an important subject for our country and the world be covered in depth as a unit in every aspect, and projects related to the subject should be prepared together with the students. In addition, it is recommended to reflect the current research on the subject to the textbooks to ensure that the content is up-to-date and interesting.

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INVESTIGATION OF THE IMPORTANCE OF RECYCLING AND ENERGY SAVING ACCORDING TO THE INTERNAL DIDACTIC TRANSPOSITION THEORY

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ABSTRACT

Many approaches can be used to shape the scientific information desired to be taught to students by the teacher, and for students to assimilate this information and turn it into a form that they can use in their lives. Didactic transposition theory is a theory that examines the educational process from the scientific knowledge produced by scientists to the assimilation by the student, and the transitions and transformations accompanying this process. The importance of recycling and energy saving is increasing day by day in many areas where the results of global climate change will shape the future. The first level where recycling and energy saving issues are addressed is the science course in primary school. The aim of this study is to examine primary school students in the teaching of recycling and the economical use of resources and its importance in the context of knowledge assimilated within the scope of internal didactic transposition theory. In this study, a case study pattern was chosen from qualitative research methods. Within the scope of the information to be taught, the subject of human and environment, which is the 6th unit of the 4th grade science textbook, was created and processed by using different methods and teaching techniques in two different classes. In the control group, traditional teaching methods with the teacher at the center were used. In the experimental group, a learning environment based on learning by doing was created. In this class, the student was taken to the center, activities were organized at all stages of the lesson and active participation of the student in the process was ensured. The participants of the study consisted of two different 4th grade students and a total of 52 students from a primary school in the central district of a province in the Black Sea Region. In addition, within the scope of the study, the parents of these students were included in the process and the parent monitoring test was applied in order to determine the behavioral changes in the students. In the study, the control and experimental group students were first administered a pre-test to measure their prior knowledge, and an achievement test at the end of the process. It was observed that the students in the experimental group, who had a learning environment based on learning by doing, participated in learning activities more willingly, had more confidence in themselves, collaborated more, and were more problem solvers compared to the students in the control group.

Keywords: Recycling, Energy Saving, Primary School Students, Didactic Transposition Theory

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1. INTRODUCTION

Many approaches can be used to shape the scientific information desired to be taught to students by the teacher, and for students to assimilate this information and turn it into a form that they can use in their lives. Didactic transposition theory is a theory that examines the educational process from the scientific knowledge produced by scientists to the assimilation by the student, and the transitions and transformations accompanying this process. Didactic transposition theory was first used in mathematics education by Chevallard [1, 2]. According to this approach, it is a theory that examines the educational process until the transposition of scientific knowledge produced by scientists. This theory states that there are differences between the scholarly knowledge by the scientist and the learnt knowledge by the students. Didactic transposition theory basically examines 4 types of knowledge and 3 transposition steps between them.It can be said that the concept of didactic transposition has two stages. Chevallard [2] gave it in its original definition as "the transposition from scientific knowledge to taught knowledge". As seen in figure 1, this distinction is expressed as external didactical transformation "transition from scholarly knowledge to knowledge to be taught" and internal didactic transformation as "transition from knowledge to be taught to knowledge taught" [3].

The stages and steps of the theory of didactic transposition are shown in Figure 1 [4].

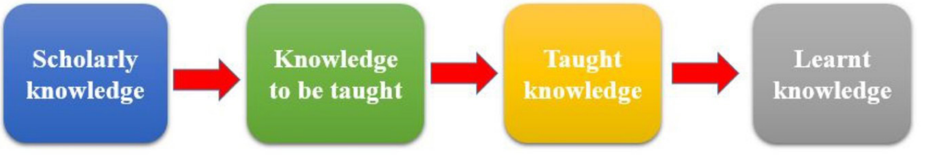

Figure 1. Stages and Steps of the Theory of Didactic Transposition [4]

The importance of recycling and energy saving is increasing day by day in many areas where the results of global climate change will shape the future. The first level where recycling and energy saving issues are addressed is the science course in primary school.

The aim of this study is to examine primary school students in the teaching of recycling and the economical use of resources and its importance in the context of knowledge assimilated within the scope of internal didactic transposition theory.

2. METHOD

In this study, a case study pattern was chosen from qualitative research methods. Within the scope of the information to be taught, the subject of human and environment, which is the 6th unit of the 4th grade science textbook, was created and processed by using different methods and teaching techniques in two different classes. In the control group, traditional teaching methods with the teacher at the center were used. In the experimental group, a learning environment based on learning by doing was created. In this class, the student was taken to the center, activities were organized at all stages of the lesson and active participation of the student in the process was ensured. The participants of the study consisted of two different 4th grade students and a total of 52 students from a primary school in the central district of a province in the Black Sea Region. In addition, within the scope of the study, the parents of these students were included in the process and the parent monitoring test was applied in order to determine the behavioral changes in the students. In the study, the control and experimental group students were first administered a pre-test to measure their prior knowledge, and an achievement test at the end of the process.

3. RESULT AND DISCUSSION

The pre-test, in which we measured the pre-knowledge and readiness of control group and experimental group students, was applied. The post-test was administered 2 weeks after the end of the unit. Table 1 was prepared by taking the averages according to the answers given by the students.

Table 1. Results of Pre and Post Test

	CG	EG
Pre-test	74,42	75,77
Post-test	79,42	80,77

When the pretest results of the students are examined, it is seen that the values are very close to each other. This shows that the readiness level of both samples is quite close to each other.

In the last step of the Transposition Didactic Theory, the taught knowledge comes to the stage of learnt knowledge, and the student constructs the knowledge. The knowledge that has been transposed by the teacher will be shaped and assimilated in the mind of the student in the teaching environment. The achievement test came into play here, aiming to measure the information assimilated.

Table 2. Results of Parent Monitoring Test

	CG	EG
Average Parent Monitoring Test	77,10	86,70

It is understood that EG's learnt knowledge causes more behavioral changes in their daily lives than CG and they use this knowledge.

4. CONCLUSION

The aim of this study is to examine primary school students in the teaching of recycling and the economical use of resources and its importance in the context of knowledge assimilated within the scope of internal didactic transposition theory.In these two samples, it is to investigate whether students transform their learnt knowledge into behavioral changes in their daily lives. Although the same program is aimed in all schools as the knowledge to be taught, different types of taught knowledge emerge. In fact, it is observed that students transform this knowledge into different behaviors by structuring them differently in their minds. In our study, it was observed that the readiness levels of control group and experimental group were very close to each other. While the transposition of the teacher in control group targets the permanence of the learnt knowledge and student success, the transposition of the teacher in experimental group aims at transforming the learnt knowledge into behavior and using it in daily life. When the achievement test results were examined, it was seen that experimental group achieved its goals more. When we examined the results of the parent process monitoring test conducted with the parents of the students, it was seen that experimental group was more successful academically than control group, they used the learnt knowledge more in their daily lives and transformed it into more behaviors. After these results, how much the teacher puts the student in the center of the teacher's transposition until the knowledge to be taught comes to the knowledge that is taught and the knowledge that is learnt, and if we allow the students to find it themselves.

Instead of arguing that the knowledge can be transferred from the teacher or from the textbooks to the students and is independent from the students, the view that the knowledge is structured by the student should be adopted. Instead of expecting all students to reach these goals at the same level by writing traditional goals, approaches and activities such as problem-based learning, cooperative learning, learning by doing should be preferred, in which student responsibility and interaction increase, based on the view that each student constructs knowledge according to himself. Our teachers should aim to make the knowledge permanent and turn it into behavior, put the student at the center, ensure that students enjoy learning by enabling them to communicate effectively with each other, and give them the opportunity to fulfill their responsibilities.

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INVESTIGATION OF THE IMPACT OF GREEN CHEMICAL ACTIVITIES ON PRIMARY SCHOOL STUDENTS' AWARENESS OF THE ENVIRONMENT

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ABSTRACT

With the development of technology and the rapid increase in the world population, the problems of the importance of the 21st century, such as water shortage and environmental questions, have emerged. In this context, it has become essential to teach the concept of environmental awareness to young age groups for environmental askers. This research aims to increase the awareness levels of primary school students with green chemistry activities and to raise individuals with high environmental awareness as individuals of the future. The research was carried out in a primary school in the city of Artvin Turkiye between 2021-2022. The study group is 26 students studying at the 4th-grade level. In order to increase the awareness of the students about environmental problems, five weeks of green chemistry activities developed by the researchers were applied to the students. The research was conducted by a mixed method. In the quantitative dimension of the research, the 44-item 'Awareness for Environmental Problems' scale developed by Güven and Aydoğdu (2012) was used to determine the awareness levels of the students as a measurement tool. The qualitative dimension of the research was carried out with a semi-structured interview form developed by the researchers with the students. The collected data were examined with a statistical program. As a result of the analysis, it was determined that the data showed a significant difference. According to the research results, it was determined that the student's awareness of the environment increased significantly. The student's awareness of their responsibilities towards the environment increased and when the interviewees were examined, they stated that they were more sensitive to the environment and that green chemistry activity was different and enjoyable, increasing their interest in the course

Keywords: Green Chemistry, Environmental Awareness, Environmental Problems

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1. INTRODUCTION

Many reasons such as the rapid increase in the population, the increase in the use of chemical and radioactive substances in production processes, the pollution of the air we breathe, the decrease in the water we drink, the pollution, and the decrease in the quality of the soil have started to be considered as environmental problems. In this context, environmental protection activities have begun. Environmental problems maintain importance in the past and today and always maintain their topicality. Environmental problems pose a threat to both our present and our future. Along with environmental problems, the concept of environmental awareness for environmental problems has also become important. For many years, scientists have been working to combat environmental problems, and it is thought that these studies will continue in the coming years. With the rapid progress of science and technology and the impact of the pandemic process, many people have understood the requirements for healthy living and a livable environment. They have increased their work for a sustainable life. When all these concepts are considered, environmental responsibility for environmental problems has become important along with environmental problems. According to Jensen (2002) [1], it is not enough to have academic knowledge of the environment to gain positive environmental behavior. Individuals must also demonstrate environmental responsibility behavior. Individuals with environmental responsibility can be defined as participants who have basic knowledge about environmental problems, take an active role in their protection, and offer solutions [2].

Humans continue to live together with other living things in the universe. While meeting the needs of a person living in a common area with other living beings, it is very important to balance with all living and inanimate stakeholders in his environment respectfully and harmony with them. Man is also a part of nature, and the protection and development of the ecosystem bear a great responsibility for all living things. Environmental problems have been a significant threat in the past years, affecting every organism, especially today. When all these situations are considered, the importance of protecting the environment has been realized since the beginning of the century we live in, and awareness raising and studies on this issue have increased. [3] One of these studies is the concept of green chemistry, which is also discussed in this study. Green chemistry; Within the scope of combating environmental problems, it has emerged as a current concept in recent years. In addition to eliminating environmental problems, green chemistry started as a pollution prevention movement based primarily on reducing or preventing environmental problems.

What needs to be considered in green chemistry applications and what the applications cover are described in the form of 12 principles in the book Green Chemistry - Theory and Practice written by P. T. Anastas and J. C. Warner, the father of Green Chemistry [4, 5]. These principles are; Prevention of waste, high atomic economy, safe solvents, preference for less harmful chemical syntheses instead of syntheses that are harmful to human and environmental health, development of safe designs that will minimize the harmful effect of the chemicals used, and use of auxiliary chemicals, efficient use of energy in chemical processes in terms of both environment and economy, use of renewable raw materials, reactions will be minimally stepped. These are the 12 principles of safe green chemistry to design, use catalysts, design chemical products harmlessly, prevent pollution, and prevent explosions and fires [6].

When these 12 principles, called green chemistry principles, are examined, the main purpose of green chemistry application is to find valuable models for the environment, minimize the damage and thus ensure sustainable development. Green Chemistry deals with basically all the stages in the life of a substance or material. In other words, there are green chemistry applications in every field of a substance's production, use, and depletion processes. To summarize, green chemistry; The formation of decay, the use of natural chemicals, the reduction of the use of toxic or dangerous chemicals, the prevention of waste formation harmful to nature, the provision of recycling and energy saving, and the prevention of environmental pollution in all processes include studies [6]. Thanks to these studies, individuals' approaches to the environment are changing, and environmental responsibility is strengthened.

In this context, this research aims to increase the environmental awareness levels of the students with green chemistry activities and to raise individuals with high environmental awareness as individuals of the future.

For this purpose, the following research questions were answered;

• Is there a statistically significant difference between the students' pre-test and post-test environmental problems awareness scores to whom the "Green Chemistry" activities are applied?

• What are the students' opinions on the concept of "Green Chemistry"?What is the relationship between environmental science and green chemistry?

2. MATERIAL AND METHODS

This research was conducted with a mixed method for the study. Qualitative research; is defined as research in which qualitative information gathering tools such as observation, interview, and document analysis are used, and a qualitative process is followed for the realistic and holistic handling of perceptions and events in the natural environment [7]. A weak experimental pattern was used to determine the effect of Creswell Green chemistry activities on students' perceptions. When weak experimental design studies are studied with a single group in research, a single group is preferred in educational research as a pretest-posttest pattern [8,9].

The working group of this research is in the spring semester of the 2021-2022 academic year in a primary school located in Hopa District of Artvin province 4. It consists of 26 students studying at grade level. During the study process, the necessary permissions were obtained from the families, the students' names were hidden from an ethical point of view, and the students were Ö1, Ö2, Ö3, ... is encoded. When examined in terms of the demographic characteristics of these students, there are 13 girls and 13 male students.

In order to obtain the data of the research, a semi-structured interview and 44-item 'Environmental Problems Awareness' scale developed by Güven and Aydoğdu (2012) were applied to the students [10]. Paying attention to the age group of the students participating in the research, the number of semi-structured questions was determined as four. These questions are;

- What does it mean to be environmentally friendly?
- What are the environmental benefits of recycling?

- Do you pay attention to the environmental friendliness of your products after your activities?
- As an environmentally friendly individual, do you advise the people around you?

In all these processes, students were informed about the importance of the application to be performed, and the researcher collected the data by making the necessary explanations to the students on a voluntary basis. At the end of the semi-structured interview application, The environmental awareness scale was applied to the students both before and after the application.

The study was conducted for five weeks. In this context, first of all, the parents obtained the necessary permissions, and the 'Environmental Problems Awareness' scale was applied to the students. Later, five different green chemistry activities were developed by the researchers and in which opinions were obtained from two faculty members who are experts in their fields, and the necessary arrangements were made to be applied to the students every week on the condition that one application was in one week. The green chemistry activities used in this study are as follows; 'My Lemon Battery', 'My Natural Gift to My Mother', 'No More Helium', 'My Lava Lamp', and 'Now is the Time for Transformation' events. After the applications were completed, semi-structured interviews with the students and the 'Environmental Problems Awareness scale' were again applied.

For data analysis, data were interpreted with the descriptive analysis method to analyze qualitative data collected in the research. Students' different opinions on the same questions were transferred to the research. The data obtained after the quantitative scale applications of the study were analyzed with SPSS statistical program. While explaining the data obtained in the Findings section, student answers were quoted one-to-one. Validity and reliability studies of the data obtained before the study were conducted. In order to ensure validity and reliability in qualitative research, qualitative data analysis and also to work with experts in the field of research and examine from various angles [11]. In this context, semi-structured interview questions were examined by three faculty members and a class teacher, and the necessary opinions were obtained. In line with these opinions, the interview questions have been updated. As a result of the reliability study conducted by Güven and Aydoğdu (2012), who created the scale for quantitative data, the Cronbach Alpha reliability coefficient of the scale was calculated as 0.90. As a result of the repeated reliability analysis for this study, the Cronbach Alpha reliability coefficient was determined as 0.86.

3. RESULT AND DISCUSSION

According to the answers of the students participating in this research to the semi-structured interview form and the data obtained from the 'Environmental Problems Awareness Scale', it was tried to determine the environmental awareness levels of the students' green chemistry activities.

In this study, descriptive statistics of the student's responses to the "Environmental Problems Awareness" scale, which is applied as a pre-test and post-test, are given in table 1.

Table 1. Environmental Problems Awareness Scale Descriptive Statistics

Implementation Time	N	Min.	Max.	$\bar{X}$	Ss
Pre-test	26	1,81	2,12	1,96	,08
Post- test	26	2,68	3,04	2,86	,09

When Table 1 is examined, 4. The descriptive statistical results of the environmental problems awareness scale applied to the class students are seen. When the preliminary test results of the environmental problems awareness scale were examined, the arithmetic mean was calculated as 1.96, and the arithmetic mean was calculated as 2.86 in the final test. The average student scores have a minimum score of 1.81 for the pre-test and a maximum score of 2.12. The minimum score for the final test results of the students was determined as 2.68, and the maximum score was determined as 3.04. In addition, the standard deviation pre-test score of the environmental problems awareness scale was determined as 0.08, and the final test score was determined as 0.09. In light of these data, the final test average scores have a higher average than the preliminary test score. In addition, to determine the statistical method to be applied to the results of the environmental problems awareness scale test applied to the students, first of all, the normality values of the data were examined, and the normality values were given in table 2.

Table 2. Environmental Issues Awareness Scale Kolmogorow Smirnow Test Results

	Pre-Test Results				Post-Test Results			
	N	$\bar{X}$	S	p	N	$\bar{X}$	S	p
Environmental Problems Awareness Scale	26	1,96	,08	,08	26	2,86	,09	0,13

When Table 2 is examined, the pre-test and post-test normality analysis results of the environmental problems awareness scale test are seen. The pre-test and post-test results of the environmental problems awareness scale test were determined as 0.08 and 0.13, respectively. Since these values are the critical value p>0.05 is large, it was determined that the environmental problems awareness scale pre-test and final test scores showed a normal distribution. In this context, parametric statistical methods will be applied to analyze the environmental problems awareness scale data.

Table 3. Environmental Issues Awareness Scale t-test Results

Dimension	N	$\bar{X}$	Ss	t	p
Pre-Test	26	1,96	,08	7,74	0,00
Post- Test	26	2,86	,09		

As can be seen in Table 3, there is a significant difference between the pre-test and post-test environmental problems awareness scale student scores since the p-value is 0.00 and p.0.05 according to the t-test result. According to this result, when the arithmetic mean scores were examined to determine which student group favored the differentiation, the student post-test scores were 2.86; pre-test scores were 1.96. In light of these data, it was revealed that the post-test arithmetic average score was high in terms of environmental problems awareness scale scores. In this context, it can be interpreted that green chemistry activities have increased students' awareness of environmental problems.

According to the answers of the students participating in the research to the semi-structured interview form, the students' perceptions of green chemistry activities and environmental awareness were determined. In this context, four interview questions were asked to the students after the application, and the researchers, with descriptive analysis, examined the obtained data. At the end of the application, the answers to the first question of the questions directed to the students are given in table 4. When the answers given by the students are analyzed, they cover more than one theme when the sentences are long, so the sums of the answers exceed 100% as a percentage.

Table 4. Students' "What Does It Mean to Be Environmentally Friendly?" Their Answers to the Question

Expressions	Frequency	Percent
Nature Conservation	17	%65
Not Throwing Garbage	11	%42
Animal/Plant Good Behavior	5	%19

When Table 4 is examined, it is determined that the students' expressions of what it means to be environmentally friendly are divided into themes and that they match the expression of environmental friendliness with the theme of protecting nature more. In addition, the students stated that environmentally friendly individuals make the behavior of not throwing garbage and that not harming animals and plants is also environmentally friendly behavior. A few examples of students' answers to this question are as follows;

O1: "*... I have a stray dog, and I feed him, give him water and food, and do not throw any garbage at school and home. After these activities, I told my mother to buy me green toothpaste...*"

Ö4: *"Eco-friendliness means avoiding harmful things and protecting trees, flowers, and animals*."

Table 5. Students are asked, "What are the environmental benefits of recycling?" Their Answers to the Question

Expressions	Frequency	Percent
Protects nature	18	%69
Enrich us/country	7	%27
I'll reuse it	6	%23
Reduction of garbage	2	%8

As seen in Table 5, the students accepted the concept of recycling with a percentage of 69% under the theme of protecting nature, similar to the previous concept of environmental friendliness. They also talked about the contribution of recycling to the country and individual economy. Some students have said that items such as clothing and toys are reused by recycling. Two students stated that recycling reduces garbage and thus prevents damage to the environment.

A few examples of students' answers to this question are as follows;

Ö24: *"My father told me that if I fix a toy, we will have more money; my teacher says that because you repair toys at that event, recycling prevents us from spending money*."

Ö17: "*If we had not framed those CDs in our house and thrown them into the ground, the soil would have been polluted, the environment would have been polluted, and we would not have been able to protect nature. When those CDs were not wasted, nature was protected, and garbage from home was reduced."*

Table 6. Students will ask, "Do you pay attention to the environmental friendliness of the products you use after our activities?" Their Answers to the Question

Expressions	Frequency	Percent
Yes	23	%88
No	2	%8
I do not know	1	%4

As seen in Table 6, they answered yes with a high rate to the question of whether you pay attention to the products you buy after green chemistry activities. Two students did not pay attention to the question, and one student stated that he did not know how to understand that it was environmentally friendly. A few examples of students' answers to this question are as follows;

Ö11: *'... yes, I tell my mother about the light experiment we lit with lemon and I said that batteries harm nature and let us not use batteries anymore and let us operate the controls with lemon.'*

Ö7: *'I do not know which environmentally friendly products, so I do not know how to buy them'*

Table 7. Students will be asked, "As an eco-friendly individual, do you offer advice to the people around you?" Their Answers to the Question

Expressions	Frequency	Percent
Yes I recommend	20	%77
I want to suggest but I can't suggest	6	%23

As seen in Table 7, after the green chemistry activities, they answered yes with a high percentage to the question do you make suggestions to the individuals around you. 23% said they wanted to make a suggestion but could not propose it.

A few examples of students' answers to this question are as follows;

Ö13: *"When we made natural detergent, we gave it to our mother as a gift, or my teacher taught that experiment to my aunt, and they will do that experiment, and they will be healthy*."

Ö14: *"My mother was tired of blowing balloons on my birthday, so I told my mother that if we bought vinegar and experimented, the balloon would inflate on its own*."

4. CONCLUSION

Students who participated in this research gained environmental awareness through green chemistry activities and increased their awareness of the environment. The world is struggling to survive pollution, so it must be ensured that the future adults are raised as environmentally conscious and conscious people. For this purpose, green chemistry activities can be preferred to increase the level of knowledge of individuals about the environment and to raise environmental awareness. Green chemistry mainly includes activities aimed at protecting the environment. Green chemistry-themed practices affect the quality of life and sustainable development [12].

After the green chemistry activities in this research, it can be said that primary school students increased their awareness levels of environmental problems. It was revealed that the significant differentiation of the data obtained from the awareness scale for environmental problems applied to the students before and after the event and the realization of this differentiation on the final test score positively affected the applied activities. In addition, in the interviews with the students after the application, it was determined that there was a positive increase in the student's awareness of environmental awareness and environmental problems. In particular, the number of students who discuss green chemistry activities and environment-friendly concepts under nature protection is relatively high. There are few studies in the literature on green chemistry applications, and assuming that the field of green chemistry is a current field, this result is considered quite normal. It is hoped that the number of studies will increase over time. In this context, when the studies reached in the literature were examined, green chemistry activities were applied to the 5-6 age group within the project scope carried out by Çubuk and Çubuk (2017), and their effects on environmental awareness and attitude were examined [13]. According to the project results, it was revealed that it increased the environmental awareness and attitudes of the students at a positive level. In a study by Karagölge, Ceyhun, and Arıcı (2019), the effects of context-based green chemistry applications on the environmental awareness and sustainability of the students were examined. It was found that the students attracted the attention of all the students who participated in the research after the application and successfully developed sustainability and green chemistry awareness [14-15]. The results obtained in these studies are in parallel with this study.

When it comes to environmental issues, every individual needs to have sensitivity. When it comes to environmental responsibility, all stakeholders around small individuals, such as schools, societies, and media, especially the family, should develop a positive attitude towards the environment and gain environmental responsibility. Green chemistry activities can be preferred to raise awareness of the environment. Environmental literacy can be encouraged with green chemistry education, and appropriate skills can be developed. In addition, individuals can acquire these skills at an early age. Therefore, attention should be paid to acquiring these activities for the students in the early period.

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QUALIFIED PRACTICES FROM TEACHERS' OWN EDUCATIONAL APPROACHES (KEY) IN IMPROVEMENT OF EDUCATIONAL QUALITY: ENVIRONMENTAL AWARENESS

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ABSTRACT

This study is an output of the project of "Sharing and Disseminating Best Practices of Teachers in Increasing the Quality of Education" carried out within the scope of TÜBİTAK 1003-Priority Areas R&D Projects Support Programme. With this project, it is aimed to reveal and disseminate the Own Educational Approaches (KEY) used by effective teachers who conduct science courses in their lessons. Within the scope of the project, classroom and secondary school science teachers who take part in the science courses in the schools affiliated to the Ministry of National Education in Samsun were interviewed. In total, 630 teachers from 17 districts were interviewed. Teachers were asked to send their lesson presentations to the project team by determining their own Educational Approaches (KEY) that they expressed effectively. The presentations sent by 198 teachers were examined by field experts who are project consultants. Field experts evaluated KEYs according to purpose/target, content, educational status, measurement and evaluation, in-class education-teaching processes and their effects on students' learning outcomes, and 148 of them were qualified as KEY. Lesson plans containing 43 achievements for grades 3-8 were prepared by teachers. When the achievements of the KEY for Environmental Awareness are examined, "F.3.6.1.2. Presents the results of the observation of the life cycle of a plant, F.3.5.2.1. Classifies the light sources around him as natural and artificial light sources, F.5.6.1.1.Question the importance of biodiversity for natural life, F.7.1.1.2. Expresses the causes of space pollution and estimates the possible consequences of this pollution, F.8.6.4.1. Pays attention to be economical in the use of resources, F.8.6.4.2. Designs projects for the efficient use of resources, F.8.6.3.3. It discusses the causes and possible consequences of global climate changes." It has been seen that appropriate plans for the gains have been developed. In addition to the importance of the environment issue in our century, it is seen that less number of activities are carried out among the effective lessons. For this purpose, it is thought that it is important to disseminate these KEYs, which were developed by teachers and determined to be effective by experts. In this research, the studies carried out to create and improve effective examples designed by teachers and developed by academicians will be conveyed, and sample KEYs will be shared.

Keywords: Teacher Qualifications, TÜBITAK, Own Educational Approaches, Environmental Awareness

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1. INTRODUCTION

Teachers are one of the most important parts of education systems. Because teachers have important roles in reaching the goals of the education process (Delice, Ertekin, Aydın, & Dilmaç, 2009). The reason for this situation is that teachers are one of the most important elements that affect the entire education process (Çetin, Bağçeci, Kinay, & Şimşek, 2013). This responsibility causes the expectations of all segments to rise from teachers. Considering that the teacher is the central and key person of the teaching-learning process, it is a fact that the quality of education and the effectiveness of the teacher are related (Himabindu, 2012).According to Güzel, Özdöl, & Oral (2010) and Villegas-Reimers (2003), teachers have important and meaningful roles in the success and development of education systems. Moreover, the influence of teachers on students is not short-term, but important enough to last a lifetime (Tatar, 2004). In this process, the qualifications of teachers come to the fore. Qualifications sought in teachers have been both the problem and the target of not only today's but also the past (Kavcar, 1980). According to the General Competencies for Teaching Profession prepared by the Ministry of National Education, there are three areas of competence that teachers are expected to have: a) professional knowledge, b) professional skills, c) attitudes and values (MEB, 2017). Professional information; field knowledge, field education knowledge and legislative knowledge. professional skills; education-teaching planning, creating learning environments, managing the teaching and learning process, and measurement and evaluation.Attitudes and values; national, spiritual and universal values, approach to students, communication and cooperation, personal and professional development. Teachers are expected to be competent in all areas of competence. However, the results of the research show that the professional qualities of the teachers rather than their personal qualities are effective in the behavioral change in students (Wenglinsky, 2000). It is accepted that teachers who can manage these professional qualifications well are effective, and those who cannot manage well are ineffective. Walls, Nardi, von Minden, and Hoffman (2002) stated that effective teachers are able to create an effective learning environment and stated that this environment is organized, prepared and open. They stated that ineffective teachers constantly create inappropriate activities, boring lessons and unproductive learning environments.

Professional skills; Educational planning, creating learning environments, managing the teaching and learning process, and measurement and evaluation dimensions are important in teachers' qualified lesson planning. In this respect, revealing and disseminating qualified lesson plans will make many contributions to trainers. The teaching profession and expectations about what teachers should know and do have a dynamic feature that changes constantly (Karataş, Ardıç, & Oral, 2017). Darling-Hammond, Wise, and Klein (1999) stated that education has changed towards higher-order thinking and transforming knowledge into performance, and society's expectations from teachers have changed in this direction.It is also stated by UNESCO (2005) that the education between 2005-2014 should be oriented towards sustainable development; therefore, it was emphasized that teachers should gain these skills. In recent years, it has been stated that innovation and entrepreneurship are at the forefront and it is necessary to focus on these skills in order to plan the future (Jegstad & Sinnes, 2015). In order to achieve this, serious support from teachers is required. In countries where the knowledge of the students can be transformed into performance and these can be seen in exams such as TIMSS and PISA, the common feature is the effective teacher factor (Barber & Mourshed, 2007; UNESCO, 2015). In Turkey, approximately 1 million teachers work in the compulsory education process.

In addition to the updated curricula, factors such as teacher appointments, changes in the teaching profession in the process within the profession, and the economic level of teachers are among the serious obstacles to an in-depth understanding of the effective teacher issue. Holiday times, working hours, salaries and social status of teachers are discussed in social media rather than the quality of teachers (Ekşi Sözlük, 2018, 2022 https://eksisozluk.com/). Many studies such as General Competencies for Teaching Profession, Teacher Strategy Document, School-Based Professional Development Model are carried out by the Ministry of National Education and other institutions to increase the quality of the teaching profession. It is quite difficult to determine exactly how effective these efforts are, as there are many factors affecting the process. In this context, TÜBİTAK announced a project titled "Improving the Quality of Education through the Improvement of Teacher Qualification" in 2018. They aimed to support the improvement of the quality of education by suggesting applicable solutions to the chronic problems in the education process. Clear and concrete data will be obtained from the field with the evidence-based information to be obtained from these projects, rather than wishes and wishes and theoretical information. Because every reform in the curriculum in our country is planned in order to correct the whole education process from the beginning. For this purpose, it is aimed to determine and disseminate the effective lesson plans that teachers apply in their classrooms.

Developing effective lesson plans is actually an indicator of what subjects the teacher is thinking about and working by doing research. The subject in which teachers develop effective lesson plans of their own can actually be considered as a process for a better understanding of the subjects they see as a problem. In this context, in the project, which was carried out in order to reach teachers who prepare effective plans in science lessons and to disseminate these plans, it is investigated whether environmental awareness is emphasized in effective lesson plans. In this context, it was examined which of the collected plans were aimed at environmental awareness. In this context, it will be determined by this study whether the teachers are doing effective and different studies on environmental awareness. Environmental studies concern the whole society. Because today, the common denominator of humanity is climate change, global warming, the melting of glaciers, the changes that will bring the end of humanity, such as the extinction of species, are constantly expressed in media channels. While there are measures that each individual can take for himself and behavioral changes he can make, many people always expect things to be done from others. It is thought that this waiting situation between the environment and people can be resolved by taking responsibility, acting consciously and respecting nature and the environment, rather than a relationship that can be corrected by rules and laws. Change will be possible with effective lesson plans given by teachers. An effective environmental education that will appeal to all segments of the society will be beneficial in the short and long term, so that people will both take part in the solution of the environmental problems they cause and will prevent the problems from occurring radically by changing their behavior (Tanriverdi, 2009). For this purpose, it is aimed to determine the ones for Environmental Awareness among the KEYs obtained from the TUBITAK project titled "Sharing and Disseminating the Best Practices of Teachers in Increasing Educational Quality", which was supported by the 1003-Priority Areas R&D Projects Support Program, and to share and disseminate an exemplary plan.

2. MATERIAL AND METHODS

This study was conducted with a multiple case study, one of the qualitative research methods. The participants of the study were determined by two different sampling methods, which are the criterion sampling method and easily accessible sampling method.

2.1. Working Group

They are the primary and secondary school science teachers who teach science courses in the schools affiliated to the Ministry of National Education in Samsun. It is also aimed to reach retired teachers who are recommended to go to all schools in Samsun. In this context, in the districts of Samsun, spruce (9), Asarcık (8), Atakum (19), Ayvacık (5), Bafra (29), Canik (19), Çarşamba (16), Havza (13), Ilkadim (29), Kavak (7), Ladik (4), Salipazari (8), Tekkeköy (18), Terme (18), Vezirköprü (40), Yakakent (4), Ondokuz Mayıs (10) 256 school related A detailed excel plan has been prepared. The relevant schools were visited one by one, and the classroom and science teachers who were there that day were interviewed. A total of 630 teachers from 17 districts constitute the study group.

2.2. Data Collection Tools

Teacher Interview Form: The data of the research were obtained with the interview form. Data were collected face-to-face during the Covid-19 pandemic period. The questions in the data collection tool were developed by the researchers, taking into account the relevant literature (Buaraphan, 2012; Booth & Coles, 2017; Walls et al., 2002). For the created form, the opinions of field and language experts were taken and the items were arranged in line with these opinions. An example question is below.

 Are there different methods, strategies, achievements or content that you teach in your lessons?

Teacher Lesson Plan Request Form: After the interviews with the teachers, the plans that were thought to have different lesson plans in terms of method, strategy and learning were requested from the teachers. The requested form was created by the researchers. The requested form image is included in Annex 1.

Consultant Content Evaluation Form: Video links and lesson plans were sent to the consultants and they were asked to evaluate the following questions and the observation form.

 What are Good Practice Characteristics for you?

 Could you briefly describe whether the plan of each of our teachers has the characteristics of Good Practices?

Teaching Process Observation Form: All researchers and consultants were requested to fill in the relevant documents and forms. The teaching process observation form (Appendix 2) was developed by the researchers and was finalized by taking expert opinion. Then, the observation reports of the researchers and consultants were examined and studies with KEY quality were determined.

2.3. Process

Within the scope of the project, classroom and secondary school science teachers who take part in the science lessons in the schools affiliated to the Ministry of Education in the center and districts of Samsun were interviewed. In total, 630 teachers from 17 districts were interviewed. After the interviews with 630 teachers, their own Education Approaches (KEY) that the teachers expressed effectively were determined and they were asked to send their lesson presentations to the project team. Considering 198 calls from teachers, they sent their own presentations. These lesson plans and video links prepared by the teachers were shared with the researchers and consultants working in the project, and they were asked to examine the sections related to their fields.

The presentations sent by the teachers were sent to the field experts who are the project consultants. Field experts were asked to evaluate KEYs according to purpose/target, content, educational status, measurement and evaluation, in-class education-teaching processes and students' learning outcomes. Field experts evaluated KEYs according to purpose/target, content, educational status, measurement and evaluation, in-class education-teaching processes and their effects on students' learning outcomes, and 148 of them were qualified as KEY.

2.4. Data Analysis Process

The objectives of 148 studies, which were developed by effective teachers and determined as KEY by academicians who are experts in their fields, were examined by researchers. As a result of the examinations 3-8. It has been determined that the Science KEY activities developed at the grade level cover 43 acquisitions in total. Those that may be directly or indirectly related to the environment are listed below according to their grade levels. (Source for achievements: Science Curriculum, 2018).

3rd Class Achievements

F.3.4.1.1. Explains the basic properties that characterize matter by using five senses.

F.3.5.2.1. He classifies the light sources around him as natural and artificial light sources.

4th Class Achievements

F.4.1.1.1. It states that the land layer of the earth's crust consists of rocks.

F.4.1.1.2. Relates rocks to mines and discusses the importance of rocks as raw materials.

F.4.1.1.3. Explain the formation of fossils.

F.4.1.2.1. Explain the difference between the rotation and rotation of the Earth.

F.4.1.2.2. Explain the events that occur as a result of the movements of the Earth.

F.4.4.3.1. Compares the basic properties of the states of matter.

F.4.3.1. Realizes the effect of force on objects.

5th Class Achievements

F.5.1.1.Explains the properties of the sun.

F.5.2.1. Knows the functions of root, stem, leaf and flower, which are parts of a flowering plant.

F.5.4.1.1 Makes inferences based on the data obtained from the experiments he has conducted to show that substances can change state with the effect of heat.

F.5.4.3.2. Interprets the results by making experiments on heat exchange as a result of mixing liquids with different temperatures.

F.5.4.4.1. Discusses the results of the experiments by conducting experiments on the expansion and contraction of substances under the influence of heat.

F.5.5.3.1. It classifies materials according to their light transmittance.

F.5.5.4.1. He demonstrates with simple ray drawings by observing how the full shadow is formed.

F.5.6.1.1. Question the importance of biodiversity for natural life

F.5.5.4.2. Explores by experimenting with the variables that affect the full shade.

6th Class Achievements

F.6.6.3.1. Discusses what needs to be done for the health of systems based on research data.

F.6.7.2.1. Predicts the variables on which the brightness of the light bulb depends on in an electrical circuit and discovers by trying their predictions.

F.6.4.3.1. Classifies materials in terms of heat conduction.

F.6.4.3.2. It determines the selection criteria of thermal insulation materials used in buildings.

F.6.4.3.3. Develops alternative thermal insulation materials.

F.6.4.3.4. Discusses the importance of thermal insulation in buildings in terms of family and country economy and effective use of resources.

F.6.4.2.1. Defines density.

7th Class Achievements

F.7.6.2.2. Explains the growth and development processes of plants and animals by giving examples.

F.7.4.5.1. Distinguish between recyclable and non-recyclable materials in household waste.

F.7.4.5.2. Designs a project for the recycling of domestic solid and liquid wastes.

F.7.4.5.3. It questions recycling in terms of effective use of resources.

F.7.7.1.2. Observes the brightness of the bulbs on the circuit when they are connected in series and parallel

F.7.4.2.2. It expresses the names, symbols and some usage areas of the first 18 elements and common elements (gold, silver, copper, zinc, lead, mercury, platinum, iron and iodine) in the periodic system.

8th Grade Achievements

F.8.4.1.1. Explains how groups and periods are formed in the periodic system.

F.8.4.1.2. Classifies elements as metals, semi-metals and nonmetals on the periodic table.

F.8.4.4.3.Uses materials that can be reached in daily life as acid-base separators.

F.8.6.4.1. It takes care to be economical in the use of resources.

F.8.6.4.2. Designs projects for the efficient use of resources.

F.8.6.3.3. Discuss the causes and possible consequences of global climate changes

Environmental Benefits

F.3.6.1.2. It presents the results of observation of a plant's life cycle.

F.3.5.2.1. He classifies the light sources around him as natural and artificial light sources.

F.5.6.1.1.Question the importance of biodiversity for natural life.

F.7.1.1.2. Expresses the causes of space pollution and predicts the possible consequences of this pollution.

F.8.6.4.1. It takes care to be economical in the use of resources.

F.8.6.4.2. Designs projects for the efficient use of resources.

F.8.6.3.3.Discuss the causes and possible consequences of global climate changes. They have developed effective plans suitable for the gains.

3. RESULT AND DISCUSSION

It has been determined that 43 of the 305 acquisitions of the Science course in the 3rd and 8th grades of the curriculum that entered into force in 2018 are under the subject area of Living things and Life and related to the environment. It has been revealed that 148 KEYs examined within the scope of the study are associated with 7 of these 43 acquisitions. In other words, it has been understood that 148 KEY developed by the teachers is directly related to the 7 acquisitions of the Science Lesson. This shows that the KEYs produced by teachers are generally aimed at similar acquisitions. In addition, it can be concluded that the majority of the acquisitions in the curriculum are not suitable for producing KEY. Perhaps, it can be thought that similar studies have been carried out because research is generally done using search engines such as Google to produce KEY.

When the objectives of the teachers' achievements are examined, it is seen that they aim to support the studies that promote conscious water consumption by creating awareness about the effect of the products used in daily life on the water footprint. Even if necessary studies have been carried out for environmental awareness, it is seen that there are deficiencies in this regard. It has been determined that by understanding the meaning of this concept in CEEs developed for biodiversity, they aim to arouse curiosity in them by giving examples of the factors that threaten living things, extinct or endangered creatures, that each living thing should continue its existence in natural life for a purpose. It has been determined that they conduct debate studies asking students to think about the causes and possible consequences of global climate changes. It is seen that different and applied studies have not been carried out. It is thought that teachers may have problems in developing an activity plan using applied and different approaches. It is thought that the reason for this situation is that the time allocated for the achievements is not sufficient and the workload given to the teachers is high.

According to Zelezny and Schult, environmental consciousness "represents psychological factors related to individuals' attitudes and evaluations towards the natural environment". In the study conducted by Yücel et al., in 2008, environmental awareness was explained as "the development of environmental awareness in individuals in order not to harm the natural environment and to leave a clean environment for future generations". Individuals with a high level of environmental awareness are more concerned about environmental degradation and other environmental problems, and their tendency to be sensitive to environmental problems increases significantly (Dunlap and Jones, 2002). When the relevant literature is examined, it has been revealed that individuals with environmental awareness exhibit more environmentally friendly behaviors (Cheema et al., 2020). It is thought that studies on environmental awareness obtained from teachers are limited and different studies on more environmental awareness should be planned. The more activities students are exposed to environmental awareness, the more their interest in that subject will be drawn.

4. CONCLUSION

In this study, the activities developed by the teachers and proven to be KEY with expert opinions are discussed in the context of the environment. In this context, it was seen that 7 acquisitions in the curriculum were included in the activities developed for direct environmental gains. It is seen that two of these gains are at the third grade level, one at the fifth grade level, one at the seventh grade level and three at the eighth grade level. It has been observed that in the KEYs developed by the teachers, an acquisition related to the environment at the 4th grade level is not addressed. Although there are 7 acquisitions that can be associated with environmental issues at the fourth grade level, the inability to reach an activity with the quality of KEY related to the environment at this grade level indicates a deficiency in the field. In addition, it is one of the remarkable results that the ratio of the number of achievements discussed at other grade levels to the total number of achievements is low. When the objectives specified in the Science Curriculum by the Ministry of National Education are examined, it can be seen that 6 of the 10 determined objectives are directly related to the environment (Science Education Program, 2018). The science curriculum aims to raise individuals who are knowledgeable about environmental issues, have strong relations with nature and the environment, understand and strive to solve environmental problems, realize the interaction between the individual and the environment, adopt the philosophy of sustainability and protect natural resources. It is a negative situation for teachers that there are few effective methods and techniques developed to achieve achievements in environmental issues, which are so important in terms of science teaching. The results obtained from this study can be interpreted as a sign of inadequacy in addressing such an important issue.

For this purpose, it is thought that it is important to disseminate these KEYs developed by teachers and determined to be effective by experts. Thus, teachers can produce similar or original new KEYs in the light of the sample applications to be delivered to them and contribute to the elimination of this deficiency in the field. As a result of the related study, an example of an applied plan that has the quality of KEY in the activities carried out by the teachers is presented in Appendix 3.

ACKNOWLEDGEMENT

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EK 1

Oğretmen Adı Soyadı:	
Okul:	
Sınıf:	
Unite:	
Konu:	
Süre:	
Yaklaşım/Yöntem/Teknik:	
Kazanımlar:	
Kullanılan Araç-Gereçler:	
Işlem Basamakları (Bir dersin başından sonuna kadar yaptığınız işlemleri basamaklar halinde yazınız):	1.
Olçme ve Değerlendirme (Öğrenci kazanımlarını nasıl ortaya çıkardığınızı açıklayınız):	
Iyi Ornek Ozellikleri (Bu uygulamanın niçin iyi örnek olduğunu açıklayınız):	
Kaynak (Bu uygulama kendinize mi ait yoksa başka uygulamalar/kişilerden alarak mı geliştirdiğinizi açıklayınız)	

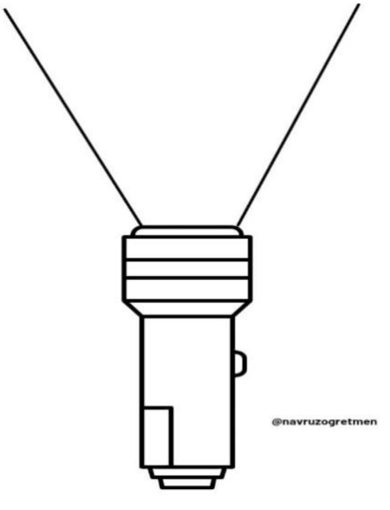
EK 2

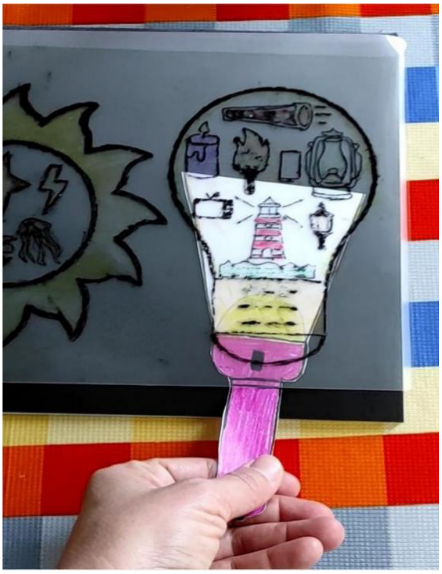
	Öğretim süreci Gözlem Formu	Çok Kötü	Kötü	Orta	İyi	Çok İyi
	İLETİŞİM- MOTİVASYON					
1	Öğrencilerin derse karşı ilgilerini çekme	(1)	(2)	(3)	(4)	(5)
2	Öğrencilerin konuları öğrenmeleri için fırsat ve zaman verme	(1)	(2)	(3)	(4)	(5)
	Soru Sorma					
3	Sınıfta tartışma ortamları oluşturma	(1)	(2)	(3)	(4)	(5)
4	Açık uçlu sorular sorma	(1)	(2)	(3)	(4)	(5)
5	Öğrencilerin düşünmelerine sevk eden sorular sorma	(1)	(2)	(3)	(4)	(5)
	Alana hakimiyet – Uygulama					
6	Ders konularını gerçek olaylarla bağdaştırma	(1)	(2)	(3)	(4)	(5)
7	Derslerde alternatif öğretim yöntemleri kullanma	(1)	(2)	(3)	(4)	(5)
	Öğrenci İle İlgili Boyutlar					
8	Öğrencileri hedef ve davranışlardan haberdar etme	(1)	(2)	(3)	(4)	(5)
9	Öğrencilerin bireysel farklılıklarından yararlanma	(1)	(2)	(3)	(4)	(5)
10	Öğrencilerin fikirlerine ve ürettiklerine önem verme	(1)	(2)	(3)	(4)	(5)
	Öğretimi Planlama ile İlgili Boyutlar					
11	Etkinliklerde bütün öğrencilere görev verme	(1)	(2)	(3)	(4)	(5)
12	Öğrencilerin öğrenecek oldukları konuyu niçin öğreneceklerinin açıklanma	(1)	(2)	(3)	(4)	(5)
	Öğretim Süreci İle İlgili Boyutlar					
13	Öğrencileri farklı ve yeni bir şeyler ortaya koymak için destekleme	(1)	(2)	(3)	(4)	(5)
14	Öğrencilerin konuya farklı bakış açıları ile yaklaşmasına ortam sağlama	(1)	(2)	(3)	(4)	(5)
15	Etkinlikler arasında bağlantı kurmaları için öğrencilere fırsat sağlama	(1)	(2)	(3)	(4)	(5)
	Ölçme ve Değerlendirme İle İlgili Boyutlar					
16	Öğrencilerin etkinliklerine geri bildirim verme	(1)	(2)	(3)	(4)	(5)

EK 3

NAVRUZ DEMİR	ÇARŞAMBA KOCATEPE İLKOKULU / ÇARŞAMBA/ SAMSUN
Ünite:	Çevremizdeki ses ve ışık
Sınıf Düzeyi:	3.sınıf
Konu:	Işığın görmedeki rolü
Süre:	40 dk.
İlgili Kazanımlar:	Çevresindeki ışık kaynaklarını doğal ve yapay ışık kaynakları şeklinde sınıflandırır.
Kullanılan Araç-Gereçler:	Işık kaynakları şablonu
KEY' in Adı:	Doğal ve yapay ışık kaynakları
Geliştirdiğiniz KEY' in Amacı:	Doğal ve yapay ışık kaynaklarını ilgili görsellerle sınıflandırmak.
Geliştirdiğiniz KEY' in Aşamaları:	Öğrenciler şablon ile iki farklı uygulama yapabilir. Birincisi şablonu uygun bir biçimde boyayıp sınıf panosuna veya tavana asabilir. İkinci olarak ışığın görmedeki rolünü kavramak için karanlık bir ortamda önceden hazırlanmış saydam ile çalışabilir. Boyama sayfası şeffaf dosya içine konur ve çıkmayan bir boya görselin üzerinden geçilir. Boyama sayfası çıkarılıp içine siyah karton konur. El feneri görseli şeffaf dosya içinde hareket ettirilerek ışığın görmedeki önemi kavratılır.

Geliştirdiğiniz KEY’e İlişkin Görseller:





KEY' in En Önemli Özellikleri ve Farklılıkları Nelerdir?	Doğal ve yapay ışıkların ana görsel içinde gruplandırılması sınıflandırma yapmayı kolaylaştırdı. Ampul içindeki yapay ışık kaynakları öğrencilerin isteği üzerine tavana asıldı bu sayede çağrışım imkânı oldu. Konuya ışığın görmedeki rolü için yapılan deney ile giriş yapılması görme için sadece gözün yeterli olmadığını pekiştirdi.

CHAPTER 5

Climate Change and Energy

HYDROGEN ENERGY IN THE EU GREEN DEAL HARMONIZATION PROCESS

Nuri Azbar[1*], Cansu Mayaoğlu Akın[2]

ABSTRACT

Climate change and environmental degradation in parallel are an existential threat to whole world. To combat and overcome these challenges, the European Green Deal has taken a radical action to transform the EU into a modern, resource-efficient and competitive economy, ensuring: no net emissions of greenhouse gases by 2050; economic growth decoupled from resource use; no person and no place left behind. In order to realize the target to be Europe climate neutral by 2050, the Commission proposed the European Climate Law, which also sets more ambitious net greenhouse gas emissions reduction target of at least-55% by 2030, compared to 1990 levels. This dictates a groundbreaking change in energy consumption habit of humankind. In this regard, hydrogen seems to be a great game changer with its endless production potential and zero emissions after use.

Keywords: Green Deal, Net Zero Carbon, Renewable Energy, Hydrogen, Carbon Footprint

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1. INTRODUCTION

The world is in a climate emergency – "a code red for humanity" according to the UN Secretary-General. The concentration of greenhouse gas (GHG) emissions in the atmosphere is wreaking havoc across the world and threatening lives, economies, health and food. The world is far from securing a global temperature rise to below 2°C as promised in the Paris Agreement. With a baseline in 1990, some countries are emitting more, some the same and others are emitting less. To limit global temperature rise to below 2°C aiming for 1.5°C, as promised in the Paris Agreement, countries must cut 30 gigatonnes of GHG emissions annually by 2030. The necessary solutions exist yet currently more emissions are entering the atmosphere making it harder to keep the planet safe The European Commission adopted a set of proposals to make the EU's climate, energy, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. According to these new legal arrangements, not only EU but also almost whole world is supposed to monitor and seek alternative energy sources to cut carbon emissions tremendously before 2050. In order to achieve the de-carbonization objectives, carbon emissions must be reduced in all sectors, from industry and energy, to transport and farming. Climate change is a global threat and can only be addressed by a global response. That is why the EU actively engages and supports its international partners on climate action, in particular through the UN Framework Convention of Climate Change (UNFCCC) and its Paris Agreement. In parallel to mitigation actions, the EU is taking action on climate adaptation, to face the unavoidable impacts of climate change. Renewable energy resources from solar, wind, biomass and hydraulic provide great potential to realize these targets. On the other hand, hydrogen as an endless production potential is considered as a game changer since it can be produced from all year long by using renewable energy alternatives and the beauty of this approach is that the end-product of hydrogen after use is only water vapor. In this paper, various aspects of EU Green Deal and hydrogen as an energy carrier will be discussed.

2. CRUCIAL COMPONENTS OF EU GREEN DEAL

Climate change is the biggest challenge of our times in human history. Moreover, it is an opportunity to build a new economic model.All 27 EU Member States committed to turning the EU into the first climate neutral continent by 2050. To get there, A common goal to reduce emissions by at least 55% by 2030, compared to 1990 levels was accepted. This will create new opportunities for innovation and investment and jobs, as well as reduce emissions, create new jobs and growth, address energy poverty, reduce external energy dependency, improve our health and wellbeing. At the same time, it will ensure there are opportunities for everyone, supporting vulnerable citizens by tackling inequality and energy poverty. Figure 1 shows the crucial components of Eu Green Deal. It is obvious that EU alone will never be able to provide a solution by Green Deal unless it can create a multiplier effect all over the world.

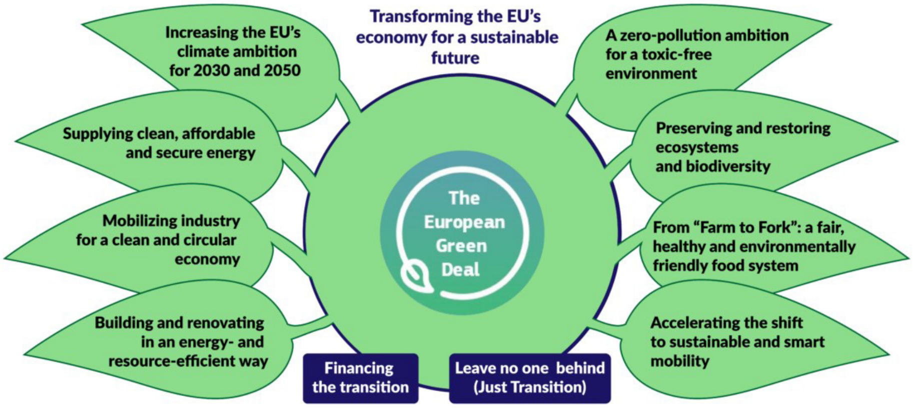

Figure 1. Crucial components of EU Green Deal (https://www.gisreportsonline.com/r/european-green-deal/)

Some of these crucial steps in realizing EU Green Deal are summarized in following sections.

2.1. Making Transport Sustainable for All

The European Commission proposes more ambitious targets for reducing the CO_2 emissions of new cars and vans (55% reduction of emissions from cars by 2030; 50% reduction of emissions from vans by 2030;0 emissions from new cars by 2035). The Commission also promotes the growth of the market for zero- and low- emissions vehicles. In particular, it seeks to ensure that citizens have the infrastructure they need to charge these vehicles, for short and long journeys.

In addition, from 2026, road transport will be covered by emissions trading, putting a price on pollution, stimulating cleaner fuel use, and re-investing in clean technologies. The Commission is also proposing carbon pricing for the aviation sector, which benefited from an exception until now. It is also proposing to promote sustainable aviation fuels – with an obligation for planes to take on sustainable blended fuels for all departures from EU airports. To ensure a fair contribution from the maritime sector to the effort to de-carbonize our economy, the Commission proposes to extend carbon pricing to this sector. The Commission will also set targets for major ports to serve vessels with onshore power, reducing the use of polluting fuels that also harm local air quality ([1] Amendment of the Regulation setting CO_2 emission standards for cars and vans 14 July 2021;https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en).

2.2. Leading the Third Industrial Revolution

The green transition presents a major opportunity for European industry by creating markets for clean technologies and products. These new proposals will have an impact across entire value chains in sectors such as energy and transport, and construction and renovation, helping create sustainable, local and well-paid jobs across Europe (35 million buildings could be renovated by 2030; 160,000 additional green jobs could be created in the construction sector by 2030). The electrification of the economy and the greater use of renewable energy are expected to generate higher employment in these sectors. Increasing the energy efficiency of buildings will also create jobs in construction, with local labour in higher demand. Therefore, the Commission proposes a mechanism to charge a carbon tax to companies importing into the EU. In this manner, both corporate and product carbon foot print management will be tremendously important to comply with the EU Green Deal targets for both 2030 and 2050 ([2] Carbon border adjustment mechanism -14 July 2021;https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en).

2.3. Cleaning Our Energy System

Reducing greenhouse gas emissions by at least 55% by 2030 requires higher shares of renewable energy and greater energy efficiency. The Commission proposes to increase the binding target of renewable sources in the EU's energy mix to 40%. The proposals promote the uptake of renewable fuels, such as hydrogen in industry and transport, with additional targets.In addition, reducing energy consumption is essential to bring down both emissions and energy costs for consumers and industry. The Commission proposes to increase energy efficiency targets at EU level and make them binding, to achieve by 2030 an overall reduction of 36-39% for final and primary energy consumption (40% new renewable energy target for 2030;36-39%

new 2030 energy efficiency targets for final and primary energy consumption) ([3]Strategic rollout plan to support rapid deployment of alternative fuels infrastructure-14 July 2021; https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en).

2.4. Renovating Buildings for Greener Lifestyles

Renovating our homes and buildings will save energy, protect against extremes of heat or cold and tackle energy poverty.The Commission proposes to: require Member States to renovate at least 3% of the total floor area of all public buildings annually set a benchmark of 49% of renewables in buildings by 2030 require Member States to increase the use of renewable energy in heating and cooling by +1.1 percentage points each year, until 2030

2.5. Working With Nature to Protect Our Planet and Health

Restoring nature and enabling biodiversity to thrive again offers a quick and cheap solution to absorb and store carbon. The Commission proposes therefore to restore Europe's forests, soils, wetlands and peatlands. This will increase absorption of CO_2 and will make our environment more resilient to climate change. A circular and sustainable management of these resources will

improve our living conditions; maintain a healthy environment; create quality jobs provide sustainable energy resources ([4] Revision of the Regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry 14 July 2021; https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en) .

2.6. Boosting Global Climate Action

The European Green Deal has already set a positive example and led major international partners to set their own target dates for climate neutrality. With investment in renewable energy technologies, good example are presented for the benefit of the rest of the world. With the shift to green transport, a tremendous reduction in both maritime transport and aviation around the world will be realized ([5] FuelEU Maritime – green European maritime space 14 July 2021;https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en).

3. HYDROGEN AS A NET ZERO ENERGY CARRIER

Hydrogen is a critical component in petroleum refining, glass purification, semiconductor manufacturing, rocket fuel, the steel industry, many pharmaceutical products, and fertilizer production. Globally, about 55% of the world's hydrogen goes towards ammonia (NH_3) production, which is critical for the agroindustry. Refineries take a 25% share, another 10% goes to methanol production, and the remaining 10% is distributed across other operations.In the global effort to meet our climate targets and lower carbon emissions, carbon-free hydrogen has been missing in action. Fortunately, governments and businesses are increasingly looking to clean the production of H_2 and promote it as a climate-change champion.

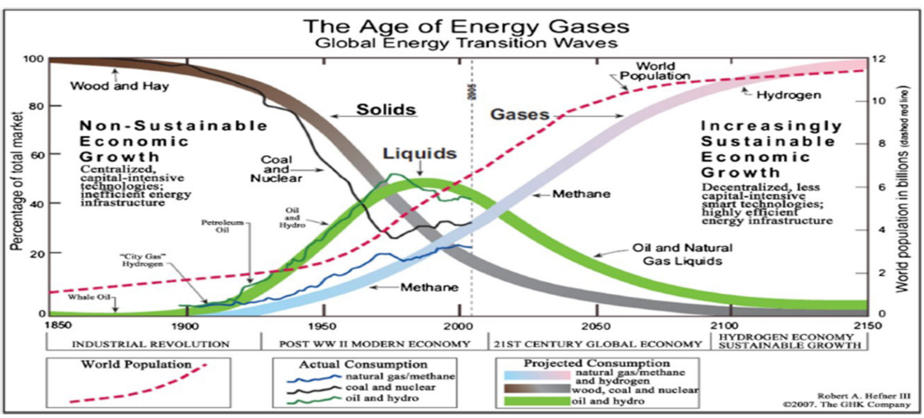

Figure 2. Global energy system transition: from 1850-2150 [6]

3.1. Colors of Hydrogen

Currently, over 90% of global hydrogen production comes from fossil fuels and the end products of many hydrogen applications are heavy carbon dioxide emitters. That has to change in the near future, as there is strong global interest in hydrogen decarbonization and a push to use renewable green energy on both ends of the production line, highlighting hydrogen's promises and challenges as a renewable resource. By generating hydrogen from low or zero-carbon renewable energy sources such as electrolysis, biogas, solar, and wind farms, investors hope to encourage the uptake of "clean" hydrogen, leading to a greener global economy.he below color code divides and explains hydrogen's energy sources:

BROWN - extracted from coal using gasification.

GREY - extracted from natural gas using steam-methane reforming.

TURQUOISE - produced by the thermal splitting of methane (methane pyrolysis).

BLUE - produced from fossil fuels where carbon is captured, stored or repurposed.

YELLOW - produced by electrolysis (splitting water with electricity) using grid electricity from various sources.

PINK - produced by electrolysis using nuclear power.

WHITE - produced as a byproduct of industrial processes or in its rare natural form.

GREEN - produced by water electrolysis, using electricity from renewable sources like wind or solar. The European Strategy considers H_2 from biogas green as well.

4. RESULT AND DISCUSSION

According to the International Energy Agency, the number of low-carbon hydrogen projects is growing. Many governments are adopting hydrogen strategies. For instance, in July 2020, the European Commission published "A hydrogen strategy for a climate-neutral Europe" to boost clean hydrogen production towards the goal of climate neutral by 2050. China, the current global leader in the clean hydrogen economy, outlined its new H_2 policies and targets in the "Medium and Long-Term Plan for the Development of Hydrogen Energy Industry (2021-2035)". Other countries such as Australia, India, and the United States, the world's second-biggest producer and consumer of hydrogen after China, have also disclosed their visions for a clean, innovative, safe, and affordable hydrogen economy.

Two of the central promises of H_2 are that it is an efficient and safe storage of renewable electricity and an excellent alternative to batteries. As a fuel, hydrogen has the highest gravimetric energy density, meaning that one kilogram of hydrogen contains an enormous amount of energy, making it a lightweight energy carrier. This results in, for example, fuel cell electric vehicles (FCEVs) traveling farther and longer compared to heavier, battery-powered vehicles.

FCEVs combine hydrogen stored in a tank with oxygen from the air to produce electricity to power the car, with water vapor as the by-product. They are already available on the market, and the number of H_2 fueling stations is growing. Gaoming District, Foshan City, China, is currently operating a hydrogen-powered tram. The shipping industry is evaluating hydrogen in the form of ammonia as a future sustainable fuel, and the first "ammonia-ready" vessel in the world is already in operation as of January 2022. Aviation designers are also working on hydrogen-powered engines that enable sustainable and economical travel at high supersonic speeds.

Hydrogen has other potentially "net zero" applications. For instance, hydrogen may replace carbon in the ironmaking process and eliminate emissions in metallurgy. Using hydrogen instead of coal will emit water steam instead of CO_2. Nevertheless, the "fuel of the future" has some challenges.The biggest hurdle, however, may be cost. The European Commission estimates the amount of investment needed to scale green hydrogen to be between US$186 billion to US$487 billion dollars by 2050. Only to supply up to 15% of the continent's total energy. Safety is another concern, as hydrogen is highly flammable and potentially explosive. The transportation of hydrogen for use at refueling stations poses additional safety risks. On the other hand, it is promising to see the increasing number of fueling stations in Us , especially California state.

5. CONCLUSION

Delivering on the promises of an abundance of carbon-neutral hydrogen energy for the future will require feasible solutions covering the entire value chain: production, storage, transportation, and utilization.As the innovation race heats up, research and development, international policy cooperation, scalability, and affordability will be vital in making systemic changes to accelerate the growth of green hydrogen and away from fossil fuels.

While not quite yet the hero in addressing climate change, hydrogen has the potential to be a unique energy carrier using low or zero-carbon renewable energy sources due to its plethora of applications across sectors. H_2 may well be on its way to finally achieving eco-friendly credentials. This space is getting a lot of attention and will be interesting to watch in the future.

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GREEN ENERGY MANAGEMENT SYSTEMS FOR EDGE COMPUTING APPLICATIONS

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ABSTRACT

Carbon dioxide (CO2) is the main greenhouse emission emitted through human activities and is present within the atmosphere as a part of the Earth's carbon cycle. The increase in carbon use has many negative effects such as causing climate change. Many factors play a role in the increase in this worldwide carbon emission especially the structures that emerge with the development of technology, such as data centres, which has an important role in increasing carbon emissions. Carbon emission caused by data centres has exceeded 200 million metric tons per year. Artificial-Intelligence-Augmented Cooling Systemfor Small Data Centres (ECO-Qube) project focuses on edge data centres since they are important because of their energy-saving potential. Several Key Performance Indicators (KPIs) are developed to evaluate the energy efficiency of the data centres and their environmental sustainability. The ECO-Qube project determines an assessment methodology for data centres following the most important standards like ASHRAE TC 9.9 2021, EN50600 Standard Series, and EU Code of Conduct. The main KPIs used in this project are Power Usage Effectiveness (PUE), Renewable Energy Factor (REF), Energy Reuse Factor (ERF), Primary Energy Savings (PES), CO2 Savings, and performance Per Watt (PPW). These KPIs are sufficient for the real-time assessment of data centres within this project and can give a good idea about the improvements achieved. Digital technologies such as EMSs (Energy Management Systems) are part of the solution to reduce energy consumption, as they enable more efficient use of resources. From this perspective, an EMS has been designed in the scope of this project to track the energy demand, operate the energy supply in cooperation with the building/district's EMS, and calculate the project's KPIs which enables precise evaluation of data centre's current state and the effects of upgrades done to a data centre.

Keywords: Data centres, Carbon footprint, EMS

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1. INTRODUCTION

Several factors will continue to push the development of smaller, building-integrated data centres forward. Among these are the roll-out of 5G and the shift to SDN, the increase in network density, which makes it more advantageous to have data centres as part of buildings, the expansion of Cloud Gaming, and real-time data processing for IoT devices, and so on. As a result of the rapid expansion in units and energy consumption, data centres are predicted to have the fastest rising carbon footprint throughout the whole ICT industry, accounting for 5-9% of global electricity consumption and more than 2% of global greenhouse gas emissions. If unchecked, ICT emissions could account for 14% of world emissions by 2040 [1].

Carbon emissions are the main reason for human-influenced climate change which has increased over the past few years. Carbon emissions and climate change are the main cause of melting glaciers and polar ice, acid rain, smog, urban air pollution, ocean acidification, and many other harms to nature. The increased usage of carbon has several negative consequences, including increasing climate change. Many causes contribute to the rise in global carbon emissions, particularly buildings that grow as technology advances, such as data centres, which play a key role in raising carbon emissions.EMS is a possible solution for this problem, since EMS monitors energy usage performance, helps increasing efficiency, enables full dependence on RES (Renewable Energy Sources),decreases overall energy consumption, and because of the energy-saving potential of edge data centres.

In order to reach the goal of making data centres more efficient and sustainable, Guitart suggested a comprehensive plan to lower the carbon footprint of data centres that employ energy as a driver of their management operations[2]. Furthermore, a holistic management architecture for sustainable data centres was built, and design recommendations to execute each stage of the planned strategy were given, referring to relevant successes and enumerating the key problems that must yet be overcome.Shriramet alproposes a smart system that leverages the Internet of Things to collect data and a machine learning algorithm for decision-making to reduce energy usage in data centres [3].On the other hand,Basmadjian looked at data centre management from two perspectives: minimizing overall energy use and lowering peak power during demand-response periods. Moreover, potential data centre methods that allowed flexibility in conjunction with flexible contracts, such as green service levels and supply-demand agreements, were examined [4].

Aujla and Kumarpresents an effective strategy for energy management with the sustainability of Cloud Data Centres in Edge-Cloud Environments utilizing SDN (Software Defined Networks) to achieve energy efficiency and optimal usage of network and computing resources [5].On the other hand,Zhanget al explored the challenge of energy management for geo-distributed data centres using renewable resources and energy storage. By utilizing the spatiotemporal variability of these system states, the goal was to reduce long-term operation costs such as power costs, water use, and carbon emissions by formulating the cost minimization problem as a stochastic optimization problem and then adopting the Lyapunov optimization technique to design a close-to-optimal algorithm to achieve a trade-off between system cost and performance of delay tolerant workloads [6].

Previous successful experiences reveal that energy efficiency measures for green data centres were either not appropriately coupled to maximize outcomes, or they were mainly focused on the design stage of data centres, necessitating big upfront investments at the start of a new construction. The ECO-Qube concept combines current tested energy-saving technologies in a dynamic framework that allows new and existing data centres to decrease their energy usage.

The EMS developed by Endoks is one of the main parts of ECO-Qube's holistic approach for data centres, since it collects and monitors the data centre's energy production and consumption, in addition to calculating, monitoring, and reporting KPIs (Key Performance Indicators) which enables data centre owners to track and recognize their energy usage efficiency, carbon footprint, energy savings, energy consumption patterns, upgrade potential, and system flaws. Moreover, it allows data centres to compareKPIswith green goals set by data centres, and therefore, it enables taking fast action to get back on trackin case of any problem.

2. MATERIAL AND METHODS

Developing ECO-Qube EMS was done in 6 main steps. In the first step, ECO-Qube KPIshave been investigated, and necessary formulas to calculate them have been prepared. The second step and one of the most important steps was creating a signal list to identify the data required from data centres in order to calculate the project's KPIs. The third step was mapping these signals to the data centre's data aiming to be able to calculate KPIs correctly. The fourth step was to create a user interface for real-time monitoring of data centres and their KPIs. The fifth step was integrating the prepared formulas and signals received from data centres into the user interface. The sixth and last step isintegrating ECO-Qube EMS to BEMSs (Building Energy Management System) of the data centres. This interface will facilitate communication between ECO-Qube EMS and BEMS which allows BEMS to receive KPI information, energy consumption suggestions, emergency alarms, and even control signals from ECO-Qube EMS if required.

An energy management system (EMS) is a set of computer-aided tools used by electric utility grid operators to monitor, regulate, and improve the operation of the generating or transmission system. It is also employed in small-scale systems such as microgrids. The main objective of an EMS is to monitor and control energy systems. There are many benefits of using an EMS in microgrids such as accelerating system faults handling which minimizes the effects of these faults by decreasing economical loss and increasing the system's reliability. Other benefits of using an EMS are energy saving, environmental protection, and future planning. Energy management systems track energy consumption, which helps users to decrease their energy consumption and reduce operating costs, moreover, EMSs canalso monitor and control renewable energy production which is useful for microgrids with local production.The main usage areas and benefits of EMS are as below:

- *Energy data acquisition, storage, and management:*Data management is the main task of energy management systems. Since a significant amount of data is needed to be gathered (within a short time interval) for optimum energy management, there is huge importance of data management.

- *Reducing operating costs and improving productivity:*There are a lot of factors that affect the costs and productivity of energy systems since even a shadow can affect the whole system. EMS plays an important role here in the optimization of these points based on information analysis.

- *Accelerating system fault handling:*One of the biggest roles of an EMS is to realize the operation dynamics of the system and be able to observe and act to fix the failures according to that concept. An important advantage of the EMS is helping to determine the failures' context and magnitude.

- *Energy saving and environment protection:*One of the most important usage areas of EMS is energy saving and environment protection. Many people have begun to realize the consequences of global warming and climate change which is taking place as a result of high CO_2 emissions since the industrial revolution. As this awareness is increasing, environment saving actions should be taken. Energy management systems provide an opportunity for effective actions. EMS's main role is to monitor and control energy systems to improve energy usage efficiency and decrease overall energy consumption. The benefits of energy management systems are not only environmental but also economical. Energy management systems also provide an infrastructure for wide renewable energy integration. EMS takes a main part in the future of energy since its usage can be universal for all kinds of systems.

- *Future planning:*Energy management systems collect data in order to calculate KPIs and sketch illustrative graphs of energy systems' performance, which enables effective future planning considering environmental and economical profits.

2.1. ECO-Qube EMS

Several approaches like using more efficient cooling systems, heat reuse, and use of renewable energy to supply data centres can be used to achieve energy efficiency goals for data centres. EMS can be used as a tool to enhance energy efficiency and is one of the most important parts of the solution for energy efficiency of data centres. It will be possible to monitor and control both produced and consumed energy within the data centre ecosystem with a holistic approach with ECO-Qube EMS which is developed in accordance with SAREF standards.

According to SAREF standards, this energy usage and power data are shared and controlled interactively. Moreover, ECO-Qube EMS can integrate other energy systems to regulate energy demand and supply for data centres using SAREF and worldwide communication standards.Supporting sustainability is a prioritized goal for ECO-Qube's smart energy management system (ECO-Qube EMS), which is designed to measure energy demand and run the energy supply in collaboration with the building/district's EMS (if applicable). This synergy enhances the energy supplied by renewable energy sources on the one hand andminimizes the energy supplied by sources with high carbon footprint on the other.

ECO-Qube EMS is a unique smart energy management system that can interface with the building's energy management system (BEMS) to regulate and manage the energy-related components within the data centre facility. Figure 1 illustrates the integration strategy as envisaged in ECO-Qube.

Figure 1. ECO-Qube architecture [7]

A traditional EMS works as explained in the previous paragraphs, but ECO-Qube EMS is customized for data centres, this customization is mainly done by including KPIs used for energy efficiency in data centres.

The ECO-Qube EMSmonitors the data centre's energy use and stores historical logs. After reading the energy demand, the EMS system reads the immediate PV generation and remaining battery power via the building/energy grid's EMS system. The EMS has both monitoring and controlling functions. One of the vital properties of the EMS "energy saving and environment protection". The EMS can monitor and control the real-time energy consumption and production and provide energy optimization so that it can be used as a tool to reduce the energy consumption of data centres.

2.2. ECO-Qube KPIs

Most data centres presently have little or no capability for tracking energy use or environmental effect. Many residences do not have a separate utility meter or bill. ECO-Qube will use its smart energy management system, which will be fully integrated with the existing building's EMS, to control and measure real-time consumption and performance of the data centre directly from IT devices, as well as detect the flow of recovered heat that can be used in the local district heating system. This will let all level end users acquire PUE, REF, ERF, PES, and CO2 values through a simple user interface, allowing them to gain a better understanding of data centre energy consumption trends, efficiency upgrade possibilities, and system problems.

The ECO-Qube KPIs, in particular, are in compliance with the "2021 Best Practice Guidelines for EU Code of Conduct on Data Centre Energy Efficiency," which is regarded the key reference in this industry since it is one of the most extensive studies in this sector [8].

The EN 50600 standard, on the other hand, indicates that the fundamental goal of KPIs is effective resource utilization, such as decreasing energy consumption, enhancing IT load efficiency, reusing unconsumed resources, utilizing renewable energy, and so on [9]. ECO-Qube aims to achieve this goal by measuring and reporting key KPIs; the usage of these KPIs aligns with both the EU code of conduct and EN 50600 requirements, such that the majority of the KPIs used in ECO-Qube are recommended by both EN 50600 and the EU code of conduct [8].

The KPIs used in ECO-Qube are available in detailed in D6.1 [10]of the ECO-Qube project, and they are summarized as follows:

1) PUE (Power usage effectiveness): A parameter that is frequently used to describe data Centre efficiency. It relates the total energy consumption of a data Centre to the energy consumption of IT equipment.

$$PUE = \sum_{i}^{n} \left(\frac{EDCi}{EITi}\right) \quad (1)$$

EDCi: Total data centre energy consumption in the period of time i.

EITi: IT equipment energy consumption during the period of time i.

2) REF (Renewable Energy Factor): REF is a quantitative metric for the use of renewable energy in the form of electricity in a data centre.

$$REF = \frac{\sum_{i}^{n}\left(E_{DCgrid-usedi} * \frac{E_{reni}}{E_{toti}} + E_{DCrenonsitei} + E_{DCrencerti}\right)}{\sum_{i}^{n}\left(E_{DCi}\right)} \quad (2)$$

EDCi : Total data centre energy consumption in the period of time i.

$E_{DCgrid-usedi}$: Energy provided from the grid and consumed in a data centre during the period of time i.

E_{reni}/E_{toti} : Renewable energy fraction of the total grid energy (provided by the supplier) in the period of time i.

$E_{DCrenonsitei}$: Renewable energy generated on-site and consumed in the data centre in the period of time i.

$E_{DCrencerti}$: RE obtained by procurement of RE certificates and retired in the data centre in the period of time i.

3) ERF (Energy Reuse Factor): ERF provides a way to determine the factor of energy reuse outside the data centre. It is defined as the proportion of energy reused divided by the total amount of energy consumed in a data centre.

$$ERF = \sum_{i}^{n} \left(\frac{EReusei}{EDCi}\right) \quad (3)$$

EDCi : Total data centre energy consumption in the period of time i.

EReusei : Reused energy and utilized for beneficial purposes in the period of time i.

4) PES (Primary Energy Savings): Primary Energy Savings indicator describes the change in the data centre energy profile after upgrading the data centre equipment or after the introduction of flexibility environmental, energetic, and economic improvement in the data centre energy profile.

$$PES = \frac{\sum_{i}^{n}((EDCi + EothDCi)\,bas - (EDCi + EothDCi)cur)}{\sum_{i}^{n}(EDCi + EothDCi)\,bas} \quad (4)$$

$(EDCi)_{bas}$: Total data centre energy consumption in the period of time i before upgrading the DC.

$(EDCi)_{cur}$: Total data centre energy consumption in the period of time i after upgrading the DC.

$(EothDCi)_{bas}$: Total primary energy produced from other sources in period of time i before upgrading the DC.

$(EothDCi)_{cur}$: Total primary energy produced from other sources in period of time i after upgrading the DC.

5) CO2 Savings: CO2 Savings is the % of savings in terms of CO2 emissions associated with DC operations.

$$CO2\ Savings = \frac{\sum_{i}^{n}((CO2ei + CO2othi)\,bas - (CO2ei + CO2othi)cur)}{\sum_{i}^{n}(CO2ei + CO2othi)\,bas} \quad (5)$$

$(CO2ei)_{bas}$: Total CO2 emissions released by the DC consumed energy in the period of time i before upgrading the DC.

$(CO2ei)_{cur}$: Total CO2 emissions released by the DC consumed energy in the period of time i after upgrading the DC.

$(CO2othi)_{bas}$: Total CO2 emissions released by the energy produced from other sources in the period of time i before upgrading the DC.

$(CO2othi)_{cur}$: Total CO2 emissions released by the energy produced from other sources in the period of time i after upgrading the DC.

6) PPW (Performance Per Watt): The performance per watt of computer architecture or computer hardware is a measure of its energy efficiency. It quantifies the pace of calculation that a computer can deliver for every watt of electricity consumed.

ECO-Qube EMS is designed to track the energy demand, operate the energy supply in cooperation with the building/district's EMS, and calculate the KPIs listed above since the calculated KPIs can be shown on the user interface of the EMS. ECO-Qube EMS can monitor all production, consumption, and energy storage. The EMS has also historical data visualization, detection of abnormal values, and automatic alarm activation functions. KPI calculation is done by using formulas 1 – 5. In addition, ECO-Qube EMS can provide data needed by the ECO-Qube AI container engine. ECO-Qube EMS provides communication options such as Modbus TCP/IP, IEC 60870-5-104, and API communication protocols.

3. RESULT AND DISCUSSION

ECO-Qube EMS user interface was designed by Endoks in order to enable data centre owners to view their assets and KPIs in real-time, in addition to providing a graphical representation of the data, automatic alarms, and many other features as will be seen in the following parts.

Figure 2 shows the preliminary design of a data centre's EMS's SLD in the user interface. This structure can be subject to some additions such as control options, constant input for KPI calculation, etc. Graphical representation of energy production and consumption, battery discharge, and other data will also be shown in the user interface as shown in Figure 3.

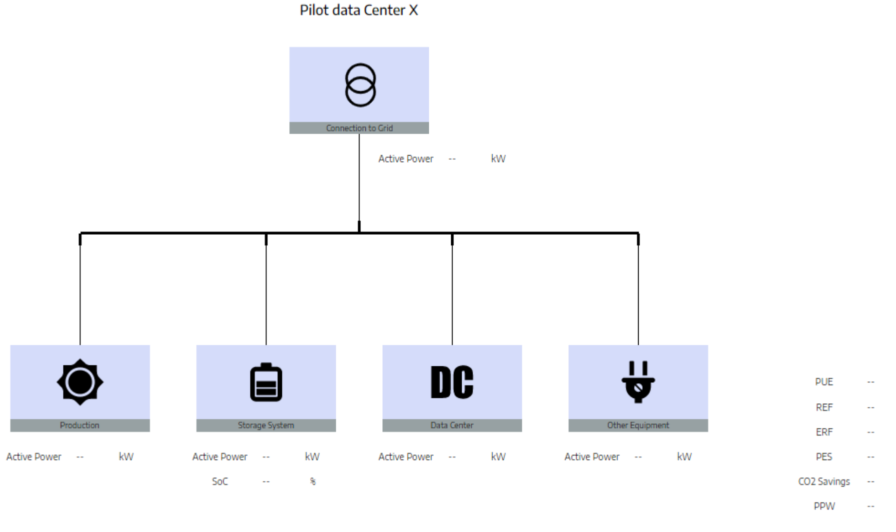

Figure 2. ECO-Qube EMS SLD UI preliminary design

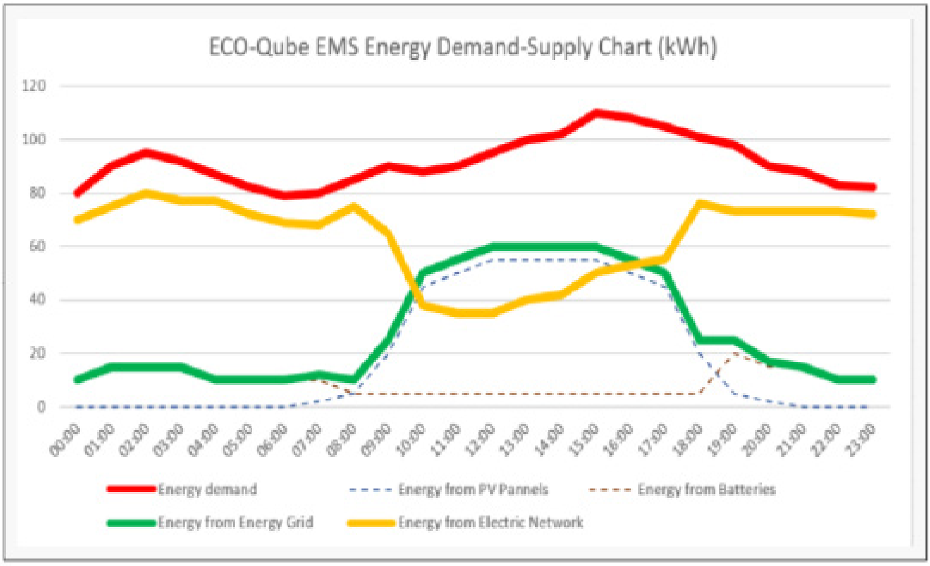

Figure 3. Graphical representation of data centre's data

There is a welcome page that shows the overall energy flow at the EMS and alarms can be tracked. Consumption, production, and storage can be investigated at separate tabs on the top left side of the screen. Energy flow, KPI performance, production, consumption, battery charging and discharging, SoC, and grid import/export values and time graphs are also available on this page. Each parameter could be viewed alone or in any combination the user chooses as shown in figure 4.

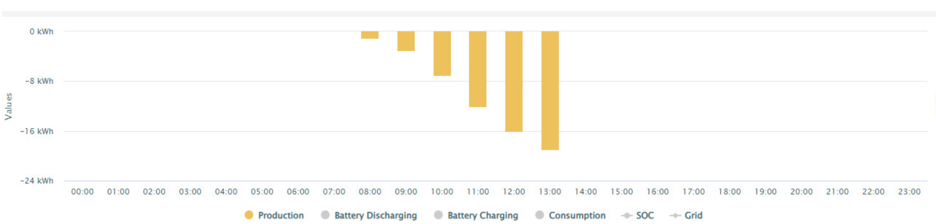

Figure 4. Production graph on welcome page

ECO-Qube EMS features could be adjusted according to data centres preferences including adding/removing KPIs. Furthermore, new modules could be added easily such as cost-benefit analysis, RES controller,BESS (Battery Energy Storage System)controller, load controller, and electrical utility grid import controller. Another profit of ECO-Qube EMS is that it could be comfortably modified to meet other sectors' needs where energy monitoring and efficiency is required, which is a very important advantage since it provides an economical – clean energy solution. This solution will motivate individuals and businesses to decrease their carbon footprint, especially in the following years where variable tariff systems are expected to be applied all around the world and therefore, achieve global green goals.

4. CONCLUSION

The need for data centres is expected to increase due to technological advance. This increase directlycausesthe data centres carbon footprint to increase. Edge data centres are more suitable than traditional large-scale data centres since edge data are faster because of their near location. Moreover, edge data centres have high energy-saving potential, which makes them a perfect target for optimization through a holistic approach. Endoks took an important part in this holistic approach by developing a smart EMS. The UI (User Interface) developed within the ECO-Qube project delivers advanced monitoring and control functions, which enables data centres to observe consumption in a comprehensive manner based on smart metering hardware used in data centres. Moreover, all data integrated into ECO-Qube EMS can be represented graphicallyalong with calculated KPIs. These data and KPI values could also be reported and compared with the historical records, which is another important feature of the EMS.All of these features provided by Endoks's local UI show beyond doubt thatECO-Qube EMS provides a chance for data centres to operate more efficiently.ECO-Qube has proven that thekey to achieve low or even zero carbon footprint goalscould beachieved byutilizing detailed monitoring and control of energy consumption. Last but not least the ECO-Qube EMS is a very useful tool which can be used for energy efficiency by data center owners and has an awareness raising effect about both energy efficiency and carbon foot print.

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IMPACT OF CLEAN COAL TECHNOLOGIES ON CLIMATE CHANGE

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ABSTRACT

In this study, the effect of clean coal technologies on climate change was investigated. Today, fossil energy sources (coal, oil and natural gas) are used intensively both as an energy source and for the production of basic chemical raw materials. Considering the current consumption rate of fossil energy resources, it is estimated that the apparent oil reserves in the world will decrease significantly after approximately 40 years, natural gas reserves after 65 years and coal reserves after 250 years. However, among these fossil energy sources, coal sources are the most influential on environmental pollution and therefore climate change. Although the negative effects of coal on the environment (such as greenhouse gas, acid rain, ozone layer depletion) are known, coal resources are still used intensively in energy production. The use of low quality coals (high in ash, sulfur, moisture and volatile matter content and low calorific value) without improving the fuel quality by burning them directly in energy production causes negative effects on environmental pollution and therefore climate change. Therefore, the quality of such low-quality coals needs to be improved to reduce their impact on the environment before they are directly burned. Various clean coal technologies (such as supercritical gas extraction, pyrolysis, liquefaction, gasification, fluidized bed technology, advanced combustion technologies) have been used to obtain clean solid, liquid and gaseous fuels from coal. In this study, a detailed research was conducted on the conversion of low quality coals, which cause environmental pollution, into a more environmentally friendly fuel with the said clean coal technologies.

Keywords: Fossil Energy Sources, Coal, Incineration, Clean Coal Technologies, Environmental Pollution, Climate Change

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1. INTRODUCTION

Global climate change is one of the most important problems of recent times. Climate is defined as the combination of the average properties of all weather conditions experienced or observed anywhere on the earth for many years, the averages of temperature, precipitation and other physical properties, and the temporal distributions of their changes[1–3]. The spread of economic activities in the world has led to a serious increase in global energy consumption, which has led to serious environmental problems such as the increase in global temperature and climate change[4]. It has shown that global temperature will continue to increase in the coming years, thus affecting human life and development[5]. Common greenhouse gases that cause global climate change include methane (CH_4), carbon dioxide (CO_2), nitrous oxide (NOx) and ammonia (NH_3), etc. gases are present. CO_2 is the main gas produced during the decomposition of organic matter by microorganisms. CO_2 plays a major role in the world's heat balance, and therefore a small increase in CO_2 in the atmosphere affects climate change[6]. The momentum driving coal consumption growth in the developed and developing world needs to be reconciled with the commitment of many countries, including IEA member countries, to significantly reduce their greenhouse gas (GHG) emissions to mitigate global climate change. According to the latest report by The Economics of Climate Change and The Intergovernmental Panel on Climate Change (IPCC), the average global temperature has increased by 0.15-0.20 °C per decade since 1995. As greenhouse gas emissions in the atmosphere increase, so does the temperature due to the greenhouse effect. The average global temperature is constantly increasing and is predicted to rise by 2°C by 2100, resulting in significant global economic losses (Figure 1). In accordance with recent reports and the Paris Agreement, it is stated that in order to avoid significant environmental and economic consequences associated with climate change, atmospheric CO_2 concentrations should range from 450-550 ppm by 2050 and the average global temperature rise should not be more than 2 °C[7–10]. In addition, it was emphasized that it is important to start reducing total global emissions within 10 to 15 five years and to achieve a 60-80% reduction in emissions from developed countries by 2050. Although not universally accepted, the reports provided a growing scientific and political consensus.

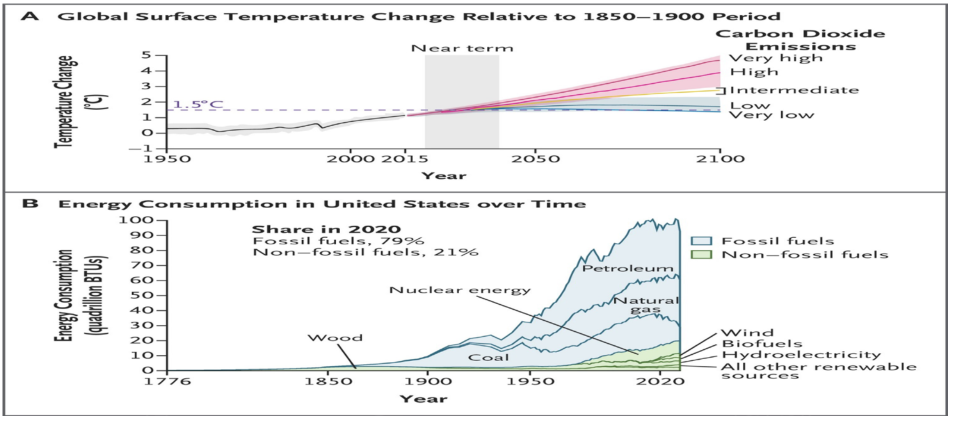

Figure 1. Global temperature change by years[7,9]

NASA derived the CO_2 concentration graph shown in Figure 2 from the analysis of air bubbles trapped in Antarctic ice cores. Figure 2 shows 400,000 years of changes in atmospheric carbon dioxide concentrations from different layers of snow included in the Antarctic ice sheet. For those who argue that the climate change we are facing now is a natural phenomenon, these data clearly show that none of the natural changes in CO_2 levels over the past half-million years have been as dramatic as those after 1950. Since this image was published in 2013, the carbon dioxide concentration has increased by another 15 ppm [11].

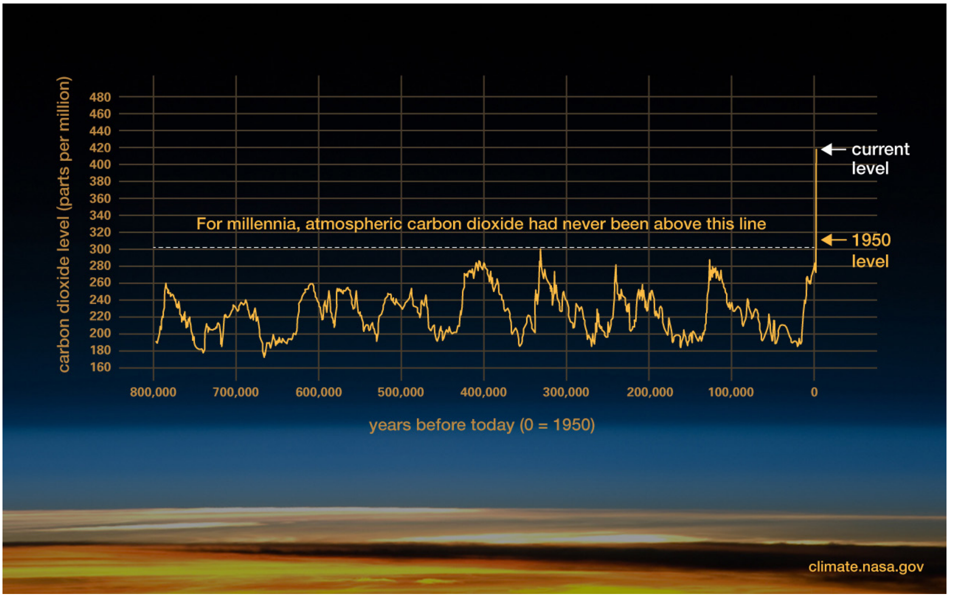

Figure 2. Carbon dioxide concentration in the atmosphere over the past 400,000 years[12].

The use of fossil fuels for power generation produces, with few exceptions, waste gases known as “combustion products” that are released directly into the atmosphere through chimneys, chimneys and exhaust pipes. The most prominent among these combustion products is carbon dioxide, a clear, odorless gas[11]. The combustion of fossil fuels (coal, oil and natural gas) is the main source of both air pollution and greenhouse gas emissions that cause climate change[13]. The burning of fossil fuels is one of the most serious contributors to global greenhouse gas emissions, releasing more than 30 billion tons of carbon dioxide into the atmosphere each year. Reducing fossil fuel combustion is therefore a top priority for climate policy. For decades, national policymakers and international agreements have sought to achieve this goal by promoting energy efficiency, low-carbon technologies, carbon pricing, and other measures aimed at reducing demand for fossil fuels[14,15]. Although energy use has decreased in 2020 due to Covid, the Global Carbon Project predicts that the use of coal and gas will increase much more in the years after 2021[16]. Figure 3 gives CO_2 emissions for coal, gas, oil and cement production. Coal and oil account for most of the greenhouse gas emissions from fossil fuels. After 2000, CO_2 emissions from coal have increased by 6 Gt. It is estimated that greenhouse gas emissions due to the use of fossil fuels will increase in proportion to the increase in energy use.

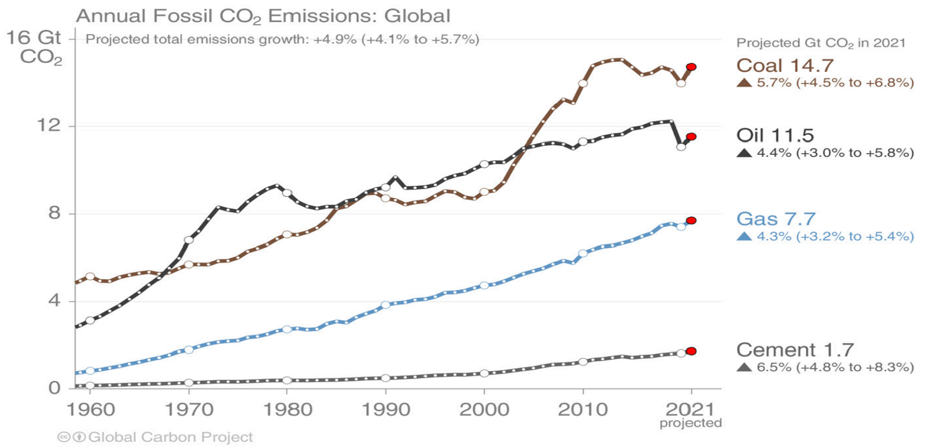

Figure 3. CO_2 emissions from fossil fuels[17]

Today, fossil fuels (oil, coal and natural gas) are used to a large extent both as an energy source and for the production of chemical raw materials. However, according to the studies conducted by various researchers, coal reserves will be used very effectively in about 250-300 years, and oil and natural gas reserves will be used quite effectively in a few decades[18]. Coal is by far the largest fossil fuel resource, with reserves known to be sufficient to meet expected demand without major increases in production costs for many years[19].Coal, one of the fossil fuel resources with the most reserves in the world, currently meets approximately 23% of the world's total primary energy demand and 38% of global electricity production[20]. Recently published statistics confirm that coal is the fastest growing component of the global energy supply; The widespread distribution and competitive cost of coal is predicted to increase its role in meeting energy demand in the future. In fact, many developing countries rely on coal reserves to support continued economic growth. While alternative energy sources exist, geographic concentration, expense or long lead times make it unlikely that they will significantly replace coal in electricity generation in the foreseeable future. Therefore, as noted in The Stern Review and IPCC assessments, the dramatic greenhouse gas emission reductions by 2050 are unlikely to be met without coal playing a significant role through new, low-emission technologies[12]. The use of low quality coals (high ash and sulfur content, low calorific value) by direct burning is not suitable due to both environmental pollution and being uneconomical. Such fuels should be cleaned by appropriate methods before use[21].Coal can be a less polluting fuel by incorporating cleaner and more efficient pre-combustion, combustion and post-combustion technologies[22]. Clean coal technologies are used to obtain a more environmentally friendly and alternative fuel from low quality lignites.

2. CLEAN COAL TECHNOLOGIES

Clean coal technologies are those that facilitate the environmentally satisfactory and economically viable use of coal[23]. The main subject of clean coal technology is to create a sustainable clean environment. Studies on clean coal technology are increasing globally, with previous research being developed by reanalyzing clean coal techniques to mitigate climate change[24]. Clean coal technologies include supercritical gas extraction, pyrolysis, liquefaction, gasification, fluidized bed technology, advanced combustion technologies

(Figure 4). The coal industry advisory board recommends that these should be strongly supported, approved and accelerated by national and international policy makers, emphasizing that to promote the development and deployment of low-carbon technologies, they can reduce the time frame required to achieve significant greenhouse gas emission reductions. CO_2, one of the emissions resulting from the use of fossil fuels in energy production, is the most important gas type on climate change. Therefore, capturing CO_2 without being released into the atmosphere is an important option in terms of climate change mitigation. In this context, the measures to be taken to mitigate climate change are briefly stated below[12]:

- Establishing a clear and balanced legal framework for the transport and storage of CO_2,

- Promote public understanding and acceptance of CO_2 capture and storage (CCS),

- Funding CCS research, development and distribution,

- Creating tax incentives and credit guarantees for CCS R&D and commercial projects,

- Promote commercial opportunities in the use of CO_2 for enhanced oil recovery (EOR) and advanced coalbed methane production as a way to develop CCS technology and infrastructure, and to promote commercial opportunities in transporting fuel and chemical production from coal as a way to develop CCS technology and infrastructure,

- Support market-based responses, such as GHG caps and trading systems, to accelerate the eventual commercialization of CCS,

- Encouraging mandatory price supports and tariff guarantees based on avoided emissions from systems with CCS,

- To encourage the participation of emerging economies in the development and deployment of CCS.

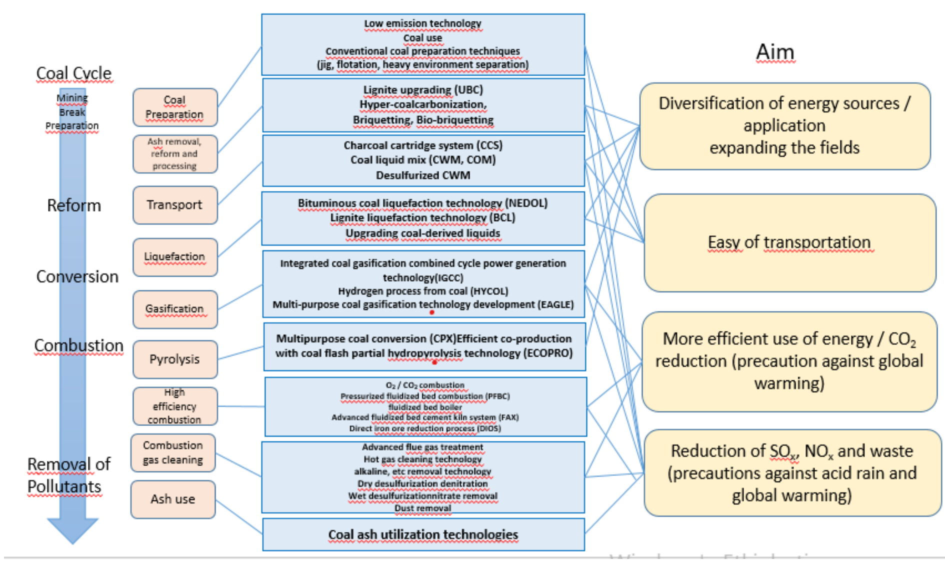

Figure 4. Clean coal technologies systems [25]

In the evaluation of traditional coal technologies and clean coal technologies, the processes after the production of coal, especially combustion technologies and their emissions are very important. However, in terms of environment and human health, everything should be considered, starting from the planning made during the production phase of coal. As seen in Figure 5, the combustion of coal emits approximately twice as much CO_2 per unit heat energy than natural gas[11]. That's why the coal industry – producers, consumers and equipment suppliers – as well as governments and institutions in countries where coal is needed, have a long experience in promoting clean coal technology. Experience continues to grow as technologies are introduced and disseminated in developing countries. The focus on clean coal technology in IEA countries is shifting to the development and operation of low and near-zero GHG emission technologies such as carbon dioxide capture and storage. The deployment of CCS as part of the effort to reduce greenhouse gas emissions has been endorsed by the G8 leaders, the IEA, The Stern Review and the IPCC. The IEA has identified four groups of CCTs (coal remediation, efficiency improvements in existing power plants, advanced technologies and near-zero emissions technologies) that can significantly reduce greenhouse gas emissions[12].

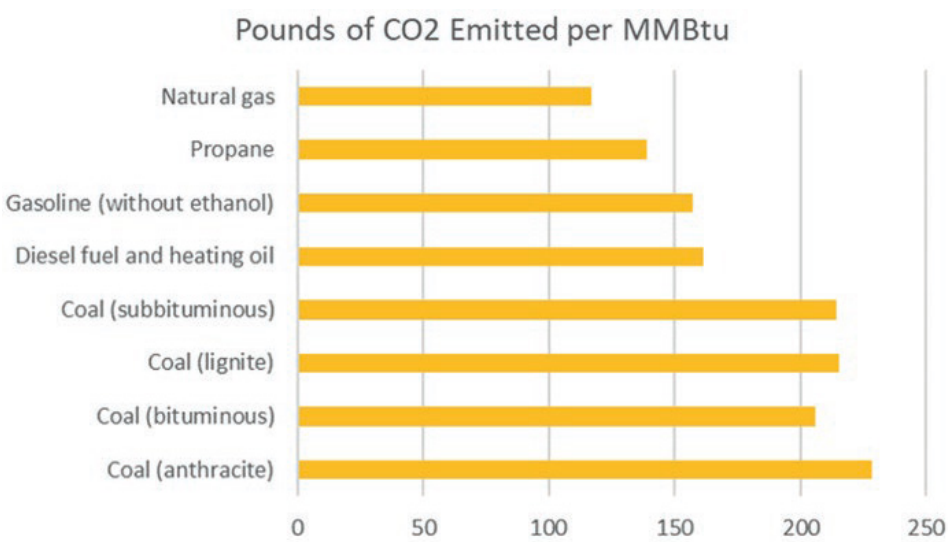

Figure 5. Carbon dioxide emissions by fossil fuel type per unit of energy[11].

2.1. Coal Cleaning and CO_2 Storage Technologies

With clean coal technologies, it is possible to reduce emissions and wastes arising from the use of coal, to increase the amount of energy to be obtained per unit ton, in other words, it is possible to produce more energy by using less coal. The ultimate goal is to use coal with almost zero emissions. It is to minimize emissions such as CO_2 and SO_2, NOx and particulate matter (PM), which are not greenhouse gases but are important in environmental protection. Coal crushing, grinding, screening, sizing, washing etc. With coal preparation technologies, it is possible to reduce the amount of sulfur in the coal, the amount of ash consisting of inorganic substances, thus increasing the quality of the coal by reducing the polluting and non-combustible inorganic substances, and minimizing its environmental impact without using it. Gas emissions before burning coal can be reduced by these technologies and their impact on climate change can be prevented[26].In the fight against climate change, especially in reaching the targets of the Paris Agreement, they are the most researched technologies that have a very important place in the future of coal, as they allow close to zero CO_2 emissions.[27].

2.2. Supercritical Gas Extraction

Coal is extracted under supercritical conditions with gas under temperature and pressure. High-temperature boiling substances and volatile products of coal pass into the gas phase. Thermal decomposition is prevented as care is taken not to procure the coal under the conditions applied in the process. For this reason, the extract obtained contains substances attached to the pores of the coal, according to the theory put forward by Vahrman [24]. The most widely used supercritical water gas process was originally developed for organic waste disposal. The process takes advantage of the unique properties of water above its thermodynamic critical point (374°C, 221 bar) to oxidize organic materials at low temperature (about 600°C). In fact, unlike the behavior of water under ambient conditions, most non-polar substances such as organic compounds are highly miscible in supercritical water, while polar materials such as inorganic salts are generally insoluble. In addition, gases containing O_2 are completely miscible in the liquid. Thus, a homogeneous, single phase is formed when organic compounds and O_2 are present. It dissolves in supercritical water and the reaction process proceeds without interfacial mass transfer limitations. Greenhouse gases such as CO_2 are filtered in the water and their emission is reduced [28]. NOx and SOx emissions in the SCWO plant are practically absent, but the specific CO_2 emissions result in very low, around 15-17 g CO_2/kWh (approximately 77 times lower than those produced in a conventional coal-fired power plant). In fact, 99% of the CO_2 produced during the coal oxidation process is kept in the liquid phase at high pressure and low temperature and is therefore ready for storage. In addition, the supercritical water gas processing plant does not need scrubbing systems for flue gas treatment[28,29].

2.3. Pyrolysis

Pyrolysis is the general name of the process of producing gas, liquid and solid products, especially from fossil fuels such as coal, by heating in an airless environment. This process is also called carbonization. Pyrolysis is generally defined as the thermal decomposition of coal in the presence of air or some other gas. Depending on the temperature used, 500°C-600°C is called low temperature pyrolysis or semi-carbonization, and 900°C-1100°C is called high temperature pyrolysis or coking[30]. However, the emissions generated during the processes with gasification and pyrolysis techniques are at a very low level compared to the combustion technique. Harmful emissions during combustion processes make gasification and pyrolysis techniques more advantageous than combustion[31]. In a study, the harmful gas emission of coal at different temperatures was investigated(Figure 6)[32]. The pyrolysis process is a very clean process when compared to the amount of harmful gases released during the conventional combustion of coal.

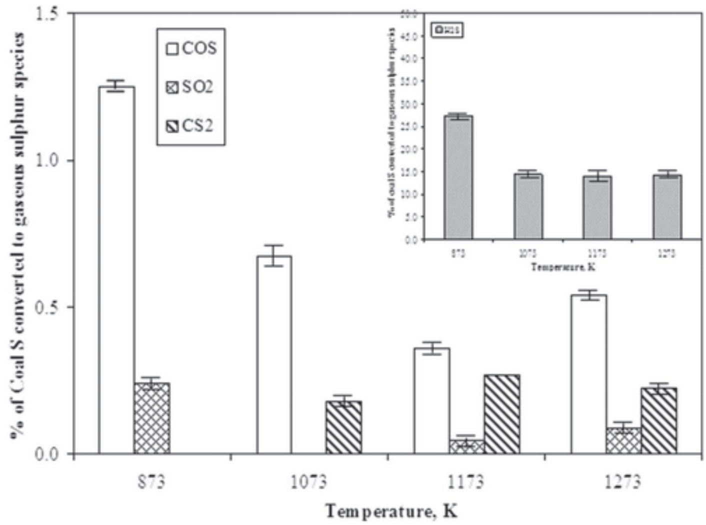

Figure 6. Amounts of gas emissions due to temperature during the pyrolysis of coal[32]

2.4. Liquefaction

In general, coal liquefaction can be defined as the decomposition of coal into free radicals using hydrogen donor solvent and catalyst under high temperature and pressure conditions and the production of both liquid fuel and chemical raw material by saturating these radicals with hydrogen. Various methods are being tried in the world regarding the production of liquid fuel from coal. Coal liquefaction is a process in which coal is converted into liquid fuels or petrochemicals. Commonly used coal liquefaction methods are direct and indirect coal liquefaction[33]. The conversion of coal into liquid products by increasing the H/C ratio without disturbing the molecular structure of the coal as much as possible is called direct liquefaction. In this method, the aim is to obtain liquid or solid clean fuel, synthesis gases and chemical raw materials by removing the mineral matter and heteroatoms of coal. As seen in Table 1, since the H/C ratio of the liquid fuel formed as a result of direct liquefaction is high, the emission of harmful gases to the environment will be considerably reduced.

Table 1. Daily Air Emission Forecast Ranges for Coal Liquefaction Processes under Normal Operating Conditions (NC: Not Considered)[34]

	Particulates		*Sulphur Dioxide*		*Nitrogen Oxides*		*Carbon Monoxide*		*Hydrocarbons*		*Carbon Dioxide*	
Process	*(tons)*	*(approx. metric tons)*	*(tons)*	*(approx. metric tons)*	*(tons)*	*(approx. metric tons)*	*(tons)*	*(approx. metric tons)*	*(tons)*	*(approx. metric tons)*	*(thousand tons)*	*(approx. thousand metric tons)*
Indirect	0.5–8	0.5–7	6–14	5–13	5–24	5–22	NC†	NC	NC	NC	21	19
Direct	0.3–7	0.3–6	16–27	15–24	5–13	5–12	1–6	0.9–5	0.01–2	0.01–1.8	11–14	10–13

With the liquefaction process, the impact of coal on climate change will be reduced[35–38]. Another way to reduce the impact of coal on climate change is to use conversion processes with biomass, which is both renewable and has the effect of increasing the H/C ratio. The amount of CO_2 released per unit of energy in the fuel obtained as a result of the liquefaction of coal alone is 5 times higher than in oil refining for coal, because the complex chemical structure of coal requires hydrocracking of carbon-carbon bonds in its largely polymeric structure. Co-liquefaction of coal and biomass may be considered a more suitable option to reduce the impact of direct coal liquefaction on CO_2 emissions [34].

2.5. Gasification

The coal gasification process is the process of separating the coal into its chemical components by a thermochemical method instead of directly burning it. The gasification process is defined as the conversion of carbon-containing materials into artificial gas, the main components of which are carbon monoxide (CO), hydrogen (H2) and methane (CH4). The raw material to be used in the gasification process is not limited to coal, but also gasification of petroleum-based materials such as petcoke, biomass and wastes [39]. Kömürün gazlaştırılması, kömürün elektrik, hidrojen ve diğer enerji ürünlerine dönüştürülmesinde kullanılan en temiz ve birden çok amaca hizmet eden yöntemlerden biridir. Bir gazlaştırıcıda, kömür yüksek basınç ve sıcaklıklarda, ortamda buhar varken, kontrollü miktarlardaki hava veya oksijene maruz bırakılır ve moleküler yapısı parçalanarak karbonmonoksit, hidrojen ve diğer bileşenlerine ayrıştırılır. Esas olarak hidrojen ve karbonmonoksitten meydana gelen bu gaza sentez gazı (kısaca syngas) denmektedir. Gazdaki diğer bileşenler, hammaddenin türüne ve gazlaştırıcının koşullarına bağlı olarak değişiklik göstermektedir[40,41].Coal gasification is one of the cleanest and multi-purpose methods used to convert coal into electricity, hydrogen and other energy products. In a gasifier, coal is exposed to controlled amounts of air or oxygen at high pressures and temperatures, in the presence of steam, and its molecular structure is broken down into carbon monoxide, hydrogen and other components. Consisting mainly of hydrogen and carbon monoxide, this gas is called syngas (short for syngas). Other components in the gas vary depending on the type of raw material and the conditions of the gasifier[42]. The gasification properties of coal are highly dependent on the type of coal and operating conditions. Coal is converted into useful gas form by gasification. Since these gases are used as chemical raw materials, their emissions to the environment are reduced. Gasification of coal is an environmentally friendly and highly efficient process in reducing CO2 emissions[43].

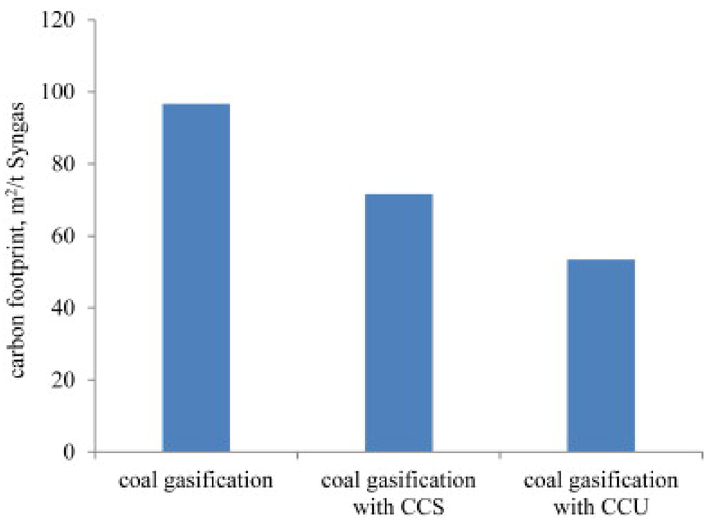

Figure 7. Carbon footprint of coal gasification processes[42]

2.6. Advanced Coal Combustion Technologies

While carbon dioxide (CO_2) emissions, the main component of greenhouse gases, make the biggest contribution to global climate change, the burning of fossil fuels mostly from coal-fired power plants accounts for approximately 90% of total CO_2 emissions. Direct burning of coal is mandatory in some areas. Therefore, combustion technologies should be developed to reduce greenhouse gas emissions. In power plants, mostly fluidized bed (CFB) and pulverized or fixed bed (PC) combustion technologies are used mostly in direct combustion[44,45]. In Figure 8, the gas composition in stationary and fluidized bed combustion processes is compared[44]. The fixed bed mode outperformed the fluidized bed mode in terms of reactivity performance and close contact between the coal gasification products and the oxygen carrier particles. This results in more coal gasification products being converted by the oxygen carrier. However, the fluidized bed mode may be a better solution in terms of long-term stable operation, as the fluidized bed mode can result in a better physical property of the oxygen carrier. Fluidized bed combustion technology is a clean and efficient technology for burning coals with high sulfur and ash content but low calorific value[46]. Combustion temperature is between 850-900 °C in CFB boilers. In pulverized boilers, this value is 1350-1500 °C. Therefore, NOx ratio is low in CFB boilers. SO_2 is kept by giving lime to the boiler. As a result, SO_2 and NOx ratios in CFB boilers are much lower than in pulverized boilers (Table 2). The most important advantage of fluidized bed combustion technology over fixed bed combustion is the reduction of sulfur dioxide and nitrogen oxide emissions, the retention of sulfur dioxide by the addition of limestone into the bed, and the reduction of nitrogen oxide formation at low combustion temperatures, without the need for an additional gas treatment plant. The development of clean combustion technologies is very important when compared to the percentage of coal burning in the world. Direct burning of coal, one of the most important causes of climate change, will be reduced by these methods[47,48].

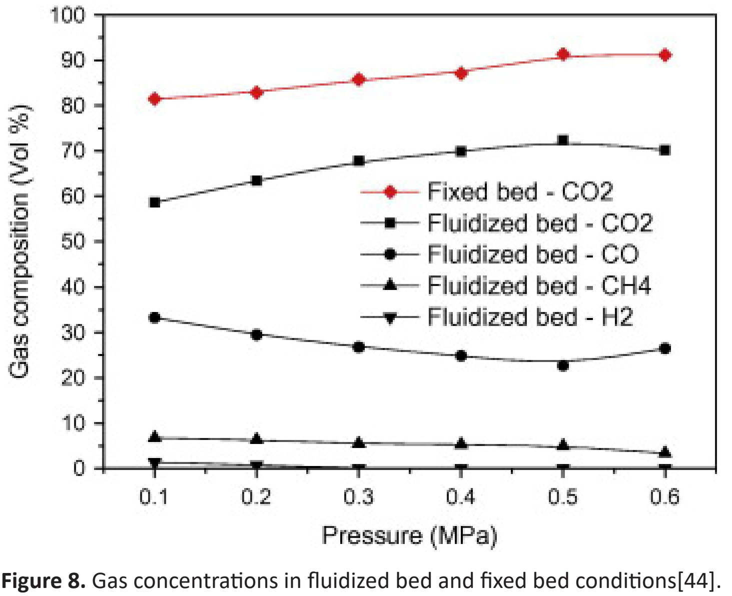

Figure 8. Gas concentrations in fluidized bed and fixed bed conditions[44].

Tablo 2. Benefits of CFB over PC in plant[49]

Description	CFB	PC	Benefits of CFB
Fuel size	6–12mm	<75μm	crushing cost is reduced
Fuel range (ash + moisture)	up to 75%	up to 60%	accepts wider range
Higher sulfur fuels (1–6%)	Limestone injection	FGD plant required	less expensive SO_2 removal system
Auxiliary fuel support (oil and gas)	up to 20-30%	up to 60%	less oil gas consumption
Auxiliary power consumption	slightly higher	lower	if FGD is used in PC, CFB power is lower
Emissions			
SO_2 ppm	<200	<250 with FGD	lower emissions in process, less expensive
NO_2 ppm	<100	<100 with SCR	no SCR system required
Boiler efficiency, %	same	same	no difference
O&M cost (85% CF)	5–10% lower	5–10 % higher	lower because of less moving equipment
Capital cost	5–10 % higher	5–10% lower without FGD & SCR	–
	8–15 % lower	8–15% higher with FGD & SCR	–

In order to provide today's emission values in pulverized combustion plants, in addition to the combustion system, a flue gas SOx removal unit and a flue gas NOx removal unit should be installed in addition to low NOx burners. It is known that it is possible to increase the amount of energy to be obtained per unit ton by reducing emissions and wastes with clean coal burning technologies. While providing most of the world's electricity with coal, clean combustion technologies are needed to reduce harmful gas emissions[50].

3. CONCLUSIONS

The results obtained in this study are briefly summarized below. Today, climate change is one of the most important global problems due to the use of fossil energy sources in energy production. The world is at a crossroads in energy needs and responding to climate change. Clean energy is not only a way to mitigate climate change, but also a way to meet sustainable development goals that emphasize environmental health and resource management. Using clean coal technologies is an important step to ensure that environmental health is not compromised while meeting world energy supply security. In order to make our current and potential coal reserves a part of the energy economy, scientific, technological, environmental, social, industrial, economic, political and sustainable development strategies, policies and implementations should be applied. Coal reserves play an important role compared to available energy sources. Therefore, policies should encourage the use of clean coal technologies to achieve sustainable development. For a cleaner and more livable environment, the amount of waste should be reduced. This can only be achieved by reducing waste generation, increasing recycling and reuse, and using natural resources rationally. Gas emissions due to the intense use of fossil fuels in energy production can be significantly reduced by the more efficient use of renewable energy sources. In addition, renewable energy sources should be preferred instead of fossil fuels in energy production. The use of fossil energy sources in energy production both causes environmental pollution and causes the existing reserves to be depleted very quickly. Conversion of fossil energy resources into valuable basic chemical raw materials by using clean coal technologies is considered as a more suitable option.

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THE CURRENT STATUS OF WIND ENERGY IN THE WORLD AND TURKEY

Kadir KAYA[1*]

ABSTRACT

Renewable energy sources are known as environmentally friendly and clean energy sources that can remain inexhaustible for a long time, such as hydraulic, wind, solar, geothermal and biomass energy. Wind energy is one of the most important renewable energy sources. In recent years, developments in wind turbine technology have reduced the cost of electricity generation from wind energy, bringing it to a competitive level with fossil fuel reserves. For this reason, countries want to benefit more from wind energy by making it a state policy. This study aims to provide a general assessment of the state of wind energy in Turkey and the world. In this context, the current condition of renewable energy resources has been evaluated by analysing the primary energy demand in the world, the amount of electricity generation and the installed power of renewable energy power plants. Then, the present status of wind energy has been examined in terms of the installed capacity of wind power plants and the amount of energy produced through wind energy plants. Lastly, wind energy policies and strategies for major countries have been presented.

Keywords: Energy, Renewable Energy, Wind Energy, Wind Energy Policies

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1. INTRODUCTION

Energy, defined as the ability to do work, is widely used in daily life. It can be found in different types, i.e. mechanical (potential and kinetic), heat, electrical, chemical and nuclear, and can be transformed from one form to another with appropriate methods [1-2].

Renewable energy sources widely used today are hydraulic, wind, solar, geothermal and biomass energy. Wind energy, one of the most important renewable energy sources, is generated due to the different heating of the ground surfaces by solar radiation. Wind turbines are used to benefit from wind energy by producing electrical energy from the kinetic energy of the wind. Developed and developing countries are trying to increase the production of electricity from wind energy to benefit more from wind energy potential [3-6].

This study presents a general evaluation of Turkey's current wind energy situation and the world. In this context, the current situation of renewable energy resources has been assessed by investigating the primary energy demand in the world, the amount of electricity generation by type and the installed capacity of renewable energy power plants. Then, the current status of wind energy is presented by using the installed power of onshore and offshore wind energy in the world and Turkey and the amount of energy produced from wind energy. In addition, forecasts and expectations about wind energy production are denoted according to the current studies and technical reports.

2. GENERAL ENERGY STATUS IN THE WORLD AND TURKEY

Countries are trying to benefit more from renewable energy systems or technologies to meet the increasing energy demand due to the increasing population and welfare level. The primary energy demand in the world by energy type between 1970 and 2020 and 2040 predictions are given in Figure 1. It is evident from the figure that the demand for renewable energy has increased considerably in recent years, and it is expected to continue in the future.

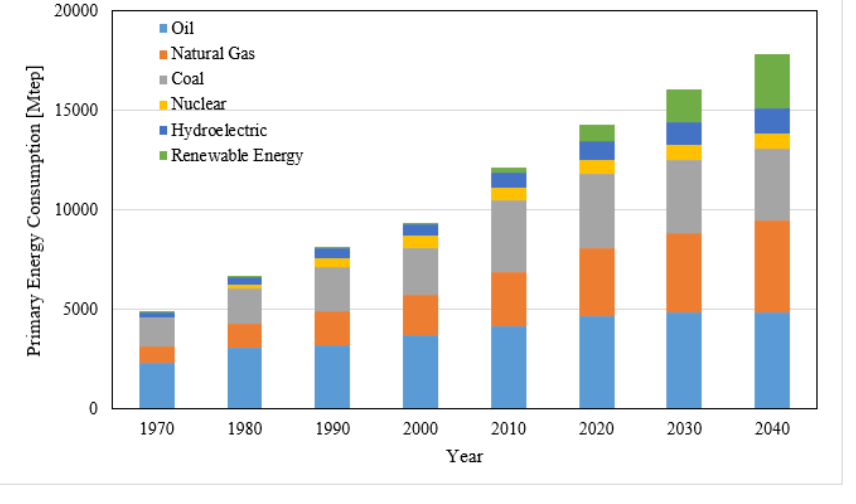


Figure 1. Primary energy demand over the years [Mtep] [7]

Nowadays, renewable energy sources are also widely used in electricity generation. Figure 2 shows the electrical energy production of OECD countries in 2010 and 2021. It can be seen from the figure that the wind energy production rate is 8.96% in 2021, indicating the second-highest renewable energy type.

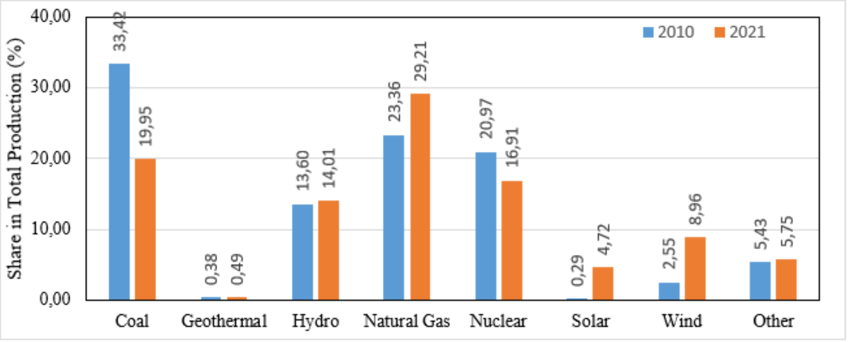


Figure 2. Electricity generation of OECD countries by sources [8]

The difference in the installed power plant capacity of renewable energy sources is given in Table 1. It can be seen from the table that the total renewable power plant capacity, which was 1226.853 GW in 2010, increased over the years and reached 3063.926 GW as of 2021. The installed power of wind turbines also increased from 180.85 GW in 2010 to 824.874 GW in 2021.

Table 1. Installed power capacity of the renewable power plants in the world [9]

Energy Generation Plant [GW]	**2010**	**2015**	**2020**	**2021**
Hydroelectric Power Plant	1024.833	1210.496	1211.092	1230.040
Wind Turbines	180.85	416.827	731.763	824.874
Solar Panels	41.542	221.993	716.788	849.473
Geothermal Energy Plants	9.992	11.812	14.073	15.644
Marine Energy Plants	0.250	0.513	0.524	0.524
Biomass	54.251	78.753	109.878	119.213
Liquid Biofuels	1.857	2.419	2.548	2.548
Biogass	9.518	15.650	20.599	21.574
Total Renewable Energy Plants	**1226.853**	**1846.060**	**2807.265**	**3063.926**

3. WIND ENERGY IN THE WORLD AND TURKEY

Countries desire to benefit more from renewable energy sources, i.e. wind energy. Countries make direct wind power plant investments according to their wind energy potential or try to increase their wind power installed capacity through the private sector. The evolution in the wind energy installed power of the countries, and the forecasts about the future situation are concerned in this section.

The countries with the highest installed capacity of total wind farms are given in Table 2. It is evident from the table that China has the highest installed wind energy capacity, with 328973 MW in 2021. Furthermore, Turkey's onshore wind energy installed power plant capacity, which was 65 MW in 2006, was increased to 10607 MW in 2021.

Table 2. Countries with high installed capacity of wind energy (Total) [MW] [9]

	Country	Years					Share in Total (2021) (%)
		2006	2010	2015	2020	2021	
1	China	2599	29633	131048	282113	328973	39.88
	European Union (EU)	48122	84398	141519	177 057	187497	22.73
2	USA	11603	39135	72573	118 732	132738	16.09
3	Germany	20622	26903	44580	62 188	63760	7.73
4	India	6270	13184	25088	38 559	40067	4.86
5	Spain	11630	20693	22943	26 819	27497	3.33
6	Great Britain	1963	5421	14306	24 485	27130	3.29
7	Brazil	237	927	7633	17 198	21161	2.57
8	France	1589	5912	10298	17 484	18676	2.26
9	Canada	1460	3967	11214	13 627	14304	1.73
10	Sweden	571	2017	5819	9 976	12080	1.46
11	Italy	2123	5794	9137	10 871	11276	1.37
12	Turkey	65	1320	4503	8 832	10607	1.29
13	Australia	-	1864	4234	8 603	8951	1.09
14	Netherlands	-	2237	3391	6 619	7801	0.95
15	Mexico	-	519	3271	6 504	7692	0.93
16	Denmark	3140	3802	5077	6 259	7014	0.85
17	Polond	153	1108	4886	6 298	6958	0.84
18	Portugal	1716	3796	4937	5 122	5248	0.64
19	Belgium	-	1069	2176	4 681	4780	0.58
20	Norway	-	425	867	4 030	4650	0.56
21	Japan	-	2294	2808	4 371	4471	0.54
22	Greece	-	1298	2091	4 119	4457	0.54
23	Ireland	-	1390	2451	4 307	4332	0.53
24	Austria	-	1106	2489	3 226	3524	0.43
25	Romania	-	389	3130	3 013	3013	0.37
Total Capacity		**-**	**180850**	**416276**	**731763**	**824874**	**100.0**

The countries with the highest installed capacity of onshore and offshore wind farms are given in Table 3 and Table 4, respectively. It can be seen from Table 3 that China has the highest installed wind energy capacity, with 302582 MW in 2021. It is also seen from Table 4 that the total offshore wind power plant capacity in the world, which was 3056 MW in 2010, increased to 55678 MW in 2021. As of the end of 2021, the countries with the highest installed capacity of offshore wind power plants are China with 26390 MW, the UK with 12700 MW, and Germany with 7747 MW respectively.

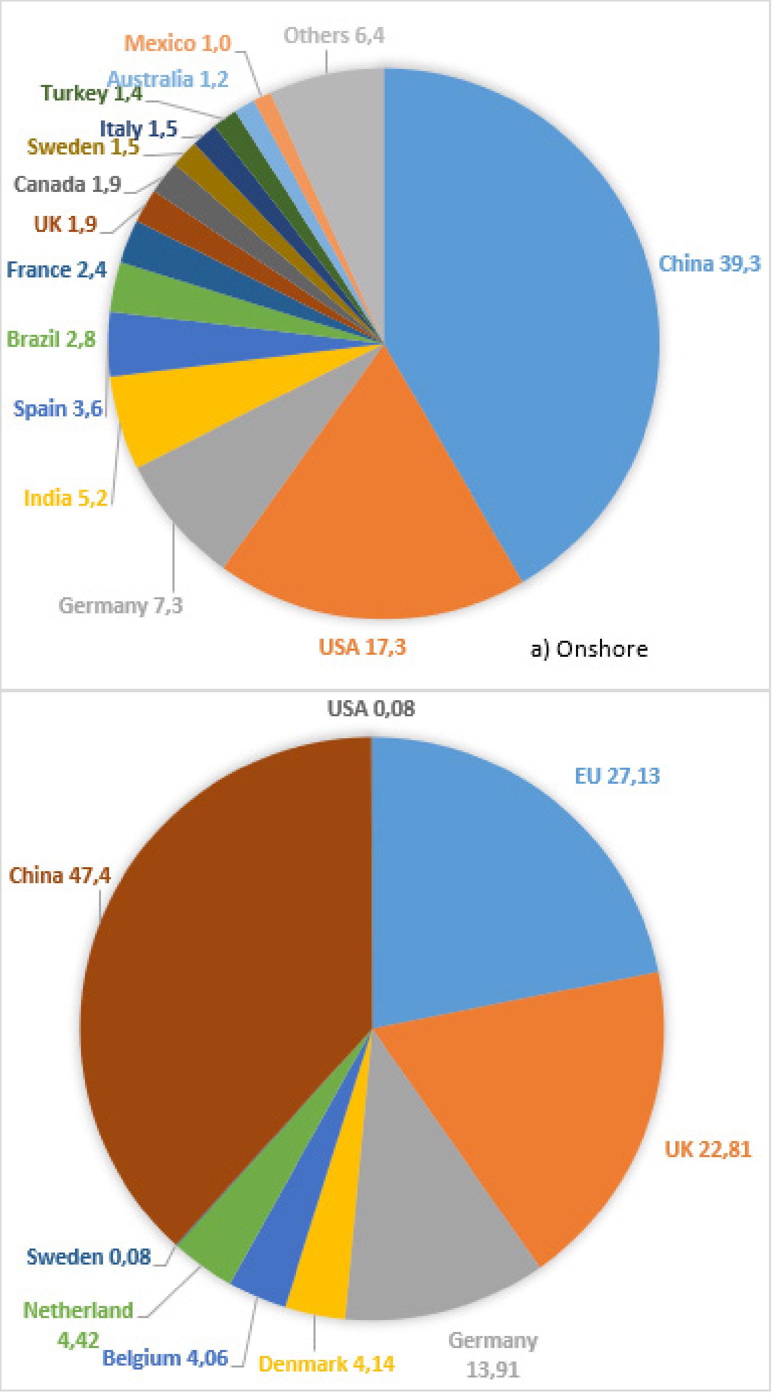
Table 3. Countries with high installed capacity of wind energy (Onshore) [MW] [9]

	Country	**Years**				**Share in Total (2021) (%)**
		2010	**2015**	**2020**	**2021**	
1	China	61306	130489	273123	302583	39.34
	European Union (EU)	102183	132014	182964	194237	25.25
2	USA	59075	72573	118703	132696	17.25
3	Germany	30711	41297	54414	56013	7.28
4	India	17300	25088	38559	40067	5.21
5	Spain	22789	22938	26814	27492	3.57
6	Brazil	1894	7633	17198	21161	2.75
7	France	7607	10298	17482	18674	2.43
8	United Kingdom	6035	9212	14102	14430	1.88
9	Canada	6201	11214	13627	14304	1.86
10	Sweden	3443	5606	9773	11877	1.54
11	Italy	8102	9137	10871	11276	1.47
12	Turkey	2261	4503	8832	10607	1.38
13	Australia	2561	4181	8603	8951	1.16
14	Mexico	1815	3271	6504	7692	1.00
15	Polond	2564	4886	6298	6958	0.90
16	Netherland	2205	3034	4159	5341	0.69
17	Portugal	4410	4935	5097	5223	0.68
18	Denmark	3240	3806	4559	4708	0.61
19	Norway	703	865	4028	4644	0.60
20	Greece	1753	2091	4119	4457	0.58
21	Japan	2537	2755	4306	4406	0.57
22	Ireland	1679	2426	4282	4307	0.56
23	Austria	1337	2489	3226	3524	0.46
24	Romania	1822	3130	3013	3013	0.39
25	Belgium	989	1464	2419	2518	0.33
Total Capacity		**261584**	**404453**	**697401**	**769196**	

Table 4. Countries with high installed capacity of wind energy (Offshore) [MW] [9]

Continent/Country		2010	2015	2018	2021	Share in Total (2021) (%)
Europe		2931	10966	18766	27814	49.96
	European Union (AB)	2928	10944	18764	15108	27.13
	United Kingdom	1341	5093	8217	12700	22.81
	Germany	80	3283	6396	7747	13.91
	Denmark	868	1271	1701	2306	4.14
	Belgium	197	712	1186	2262	4.06
	Holland	228	357	957	2460	4.42
	Sweden	163	213	203	203	0.08
Asia		125	722	4833	27822	49.97
	China	100	559	4588	26390	47.40
America		-	0	29	42	0.08
	USA	-	0	29	42	0.08
Total		**3056**	**11717**	**23629**	**55678**	**100**

As of 2021, the distribution of onshore and offshore wind energy installed power plants by countries are shown in Figure 3. It is apparent from the figure that 39.3% of the world's onshore wind energy installed power plants are located in China, 17.3% in the USA and 7.3% in Germany. Besides, 1.4% of the installed onshore wind power plants are in Turkey. On the other hand, 47.4% of the installed offshore wind farms are also located in China, 22.81% in the UK and 13.91% in Germany. Turkey has no offshore wind farm yet, even with considerable offshore wind energy capacity.



b) Ofshore

Figure 3. Installed onshore and offshore wind power plants by countries

According to the Turkish State Meteorological Service, Turkey's onshore wind energy potential is 13.1756 GW, and its offshore wind potential is 17.393 GW, based on a wind speed of 6.5 m/s and above. However, an economic wind power plant investment requires an average wind speed of 7 m/s at 50 m altitude. For this reason, Turkey's onshore wind potential is 48 GW, and its offshore wind potential is 5.3 GW [10]. The evolution of Turkey's installed wind power plant capacity is shown in Figure 4. It can be observed from the figure that Turkey's installed wind power plant capacity, which was 146.3 MW in 2007, increased to 11101.82 MW in 2021.

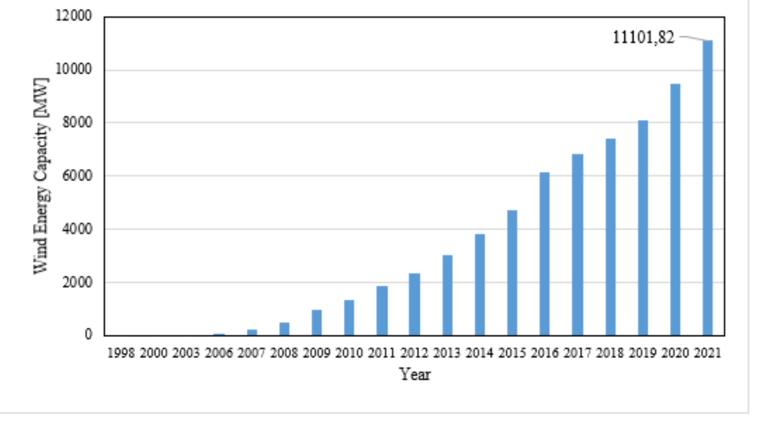


Figure 4. Installed wind turbine plant capacity in Turkey [MW] [11]

The amount of electrical energy produced from wind power plants in Turkey and its share in total production are shown in Figure 5. It can be seen from the figure that the amount of electrical energy produced by wind turbines raised to 30900.72 GWh at the end of 2021. Similarly, the rate of electrical energy produced from wind power plants in total generation reached 9.8% at the end of 2021.

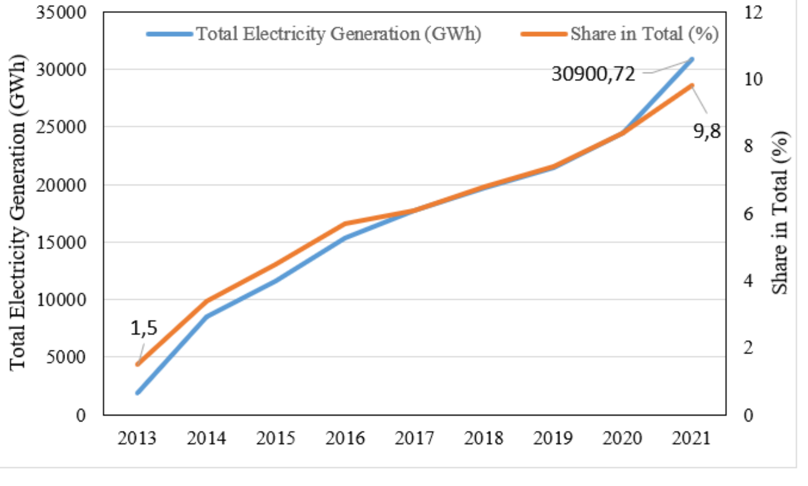


Figure 5. The current situation of the electricity generated by wind plants in Turkey [11]

4. THE FUTURE PREDICTIONS RELATED TO THE WIND ENERGY

The total installed capacity of onshore and offshore wind turbines in the world in 2018 and the forecasts for 2030 and 2050 are given in Table 5. In 2018, 231 GW of the total 542 GW of wind turbine installed power is located in the Asian continent, where China is also located. It can also be seen from the table that 2646 GW of the 5044 GW onshore wind energy installed power projected for 2050 is expected to be located in the Asian continent. Although Europe has the highest number of offshore wind farms in 2018, it is expected to be in Asia in 2030 and 2050.

Table 5. Current status and forecasts of wind energy in the world [12]

Wind Turbine	Year	North America	South America	Europe	Middle East And Africa	Asia	Oceania	Total
Onshore (GW)	2018	107	25	164	6	231	7	542
	2030	330	71	215	84	1067	19	1786
	2050	1146	182	483	525	2646	62	5044
Offshore (GW)	2018	0	0	19	-	5	0	23
	2030	23	1	78	-	126	1	228
	2050	164	5	215	-	613	3	1000

5. CONCLUSION

The use of wind energy, a clean, renewable and environmentally friendly energy source, is increasing daily worldwide. The current situation of wind energy in the world and Turkey were assessed in this study. The main results are summarized below.

- The demand for renewable energy sources, which was almost non-existent in the 1970s, has increased over the years and is expected to continue.
- Worldwide installed wind turbine power plants, which was 180.85 GW in 2010, increased to 824.874 GW in 2021.
- China has the highest installed wind energy capacity globally, with 328973 MW in 2021. Turkey's installed onshore wind energy power capacity has increased to 10607 MW in 2021, equaling the world's 1.4% of total capacity.
- In Turkey, electrical energy generated from wind plants has increased to 30900.73 GWh in 20121. It is needed to be highlighted that the rate of wind energy use in electrical energy production has increased to 9.8% in 2021.

As a result, although the use of renewable energy in Turkey is becoming increasingly widespread, a large part of Turkey's energy needs are still supplied from non-renewable energy sources. The current wind energy projects should be completed quicklyto benefit more from the renewable energy potential of Turkey.

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EFFECTS OF JET FUELS PRODUCED FROM MİCROALGAE ON CLİMATE CHANGE

Cemil Koyunoğlu[1*]

ABSTRACT

Petroleum-based jet fuel is essential for the aviation sector since it is the most efficient energy carrier. A growing number of people are interested in alternative fuels due to economic and environmental concerns. Diversification of energy sources produced from natural resources is required. These materials need to be affordable and sustainable. There is currently great worry over the environmental impacts of fossil fuels on climate change and global warming. The fluctuation in oil prices and the requirement for a sustainable fuel supply have a significant impact on the economy of fuel consumers as well. Microalgae-derived jet fuel is one of the aviation industry's alternatives that is getting a lot of interest since it can diversify energy sources. There are many different types of microalgae species that can produce lipids; they don't require a lot of land, freshwater, or special growing conditions; they can grow in saltwater or wastewater; they grow quickly; and the oil they produce doesn't threaten the security of the world's food supply. Similar to this, due to the fuels' low carbon footprint, the effects of climate change and global warming brought on by the generation of greenhouse gases (GHG) from petroleum jet fuel can be considerably reduced. In order to create a fuel that is more effective, aviation fuels made from algae can be viewed as an alternative to conventional fuels. On the other hand, the main difficulty is that many algae species have reduced lipid content. Costly upstream methods are used to turn microalgae oil into jet fuel as well as the harvesting and drying processes. Algae biofuels are now minor participants in the aviation sector, but there is potential for growth. This paper examines some potential or existing methods for obtaining aviation fuel from microalgae oil, along with those routes' advantages and disadvantages, present trends, and potential conceptual approaches.

Keywords: Microalgae Base Jet Fuel, Climate Change Effetcs, Biofuel Technology

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1. INTRODUCTION

Renewable electricity reassets have received significance in latest years because of the declining deliver of petroleum-primarily based totally fuels and confined manufacturing areas. Both conventional and alternative fuels are becoming increasingly important to the transportation of passengers and cargo in the airline industry. Petroleum derivatives used in aviation have a negative impact on air quality. We need to reduce the source of greenhouse gas (GHG) emissions from aviation. However, these fuels are not environmentally friendly and are not used in aircraft. Developed countries are actively researching biofuels that have the potential to replace petroleum fuels and reduce emissions for self-sufficiency, sustainability and environmental improvement. To reduce fuel costs and pollution, the aviation sector can turn to biofuels already used for land transportation. Overall, sustainable resource use promotes both social and economic development. Many industrial efforts have been made to create new bio-aviation fuel sources. As a result, research into alternative biomass-based aviation fuels has increased in recent years. Establishing a cost-effective manufacturing process for biofuels and sourcing essential raw materials is critical [1].

Microalgae provide sensible and complete answers to the urgent issues of power protection and weather change. One of the major challenges in using algal biomass is the need to control large amounts of post-harvest moisture. This increases the cost of the dewatering processOne of the emerging technologies that can convert algal biomass feedstock into biodiesel without extraction and drying is in situ transesterification. This process can be improved by simultaneously operating the system under subcritical conditions. This can also reduce the need for catalysts and provide tolerance to the free fatty acid content of feedstocks. A final screening plan was used to estimate the impact of key process variables such as temperature, reaction time, and solvent-to-solids ratio on the potential fatty acid methyl ester (FAME) yield and power consumption of the process. it was done. 220 °C, 2 hours, and 8 ml of methanol (80 wt %) per gram of biomass were found to be the optimum working settings. This combination resulted in increased FAME yields and reduced power consumption during the process. This gives a yield of 74.6 MEs compared to the maximum amount of FAMEs that can be collected. Sensitivity analysis results were analyzed with respect to the relative significance of two related responses[2].

In the study, it is compared the LCA of low N and normal culture conditions to balance lipid content and specific productivity. To understand the potential contribution of lipid content to LCA, this study established the relationship between lipid content (nitrogen effect) and specific productivity using three types of microalgae.

Chlorella, Isochrysis, Nannochloropsis. For jet gasoline crafted from microalgae, lipid content material has the equal effect on fossil gasoline intake and greenhouse gas (GHG) emissions. Both fossil fuel consumption (0.32-0.68 MJMJF) and greenhouse gas emissions (17.23-51.04 g CO_2eMJF) increase with fat content (59.70-192.22% increase). As lipid content increased, total energy input decreased (2.13-3.08 MJMJF, 14.91-27.95%). LCA index increased (0-47.10%) and nitrogen recovery efficiency decreased (75-50%) [3]. With the introduction of environmental and sustainability legislation, and the finite nature of fossil fuels, the concept of gradually replacing petroleum products with biofuels has become popular. Microalgal biofuels (3rd generation biofuels) and cellulosic biofuels (2nd generation biofuels) are struggling to become widespread and commercially viable. Despite the fact that waste from biofuel production can be used as an input to improve the resource use efficiency, environmental sustainability and economic viability of each generation, there is a significant gap between these two generations. There are few studies on the integration of To fill this knowledge gap, this study proposes a new industrial symbiosis (IS) approach for co-producing second and third generation biofuels. The creation of material flow, energy flow, cost performance and environmental impact models considers stakeholder interactions within the IS system. Key economic and sustainable performance indicators are comprehensively analyzed for four scenarios, including a base case without IS, three IS situations, and three different microalgal species.

The results show that the synergistic effect of the bioenergy IS system reduces annual production costs by more than 10% compared to the base case for all IS scenarios. Additionally, the symbiotic design was found to reduce acidification potential by 7.5%, eutrophication potential by 9.4% and greenhouse gas emissions by 36% while using the same type of microalgae (AP). it was done. Synergies among various stakeholders in bioenergy IS systems have been shown to be beneficial and effective in improving both environmental and economic sustainability[4].

Various harvesting methods that help improve carbon cycling and remove nutrients can reduce microalgae development costs. Potential processes that convert biomass into fuels or bio-crude are being used to produce higher quality bio-oils. Hydrothermal liquefaction has been used to convert aquatic biomass when the biomass has a high moisture content. So it's a practical method. Catalytic hydrothermal liquefaction of ozone air flotation to capture microalgae growing in wastewater was investigated with the aim of producing bio-crude oil. Experimenting how different reaction parameters of catalytic HTL affect bio-crude and hydrocarbon partitioning using microalgae harvested from wastewater-grown microalgae by ozone air flotation and gravity sedimentation thoroughly investigated. ZSM-5 and MCM-41 catalysts were used for hydrothermal liquefaction at temperatures of 300–350 °C and reaction times of 30–120 min. 17.3 to 39.7 percent raw bio-yields from catalytic and non-catalytic bio-oils. Most of the bio-oil was produced by the ZSM-5 catalytic hydrothermal liquefaction process (39.7 wt%). In contrast to the non-catalytic and catalytic MCM-41 processes, the hydrocarbon yield production was twice as high when using the ZSM-5 catalyst in the HTL reaction. Bio-oil produced during the HTL reaction was used to determine the net energy ratio and carbon footprint. Collected microalgal HTL catalytic bio-oil was found to significantly reduce greenhouse gas emissions compared to traditionally cultivated microalgal HTL bio-oil. Deamination and deoxygenation processes were observed in the catalyst-free study as the temperature increased and improved with the ZSM-5 catalyst. This reduced his N and O content in his bio-oil [5]. Sustainable aviation fuel use is a technology that reduces harmful gaseous exhaust compounds and particulate matter emissions from aircraft engines. Alternative aviation fuels should not cause climate change and should not produce net GHG emissions over their lifetime. By using a blend of approved alternative aviation fuels and conventional aviation fuels, the amount and mass of particulate matter emitted directly behind the aircraft can be reduced by 50-70% compared to pure conventional gasoline. increase. Currently, the ASTM D7566 standard allows alternative aviation fuels to be produced in seven different ways, including using biomass, algae, agricultural waste, and animal or vegetable fats as raw materials[4]. Aviation is one of the main contributors to greenhouse gas (GHG) emissions. Transitioning from traditional fossil fuel-based jet fuel to sustainable jet fuel is critical to achieving the net zero goal by 2030. In this study, microalgal oil was modified to provide hydrocarbons with different boiling points, similar to that of jet fuel. Fractional distillation was performed after transesterification of algal oil fatty acids to algal oil methyl esters. We constructed an attempt to use resources efficiently by using the Box-Behnken technique to reduce the number of tests performed during transesterification. Analysis of variance (ANOVA) established a quantitative relationship between process output (% yield of methyl ester) and input (molar ratio of methanol to oil, catalyst concentration and temperature). We have developed a FIS (Adaptive Neuro-Fuzzy Inference System) prediction model with good prediction accuracy. A correlation-based predictive model was also built using the multi-objective response surface approach (MORSM). The accuracy of predictions of ANFIS and MORSM and the level of model uncertainty were evaluated using Theil's U2 and a set of statistical measures. The ANFIS-based model outperformed the other models on both Theils U2 and statistical measures. Operational settings were refined using desirability techniques for best results[5].

Emissions from the aviation industry account for almost 2% of global anthropogenic CO2 and the trend is increasing. The search for low-cost, environmentally friendly bio-based aviation fuels made from natural resources is gaining momentum. Microalgae growth conditions such as temperature, pH, light intensity, and nutrients have a significant impact on the chemical composition and growth rate of microalgae, so there is an opportunity to improve the production and quality of microalgae biofuels for aircraft. The production of bio-jet fuel from microalgal oil using hydroprocessing methods is the main topic of this review, along with innovative theoretical approaches such as Fischer-Tropsch gasification and sugar-to-jet.

One of the best alternatives to natural aviation fuels is Fischer-Tropsch synthesis from biomass with maximum energy efficiency and low greenhouse gas emissions. Biodiesel from microalgae was hydrotreated using Ni and zeolite catalysts to produce bio-jet fuel with high yield and alkane selectivity. Hydrotreating had the lowest production cost and longest production time among these processes, while gasification using the Fischer-Tropsch process produced highly selective bio-jet fuels (C8-C16). did it. Therefore, future methods of producing bio-jet fuel from microalgae may replace existing methods such as gasification, Fischer-Tropsch and Sugar-to-Jet. Microalgae biofuel production will reduce aviation fuel prices and improve energy security [6].

Alternative aviation fuels are seen as an effective short-term strategy for decarbonizing flights. We provide an assessment of the greenhouse gas (GHG) reductions of a recently approved commercial aviation fuel derived from sustainable algae. Three case studies with different plant designs and cultivation techniques were considered. The International Aviation LCA methodology Carbon Offset and Reduction Scheme is used to assess the potential of algae-based aviation fuels to reduce greenhouse gas emissions. The technology used here allows fair comparison with other alternative fuel production technologies. It shows that agricultural approaches focused on maximizing oil are not always effective in reducing greenhouse gas emissions. Compared to reducing greenhouse gas emissions from other common bio-based feedstocks such as rapeseed, the results show that algae is a competitive alternative to kerosene. However, algal growth has some unique requirements, including: B. Advanced process optimization, nutrient recycling and use of renewable energy to cover input demand. The study also evaluated the space required for an algae production facility capable of supplying large amounts of feedstock to an operating commercial biorefinery[7].

In this work, hydrothermal liquefaction of algal mucus was used to produce algae-derived biocrude oil, and a mixture of microalgal oil and RP-3 aviation kerosene was used as an alternative fuel for aircraft. The effects of initial temperature, initial pressure, and addition of microalgal oil on the laminar burning velocity (LBV) of microalgal oil/RP-3 mixtures over a wide equivalence ratio range of 0.8 to 1.4 were investigated in a constant volume chamber (CVC). Investigated by experiment.). Experimental results show that the LBV of the microalgal oil/RP-3 mixture increases as the starting temperature increases and the amount of microalgal oil increases. However, it decreases as the initial pressure increases. According to the Metghachi method of determining the relationship between LBV and its influencing factors, the exponents of T(), P(), and R() show an effect on LBV around an equivalence ratio of 1.1 with varying initial temperature and pressure. indicates that there will be less Relative to other equivalence ratio conditions, changing the microalgal oil addition has a greater impact on improving LBV at an equivalence ratio of 1.1 [8].

Dunaliella salina has a low lipid content and good environmental adaptability, but can absorb organic compounds from wastewater. An ecosystem model was developed based on systematic data from preliminary studies, and bio-oil emissions in this model increase significantly by 49.09%. This model is used to convert microalgae to kerosene using catalysts and the HTL method. The integration of heat in the separation distance optimization had a 65.44% and 122.86% impact on the impact categories acidification/eutrophication and fossil fuels, as electricity and heating energy were reduced by 46.1% and 63.4%, respectively. . According to the life cycle assessment (LCA) results of aqueous phase separation, the categories of acidification/eutrophication, climate change, ecotoxicity, and effects on the ozone layer were all 18.87%, 18.14%, 17.72%, and 17.72%, respectively. Reduced by 18.31% [9].

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BIO JET FUEL PRODUCTION WITH DOWNDRAFT GASIFIER TECHNOLOGY: A LITERATURE REVIEW

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ABSTRACT

The rising cost of fossil fuels, as well as worries about national security and the economy, have led to a rise in the use of fuels derived from biomass. Gasoline, diesel, heating fuel, jet fuel, synthetic natural gas, and oxygenates are just a few of the many fuels and chemicals that can be created from biomass. The complex mixture of paraffins, isoparaffins, aromatics, and naphthenes that makes up aviation turbine fuels (ATFs) ranges in size from C8 to C17. They are currently made by distilling the kerosene portion of petroleum and hydro-processing the heavier portion of petroleum. The manufacturing of ATF from shale, coal, and tar sands has received a lot of attention in recent decades. Using aviation engines for testing and demonstration, JP-4 generated from shale was proven to have no negative effects.

Keywords: Aviation Turbine Fuels, Biomass to Liquid, Aromatics

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1. INTRODUCTION

1.1. Literature Review

The development and use of renewable and eco-friendly fuels generated from residues have drawn attention on a global scale due to their benefits for the environment and the economy. Regarding the used feedstock, gasifier type, and applications for the produced gas, gasification, a thermo-chemical waste valorization technology is regarded as a flexible recycling method. The producer gas quality is primarily determined by several operating parameters in conjunction with feedstock characteristics. It seems illogical to investigate the effects of each variable separately and come up with an optimal operating state experimentally because the defining parameters in a gasification process are interrelated and probably have complex effects on the process. Implementing mathematical and computer-based models is a vital tactic for quickening research and advancement in this area. The most common modeling approach, thermodynamic equilibrium modeling, is frequently used in studies involving biomass gasification. However, because this approach takes into account several simplifying assumptions, particularly the equilibrium state condition, there have been reports of significant differences between experimental and model results. Studies based on thermodynamic modeling have suggested many modification techniques to improve the modeling accuracy, including restricted chemical equilibrium modeling, tar and char inclusion, use of modifying coefficients, and addition of heat dissipation factor [1].

Using the Sustainable Development Goals (SDG) of the UN as a frame of reference, a study of the sustainability-related elements of biomass gasification and the use of syngas from biomass for small-scale power production is presented. The most important SDGs connected to the energy transition and the energy trilemma are discussed first, along with many ideas on how to make bioenergy from biomass sustainable. In order to identify the most significant limitations of gasification processes within the context of sustainability, the elements connected to the sustainability of the gasification processes are also discussed and divided into many categories. When evaluating the sustainability of biomass as a resource for small-scale power generation, factors like the availability of land, the creation of policies that support the use of bioenergy, and the effects of syngas on the power and efficiency of combustion engines are the most pertinent. In order to determine the best configurations and features to provide these energy solutions, mostly to rural areas of developing nations, it has been discovered that the relationship between bioenergy and sustainability demands the development of extensive studies into the different aspects [2].

A significant opportunity to produce bio-renewable energy and displace traditional fossil fuels is biomass gasification. Nevertheless, several unsolvable problems have prevented its practical development for the production of hydrogen and syngas. This review compares the effects of identified problems on the commercial viability of large- and small-scale biomass gasification. Key performance indicators are presented along with an exploration of gasifier development. Using the essential indicators to assess performance, a framework is constructed to identify preferable commercial gasifier technology choices. The dominance of derivatives of downdraft fixed bed gasifiers is confirmed after an assessment of current commercial small-scale (70 kW-3 MW) gasifier technology. The purpose of this study is to highlight the economic advantages of commercial small-scale gasification systems over larger-scale projects, encourage their continued use, and provide a framework for ranking different gasifier designs so that research and development efforts can be focused on the greatest possible benefit [3].

A practical technique for producing tiny amounts of heat and power is the combination of reciprocating internal combustion engines (RICEs) and biomass downdraft reactors. Information on the impacts of biomass feedstock particle size, moisture content, and air/fuel equivalency ratio utilized in the gasification process on the quality of the producer gas was acquired from a review of published articles for this work. Additionally, information on the characteristics of producer gas is systematized, including information on its energy density, flame speed, knock tendency, auto-ignition delay duration, and normal spark ignition timing. Finally, details on the usual operation of various producing gas-fueled diesel and spark ignition RICEs are provided [4].

In addition to reducing dependency on fossil fuels, addressing environmental issues in long-term planning, and meeting sustainable development goals, biomass gasification is a promising renewable energy technology. Effective renewable energy laws, such as those of biomass and bioenergy, have been implemented in India. The technology of biomass gasification has many applications, including the production of hydrogen, second-generation biofuels, chemicals, and heat and power. The choice, use, and commercialization of gasification technology involve many factors. Biomass gasification has some advantages, including higher efficiency and lower CO_2 emissions, but it has a slow commercialization rate because of unique problems with technology, execution, and regulation [5].

The future paradigm for renewable energy may include a significant role for biomass resources as a feasible renewable technology. This renewable energy source has net zero emissions since the CO_2 produced during the production of bioenergy is equivalent to the CO_2 absorbed during the growth of biomass. Utilizing a reactor to undergo a thermochemical conversion of biomass material, biomass gasification is a flexible process for converting waste into energy. The scientific and industrial potential of biomass gasification is stimulated by gasification's greater flexibility, including both in terms of biomass type and heat generation or energy production alternatives. While fluidized beds and entrained flow gasifiers already achieve large economies of scale for fuel, downdraft gasifiers appear to be well-suited for small-scale generation of heat combined with energy. Operational parameters, feedstock kinds, and reactor design are only a few of the variables that affect how gasifiers operate. In these cases, modeling is a useful tool for creating a unit based on predictions made by the model using various operating factors and feedstock. Once validated, an appropriate model may be employed to determine how sensitively the performance of a gasifier is affected by changes in various operational and design factors. Effective models could aid in the creation and application of this technology by allowing designers to theorize and anticipate the effects of many parameters without the need for additional empirical evidence [6].

1.2. Downdraft Gasifier Basics

In a gasifier, the biomass feedstock is transformed by the thermochemical process known as biomass gasification into a mixture of combustible and non-combustible gas known as producer gas. Fixed bed gasifiers can be classified as updraft, downdraft, or cross draft depending on the biomass feedstock and producer gas flow in the gasifier. As depicted in Figure 1, the biomass feedstock is fed into a downdraft gasifier from the top and is then processed as it flows down through the gasifier via drying, pyrolysis, oxidation, and reduction. Gasifiers' lower gas outlet allows producer gas, a byproduct of gasification, to leave the gasifiers. Producer gas often consists of a combination of combustible gases like CO, H_2, and CH_4 and non-combustible gases like CO_2 and N_2 [6, 7].

Indicators of producer gas quality include tar content and heating value. High heating value and little tar make up a good producer of gas. Some significant factors, including the characteristics of the biomass, the process parameters, and the design of the gasifiers, have an impact on the quality of the producer gas produced from biomass gasification. Size, density, elemental composition (C, H, O, N, which are determined from final analysis), fixed carbon, volatile matter, ash content, and moisture content are all aspects of biomass that must be taken into account during gasification (obtained from proximate analysis). Equivalence ratio, gasification temperature, and biomass consumption rate are the gasification process' operating parameters. Fuel for gas burners or internal combustion (IC) engines can be made from the producer gas created during the gasification of biomass [6, 7].

Small-scale uses are better suited for downdraft gasifiers. Downdraft gasifiers typically have a capacity of 10 kW to 1 MW. For the feedstock of woodchips, there are a few small- to medium-scale commercial uses for power generation. Due to their straightforward construction and operation as well as the low tar content of the producing gas, downdraft gasifiers are particularly appealing. However, downdraft gasifiers have limitations such as grate blocking, channeling, and bridging, usually for feedstock with low bulk density. The fact that gasifiers can only be used with feedstock with low moisture content is another drawback. Low-quality producer gas is produced by feedstock with a moisture content greater than 30%, which results in low gasification efficiency. More heat is needed to dry feedstock with a higher moisture content than feedstock with lower moisture content. This implies that drying the feedstock with a greater moisture content requires more heat energy from the oxidation process. As a result, during gasification, there is not enough heat available for subsequent endothermic reactions. Researchers from all around the world have done and documented several modifications to the downdraft gasifier's basic design to address these disadvantages [6, 7].

Modifications to the basic downdraft gasifier's feeding system, air supply system, producing gas recirculation system, and discharge system can all be characterized as design improvements. Different types of conveyors and grates have been utilized for feedstock feeding and ash/char removal, respectively, in the continuous operation of gasifiers. The introduction of a multi-stage air supply system and an additional air preheating system improved the air supply unit. Air is delivered to the gasifier using two or more stage tuyers or nozzles in a multi-stage air supply system. The air is heated before entering the gasifier when heated air is utilized in place of ambient air. To use producer gas heat, a producer gas recirculating system was created. Both air heating and feedstock drying are possible uses for heat [6, 7].

There have been many review papers written about downdraft gasifiers, but none of them focused on the design parameter and how it affects the gasifiers' performance. The current paper's goal is to give a review of the literature on downdraft gasifier design advancements and how their performance is impacted. The outcomes of several works on small-scale downdraft gasifier basic model design improvements are reported in Table 2 after the paper. These works are referenced and talked about [6, 7].

1.3. Downdraft Gasifier Procedures

As depicted in Fig. 1, the downdraft gasifier's sequential processes are drying, pyrolysis, oxidation, and reduction. The heat from the oxidation process drives moisture from the biomass during the drying phase. The heat generated during the oxidation process is used not only for drying but also for the pyrolysis and reduction processes. The pyrolysis process results in the release of volatile gases. During the reduction process, producer gas is created and leaves the gasifier through the gas outlet [6, 7].

1.3.1. Drying Stages

The drying zone typically has temperatures between 100 and 200 °C. During drying, moisture is transformed into water vapor. Hot gases from the oxidation zone transfer their heat to biomass in the drying zone, causing the conversion to occur. The equation can be used to express the amount of moisture released in terms of mass balance since it is equal to the amount of water vapor generated (1) [6, 7].

$$m_{H2O(l)} = m_{H2O(g)} \tag{1}$$

Where $m_{H2O(g)}$ is the mass of generated water vapor and $m_{H2O(l)}$ is the mass of moisture in the biomass. Biomass with a high moisture content generates more water vapor and needs more heat to dry. In order to evaporate one kilogram of moisture in biomass at atmospheric pressure, water needs an additional 2260 kJ of heat from the gasifier. Typically, the biomass's acceptable moisture content for downdraft gasifiers falls between 5% and 35% [7].

1.3.2. Pyrolysis Stage

Figure 2 illustrates the process of pyrolysis, which converts biomass molecules into condensable gases, tar, and char at temperatures between 200 and 700 °C without the presence of oxygen. The condensable gases are broken down into liquid, char, and non-condensable gases (CO, CO_2, H_2, and CH_4) in sequence [5]. Between the gas-gas phase (homogeneous reaction) and the gas-solid phase, there is a breakdown (heterogeneous reaction). Condensable vapor is cracked into permanent non-condensable gases (CO and CO_2). Equation's reaction serves as a representation of the biomass pyrolysis process (2) [6, 7].

$$C_nH_mO_p \text{ (Biomass)} \longrightarrow \Sigma\sum_{liq} C_xH_yO_z + \sum_{gas} C_aH_bO_c + H_2O + Char \tag{2}$$

1.3.3. Oxidation Stage

During reduction, heat from oxidation is utilized for endothermic processes including drying and pyrolysis. Approximately 800-1400 °C is the oxidation temperature. Carbon monoxide and heat are produced during the partial oxidation of char (C) (Equation 3), whereas carbon dioxide and more heat are produced during the whole oxidation of char (Equation 4)). Three times as much heat is generated during whole oxidation as it is during partial oxidation. A total of 394 kJ/mol of heat is produced by oxidation, while partial oxidation produces only 111 kJ/mol.

$$C + \tfrac{1}{2} O_2 \longrightarrow CO \text{ (-111 kJ/mol, partial oxidation)} \tag{3}$$

$$C + O_2 \longrightarrow CO_2 \text{ (-394 kJ/mol, total oxidation)} \tag{4}$$ [6, 7].

1.3.4. Reduction Stage

During the reduction process, the main gasification reactions take place. The following reactions occur during reduction to produce combustible gases in the producing gas [6, 7].

$$C + CO_2 \longrightarrow 2CO \text{ (172 kJ/mol, Bouduard reaction)} \quad (5)$$

$$C + H_2O \longrightarrow CO + H_2 \text{ (131 kJ/mol, water-gas reaction)} \quad (6)$$

$$CO + H_2O \longrightarrow CO_2 + H_2 \text{ (-41,2 kJ/mol, water-gas shift reaction)} \quad (7)$$

$$C + 2H_2 \longrightarrow CH_4 \text{ (-74,8 kJ/mol, methane reaction)} \quad (8)$$

During the reduction process, endothermic and exothermic reactions take place. Both Bouduard and Water-Gas reactions are endothermic. Exothermic reactions include the methane reaction and the water-gas shift. Exothermic reactions produce 116 kJ/mol of heat while endothermic reactions use 303 kJ/mol of heat [6, 7].

2. Jet Fuel Production Via Gasification Technology

Fischer Tropsch-based catalysts, such as iron and cobalt catalysts, are currently being used to convert syngas into long-chain paraffins. To transform these long-chain paraffins into the necessary spectrum of ATFs or jet fuels, these products go through the hydrotreating and/or hydrocracking processes. The number of aromatics and/or naphthenes in the FTS-derived ATF fraction should be raised in order to meet the freezing point (40 to 47 ^{o}C) and other critical parameters of commercial ATF (Jet A) and military ATF (JP-8). To meet these requirements of Jet A and JP-8, FTS liquids must undergo several processing stages. But adding too many processing steps will make the product more expensive and reduce the process' overall effectiveness. In order to create synthetic-ATFs (SATFs) by FTS, it is important to investigate straightforward procedures as opposed to a multifunctional catalyst. Numerous research has been done to create liquid fuels from high-quality syngas, which are mostly made from coal or natural gas and consist primarily of CO and H_2. There aren't many articles describing the production of hydrocarbons from syngas that is nitrogen-rich and high in CO_2. At Mississippi State University, the downdraft gasifier now in use creates syngas from biomass (known as producer gas). The current composition of production gas is roughly 18% hydrogen, 21% CO, 12% CO_2, 2% CH_4, and 47% N_2. For economical hydrocarbon synthesis utilizing the current catalyst technologies, the nitrogen and carbon dioxide levels must be below a certain level. Creating catalysts with high activity and stability is crucial for employing producer gas to achieve better results overall. This study constructed a continuous process to show off biomass to liquid (BTL) fuel technology, which included catalyst preparation, gasification, syngas purification, and FTS. For the catalytic conversion of producer gas obtained from wood to form SATFs, a multi-functional catalyst was developed and evaluated. The catalyst's activity, selectivity, stability, and lifetime were assessed. The liquid product underwent analysis and was contrasted with Jet A fuel [8].

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DESIGN AND SIZING OF SOLAR PHOTOVOLTAIC STAND-ALONE SYSTEM OF A TYPICAL HOUSEHOLD IN NIGERIA

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ABSTRACT

The rapid population increase in Nigeria and the over-reliance on fossil fuels have createdsignificant environmental, health, and economic consequences. solar photovoltaic devices' economic and environmental merits have made it the most suitable clean energy alternative to help developing countries such as Nigeria achieve SDG-7.Nigerian Electricity Regulatory Commission (NERC) has created an off-grid electrification strategy as part of the Power Sector Recovery Program (PSRP) by approving an off-grid solar rooftop generation capacity of 5,000MW. Also, a feed-in tariff system was signed into law by NERC in 2016 to promote self-generation and reduce the overloading of the national grid.This studyproposed a design of a stand-alone solar PV system for a sustainable home that matches the Nigerian sunlight and weather conditions to meet the required energy need of the household by Sizing each component used in thestand-alone system that will power all electric appliances at a medium-energy-consumption household in Nigeria based on Watt-hour.

Keywords: Solar PV, Stand-Alone, System Sizing, Peak Sunshine Hours (PSH), Inverter

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1.INTRODUCTION

Considering the location of Nigeria in Sub-Saharan Africa (Latitude 9.0820°N and Longitude 8.6753° E), the amount of available solar energy is enormous [1]. Nigeria is estimated to have an average sunshine duration of 12 hrs/day [2] with solar radiation of 22.88MJ/m^2/day for the northern part of the country, 18.29MJ/m^2/day for the central part, and 17.08MJ/m^2/day for the southern part [2]. Solar radiation is high in Nigeria and this makes it a good location for photovoltaic (PV) system adoption. In Nigeria, connecting households of rural or remote communities to the utility grid is usually not feasible because of the increasing population and high capital cost involved in expanding the grid in these areas. Even the major communities and cities that are connected to the grid often experience frequent electricity outages which makes the grid very unreliable [3, 4]. As electricity outage is a regular phenomenon in Nigeria, the majority of households depend heavily on other sources of energy which are generally classified as fossil fuels. Also, energy consumption in Nigeria is increasing exponentially [4, 5]. The residential sector has the highest rate of energy consumption when it is compared to other sectors. The residential sector represents 37% of the total energy consumption and this consumption rate grew by 14% between the years 2000 and 2011 [6-9].

Nigeria's median residential electricity consumption has been estimated to be around 8 to 27kWh per capita which varies through geographical zones [10], the North East and South West are having the highest rate of electricity consumption. In Nigeria, which has a population of 190 million people and an average annual population growth rate of 2.8% [10], the annual energy consumption is expected to grow between 11.5% to 13% in the next twenty years [11]. This increase in energy demand means that fossil fuels cannot supply the energy needed by the populace. As the price of oil is constantly increasing, and with the predicted end of world oil production not too far away [12], the search for alternative sources of energy that are clean and cost-effective is necessary to meet the growing energy demand. Thus, there is an urgent need to plan the energy sector of the country and shift to alternative sources of energy. In addition, energy conservation or optimization measures are essential in order to meet this exponential growth.

Renewable energy technologies are emerging as alternative sources of energy that are pollution free [13], such as solar, wind, biomass, and geothermal. Cost-effective ways of harnessing these clean and sustainable sources of energy, and ways in which the environment can be made safe from the carbon emission resulting from the use of fossil fuels, are being constantly researched, yet there is low adoption of these energy sources in developing countries. Even though these energy sources can be used for many purposes such as for generating electricity, cooling, heating, and transportation, many households in developing countries are yet to fully embrace these clean energy sources due to their high initial cost of installation, uncertainty, and intermittent nature [14].

2. MATERIALS AND METHODS

2.1. Components

Solar PV system includes different components that should be selected according to your system type, site location, and applications. A Balance-of-System that wired together to form the entire fully functional system capable of supplying electric power and these components are:

2.1.1 PV Module: The PV converts sunlight into DC electricity. The most common PV modules include single and polycrystalline silicon and amorphous silicon. other technologies are now entering the market.

2.1.2 Battery – stores energy for supplying to electrical appliances when there is a need. Battery bank, which is involved in the system to make the energy available at night or at days of autonomy (sometimes called no-sun-days or dark days), when the sun is not providing enough radiation. Usually, Sealed lead-acid batteries are used and they are designed to gradually discharge and recharge 70% of their capacity hundreds of times [15].

2.1.3 Solar Charge Controller – regulates the voltage and current coming from the PV panels going to the battery and prevents battery overcharging/over-discharging and prolongs the battery life span.

2.1.4 Inverter – converts DC output of PV panels to an AC current for AC appliances. It is one of the solar energy system's main elements, as the solar panels generate DC voltage. Inverters are different by the output wave format, output power and installation type. The efficiency of all inverters reaches their nominal efficiency (around 90%) [16].

2.1.5 Loads– are electrical appliances that are connected to solar PV systems such as lights, radio, TV, computer, refrigerator, etc.

2.2. Configuration

The photovoltaic systems are classified according to how the system components are connected to other power sources such as standalone (SA) and utility-interactive (UI) systems. In a stand-alone system depicted in Figure 1, the system is designed to operate independent of the electric utility grid, and is generally designed and sized to supply AC electrical loads.

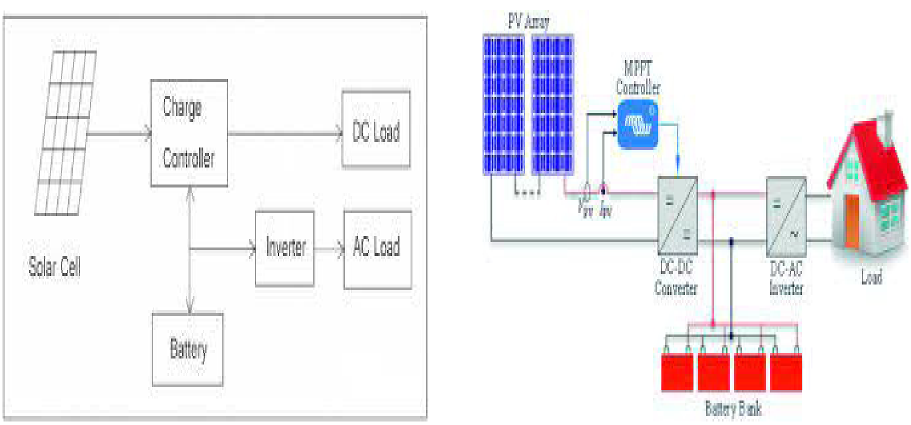

Figure 1. Block and Schematic diagrams of standalone Photovoltaic system

2.3. System Sizing

System sizing is the process of evaluating the adequate voltage and current ratings for each component of the photovoltaic system to meet the electric demand at the facility and at the same time calculating the total price of the entire system from the design phase to the fully functional system including, shipment, and labor.

2.4. Household Devices

As a first step, the electrical devices available at the residence are itemized with their power ratings and time of operation during the day to obtain the average energy demand in Watt-hour per day as shown below in Table 1 The total average energy consumption is used to determine the equipment sizes and ratings starting with the solar array and ending with system wiring and cost estimate as shown in the table below:

Table 1. Electrical Energy Load of the Household Appliances

Appliances	Quantity (Q)	Power (W)	Power Factor (P.F)	Q×W	Q×W/P.F	Hours/ day	Wh/day
LED bulb	15	10	1.0	150	150	12	1800
Television	2	100	0.7	200	285.7	6	1714.3
Satellite Receiver	1	80	0.8	80	100	6	600
Refrigerator	1	200	0.7	200	285.7	7	2000
Washing Machine	1	250	0.9	250	277.8	3	833.33
Ceiling Fan	3	100	0.8	300	375	12	4500
A/C	1	100	0.8	100	125	6	750
Phone Charger	3	20	0.9	60	66.7	3	200
Laptop Computer	1	300	0.9	300	333.33	3	1000
Radio	1	50	0.7	50	71.43	2	142.86
Iron	1	1000	1.0	1000	1000	2	2000
Oven	1	300	1.0	300	300	2	600
Coffee Maker	1	400	1.0	400	400	1	400
TOTAL					**3770.66**		**16540.49**

Design Assumptions

In this design of an off-grid solar PV system, we employed the following assumptions:

- Peak Solar Intensity at the earth's surface is taken to be 1000W/m^2.
- Inverter converts DC into AC power with an efficiency of 90%.
-The number of the autonomy days in Nigeria is taken to be 1 days.
- The maximum depth of discharging is assumed to be 30%.
-The design system voltage is 48V.

2.5. Sizing of the Inverter

When sizing the inverter, the actual power drawn from the appliances that will run at the same time must be determined as a first step. An inverter is used in the system where AC power output is needed. The input rating of the inverter should never be lower than the total watt of appliances. The inverter must have the same nominal voltage as your battery. For stand-alone systems, the inverter must be large enough to handle the total amount of Watts that will be used at one time. The inverter size should be 25-30% bigger than total Watts of appliances [17]. In the case of the appliance, the type being motor or compressor then the inverter size should be a minimum of 3 times the capacity of those appliances and must be added to the inverter capacity to handle surge current during starting. The total Wattage of all equipment in the design is 3770.66 Watt. Therefore, The Inverter size needed must be able to handle about 4000-W, 24-Vdc, at 220-Vac.

2.6. Sizing of the Solar Array

Before sizing the array, the total daily energy in Watt-hours, the average sun hour per day and the DC-voltage of the system must be determined. Once these factors are made available, we move to the sizing process. To avoid under-sizing, losses must be considered by dividing the total power demand in Wh/day by the product of efficiencies of all components in the system to get the required energy. To avoid sizing we begin by dividing the total average energy demand per day by the efficiencies of the system components to obtain the daily energy requirement from the solar array [18]. The following equations (1-13) are used in the calculation:

$$SED = \frac{CED}{PR} \qquad (1)$$

Where:

SED = Solar Energy Demand

CED = Consumer Energy Demand

PR = Performance Ratio

$$SAP = \frac{SED}{PSH} \qquad (2)$$

Where:

SAP = Solar Array Power

PSH= Peak Sunshine Hours

$$Nm = \frac{SAP}{Module\ Wattage} \qquad (3)$$

$$Nms = \frac{Vsystem}{Vmodule} \qquad (4)$$

$$Nmp = \frac{Parray}{Nms \times Pmodule} \qquad (5)$$

Where:

Nm = Number of modules

Nms = Number of modules in series

Nmp = Number of modules in parallel

2.7. Sizing of the Battery Bank

The amount of rough energy storage required is equal to the multiplication of the total power demand and the number of autonomy days. For safety, the result obtained is divided by the system voltage maximum allowable level of discharge DOD [17]

$$\mathbf{C} = \frac{BD \times DOA}{Vsy \times DOD} \qquad (6)$$

Where:

C = Battery Capacity

BD= Battery Demand

DOA=Day of Autonomy

DOD=Depth of Discharge

The number of batteries can be calculated by dividing battery capacity by chosen batteryrating as shown in equation (7) below;

$$Nb = \frac{C}{Battery\ rating\ (Ah)} \qquad (7)$$

$$Nsb = \frac{Vsystem}{Vbattery} \qquad (8)$$

$$Npb = \frac{Nbatteries}{Nbseries} \qquad (9)$$

Where:

Nb=Number of batteries

Nsb=Number of batteries in series

Npb=Number of batteries in parallel

2.8. Sizing the Charge Controller

According to its function it controls the flow of current. A good voltage regulator must be able to withstand the maximum current produced by the array as well as the maximum load current. Sizing of the voltage regulator can be obtained by multiplying the short circuit current of the modules connected in parallel by a safety factor Fsafe. The result gives the rated current of the voltage regulator. The factor of safety is employed to make sure that the regulator handles maximum current produced by the array that could exceed the tabulated value. And to handle a load current more than that planned due to addition of equipment, for instance. In other words, this safety factor allows the system to expand slightly. The number of controllers equals the Array short current Amps divided by the Amps for each controller [16]:

$$Irated\ of\ SCC = Nmp \times Isc \times Fsafe \qquad (10)$$

$$Nvreg = \frac{Irated}{Iselected} \qquad (11)$$

Where:

SCC= Solar Charge Controller rating

Nvreg=Number of voltage regulator

2.9. Sizing of the System Wiring

Selecting the correct size and type of wire will enhance the performance and reliability of a photovoltaic system. The max current can be calculated as following from equation (10) and the cross-sectional area of the cable is given by the equation below:

$$A = \frac{resistivity\ of\ copper\ wire \times Imax \times length\ of\ cable}{maximum\ voltage\ drop} \times 2 \qquad (12)$$

The resistivity of copper wire is taken as 1.7×10^{-8} Ωm according to American wire gauge (AWG) and the cable length assumed to be 10m. The maximum voltage drop for the DC wiring is taken not to exceed the 4% [18]. And can be calculated by the following formula:

$$Vd = \frac{4}{100} \times Vsystem \qquad (13)$$

3. RESULT AND DISCUSSIONS

The results obtained and discussion are as follows:

3.1. Results

3.1.1. Module Sizing

Equations (1-5) was used to compute the values of Solar energy demand, Solar array power, number of modules as well as number of modules in series and parallel required.

$$\text{Consumer Energy Demand} = \frac{Total\ Wh/day}{Inverter\ efficiency}$$

$$= \frac{16540.49}{0.9}$$

$$= 18378.322\ \text{Wh} \quad \approx 18.378\text{kWh}$$

Add 1% of Inverter size value to the above and thus, 1% of 4kW = 40W

40W x 24hrs = 960Wh

Therefore, 18378.322Wh + 960Wh

CED = 20298.322Wh

From equation (1) **SED** = 20298.322Wh/0.65

= 31228.19Wh

From equation (2) **SAP** = 31228.19/5h

= 6245.64Wp

From equation (3) **Nm** = 6245.64/350W

≈ 18 no, 8.5A, 24V modules

From equation (4) **Nms** = 48/24 = 2 modules

From equation (5) Nmp = 6245.64Wp/2×350W

≈ 9 modules

3.1.2. Battery Sizing:

Equations (6-9) were used to calculate Battery capacity, number of batteries, number of batteries in series and parallel as shown below;

From equation (6) **C** = 20298.322VAh/48×0.3

= 1409.61Ah

From equation (7) **Nb =**1409.61Ah/100Ah

≈ 14 no., 100Ah, 24V batteries

From equation (8) **Nsb** = 48/24= 2 batteries

From equation (9) Npb = 14/2 = 7 batteries

3.1.3. Charge Controller Rating:

The number of Voltage regulator required for the design and its rating was calculated using equation (10) and (11) as follows;

From equation (10) Irated of SCC = 9×8.5×1.25

≈100A

From equation (11) Nvreg = 100A/50A = 2 no., 50A, 24V Charge controllers.

3.1.4 Cable Sizing

The max current of the cable can be calculated as following from equation (10):

Imax = Np × Isc ×Fsafe

= 9 × 8.5 ×1.25 = 100A

From equation (13) Vd =4/100×48

=1.92V

From equation (12) A $=1.7\times10^{-8}\,\Omega m \times 100A\times 2l/1.92V = 1.77mm^2$

This means any copper cable of cross-sectional area $1.77mm^2$ 100A and resistivity of 1.7×10^{-8} Ωm can be used for the wiring between PV modules and batteries through the voltage regulator.

Table 2. Estimate of system Components

Components	**Specification**	**Quantity**	**Unit Price ($)**	**Total Price ($)**
Solar Modules	Yangtze 350W, 24V (Polycrystalline Silicon panel)	18	77	1386
Battery	Yangtze Solar Power 100Ah, 24V Lead acid (Sealed battery)	14	130	1820
Inverter	Latronics LS-4000W, 24V (D.C), 220V (A.C.)	1	300	300
Voltage Regulator	Sunny Island, 24V, 50A.	2	80	140
Wire	PV $1.77mm^2$, 40°C-90°C (MQQ=1roll=50m)	1	50	50
Micelle nous Cost				200
Total				3896

3.2 Cost Analysis for PV System

The operating costs for solar PV installations are negligible, but the annual maintenance cost may amount to 0.5% to 1% of the capital cost of the system. Maintenance cost of the PV system is taken to be 0.8% of the capital cost of the system as:

$AnnualMaintenanceCost$ **= 0.8% ×** $CapitalCost$ **= 0.8% × $3896 = $311.68**

Therefore, the overall cost of the system can be found by adding the capital cost of the system with annual maintenance cost as given below:

$Overallcost$ **of Solar PV System=** $capitalcost + annualmaintenancecost$ **= $3896 + $311.68 = $4207.68**

3.3. Cost Analysis for Generator

Assuming it is taking 6hours per day to power the house using generator:

-The generator consumes 2 litres of petrol per hour

-1 liter of petrol=$0.436 in Nigeria (2022)

-Cost of 4KW Generator=$600

-1 litre of petrol produces about 2.4 kg CO_2

Table 3. Fuel consumption of the Generator and CO_2 produced

Time	**Liters**	**Price ($)**	**CO_2 (kg)**
Day	12	5.232	28.8
Month	360	156.96	156.96
Year	**4380**	**1909.68**	**1909.68**

$AnnualMaintenanceCost$ **of Generator = 20% ×** $CapitalCost$**= 20% × $600 = $120**

Therefore, the overall cost of the system can be found by adding the capital cost of the system with annual maintenance cost as given below:

$Overallcost$ **of Generator =** $capitalcost + annualmaintenancecost$ **= $600+ $120 = $720.**

Total running cost of generator= Overall cost of generator + fuel consumption =

$720+$1909.68=**$2629.68 per year**

3.4. Payback Period of the System

The payback period of the system is equal to the ratio of the overall cost of the solar PV system to the total running cost of the fuel and cost of the generator.

$$Payback\ period = \frac{Overall\ cost\ of\ solar\ PV}{Runnig\ cost\ of\ fuel\ and\ cost\ of\ Generator}$$

$$Payback\ period = \frac{4207.68}{2629.68} = 1.6 \text{ years}$$

3.5. Discussion of the Results

The system was design and sized based on the daily electrical energy demand for the household in Nigeria. The load was estimated as 16540.49Wh/ day based on the watt-hour rating of the household appliances. The result of the estimated daily electrical energy demand was presented in Table 1. The stand-alone solar PV system was designed based on the estimated load. The results in Table 2 shows that the house requires 18no. (350W, 24V) polycrystalline solar PV which consist of series and parallel connections of the solar PV arrays of 2 modules and 9 modules to generate electrical energy 16540.49Wh/day to the house. For storage of energy for use when there is demand a storage battery bank has been designed and selected. The house requires 14 batteries of which 7 are connected in parallel while 2 batteries are connected in series. A battery bank with a capacity 100Ah, 24V manufactured by Yangtze Solar Power was selected. To safely charge the batteries and to maintain longer lifetime for them, the house requires a voltage regulators of capacity 100A.

The house appliances are AC current appliances, so the house requires inverters that convert its DC current to AC current. The number of the inverter required by the system is only one. Finally, the capital cost of the system was $3896 whereas the overall cost of the system was $4207.68. From table 3.1 we can see that the modules, the batteries and the inverter are the costliest components of the photovoltaic system. Therefore, Increasing the size of these components will increase the overall cost of the system. A cost estimate of the system provides the payback period of the system is estimated to be 1 years and 6 months which is obviously much shorter than the lifespan of the solar PV modules which is about 20 years.

From table 3 we can see that if we are to run the household appliances for 6hour per day, the 4kW generator at full capacity consumes 2 litres of petrol and one litre produces 2.4kg of CO_2. For one year the system will discharge about 1909.68kg of CO_2 to the atmosphere which can bring about negative effect to the climate change and contribute significantly to the global warming.

4.Conclusion and Recommendation

In this research work, the electrical energy demand for a typical household in Nigeria was estimated as 16540.49Wh/ day. System design, sizing and selection of the components were provided based on the estimated load. The results of the research revealed that a 350W, 24V solar PV array capacity of 18 modules, 14 (100Ah, 12V) batteries and 2 (50A, 24) voltage regulator are needed to supply the electrical load of the house. The overall cost estimate of the system was $4207.68 which is relatively high when compared to that of fossil fuel generator $2629.68 used by the house but the payback period of the system is estimated to be 1 years 6 months, which is obviously much shorter than the lifespan of the selected PV modules which is 20 years. The recommendation would be that the renewable energy systems should be encouraged for use because it has zero pollution as seen from this system if properly installed and utilized can prevent release of 1909.68kg of CO_2 into the atmosphere.

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α-Fe_2O_3/CdS/g-C_3N_4 COMPOSITE MATERIAL for DEGRADATION of MB DYE and H_2 EVOLUTION

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ABSTRACT

Environmental remediation and renewable energy production were studied employing photocatalytic degradation of waste materials in aqueous medium, as well as photocatalytic hydrogen generation. α-Fe_2O_3 and CdS are common visible-light-driven semiconductor photocatalysts due to their low cost, easy fabrication, and stability. However, its applications are reduced by the photo corrosion, narrow optical band gap for solar-light operations and weak separation of photogenerated electron-hole pair. To boost the implementation of α-Fe_2O_3, CdS, α-Fe_2O_3/CdS, and g-C_3N_4; a ternary nanocomposite (α-Fe_2O_3/CdS/g-C_3N_4) was created. CdS nanoparticles were expanded on α-Fe_2O_3 nanorods-cubes utilizing simple wet-chemical procedure to acquire binary structure, and as-prepared g-C_3N_4 was decorated with binary material. Material characterizations were employed to investigate the crystal structures, surface morphology, optical properties and functional groups. Photocatalytic investigations for hydrogen production and MB dye degradation under solar light irradiation were carried out by regarding optical absorption characteristics. The ternary semiconductor had the highest photocatalytic H_2 evolution, 165 µmolg^{-1}2h^{-1} from water, among the produced samples. The photocatalytic performance yielded in 99.4% percent degradation of the MB after 120 minutes. The higher performances were ascribed to Z-scheme mechanism, optical band levels and stringent heterojunctions of the photocatalysts that brings significant electron-hole separation, afterward quick diffusion of photogenerated charge between structures and the optical bandgap value of the ternary structure that more suitable for solar lights implementations. This research lays the way for photocatalysts to improve in actual pollution and energy situations.

Keywords: Photocatalysis, Hydrogen Evolution, Photodegradation, α-Fe_2O_3/CdS/g-C_3N_4

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1. INTRODUCTION

Several semiconductors were discovered to exhibit enhanced efficiency under UV light during the hunt for photocatalysts for hydrogen production and the degradation of contaminants by renewable energy approaches. While when metals, metal oxides, metal sulfides, or non-metals are doped or semiconductor composites are created and carried out under visible light or solar light irradiation, significant development in H_2 production on semiconductors has been documented [1]. Numerous investigations have shown that composites with metal, metal oxide, or metal sulfide reinforcement on the photocatalyst surface have increased H_2 production capacities [2]. The material that has been deposited can act as a co-catalyst or a sensitizer. Due to the potential for metals or metal oxides-sulfides to be quickly deposited on the photocatalyst, these photocatalysts are crucial for water splitting and wastewater treatment applications. In order to achieve better photocatalytic activity for dye degradation and photocatalytic hydrogen production by easily sensing H_2, we created a solar-light-driven Z-scheme photocatalyst composite in this study. For the overgrowth of CdS nanoparticles, we employed the premade α-Fe_2O_3nanorods-nanocubes template using a straightforward solution technique under mild reaction conditions. Additionally, g-C_3N_4 was independently synthesized and decorated with α-Fe_2O_3/CdS composite to assess and determine the efficiency on photocatalytic capabilities. Individual catalysts, such as single α-Fe_2O_3, CdS, and g-C_3N_4 structures, as well as binary (α-Fe_2O_3/CdS) and ternary (α-Fe_2O_3/CdS/g-C_3N_4) structures, were created using an aqueous process, comprising hydrothermal reaction, and embellished with a simple physical methodology.

2. MATERIAL AND METHODS

All compounds were obtainable commercially, and they were all utilized without further purification. Ferric chloride ($FeCl_3 \cdot 6H_2O$, 99.9%), Sodium hydroxide pellets (NaOH, ≥97.0%), Thiourea (CH_4N_2S, ≥99.0%) Urea ($CO(NH_2)_2$, ≥99.5%), Ammonium hydroxide solution (28% NH_3 in H_2O; ≥ 99.99%) were attained from Merck chemical co., Sodium sulfide (Na_2S), Sodium sulfite (Na_2SO_3, ≥99.5%), Cadmium sulfate ($Cd(SO_4)$, ≥99.0%) from Sigma Aldrich.

Cu K radiation source, Ultima IV (Rigaku) spectrometer, operating at 40 kV and 40 mA, and equipped with a Cu K radiation source, were used to measure the powder X-ray diffraction (XRD) of the samples. Scanning Electron Microscopy (SEM) was used to analyze the grain and surface morphologies of powder materials (Thermo Scientific Apreo S). Energy dispersive spectroscopy (EDS) coupled to scanning electron microscopy (SEM) was used to determine the elemental compositions of the manufactured semiconductors. On a Lambda 950 UV/VIS/NIR (Perkin Elmer) spectrometer, UV-Vis spectra were recorded. One to two mg of composite samples were combined with 100 mg of KBr for Fourier transform infrared (FT-IR) analysis using a Spectrum BX (Perkin Elmer) spectrometer with data acquired in the 400 to 4000 cm^{-1} range at a resolution of 10 cm^{-1}.

2.1. Synthesis of α-Fe_2O_3/CdS/g-C_3N_4

Pre-synthesised g-C_3N_4 and α-Fe_2O_3/CdS were weighed (1:10), using the determined methods.

α-Fe_2O_3/CdS binary composite semiconductor material was decorated with dispersed g-C_3N_4homogenously using ultrasonic sonicator in aqueous suspension to get ternary composite due to the high surface area, volume, and low weightiness of g-C_3N_4. The solid materials were placed in 30 ml of deionized water and immediately ultrasonically processed at room temperature for 1 hour. The suspension that was produced was filtered and washed with ethanol and DI water, respectively. The precipitate was then dried overnight at 70 °C. The aqueous method was used to create the ternary heterostructured α-Fe_2O_3/CdS/ g-C_3N_4 composite material in an aqueous solution

3.RESULT AND DISCUSSION

According to the JCPDS card no., the synthesized single CdS nanoparticles with aqueous-phase route and also adsorbed CdS on the surface of the α-Fe_2O_3 represented the typicial diffraction peaks belong to hexagonal structure 2θ at 24.8, 26.6, 28.1, 43.9, 47.7 and 52.1° which are explicable for the lattice planes of (100), (002), (101), (110), (103) and (112) respectively. The characteristic peak of CdS (100) slightly appeared at 25° on α-Fe_2O_3/CdS orange colored curve. g-C_3N_4 exhibited two characteristic peaks on the black curve at diffraction angles of 12.84° ascribed to the (100) in-plane packing motif and 27.23° ascribed (002) interlayer stacking of aromatic segments. As seen on the blue on Fig 1. α-Fe_2O_3/CdS/ g-C_3N_4 curve, the peak at 27.23° regarding the g-C_3N_4 (002) plane was suppressed by intense CdS peaks at 26.6°and 28.1° [3-6].

The average crystallite size was calculated from the XRD peak using the Debye-Scherrer equation as follows:

$$D = (k \, X \, \lambda)/\beta cos\vartheta \qquad (1)$$

where D is the crystallite size (nm), λ is the X-ray wavelength (nm), k is a constant related to the crystallite shape and normally taken as 0.89, β is the peak width at half maximum (FWHM) of the XRD peak and θ is the diffraction angle. The crystallite average size of α-Fe_2O_3 and CdS was 20.33 ± 1.28 nm and 9.89 ± 0.85 nm, respectively.

SEM was employed to investigate the morphology and nanostructure of the synthesized samples. Fig. 2(a-e) shows the SEM images of α-Fe_2O_3, CdS, α-Fe_2O_3/CdS, α-Fe_2O3/CdS/ g-C_3N_4, g-C_3N_4 and EDX analysis spectrum of the α-Fe_2O_3/CdS/ g-C_3N_4, respectively. The composition of the ternary nanocomposite was further confirmed by EDX analysis demonstrating that the nanocomposite is composed of C, O, N, S, Cd and Fe elements as seen in Fig 2(f).

To acquire more insight into the chemical environment and functional groups of the samples, FT-IR analysis was recorded for single, binary and ternary materials, as shown in Fig. 3. The appeared peaks for bare g-C_3N_4 at 1240, 1320, 1415, 1462 and 1560 cm^{-1} are correlated with the typical stretching vibration of C – N heterocycles. The peak at 1638 cm^{-1} is concerned with C = N stretching vibration mode [7]. The typical peak at 810 cm−1 belongs to the characteristic breathing vibration mode of the triazine ring [8]. The wide bands at 3000 – 3500 cm^{-1} is due to the stretching modes of terminal NH groups at the defect sites of the aromatic ring and OH stretching vibration of adsorbed water molecules so the band at 3180 cm^{-1} is dedicated to the stretching modes of uncondensed amine groups and the peak is observed at 3421 cm^{-1} is attributed to the stretching vibrating of O – H mode. For pure α-Fe_2O_3, the peaks at 538 and 472 cm^{-1} represent the presence of Fe-O metal-oxide bonds [9]. As for the pure CdS sample, the band at 710 cm^{-1} is attributed to the Cd–S bond. The presence of characteristic peaks at 1120 and 1630 cm^{-1} assigned to O – H stretching mode of H_2O molecule, the peak at 1425 cm^{-1} is mainly due to C – O stretching vibrations.

In a closed-gas system with a pyrex cylindrical reactor placed 10 cm from a 1000 W xenon lamp with solar light irradiation, the evolution of H_2 was measured in a liquid medium (100 ml) containing 0.1 g photocatalyst and 0.1 M Na_2S/0.0_2 M Na_2SO_3 as a sacrificial agent. Before the reaction, water suspension containing the photocatalyst, Na_2S, and Na_2SO_3 was treated in an ultrasonic bath for 10 minutes and deoxygenated for the same amount of time with argon. In order to conduct the experiment, 100 mg of photocatalyst powder was added to 100 mL of MB dye solution, which had a starting concentration of 10^{-5} M and a pH of 7. The 1000 W xenon lamp and MB dye suspension were suspended in a cylindrical reactor for use as a light source. Xenon lamp was employed as the light source while MB dye suspension was used to irradiate the catalyst vertically in the cylindrical reactor. The Xe lamp was placed 10 cm from the cylindrical reactor, and a solarimeter was used to measure the light's intensity from that distance (KIMO SL 200). To develop the adsorption-desorption equilibration of the dye on the photocatalyst, an air pump was used to stir an MB dye suspension with photocatalyst for 15 minutes while it was kept in the dark.

All the samples exhibited various degrees of photocatalytic activity for hydrogen evolution as seen in Fig. 4 (a-b). The photocatalytic activities of the nanostructure synthesized photocatalysts were assessed by observing the degradation of MB dye molecules under Xenon lamp irradiation that simulates solar light. The hydrogen generation ratio after decorating g-C_3N_4 with α-Fe_2O_3/CdS reached around 165 mol, which is almost 3.8, 1.6, and 1.8 times greater than that of pristine g-C_3N_4, CdS, and α-Fe_2O_3/CdS, respectively. This is because the optical bandgap connection between these three semiconductors and the simple electron transport through the Z-scheme mechanism result in less electron-hole recombination.

The degradation rates were 77.9%, 80.2%, 83.8%, 99.4% and 97.3% for α-$Fe_2O_{3,}$ CdS, α-Fe_2O_3/CdS, α-Fe_2O_3/CdS/ g-C_3N_4 and g-C_3N_4, respectively as seen in Fig. 5(b). It exhibited that the prepared α-Fe_2O_3/CdS/g-C_3N_4 sample showed much better photocatalytic degradation capability to methylene blue under solar light irradiation.The band structure of the ternary composite which exhibits Z-scheme heterojunction constructed between α-Fe_2O_3, CdS and g-C_3N_4. Due to the strict interface and thermodynamically proper band bending between the α-Fe_2O_3 and CdS, electrons generated by light in the CB of α-Fe_2O_3 transfer to the VB of CdS and then recombine with the holes in the VB of CdS nanospheres under solar light illuminatio. Then the generated electrons move from CB of CdS to HOMO level of g-C_3N_4.

4. CONCLUSION

The photocatalytic experiments showed that the α-Fe_2O_3/CdS/ g-C_3N_4 ternary nanocomposite displayed the best photocatalytic activities when exposed to solar light. This was attributed to the interaction between semiconductors and the nanorods-cubes of α-Fe_2O_3, the spherical structure of CdS, and the effect of the g-C_3N_4 structure, which wraps inorganic semiconductors to prevent photo corrosion and These findings show that the α-Fe_2O_3/CdS/g-C_3N_4 material has the potential to be used as a high-performance photocatalyst powered by solar light. This method of mixing two catalyst materials that respond to visible light with an organic semiconductor could be used as a quick and simple way to make a photocatalyst with a high rate of efficiency.

Tables and Figures

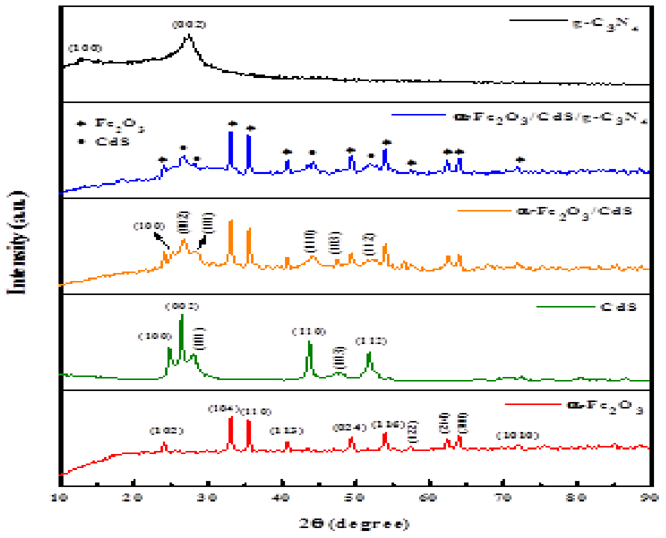

Fig. 1. XRD patterns of as synthesized photocatalysts.

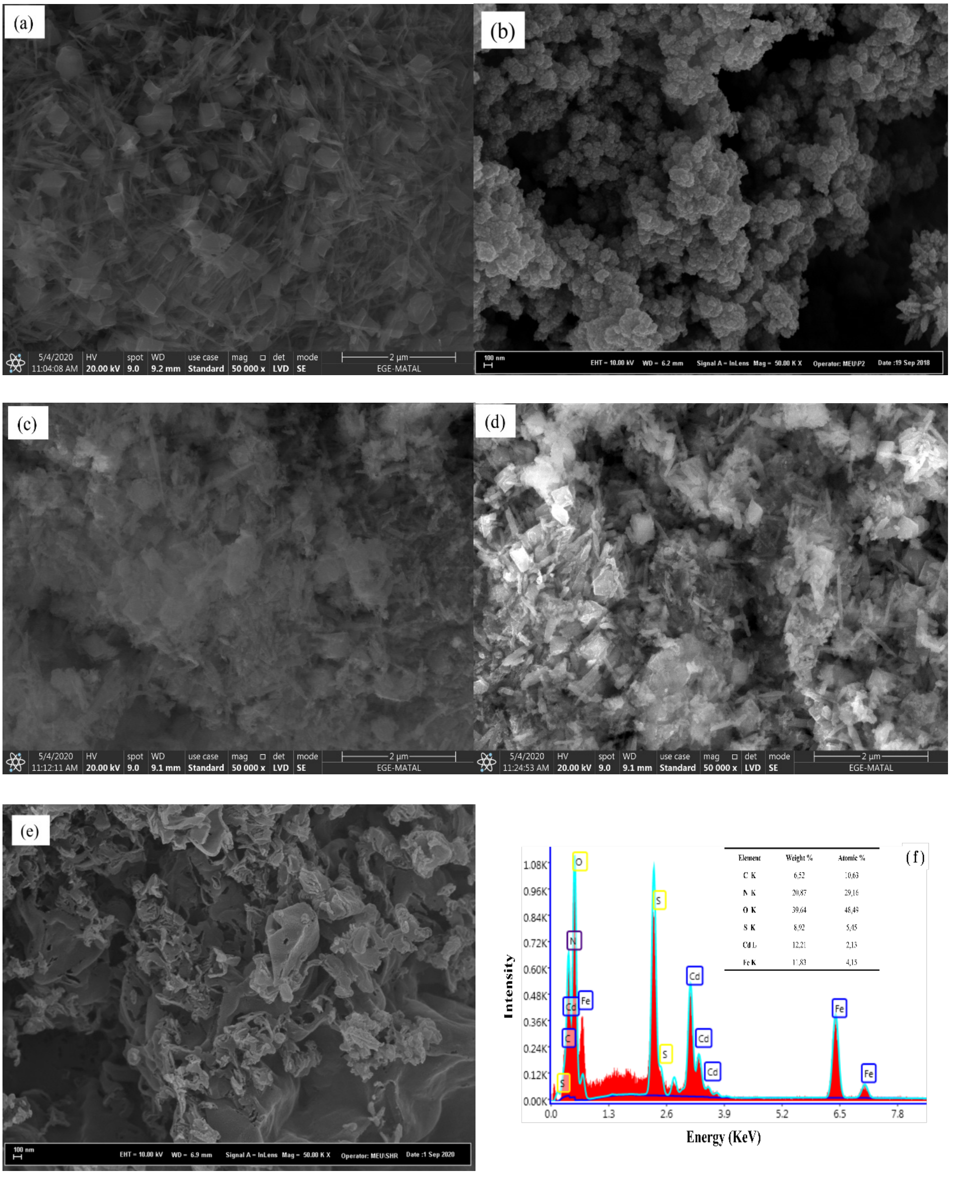

Fig. 2. SEM images of (a) α-Fe_2O_3, (b) CdS, (c) α-Fe_2O_3/CdS, (d) α-Fe_2O_3/CdS/g-C_3N_4, (e) g-C_3N_4 and (f) EDX analysis spectrum of the α-Fe_2O_3/CdS/g-C_3N_4.

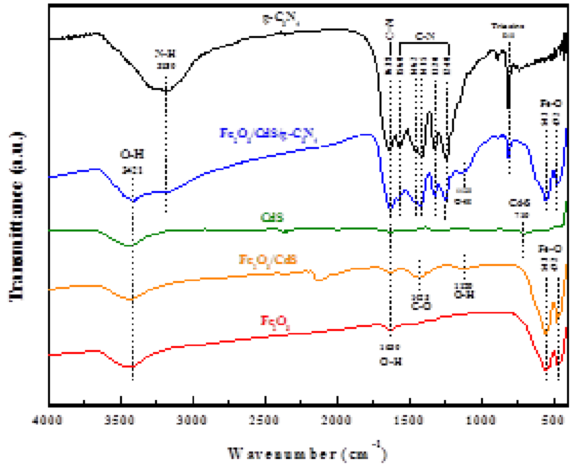

Fig. 3. FT-IR spectra of photocatalysts

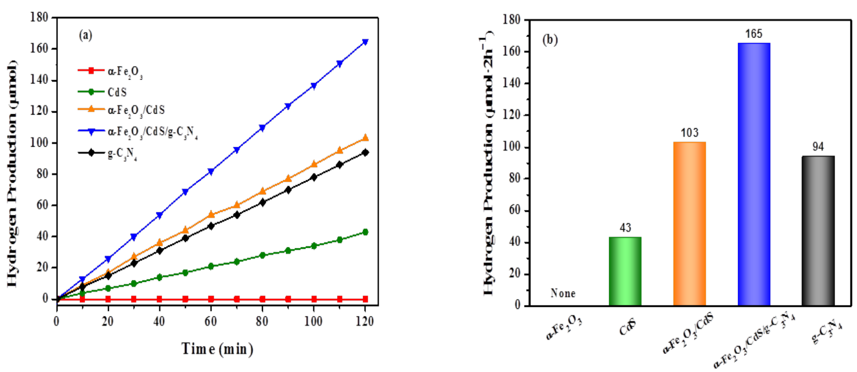

Fig. 4. (a) H_2 evolution with time for different photocatalysts, (b) H_2-evolution rates.

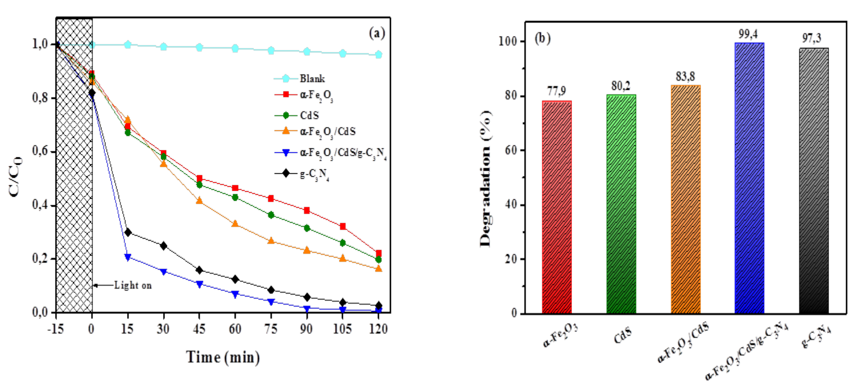

Fig. 5. (a) Photocatalytic degradation of MB in aqueous solution using prepared nanocomposites, (b) The degradation rates of the MB solution using photocatalysts at 120 min

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EFFECT of g-C_3N_4 REINFORCEMENT in BINARY ZnO/CdS for PHOTOANODE of DSSC

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ABSTRACT

Due to the direct wide band gap (~3.3 eV) of ZnO, the photoconversion efficiency is significantly reduced due to limited light absorption and charge transfer properties caused by defects in the structure. For heterostructured photocatalysts, besides charge carrier transfer mechanisms, an increase is observed in photocatalytic processes and efficiency values of solar cell applications, especially for long-term applications. It is known that conventionally prepared CdS and ZnO are generally exposed to severe photocorrosion in long-term photocatalytic reactions. Therefore, hybridization of conjugated g-C_3N_4 with binary (ZnO/CdS) can effectively improve their visible light response and photovoltaic power conversion efficiency activities. In this study, it is thought that by growing CdS nanospheres on ZnO, the absorbance limit shifted towards the visible region and type II mechanism harmonization was achieved, which would make the electron-hole transfer effective at conduction - valence band levels. The current density and efficiency values of DSSC produced with a triple structure (ZnO/CdS-g-C_3N_4) were calculated as 9.34 mA/cm^2 and 2.23%, respectively, and showed the highest performance.

Keywords: Photoanode, DSSC, ZnO, CdS, g-C_3N_4

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1. INTRODUCTION

Solar energy harvesting is a difficult task. A few fresh concepts for converting solar energy into electricity have surfaced in the last ten years, posing a threat to the p-n heterojunction-based conventional photovoltaic devices [1]. Due to their affordable ingredients and straightforward manufacturing processes, dye-sensitized solar cells stand out as affordable and effective photovoltaic devices in comparison to more expensive traditional silicon solar cells. TiO_2 nanoparticles-based DSSC, which has a conversion efficiency of more than 10%, is the most promising of them all [2].

Since ZnO and TiO2 have comparable physical qualities and their conduction band edges are situated close to one another, ZnO is currently being researched as a potential substitute for TiO2 in DSSCs. Additionally, ZnO has a substantially greater electron mobility at ambient temperature (115-155 $cm^2\ V^{-1}\ s^{-1}$) compared to anatase TiO_2 ($\leq 10^{-5}\ cm^2\ V^{-1}\ s^{-1}$) [3–5], and different ZnO nanostructures can be easily created by manipulating preparation procedures and growth environments. Single-crystal, vertically oriented nanowire arrays are among the most intriguing and exciting ZnO nanostructures. It is advantageous for the quick separation of electrons and holes because this ZnO structure can perform high-speed electron transmission via rectilinear conduction pathways. The development of ZnO-based DSSCs has received a lot of attention, but their light to electric power conversion efficiencies are still quite low and far from adequate [6–9]. The breakdown of ZnO in acidic dyes, which results in the production of Zn^{2+}-ruthenium dye aggregates impeding the electron injection efficiency, is blamed for the low energy conversion efficiencies of ZnO-based DSSCs with ruthenium photosensitizers. Inorganic semiconductor quantum dots (Q dots), such as CdS, PbS, CdSe, and InP [10–12], with variable bandgaps in the visible range are used as alternatives to traditional dyes for quantum-dots sensitized solar cells to address the issue (QDSSCs). In comparison to traditional dyes, they display a number of innovative qualities and benefits, including a higher extinction coefficient and improved radiation stability. It is well known that a solar cell with a high extinction coefficient has a lower dark current and a higher overall efficiency. Another benefit of Q dots is that the absorption spectrum may be adjusted by adjusting the sizes of Q dots since it is simple to control the fabrication process of Q dots in order to manage the quantum confinement effect. The absorption spectra of cadmium sulfur (CdS), an n-type semiconductor with a direct band gap of 2.4 eV, is observable at ambient temperature. CdS is a material that has undergone substantial research and is regarded as a good photosensitizer for ZnO-based solar cells because of its narrow band gap and outstanding photoconductivity.

Additionally, graphitic carbon nitride (g-C_3N_4), a metal-free semiconductor, has drawn a lot of interest in photovoltaics and photocatalysis due to its distinctive inherent properties, such as a visible light driven bandgap and excellent stability [13-16]. Since g-C_3N_4 has a CB that is higher than that of TiO_2 (1.12 eV) (0.29 eV), it can be employed as a blocking layer to provide an energy barrier that effectively inhibits the recombination reaction [17].

2. MATERIAL AND METHODS

All compounds were obtainable commercially, and they were all utilized without further purification. Zinc chloride (ZnCl2, ≥ 98%, Cadmium chloride (CdCl2, 99.99%), Thiourea (CH_4N_2S, ≥99.0%) Urea ($CO(NH_2)_2$, ≥99.5%), Ammonium hydroxide solution (28% NH_3 in H_2O; ≥ 99.99%) were attained from Merck chemical co., Sodium sulfide (Na_2S), Sodium sulfite (Na_2SO_3, ≥99.5%), Cadmium sulfate ($Cd(SO_4)$, ≥99.0%) from Sigma Aldrich. FTO conductive glass (FTO, 15 Ω/sq., 2.2 mm) and N719 ruthenium-based dye used in the production of dye-sensitized solar cells are from Solaronix company; iodide electrolyte and Pt gel materials were obtained from Dyesol company.

Cu K radiation source, Ultima IV (Rigaku) spectrometer, operating at 40 kV and 40 mA, and equipped with a Cu K radiation source, were used to measure the powder X-ray diffraction (XRD) of the samples. Scanning Electron Microscopy (SEM) was used to analyze the grain and surface morphologies of powder materials (Thermo Scientific Apreo S). Energy dispersive spectroscopy (EDS) coupled to scanning electron microscopy (SEM) was used to determine the elemental compositions of the manufactured semiconductors. On a Lambda 950 UV/VIS/NIR (Perkin Elmer) spectrometer, UV-Vis spectra were recorded. One to two mg of composite samples were combined with 100 mg of KBr for Fourier transform infrared (FT-IR) analysis using a Spectrum BX (Perkin Elmer) spectrometer with data acquired in the 400 to 4000 cm^{-1} range at a resolution of 10 cm^{-1}.

2.1. Synthesis of ZnO/CdS/g-C_3N_4

Pre-synthesized 1 g ZnO/CdS composite material was mixed in 50 ml distilled water ethanol, simultaneously 0.1 gr g-C_3N_4 was separated in 50 ml distilled water-ethanol in an ultrasonic sonicator device, and this solution was added into the ZnO/CdS solution for 3 hours in a magnetic stirrer. After the solution obtained was filtered and washed, it was dried in the oven. All of the produced samples were heat treated in a muffle furnace at 300 °C for 2 hours.

3. RESULT AND DISCUSSION

The peaks of the ZnO hexagonal lattice structure were observed at 31.6°, 34.3°, 36.1°, 47.4°, 56.5°, 62.7°, 66.6°, 67.7° and 69.2° values and were (100), (002), (101), respectively. They have been found to have miller indices (102), (110), (103), (200), (112) and (201) and overlap with ZnO (JCPDS No. 36-1451) [18]. The peaks of the CdS sample occurred at 24.7°, 26.58°, 28.40°, 43.69° and 51.90° positions. Significant diffraction peaks of g-C3N4 were not observed in the tripartite structure due to the low content of g-C3N4 in the composite structure [19]. As seen in the graph in Figure 1., peaks at wavelengths of 2θ = 24.7°, 26.58° and 28.40° in binary and triple structure indicate that hexagonal CdS nanospheres grow on ZnO nanorods and composite material is formed. The relatively low characteristic peak intensities of CdS caused a slight increase in FWHM values, indicating that CdS exists in the form of NPs. The presence of diffraction peaks from both types of structures confirms the formation of nano- and micro-scale composites without phase separation.

SEM images of ZnO hexagonal nanorods, CdS nanospheres, g-C_3N_4, binary and ternary composites are given in Figure 4.1. In Figure 2. (a), ZnO nanorod structures were synthesized homogeneously and did not undergo agglomeration. While the edge lengths of these hexagonal formations vary between 600 nm – 4 µm; diagonal lengths are between 50-200 nm. In Figure 2. (b), agglomeration occurred due to the small diameters of the CdS nanospheres, and as seen in Figure 2 (c-d), CdS nanospheres were grown on ZnO nanorods and the agglomerations were removed. The diameters of the nanospheres range from 40 to 100 nm. On the SEM image of the triple structure, the g-C_3N_4 polymeric structure filled the intergranular spaces in the binary structure and facilitated the electron transitions.

Also, thanks to its large and porous surface area, it increased the contact surface to the ZnO/CdS composite and formed a strong bond between the heterojunctions.

The functional groups and chemical bonds of the ZnO group photocatalysts were determined by FT-IR spectra and the results are given in Figure 3. The peak at 442 cm^{-1} in the FT-IR spectrum of ZnO belongs to the stretching vibration of the Zn–O bond. Due to the adsorption of water molecules on the oxide and sulfur surface, the hydroxyl absorption peak can be observed at 3356-3600 cm^{-1} [20]. The peaks at 1243 cm^{-1} and 1636 cm^{-1} in the FT-IR spectrum of g-C_3N_4 belong to the C–N and C=N stretching vibration modes, respectively. The peak occurring at 808 cm^{-1} can be attributed to the triazine units of g-C_3N_4. The peaks around 3180 and 3280-3450 cm-1 are caused by amine groups and adsorbed water molecules on the g-C_3N_4 surface. The characteristic peak of the CdS sample was detected at 710 cm^{-1} due to Cd–S bond vibrations. In addition, it can be seen that the characteristic peaks of pure g-C_3N_4 also appear in the ZnO/CdS/g-C_3N_4 ternary composite structure.

Figure 4. shows I-V plot of DSSCs fabricated with ZnO-based photoanode. Derived photovoltaic systems such as DSSCs V_{OC}, I_{SC}, FF and η parameters are summarized in Table 1. The DSSC short-circuit current density of the ZnO sample is slightly lower than the composite structures, and it was calculated as 5.13 mA/cm^2, while the voltage value was determined as 556 mV. While the current density and efficiency values of the binary structure (ZnO/CdS) increased, a slight decrease was observed in the voltage value, these values were determined as 7.42 mA/cm^2, 1.56% and 508 mV, respectively. CdS is the reason for this situation. It is thought that by growing the nanospheres on ZnO, the absorbance limit shifted towards the visible region and type II harmonization was achieved, which would make the electron-hole transfer effective at CB-VB levels. The current density and efficiency values of the triple structure were calculated as 9.34 mA/cm^2 and 2.23%, respectively, and showed the highest performance. This improvement can be attributed to three main reasons: i) Relatively high specific surface area of the triad ii) Coherent energy band level and structure iii) Inhibition of electron retransfer. The improvement in the efficiency of ZnO/CdS/g-C_3N_4-based DSSC can be explained based on more efficient carrier production and transport processes with band alignment. Electrons generated in CdS and g-C_3N_4 by visible light, as well as electrons excited by dye molecules, can be transferred to ZnO via the interface. As a result of the more positive valence band level of ZnO, photogenerated holes cannot transfer from g-C_3N_4 to ZnO. Thus, photoelectrons flow from the CB of gC_3N_4 to the CB of ZnO, and hole diffusion takes place towards the VB of g-C_3N_4. As a result, CdS, g-C_3N_4 and dye decoration offer a wider light absorption range, a relatively low electron provided the possibility of recombination and more effective separation of e^-/h^+ pairs.

4. CONCLUSION

The energy levels of the g-C_3N_4 are slightly higher than those of the CdS and the energy levels of the CdS are slightly higher than those of the ZnO. Multiple components were evolved into a well-aligned, structurally-optimized heterostructure for effective solar energy conversion. The photoelectric performance of the ZnO/CdS/g-C_3N_4/dye heterostructure was greatly improved. As a result, dye decorating increased the light absorption range, the efficiency of electron separation, and the likelihood of electron recombination.

Tables and Figures

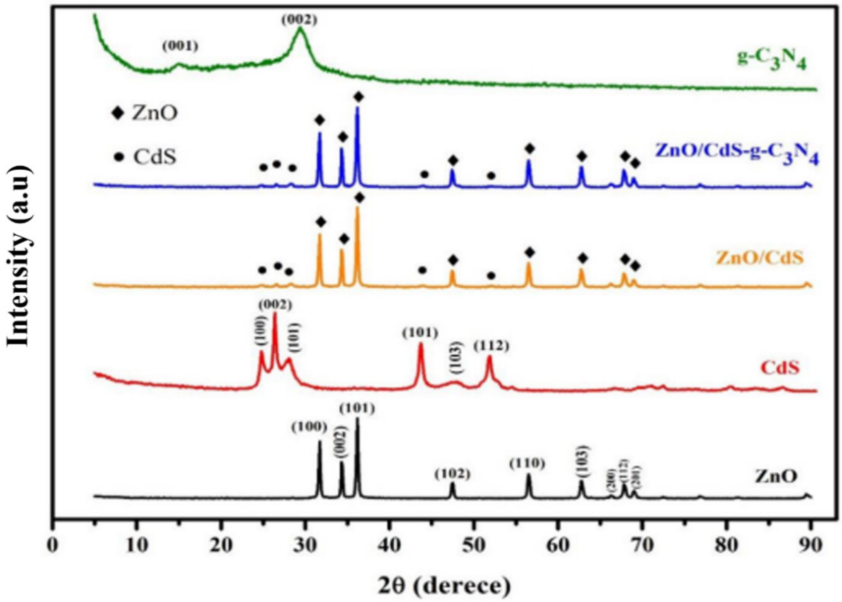


Fig. 1. XRD patterns of samples.

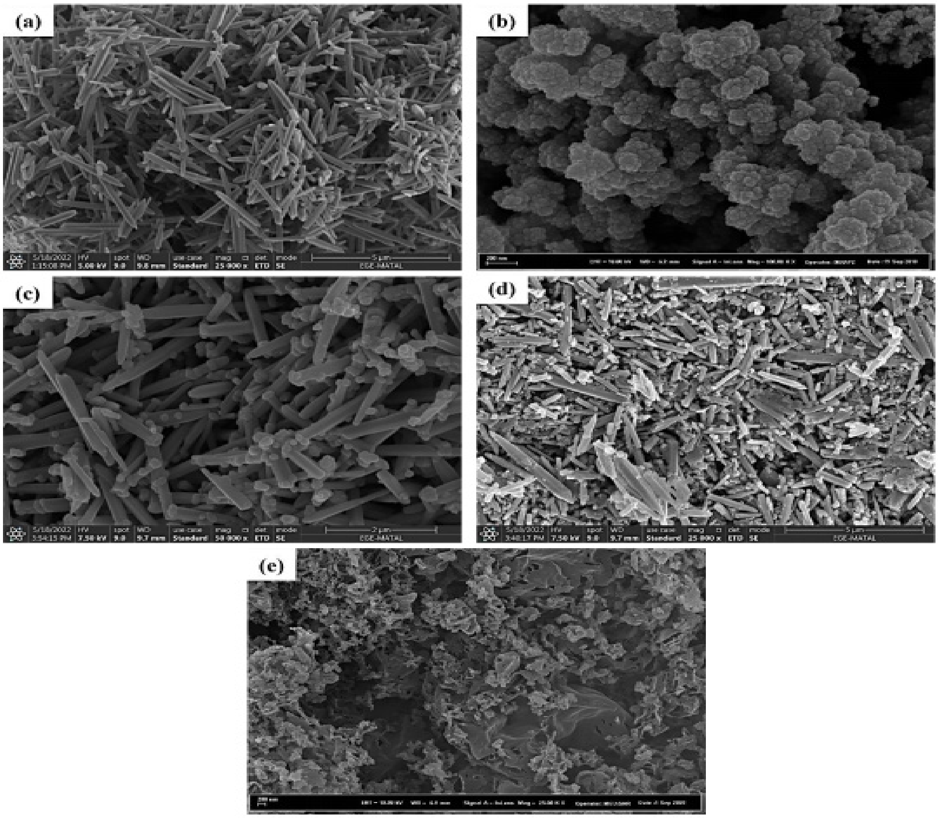
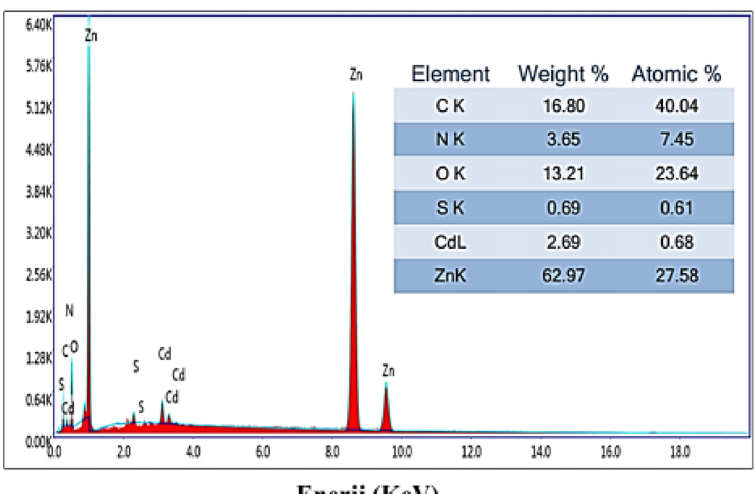


Fig 2. SEM images of (a) ZnO, (b) CdS, (c) ZnO/CdS, (d) ZnO/CdS/g-C_3N_4 ve (e) g-C_3N_4



Element	Weight %	Atomic %
C K	16.80	40.04
N K	3.65	7.45
O K	13.21	23.64
S K	0.69	0.61
CdL	2.69	0.68
ZnK	62.97	27.58

Fig 3.EDX Spectrum of ZnO/CdS/g-C3N4

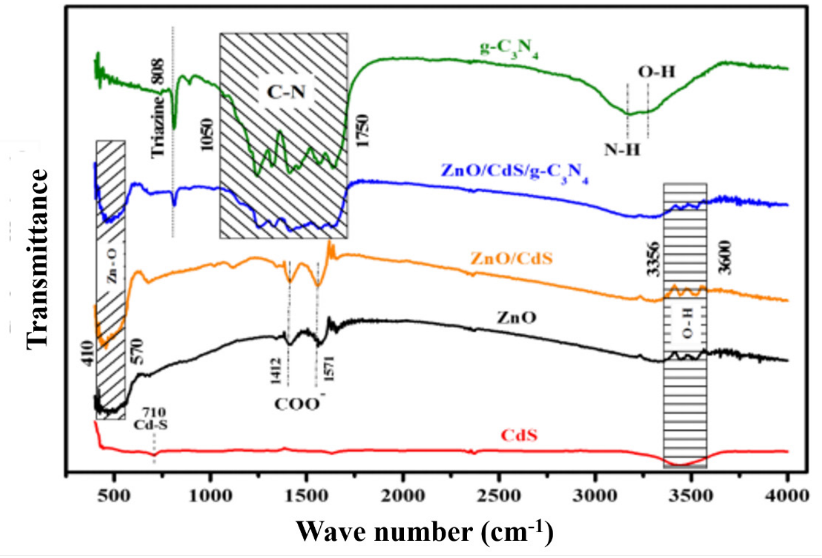


Fig. 4. FT-IR spectra of samples

Table 1. Photovoltaic Performances of DSSCs Using ZnO Group Photoanodes

Photoanode	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF	η (%)	Dye adsorption (nmol/cm^2)
ZnO	556	5.13	0.41	1.21 ± 0.05	103.6
ZnO/CdS	508	7.42	0.42	1.56 ± 0.05	127.3
ZnO/CdS/g-C_3N_4	535	9.34	0.44	2.23 ± 0.06	141.7

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PLC CONTROLLED SENSOR-LESS SOLAR TRACKING SYSTEM DESIGN AND IMPLEMENTATION

Cenk Gezegin[1*], Hasan Dirik[2], Atefeh Gholipour[3]

ABSTRACT

Due to the increasing population, developing technology and industrial investments, the demand for electrical energy is increasing day by day. Fossil fuels are used to a large extent in the production of electrical energy. Access to fossil fuels becomes difficult due to political, financial and pandemic problems, and it turns into a global energy crisis as it has been recently. Climate change and increasing energy security problems increase the interest in renewable energy sources. In recent years, large investments have been done in electricity generation from solar energy, which is one of the renewable energy sources, with photovoltaic (PV) systems. The amount of energy obtained from PV systems is directly proportional to solar radiation. Electricity generation efficiency can be increased if the PV panels are positioned exactly perpendicular to the sun. For this purpose, the PV panel must accurately track the position of the sun. In this study, a prototype design and application of a solar tracking system using PLC (Programmable Logical Controller) is described. The solar tracking system has biaxial movement and is controlled as an open loop. The position of the sun is calculated with the help of astronomical time equations using the PV panel position (latitude, longitude and altitude), date and time information entered via HMI (Human Machine Interface). PLC enables the panel to follow the sun by controlling two stepper motors according to the calculated position information. If the operator wishes, it can be selected for fixed, single-axis or dual-axis control of the PV panel on the HMI. The equipment used in the system and its features are given. In addition, it has been shown that the PV panel is positioned with high accuracy to the azimuth and elevation angles obtained as a result of the calculation.

Keywords: Photovoltaic Systems, PLC, Astronomical Coordinates, Sun Tracker, Dual-Axis

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1. INTRODUCTION

According to the International Energy Outlook 2019 (IEO2019) published by the US Energy Information Administration (EIA), population growth, rising incomes, urbanization and increasing access to electricity increase the demand for energy. According to IEO2019, it is predicted that the energy need will increase rapidly between 2018 and 2050 in OECD and non-OECD countries. It is estimated that the increase in energy consumption worldwide will be approximately 50% between 2018 and 2050. The increase in consumption of electrical energy causes an increase in electricity production by 79% between 2018 and 2050. In 2018, 28% of global electricity production was made from renewable energy sources. By 2050, it is predicted that the electricity obtained from all renewable energy sources will increase to 49% of the global electricity production. According to the EIA, in terms of electricity generation growth rates from the three largest renewable energy sources (solar, wind and hydro), it is estimated that the share of solar energy will increase the fastest and the share of hydraulics the slowest. [1]. According to the "Renewable Capacity Statistics 2022" published by IRENA, by the end of 2021, the world's global renewable energy capacity has reached 3,064 GW and the share of solar energy has been 849 GW [2]. In addition, features such as policies supporting renewable energy, reduced costs, ease of installation and quick commissioning increase the interest in solar energy investments. PV systems offer many advantages such as the continuity of the solar source, modularity that allows the installation of systems with the desired capacity, low maintenance cost, no noise and being able to replace diesel generators in power cuts [3].

The amount of power a PV system produces depends on the amount of solar radiation it is exposed to. Since the position of the sun changes throughout the day, the maximum possible power can be produced if the panels in the PV system are oriented exactly towards the sun. Solar tracking systems are used to ensure the continuity of maximum radiation. Solar tracking systems are generally divided into two as single and double axis. Single-axis tracking systems are relatively inexpensive, low-maintenance, and easier to build. However, their efficiency is lower than biaxial solar tracking systems [4]. In PV systems with solar tracking systems, it is possible to increase electricity production by 20%-30% with single-axis tracking systems and approximately 30%-40% with dual-axis tracking systems. The single-axis tracker segment has the highest market share in 2021. This is because they are cheaper and easier to build than biaxial ones. The global solar tracker market size is set at $8.9 billion in 2021. It is estimated that the size of this market will reach 16 billion dollars by 2031 [5]. The demand for solar tracking systems also increases the interest in studies on this subject.

Solar trackers can be classified according to different criteria such as movement type, degrees of freedom and control method. According to the type of movement, sun trackers are classified as passive and active. Passive solar trackers use the density difference that occurs when the tracker changes the temperature of a substance to control its movement and do not need electronic components. Active followers are motors, actuators, gears, etc. to realize the motion of the PV panels. use motion providers. Solar trackers are classified as uniaxial and biaxial according to their degrees of freedom. Different configurations can be designed for each of these types. The main configurations are shown in Figure 1 [6].

- East–west horizontal single-axis.
- North–south horizontal single-axis.

- North–south inclined single-axis with tilt equal to latitude.
- Vertical single-axis with tilt equal to latitude.
- Two-axes.

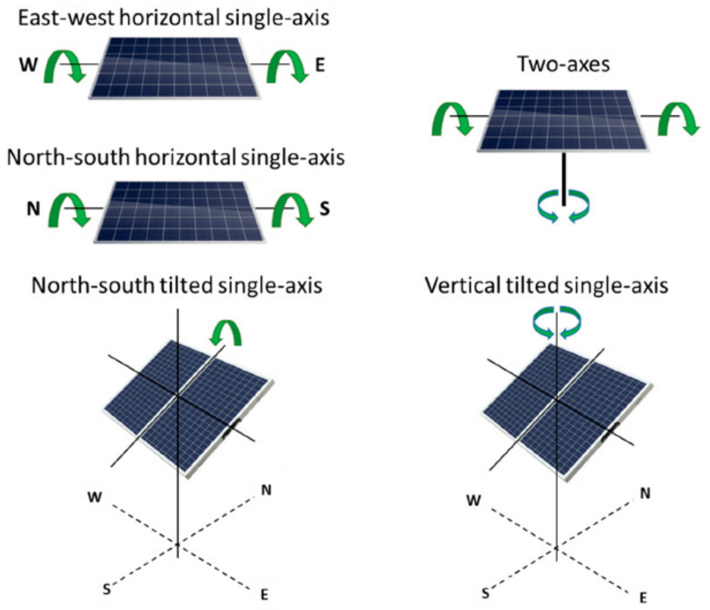

Figure 1. Forms of the main types of solar tracking systems

Open and closed loop control systems are used as control methods. Open loop control systems use variables such as location, date and time to calculate the angles that provide the movement of the PV panel with complex algorithms on microprocessors. Sensors are not needed in open loop control systems. Closed-loop control systems, on the other hand, provide the movement of the PV panel by using the feedback they provide from the sensors. For this, they use algorithms or electronic circuits embedded in processors. In solar tracking systems with closed loop control systems, photosensors or cameras that give voltage or current are used as feedback signals. Microprocessor-controlled drive systems use algorithms and mathematical equations to calculate the sun's position. Generally microcontrollers, computers or PLCs are used to run these algorithms [7].

2. MATERIAL AND METHOD

PLCs are widely used in many areas where there is a need for control and automation. The main reasons for its widespread use are its features such as easy programmability, reliability, robustness and cost-effectiveness. PLC is a very fast hardware that processes the electrical (digital and analogue) information coming to the input terminals with the program loaded into it and sends the output signals it obtains to the output unit [8]. In addition, it has remote monitoring and control features thanks to its modular structure and various communication features. In addition, PLCs have features that can exchange data with SCADA (Supervisory Control and Data Acquisition) systems over HMI and PCs [9].

In this study, a PLC controlled solar tracking system was implemented. The PV panel follows the sun using angles calculated based on astronomical equations. In order for a panel to follow the sun, basically two angle values must be calculated. These are the azimuth and elevation angles, respectively. The azimuth angle shows the angle the panel makes with the north line. It varies between 0-360 degrees. 90 degrees means the panel faces east, 180 degrees means the panel faces south, and 270 degrees means the panel faces west. Elevation angle is the angle between the horizon line where the panel is located and the point where the sun is in the sky. It varies between 0-90 degrees. 0 degrees means that the sun is on the horizon and 90 degrees means that the sun is directly overhead [10].

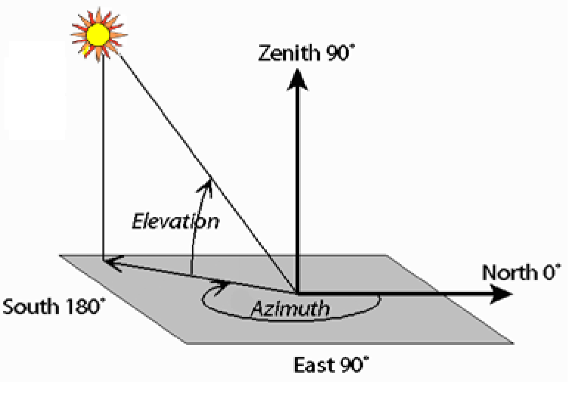

Figure 2. Orientation angles

2.1. Structural Parts of Solar Tracking System

The developed solar tracking system consists of operator panel, PLC, power supply, stepper motor drivers, stepper motors, PV panels, sigma profile and connection parts, respectively. There are four main pages on the operator panel (HMI). These are respectively the page where the information about the position of the PV panels is entered, the page where the PV panel reference position values are created, the page where the stepper motor driver settings are made, and the screen pages where the selections for the tracking system are made. On the first page, the coordinates of the PV panels (latitude, longitude and altitude), date, time and the time difference with respect to the Universal Time Coordinate (UTC) time, which represents the start of standard time, are entered. On the second page, the necessary manual positioning is done to orient the PV panels to the reference starting axes (azimuth to the north and elevation horizon line) with the help of the operator panel and determined as a reference. On the third page, how many steps the stepper motors complete their full revolution on the relevant axis and the step speed information related to this are entered. On the fourth page, the necessary selection is made for the solar tracking system to work as fixed, single axis or double axis. The desired positioning angles are determined on the screen where the selection is made. Thus, the axis to be tracked moves according to the calculated value. Figure 3 shows the structure of the solar tracking system.

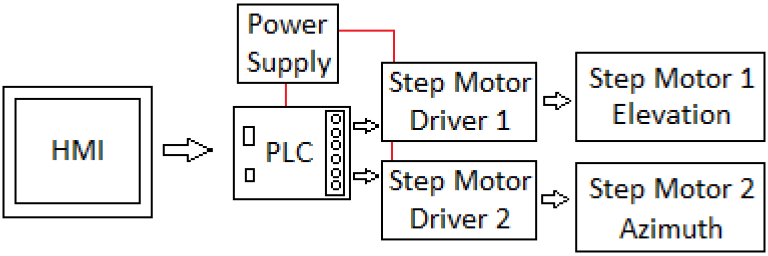

Figure 3. Structure of solar tracking system hardware

Table 1. Information on the equipment used

Quantity	Name	Properties	Cost (Dolar)
1	Operator Panel (HMI)	√ Touch Color display 7" TFT Screen √ Processor: ARM RISC 32bit 792MHz √ Memory: 128MB NAND Flash, 128MB DDR3 √ Ethernet, COM port, USB	105
1	Programmable Logical Controller (PLC)	√ 9 channel 24V DC PNP/NPN input √ 6 channel 24V DC 300mA short circuit protected transistor output √ 3 axis servo/step drive with 3 channels 100kHz √ 100MB ethernet port √ RS232 ve RS485 COM port √ 12ns command processing speed	95
2	Step Motor Driver	√ Selectable excitation mode (1/1, 1/2, 1/4, 1/8, and 1/16 step) √ 42V DC ye kadar besleme voltajı √ IOUT= 4.0 A (absolute maximum ratings, peak, within 100ms) √ Optical isolation between high speed input and output signal √ Motor control can be done manually with the switch panel on it	15
1	Step Motor	√ Motor Type: Bipolar Stepper √ Step Angle(W/O Gearbox): 1.8° √ Holding Torque: 230N.cm √ Rated Current/phase: 1.68A √ Recommended Voltage: 12-24V	25
1	Step Motor	√ Tork: 2.2 Nm √ Reduction: 1:5 √ Rated Current/phase: 3.0 A √ Recommended Voltage: 12-24V √ Step Angle(W/O Gearbox): 1.8°	50
2	PV Panels	√ Max Power:10W √ Max Voltage: 19,4V √ Max Current: 0,6A √ Open Circuit Voltage: 22,9V √ Short Circuit Current:1,11A	20
1	Power Supply	√ 220V AC input, 24V DC output √ Max Current: 3A	15
	Structural Parts	√ Sigma aluminum profile √ Sigma Profile Corner Connection √ Polyester Board	60
		TOTAL	**385**

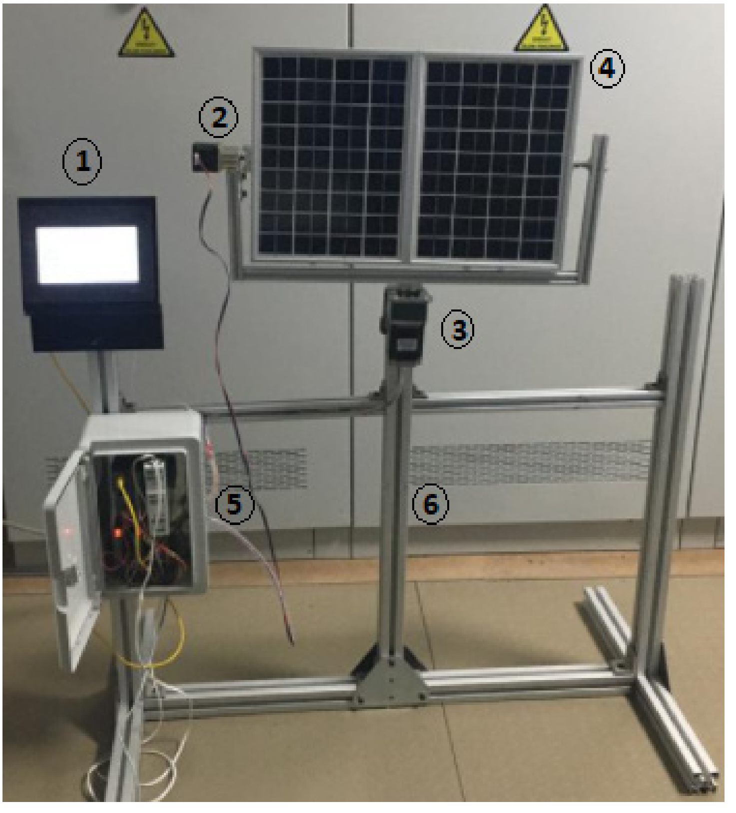

Figure 4. General view of the solar tracking system (1-HMI, 2-Step Motor: Elevation, 3-Step Motor: Azimuth, 4-PV Panel, 5-PLC, 6- Building Body

2.2. Calculation of Azimuth and Elevation Angles

The input variables of the method given here are the latitude (Lat), longitude (Lon), altitude (Alt) and the year (Y), month (M), day (D), hour (H), minute (Min) and second (Sec) values at the time the sun angles of the same location will be calculated. The calculated output values are the Azimuth (Az) and Elevation (El) angles. For this, the Julian day number (JD) of the relevant time is calculated first:

$$JD = \left\lfloor 365.25\left(Y+4716\right)\right\rfloor + \left\lfloor 30.6001\left(M+1\right)\right\rfloor + 2 + \left\lfloor \frac{Y}{100} \right\rfloor + \left\lfloor \frac{\left\lfloor \frac{Y}{100} \right\rfloor}{4} \right\rfloor + D - 1524.5 + \frac{\left(H + \frac{Min}{60} + \frac{\mathrm{Sec}}{3600}\right)}{24} \quad (1)$$

The next steps are generally as follows. First of all, the orbital angles of the sun with respect to the earth, the mean longitude angle and the elliptical inclination are calculated. Next, the perpendicular coordinates in the elliptical plane are calculated. The elliptical orthogonal coordinates of the sun are first converted from equatorial coordinates to spherical equatorial coordinates. In the next step, the equatorial coordinates are converted to the orthogonal coordinate system. Finally, after transforming to a horizontal axis ($xhor$, $yhor$ and $zhor$) in the east-west direction with the help of equations (2), (3) and (4), the azimuth (Az) and elevation (El) angles are obtained by equations (5) and (6) [11].

$$xhor = x \cdot \cos\left((90 - Lat) \cdot \frac{\pi}{180} \right) - z \cdot \sin\left((90 - Lat) \cdot \frac{\pi}{180} \right) \tag{2}$$

$$zhor = y$$

$$zhor = x \cdot \sin\left((90 - Lat) \cdot \frac{\pi}{180} \right) + z \cdot \cos\left((90 - Lat) \cdot \frac{\pi}{180} \right) \tag{3}$$

$$Az = a\tan 2(yhor, xhor) \cdot \frac{180}{\pi} + 180 \tag{4}$$

$$El = a\sin(zhor) \cdot \frac{180}{\pi} \tag{5}$$

3. RESULTS AND DISCUSSION

The accuracy of the designed and implemented solar tracking system was made by comparing the angle values calculated by the PLC with the angles obtained for the same input parameters (position, time and date) on the www.suncalc.org website. Verification was also done by measuring the actual position of the PV panel. For this, the azimuth and elevation angles of the PV panel were measured and controlled with the mobile phone protractor application. It has been observed that the PV panel makes the desired angular rotational movements. In Figure 5, the comparison of the angular values obtained from the web page and the values calculated by PLC is given. Figure 6 shows the measurements made with the mobile phone protractor application.

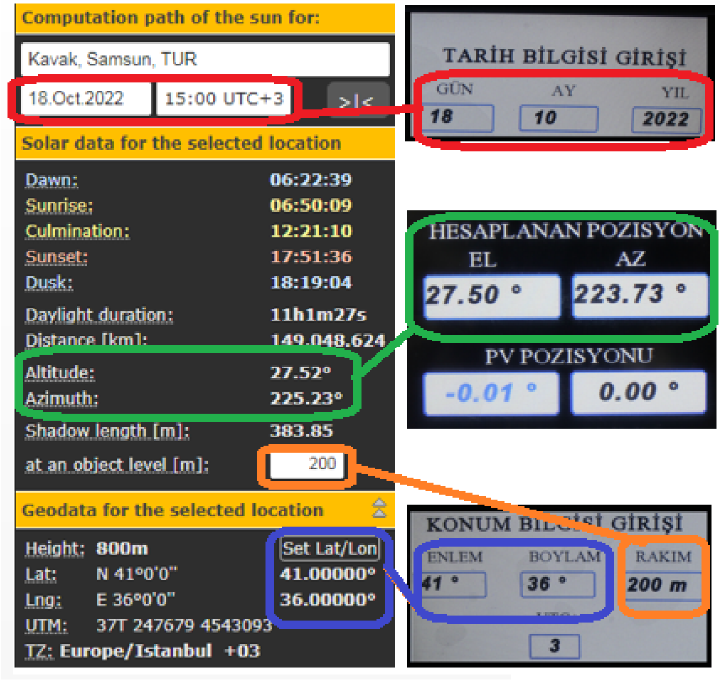

Figure 5. Comparison of web page and calculated values with PLC

Figure 6. Angles measured with the mobile phone protractor application

4. CONCLUSION

The increase in investments made for electricity generation from solar energy and the demand for tracking systems are increasing day by day. This demand also increases the need for cost-effective, reliable and efficient solar tracking devices and the need for qualified personnel with knowledge on these issues. In this study, a cost effective and PLC controlled solar tracking system has been put forward. The system calculates the azimuth and elevation angle using astronomical time equations and performs the movement with high accuracy with two stepper motors. With the developed system, fixed, single axis or double axis sun tracking can be done as desired. Thus, PV panels can be provided to produce more energy by following the sun at any location in the world. In addition, it can be ensured that students in educational institutions understand the angles that express the daily and seasonal movements of the sun and can compare the electricity production differences between a fixed, single axis or double axis solar tracking system and a PV panel at any point in the world.

ACKNOWLEDGEMENT

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CHAPTER 6

Climate Change and Health

CLIMATE CHANGE AND HEALTH

Ahmet Tevfik SÜNTER[1*]

ABSTRACT

Climate change is the single biggest health threat facing humanity, and health professionals worldwide are already responding to the health harms caused by this unfolding crisis. The climate crisis threatens to undo the last fifty years of progress in development, global health, and poverty reduction, and to further widen existing health inequalities between and within populations. Climate change is already impacting health in a myriad of ways, including by leading to death and illness from increasingly frequent extreme weather events, such as heatwaves, storms and floods, the disruption of food systems, increases in zoonoses and food-water- and vector-borne diseases, and mental health issues.

Between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year from malnutrition, malaria, diarrhoea and heat stress alone. The direct damage costs to health are estimated to be between US$ 2–4 billion per year by 2030. Areas with weak health infrastructure – mostly in developing countries – will be the least able to cope without assistance to prepare and respond.

WHO supports countries in building climate-resilient health systems and tracking national progress in protecting health from climate change, as well as in assessing the health gains that would result from the implementation of the existing Nationally Determined Contributions to the Paris Agreement, and the potential for larger gains from more ambitious climate action. WHO's work plan on climate change and health includes; advocacy and partnerships, monitoring science and evidence, supporting countries to protect human health from climate change and building capacity on climate change and human health.

Keywords: Climate Change, Health, Climate-Resilient

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1.INTRODUCTION

Climate change is the single biggest health threat facing humanity, and health professionals worldwide are already responding to the health harms caused by this unfolding crisis.

The Intergovernmental Panel on Climate Change (IPCC) has concluded that to avert catastrophic health impacts and prevent millions of climate change-related deaths, the world must limit temperature rise to 1.5°C. Past emissions have already made a certain level of global temperature rise and other changes to the climate inevitable. Global heating of even 1.5°C is not considered safe, however; every additional tenth of a degree of warming will take a serious toll on people's lives and health [1].

Burning fossil fuels — such as coal, oil and gas — releases carbon dioxide into the atmosphere. Once released it traps heat, causing the Earth's temperature to rise, which then changes wind, moisture and heat circulation patterns and leads to extreme weather events. Some relationships between extreme weather and health include:

Severe Storms and Floods

- **Water contamination** caused by bacteria, parasites and toxins can result when heavy precipitation overwhelms drainage or wastewater treatment systems.
- **Drowning** in floodwaters poses a direct risk.
- **Injury** can result from intense storms that knock down trees and power line and generate debris.
- **Mold** can grow in flooded buildings, affecting indoor air quality and leading to increased asthma attacks and respiratory tract infections, such as pneumonia.
- **Loss, displacement, and job insecurity** can increase stress and anxiety and worsen the mental health toll.
- **Standing water** that remains after flooding creates a favorable environment for disease-carrying vectors including mosquitoes, increasing risk of **vector-borne disease** transmission including the Zika and West Nile viruses.

Extreme Heat

- **Dehydration, heat exhaustion and heat stroke** may lead to death or permanent disability.
- Warmer temperatures lead to increased pollutants. **Increased particulate matter** can cause lung and heart problems and shorten overall life expectancy.
- **Increased ground-level ozone** can promote asthma attacks and aggravate allergy symptoms.
- Extreme heat events are linked to **worsened mental health conditions**, including dementia and schizophrenia [2].
- Exposure to extreme heat is also associated with acute kidney injury, heatstroke, adverse pregnancy outcomes, worsened sleep patterns,worsening of underlying cardiovascular and respiratory disease, and increases in non-accidental and injury-related deaths [3].

Drought

- Drier soil and vegetation increase the risk for **larger and more intense wildfires**, which can harm lung and heart health.
- Drought-induced **disruptions in food production** can affect food security, and reduced access to healthy foods can contribute to malnutrition. Rising temperatures, variable climates and higher carbon dioxide levels in the air also decrease nutrients in crops.
- **Water shortages** can have a severe impact on communities. People with livelihoods or cultural practices tied to the land — agricultural and indigenous communities, particularly — have a higher water shortage burden.
- **Stress and anxiety** about land conditions can make existing mental health problems worse [2].

While no one is safe from these risks, the people whose health is being harmed first and worst by the climate crisis are the people who contribute least to its causes, and who are least able to protect themselves and their families against it - people in low-income and disadvantaged countries and communities [1].

Children, older adults, communities of color, people with chronic disease or mental health issues, those who work or exercise outdoors and live in low-income and, minority communities need special attention. Neighborhoods with the fewest resources are most susceptible to extreme weather [2].

Vulnerable Population	**Vulnerability**	**Climate Effects**	**Health Threats**
Children	• Breathe more air and drink more water per body weight than adults • Developing organs and low immunity • Dependent on adults • More time spent outdoors	• Air pollution • Extreme heat • Flooding and water contamination • Food insecurity • Drought	• Asthma and allergies • Neurological disorders • Heat-related illness • Dehydration • Diarrheal illness • Drowning and injuries • Psychological stress/imbalance • Increased vector-borne diseases (e.g. Zika, West Nile Virus, Lyme disease) • Malnutrition
Older Adults	• Low immunity • Pre-existing conditions • Limited mobility	• Extreme heat • Air pollution • Flooding	• Heat-related illness • Dehydration • Heart disease • Psychological stress • Falls
Communities of Color	• Structural racism • Inadequate infrastructure • Health disparities • Lack of social capital • Language barrier	• Flooding • Physical damage to communities	• Psychological stress/imbalance • Increased heart and lung complications
Low-Income Communities	• Less resources and means to evacuate • Inadequate infrastructure	• Flooding • Physical damage to communities • Food insecurity	• Psychological distress/imbalance • Physical displacements • Malnutrition

Other groups that are particularly vulnerable to the health effects of climate change include: pregnant women, immigrant groups, indigenous peoples and the disabled [4].

2. WORLD HEALTH ORGANIZATION'S RESPONSE

WHO supports countries in building climate-resilient health systems and tracking national progress in protecting health from climate change, as well as in assessing the health gains that would result from the implementation of the existing Nationally Determined Contributions to the Paris Agreement, and the potential for larger gains from more ambitious climate action.

WHO's work plan on climate change and health includes:

- advocacy and partnerships: coordinating with partner agencies within the UN system, and ensuring that health is properly represented in the climate change agenda, as well as providing and disseminating information on the threats that climate change presents to human health and opportunities to promote health while cutting carbon emissions;
- monitoring science and evidence: coordinating reviews of the scientific evidence on the links between climate change and health; assessing country's preparedness and needs when facing climate change; and developing a global research agenda;
- supporting countries to protect human health from climate change: strengthening national capacities and improving the resilience and adaptive capacity of health systems to deal with the adverse health effects of climate change; and
- building capacity on climate change and human health: assisting countries to build capacity to reduce health vulnerability to climate change and promoting health while reducing carbon emissions [5].

3. SUPPORTING COUNTRIES TO PROTECT HUMAN HEALTH FROM CLIMATE CHANGE

WHO has been working on climate change and health for over 25 years and has developed a comprehensive approach aiming to support countries to assess and manage the health impacts posed by climate variability and change.

WHO's approach aims to strengthen national capacities and improve the resilience and adaptive capacity of health systems to deal with the adverse health effects of climate change.

The package of technical support being provided by WHO to Member States ranges from specific topics (e.g. development of plans and strategies or climate-informed health early warning systems) to more programmatic approaches to those countries implementing projects on climate change and health.

The key initiatives and projects by which WHO assists Member States and partners on climate change and health are:

- Conducting climate change and health Vulnerability and Adaptation Assessments (V&As);
- Development and implementation of the health component of National Adaptation Plans (H-NAPs);

- Country projects on climate change and health;
- Strengthen the climate resilience of health systems;
- Strengthen the climate resilience and environmental sustainability of healthcare facilities;
- Streamline financial resources for health and climate change;
- Develop tools, guidance and training packages on climate change and health;
- Integrated surveillance and climate-informed health early warning systems;
- WHO Special Initiative on climate change and health in Small Islands Developing States (SIDS)[6].

3.1. Country Projects

Building resilience of health systems in Asian LDCs to climate change

- This project supports six Asian least developed countries (LDCs) – Bangladesh, Cambodia, Lao People's Democratic Republic, Myanmar, Nepal, and Timor-Leste – to strengthen the capacity of their health systems to adapt to the impacts of climate change. In particular, the project aims to strengthen institutional capacity to improve health sector planning and effective decision-making to ultimately develop climate-resilient health systems.

- The overall goal of this project is to increase the adaptive capacity of national health systems and institutions to respond to and manage climate-sensitive health risks in six Asian LDCs (Bangladesh, Cambodia, Lao PDR, Myanmar, Nepal and Timor-Leste)[7].

Strengthening the resilience of the Mozambique health system to climate change impacts

- This WHO project supports Mozambique to strengthen the climate resilience of its National Health System, enabling it to better prepare for, cope with, and manage the health risks posed by climate change.

- Mozambique is one of the most vulnerable countries in the world to the impacts of climate variability and long-term climate change due to its geographical location in the inter-tropical convergence zone; its widespread poverty; the climate sensitivity of its main socio-economic activities; and its overstretched public services and infrastructure.

- The goal of the project is to strengthen the climate resilience of Mozambique's National Health System, enabling it to better prepare for, cope with and manage the health risks posed by climate variability and change. These efforts will ensure that essential functions of health systems are less vulnerable to climate and sustained improvements in population health outcomes are achieved despite an unstable climate [8].

Delivering climate-resilient water and sanitation in Africa and Asia

- This project provides targeted support to five countries in Africa and Asia (Ethiopia, Malawi, Mozambique, Nepal and Bangladesh) to improve climate-resilient health service delivery. The main objectives of the project are to enhance climate-resilient water safety and sanitation management to effectively respond to climate change impacts, as well as to develop integrated surveillance for climate-sensitive diseases and, where feasible, early warning systems. This project builds on a previous initiative on climate-resilient water and sanitation systems in Ethiopia, Tanzania, Malawi, Mozambique, and Nepal [9].

The Global Framework for Climate Services (GFCS) Adaptation Program in Africa

- Currently in its second phase, this multi-agency project aims to guide decision-makers and public health authorities in Malawi and Tanzania to provide well-targeted climate services to obtain accessible and accurate climate service information. By strengthening national climate services, the GFCS program strives to increase the resilience of those most vulnerable to the impacts of weather and climate, such as droughts and flooding, as well as the associated health risks, including malnutrition and vector- and water-borne diseases [10].

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PUBLIC HEALTH IN THE PROCESS OF CLIMATE CHANGE

Dilek Çelik Eren[1*]

ABSTRACT

Climate change is the rise in global temperature and the change in average climate values, with the increase in the concentration of greenhouse gases in the atmosphere, mainly as a result of human activities. Awareness of climate change in the world started in the 1980s. In 1988, the United Nations General Assembly adopted a resolution stating that "Climate change is a common concern of humanity". Climate change has many national and international economic, social, environmental and health effects. Observed and predicted changes in climate are problems such as decrease in water resources, forest fires, erosion, changes in agricultural productivity, drought and related environmental degradation, deaths due to heat waves and increases in vector-borne diseases. In addition to the direct effects of climate change such as being under the influence of temperature extremes, changes in the frequency or severity of extreme weather events and sea level changes, ecological system disorders, changes in the distribution and effectiveness of vector and infectious diseases, air pollution, decrease in food production due to cultivation areas and insect ecology, There are also indirect effects such as immigration and causing mental illnesses. In the determination of sustainable practices and environmental policies at the national level, they should first educate themselves, then individuals, families and society for waste management practices, healthy lifestyle behaviors, awareness of the effects of climate change and struggle in the institutions they work at individual level.

Keywords: Climate Change, Health, Public Health.

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1. INTRODUCTION

The environment is both effective on human and public health due to direct and indirect interactions, and a safe environment is a basic requirement for health. When considered in terms of public health, the environment; It has features such as preparing the ground for diseases, being a direct cause of disease, facilitating catching some diseases, and affecting the course and results of some diseases. For example, climatic conditions cause an increase in respiratory system diseases, and vectors in the environment facilitate the spread of diseases are among the effects of the environment on health [1,2]. Climate change is defined as “changes in the mean state and/or variability of the climate over a period of decades or longer, whatever the cause” [3]. Climate change and its effects have increased in recent years. Heat waves, precipitation, sea level rise directly affect human health. At the same time, water and food quality, agriculture, blood sucking diseases, and some other known or unknown infectious diseases are indirectly affected by climate change [4]. Migration from rural areas to cities, urbanization, technology, industry, changes in land use habits accelerate climate change. Some natural disasters, hurricanes and floods that increase due to the effects of climate change lead to large migrations [4, 5].

2. CLIMATE CHANGE

Climate change is defined as “significant long-lasting changes in climate-forming factors such as temperature, precipitation and wind” [6]. Climate change commonly refers to global warming (the continued increase in global average temperature) and its effects on the world’s climate system. These long-term changes in temperatures and weather patterns can be natural, such as changes in the solar cycle. But since the 1800s, human activities have been the main driver of climate change, especially due to the burning of fossil fuels such as coal, oil and gas. Burning fossil fuels produces greenhouse gas emissions that act as a blanket that envelops the earth, trapping the sun’s heat and raising temperatures. Examples of greenhouse gas emissions that cause climate change are carbon dioxide and methane. These result from using gasoline to drive the car or coal to heat a building. Clearing land and forests is also carbon dioxide; landfills are a major source of methane emissions. Energy, industry, transportation, buildings, agriculture and land use are the main emission sources [4, 7].

According to the results of research on climate change;

- The average temperature of the Earth’s surface has increased by 0.6 0C over the 20th century,
- Temperatures have increased in the 8 km lower part of the atmosphere for the last forty years,
- Reduced snow cover and icing,
- The average sea level on Earth has risen and the amount of heat held by the oceans has increased,
- Changes have also occurred in other important elements of the climate [8].

If human-induced greenhouse gas emissions, which increase the world average temperature and thus cause unexpected climate changes, cannot be stopped despite all the measures taken, it is strongly predicted that there will be an increase of 2 ^{0}C in the world average temperature towards 2050 [4]. The negative changes that this increase will cause on the climate will be felt in developed countries and more heavily in developing countries. If this increase continues in the second half of the 21st century, average temperature increases that will be above 2 ^{0}C will lead to much more serious climate changes that will be called a global catastrophe [9]. According to the forecasts, the number of cold days will decrease, the number of hot days will increase, and more severe storms will become more frequent due to increased humidity in many parts of the world. On the other hand, long and hot summers will bring severe droughts. Meanwhile, heavy rains and flash floods may appear stronger and more frequent. Compared to the last years of the 20th century, extreme temperatures will occur 100 times more in the 21st century. The frequency and severity of extreme weather conditions will also increase [10].

Climate change also has some effects on agriculture. The milder climate and the increasing amount of CO_2 in the atmosphere show that until 2050, the yield of agricultural products will increase somewhat. However, this increase in yield will be seen in the northern countries, and in regions located in more southern latitudes, scorching heat and drought will be more prevalent. In the meantime, although it is known that the CO_2 emerging from the use of fossil fuels (oil, coal, natural gas) will accelerate the growth of plants a little, at the same time, the increase in the amount of "ozone" in the atmosphere close to the earth caused by fossil fuels will have the opposite effect and will quickly destroy the increase in yield that will be provided by the increase in CO_2. After 2050 or a temperature increase of 2 ^{0}C, a definite decrease in productivity will occur in agriculture. In this case, either the agricultural lands will be moved to more northern regions, or the development of plant species that are resistant to arid and hotter climate will be emphasized [4,9,11].

As the effects of climate change on clean water resources, the supply of clean water in terms of quantity and quality in terms of drinking water, cleaning, agriculture and industry needs will become very difficult. While excessive rainfall in some parts of the world will cause floods, thus damaging agricultural products, loss of life and property, extreme droughts in other parts of the world will cause loss of life, migration, damage to agricultural products, and thus hunger. In addition, the decrease in the snow and ice masses in the mountains that feed the rivers that are vital for people will cause the rivers to not carry enough water during the summer months, that is, when the water is most needed. A similar situation was experienced in the Marmara and Aegean regions of Turkey in 2007. [10,11].

The negative effects of climate change on human health and ecosystems will increase gradually. Increasing temperatures will make it easier for some microbes to live longer and spread. Changing climatic conditions will change the structure of ecosystems, and some living species will disappear. One of the current problems is that some fish species cannot be found or appear late on the coasts with increasing average temperatures [10].

3. PUBLIC HEALTH

Public health aims to protect from diseases and prolong life by improving environmental health conditions, providing health information to individuals, preventing communicable diseases, providing early diagnosis and treatment of diseases, establishing health organizations, developing social works in a way that will ensure a life level that will maintain the health of each individual, as a result of organized community studies. It is a science and art that provides physical and mental health and increasing working power [12].

There are main points of public health understanding and one of them is the "integrity with the environment" clause. According to this article; There is an interaction between man and his physical, biological and social environment. Environmental factors affecting individuals, families and societies should be considered in the process of protecting and improving public health [2].

Public health service is aimed at individuals, families and communities. Getting to know individuals, families and communities well in order to provide a good service; It is important to identify and clarify its characteristics. It is essential to benefit from the knowledge and services of a multidisciplinary team for an effective public health service. Disciplines providing public health services have duties such as determining the level of public health, existing and developing problems and determining the causes of these problems, determining the health needs of the society, developing health policies, and producing solutions [2,12].

4. PUBLIC HEALTH IN THE PROCESS OF CLIMATE CHANGE

The effects of climate change on human health are quite large. These effects will be felt in a wide area, affect many people, occur over a wide period of time, and are complex/difficult to research. The effects of climate change on public health will grow as a vicious circle interacting with other components of global change [1,7]. The direct effects of climate change on health are seen as a result of extreme changes in weather events. The fact that the air is too cold, too hot, too humid or too dry affects human health negatively. Exposure to extreme heat can lead to physiological stress, illness, and even death. Deaths due to hot weather depend on the intensity and frequency of the temperature; When the body temperature reaches 39°C, symptoms related to salt and water loss are observed in the body, while deaths can occur when the body temperature exceeds 40.6°C [11].

Public Health Impacts of Climate Change

According to the findings of studies on the effects of climate change on human health, climate change;

- Changes in the distribution of some infectious disease vectors,
- With the decrease of water resources, the shrinkage of agricultural areas,
- Changes in seasonal distribution of some allergic pollen species,
- Increase in deaths caused by heat waves,
- Increasing the number of injuries, diseases and deaths caused by weather events such as heat waves, floods, storms, fires and droughts,
- Continuing changes in the vectors of some infectious diseases will cause the warmer climate zones to shift northward,
- Changes in the geographical distribution of malaria, the increase in regions where the disease is likely to occur, and the change in the season of its spread,
- Increase in immigration,
- Increase in diarrheal diseases,
- The increase in heart and respiratory diseases and death rates from these diseases, especially due to the increase in ozone level at ground level,

- ❖ Increasing the number of people affected by diseases caused by some viruses,
- ❖ It causes an increase in the effect of malnutrition on the growth and development of children [11,13-15].

The effects of climate change on health can be observed directly or indirectly.

- ➢ **Direct effects** are exposure to temperature extremes, changes in the frequency or severity of extreme weather events, changes in the rates of illness and death due to heat and cold, deaths, injuries and disabilities, mental illnesses, and deterioration in public health infrastructure. These effects occur as a result of heat waves, floods, storms and extreme weather events [1,15].

- ➢ **Indirect effects**, changes in the geographic distribution and incidence of vector-borne diseases, changes in the incidence of diarrheal and other communicable diseases, communicable diseases, increased risk of mental disorders, malnutrition and starvation, growth and development impairment, asthma and allergic diseases, other acute and chronic respiratory diseases diseases and death, a wide range of public health consequences, mental problems and nutritional deficiency, infectious diseases, and civil conflicts [1,15].

The Center for Disease Prevention and Control has created the "Building Resilience to Climate Impact" framework, a five-step process that allows health professionals to develop strategies and programs to help communities prepare for the health impacts of climate change. These; forecasting climate impacts and assessing vulnerable populations, estimating disease burden, evaluating public health interventions, developing and implementing a climate and health adaptation plan, assessing impact and improving the quality of activities [16]. Since everyone living in the world has the right to live in a healthy and safe environment, the United Nations has set the goal of "Immediate Action to Combat Climate Change and Its Impacts", which aims to alleviate the negative health effects of climate change in its Sustainable Development goals [17].

The American Public Health Association (APHA 2011) recommends a model of disease prevention that includes primary (preventing a health event from occurring), secondary (early detection or treatment of a health event), and tertiary (minimizing long-term complications or sequelae) to prevent a health event. recommends its use. Unless effective primary, secondary and tertiary prevention measures are taken, it will be very difficult to cope with these effects [15,18].

In this direction, the prevention approach (illness, injury, premature death and disability), which constitutes the basic mission of public health services, also forms the basis of environmental health services. Prevention includes both the control of hazards (such as clearing a hazardous landfill, reducing air pollutants from a chimney or exhaust pipe) and promoting health through environmental strategies (by providing parks, sidewalks, bike paths). The prevention approach ranges from precise approaches, such as the complete elimination of a hazardous substance used, to behavioral approaches. Public health service providers can take part in the prevention and mitigation of climate change events in their regions. It has a unique opportunity to influence decisions made in healthcare organizations and advocate for changes that help protect the environment [1,6,18].

5. CONCLUSION AND RECOMMENDATIONS

Climate change is one of the most important problems of today's world, which is followed with concern by the whole world due to its irreversible negative effects. It is a problem that has effects in many areas such as health, sociology, economy, geopolitics and politics. Various health and health problems, air pollution, destruction of fertile lands, clean water problem and drought, forest fires, melting of glaciers, weather events such as hurricanes, decrease in ecological diversity cause negative effects in many areas that will directly and indirectly affect public health. It is known that the increase in carbon emissions due to human-induced uncontrolled industrialization, urbanization, increasing energy demand, forest destruction and intensive livestock activities, and the use of fossil fuels in transportation increase the effects of climate change.

Negative consequences of climate change, which threatens human future at a significant level; urgent measures require the implementation of action plans to mitigate their effects. Every country should be systematically prepared with a multisectoral approach against its negative effects on health. Information about the potential consequences of climate change, climate-sensitive consumption, adaptation plans, and environmental literacy awareness should be brought to the societies. Individually, behaviors such as using flasks, cloth bags to use less plastic, saving water and energy, using less paper, cardboard, glass to reduce waste, sorting waste, reusing, repairing/exchange, not buying products if there is no need, planting seeds , planting saplings, walking to reduce carbon emissions, cycling, taking public transport are recommended.

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CLIMATE CHANGE AND INFECTIOUS DISEASES

Mehtap Ünlü Söğüt[1*], Merve Eroğlu[2]

ABSTRACT

In this study, it was aimed to evaluate the effects of climate change in terms of infectious diseases. The destruction and alteration of natural ecosystems, the reduction in biodiversity, the unhygienic combination of wild and domesticated species increase the possibility of transmission of viruses and other pathogens to humans and the risk of infection. Air pollutants are mainly; It plays a role in deterioration in respiratory functions, increase in respiratory system diseases, and increase in disease exacerbations in people with chronic respiratory system and heart diseases. Asthma symptoms may worsen due to the increase in the density of fungal spores and pollen in the air. Some diseases such as upper respiratory tract infections, flu, sinusitis, asthma, bronchitis, chronic bronchitis and even pneumonia are more common in areas where polluted air density is evident. Those most affected by air pollution are children under the age of five, chronic patients (such as asthma, bronchitis, COPD, cardiovascular disease, diabetes) and the elderly. It has been reported that there may be changes in the diversity of hosts and vectors transported to new geographical areas by human activities. This situation has also been shown to be the reason for the increase in the frequency of some arthropod-borne zoonotic diseases. In addition, some extinctions due to climate changes, it has been reported that it can increase the risk of zoonotic infections in both wildlife and humans. It has also been stated that habitat-specific outbreaks may occur, as the synchronization of life cycles between the agent and the vector may be disrupted in relation to the temperature changes that occur. The climate variables that directly affect the ecosystems of vector-borne diseases are mainly temperature and precipitation.

Keywords: Climate Change, Infectious Diseases, Zoonotic Infections

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INTRODUCTION

Significant long-lasting changes that occur with factors such as temperature, precipitation and wind that make up the climate are defined as climate change. The geographical features of the world have changed several times in the process until the emergence of people on the stage of history. In certain periods, depending on the deterioration of the natural balance between the elements of our world for various reasons, there have been great changes in the climate.

Climate tends to change over time with natural and human influences. Climate change, especially caused by human activities, adversely affects human health [1]. Until today, changes in the global climate have occurred for centuries due to natural causes such as continental drift, numerous astronomical cycles, variations in solar energy efficiency, and volcanic activities. However, in the last centuries, a new era has been entered in which human activities affect the climate. Pollutants resulting from the use of fossil fuels such as coal, oil and natural gas change the balance in the climate [2].

Climate change generally causes negative effects such as global warming and/or cooling, heavy rains, flash floods, melting of glaciers, rise in sea level, decrease in agricultural areas, affecting ecosystems, migrations, epidemics. Climate change has direct or indirect effects on health [3].

Direct effects; temperature extremes, heat/cold waves, hurricanes, storms, floods and fires; indirect effects; vectorial diseases, infections, epidemics, water and foodborne diseases, air pollution and respiratory diseases, stratospheric ozone depletion and UV Radiation, allergic diseases and field dust [4]. The increase in ultraviolet rays reaching the earth causes DNA defects, decreased photosynthesis, negative effects on plant growth and reproduction, but also causes ecological effects such as the death of phytoplankton. Climate change will affect many populations in the coming years and expose billions of people and living things to various risks [1].

1. Direct Effects of Climate Change

While extremely hot weather triggers cardiovascular, cerebrovascular and respiratory tract deaths, the highest death rates due to hot weather are seen in people over 65 years of age. As a result of the examinations, when the seasonal distribution of deaths in hot countries is examined, it is seen that there are more deaths in winter than in summer months [3]. Cold weather affects blood pressure, and as a result, deaths occur as a result of blood clots [1].

Hurricanes, floods, tornadoes, blizzards, windstorms and drought are the most important extreme weather events. Another important event is forest fires that occur due to meteorological conditions. Extreme weather events; It also brings problems such as deaths, injuries, post-disaster epidemics, migration and malnutrition [4].

2. Indirect Effects of Climate Change

Vector-borne diseases are diseases caused by the bites of arthropods such as mosquitoes, ticks and houseflies that transmit the disease agent to humans. Vectors are generally affected by humidity and temperature. A change in vector distribution will also affect human health. Increasing temperature values affect the distribution and number of vectors, causing pathogens to multiply more rapidly [1].

According to the World Health Organization, infectious diseases affected by climate change; avian flu, Crimean-Congo Hemorrhagic Fever, cholera, sleeping sickness, ebola, parasites, plague, tuberculosis, Lyme disease, harmful seaweeds, scarlet fever and yellow fever. Climate change affects the conditions for safe drinking water, adequate food and safe shelter. According to WHO; Between 2030 and 2050, 250,000 deaths are expected each year due to malnutrition, infectious diseases and heat stress caused by climate change [5,6]. 55% of foodborne diseases are caused by bacteria (Salmonella), and 33% by viruses. However, it is estimated that foodborne illnesses will increase by 5-20% by 2050 [2].

Waterborne diseases; are diseases transmitted by mosquitoes such as typhoid, cholera, diarrhea, skin and eye infections (scabies, trachoma), diseases carried by fleas (epidemic typhus), cercacial dermatitis, malaria, dengue. While the rate of disease spread after precipitation was 51% between 1948-1994, this rate increased to 68% in the 1990s [2].

Air pollutants; It leads to consequences such as deterioration in respiratory functions, recurrence of the disease in people with chronic respiratory system and heart disease, increase in cancer incidence and premature death. Asthma symptoms may worsen due to the increase in fungal spores and pollen density in the air [1].

Increases in temperature can also cause premature death in the elderly and those with respiratory pathology such as chronic lung disease. Some diseases such as upper respiratory tract infections, flu, sinusitis, asthma, bronchitis, chronic bronchitis and even pneumonia are more common in areas where air density is polluted. Ultraviolet radiation (UVR) is caused by the sun and aids in the body's production of vitamin D. As with anything, too much is bad. It has side effects ranging from skin aging to cancer, according to wavelengths [4].

Changes in weather conditions cause many allergic diseases through pollen with the onset of spring. Changes in pollen season and duration also affect allergic disease attacks. The most important of these allergic diseases is hay fever. Increasing CO2 concentration and temperature increase hay fever [1].

3. Climate Change and Infectious Diseases

Infectious diseases, one of the health problems of our age, are still seen as an important problem [7]. According to the latest research, approximately 25 of the deaths occur due to infectious diseases [8]. Since climate change is predicted to have significant effects on infectious diseases, research on vector-borne diseases, food and water-borne diseases, bacterial, viral and fungal infections is increasing. Appropriate climatic and weather conditions are required for the survival, reproduction, distribution and transmission of disease pathogens, vectors and hosts [9]. Therefore, changes in weather conditions affect infectious diseases by affecting pathogens, vectors, hosts and their habitats [8].

For this reason, a state of alarm has been set in the world and Global Burden of Disease (GBD) programs, which define "climate sensitive infectious diseases" (CSIDs) with climate change indicators, have been established to inform public health against climate change due to global warming. Through these programs, it was aimed to develop new policies in global health management by guiding mortality rates, risk factors affecting health and health surveillance. Many infectious diseases and pathogens need to be monitored in terms of changes in climate caused by changes in these diseases and pathogens [10].

4. Climate Change and Pathogens

A wide variety of disease agents are called pathogens, including viruses, bacteria, parasitic microbes, and fungi. Climate change can have a direct impact on pathogens, affecting their survival, reproduction and life cycle. Climate change can have a direct or indirect effect on paogens. It can directly affect the survival, reproduction and life cycles of pathogens. It can also exert an indirect effect by influencing the pathogen's habitat, environment or competitors. As a result, not only the amount of pathogens, but also their geographical and seasonal distribution can change [11].

Temperature can affect disease by influencing the life cycle of pathogens. Well; A certain temperature range is required for a pathogen to survive and complete its development. Increasing temperature can affect the growth of pathogens and external incubation time, providing a suitable environment for the pathogen. The environment for microorganism reproductive cycles and algal blooms, as well as increased temperature, can limit the growth of a pathogen in favor of competitors [12].

Changes in weather conditions affect the spread of waterborne pathogens. As a result, heavy rain can mix sediments in the water, causing the accumulation of fecal microorganisms. However, unusual rainfall following a prolonged drought can cause an increase in pathogens, resulting in an outbreak of disease. Drought/low precipitation leads to low river flows, resulting in a concentration of wastewater-borne pathogens [2].

Humidity change also affects pathogens of infectious diseases. Pathogens of airborne infectious diseases (such as influenza) tend to be sensitive to moisture. Humidity change also affects viruses of waterborne diseases. For example, the survival of waterborne viruses near the water surface is restriced due to the drying effect of surface water. Sunlight is another important climate variable that can affect pathogens of infectious diseases. Wind is another important factor affecting the pathogens of airborne diseases. Studies suggest that there is a positive relationship between airborne particles and virus survival/transmission [12].

5. Climate Change and Vectors

Host means live animals or plants that harbor disease pathogens on or in them. Vectors are intermediate hosts and carry the pathogen and transmit it to living organisms that become hosts. The geographic locations of their vectors and population changes are closely related to the patterns and changes of the climate. Therefore, climate change can cause changes in the spread, duration and intensity of infectious diseases by affecting disease vectors [10].

6. Effects of Climate Change on Vector-Borne İnfectious Diseases

There are important factors affecting infectious diseases transmitted by vectors. These factors are the ecology and behavior of the host, the ecology and behavior of the carrier, and the immunity level of the population. Pathogens carried by vectors are particularly susceptible to climate change. Temperature provides more favorable conditions for vector survival and completion of its life cycle[13]. Examples of vector-borne diseases are Malaria, Dengue, West Nile Fever, Encephalitis, and Lyme, Yellow Fever Virus, Crimean-Congo Hemorrhagic Fever Virus [9].

6.1. Malaria

Malaria caused by *Plasmodium spp*, which causes 214 million new cases due to mosquito carriers, is the leading vector-borne infection. As a result of climate change, changes in the distribution of malaria in Africa and the intensity of transmission have been reported. In addition, the number of malaria cases in Kenya has been associated with precipitation and high maximum temperature [9].

6.2. Dengue Fever

Dengue fever is an acute, epidemic, febrile disease caused by the Dengue virus and transmitted to humans by mosquitoes of the Aedes genus (*A.aegypti* and *A.albopictus*). While there are reports suggesting a relationship between current climate changes and dengue outbreaks, there are also reports suggesting that there is no relationship. The reason for this has been shown to be many other factors in addition to climatic factors [14].

6.3. West Nile Fire

West Nile fever is a viral contagious disease and is transmitted by the Culex mosquito species. The habitats of these vectors are usually near swamps, ponds, stagnant water bodies, waterways, parks, golf courses, and temporary wetlands in densely populated residential area [15]. Although mosquito lifespans shorten with temperature, viral maturation rates increase with temperature. This causes an increase in mosquito vector infections [14].

6.4. Encephalitis and Lyme

Diseases vectored by ticks have increased considerably in recent years. Tick-borne diseases are increasing due to global warming in cold regions. It is thought that increasing temperatures accelerate the development cycle, egg production, population density and distribution of the tick. Accordingly, the increase in the incidence of encephalitis and lyme diseases transmitted by ticks in Europe has been associated with the prolongation of the lifespan of ticks as a result of milder winter weather conditions and shortening of the winter season [2].

6.5. Yellow Fever Virus

This *Filavivirus* infection, mostly observed in the equatorial areas of the Americas and Asia, is transmitted by *Aedes aegyti* in forests and urban settlements. It has been reported that the change of forests with climatic warming may increase the contact between humans and the transmission cycle in the forest and increase epidemics [14].

6.6. Crimean-Congo Hemorrhagic Fever

Crimean-Congo Hemorrhagic Fever is an important *bunyavirus* transmitted by Ixodidae ticks of the genus Hyalomma. It has been determined that birds host many infected Hyalomma tick species. The effects of climate changes on transmission of infection are explained by changes in the paths of migratory birds carrying infected ticks. İncrease in the incidence of infection in Turkey; It is explained by the increase in the number of infected ticks due to global warming and the virus leaving endemic areas by changing its developmental characteristics [9].

7. Effect of Climate Change on Airborne and Droplet Spread Infections

The increase in deaths in cold regions is the cause of the epidemic spread of airborne viral infections and secondary bacterial infections. With increased rainfall and higher population densities, an increase in influenza is expected in all climates. Unlike seasonal flu, outbreaks of human avian influenza viruses such as H5N1 and H7N9 occur sporadically and result from direct interaction of humans with wild or domesticated birds. H7N9 infections were strongly associated with temperature as well as relative humidity between 70% and 80% [16].

Climate change can potentially increase the incidence of pneumonia in several different ways. For example; people being indoors during periods of heavy rainfall, variability in vitamin D levels caused by variability in sun exposure, and a weakened immune system. [9].

8. Climate Change and Covid-19

The severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) pandemic, which affected the whole world, emerged in Wuhan, China, in late December 2019. According to WHO, by 12 July 2021, 190 million cases and 4 million deaths were reported worldwide due to coronavirus [17]. Increasing evidence points to airborne transmission. The extent to which various modes of transmission (contaminated surfaces, fecal-oral transmission, and other body fluids) affect the dynamics of the infection is still being investigated. The relationship between the incidence of COVID-19 and meteorological factors is widely discussed in the literatüre [18].

Other coronaviruses and respiratory viruses show strong seasonal disease incidence patterns that can be explained to some extent by meteorological factors in temperate regions. Therefore, a link between meteorology and COVID-19 is likely [19].

There are several ways that meteorological factors affect the incidence of COVID-19. Extreme climatic conditions cause people to spend more time in closed, poorly ventilated areas, increasing the transmission of SARS-CoV-2. Furthermore, lower temperatures increase the stability of viral lipid envelopes and lower humidity promotes droplet core formation which increases the viability and transmissibility of SARS-CoV-2. Also, cold and dry conditions affect the human innate and adaptive immune response in various ways. In conclusion, these mechanisms support the hypothesis that colder and drier conditions will favor SARS-CoV-2 transmission and increase the incidence of COVID-19 [20].

The SARS-CoV-2 outbreak has shown that global crises can occur suddenly and have a significant impact on public health. In order to control and reduce the negative health effects of climate change due to global warming, public health programs need to be continuously improved [19].

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ONE HEALTH APPROACH AND CLIMATE CHANGE

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ABSTRACT

One Health is a concept that emphasizes a multidisciplinary approach to reveal better policies, practices and research for the protection and development of public health. The concept of One Health has a key role in keeping the public health consequences of global climate change under control. In this study, it is aimed to investigate collaborations made in the conflictagainst globalclimate change within the scope of One Health approach. The study was designed as a literature review. It is recommended to increase awareness activities for the provision of better health services to the public and the cooperation of different disciplines for the protection of health.

Keywords: One Health, Environmental Protective Health Services, Health Policies, Climate Change.

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1. INTRODUCTION

Effective and efficient delivery of health services is an indicator of social growth and development. Continuous improvement and development of health services is essential for a healthier society and healthier generations. However, it is necessary to keep up with technological developments and changes quickly by increasing quality and quantity of health services. Health services provide services with the aim of protecting and improving health, treating sick and rehabilitating the injured. Health Service; preventive health services, curative health services, rehabilitation services and health promotion services are examined in four groups.

Today, the perception towards health services and diseases has changed. While health care was a need after the emergence of diseases in the past, taking precautions before the emergence of diseases has become a priority for health services. Now, states are going to change their policy in this sense. Because providing preventive health care before illness is cheaper than providing curative health care in terms of costs. Again, receiving preventive health care services before getting sick is less tiring, both materially and morally, than after the illness.

Preventive health services are struggling to reduce the diseases and risks in the society and to create a society with a higher health level before disease or disability occurs. Preventive health services are divided into two as personal and environmental protective health services. Personal preventive health services are provided in the form of early diagnosis, treatment, spraying and vaccination. Environmentally oriented preventive health services, on the other hand, concern professions that require many specializations outside the health sector, such as residential health, industrial health, and air pollution. One Health is a concept that emphasizes a multidisciplinary approach to reveal better policies, practices and research for the protection and development of public health. The concept of One Health has a key role in keeping the public health consequences of global climate change under control. In this study, it is aimed to investigate the collaborations made in the fight against global climate change within the scope of One Health approach. The study was designed as a literature review. The concept of one health, one health approach, public health, preventive health services for the environment and climate change are mentioned. In this study, it has been tried to reach a conclusion by evaluating the effects of the single health approach on health in the fight against climate change, and the cooperation of different disciplines to prevent the problem of climate change.

1.1. One Health Approach and Public Health

The concept of One Health states that veterinarians and human physicians, clinicians, researchers and all other health professionals working together for the benefit of society should interact. These interactions can occur at many levels, from the management of zoonotic infectious disease outbreaks in the field to joint research programs and public health policy making [1]. One Health refers to the health connections between humans, animals and our shared ecosystems [2]. However, it is a systems-oriented approach to eliminate disease threats for humans and animals [3]. In this sense, the One Health approach assumes a role that takes into account the environmental changes that affect humans and other living things in terms of the risks of infectious and chronic diseases [4].

From this point of view, in 2010, the World Health Organization (WHO), the World Organization for Animal Health (OIE) and the United Nations Food and Agriculture Organization (FAO) presented a joint statement and accepted the One Health concept as a multidisciplinary approach. In addition, in order to understand the importance of a single health in terms of public health, the number of zoonotic pathogens, which was 86 in 1950, has reached more than 200 and is increasing gradually [5]. In addition, the United Nations Environment Program (UNEP) was established in 1973 to contribute to the protection of the environment and to guide these studies. In this way, it provides an opportunity to raise awareness of member countries about environmental hazards and to take necessary precautions [6]. The One Health approach is directly related to the field of public health, which states that measures should be taken to prevent harmful effects on organisms before disease and health risks occur.

The World Health Organization (WHO) carried the desire and wish of all world citizens to be healthy with the slogan of Health for All in 2000. As a result of the meeting held in Ottawa in 1986, Health Promotion Policy, which provides a general perspective on public health, was summarized as Health for All [7]. Public health practices include health services in two ways: personal and environmental. Within the scope of the study, environmental health services have been tried to be explained below.

2. ENVIRONMENTAL HEALTH SERVICES

All of the services offered to treat patients, protect and improve health, treat the sick and rehabilitate the injured are called health services [8]. The main purpose of health services is to provide the needed health service to the communities at the desired time, quality and low cost [9]. In addition, the scope of health services is too wide to be carried out only by the health sector and includes many different sectors and occupational groups. The state provides preventive health services for the whole society, including improving health conditions and eliminating the elements that may impair human health [10]. Preventive health services are based on the preventive medicine system. According to the definition of the World Health Organization, preventive medicine; “In addition to preventing the formation and development of physical and mental disabilities with the organized efforts of the society, by a good physician who is responsible for the health of individuals and their families, by immunization, health education and similar efforts by all, by using all possibilities to improve the health of the community as a whole. is the practice of medicine” [11].

In the Directive on the Execution of Health Services, preventive health services; “Health services provided to protect people from illness, injury, disability and premature death. Immunization for the person, protection with drugs and serum, early diagnosis, family planning, food safety and healthy eating habits to improve nutritional status, health education, and to prevent health problems arising from adverse conditions in the physical, biological and social environment. Interventions are described as “protective services”. In other words, preventive health services are a struggle that is obligatory to be provided by the state to the whole society, regardless of its ability to pay, and to respond to risk groups, before disease or disability occurs. Its aim is to reduce the risk of disease by creating a society with a higher health level [8]. In addition, “preventive health services” have a higher priority than others, as protection is much less costly than treatment in the provision of health services. Depending on the level of development of the countries, the efficiency of these services also increases. Health services also include drug and pharmacy services and laboratory services [11]. All efforts to make the environment more livable by destroying the biological, physical, chemical and social factors that surround people and negatively affect their health, or to prevent negative environmental factors from affecting people, are all within the scope of environmental protective health services [12]. In other words, preventive health services for the environment are all attempts to reduce the negative effects of sociological, economic and physical environmental conditions on human health. These are services that physicians are not directly involved in, which generally include engineering services. Environmental health services are carried out by professional groups such as engineers, chemists, veterinarians and technicians specialized in this field [8, 13].

The main services rendered; housing health, industrial health, providing enough and clean water, making solid and liquid wastes harmless, fighting vectors (fighting pests), fighting air pollution, fighting radiation and noise [12]. As can be seen, environmental health services are services that should be carried out by professionals in other sectors, in line with the consultancy and supervision of the health sector, rather than the health sector [12]. Again, service areas that are close to health, directly effective, and sewerage within the scope of protective health services for the environment, drinking water network, some services such as municipal services, veterinary medicine, phytosanitary services and the like are areas that overlap to a large extent with the main health services area and cover statuses close to it [14].

In addition to this information, it is useful to remember that the effect of environmental conditions on health comes from the Hippocratic period. Hippocrates; emphasized that the biological and physical structure of soil, water, air is important in terms of social security. For this reason, it is important that the parameters of the physical and biological environment are under control. Climate changes with global warming cause negative area changes. As a result of floods, hurricanes and droughts, living things in the ecosystem will be adversely affected. Therefore, it is necessary to abandon the practices that trigger climatic changes and the use of resources [7]. Changes in ecological systems caused by sudden climate changes cause air pollution, infectious diseases and many climatic events. This increases the application and workload of health systems [15]. It is seen that public health practices within the One Health approach are affected by physical and biological environmental factors. For this reason, the climate changes experienced have a critical importance for the health services provided and the measures to be taken for human health.

3. CLIMATE CHANGE

Fossil fuels such as coal, natural gas and oil, whose consumption has increased greatly in recent years, release serious harmful gases and particles into the atmosphere. As a result of this, there has been a great increase in the amount of greenhouse gases such as carbon dioxide, methane, and nitrous oxide in the atmosphere. As a result, today's global warming and climate change problems have emerged [16]. State of climate change and its global effects; It is explained by indicators in different categories such as atmosphere and climate, glaciers, snow and ice, marine systems, terrestrial ecosystems and biodiversity, agriculture, water, economy and human health [17]. Particularly the most devastating ones related to climate change are related to the increase in the frequency or severity of extreme events [18]. The Intergovermental Panel on Climate Change (IPCC) was established, where the most reliable and comprehensive reports on climate change, created with the contribution of many scientists from all over the world, are published. The Intergovernmental Panel on Climate Change (IPCC) was established in 1990 to provide countries with robust data sources. According to the result of the report published in September 2013, it has been stated that climate changes are affected by human activities with 95% confidence [19]. The efforts of many institutions and organizations, non-governmental organizations, central and local governments are important in order to determine climatic changes and their effects so that people can live in healthier and better conditions [20]. Considering all this information, the effects of climate changes on the world are directly related to humans and living things. For this reason, climate changes are an important factor for human health and continuity of life.

4. CONCLUSION

Today, health services are focused on providing "protective" services depending on the person and environmental factors rather than being "curative". Studies have been intensified for preventive health services in the management of the Covid-19 pandemic and in the management of future pandemics. From this point of view, every member of the health sector who can provide preventive health services is important. All kinds of negative changes in the ecosystem directly affect human and animal health. Climate change has increased its impact day by day with the policies of states and the unconsciousness of people. It is thought that climate change, which threatens human health within the scope of environmental health services and public health, will fill a multidisciplinary gap under the concept of one health. With a multidisciplinary approach, the best use of natural resources will be possible with a single health approach. It is recommended to develop more integrated health policies by increasing awareness activities in order to provide better and qualified health services to the society, and to gain the spirit of cooperation and cooperation between different disciplines for the protection of health.

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CLIMATE CHANGE AND WOMEN'S HEALTH

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ABSTRACT

Purpose: Climate change is a significant global health problem that has become a priority. Its harmful effects on the world, directly and indirectly, affect human health. Natural disasters, vector-borne diseases, poor air quality, and extreme climate temperature variations can cause human health changes. Climate change may increase the health needs of women, who are more in number than men in developing countries, especially in adulthood and old age when pregnancy occurs. This review aims to reveal the effects of climate change on women's health.

Material method: This review was searched on PubMed, Cochrane, Science Direct, and Google Scholar pages using the keywords "climate change," "women," and "women's health" and their combination, and the results of the research were given in an interpretative way. Database research was carried out between 27 September and 05 October 2022.

Conclusion: Women's health experiences social, cultural and economic inequality can significantly affect climate change. For this reason, the women's population should be addressed against climate change, and the countries should plan and implement the necessary interventions.

Keywords: Climate Change, Environmental Pollution, Women, Women's Health

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1. INTRODUCTION

Climate change is a critical issue worldwide [1]. The five years from 2015 to 2019 were the warmest five years on record [2]. Globally, the number of cold days and nights has decreased, and the number of warm days and nights has increased [3]. Changes in extreme weather events, such as floods, drought, cyclones, and wildfires, have impacted human health across countries [4]. The health consequences of events related to climate change are classified as direct or indirect. Direct effects relate to the physiological effects of heat or cold and cellular and organismal responses to pollution, water pollutants, or disruption of services. Indirect effects relate to vectors and pathogens whose increase or distribution is ultimately a result of climate change. The effects of climate change on women's health; support its direct impact on fertility, prenatal health problems, mental health, sexual and reproductive health, and survival [5, 6]. Depending on the disasters experienced, communities may experience post-traumatic stress, suicides, and adverse pregnancy outcomes in survivors [7]. Women with unmet family planning needs will increase their problems during a disaster. Population subgroups such as pregnant women, older adults, children, co-existing chronic morbidities, and people with lower socioeconomic status are at risk of climate change and air pollution-related health impacts.

2. MATERIAL AND METHODS

This review was searched on PubMed, Cochrane, Science Direct, and Google Scholar pages using the keywords "climate change," "women," and "women's health" and their combination, and the results of the research were given in an interpretative way. Database research was carried out between 27 September and 05 October 2022.

3. RESULT AND DISCUSSION

3.1. The Effect of Climate Change on Child Health

The increased air temperature due to climate change and events such as floods negatively affect children children's children children's and women's health due to malnutrition, diarrhea, low birth weight, premature death, and heat-related diseases. Because of this situation, women and children are vulnerable groups [8]. Affected by air pollution, in particular particular particular, girls have a higher risk than boys; there is a significant gender difference in the risk of stunted and underweight children in terms of exposure to air pollution, supporting a positive relationship between exposure to air pollution and the risk of malnutrition in children [9]. It demonstrates that air pollution can stunt children's growth, suggesting recurrent episodes of respiratory disease associated with an increased risk of child stunting [10]. Children are more susceptible than adults to climate change-related respiratory morbidity due to their higher ventilation rates, developing respiratory and immune systems, and smaller peripheral airways [11]. Also, children usually spend more time playing outside during the warm season, so they are at higher risk of exposure to dangerously high temperatures [12]. An Australian study has shown that cold and hot temperatures can affect the risk of accessing emergency care for asthma. Mainly boys were found to be more sensitive to heat than girls; It has been found that boys between the ages of 10-14 are more susceptible to cold than girls, which is the result that extreme temperatures trigger asthma attacks in children [13]. The parent's education level, especially the mother, affects the children's nutrition. In regions experiencing severe drought, preschool children with illiterate and older mothers are more likely to experience Vitamin A deficiency than others [14].

3.2. The Effect of Climate Change on Adult Women's Health

The 2019 Lancet Countdown report noted that women are one of the vulnerable groups to the effects of climate change in a range of social and cultural contexts [15]. This vulnerability stems from gender roles in that woman and their children spend more time at home than men. Currently, many societies are more likely to be exposed to indoor particulate matter than males due to traditional stoves for cooking and heating [16]. Inhalation of such particles may lead to decreased reproductive ability and increased risk of cardiovascular and respiratory system diseases [17].

While women are exposed to air pollution and are more affected by disaster-related events than men, natural disasters such as floods increase the risk of physical injury because women spend more time in their homes. Pollution and exposure to profound toxic substances during flooding, prolonged exposure to water-filled and unhealthy environments, severe stress, anxiety and depression, cultural norms that interfere with women's ability to survive floods, and food insecurity can be counted as factors affecting health [18].

Air pollution has been associated with hypertensive disorders in pregnant women and other vulnerable populations [19]. Numerous studies have shown a link between prep-regnancy, prenatal exposure to air pollutants, and low fertility and live birth rates in spontaneous pregnancies and after in vitro fertilization and embryo transfer (IVF-ET) [20,21]. With the closure of the oil plant, air pollution decreased over ten years, accompanied by a reduction in otherwise unexplained preterm births [22].

With forest fires and firestorms increasing due to global warming, there is a significant seasonal impact on air quality and, thus, the risk of perinatal complications.

It was concluded that the proximity of the houses to the main roads increases the risk of infertility among nurses and couples undergoing IVF in the USA. The percentage of IVF applications that resulted in a live birth was 33% for those living less than 50 m from the main road and 46% for those more than 400 m from the main road. [23].

Extreme temperatures and water shortages accompanying pest damage potentially result in reduced crop production [24]. Food insecurity negatively affects women and children, increases the likelihood and size of population migrations, and puts women at risk of mental and physical stress.

Women are more likely to skip meals than men. As a result, it is more affected by nutritional deficiencies such as malnutrition and anemia due to food insecurity [25]. Women in rural areas are more likely to be at risk of vector-borne disease, as they are likely to be close to wells, rivers, and ponds when collecting water sources [26].

3.3.Women's Cancers and Climate Change

The most common cancers in women are breast, lung, colorectal, cervix, and stomach. The leading environmental and social causes of cancer are open to interventions throughout the cancer control process, including actions against the use of tobacco products, unprotected exposure to ultraviolet radiation, and some infectious agents such as the human papillomavirus (HPV). Climate change, air pollution, ultraviolet rays (UV), environmental toxins, and deterioration in food use and health systems will affect the development of cancer in the body. Climate change can affect the availability and quality of food, clean air, water, and shelter, thus affecting primary health care. Women may suffer more due to poverty, migration, and social inequalities. Therefore, since women's access to health services will be restricted due to climate change, they will be interrupted in terms of cancer screenings [28].

While mortality rates from lung cancer are higher than those from breast cancer in Turkey, the number of non-smokers and women with lung cancer is increasing. This may be due to environmental carcinogens produced from air pollution, such as polyaromatic hydrocarbons (PAHs), particulate matter, and benzene, and climate-related factors, such as forest fires. It has been revealed that deaths from particulate pollution have increased by 20% in the last three decades, and 15% of lung cancer is caused by air pollution [27]. The increasing frequency of forest fires in the world contributes significantly to air pollution. PAHs are directly linked to the incidence of breast cancer, and climate change is likely to increase such exposures [28]. Colorectal cancer is the fourth most common cause of cancer-related death in women worldwide. Food grown in the world, increased consumption of red meat, and dietary factors are associated with the incidence of colorectal cancer. Rising temperatures, floods, droughts, extreme weather events, rising sea levels, and ozone layer damage negatively affect food production and crop yields.CO2 in higher geographies reduces the nutrient content of essential cereal crops, including the amount of protein and micronutrients in these crops. Rising seawater temperatures and ocean acidification reduce fisheries productivity and may affect the consumption of omega-3 fats, which are protective against certain cancers [29]. Colorectal cancer screening has successfully reduced the incidence and mortality of this disease. Still, participation in screenings may be interrupted by climate change, particularly in communities and populations where health services are already inadequate [28]. Melanoma and other skin cancers are other vital diseases in the world. It will likely increase with climate change and greater exposure to harmful UV. Rising temperatures and heat waves can increase skin cancer rates if people spend more time outdoors, with unprotected sun exposure [30]. Cervical cancer continues to be a significant cause of morbidity and mortality in women in low- and middle-income countries. Climate change may prevent women from accessing regular vaccination and screening programs [28].

4. CONCLUSION

Climate change is one of the most dangerous threats to women's health. In addition, women are uniquely vulnerable to climate change because of their gender roles. The adverse effects of climate change on women's health are pretty high. It is essential to eliminate the health problems of women who raise and raise society due to climate change. This is necessary for a healthy community.It can play a relevant role in a range of actions, including education planning for children, caring parents, and their involvement in policy work. Mixed methods are recommended in future research to assist policymakers in responding to climate change.In this context, local governments should cooperate with decision-makers, including universities, schools and community leaders.

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EFFECTS OF CLIMATE CHANGE ON MATERNAL AND NEWBORN HEALTH

Neşe Karakaya[1*]

ABSTRACT

Climate change directly or indirectly affects human health in the short and long term. Changing weather conditions and environmental disasters are making living conditions more and more difficult. Climate-sensitive health risks particularly affect vulnerable and socioeconomically disadvantaged groups such as women and children. There is increasing epidemiological evidence between maternal exposure to air pollution before pregnancy, during pregnancy, and in the early postpartum period and adverse birth outcomes such as preterm birth. In recent studies, it has been reported that the risk of pregnancy complications such as preeclampsia and gestational diabetes mellitus may increase in mothers exposed to air pollution. Decreased lung function, increased respiratory symptoms, and development of childhood asthma in infants born to mothers exposed to air pollution are also associated factors. Infants affected by preterm birth and low birth weight are more likely to encounter neurodevelopmental disorders, immunological complications, obesity, and cardiovascular diseases later in life.The majority of healthcare providers see climate change as a major threat to human health. However, lack of guidance, education, and resources are seen as major obstacles in tackling climate change. Therefore, the provision of education, patient education materials, and clear policy guidance will contribute to the efforts of healthcare providers to reduce health risks.

Keywords: Climate Change, Air Pollution, Maternal Health, Newborn Health

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1. INTRODUCTION

Climate change is a difficult situation that can prevent all living things from living healthy life. Although we are experiencing short-term effects, research on the long-term effects has continued to increase in recent years. Clean air, safe drinking water, nutritious food, and safe shelter are essential requirements for health. When climate change and the disasters it causes to reach a level that prevents even these basic needs from being met, human life and health are endangered [1, 2].

Changing weather conditions and environmental disasters make living conditions more difficult and mainly affect vulnerable and socioeconomically disadvantaged groups such as women and children [3]. Women are easily affected by situations they may perceive as stress during pregnancy. This influence can be both physiological and psychological. Any environmental change during this delicate pregnancy can cause immediate or permanent problems for the mother and her baby. However, studies on the effects of climate change on maternal and newborn health are limited [4].

This review presents the effects of climate change and related environmental factors on maternal and newborn health with scientific studies and solutions.

2. CLIMATE CHANGE

Climate change is the long-term changes in natural events such as air temperature, precipitation, and wind [5]. These changes also cause intense environmental disasters such as heat waves, forest fires, and hurricanes [5]. Intergovernmental Panel on Climate Change (IPCC), in its report in 2007; It was stated that “a child born today will live in an environment that is on average 4 degrees warmer than a child born in the pre-industrial era” [6, 7]. Since this increase in temperature will lead to a rise in environmental events, it is thought that people living in the 21st century will be more affected by this situation.

Meetings are held to produce global solutions for adaptation to climate change and the measures to be taken. In its report published in 2021, the IPCC suggests that human activities are effective in the planet’s rapid warming and extreme weather events [8, 9]. Climatic variability caused by human activities, health, agriculture, water resources, economy, etc., causes adverse effects on the situation [10]. Countries prioritize these issues and demonstrate efforts to adapt and cooperate with climate change.

Climate change and air pollution are linked. The concentrations of air pollutants depend on wind, altitude, day/night, and seasonal weather changes. Indoor and outdoor air pollution adversely affect human health. In the air, women and newborns may be exposed to smoke, pesticides, biological materials, and household chemicals [9, 11]. However, this exposure may not be only by air. Air pollutants can also contaminate soil and drinking water, threatening the digestive tract mother’s and baby’s health [9, 12].

3. EFFECTS OF CLIMATE CHANGE ON MATERNAL AND NEWBORN HEALTH

Climate change and the environmental events it causes affect human health directly or indirectly in the short and long term. The effects of climate change on maternal and infant health can be explained in three dimensions [7].

1. Direct effects through environmental disasters
2. Indirect effects through changes in the natural environment
3. Indirect effects through changes in the social environment

Pregnant women are more prone to heat stress as their thermoregulation and homeostasis abilities are delicate. A meta-analysis on this subject stated that the risk of preterm birth is 16% higher on days with heat waves [7, 13]. High temperatures are more likely to affect women with pre-pregnancy health problems and those who smoke during pregnancy [14]. It has also been associated with severe other pregnancy outcomes such as premature rupture of membranes [15], gestational hypertension, and preeclampsia [16].

Research on the effects of forest fires on maternal and infant health is still insufficient. However, the known effects of cigarette smoke and air pollution can help form an idea. Forest fire smoke is a complex mixture of gaseous pollutants, organic compounds, and fine particles [17]. When studies on the effects of forest fires on pregnancy outcomes are examined, findings show an increased risk of preterm birth [18], low birth weight [19], fetal death, and neonatal death [7, 20].

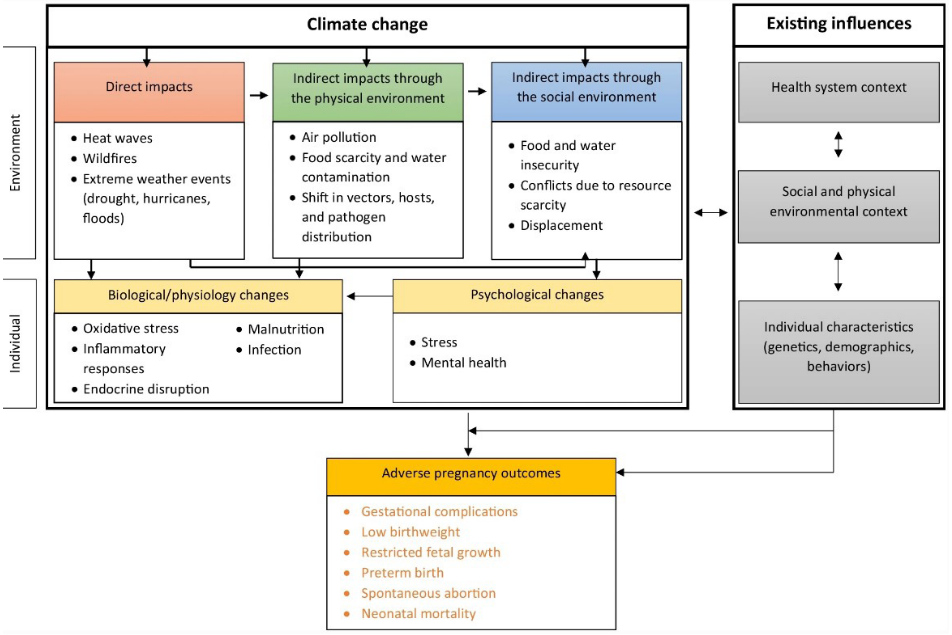

Figure 1. Impacts of Climate Change on Pregnancy Outcomes [7]

Extreme weather events (drought, flood, hurricane, Etc.) make pregnancy follow-up difficult and endanger the health of the mother and baby. Studies show an increased risk of gestational hypertension, birth complications, cesarean section, and neonatal complications [21]. It is also known that individuals exposed to extreme weather events experience post-traumatic stress disorder, insomnia, and mental health complications [22]. These mental changes cause biological and physiological changes in individuals (Fig.1).

The rising sea level in recent years may cause more frequent tidal-related flooding, especially for people living in coastal areas, and expose pregnant women to mold and other hazardous chemicals [7].

The changing climate directly impacts both outdoor and indoor air quality. It has been shown that there is a relationship between maternal exposure to air pollution and adverse birth outcomes before pregnancy, during pregnancy, and in the early postpartum period. There is also growing evidence that policies that reduce this exposure improve birth outcomes [9]. Recent studies have reported that the risk of pregnancy complications such as preeclampsia and gestational diabetes mellitus may increase in mothers exposed to air pollution [23]. The detrimental effects of exposure to air pollution during pregnancy have been demonstrated for different birth outcomes: preterm birth [24], low birth weight [25], fetal death [26], impaired lung development[27], increased later respiratory morbidity, and early changes in immune development [28, 29].

In many parts of the world, hunger and poverty are major health problems, especially for pregnant women. It is known that difficulty obtaining safe food is associated with significant health risks such as congenital malformation, low birth weight, preterm birth, gestational diabetes, and gestational hypertension. Problems related to safe drinking water and food supply in socioeconomically disadvantaged regions where temperature increase is felt intensely bring health risks. In addition, pregnant women exposed to waterborne pathogenic microorganisms have an increased risk of many pregnancies and fetal complications (septicemia during pregnancy, spontaneous abortion, preterm delivery, intrauterine growth restriction, and congenital disabilities) [7].

Due to climate change and related factors, people must migrate to survive. The need for pregnant women to seek prenatal care is delayed, as safe food, water and shelter are a priority for survival. Therefore, the diagnosis of high-risk pregnancies is delayed, which may lead to poor perinatal outcomes [7].

4. CONCLUSION

In line to start a healthy life, it is necessary to take the health of the mother and newborn at the highest level and take the proper steps. Climate change and related weather events should also be evaluated under health risks before and during pregnancy. In addition, the impact of climate change on maternal and newborn health is not limited to this period. This health risk can be passed on throughout an individual's lifetime and even to future generations. Climate change is recognized as the twenty-first century's most significant public health threat. Pregnant women and the growing fetus are particularly vulnerable to direct and indirect effects, especially in regions with fewer resources. Policy, clinical, and research strategies are now more critical than ever to adapt to or mitigate the effects of climate change. A successful solution must involve interdisciplinary collaboration (government, public, employers, health professionals, and researchers). Despite the challenges, joint efforts for cohesion and cooperation must be sustained and strengthened. Training to facilitate behavioral changes and raise awareness. Finally, more research is needed on how climate change and its environmental consequences affect maternal and newborn health.

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IN THE CITY OF AMASYA INVESTIGATION OF THE RELATIONSHIP BETWEEN THERMAL COMFORT CONDITIONS AND RESPIRATORY DISEASES

Savaş Çağlak[1*]

ABSTRACT

Studies on the effects of thermal comfort conditions on human health have been very limited in Turkey, which is located in the transition zone of air masses in the middle belt. In this study, PET (Physiologically equivalent temperature) is aimed to examine the relationship between thermal comfort conditions and respiratory diseases by using the index. To determine the thermal comfort conditions in the study, hourly between 2017 and 2019; the PET index obtained from the RayMan model was used by using the air temperature (ºC), relative humidity (%), wind (m/s), and cloud cover (octa) data. The relationship between PET values and respiratory diseases hospital admissions Pearson Correlation analysis and linear regression analysis were used. As a result of the study, a high and very high level of statistically negative correlation was found between thermal comfort conditions and respiratory diseases. It has been stated that when PET values increase by 1 ˚C, there will be a decrease of-39.556 to-87,436 units in respiratory diseases. Cold thermal conditions have been found to increase hospital admissions for respiratory diseases. These findings can be informative and guidance for decision-makers to protect public health, preventive and preventive medicine studies, and for studies on the effects of climate change on human health.

Keywords: Thermal Comfort, Respiratory Diseases, Public Health, PET (Physiological equivalent temperature), Amasya

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1. INTRODUCTION

Studies on the effects of climatic conditions on human health date back to the years before Christ. It is known that the first study dealing with the relationship between climate and human health belonged to Hippocrates 2500 years ago [1]. It is stated that the frequency of heat waves has increased in recent years and the hottest period is experienced [2]. Both extreme temperatures and extreme cold put pressure on the human body. Depending on this situation, the incidence and incidence of some health problems increase, and there is an increase in death rates [3, 4]. It is stated that the health burden will increase due to climate change [5]. It is necessary to take some measures to protect public health and prevent possible health burdens in the future. In this regard, studies that reveal the thermal comfort conditions of cities and their relationship with diseases are important [6].

Thermal comfort is the state of people feeling happy and comfortable in their thermal environment [7, 8]. Uncomfortable conditions, especially health, social and economic, etc. lead to negativities [9, 10]. Studies in different disciplines have shown that there is an important relationship between thermal comfort conditions and human life and activities [11, 12].

Although there are many studies examining the relationship between thermal comfort conditions and death events, studies on respiratory diseases and thermal comfort conditions have been limited [9, 13, 14]. Most of the studies have examined the relationship between hospital admissions and climate elements [15, 16, 17].

In Turkey, studies dealing with the relationship between thermal comfort conditions and human health are scarce. On the other hand, it is stated that the air temperatures in Turkey tend to increase in recent years [18]. This study, it was aimed to examine the relationship between thermal comfort conditions and respiratory diseases in the city of Amasya, which is located in the Central Black Sea Region of Black Sea Region and where there is not much human mobility. It is expected that the findings will be a guide for the measures and plans to be taken in public health studies, preventive and preventive medicine studies, and to reduce the negative effects of thermal conditions.

2. MATERIAL AND METHODS

According to NUTS, it is located in the Samsun sub-region of the Western Black Sea Region (TRA83 Level) as a study area. The city of Amasya is located in the Central Black Sea Region of the Black Sea Region, in the posterior region of the Canik Mountains, between latitudes 40°40’22” N - 40°38’11”N and longitudes 35°47’3”E - 35°51’24”E. is located. The city of Amasya, which was established and developed along the Yeşilırmak river, has developed at altitudes between 350 and 500 meters [Figure 1]. According to 2021 data, the total population of the city is 147,380 people. 50.2% of the population is female, 49.8% is male, 15.7% is the elderly population aged 65 and over, and 27.3% is the child population.

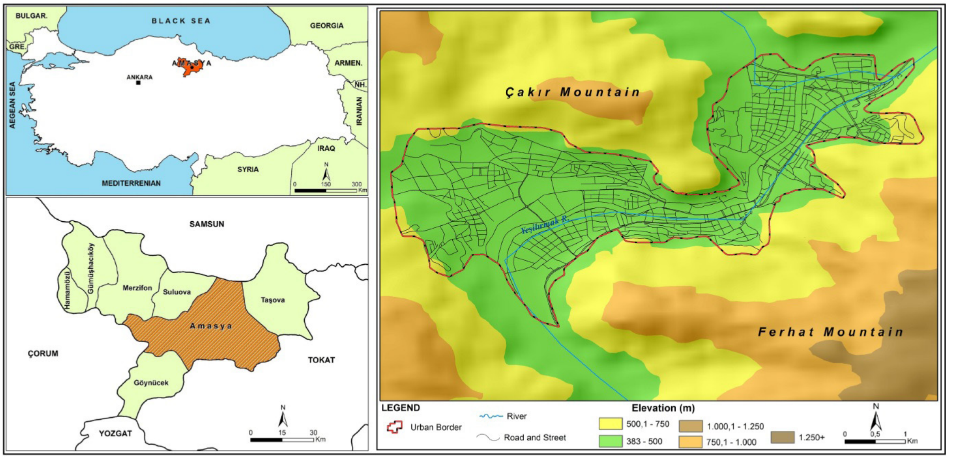

Figure 1. Location of Map Amasya City

In Amasya, according to Köppen-Geiger; (Csa) climate with mild winters, very hot summers, and dry climates; According to Erinç; steppe-semi-arid; According to de martonne; step-damp; According to Thornthwaite; D, B’2,d,b’3 (D: semi-arid, B’2: Mesothermal, d: no or little water, b’3: summer evaporation rate: 53%) [19].

The monthly number of patients for 2017, 2018, and 2019 were obtained from the Amasya Provincial Directorate of Respiratory Diseases based on residence (patients residing in the city center). In the study, data up to 2019 were used due to the Covid 19 epidemic. The meteorological parameters of the meteorological station no. 17085, which is located at an altitude of 405 meters in the city center, between 2017 and 2019; air temperature (ºC), relative humidity (%), wind (m/s) and cloudiness (octa) data were obtained. As a method, the radiation model, which is widely used in the world, is obtained from RayMan software, which calculates both atmospheric factors (temperature, relative humidity, wind speed, cloudiness, and solar radiation) and personal factors (clothing, activity, metabolic processes, etc.) in determining thermal comfort conditions. The obtained PET [Physiologically Equivalent Temperature] index was used [20]. The index calculates all the effects of the thermal environment on humans (short and long-wave solar radiation, air temperature, relative humidity, and wind speed) and the thermo-physiological conditions of the human body (clothing type and activity) [20, 21]. Thermal sensation levels of PET index; it was determined by considering a 35-year-old, 175 cm tall, 75 kg, male, healthy individual with 0.9 clo clothing load and 80W workload [20, 21, Table 1].

Table1. Human Thermal Sensation and Stress Ranges for PET [8, 20]

PET (°C)	Thermal Sensation	Level of Thermal Stress
<4,0	Very Cold	Extreme cold stress
4,1–8,0	Cold	Strong cold stress
8,1–13,0	Cool	Moderate cold stress
13,1–18,0	Slightly Cool	Slightly cold stress
18,1–23,0	Neutral (Comfortable)	No thermal stress
23,1–29,0	Slightly Warm	Slightly warm stress
29,1–35,0	Hot	Moderate heat stress
35,1–41,0	Very Hot	Strong heat stress
>41,0	Extreme Hot	Extreme heat stress

The Pearson Correlation Analysis method was used to determine the direction of the relationship between thermal comfort conditions (PET) and respiratory diseases, and the Linear Regression Analysis method was used to determine the effects of thermal comfort conditions on respiratory diseases.

Pearson Correlation Analysis; It is a statistical method that examines the direction and strength of the relationship between two variables [22]. The correlation coefficient takes a value between +1 and -1, and if it is negative, there is an inverse relationship between the two variables, and if it is positive, there is a right relationship. The closer it is to 1, the stronger the relationship. Table 2 is used to interpret the relationship [23].

Table 2. Pearson Correlation Coefficients and Expressed Comment [23].

Correlation Coefficients (R)	**Expressed comment**
R< 0.2	No Correlation
0.2 – 0.4	Low Correlation
0.4 – 0.6	Moderate Correlation
0.6 – 0.8	High Correlation
0.8 >	Very High Correlation

Linear Regression Analysis; it involves creating an equation that allows estimating the value of the dependent variable from the independent variable based on the relationship between two variables. It is expressed by the following equation;

$$\text{“}y = a + bx\text{"}$$

y: Dependent variable, x: Independent variable, a: Constant, x: Regression coefficient.

3. RESULT AND DISCUSSION

First of all, the distribution of the years 2017, 2018, and 2019 and the mean thermal comfort conditions of the city of Amasya were determined. Then, the average monthly patient numbers for the years 2017, 2018, and 2019 and the mean were announced. Then, the relationship between monthly patient numbers and thermal comfort conditions was examined.

3.1. Thermal Comfort Conditions of Amasya City

The thermal comfort conditions of the city of Amasya were examined at 10-day intervals and monthly. In Amasya, “very cold” and “cold” stresses are experienced in the first 50 days and the last 30 days of the year. “Cool” stress is perceived from the 50th to the 90th day of the year and between the 310th and 330th days of the year, and the “slightly cool” stress is perceived from the 100th to the 120th and 300th days of the year. “Comfortable” conditions were determined between the 130th and 150th days of the year, and between the 280th and 300th days of the year, and “slightly warm” stress from the 160th to the 180th day of the year and between the 260th and 270th days of the year. It was determined that “warm” and “hot” stresses were effective from the 190th to the 250th day of the year [Figure 2].

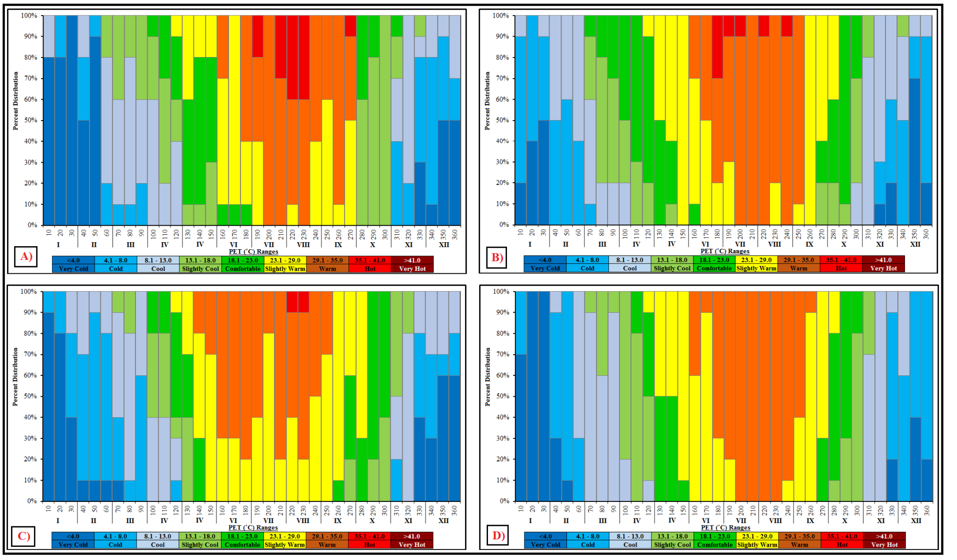

Figure 2. Distribution of 10-days Thermal Comfort Conditions (A: 2017, B: 2018, C: 2019, D: Mean)

According to the monthly averages, “cold” stress in December, “cool” stress in November, and “warm” stress in July and August were determined in all years and averages. “cold” stress in 2018 in January, “very cold” stress in other years and on average, “cool” stress in February in 2018, “cold” stress in other years and on average, “slightly cool” stress in 2018 in March, in other years and On average, “cool” stress is perceived. “Comfortable” conditions in 2018 in April, “slightly cool” stress in other years and on average, “comfortable” conditions in May 2017, “slightly warm” stress in other years and on average, “slightly warm” stress in June 2017. “slightly warm” stress, “warm” stress in other years and on average, “warm” stress in September in 2017, “slightly warm” stress in other years and on average, and “slightly cool” stress in October 2017, “comfortable” in other years and on average conditions were determined (Table 3).

Table 3. Distribution of Monthly Thermal Comfort Conditions

Years	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2017	0,6	4,4	11,4	15,5	21,5	27,3	32,7	33,0	29,2	16,1	8,7	5,4
2018	5,0	8,5	14,3	18,6	25,0	29,1	32,2	32,1	27,0	19,1	9,3	5,8
2019	1,5	6,9	9,3	15,6	24,4	30,6	30,8	30,3	25,0	20,7	9,6	5,2
Mean	2,4	6,6	11,7	16,6	23,6	29,2	31,2	31,8	27,1	18,6	9,2	5,5

PET (°C)	<4.0	4.1 – 8.0	8.1 – 13.0	13.1 – 18.0	18.1 – 23.0	23.1 – 29.0	29.1 – 35.0
Thermal Sensations	Very Cold	Cold	Cool	Slightly Cool	Comfortable	Slightly Warm	Warm

3.2. Respiratory Diseases in The City of Amasya

The average number of applications for respiratory diseases between 2017 and 2019, obtained from Amasya Provincial Health Directorate, was obtained. Due to the Covid 19 pandemic, data up to 2019 were examined in the study.

According to the monthly number of patients, the highest number of patient applications for respiratory diseases occurred between October and March, and the least number of patient applications were between June and September [Table 4]. This indicates the course of respiratory diseases throughout the year.

Table 4. Monthly Distribution of The Number of Patients Admitted to Respiratory Diseases in Amasya City

Yrs.	Jan.	Feb.	Mar.	**Apr.**	**May**	**Jun.**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Total**
2017	2.272	3.125	3.092	2.374	2.858	1.888	2.148	1.744	1.603	2.626	3.099	3.485	30.314
2018	3.137	3.928	3.867	2.821	1.668	1.759	1.320	1.334	1.372	1.883	3.428	3.115	29.632
2019	3.929	4.538	3.868	3.522	3.534	2.015	2.701	2.134	2.634	2.968	2.634	3.400	37.877
Mean	3.113	3.864	3.609	2.906	2.687	1.887	1.719	1.737	1.870	2.492	3.054	3.333	32.271

3.3. Determination The Relationship Between Thermal Comfort Conditions and Respiratory Diseases

Pearson correlation analysis was performed to determine the direction and strength of the relationship between thermal comfort conditions (PET) and respiratory diseases. According to the analyses made; in 2017, r= -.738 (p= 0.006), in 2018 r= -.880 (p= 0.000), in 2019 r= -.756 (p= 0.004) and on average r= -.886 (p= 0.000) has been identified. According to these findings, statistically high and very high correlations were found between thermal comfort conditions and respiratory diseases [Table 5].

Table 5. Correlation Analysis Results Between Respiratory Disesases and Thermal Comfort Conditions

Years			PET	Respiratory Diseases
2017	PET	Pearson Correlation	1	-,738**
		Sig. (2-tailed)		0,006
		N	12	12
	Respiratory Disesases	Pearson Correlation	-,738**	1
		Sig. (2-tailed)	0,006	
		N	12	12
2018	PET	Pearson Correlation	1	-,880**
		Sig. (2-tailed)		0,000
		N	12	12
	Respiratory Disesases	Pearson Correlation	-,880**	1
		Sig. (2-tailed)	0,000	
		N	12	12
2019	PET	Pearson Correlation	1	-,756**
		Sig. (2-tailed)		0,004
		N	12	12
	Respiratory Disesases	Pearson Correlation	-,756**	1
		Sig. (2-tailed)	0,004	
		N	12	12

Mean	PET	Pearson Correlation	1	-,886**
		Sig. (2-tailed)		0,000
		N	12	12
	Respiratory Diseases	Pearson Correlation	-,886**	1
		Sig. (2-tailed)	0,000	
		N	12	12
**. Correlation is significant at the 0.01 level (2-tailed).				

Regression analysis was performed to determine the effects of thermal comfort conditions on respiratory tract diseases. According to the analyzes made; it was found that thermal comfort conditions had a significant effect on respiratory diseases in all years (2017, 2018, 2019) and averages (F= 11,942; F= 34.411; F= 13,335; F= 36,554, respectively). Approximately 54.4% (approximately 16,490 patients) of total respiratory diseases in 2017, 77.5% (approximately 22,965 patients) in 2018, 57.1% (approximately 21,628 patients) in 2019 and % It is understood that 78.5 of them (approximately 25,333 patients) can be explained by thermal comfort conditions. According to the coefficients obtained as a result of the analysis; even if the thermal comfort conditions are ineffective, it was determined that 3.204 (p= 0.006) people in 2017, 4.116 (p= 0.000) in 2018, 4.107 (p= 0.004) in 2019 and 3.772 (p= 0.000) people according to the averages will apply to respiratory diseases. When an increase of 1 ˚C occurs in thermal comfort conditions (PET), respiratory diseases are -39.556 (p= 0.006) in 2017, -87.436 (p= 0.000) in 2018, -54.893 (p= 0.004) in 2019, and according to the averages - It is understood that there will be a decrease of 59,168 units (p= 0.000) [Table 6].

Table 6. Regression Analysis Results Between Respiratory Disesases and Thermal Comfort Conditions

2017	**Model Summary**						
	Model		R	R Square	Adjusted R Square	Std. Error of the Estimate	
	1		,738a	,544	,499	434,81064	
	a. Predictors: (Constant), PET						
	ANOVAa						
	Model		Sum of Squares	df	Mean Square	F	Sig.
	1	Regression	2257788,743	1	2257788,743	11,942	,006b
		Residual	1890602,924	10	189060,292		
		Total	4148391,667	11			
	a. Dependent Variable: Respiratory Disesases			b. Predictors: (Constant), PET			
	Coefficientsa						
	Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	1	(Constant)	B	Std. Error	Beta		
			3204,548	233,004		13,753	,000
		PET	-39,556	11,446	-,738	-3,456	,006
	a. Dependent Variable: Respiratory Disesases						
2018	**Model Summary**						
	Model		R	R Square	Adjusted R Square	Std. Error of the Estimate	
	1		,880a	,775	,752	504,22539	
	a. Predictors: (Constant), PET						

2018

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8748708,256	1	8748708,256	34,411	,000[b]
	Residual	2542432,411	10	254243,241		
	Total	11291140,67	11			

a. Dependent Variable: Respiratory Disesases b. Predictors: (Constant), PET

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4116,041	316,211		13,017	,000
	PET	-87,436	14,905	-,880	-5,866	,000

a. Dependent Variable: Respiratory Disesases

2019

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,7566[a]	,571	,529	527,15056

a. Predictors: (Constant), PET

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3705595,837	1	3705595,837	13,335	,004[b]
	Residual	2778877,080	10	277887,708		
	Total	6484472,917	11			

a. Dependent Variable: Respiratory Disesases b. Predictors: (Constant), PET

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4107,433	301,632		13,617	,000
	PET	-54,893	15,032	-,756	-3,652	,004

a. Dependent Variable: Respiratory Disesases

Mean

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,886[a]	,785	,764	348,43525

a. Predictors: (Constant), PET

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4437917,456	1	4437917,456	36,554	,000[b]
	Residual	1214071,211	10	121407,121		
	Total	5651988,667	11			

a. Dependent Variable: Respiratory Disesases b. Predictors: (Constant), PET

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	3772,496	201,433		18,728	,000
	PET	-59,168	9,786	-886	-6,046	,000

a. Dependent Variable: Respiratory Disesases

In the city of Amasya, a very high negative relationship between thermal comfort conditions and respiratory diseases, and statistically significant relationships between thermal comfort conditions on respiratory tract diseases were found. As PET values increase, the number of patients admitted to respiratory diseases decreases. The number of patients who applied to respiratory diseases in the months when the PET values were below 18 ˚C and the cold thermal comfort conditions was more than the other months.

4. CONCLUSION

According to the thermal comfort conditions obtained by using the PET index, cold thermal perceptions are experienced from November to March, and warm thermal conditions are experienced from June to September. The highest number of applications to health institutions for respiratory tract diseases occur between October and March.

The relationship between thermal comfort conditions and respiratory tract diseases was analyzed by statistical methods. As a result of the analyzes, statistically high and very high level of negative correlations (r= -,738, r= -,880, r= -,756, r= -,886, respectively) were found in 2017, 2018, and 2019 years and their averages. According to the regression analysis; it is understood that approximately 54.4% to 78.5% of total respiratory diseases can be explained by thermal comfort conditions. When an increase of 1 ˚C occurs in thermal comfort conditions (PET), it is understood that there will be a decrease of -39.556 (p= 0.006) and -87.436 (p= 0.000) units in respiratory tract diseases.

The study presents significant relationships that cold thermal comfort conditions increase hospital admissions for respiratory diseases in Turkey. Sensitive groups in the population, such as the elderly population aged 65 and over, the child population, and citizens with chronic diseases, are likely to be more affected by such conditions. These results can benefit decision-makers in protecting public health and preventive and preventive medicine studies. It can also be informative and guide for studies on climate change and human health.

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CLIMATE CHANGE AND ARTIFICIAL INTELLIGENCE

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ABSTRACT

Climate change is becoming a much more important concept every year in terms of all living things and the environment. The direct impact of climate change and the environmental impacts caused by these changes indirectly affect the quality of life of living things. Adapting to this change and determining the effects that the change will cause over time is very important in terms of preventing the negativities that may arise in the quality of life of living things. Artificial intelligence and machine learning can make an important contribution in this sense and is an important concept that has increased its importance in almost every field in recent years. With artificial intelligence-based analysis of climate and environmental changes, the risks that may arise from these changes can be evaluated more quantitatively in the early period and a risk map and a plan to combat these risks can be provided.

Keywords: Climate, Climate Change, Artificial Intelligence

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1. INTRODUCTION

Artificial intelligence is a learning model developed with the correct labeling of data. There are models that can be developed with or without supervision. With artificial intelligence, studies are carried out in areas such as health, transportation, economy, agriculture, etc. It is seen that a wide range of studies are carried out from artificial intelligence-supported agricultural machines to robot nurses around the world. In artificial intelligence's machine learning and deep learning studies, it is important to label the data correctly and to enter objective definitions. Entering as much data as possible is another parameter in the thumb of machine learning. In order to carry out artificial intelligence-based work, first of all, the parameters related to climate change should be determined. Climate and seasonal changes such as heat, wind, rain, daylight and environmental factors such as earth's water ratio, green space, regional agricultural area and vegetative diversity can be used in artificial intelligence-based studies as some of these parameters.

The relationship of these parameters with the life expectancy, quality of life and diseases of living beings can thus be better analyzed and the effect of these changes on the quality of life of living beings over time can be evaluated in advance. Climate change is increasingly affecting every aspect of human life. by 2100, global mortality rates due to heat exchange are projected to increase by 73 per hundred thousand[1].

In order to make these evaluations, a database should be created where all these parameters will be included and will create data for the artificial intelligence process. Thanks to this database, artificial intelligence can be trained and the risk relationship of regional and seasonal changes with diseases can be analyzed and financial resources can be allocated more effectively for the necessary infrastructure and treatment expenditures in terms of preventive health and the treatment process of diseases [2].

It is known that due to changes in daylight, there may be an increased risk of diseases such as Multiple Sclerosis, Psoriasis and depression, especially with vitamin D deficiency and vitamin D receptor polymorphism [3]. Studies showing that vitamin D deficiency is related to neonatal respiratory distress also show that climate change affects many age groups and many disease groups [4]. With the artificial intelligence analysis of climate change, a significant reduction in the negative impact of this change on the quality of life of living beings can be achieved both in the more livable environment and in parallel.

Again, depending on geographical differences, the risk of many autoimmune diseases such as diabetes and MS may increase. There is an increased risk of cancer and neurodegenerative diseases due to environmental factors, especially toxic substance exposure and dietary habits.

2. MATERIAL AND METHODS

Climate change can cause an increase in the risk of disease due to changes in all these and similar environmental factors or directly with its effect on living things. With the database to be developed and artificial intelligence learning, the increase in the risk of disease that may arise can be determined more objectively and this risk can be reduced with the measures to be taken.

The big data collected, processed, and used for weather forecasting results in extensive computational requirements. When the data is too complex to be understood directly, people often use some estimation techniques, presenting the data indirectly in multiple dimensions using tables or by visualizing the data. One of the most widely used data presentation methods in meteorology is visualization. The use of visual diagrams is valuable both in terms of artificial intelligence education and the creation of a language that people can understand more. The use of visualization also increases the availability of data. The data can be taught to the machine by supporting it with image processing. If we talk about the importance of greenhouse gas impact; GHG, which has an important place in climate change, should be included in the database as a parameter. Itprovides a systematic framework covering three categories to define the effects of M akine learning (ML) on greenhouse gas emissions; computational impacts, immediate effects of machine learning application, and system-level impacts. The evaluation of the combination of environmental factors and emission mechanism becomes important here [5].

Our studies and researches have shown us that it would be the right approach to support artificial intelligence studies in the field of health with treatment. In this context, the role of various parameters in climate change should be well determined and a database should be created first, and then the forecasting system should be developed.

2.1. Climate Database

The methods we plan to use in creating a database are as follows; is the creation of a database in order to collect and process the data planned to be used in a single center and to share it with the researchers in the later stages [6]. This database should be integrated into a desktop application interface and made available tousers. Authorized persons can enter new data into the system thanks to the desktop application as well as access the data previously entered into the system. With the determination of parameters, the interfaces of the desktop application have started to be created.

Thanks to the database planned to be created, authorized persons will be able to enter the data into the system on a daily basis. From these data, researchers will be able to access many data such as cities, climate types in cities, precipitation patterns, rainfall amounts. Future predictions can be made by using artificial intelligence to make analyzes about climate change. Within the scope of this project, it is planned to train artificial intelligence with the data collected over time in the data to be created and to obtain preliminary information about natural disasters that are likely to occur in the future. In this way, it will be possible to have prior information about the disasters that may arise due to climate change and to take measures for the consequences of these disasters[6, 7].

3. RESULT AND DISCUSSION

We are working on this Project. We have begun to work on preface of aplication.

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CLIMATE CHANGE AND NURSING

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ABSTRACT

Climate change refers to long-term changes in temperatures and weather patterns.Climate change, one of the most important global threats of the 21st century, is a serious public health problem.When the health problems that occur as a result of climate change are examined; diseases associated with heat and cold, side effects of ultraviolet radiation, health problems caused by air pollution, diseases related to food and water, changing infectious disease factors, and mental problems.The role of the nurse, who is in one-to-one communication with the society, is quite large in preventing these problems.The role of nurses in preventing climate change and the problems that may occur as a result, and in addressing health sequelae by using their professional roles is very important and nursing is a key role for health policy and advocacy in the 21st century.

Keywords: Climate Change, Climate Action, Global Warming, Climate and Nursing, Sustainable Development Goals

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INTRODUCTION

Climate change; It is a situation that causes an increase in air temperatures, frequent and severe weather events such as storms, floods, hail, rising sea levels, increased droughts, damage to forests by acid rain, migration of some animal species or extinction of some species [1]. When the problems brought by climate change are examined; It is seen that there are health problems related to temperature changes, water, health, food, air pollution and mental and mental health. Due to these situations, it is estimated that the death rate due to climate change in the world in 2000 was 150,000, and in 2040 this number will increase to 250,000 [2,3].

As climate change accelerates, the need to treat diseases caused by climate change continues to increase.It is very important for health institutions to act together to reduce the effects of climate change on both environmental and human health.In particular, the nursing profession, which is at the center of health service delivery, should take action by taking important steps to reduce its environmental impact, by fully understanding the science, taking into account the current health problems worldwide due to climate change [4-6].

In the rapidly changing world order, the consequences of both social change and climate change affect all humanity.Situations such as increased consumption due to population growth and technological developments, increase in the amount of waste, and unplanned urbanization have triggered the deterioration of the natural balance and accelerated global climate change [5,7].Climate change causes the burning of fossil fuels, industrial processes, nitrogen fertilizers, reduction of forests, the release of increasing amounts of carbon dioxide and other greenhouse gases, and causes global climate change with further warming of the atmosphere [8,9].Climate change is not just a temperature change issue. Climate change also affects other systems and brings with it some serious problems.The consequences of climate change include intense droughts, water shortages, severe fires, rising sea levels, flooding, melting polar ice, devastating storms and diminishing biodiversity [10].Hot air, increased levels of polluted ozone are associated with respiratory diseases and cardiovascular disease and death [11].In addition, due to climate change, hygiene, clean water and sanitation have started to decrease, and many infectious diseases such as childhood diarrhea have begun to emerge [12].Events such as extreme temperatures, forest fires and floods affect vulnerable groups such as infants, children, the elderly, those with chronic diseases, and immigrants more.Problems such as lack of water and food as a result of disasters, and interruption of health services due to migration can also cause health problems [13].

According to the Centers for Disease Control and Prevention, it is estimated that there will be 1,000 to 4,300 premature deaths per year by 2050 due to bad weather from climate change[14]. Climate change is identified as the greatest global health threat of the 21st century.Significant developments and changes are experienced with globalization, space age technology and the Covid 19 pandemic [15].The Covid 19 pandemic, which caused the death of many people, shows that the whole world is completely unprepared for such epidemics.On the other hand, when possible consequences such as forced migration, lack of access to clean water, infectious diseases and natural disasters in climate change are added, it is estimated that the picture that will emerge will be even more frightening [15].As with the pandemic, climate change is disproportionately affecting the world's most vulnerable populations [5].Inequalities, which remain a persistent concern for public health everywhere, it comes to the fore even more due to the unequal distribution of environmental hazards and risks.At this point, nurses, who are the closest professional group to the individual and the society, and who are the defenders of the disadvantaged groups, have important duties in determining the health needs of the society and taking action [16,17] .While nurses are at the forefront of efforts to improve all climate-related health effects, they have an important role in reducing the vulnerability of the society to the negative effects of future climate change and in coping with the expected health problems of the climate [18,5].Nurses, as individuals, are members of the professional profession.Nurses have different roles as members of a multidisciplinary team.Nurses are shown as a leading voice to achieve the global health goal, as outlined in the International Nurses Day 2020 theme [19].At this point, nurses have an important opportunity to be effective in health care policies and decision-making by taking part in sustainable development goals, which include global health goals, which aim for all people to live in prosperity [20].

Sustainable development goals; It is a universal call to action to take action and build a better world while meeting the needs of the present without compromising the needs and possibilities of future generations. To ensure that people live in prosperity, 17 global goals have been determined to be achieved by 2030.Nurses, who make up the majority of the health workforce, are in a unique position to achieve all goals, particularly inequalities in health care, to help everyone achieve the goal of better health [21, 22].Nurses' participation at all levels is essential for the success of sustainable development goals, not only in terms of health, but also in research and educational practices, teamwork, leadership, advocating for human rights, promoting policy change and environmental management.In addition, nurses have the opportunity to set an example for both individuals and society by fulfilling their responsibility to practice a sustainable lifestyle as a citizen [23].

The thirteenth of sustainable development goals, which cover issues such as end poverty, end hunger, health and quality life, gender inequality, responsible production and consumption, has been determined as "immediate action to combat climate change. Strengthening resilience and adaptation capacity against climate-related hazards and natural disasters in all countries, integrating measures related to climate change into national policies and strategies, reducing climate change and its impact, Developing knowledge, capacity and awareness to combat climate change constitutes the sub-goals of climate action [22].

Environment, society and economy are the three pillars of sustainable development. Climate change has ceased to be an environmental issue and has been reflected in economic and social targets in the new agenda. Combating climate change has begun to be seen as a prerequisite for achieving many goals [24].Food, water, sanitation and shelter are basic needs for human survival, but due to climate change, these requirements are difficult to achieve for low-income societies.Climate change, reduced agricultural production, increasing malnutrition and lack of public health services in developing countries,It constitutes an obstacle to achieving sustainable development goals such as ending poverty, ending hunger, health and quality life, and reducing inequalities, which are planned to be achieved by 2030. This highlights the need to make the climate action plan a more central element. Urgent action is needed to build a sustainable world for all by tackling climate change caused by human activities that threaten the future of humans and the Earth [16, 25].In this context, the aim of this review is to address the concept of climate change, which threatens the future of the world and people, with a nursing approach.Thus, it is aimed to raise awareness about climate change and its effects and to take action.

EFFECTS OF CLIMATE CHANGE ON HUMAN HEALTH AND NURSING

Climate change is a major threat to human health throughout the life cycle [13].It is possible to classify the effects of climate on human health as direct effects and indirect effects. The direct impacts relate to extreme weather conditions, particularly the increased frequency and severity of heatwaves, droughts, storms, floods and rising sea levels that pose a threat to coastal cities and island nations [3, 26].Indirect effects; vector-borne diseases, epidemics, food and water-borne diseases, mental illnesses.For example, increased temperatures are known to cause heatstroke, heat stress, and death, especially in those with pre-existing health conditions, as well as an increase in cardiovascular, respiratory, and kidney-related diseases. Floods and storms can cause traumatic injuries, drowning, and the spread of vector-borne and water-borne infectious diseases.Ecosystem-mediated impacts of climate change include a wider distribution and increased burden of vector-borne and water-borne infectious diseases, as well as sequelae related to bad weather and allergic disease [3, 13, 26].In short, the consequences of climate change; temperature fluctuations, increased precipitation and flooding, increased drought and water scarcity, increased ozone and bad hava mass, increased infectious diseases and increased psychiatric diseases.

Temperature fluctuations;As a result of changes in the atmosphere, the number of hot days increases and the duration of the air temperature during the day is also prolonged. Due to excessive heat, the mortality rate has started to increase especially in individuals with chronic diseases and in the elderly.In addition, if the human body cannot tolerate sudden temperature changes, illness or death may ocur [27].In another situation, as global warming increases, the poles and glacial lakes will turn into land due to melting, which will prevent the reflection of sunlight and cause more warming.In other words, glaciers act as air conditioners and prevent the world from overheating [28].Decreased precipitation and increasing temperatures increase soil erosion. Soil dust particles cause the transport of microbial agents such as bacteria, fungi and viruses, causing deterioration in health [29]. Heat waves cause high temperature health problems during the day.Regardless of the climate zone, heat stress, heat stroke and dehydration symptoms are more common.Especially due to the increase in the number of aging population, it is predicted that summer heat waves will increase the death rate in the coming years [30].

Increased precipitation and flooding;As the amount of water vapor in the atmosphere increases, it causes more intense snowfall, more intense rain events and increased flood events in some regions.During flood events, water networks are damaged, sewer overflows occur, human and animal wastes mix with drinking water, causing pollution of drinking water.As a result, epidemics and infectious diseases occur [31].On the other hand, devastating floods caused by heavy rains carry a significant amount of harmful factors such as heavy metals, plastic debris and pesticides into the water.If these waters come into contact with the skin, they cause skin diseases, and drinking these waters causes gastrointestinal diseases.In addition, these waters cause pollution of agricultural areas and transfer of heavy metals to plants grown in this area.As a result, chemical pollution has many negative effects on health and causes food shortages [32].As excessive precipitation tends to trigger natural hazards such as floods and landslides, it leads to serious disasters that cause massive infrastructure damage and human and economic losses [33].

Increasing drought and water scarcity; Changes in the amount of water in the world are predicted to cause water scarcity and drought. As climate change continues to reduce water resources in water-stressed regions of the world, people meet their basic needs from unhealthy water sources.This causes an increase in water-borne diseases.Increasing drought also reduces agricultural productivity and jeopardizes food security in many parts of the world.It also shows that increasing temperatures and increasing water scarcity will also affect agriculture and this situation will face famine [34].On the other hand, it seems likely that childhood diarrheal diseases, which are an important public health problem, will increase due to the problems of hand washing, sanitation and access to adequate safe water [12].

Increased ozone and bad air mass; The rise in global temperatures increases ground-level ozone formation.Considering the negative health effects of ozone exposure; It is known that it causes decrease in lung functions and lung tissue damage, increased risk of asthma attack and exacerbation of other lung diseases, also affects the cardiovascular system and may increase the risk of heart arrhythmia.The depletion of the ozone layer in the upper atmosphere can lead to an increase in skin cancer and cataracts [35].

Increasing infectious diseases; The spread of communicable diseases is one of the most important issues affecting the health consequences of climate change worldwide.For example; Mosquitoes, which can carry malaria and other diseases, are very sensitive to temperature changes.Higher temperatures increase mosquito breeding and bite rates, extend their breeding season, and shorten the time it takes for the malaria pathogen to become contagious. Rising temperatures could extend mosquitoes' viability to higher altitudes and more northern latitudes, putting populations that were not previously exposed to mosquitoes at risk.Rising temperatures, as well as changes in precipitation, can worsen the spread of infectious diseases such as malaria.Considering the effect of climate change on glaciers, which is another dimension; Cold-adapted microorganisms live in frozen water bodies in glaciers.Given the clear link between ocean temperature and the composition of microorganisms, climate change will affect the structure and dynamics of the microbial community.Thanks to their versatile metabolism, microorganisms control most of their nutrient flows, particularly the six main building blocks of life (hydrogen, carbon, nitrogen, sulfur, oxygen and phosphorus), thereby shaping ocean biogeochemistry [36].Global warming, along with the thawing of frozen soils, will result in new diseases due to viruses that have been frozen for many years.For example; Experts think that the cause of the death of many reindeer and the transmission of the disease to people in the anthrax epidemic in Siberia in 2016 is the frozen soils.Therefore, many viruses and greenhouse gases will be released from the melting of frozen glaciers and large water bodies and tt is predicted that this will cause unprecedented epidemics for world health [37].

Increasing psychiatric diseases; Climate change causes psychological problems as well as many physical problems.Disasters due to climate change can also cause psychological problems such as stress, depression, trauma, shock, sleep and eating disorders due to injuries, deaths, and financial losses [3,38]. In addition, climate change jeopardizes many social determinants of health, such as livelihoods, equity and access to health services and social support structures. These climate-sensitive health risks are disproportionately felt by the most vulnerable and disadvantaged, including women, children, ethnic minorities, poor communities, migrants, the elderly and people with chronic illnesses [39].

EFFECTS OF CLIMATE CHANGE ON VULNERABLE GROUPS

Vulnerability to health risks associated with climate change relates to the social determinants of health (the social, political, cultural and economic conditions in which a person lives). Populations that fall into disadvantaged groups and face discrimination have limited resources and fewer opportunities for health-promoting behaviors and general well-being, especially in our climate-changing world. Populations living in areas with poor infrastructure, less access to health services, and sub-optimal living conditions are the most vulnerable. However, vulnerability exists in resource-rich countries where vulnerable populations cannot access high-quality universal health care. In climate-related events such as hurricanes and forest fires, the degree of health and well-being of individuals, communities or population groups living under these conditions and that will be adversely affected increases significantly. This is primarily related to the lack of vital resources and infrastructure that impedes or reduces adaptive capacity. Therefore, those living in poorer areas are most susceptible to health effects [3,40].

Nurses, who take part in every step of health services, have great responsibilities in order to reduce the effects of climate change on both environmental and public health. Nurses must take action to reduce the environmental impact of climate change [5]. However, in order for nurses to be sufficient in this regard, it is necessary to strengthen the content and issues related to climate change in nursing education. At this point, the nursing education curriculum needs to be improved.

CLIMATE CHANGE EDUCATION IN NURSING NURSING EDUCATION

Nursing profession; It is a profession that covers the concepts of human, health and environment. The importance of the concept of environment has been emphasized since the first periods of the nursing profession.First of all, Florence Nightingale explained the effects of environmental factors on health and especially focused on the physical environment. From this point of view, it is very important to train nurses who have knowledge about environmental health and the factors affecting environmental health and who can use all their roles[41].Nurses have important roles and responsibilities in reducing the negative effects of climate change on human health. At this point, the American Nurses Association (ANA) has determined the nursing competencies that reflect the professional role of nurses in climate change [42]. ANA, argues that the integration of climate change-related content into nursing education is essential for nurses to be prepared to face this public health crisis [43]. Nurses trained in climate health play an important role in recognizing areas to mitigate the negative effects of climate change, supporting climate adaptation, and working interdisciplinary to foster resilient populations and communities. Therefore, it is important for nurse educators to include climate science and climate change-related nursing interventions in the nursing curriculum. Nurses can consider this in three tages when evaluating the effects of climate change on human health.Climate change and health can be evaluated as introducing nursing students to climate terminology and interdisciplinary work [44]. It is clear that the environment plays an important role in human health, and nurses appear to be the best suited to raise awareness of environmental risks, educate the public, and address environmental health issuesand therefore nurse educators are beginning to realize the need to focus on environmental health education in nursing [45]. For example; In the United States, many nursing schools have continued to work on integrating environmental health content into existing courses, courses, and certificate programs for many years. For example, Richardson et al. (2014) while working on incorporating climate change and resource scarcity issues into the nursing clinical skills session, Leffers et al. (2017) identified strategies for integrating climate change content into existing nursing courses, Walpole et al. (2019) conducted studies on integrating planetary health into clinical education. Many examples in the literature illustrate the efforts of nurse educators to add environmental health content to nursing courses [43, 46, 47]. In order to develop a climate-health-responsive nursing workforce, it seems necessary to incorporate climate change into the nursing curriculum, the entire study program of students, including the nursing skills laboratory and clinical experiences.When the education programs in nursing schools in Turkey are examined, it is seen that information about climate change is included in the units of certain courses, including the "Public Health Nursing" course. In some schools, it is seen that courses such as "Environmental Health Nursing" and "Healthy Environmental Order and Aesthetics" are included in undergraduate and graduate education [48].It is seen that in some schools, lessons related to climate change are given under different names (Disaster Nursing, Disaster Culture, Basic Disaster Knowledge, Nursing in Disasters, Nursing in Disasters and First Aid, etc.), and there is no standardization.The content of these courses includes topics such as the importance of disaster, types of disasters, measures to be taken against disasters, disaster management, and the effects of disasters on public health [49]. In recent years, more climate change has begun to be integrated into the nursing curriculum.For example; The course titled "Climate Change and Health" is given as an elective course in the nursing department of the Faculty of Health Sciences of Üsküdar University [50]."Climate Change and Its Effects" is given as an elective course at Turgut Özal University, Faculty of Health Sciences, Department of Nursing [51].In the content of the course titled "Environmental Health Nursing" in Ege University Nursing Department, climate change and health are covered [52].In order to develop a climate-sensitive nursing workforce, it is very important to integrate climate change-related topics into the nursing curriculum and nursing skills.

THE ROLE OF THE NURSE IN CLIMATE CHANGE

According to the World Health Organization (WHO); Between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year from malnutrition, malaria, diarrhea and heat stress alone and direct costs of harm to health are estimated to be between US$2-4 billion per year by 2030 [39]. It is very important for nurses and other healthcare professionals to understand the link between environmental events as a result of climate change and their impact on health outcomes. Because it is very important to plan preventive and therapeutic services as a result of unhealthy health as a result of climate change. The Canadian Nurses Association (CNA) has published a status paper highlighting the serious consequences of climate change for individuals, families and communities and called for nurses to support climate change adaptation and mitigation through nursing practice, research, management, education and policy [53]. The Alliance of Nurses for Healthy Environments as a nursing organization and the National Nursing Collaboration on Climate Change, which brings together the leadership of key nursing organizations for a climate and health agenda, are examples of leadership mobilizing climate action among nurses [40].

Ethical responsibility of nurses is quite high in the realization of sustainable goals, the protection and development of health. Therefore, it becomes even more important for nurses to be sensitive to climate change [54]. In addition, the International Nursing Council

(ICN) drew attention to the issue by stating that nurses should be aware of how climate change affects human health and should support actions that try to reduce the effects of climate change on health.In a study conducted in the United States, nurses stated that their profession has a responsibility to address the health effects of climate change [55]. Watts and colleagues (2017) argued that health professionals have a responsibility to communicate the specific threats climate change poses to human health and well-being to both policy makers and the public.The public recognizes nurses as trusted experts who are committed to evidence-based practice and advocate for change [56]. Nursing as a profession, according to the CNA is prepared to successfully respond to the health impacts of climate change because of their expertise and scientific knowledge bases in policy and advocacy, health promotion, and behavior change [53]. The nursing profession is seen globally as having a significant commitment to optimal health outcomes for patients, families, communities and populations. To this end, nurses can be influential in many areas, including direct care, policy and advocacy, education and research. In addition, due to their specific focus on population health and the impact of social determinants on health, the community and nurses have the expertise to respond to climate-related disasters and address climate-related direct and indirect health impacts. Therefore, it is in a proactive position to support climate change adaptation, mitigation and resilience. At this point, nurses play an important role in addressing the health effects of climate change that threatens public health and individuals at risk who are disadvantaged against the health effects caused by climate change [57]. Nurses showed a multidisciplinary approach brought about by climate change; to balance temperatures by reducing carbon emissions, to increase the knowledge of individuals about the risks of extreme heat, to raise public awareness, to take action against the events that occur as a result of climate change, to vaccinate individuals at risk of a disease that may arise from contaminated flood waters, to create appropriate health systems to cope with adverse health consequences, can take part in primary, secondary and tertiary prevention strategies such as supportive counseling to disaster survivors. They can also take part in important tasks such as supporting the development and implementation of programs and policies to prevent adverse health outcomes and improve physical and social environments [57, 58]. Environmental risk factors arising from climate change, vulnerability of the population living in that region, surveillance of climate-sensitive diseases, analysis of risks and current problems, informing, educating and empowering the public about climate change, mobilizing partnerships to anticipate and respond to health threats from climate change and contributing to the development of health policies that support climate change mitigation and adaptation [59]. Together with the authorities, nurses play a key role in first identifying the most vulnerable geographic areas, then monitoring the anticipated health threats to the population in that region, and adjusting emergency preparedness and response plans [5]. In particular, nurses working in health institutions provide direct guidance to patients from posters and educational materials in waiting rooms. Studies have shown the need for educating patients through a variety of media, from email and phone alerts advising patients and their families on how best to deal with extreme heat or weather extremes [60].

CONCLUSION AND RECOMMENDATIONS

Climate change is one of the current issues that have seriously affected human health in recent years. In this context, WHO supports national progress in creating climate-resilient health systems and protecting health from climate change. Improvement of health can be achieved by reducing greenhouse gas emissions, especially by reducing air pollution, through better transportation, food and energy use options. At this point, health workers and nurses who take part in every stage of health services play an important role. Nurses must be competent practitioners, advocates and change agents to protect and improve public health in the face of climate threats. Addressing political, social, cultural, economic and environmental relationships is crucial for human health and the health of the planet. Nurses should work on this issue with a multidisciplinary approach and raise awareness. Nurses working on geriatrics and school health, especially in preventive services, have important roles and responsibilities in raising social awareness about climate change and its effects on human health. Nurses should make an effort to minimize the effects of climate change on human health by reflecting their work on their fields of practice. However, nursing students should be taught to view climate change more broadly and to see climate health impacts within their professional practice roles nationally and in society. It is conceivable that our changing climate will foster a nursing workforce prepared for future health outcomes. In this regard, in particular, the integration of climate change into nursing education is essential for incorporating knowledge, skills and insights critical for clinical practice in our climate-changing world into curricula, practice, research and policy.

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THE ROLE OF CELL DEATH IN PYRETHROID TOXICITY

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ABSTRACT

Pyrethroid pesticides are widely used in plant, public and animal health. When applied, these chemicals become a threat to human health by entering the food chain by accumulating in plant parts, water, soil, air and biota. They also enter groundwater, streams, rivers, and lakes, causing damage to non-target species and ecosystems. Residue studies in biological samples such as blood, urine and adipose tissue show that living beings are exposed to pyrethroids in various ways. The toxic effects of pyrethroid insecticides have been demonstrated primarily in organs such as the liver and kidney, which are responsible for detoxification and elimination, and also on the cardiovascular, urinary, reproductive, immune and nervous systems. In vitro and in vivo studies highlight the importance of cell death among the mechanisms mediating the toxicity of pyrethroids. Cell death can occur in three different ways: necrosis, apoptosis and autophagy. Necrosis is defined as the local death of tissues and cells. Molecules called caspases are involved in apoptotic cell death. There are two different pathways, extrinsic and intrinsic, in the formation of apoptosis, which is also known as programmed cell death. Autophagy is a process that occurs when various components are transported to lysosomes in the cell cytoplasm and degraded. The degradation products are reused through recycling and play an important role in cell survival and protection. Mechanistic studies on the effects of long-term low-dose exposure to pyrethroids on non-target organisms play an important role in risk assessment. Therefore, investigation of cell death mechanisms at the molecular level and evaluation of results in toxication caused by pyrethroid exposure are important for public and animal health.

Keywords: Pyrethroid, Cell Death, Apoptosis, Autophagy

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1. PYRETHROID TOXICITY

Pyrethroids, a synthetic organic insecticide from the pyrethrin group, are among the most commonly used insecticides worldwide. Synthetic pyrethroids are used in different formulations against many ectoparasites in pets and large animals. They target various pests in agricultural areas such as cereals, nuts, and vegetables. It plays an important role in mosquito control in terms of public health[1, 2]. Pyrethroids act by disrupting the function of sodium ion channels. [3]. Its toxic effect varies according to the type of pyrethroid isomers. Generally, they delay the inactivation of voltage-sensitive sodium channels. As a result of being open for a long time, the membrane potential is depolarized. Also, pyrethroids may act via voltage-dependent chloride channels and γ-aminobutyric acid (GABA)-gated chloride channels in the brain, nerves, muscle tissue and salivary gland [1, 4]. Pyrethroid pesticides were detected at high levels in sediment samples [5]. Pesticide residues can be found in both the environment and the human body. They circulate in the environment in different phases, such as solid, liquid and gas. Then it enters the food chain and threatens human health [6]. In 2018, 4.15 million tons of pesticides were consumed worldwide in agriculture. In Asia, half of this amount was used [7]. About one-third of the insecticides used worldwide consist of pyrethroids [8].

Acute or chronic toxicity may appear due to pesticide exposure. Acute toxicity usually occurs by skin contact, inhalation or ingestion. In this type of toxicity, compounds are accidentally or intentionally ingested. Occupational exposure is also present in acute and chronic toxicity [9]. Exposure as an occupational accident is encountered during pesticide application, especially in people occupied with plant protection and farming. For these people, dermal exposure due to splashes and spills during pesticide application is one of the most common and effective ways [10]. Toxicity is also shaped by consuming contaminated food and inhalation in the human population.Studies have obtained results on pesticide residues in many foods. In residue studies, many different pyrethroid residues were found in foods such as milk [11], chicken [12], fish [13], soybean [14], tea, cucumber, apple [15] and mango [16, 17].

Acute pyrethroid toxicity can cause serious symptoms such as seizures, coma, pulmonary edema and bleeding [18]. Long-term low-dose pyrethroid exposure plays a role in the development of chronic diseases. In mammals, it can have toxic effects on different systems such as immune [19], nervous [20] and cardiovascular [21]. Adverse effects on the male reproductive system due to pyrethroid exposure have also been observed by Koureas et al [22]. Subcutaneous deltamethrin exposurehas been shown to cause dose and time-dependent toxicity in the gonads and prevent spermatogenesis in rats [23]. Metabolites of pyrethroids have also been detected in the urine of children. Accordingly, it has been reported that pyrethroid exposure may be a risk factor in the occurrence of diseases such as coronary heart disease, acute lymphocytic leukaemia and brain tumors in children[24-26].

2. CELL DEATH

Cell death can occur in three ways: apoptosis, necrosis, and autophagy. Apoptosis is defined as programmed cell death. It occurs physiologically during development and morphogenesis, as well as in pathological conditions such as cell damage and stress. Apoptosis can occur in two different ways, extrinsic and intrinsic. Cell surface receptors such as Fas, TNF alpha and TRAIL are comprised in the extrinsic pathway, while mitochondrial signalling is involved in the intrinsic pathway [27, 28]. Activation of cysteine aspartyl proteases, called caspases, plays a central role in accruing apoptotic cell death [29].

In the extrinsic pathway, some molecular changes occur in the cell cytoplasm with the binding of death ligands to death receptors such as the FasL/FasR and TNF-α/TNFR1 models on the cell plasma membrane. Binding leads to the formation of a death-inducing signalling complex (DISC), resulting in the activation of procaspase-8 to caspase 8 [30]. Caspase cascade activation begins with the death domain, formed by the participation and activation of many molecules. Caspases are classified into 3 groups as initiators (caspase-2,-8,-9,-10), effectors (caspase-3,-6,-7) and inflammatory caspases (caspase-1,-4,-5) [31, 32].

Radiation, toxins, hypoxia, hyperthermia, viral infections and free radicals could stimulate the intrinsic pathway. It causes changes to the mitochondrial permeability transition (MPT) pore [33]. Thus, pro-apoptotic proteins are released from the intermembrane space into the cytosol, and then an apoptosome is formed with the activation of Cytochrome c, procaspase-9 and Apaf-1 triad [34, 35]. Subsequently, caspase-9 and caspase-3 activation occur, respectively. The result of both the extrinsic and intrinsic pathways results in caspase-3 activation. Depending on the activation, some changes such as cytoplasmic condensation, and nuclear fragmentation occur, and as a result, apoptotic bodies are formed [36].

Necrosis is an uncontrolled form of cell death. Various proinflammatory proteins and compounds, such as nuclear factor-κB, are involved in the necrosis process. The cell is damaged due to the rupture of the cell membrane. The presence of energy source ATP on the way to cell death can guide the choice of apoptosis or necrosis. While apoptosis can occur at high ATP levels, it cannot at low ATP levels, and the cell goes into necrosis. In cases such as radiation, heat, chemicals and hypoxia, the cell is severely damaged and goes into necrosis[37].

Autophagy is a process that acts as a recycling mechanism. In brief, unnecessary or damaged cellular components and pathogens are surrounded by a membrane, transported to lysosomes, and degraded. Beclin-1, part of the class III PI3K enzyme complex, is responsible for participating in the formation of the autophagosome structure. LC3 is recognized as an indicator of autophagy. LC3-I is the cytosolic form, when this structure is conjugated with phosphatidylethanolamine is called LC3-II. It is found in both the outer and inner membrane of the autophagosome [38-40]. The ubiquitin-related protein p62 is an autophagy adapter protein which is involved in autophagic flow by binding to LC3 [41].

3. CELL DEATH MECHANISMS OF PYRETHROID TOXICITY

The toxicity mechanisms of many compounds in the pyrethroid group in different organs or systems concerning cell death are well documented in the literature. Since the kidneys are the organ that performs the filtering process, they are exposed to many chemicals and metabolites. In the renal tissue of rats, different doses of permethrin induced apoptosis and necrosis were observed. The study results suggest that caspase-9 and mitochondria-associated apoptotic cell death may play a role in permethrin-induced nephrotoxicity. In addition, the presence of necrotic cells histopathologically indicates that necrosis occurs as well as apoptosis [42].

Deltamethrin-induced cell death has been studied in a variety of cell types, including thymocytes [43], hippocampus and cerebral cortex [44], glioblastoma cells [45] and testicular tissue [46]. Different pathways are involved in the induction of cell death by deltamethrinAmong these pathways are the Ca signalling pathway, Ca dependent phospholipase C activity, Ca dependent ER stress, oxidative stress, and the p53 signal [47]. Deltamethrin has an inhibitory effect on the mitochondrial complex and causes disruptions in transport mechanisms. Thus, it causes changes in membrane permeability and mitochondrial enzyme activities[48]. Deltamethrin has been reported to cause apoptosis with increased p53 and Bax levels and decreased Bcl-2 levels in cerebral cortical neurons [49]. In an in vivo study, many apoptotic cells appeared in the hippocampus and cortex of the rat brain due to deltamethrin toxicity [50].According to previous reports, apoptosis plays an important role in the neurotoxicity of deltamethrin.

Cyfluthrin is another commonly used pyrethroid insecticide. It was determined by an immunohistochemical method that Cyfluthrin caused apoptosis through Bcl-2, caspase-9 and caspase-3 signalling. TUNEL staining showed positive cells in the cerebellum and substantia nigra [51]. Flumethrin has shown a neurotoxic effect on SH-SY5Y neuroblastoma cells. Flumethrin has increased the expression of apoptosis associated genes such as Bax, caspase-3, BNIP3, APAF1, and AKT1 on SH-SY5Y neuroblastoma cells. Also, it has increased oxidative stress and antioxidative mediators (SOD2 and NFkB) [52].

The liver is the main detoxification organ for xenobiotics and their metabolites. Due to its high rate of oxidative metabolism and role in detoxification, it is vulnerable to the harmful effects of toxic substances, such as pesticides [53]. Permethrin has a dose and time-dependent hepatotoxic effect on hepatocellular carcinoma cell line (HepG2) was revealed. The increase in SOD1 levels due to the formation of oxidative stress proves the role of oxidative stress in hepatotoxicity in the study [54].

3-Phenoxybenzoic acid (3-PBA) is a common metabolite of many synthetic pyrethroids. The toxic effect of this metabolite on the liver was determined on HepG2 cells. It was observed that the level of caspase-3 was increased, and the level of antiapoptotic protein Bcl-2 was minimal on 3-PBA exposed cells. It was concluded that caspase-3 and Bcl-2 proteins play a role in the molecular mechanism of apoptotic cell death [55].

Some studies have exhibited a relationship between pesticide-induced toxicity and the autophagy mechanism. Pesticides can damage immune system cells, as with many organs and systems. The effect of β-cypermethrin on murine macrophages was investigated in a previous study. Autophagy has been shown to play a protective role in β-CYP-induced mitochondrial toxicity in macrophages via oxidative stress reduction [56].

Neurotoxicity due to fenvalerate (FEN) exposure has been investigated in zebrafish and PC12 cells. Autophagy was determined in zebrafish embryos and PC12 cells by western blot method. Conversion of LC3-I to LC3-II increased while p62 levels decreased [57]. Deltamethrin has induced autophagy through autophagosome accumulation and inhibition of proteasomal enzyme activity on mouse neuroblastoma Neuro-2a cells [58].

4. CONCLUSION

Pyrethroid insecticidesand their residues enter the food chain and pose a potential risk to public health. Many in vivo and in vitro studies show that chronic exposure to these compounds has an adverse effect on organs and systems. It is important to investigate cell death due to the damage caused by these chemicals in the kidney, liver, nervous system and reproductive system. According to literature data, apoptosis, necrosis, and autophagy are processes that play a role in pyrethroid toxicity. Considering the potential threat to health on the subject, various precautions should be taken to protect populations with high-risk groups, especially the elderly, pregnant woman and children. When preparing, applying and disposing of pesticides, the information on the package insert must be strictly followed. In particular, empty containers should be kept away from water sources. During storage and transportation, contact with food should be prevented. Consideration should be given to the use of protective equipment to minimize occupational exposure. Furthermore, for a sustainable environment, the use of these chemicals should be reduced. As a precaution, integrated pest management and the application of alternative methods can be expanded. Among the alternative biological options, biological control, biopesticides, semiochemicals, and transgenic products can be used.

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CHAPTER 7

Climate Change and Hemp

PHARMACOLOGY AND TOXICOLOGY OF CANNABIS

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ABSTRACT

Cannabis (Cannabis sativa), with origins dating back to antiquity, has been used for thousands of years worldwide for various purposes, such as clothing, construction, textiles, paper, and medicine. Today, cannabis, mostly used for its therapeutic properties, although it is known as one of the most abused plants. The plant contains many cannabinoids, especially delta-9-tetrahydrocannabinol (delta-9-THC) and cannabidiol (CBD). In recent years, characterization of cannabinoid receptors and exploring the role of second-messenger systems at the cellular level have considerably aided in understanding the mechanism of cannabinoids' action. Cannabinoids exert pharmacological effects by binding to the cannabinoid receptor subtypes CB_1 and CB_2. These receptors, along with endogenous cannabinoids and the association, oxidation, reduction, and cleavage reactions of these cannabinoids, are referred to as the endocannabinoid system. Toxic effects associated with cannabis are divided into acute and chronic toxicity. Acute toxicity studies in animals usually focus on THC, the main psychoactive component of cannabis. On the other hand, chronic toxicity studies draw attention to the effects on various animal tissues and systems due to long-term exposure to this compound. These effects include respiratory and pulmonary lesions, neurotoxicity, tolerance, addiction problems, immune and endocrine disorders. Cannabinoids are used to treat many diseases and symptoms. Cannabinoids play an essential role in the symptomatic treatment of nausea, pain, insomnia, post-traumatic stress disorder, anxiety, anorexia, Tourette syndrome, and epilepsy. Although cannabis has been banned in many countries for many years, the cannabis value is increasing every day. Cannabis is being legalized to treat various diseases that affect human and animal health. This paper presents the history, chemical content, pharmacokinetics/pharmacodynamics, and toxicology assessment of cannabis.

Keywords: Cannabinoids, Cannabidiol (CBD), Tetrahydrocannabinol (THC), Endogenous Cannabinoids, Cannabinoid Receptors.

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1. INTRODUCTION

Cannabis, whose medicinal use dates back thousands of years, is one of the world's most widely used plants for various purposes [1]. Cannabis was first described as a medicinal plant by Carl Linnaeus as *Cannabis sativa* L. in 1753. Later, Jean-Baptiste Lamarck discovered *Cannabis indica* in 1785, and Janischevsky discovered *Cannabis ruderalis* in 1924 [2]. Cannabis contains many cannabinoids, especially delta-9-tetrahydrocannabinol (delta-9-THC) and cannabidiol (CBD) [3]. The studies on cannabis conducted so far have mainly focused on THC and CBD [4, 5]. Cannabinoids exert pharmacological effects by binding to the cannabinoid receptor subtypes CB_1 and CB_2. CB_1 is mainly located in the central nervous system, while CB_2 is located in peripheral tissues [6]. These receptors, endocannabinoids, and reactions of association, oxidation, reduction, and cleavage of these cannabinoids are termed the endocannabinoid system [4, 7]. Many studies aimed at understanding the mechanism of action of cannabinoids have focused on the pharmacokinetic and pharmacodynamic profile of these compounds in humans. Cannabinoids trigger complex behavioral processes via cannabinoid receptors and other neurochemical systems. The selective efficacy of the synthetic cannabinoid derivatives available on the drug market is relatively low. Since these drugs have many side effects, their therapeutic use is limited. CBD does not produce typical cannabimimetic behavioral effects. Therefore, it is assumed that CBD is irresponsible for the psychotropic effects of cannabis. Many studies in this field draw attention to the therapeutic effects of CBD. These studies have produced data on the mechanism of action and therapeutic potential of CBD. In addition, these studies focus on the molecular mechanism of CBD's therapeutic effect and its analgesic [3] and anti-inflammatorypotential [4, 8]. It has been reported that abuse of the cannabis plant can lead to dependence, behavioural and psychotic disorders. Cross-tolerance and susceptibility between cannabinoids and opioids have been demonstrated in laboratory animals [9, 10]. This plant has been banned in many countries for many years, cannabis, whose medicinal value is appreciated[11]. This paper provides a brief history, chemical composition, pharmacokinetics/dynamics and toxicological evaluation of cannabis.

2. GENERAL INFORMATION ABOUT CANNABIS

2.1. Brief History of Cannabis

The use of the cannabis plants dates back to antiquity. Cannabis has been cultivated for thousands of years in various fields, such as clothing, construction, textiles, paper and medicine [12, 13]. Cannabis has been used as a medicine in China, India, the Middle East, South Africa and South America for centuries. Artefacts of the rulers of Egypt and China (2700 BC) show that cannabis is one of the oldest medicines in history. The Chinese emperor Shen Nung introduced medicinal cannabis, which became the standard medicine for centuries. It has been reported that cannabis was used as a medicine by the Chinese in the Pen Tsao. This book is the oldest pharmacopeia, based on oral traditions from the time of Emperor Shen in the world [14]. Medicinal cannabis is used to treat constipation, malaria, rheumatic pain and gynecological disorders in China[15, 16]. Cannabis is one of the oldest medicinal plants in history, found in the Ebers papyrus around 1550 BC [3]. Cloth and paper made of cannabis were found in the tomb of the Chinese emperor Wu of Han (104-87 BC) [14, 15, 17, 18]. The introduction of cannabis into western medicine came in the early 19th century. While serving in the British army in India, it was introduced into western medicine following the publication of a report by William Brooke O'Shaughnessy in 1839 [19]. While the therapeutic efficacy of cannabis for various diseases was understood in western medicine, the 20th century saw increased recreational drug use based on the abuse of this plant. This has impaired progress in understanding the benefits of the cannabis plant and its constituents [20].

2.2. Chemical Composition of Cannabis

The golden age of cannabis and cannabinoid pharmacology began in the 1960s when Raphael Mechoulam and his colleagues in Israel isolated and synthesized CBD, THC and other phytocannabinoids [13, 21]. The pharmacological effects of many cannabinoids on humans and animals are not yet fully known. However, delta-9-THC, the most potent psychoactive substance among the cannabinoids, has been isolated and synthesized, and its pharmacological effects have been studied [22]. When cannabis is abused, more than 2000 compounds are formed by pyrolysis. These compounds consist of various chemical classes, including nitrogenous compounds, hydrocarbons, sugars, amino acids and simple fatty acids [23-26]. A list of the major cannabinoids, terpenes (monoterpene-sesquiterpenes) and flavonoids found in cannabis is shown in Table 1.

Table 1. Major cannabinoids, terpenes and flavonoids identified in the cannabis plant [21, 27]

Cannabinoids	Non- cannabinoid substances		
	Terpenes		Flavonoids
Phytocannabinoids	**Monoterpenes**	**Sesquiterpenoides**	
Delta-9-tetrahydrocannabinol	β-myrcene	β-caryophyllene	Cannaflavin
Delta-8-tetrahydrocannabinol	D-limonene	Caryophyllene oxide	Quercetin
Cannabidiol	β-ocimene	Humulene	Luteolin
Cannabigerol	γ-terpinene	β-elemene	Kaempferol
Cannabichromene	α-terpineol	β-farnesene	
Cannabinol	Terpinolene	Guaiol	
Tetrahydrocannabinolic acid	α-pinene	Eudesmol ısomers	
Cannabidivarin	β - pinene	Nerolidol	
Cannabidiolic acid	Linalool	Gurjunene	
Cannabigerol monomethyl ether	Camphene	γ-cadinene	
	α-phellandrene		
	γ-cadinene		
	p-cymene		
	Fenchol		
	1,8-cineole (eucalyptol)		

2.2.1. Cannabis Phytocannabinoids

More than 100 cannabinoids have been isolated from the cannabis plant. Cannabinoids are derived from cannabigerolic acid (CBGA). This acidic form has no psychotropic effect [28]**.** Various cannabinoids are formed from this acidic precursor form by the cyclization reaction. After biosynthesis as cannabinoid acids, the cannabinoids are decarboxylated to neutral forms. Phytocannabinoids are cannabidiol, cannabinol and others. CBD and delta-9-THC have been studied more than other phytocannabinoids. CBD is a decarboxylation product of cannabidiol acid formed by reactions induced by UV rays and heat [29].

2.2.2. Cannabis Terpenes

Terpenes belong to a large and diverse group of phytochemicals found in plants [5]. Terpenes, also called terpenoids, are components of the plant essential oils found in the cannabis. These aromatic compounds provide odor and taste to cannabis [27]. Since terpenes, like cannabinoids, are lipophilic, they cross the blood-brain barrier and contribute to the medicinal effects of cannabis. Some of the most common terpenes in the cannabis plant are β-pinene, myrcene, limonene, β-caryophyllene, and linalool [7]. The different composition of terpenoids contributes to the biodiversity of cannabis, the origin of the medicinal effects of cannabis and its pharmacological properties [30, 31].

2.2.3. Cannabis Flavonoids

Flavonoids are the most potent polyphenols that contribute to planting, pigmentation, and pollination. About 20 different types of flavonoids have been identified in the cannabis. Similar to terpenoids, many of these compounds have anti-inflammatory, neuroprotective, and antitumor activity. The flavonoids found in plants are estimated to contain more than 8.000 metabolites with wide structural and functional diversity. Flavonoids are divided into six main subgroups. These groups are flavones, flavonols, flavanones, flavanols, isoflavones, and anthocyanidins. Flavonoids make up about 10% of the known compounds in cannabis. Some of the best-known flavonoids are quercetin and kaempferol. Therefore, cannaflavin is unique to cannabis. The distribution of flavonoids in the cannabis plant varies in parts of the plant. Flavonoids provide anti-inflammatory and antioxidant properties to the cannabis. They are potent inhibitors of cyclooxygenase-2 (COX-2) enzymes. They affect the production of prostaglandin E2 (PGE2) so flavonoids reduce inflammation [5, 31].

3. PHARMACOLOGY OF CANNABIS

3.1. Pharmacokinetics of Cannabis

The use of synthetic or herbal products containing THC, CBD or the combination of THC and CBD from the cannabis plant is permitted in the United States, Canada and many European countries. These products are available in various pharmaceutical forms, including capsules, oral solutions and sprays, tinctures, lozenges, and inhalation by vaporization. The different administration routes of cannabinoids affect the pharmacokinetics of these substances. Pharmacokinetic studies with cannabinoids are fraught with problems. These include their low body concentrations, rapid metabolism, and difficulty separating the compounds sought from the biological matrices [32].

3.1.1. Absorption

The pharmacokinetics of inhaled cannabinoids are similar to those of intravenously administered cannabinoids in humans. After inhalation of cannabinoids, both THC and CBD reach their maximum plasma concentrations rapidly (within 3-10 min), and their maximum plasma concentrations are higher than with oral administration. Oral administration has an onset of action of about 15-40 min and a duration of action of 2-4 hours [32].The most common route of exposure is oral ingestion in animals. The onset of action is 30 to 90 min after oral ingestion, and the duration of action can be up to 72 hours in dogs. Bioavailability of THC varies between 10-35% depending on inhalation characteristics such as breathing frequency, duration, breath-holding time, inhalation volume, inhalation device, accumulation area of inhaled particles in the airways, and the size of these particles. Inhaled CBD has an average systemic bioavailability via inhalation of 11% to 45% (mean 31%) and a similar plasma concentration-time profile to THC [33]. THC and CBD are both highly lipophilic and have low oral bioavailability (6%). Oral THC formulations have a variable absorption profile and are subject to a first-pass effect [34]. This results in a lower peak THC concentration in plasma and a longer time (approximately 120 min) to reach peak concentration than with inhalation. CBD was observed to have a similar plasma concentration-time profile to THC after oral administration. Transdermal administration of cannabinoids prevents the first-pass effect. However, due to their hydrophobicity, cannabinoids have limited diffusion through the aqueous layer of the skin. *In vitro* studies with human skin, permeability of CBD was found to be ten times higher than that of delta-9-THC and delta-8-THC. This is because CBD is less lipophilic than THC. Although transdermal administration is not currently used clinically, it shows a potential benefit in the treating of nausea, and anorexia [34, 35].

3.1.2. Distribution

Cannabinoids distribute rapidly in well-vascularised organs such as lungs, heart, brain, liver, and spleen. Then, they are stabilized by distribution in less vascularised tissues. Distribution can be influenced by body size and composition. In addition, diseases that affect the permeability of blood-tissue barriers are major factors that influence distribution. Because of chronic use, cannabinoids accumulate in adipose tissue due to their high lipophilic properties. This causes the release and redistribution of cannabinoids to continue for weeks. In humans, the distribution volumes (Vd) of CBD and THC are high. THC is found in plasma with an unbound fraction of 3-5%, while the rest (97-95%) is strongly distributed and bound to lipoproteins [34-37].

3.1.3. Metabolism

THC is metabolised in the liver by microsomal hydroxylation and non-microsomal oxidation [37]. THC is metabolised via cytochrome P450 isoenzymes. It is mainly carried in the liver via CYP2C9, CYP2C19, and CYP3A4. THC is metabolised to 11-hydroxy-THC and 11-carboxy-THC which are excreted in the feces and urine via glucuronidation. Metabolism also occurs that express CYP450 in non-hepatic tissues, including the small intestine and brain. The metabolite 11- OH-THC is reported to have a psychoactive effect. Lipophilic THC can cross the placenta and cause brain toxicity in newborns. Additionally, THC is a cannabinoid with a very high potential to pass into breast milk. CBD is metabolised in the liver by the isoenzymes CYP2C19 and CYP3A4, CYP1A1, CYP1A2, CYP2C9 and CYP2D6. CBD is metabolized in the liver after hydroxylation to 7-hydroxy-cannabidiol. This metabolite is excreted in the feces and to a lesser extent in the urine. There are few studies on the pharmacological activity of CBD metabolites in humans [7, 34, 35].

3.1.4. Elimination

It has been demonstrated by pharmacokinetic studies that the elimination half-life of THC varies. Population pharmacokinetic modelling described a rapid initial half-life (approximately 6 min) and a long terminal half-life (22 h). The length of this terminal half-life is related to the balance between adipose tissue and blood. THC has a long elimination half-life in chronic use due to its redistribution in adipose tissue. THC has a short plasma half-life [37]. A study on repeated daily oral administration of CBD showed an elimination half life of 2 to 5 days. The main route of excretion of THC is the bile. Within 72 h after oral ingestion, about 35% of the oral dose is excreted as unconjugated metabolites, 10% to 15% in the urine as acid metabolites and conjugates; a small portion is excreted unchanged in the urine [34, 37].There are only a few studies on the pharmacokinetics of cannabinoids in animal species [7, 32].

3.2. Pharmacodynamics of Cannabis

3.2.1. The Endocannabinoid System and Cannabinoid Receptors

The endocannabinoid system (ECS) is a neuromodulatory network in the central nervous system that is critical for regulating many cognitive and physiological processes. This system also known as the endogenous cannabinoid signalling system, plays an important role in maintaining homeostasis with its multiple physiological effects. The ECS consists of endogenous cannabinoids, cannabinoid receptors and enzymes responsible for the synthesis and degradation of cannabinoids. Cannabinoid receptors are the primary target of delta-9-THC, the psychoactive component of the cannabis [38]. The ECS was discovered in the early 1990s with the endogenous ligand N-arachidoneethanolamine (anandamide, AEA) and the cannabinoid receptor types 1 and 2. These discoveries have accelerated the pharmacodynamic studies of cannabinoids [7, 39].

3.2.2. Endocannabinoids

Endocannabinoids are endogenous compounds associated with cannabinoid receptors. These compounds are lipophilic substances produced by the body. Over the years, various compounds with endocannabinoid activity have been isolated and synthesized. However, the most studied endocannabinoids are anandamide (AEA) and 2 arabidonylglycerol (2-AG). Different pathways have been defined for the synthesis and degradation of endocannabinoids. Endocannabinoids are found in the plasma membranes of neurons. In the enzymatic destruction of these compounds endocannabinoids are transported to the presynaptic cell and then hydrolyzed by specific enzymes with amide or ester bonds [7]. The identification of cannabinoid receptors followed the identification of endogenous ligands. According to the recent research, five different endocannabinoids have been defined. These endocannabinoids are anandamide, 2-AG, 2-arabidonylglycelyl ether (noladin ether), O-arabidonyl-etanolamine (virodhamine) and N-arabidonyl-dopamine (NADA). Cannabinoid receptors and endogenous ligands, mammalian and many other types of the cannabinoid system. Endocannabinoids also serve as neurotransmitters or neuromodulators. Anandamide and NADA bind to cannabinoid receptors and stimulate vanilloid receptors (VR1) [40]. The ECS consists of endogenous ligands, G protein-coupled receptors (GPCRs) and enzymes used to degrade the ligands and re-uptake presynaptic neurons. The mechanism of action of CBD is unknown. It is assumed that some therapeutic effects of CBD are caused by the activation of VR1 and the negative allosteric modulation of CB_1. It is therefore assumed that cannabidol mediates the psychomimetic effects of THC. Other possible mechanisms of CBD are agonization of serotonergic 5HT1A receptors, GPCR antagonism, a regulatory function in the central nervous system and inhibition of fatty acid hydrolysis. In addition, CBD leads to a reduction in the hydrolysis of anandamide [32]. In the last 15 years, with the discovery of cannabinoid receptors and endogenous ligands in humans. Studies conducted in this field have shown that ECS plays an essential role in neuronal signalling [41].

3.3. Interactions of Cannabis With Other Drugs

Research on the dose-response and drug-drug interactions associated with the cannabinoids is limited. Pharmacodynamic and pharmacokinetic interactions between THC, CBD and other drugs may occur due to inhibition/induction of enzymes or transporters. Drug interactions play an essential role in the effectiveness of the chemicals in the cannabis. Along with other drugs, THC may enhance or attenuate the specific effects of that substance. Lane *et al.* (1991) demonstrated that the combination of prochlorperazine and dronabinol was more effective in reducing the adverse effects of the antineoplastic drug than phenothiazine administered alone. In addition, this study found that dronabinol along with prochlorperazine, which has antipsychotic properties, resulted in a reduction in cannabinoid adverse effects. It is clinically essential that THC is potentiated by interactions with other psychotropic substances such as alcohol, benzodiazepines and drugs that affect the cardiovascular system. The cyclooxygenase inhibitors indomethacin, aspirin and other non-steroidal anti-inflammatory drugs counteract the effects of THC [40]. Both cannabis and tobacco use induce CYP1A2, and concurrent use leads to an additive interaction. This leads to a vital interaction when cannabinoids are taken concomitantly a drug that is metabolized by CYP1A2. Cases of mania due to taking cannabinoids with fluoxetine and cases of delirium and hypomania due to cannabinoids with disulfiram have been reported. *In vitro* studies have shown that CBD significantly inhibits p-glycoprotein-mediated drug transport and that CBD have the potential to affect the absorption and excretion of concomitantly administered drugs. Therefore, clinicians should be mindful of the potential for drug interactions. Co-administration of rifampicin with CBD significantly decreases peak plasma concentrations of CBD. In contrast, co-administration with ketoconazole was reported to almost double the peak plasma concentrations of the drug [42]. CBD is a potent inhibitor of CYP2C19 enzymes *in vitro*[43]. Drug interactions are primarily due to the concomitant use of central nervous system depressants and cannabinoids. Interactions resulting from the use of cannabinoids with other drugs are clinically rare. Although recent studies have shown no toxicity or loss of efficacy from medications taken concurrently, these situations are theoretically possible [44]. Interactions with other drugs may be due to activity at similar receptors or metabolic interactions. Since cannabinoids are tightly bound to plasma proteins, they may interact with other drugs that bind to these proteins. They may also interact with drugs metabolized by cytochrome P450 enzymes, such as THC. However, cannabis use and oral dronabinol has been reported to affect the pharmacokinetic parameters of antiretroviral drugs used in HIV infection that are metabolized by cytochrome P450 enzymes [45]. It has been reported that cessation of tobacco and cannabis use leads to increased blood levels of antipsychotic drugs (clozapine or olanzapine) because induction of CYP1A2 by smoking components ceases [40].

4. TOXICOLOGY OF CANNABIS

The toxic effects associated with the cannabis plants are divided into acute and chronic toxicity. Acute toxicity studies in animals often focus on THC, the main psychoactive component of cannabis. Studies show that this compound is unlikely to cause death due to acute exposure. However, chronic toxicity studies draw attention to the effects on various animal tissues and systems because of long-term exposure to this compound. These effects include respiratory and lung damage, neurotoxicity, tolerance, addiction problems, immune and endocrine system disorders [46]. Research on laboratory animals is crucial in determining the toxicity of cannabinoids in the cannabis. These studies include cannabinoids that allow acute/chronic toxicity to be determined by varied routes and at different doses in various animal species. In addition, studies in laboratory animals allow the direct pathological evaluation of all organs. However, many challenges arise when translating data from laboratory animal studies to humans. There are three main approaches; based on body weight, body surface area and pharmacokinetic parameters are used to translate data obtained in these studies to humans. However, none of these approaches is accurate for determining the toxicity of cannabinoids. Transferring the results of studies on laboratory animals to other species leads to surprising results. It is found that the lethal dose of THC in monkeys was 5–10 times higher than that in rats and dogs [47]. Therefore, it is a challenge to translate data from toxicity studies in laboratory animals to humans. Extreme caution is required when interpreting results from animal studies and applying them to humans. The most accurate approach to the acute and chronic toxicity of cannabinoids in humans is based on a review of human data. Further studies and data are needed on this topic [46, 48]. Therefore, it is a challenge to transfer data from toxicity studies in laboratory animals to humans. Extreme caution is required when interpreting results from animal studies and applying them to humans. The most accurate approach to the acute and chronic toxicity of cannabinoids in humans is based on a review of human data. Further studies and data are needed on this topic [46, 48]. The acute toxicity of cannabinoids is low. The dose of THC required to cause 50% mortality (LD_{50}) in rodents is high compared to other commonly used drugs [49]. Acute exposure of animals to high doses of THC, other or endogenous cannabinoids (endocannabinoids) such as anandamide causes hypothermia, hyperlocomotion, catalepsy and antinociception. Research on knock-out mice has shown that the cannabinoid receptor CB_1 is responsible for these effects [47].

5. CONCLUSION

Although the medicinal use of the cannabis has a long history, pharmacological and toxicological studies on this plant are still in their beginning. Researchers have uncovered the medicinal potential of cannabis and revealed this plant's importance for clinical practice in the last decade. These researches focus specifically on THC and CBD. Although there are many pharmacokinetic and pharmacodynamic studies on THC, other cannabinoids, terpenes and flavonoids are limited. These compounds should also be of importance in research related to cannabis plants. The study of the pharmacological activity of all these compounds in cannabis is essential to uncover and develop the medicinal use of these substances. In addition, determining the pharmacokinetic and pharmacodynamic profiles of these compounds and their toxicological evaluation is crucial for understanding the therapeutic potential of the plant [5, 7]. The cannabis, with its various compounds such as cannabinoids, terpenes and flavonoids, has numerous effects on human and animal physiology. In cannabis species, different numbers of these compounds lead to different physiological effects in humans and animals [50]. Although the medicinal use of the cannabis has a long history, its importance in both human and veterinary medicine is increasing. The fact that the plant is banned in many countries because of its abuse also limits its medicinal use. Reliable and effective methods against cannabis abuse need to be developed. In particular, it should be investigated how synthetic cannabinoid compounds can be used safely and effectively in ECS [7]. The discovery of cannabinoid receptors and endogenous ligands has led to studies on the possible therapeutic potential of cannabinoids in animal models. The results of these studies have also guided the investigation of the therapeutic effects of cannabinoids in humans. The therapeutic effects of cannabinoids in domestic animals remain controversial. The problems limiting the use of the cannabis in human and veterinary medicine should be highlighted and research should be conducted for these reasons [51]. More data are needed on the toxicity and side effects of the cannabis plant. Animal studies specifically focus on the effects of this plant on the brain and immune system. Extreme caution is required when interpreting the results of animal studies and their application to humans. The toxicological evaluation of this plant should be based on species-specific data from studies on each species and not on comparisons between species [46].

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ECOLOGICAL FOOTPRINTS OF HEMP

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ABSTRACT

In our world, the decrease and pollution of natural resources have led industries and scientific circles to seek more sustainable and renewable products. Hemp, originating from Central Asia, has formed a history of approximately 3500 years by adapting to Anatolia's soil, climate, and ecological conditions. Based on hemp plant cultivation, its ecological footprints show much cleaner production compared to other fibrous plants with its oxygen production, carbon dioxide assimilation, and conscientious use of water, being an ideal alternation plant, its resistance to diseases, pests, and weeds. Also, hemp is a good candidate for the phytoremediation of heavy metal-contaminated soils in absorbing and accumulating heavy metals due to its high biomass. Eco-friendly, low-cost, easy-to-process, and high-value-added renewable products with high mechanical properties can be produced from hemp. Textile, Automotive, Construction, cosmetics, medical, and other industries. Exhibiting antistatic, anti-allergic, antimicrobial and biological behavior besides traditionally produced products. New generation products are being developed. Based on hemp agricultural activities and industrialization, the low carbon and water footprint and the development of edible new-generation products create hope for sustainable and clean production. In this article, we examine the belief that this ecological and economic structure will positively affect climate change that threatens the world.

Keyword: Hemp, Sustainability, Footprint, Climate Change

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1. INTRODUCTION

Our environment is sometimes polluted indirectly and sometimes directly by the intensive and unconscious use of air, water, and soil. Among the causes of environmental pollution, population growth, urbanization, industrialization, intensive use of Natural Resources, increasing energy needs, with the development of technology is one of the important factors that herbicides used in agriculture can pollute the environment. Environmental pollution has adverse effects on all living things. Humanity has realized this deterioration and has turned to produce nature-friendly policies. This innovative understanding has also entered the agricultural sector. In order to achieve ecological balance, new technologies and scientific studies aimed at protecting and improving the health of air, water, and soil have begun to be developed. The plants used in this direction have been developed, and production has gained richness. One of the plants used in this regard is hemp. Although hemp has a positive interaction with the environment, it is also a plant that contributes by increasing the efficiency of biological factors in the region where it is located.

Hemp has been a plant used throughout human history in textile, medical and recreational fields. Hemp is an industrial plant from the Cannabinaceae family with single or double domesticated types with a chromosome number of 2n=20 and foreign fertilized. Over the years, hemp has been banned from cultivation worldwide due to its narcotic properties. As a new generation of industrial products is developed in hemp, hemp has started spreading rapidly worldwide again.

Recently, hemp has been back on the agenda and gained popularity on the issues of global climate change and the green accord. Hemp attracts much attention in terms of having a low carbon and water footprint, a tendency to clean production, protecting environmental resources, ensuring the continuity of biological balance Jul and reducing the destruction caused to the environment.

2. HISTORY OF HEMP

It is known that the origin of hemp dates back to 850 years BC. Hemp originated in Asia and India and has spread to different parts of the world. During the Ottoman period, the raw materials needed in shipping, such as tether and rope, were the raw materials. In the Ottoman Empire, hemp production has been at the forefront in the cities of Trabzon, Ordu, Canik, Aydin, Izmir, and Kastamonu. In fact, it has been reported that hemp is sent to Europe as an export product from time to time [1].

Figure 1. Hemp harvest

It first started to be cultivated to obtain hemp oil, then produced to benefit from its fibers [1].

In the first years of the Republic, Turkey ranked 10th in terms of production in the world. It is reported that he is next. At that time, it was reported that Kastamonu, Izmir, Samsun, Ordu, and Zonguldak, respectively, were the provinces where the broadest hemp production was carried out in terms of land in our country [1].

2.1. GENETIC FOOTPRINTS OF HEMP IN ANATOLIA

Hemp (*Cannabis sativa* L.), this species originated in West and Central Asia, was an important agricultural activity of Anatolia in the past. The history of hemp in Anatolia dates back to BC. It is thought to date back to the 1500s [2]. It is also frequently referred to by names such as hemp, kendir, and Indian hemp, and its seeds have been widely used in Anatolia for centuries under the name 'çedene'. It is produced for fiber and seed in 20 provinces in our country with permission.

Today, hemp studies with populations of the Ministry of Agriculture and forestry village in Anatolia Aegean Agricultural Research Institute and cultivars obtained from the gene bank at the phenological, morphological, and technological properties of new varieties and candidates with the determination may occur. Accordingly, NARLI and VEZIR 55 varieties were bred by the breeding teachers of Ondokuzmayis University and registered as the first domestic hemp in our country. When naming the varieties, it was inspired by the Vekirköprü district of Samsun and Narlisaray village. It is understood from here that by looking at the village populations, it is seen that genetic footprints of hemp have been found in Anatolia.

2.2. HEMP AND FOOTPRINT

The carbon footprint is the amount of use and other greenhouse gases emitted per product produced, while the footprint is the amount of energy consumed per product produced [3].

The greenhouse effect is one of the main factors in climate change and global warming. One factor that creates the greenhouse effect is the emission of fuels, such as oil, coal, and natural gas, into the atmosphere as carbon dioxide [4].

While a carbon footprint is produced, there is a carbon cost in the creation of each product. The higher this cost, the greater the damage. For this reason, it is necessary to develop healthier methods that will leave low carbon footprints for environmentally friendly production [4].

Figure 2. Hemp leaf

Figure 3. Carbon footprint

According to Lynas [5], the Climate Change Board reports that the world temperature will increase between 1.4 and 5.8 °C in the next 100 years. Other studies support this argument. So that the international climate change panel has developed a simulation model that shows that if the carbon footprint of the activities and productions is taken as a precedent until 2100, the average surface temperature will increase by 2.5 degrees. This temperature increase will increase the sea level by 80 centimeters in the next 100 years. As a result, a study has revealed that it can cause serious problems, such as changes in local climatic conditions, a decrease in forest areas, a decrease in agriculture, and a decrease in water resources [4].

Among the factors that increase the carbon footprint, food from other countries, cars we use, lights used in streets and shopping centers, and carnivorous diet are among the criticalfactors that increase the greenhouse gas in the atmosphere. We need to change this way of life and use fewer fossil fuels, and precious metals should not be extracted from underground [5].

The import of hemp in our country until recently is one factor that increases the carbon footprint. However, hemp is an essential plant with a low carbon footprint. With its arrival from abroad, its carbon footprint converts into a high-cost product during shipping. Hemp is one of the plants that can be easily cultivated and processed in our country's geography. Today, hemp is cultivated in our country, and it is increasing day by day in the regions where it is cultivated.

2.2.1. Measures That can be Taken to Reduce our Carbon Footprint

With approaches such as using our energy resources renewable, using energy-efficient tools and equipment, using solar energy for heating, using public transportation services while traveling, drying our clothes by hanging them instead of in the machines, turning off electrical devices when we are not using them, and unplugging rechargeable devices such as mobile phones when they are fully charged, we can reduce our carbon footprint [4]. The extent of the damage caused by the problematic measurement of by-products and wastes resulting from agricultural activities has been neglected. Thanks to the carbon footprint measurement carried out, the damage caused to the environment by agricultural production has been determined [6]. It has been reported that by constructing buildings using earth resources and developing transportation, industry, and agriculture increases the accumulation of greenhouse gases in the atmosphere, causing global climate change and significant problems in human health [4].

Climate change is a global problem, and the countries of the world are together on this issue, and the United Nations Framework Convention on Climate Change (UNFCCC) was opened for signature at the United Nations Environment and Development Conference held in June 1992. The primary purpose of this convention is to prevent the accumulation of greenhouse gases in the atmosphere and to try to prevent its impact on the climate and human health. In this way, it is aimed to adopt a production method infected with nature and create sustainable production [6].

In this regard, hemp is a plant with a low ecological footprint that is sustainable. So hemp is included in the measures taken on climate change. The fact that there are few inputs in hemp agriculture is significant from an ecological point of view. Studies conducted on the hemp plant have shown that the oxygen production in the forest equivalent also provides paper from 1 decare of hemp obtained from 4 decares of wood in cellulose. It does this in a short development period of 4 months, making hemp more attractive [7]. At the same time, it has been found that hemp absorbs more carbon dioxide in terms of carbon dioxide absorption compared to forest land [2]. In this context, it is understood how great the place and importance of hemp in the ecological balance is. It is one of the plants whose ecological and economic agriculture is possible with little agricultural input.

2.3. THE RELATIONSHIP BETWEEN HEMP AND WATER

Developing industries are causing water scarcity and pollution directly and indirectly, and this risk is gradually increasing; environmentalist groups are warning humanity about this. Therefore, an increasing number of companies have begun to explore their water footprint and look for ways to become better water protectors [8].

Today, 36% of the world's textile industry is produced from cotton fiber. The disadvantage of using cotton in textile production is the excessive water consumption of cotton and its negative impact on water quality. The negative impact on the environment can be reduced, given the use of other fiber crops for textile production and lower water requirements. The most important of the plants that can be used in this regard is hemp, which has also been used in history. The water footprint of cotton textiles is three times higher than that of industrial hemp textiles. In addition, cotton production areas are often in water-scarce regions of the world. Compared to industrial hemp, it is grown in places around the world with little or no water scarcity. Therefore, industrial hemp production has a less negative impact on water resources [9].

Figure 4. Cotton plant

Figure 5. Hemp plant

2.4. HEMP AND PLANT PROTECTION

Common diseases in industrial hemp are gray mold (*Botrytis cinerea*) and white mold (*Sclerotinia sclerotiorum*). In addition, *Pythium* infections, root rot, rice burn, leaf bacteria, and some viral infections have been reported to be encountered. Although hemp shows resistance against many insect species, seasonal problems have been reported [10].

Figure 6. Diseased and undamaged hemp

2.4.1 Hemp and Diseases

It has been reported that most of the diseases in hemp farming are caused by fungi. Of the 88 fungal species, only a few are reported to cause economic losses. Due to this situation, it has been reported that the seeds have been treated with fungicides to reduce diseases [11].

It has been reported that four soil bacteria can cause diseases in hemp: *Pseudomonas syringae*, *Xanthomonas campestris* pv. hemp, *Erwinia tracheiphila* (bacterial wilt), and *Agrobacterium tumefaciens* (crown gall tumor). The four pathological types of Pseudomonas syringae (pv for short. pseudomonas syringae pv has been identified as *Pseudomonas syringae* pv. cannabina (bacterial leaf spot and bacterial blight), *P. syringae* pv. mori, *P. syringae* pv. tabaci, *P. syringae* pv. mellea (Wisconsin leaf spot). Phytoplasma (mycoplasma-like organisms) are bacterial parasites in plant phloem tissues and vectorial insects, and one type of it has been found in hemp" [10].

2.4.2. Hemp and Pests

It has been determined that approximately 300 insect species cause damage to hemp, but very few cause significant damage. These pests are the cornworm (*Ostrinia nubilalis*) and the hemp worm (*Grapholita dilineana* and *G. tristrigana*). The larvae of the hemp flea beetle (*Psylliodes attenuata*) eat the root of the plant, while adults feed on its leaves and flowers. However, it has been reported that hemp is generally tolerant and resistant to pests [11]. The reason is that the THC it contains has been reported to give the plant an advantage against injuries and diseases. Apart from this, the fact that the plant has short vegetation has given it superiority over harmful and disease factors [11]. So hemp agriculture also does not have any registered chemicals.

Figure 7. The Hemp leaf

2.5. HEMP AND ALTERNATION

Hemp can be grown on the same soil for several years. However, it is beneficial to plant hemp in alternation with most cultivars [12]. Hemp can alternate with grains and vegetables. The fact that the plant is suitable for alternation is also very favorable. The alternation of hemp, which the farmers state is a perfect alternative plant, with corn, which has similar ecological demands, is much more economical. Hemp is a beautiful product both in increasing corn yield and supporting corn cultivation with its savings in fertilizer use. Another advantage of the plant is that it suppresses weeds with its rapid development so, it is suitable for frequent planting and leaves a clean field for the plant [13]. The use of herbicides will be reduced while controlling the weeds of the infected plant, thus providing environmental and economic benefits.

In hemp, the root system is pile-rooted and consists of secondary and lateral roots. When suitable soil conditions and moisture are provided, it can descend to 3-4 m. The root system is spread in the form of a net from 15-20 cm below the soil. Hemp prefers nitrogen-rich soils. Accordingly, the previous plant uses no more than 50% of the nitrogen in the soil, and the remaining nitrogen mixes with water and soil, creating pollution. Hemp, planted after the cultivated plant, eliminates nitrogen by taking nitrogen into its body thanks to its deep roots. Thus, hemp prevents contamination of groundwater and soil. Hemp prepares the appropriate environment for the next crop by leaving the soil in a clean and ventilated state. In this sense, hemp is in an excellent pre-plant position.

2.6. SUSTAINABLE LIVING WITH HEMP PRODUCTS

The decrease in natural resources and the increase in environmentally friendly approaches have encouraged people and sectors to research sustainable and renewable resources. In this context, it is of great importance that they are environmentally friendly, low-cost, easy to process, and have high mechanical properties when evaluated within the scope of sustainable economies. Accordingly, the hemp plant is vital in industrial and economic sustainability due to its sustainable and renewable properties. As hemp is a sustainable and renewable crop, most of what we can do with cotton can be done with hemp with much less impact on the world (Image 10).

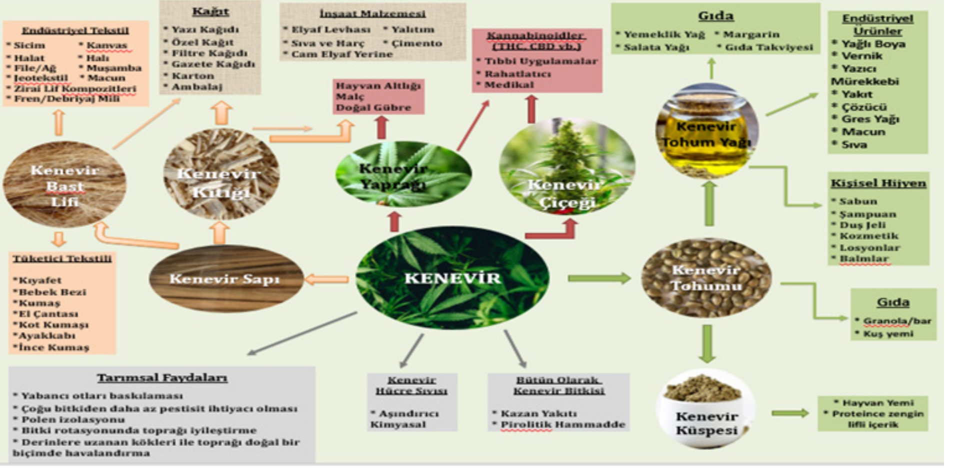

Figure 8. Areas of Use of Hemp

The hemp plant is a durable, sustainable, and biodegradable material that can compete with hemp fibers, glass fiber, and other synthetic fibers, showing high hygienic properties with its antistatic, anti-allergic, and antimicrobial behaviors. Hemp is widely used in textile, automotive, construction, biofuel, cosmetics, and other industries. Hemp fibers are widely used in every sector where petroleum and petrochemicals are used. Unlike fibers that require chemical fertilizers and pesticides, hemp fiber naturally resists insects and aerates the soil. Due to their clean growth, sustainability and biodegradability, hemp fibers have significant advantages from an ecological pointof view. When evaluated in this context, it should be ensured that hemp fiber is used more widely in sectors in sustainable areas. Use all the above-ground parts of hemp, from seeds to leaves. When we look at the usage areas of hemp, it is a plant suitable for both the Green Agreement and the Paris Agreement.

2.7. HEMP AND POLLUTION

In order to increase the yield of the crop obtained from the unit area to meet the food needs according to the rapidly increasing population today, human beings have taken initiatives that may harm the environment. With the developing technology, the use of fertilizers and chemical drugs has increased the yield, and as a result, there has been a great deal of damage to the environment. These damages: deterioration of the soil structure, erosion, contamination of groundwater, deterioration of the ecological balance, deterioration of living standards, and increased production costs have caused [14].

Among the various Organic and inorganic pollutants, heavy metals are pretty dangerous for living life decently [15]. Hemp is essential in purifying (remediation) areas contaminated with heavy metals. It is also an economical and environmentally friendly method [16]. Studies have shown that hemp contains heavy metals such as Cd, Ni, and Cr in its roots [17]. Nevertheless, it has also been found that these heavy metals are not found in products obtained from hemp.

Hemp uses carbon dioxide in the air by photosynthesizing more than other plants and adds it to the air as oxygen. Thus, it reduces air pollution. Hemp can be defined as a carbon-negative product, which means that products made from hemp are carbon-neutral and play a vital role in reducing the environmental pollution. In addition, when hemp is used as an alternative plant, it leaves a weed-free area for the plant planted after itself, and the herbicide application is reduced, thereby reducing soil and environmental pollution. In addition, hemp cleans the soil with its roots, which go down to a depth of 3-4 meters, of toxic substances left by the plant October before it was planted. Due to the positive impact of hemp on the environment and climate, it can be grown as a plant that complies with the Paris agreement and the Green Agreement [18].

2.8. HEMP AND CLEAN AGRICULTURE

Ecological agriculture is the production of plants and animals in harmony with nature and without destroying the environment positively. It is ensured that there is no harmful accumulation in the soil where agriculture is carried out, and organic and green fertilization, rotation, and soil preservation are provided. In this regard, high-quality production is observed by cultivating resistant varieties against pests. Hemp is a suitable plant that can be cultivated from an ecological point of view. At the same time, being a contented plant in all respects, having a broad adaptation ability, and being planted on the same land for many years provide advantages for ecological agriculture. The hemp crop, which is preferred for rotation, leaves a clean area for the next crop. Besides being an excellent primary crop, hemp can enter into rotation with both legumes and grasses [19].

3. RESULTS E-SUGGESTIONS

- Hemp is a plant that does not destroy nature and is also a contented plant regarding its wishes.
- The fact that hemp can be planted in the same field repeatedly and its high adaptation ability is also a plus feature.
- In response to the increasing energy need, hemp is shown as an alternative energy source in bioenergy and biofuels.
- More and more studies have been conducted on the fact that hemp cleanses the air and soil and purifies them from pollutants, and positive results have been obtained.
- Hemp is a plant used to clean soils contaminated with heavy metals, and this process is cheaper and more practical than other engineering processes, as well as a healthier application in a biological sense.
- Hemp is a plant with easy biodegradability that does not leave toxic waste in the soil.
- Judging by the environmental pollution caused by agricultural activities, it is seen how important the use of hemp in agriculture will be for sustainable agriculture.

- Hemp is an excellent alternative plant. Studies have shown that the alternation of cereals with hemp increases the yield of cereals and saves on inputs such as fertilizers. The weed problem has been proven to prevent the development of weed seeds in the lower and upper parts of the plant.

- The role of hemp in producing oxygen and absorbing carbon dioxide is quite large. So, hemp plays an essential role in the environment-living interaction.

- No chemicals are needed in hemp farming. In this way, the inputs are less, and there is no environmental damage.

- Hemp needs less water compared to cotton. At the same time, compared to cotton in the geography of our country, it has the potential to be farmed in more regions. In addition, hemp is widely used in many industries (weaving, paper industry, human and animal nutrition, and fuel) and is a source of raw materials.

- When all these factors are considered, the relationship of hemp with the environment and living things should be taken into account. Innovations and regulations are being made in every sector to improve our polluted world compared to the increasing population. The place and importance of hemp in the innovations made in the agricultural sector are undeniably important. The spread of hemp agriculture is essential for both the improvement of the environment and industry development.

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MODERN ASPECTS OF HEMP ANALYSIS

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ABSTRACT

The legalization of hemp in some countries has led to the development of hemp-based drugs, hemp extracts, creams, oils, nutritional supplements, etc. Accordingly, the use of hemp for medical and industrial purposes has rapidly increased in recent years. However, hemp products may contain pesticides, heavy metals, pathogens, mycotoxins, and residual solvents, and testing these contaminants is of primary concern for consumer safety. On the other hand, potency, moisture determination, and terpene profiling tests are needed to assess products' quality. Several guidelines have been established to evaluate the efficacy and safety of hemp products. However, the variety of products and the complexity of matrixes are challenging for most laboratories. Sampling techniques and analytical methods also differ depending on the product type. In order to overcome the difficulties of hemp testing, a methodological step-wise approach is needed. Many analytical tools and methods have been introduced for the detection, identification, quantification, and analysis, such as solid phase microextraction (SPME), microwave-assisted extraction (MAE), ultrasound-assisted extraction (UAE), supercritical fluid extraction (SFE), pressurized liquid extraction (PLE), gas/liquid chromatography-mass spectrometry (GC-MS/MS, LC-MS/MS), ınductively coupled plasma spectrometry (ICP-AES, ICP-MS) and nuclear magnetic resonance spectroscopy (NMR). This study aimed to describe modern methods of hemp analysis and discussed the main aspects of sampling and testing techniques.

Keywords: Cannabinoid, CBD, Chromatography, Methods, THC

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1. INTRODUCTION

Legalization of medical hemp/cannabis in some countries [1] leads to the development of cannabis-based drugs such as Cesamet®, Sativex®, and Marinol® and products such as cream, essential oil, supplementary foods containing cannabis plant or seed extract [2-4]. These products are routinely tested by authorities to protect consumers' health and confirm quality. The tests include pesticide and heavy metal analyses, potency and terpene analyses, microbiological contamination, and residual solvent tests [5]. Cannabis analyses are somewhat complicated, as the variety of products offers significantly different matrices, which creates a need for specially designated and validated analyses

2. METHODS OF SAMPLING AND ANALYSES

Cannabis analysis begins with the correct sampling, as the plant or the product can be affected by many factors. For example, different parts of the plant may contain different terpene and cannabinoid content [6]; the upper layer of the hashish or cannabis resins easily oxidizes, which requires deep sampling; liquid products (cannabis drinks, oil, extracts) could precipitate during long-term storage and must be shaken well before collecting specimen [7].

The second step is extraction, which starts with grinding/milling to obtain a homogeneous sample. Grinding/milling is usually done through electrical grinders or homogenizers [8]. Another method is cryoextraction, where the sample is processed with dry ice or liquid nitrogen to protect thermo-labile compounds in the product [9, 10].

The third step covers extraction methods, in which the targeted analytes are extracted from the products' matrices. Many extraction methods have been used for cannabis analyses, and the main advantages and disadvantages are summarized in Table 1. Among these methods, liquid-liquid extraction (LLE) and solid phase extraction (SPE) step forth with ease of operation and lower cost. Furthermore, these two methods offer great flexibility regarding pH and polarity; however, they require a significant amount of time and organic solvents compared to the other methods. Pressurized liquid extraction (PLE), microwave-assisted extraction (MAE), and ultrasound-assisted extraction (UAE) are highly efficient regarding speed, performance, and low solvent consumption, although they require special equipment. Supercritical fluid extraction (SFE) allows a substantial amount of sample to be extracted quickly and is considered eco-friendly because it uses CO_2 as the extraction solvent, evaporating completely. Nevertheless, it is costly, and not all analytes can be extracted by SFE [11-13]. At the end of the extraction procedure, the extract is usually filtered through 0.22 or 0.45 µM filters, reducing unwanted interferences during analyses [14, 15].

Chromatographical techniques mainly constitute analytical methods for cannabis and cannabis-based product analyses. However, these methods are still being developed and validated by international authorities since the complexity of the matrices, and chemical variability among different types of analytes makes cannabis testing compelling. Accordingly, this paper briefly describes and outlines the most current analytical techniques, their advantages/disadvantages, and the commonly used methods in cannabis and cannabis product testing.

Table 1. Advantages/disadvantages of some extraction methods [6, 16-21]

Method	Process	Advantage	Disadvantage
LLE	Analytes are obtained by treating the sample with polar/apolar solvents and concentrated by solvent evaporation.	Easy, economical. Does not require special tools.	Slow. A significant amount of solvent is used. Non-target compounds are extracted too. Requires a clean-up procedure such as SPE.
SPE	The sample is put onto an adsorbent material, where the analytes are held, and the non-target compounds pass through.	Offers great sensitivity. Does not require special equipment.	Slow. Requires practice and experience. It may not be used for all types of analyses.
SPME	The sample is held in a closed vial and heated. SPME needle covered by a special fibre adsorbs the analytes evaporated from the sample.	Easy. Does not use solvent. Incredibly effective for volatile analytes.	Requires special equipment, slow. Not suitable for multiple samples and thermolabile analytes. SPME needles and fibres are delicate and require regular maintenance.
UAE	The sample is mixed with solvent and sonicated with 20-200 kHz ultrasound.	Fast. Reduced solvent use.	Requires special equipment, not economical. Sample particle size should be kept minimum (<50 µm).
MAE	The sample-solvent mixture is transferred into a closed microwave system, heated, and microwaved to obtain analytes.	Fast. Reduced solvent use.	Requires special equipment, not economical. Heating is usually heterogenic, which reduces extraction efficiency. Microwave power/time should be optimized.
PLE/ASE	Under high pressure, solvents are heated above their boiling temperature and passed through the sample.	Fast. Reduced solvent use.	Requires special equipment, not economical. After extraction, a clean-up process is usually needed.
SFE	The sample is extracted with supercritical carbon dioxide in a closed and pressurized system.	Fast. Cleanest and eco-friendly.	Requires special equipment, expensive. Different solvents are needed to extract polar analytes.

LLE: Liquid-liquid extraction, **SPE:** Solid phase extraction, **SPME:** Solid phase microextraction, **UAE:** Ultrasound assisted extraction, **MAE:** Microwave assisted extraction, **PLE/ASE:** Pressurizes/Accelerated liquid extraction, **SFE:** Supercritical fluid extraction

2.1. Potency Analyses

Potency analyses cover the determination of cannabinoids in the product, such as tetrahydrocannabinol (THC), cannabidiol (CBD), and cannabigerol (CBG). Some products are specifically designed with a high THC content to provoke psychoactive effects [22, 23], although increasing THC levels are associated with anxiety, depression, and physical dependence on cannabis [24-26]. Therefore, potency testing (particularly for Δ^9-THC) is crucial for medical cannabis consumers. Potency is generally analyzed by Gas Chromatography (GC) and Liquid Chromatography (LC) [27]. In the GC technique, Mass Spectrometer Detector (MSD or MS offers excellent sensitivity with high cost) and Flame Ionization Detector (FID, low sensitivity, economical) are the most preferred detectors [28, 29]. GC analyses require a high-temperature setting, where the acidic cannabinoids are decarboxylated into neutral forms (e.g., Δ^9-THCA decarboxylated into Δ^9-THC). For this reason, GC analyses cannot distinguish acidic and neutral cannabinoids [30]. The differentiation can only be made after derivatization (esterification, methylation, silylation) of acidic analytes [31, 32]; however, this adds extra time and cost to the sample preparation.

LC operates at room temperature and does not require a derivatization step in potency testing [32-34]. MSD, Flourescent Detector (FLD), Photodiode-Array Detector (PDA), and Ultraviolet Detector (UV) are commonly used in LC analyses [10, 35, 36]. Among these, UV and DAD detectors suffer from poor sensitivity for some cannabinoids lacking chromophore regions in their structure [15, 32, 34]. As for fluorescent detection, the pH is the main parameter on the fluorescence spectrum of cannabinoids. Neutral cannabinoids are fluorescent in acidic conditions, while acidic cannabinoids are not. Therefore, LC-FLD is rarely used for potency testing [31, 34]. On the other hand, LC-MS can separate and distinguish cannabinoids in detail, thus being the most preferred potency analysis technique [33]. However, in a much more detailed analysis, such as differentiation between Δ^9-THC ve Δ^8-THC, a Quadrupole Time of Flight Spectrometry (Q-TOF/MS) or Tandem Mass (MS/MS) provides better results [10, 31, 34, 37]. Q-TOF and MS demand special analytical standards (isotope-labelled, deuterated), which are expensive, while UV, DAD, and FLD analysis can be carried out with conventional analytical standards, which offer lower costs. [6, 31]. Table 2 presents some potency tests in various cannabis and cannabis-based products.

Table 2. Extraction and analysis methods of some cannabis and cannabis-based products

Product	Analyte[a]	Analysis Technique[b]	Extraction Method[c]	Reference
Cannabis (plant)	Δ^9-THC, Δ^9- THCA, CBD, CBDA	*HPLC-DAD* Column: C8, Mobile Phase: 25 mM trietilammonium phosphate + acetonitrile	LLE (Methanol/ Hexane, 9:1, v:v) + ultrasound)	[38]
Cannabis (plant)	Δ^9-THC, Δ^9- THCA, Δ^9-THCV, CBD, CBG, CBN	*HPLC-MS/MS, UPLC-qTOF* Column: C18, Mobile Phase: 0.1% formic acid + methanol	Cryoextraction + SFE (CO_2 +Ethanol)	[10]
Cannabis (plant)	Δ^9-THC, Δ^9-THC, CBC, CBD, CBDV, CBL, CBT	*GC-MS-FID* Kolon: 5% diphenyl/95% dimethyl siloxane	Hydrodistillation n-heptane dilution	[39]
Cannabis (plant)	Δ^9-THC, Δ^9-THCA, Δ^9-THCV, Δ^8-THC, CBC, CBL, CBD, CBDV, CBDA CBG, CBGA, CBN	*UHPLC-MS/MS* Column: C18, Mobile Phase: acetonitrile (1% acetic acid) + 1% acetic acid	LLE Ethanol + ultra-sound	[15]
Cannabis (plant), marijuana, resin, oil	Δ^9-THC, Δ^8-THC, THCV, CBD, CBC, CBG, CBN	*GC-FID*	LLE (Chloroform, meth-anol)	[22]
Food supplements, cream, lotion, e-cig liquid, cannabis sweets/drinks	Δ^9-THC, Δ^9- THCA, Δ^9-THCV, CBD, CBDA CBDV, CBN, CBC, CBGA	*GC-MS* Column: 35% silphenylene	LLE (Etanol, Asetonitril)	[40]
E-cig liquid	Δ^9-THC, Δ^9-THCA, CBC, CBD, CBG, CBN	*HPLC-MS/MS* Kolon: C18, Mobile Phase: methanol + water	Unspecified	[41]
Cannabis tincture, capsule, gum	Δ^9-THC, Δ^9- THCA, Δ^9-THCV, Δ^8-THC, exo-THC, CBN, CBC, CBD, CBDA, CBDV, CBG, CBGA	*UPLC-DAD-MS*	LLE (Isopropanol + ace-tonitrile)	[42]

[a] **Δ^9-THC**: Δ^9-tetrahydrocannabinol, **Δ^9-THCA**: Δ^9-tetrahydrocannabinolic acid, **Δ^9-THCV**:Δ^9-tetrahydrocannabivarin, **Δ^8-THC**: Δ^8-tetrahydrocannabinol, **CBC**: Cannabichromene, **CBD**: Cannabidiol, **CBDA**: Cannabidiolic acid, **CBDV**: Cannabidivarin, **CBG**: Cannabigerol, **CBGA**: Cannabigerolik acid, **CBL**: Cannabicyclol, **CBN**: Cannabinol, **CBT**: Cannabitriol, **exo-THC**: $\Delta^{9,11}$-tetrahydrocannabinol.

[b] **FID**: Flame ionization detector, **GC**: Gas chromatography, **HPLC**: High-performance liquid chromatography, **LC**: Liquid chromatography, **MS**: mass spectrometer, **q-TOF**: Quadropole time of flight spectrometry, **UPLC**: Ultra performance liquid chromatography, **UV**: Ultraviolet detector

[c] **LLE**: Liquid-liquid extraction, **SFE**: Supercritical fluid extraction.

2.2. Terpene Analyses

Terpenes are hydrocarbons constituted by isoprene units (C_5H_8), and more than 150 terpenes are identified in cannabis. Terpenes protect the plant against pathogens, aid in pollination by attracting bugs, and give off the characteristic cannabis smell [43-45], and they are also considered to have therapeutic effects [46]. Mono and sesquiterpenes are quite volatile compounds and therefore require cryogenic sample preparation methods to avoid analyte loss [47]. Terpene extraction is usually done through LLE and SPE; however, volatile-specialized techniques, such as headspace and SPME, are more suitable for terpene analysis [48]. After extraction, terpenes are analyzed mainly by GC-MS or GC-FID due to their volatility [29, 44].

2.3. Heavy Metal Analyses

Contaminated soil and low-quality plant nutrients/minerals are the primary sources of heavy metal accumulation in cannabis plants [49]. For heavy metal analysis, samples are first digested either by mineral acids (HNO_3, H_2SO_4,HCl) or by high temperature to remove organic content [50-52]. Analyses are carried out by various techniques, including Atomic Emission Spectrometry (AES), Atomic Absorption Spectrometry (AAS), X-Ray Fluorescence Spectroscopy (XRF), Inductively Plasma Optic Emission Spectrometry (ICP-OES), Inductively Coupled Plasma Mass Spectrometry (ICP-MS) [49, 53]. Among these, LC-ICP-MS is the most sensitive technique, frequently preferred despite its high cost [42, 54-56], while AAS is also an economical alternative despite its low sensitivity [57-59].

2.4. Residual Solvent Analyses

Organic solvents are used in the manufacturing process of some cannabis products, such as cannabis oil, extracts, and food supplements. Accordingly, these solvents can be found in residual amounts in the product [60-63]. Because of their volatility, residual solvents are analyzed through GC-FID and GC-MS. These analyses offer excellent sensitivity, especially when they are combined with Headspace sampling techniques [64, 65], such as Full Evaporation Technique (FET) [66], SPME [65], Static Headspace Sampling (SHS) [67-69].

2.5. Pesticide Analyses

Cannabis growers rarely use pesticides as the plant is naturally resistant to many pests [70, 71]. Pesticide contamination usually occurs in trace amounts; therefore, the extraction and analysis of pesticides should be carefully performed to minimize analyte loss [70]. Pesticide extraction from samples is generally done through LLE and QuEChERS, followed by SPE. Pesticide analysis is carried out by GC-MS or LC-MS owing to their sensitivity and multi-residue determination ability [72-74].

2.6. Mycotoxin Analyses

Fungal contamination is an occasional problem in cannabis cultivation [75]. *Aspergillus spp*., *Cladosporium spp*., and *Penicillium spp*. are dangerous fungus species because these can produce mycotoxins dangerous to human/animal health [71, 76]. For mycotoxin analyses, samples are prepared and processed using Immunoaffinity Columns (IAC), LLE, and SPE. After extraction, Enzyme-Linked Immunosorbent assay (ELISA), GC-MS, and LC-MS/FLD/DAD/UV techniques are primarily used for the analysis. The drawback of GC is the need for a derivatization step, while the drawback of ELISA is the cross-reactions, although it is the easiest and fastest technique [77]. Therefore, LC techniques, especially LC-MS, are the most preferred analysis tools in cannabis mycotoxin analyses [78].

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HEMP AS A SUSTAINABLE PHARMACEUTICAL RAW MATERIAL SOURCE

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ABSTRACT

The meaning of sustainability is constantly evolving in this rapidly changing world. One of the first official definitions of sustainable development was expressed in the Burtland Report published by the United Nations in 1987 as "development that meets the needs of the present without compromising the ability of future generations to meet their personal needs". One of the biggest problems in health is the sustainability of the acquisition and management of qualified and eco-friendly pharmaceutical raw material resources. A sustainable source of pharmaceutical raw materials should serve the people of today's world and respond to the health needs of future generations with a qualified approach. Hemp products are gaining importance as the need for products with a lower environmental footprint increases. As a low-input, fast-growing and high-yielding crop, hemp has great potential for future sustainable crops. Hemp has been used in medical applications for thousands of years as a sustainable drug raw material source with its rich secondary metabolite content and phytocannabinoids. It is a plant used in traditional Chinese medicine for thousands of years as an alternative medicine product in treating diseases. When the cannabis plant is grown, its leaves and flowers are valued for their medicinal wealth. The remaining parts of the plant are also the subject of many researches; It is used in domestic and industrial applications such as paper packaging, cigarette paper, waxed paper, electrical insulation paper, textile, pulp, composite material, construction material, fuel, food, cosmetics, synthetic plastic. Cannabis offers an excellent opportunity for sustainable raw material and climate change control due to its fast-growing crop cycle of around four to five months, its wide range of applications, and its capture of two-three times more carbon dioxide per hectare per year than forests.

Keywords: Hemp, Medicine, Sustainability

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1. INTRODUCTION

Industrial cannabis (*Cannabis sativa* L.) is an annual herb harvested as an all-purpose crop [1]. It is estimated that the cannabis plant spread worldwide, most likely from the temperate regions of Asia. It is thought that cannabis originated in Central Asia and spread to China, Thailand and Malaysia. Evidence of textile products produced from hemp fibers is mainly found in China 6000 years ago [2]. It is estimated that the plant and its textile-related products were later brought to Western Asia, Egypt and Europe. Although the cannabis plant has a long history as a textile material, the uses of the hemp plant are not limited to textiles. In ancient China, besides its medicinal uses, the cannabis plant was also a part of Hebrew rituals performed after people died [2, 3].

Medicinal uses of cannabis have a history equivalent to industrial uses. Both hemp seeds and cannabis oils are known to be used in traditional Asian medicinal practices to relieve many diseases and symptoms[4-6]. It is known that the medicinal applications of cannabis were primarily identified in India and China in the past. B.C. Cannabis products have been used frequently in China and India since 5000 for indications such as antipyretic, pain reliever, controlling rheumatic pain, and constipation.

This review study was carried out to evaluate the sustainability of hemp as a source of pharmaceutical raw materials for medicinal purposes. We need sustainable raw material resources to prevent climate change, protect the ecology as it is without harming it and have a livable planet with all of these. The need to evaluate nature-friendly products as sustainable drug raw material sources in the health and pharmaceutical sector is increasing daily. Because of all these, this compilation study aims to evaluate the sustainability of cannabis, a nature-friendly/positive additive product, as a raw drug material source and raise awareness on this issue for a livable world.

2. SUSTAINABILITY OF THE PHARMACEUTICAL INDUSTRY

The pharmaceutical industry covers the research and development of drugs, vaccines, new methods and products to be used in the treatment and diagnosis of diseases and the delivery of these products to everyone who needs them. As the need for the diagnosis and treatment of diseases increases, the need for the pharmaceutical industry to act with the awareness of sustainability also increases. Therefore, the steps to be taken within the framework of the recent climate crisis include the sustainability of the pharmaceutical industry, pharmaceutical raw material resources and the activities to be carried out in this direction [7].

The first step in the sustainability of the pharmaceutical industry is in the environmental dimension. The environmental effects of pharmaceutical production have supportive findings in the emergence of ecological problems [8, 9]. The emission values of pharmaceutical production reveal that the carbon emissions in this production chain are at substantial levels [10]. For this reason, it is considered important in terms of sustainability to support green activities more in drug production and to find materials that respect the natural environment instead of synthetic raw material sources in the pharmaceutical industry [11, 12].

It is possible for the pharmaceutical industry to create an environmentally friendly drug production and marketing cycle with a holistic understanding of sustainability and to ensure sustainability in environmental, social and economic dimensions [13]. It is not enough to carry out only the production of drugs with environmentally friendly methods. At the same time, the pharmaceutical supply chain should proceed in the same sustainable framework [14]. In this direction, it is of great importance to bring raw material resources that respect nature and the planet and allow green activities to the pharmaceutical industry.

3. SUSTAINABILITY OF HEMP

Cannabis, a C3 plant, can compete with forest areas regarding carbon uptake and photosynthesis rate, and carbon consumption can reach up to 22 tons per hectare [15]. 74 Cannabis suppresses weeds in the area where it is grown. It is known to remove heavy metals and pollution in the soil by phytoremediation. Thanks to its quality suitable for exchange, it offers suitable field conditions for the plants grown after it. It also has a positive effect on biodiversity. In addition, due to the high adaptability of hemp, it can be grown in different climatic conditions [16-18]. All these reveal that hemp is a sustainable product when considered within the framework of nature's perfect cycle.

Changing climatic conditions prevent agriculture from being carried out sustainably. An increase in air temperatures, changes in precipitation levels, and extreme weather conditions cause yield loss in agricultural practices. In addition, due to pesticides used to reduce yield loss, uncontrolled fertilization and irrigation practices applied to increase yield, the natural structure of nature is damaged, and sustainable agriculture rates decrease. It is thought that plants can support sustainable agricultural practices with high sustainability potential within the framework of adaptation to climate change. In addition to the view that sustainable agricultural practices can progress in cooperation with countries, it is stated that sustainable agriculture is possible with nature-friendly plants that do not require pesticides, have low water needs, and have strong adaptability [19]. Considering the qualities of hemp, it can be stated that hemp is a highly suitable plant for sustainable agricultural practices.

4. HEMP FROM A PHARMACEUTICAL PERSPECTIVE

Hemp is used in alternative and traditional medicine because of its phytocannabinoids. The remarkable pain-relieving and anti-nausea effects of cannabis are the most common indications for medical uses of cannabis. It is stated that the majority of the undesirable side effects that occur after cannabis applications are related to THC [20]. Generally, other phytocannabinoids, such as non-psychotropic CBD in cannabis content, are used to balance the side effects caused by THC.

Preparations and active ingredient mixtures produced from cannabis have been used for many years in the treatment of chronic pain characterized by diseases such as cancer, neuropathic pain or MS. In addition, the traditional use of the cannabis plant is to treat nausea and vomiting, and the phytocannabinoids contained in cannabis are effective antiemetic agent in clinical trials. Phytocannabinoids act as antiemetic agents on CB1 and 5-HT3 receptors in the vomiting center and dorsal vagal complex (DVC) [21].

Cannabis is an effective plant to the point of increasing appetite. Literature studies show that inhaled cannabinoids increase food consumption and calorie intake [22, 23]. Besides, it is known that cannabis has an effective place in the treatment of multiple sclerosis. In this context, the Sativex oromucosal spray drug containing the FDA-approved nabiximols active ingredient is used to reduce severe muscle spasticity in MS patients. [24].

In cancer therapy, cannabinoids have been found to inhibit tumor cell proliferation, angiogenesis, and tumor invasion and induce apoptosis in vitro and in vivo by activating cannabinoid receptors [25]. Known cannabinoid mechanisms to induce apoptosis are listed as orphan G-protein coupled receptor 55 (GPR55), transient receptor potential channel subfamily V member 1 (TRPV1), and transient receptor potential channel subfamily M member 8 (TRPM8) [26].

Amid the promising therapeutic benefits, high propensity for abuse, and safety concerns, further research is needed to better understand cannabinoid interactions in the human body and elucidate the potential medical applications of cannabis.

5. CONCLUSION

Cannabis is a remarkable source of pharmaceutical raw materials with its climate adaptation, environmentally friendly qualities, rich cannabinoids and medicinal effects. The fact that cannabis production contributes to the environment and is highly sustainable for nature is also essential in terms of obtaining medicinal active substances. Now, hemp is seen as a drug production machine that can sustainably produce the same active substance without waste. However, more research is needed to elucidate the medical efficacy of these sustainably produced riches.

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CLIMATE CHANGE AND HEMP

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ABSTRACT

It has important targets for 2030 and 2050 within the scope of the implementations of the "European Green Deal - EU Green Deal" accepted by the European Union Commission. These targets are; It is structured under 7 policy areas: a) clean energy, b) sustainable industry, c) construction and renovation, d) farm to fork, e) elimination of pollution, f) sustainable mobility and g) biodiversity. From these established policies; In terms of our country, it is expected that the sectors that use coal as energy in production, such as Automotive, Textile, Plastic, White Goods, Construction Materials, Chemistry, will be affected more. On the other hand, in accordance with the Paris Climate Agreement signed by Turkey in 2021, it is necessary to present and implement the details showing the 30% reduction targets of emissions in the energy, waste, transportation, buildings and agriculture sectors for 2030. Hemp agriculture and industry presents a great opportunity in order to fulfill the provisions of both the EU Green Deal and the Paris Climate Agreement. Turkey's first venture in the industrial sector of hemp was with textiles. The construction of a facility that can process hemp and similar products for textile purposes, which is expected to come into service in May 2023, continues in the Havza district of Samsun. It is necessary to discuss the scope of the subject as textile first. It is expected that the "Border Carbon Tax" applications will be started as soon as possible during the entry of textile products with a high "Carbon Footprint" into the European Union Member States. Carbon Tax at the border is planned to be implemented not only in the textile sector, but also in many sectors. Since we export a significant part of our exports to European Union countries, these practices will have a significant impact on our country. Precautions must be taken as soon as possible in order to reduce the "Carbon Footprint" of the products we manufacture, starting with our exported products. In the case of textiles obtained from natural products; In conventional production of cotton plant, carbon and water footprint is very high compared to flax and hemp plants. For this reason, it is certain that increasing the use of alternative fiber plants in our cotton-based textile industry will make significant contributions to reducing the carbon and water footprint of textile products. Hemp is one of the leading non-cotton fiber plants that can reduce the carbon footprint in textile products. Registration of hemp varieties suitable for fiber production is one of the most important steps to ensure standard and quality fiber production in fiber-purpose hemp cultivation areas in our country. Considering the material value and market share that will be lost in the carbon tax application at the border to be applied by the EU; The investment costs required to increase the use of alternative fiber plants such as hemp in the textile industry will be a significant gain and gain rather than a loss.

Keywords: Hemp, Green Deal, Paris Climate Agreement

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1. INTRODUCTION

Hemp is an agricultural product that contributes significantly to the livability of the world with its product variety and function in nature, and it has a very important role in protecting the environment. Due to the pressure of synthetic products, insufficient and inappropriate investments, sufficient development has not been achieved in the agriculture and industry of this plant in the last 50 years. The hemp plant, which is very important in the industrial sense, acts as a bridge between the economy and the environment. In the last 20 years, with the increase in consumer awareness in the world, the demand for natural products tends to increase. The attraction of natural fibers and products obtained from these fibers, especially in the textile and clothing sector for babies and children, is increasing. Hemp has a wide range of uses. It can be used as food, as well as to provide raw materials for the textile and pharmaceutical industry, high quality construction material production, and many other similar areas. Other usage areas are soil and water improvement, carbon sequestration, wind erosion, polymer and carbonite production that can be used in the automobile industry and paint industry, and raw material in the pharmaceutical industry.

2. CARBON FOOTPRINT AND HEMP

Hemp produces abundant leaves per unit area. Therefore, O2 production is relatively high[1]. In addition to improving soil structure, it can often be produced with low environmental impact. It can replace unsustainable raw materials (plastic from petroleum derivatives, paper from forests, etc.). Thus, it can prevent environmental pollution as well as contribute to the protection of the tree population [2]. Even if hemp stalks are used as fuel, it is an advantageous plant in terms of carbon footprint. Because, in a period, it produced more oxygen in advance than it would consume. Due to this feature, it is stated that it contributes to prevent global warming [1]. Hemp can produce 750-2000 kg of dry habitat per decare. This figure is higher than many forests on an annual basis [3]. According to Hemp Global Solutions, each dry hemp habitat produced absorbs 1.63 tons of CO_2 when produced [4]. Hemp can replace most toxic petrochemical products. Work is underway to produce plant-based recycled plastics and biodegradable plastic products from hemp, and petro-chemical plastics and polymers may be replaced by vegetable plastics and polymers in the near future [5].

Brick (Hempcrete), which is obtained by mixing ground hemp stalks with lime, is expected to become widespread in the future[6]. It is stated that after the hemp stalks are used in any sector or applied on the wall, Hempcrete has a low carbon footprint because it continues to emit CO_2 [7].

3. AGRICULTURAL ENVIRONMENT AND HEMP

Being superior to other field crops in combating weeds makes hemp advantageous. It has a very tight vegetation that can rise 2.5-6.0 meters. In particular, the plant that comes after hemp is lucky when grown by frequent planting (120-180 plants per m^2) and irrigation. Because it does not give life to weeds by overshadowing them due to its very fast growth, hemp is very effective in the struggle of fast-growing weeds, especially wild oats. Thus, there is no need to use weed pesticides in hemps farming. Since it leaves a clean field for the next plant, it also reduces the use of herbicides in the cultivation of plants in the rotation system. In one study [8]; They determined that hemp suppresses the majority of weeds in wheat-hemp alternation. It is stated that the competitive power of hemp with weeds is high with the appropriate frequency of production [9]. In our country, in hemp production, insecticide, fungicide, etc. Medicines are not needed as well. Therefore, hemp; It is environmentally friendly and a very suitable plant for a nature-friendly farming system [10].

4. CLEANING SOILS OF HEAVY METALS AND HEMP

Industrial establishments are the basic building blocks of the country's economy and they are a necessity in order to avoid foreign dependency. However, as these organizations have beneficial aspects, they also cause harm when they are acted unconsciously. Heavy metals are used in the operation of many industrial establishments and these metals are released directly or indirectly to the environment. These metals are cadmium, chromium, copper, mercury, lead, nickel, tin, and zinc [11]. Source-specific heavy metal wastes cause damage to the ecosystem that is very difficult to recycle. Measures should be taken to prevent the metals discharged from these facilities from spreading to the environment, and these heavy metals emitted to the environment should be taken from nature again without further contamination and loss of time. According to the researchers, removing heavy metals with plants is ten times cheaper than removing heavy metals by physical and chemical methods. In these areas, hyperaccumulator plants can be grown, grown plants can be harvested, and the metals accumulated in their bodies can be recovered by burning the dried plants, and the cost of production can be reduced by selling these metals obtained. Ash obtained by burning plants is also a metal mine [12]. A number of studies on hemp have revealed that due to its high biomass and deep roots, it can accumulate significant heavy metals from contaminated soils, making it a good candidate for soil remediation. The discovery of the high potential of hemps in soil restoration was discovered by the Ukrainian Institute of Bast Plants in the improvement of Chernobyl soils [12]. A number of studies on hemp have revealed that due to its high biomass and deep roots, it can accumulate significant heavy metals from contaminated soils, making it a good candidate for soil remediation. In many studies, various heavy metals such as Ni, Pb, Cd, Zn and Cr have been reported to accumulate in hemp [13]. Since the majority of plants with high heavy metal intake do not constitute economic gain, hemp is one of the most suitable plants with a high economy, which is widespread in different areas of use and can be grown in every ecology.

5. CONCLUSION

Hemp is an easy plant to cultivate and produce. It also provides a lucrative income source to the producer. It is expected that hemp agriculture will increase in the world and the hemp industry will become more widespread with the help of developing technologies. It will be even more important in changing climatic conditions due to thelow carbon footprint and water footprint of hemp.

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COMPARISON OF VARIOUS BUILDING MATERIALS PRODUCED WITH HEMP FIBER AND HEMP STRAW WITH TRADITIONAL BUILDING MATERIALS

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ABSTRACT

After understanding the strategic importance of hemp in Turkey and starting to reproduce it, it has started to be the subject of multidimensional scientific studies. The usability of hemp products, whose production has become widespread in Samsun and its vicinity, where the Hemp Research Institute is located, is among the research topics. The hemp products investigated for use are mostly broken-tow type products produced from waste hemp stalks. However, the usability of hemp fiber, which is accepted as the main product, is also included in the studies and its contribution to the results is examined. In this study, four types of tow material (in all samples) obtained from fiber (in some experimental groups) and hemp stalk called waste (in all samples) were used as hemp product (T1, T2, T3, T4, respectively, from coarse to fine). In the experimental study, six different binders were used: three types of lime (for plastering, natural hydrolytic and cream), cement, gypsum and water-based glue. Small amounts of silica sand and brick tow were included in some samples using lime cream. Brick tow was used for Horasan type mortar sampling. Carbon dioxide gas was applied for three days to accelerate the chemical reaction, but it was not possible to measure its effect. Clay obtained from the Kavak region, which is used in traditional brick making, which is not a binder but a good bonding material, was also used in the sample production. The main purpose of this is to determine the temperature behavior in the mass of hemp products. Various ratios of binder/binding materials and various ratios of hemp products and water were used in the samples produced. Changes in unit volume weights and thermal conductivity coefficient measurements were made on all samples. Compressive strength tests were also carried out on the cube samples, in which binders were used, and the size changes were examined. According to the measurements made on the samples with 15 different compositions, the unit volume weight of 13 of them was found to be less than 1 kg/dm3. According to the thermal conductivity coefficients, some samples were found to be called "Insulation Material" (k<0.06). In some compositions, the k coefficient was found to be higher than the lower limit of the insulation material (in the range of 0.060-0.085). According to the pressure test, highly flexible, non-destructive, low unit volume weight (very suitable for earthquake) materials were obtained. According to the results of the produced building material samples, it was concluded that it cannot be used as a load-bearing structural element in its current state, that it can be applied on-site and easily as a partition element and insulation material, and that it can also be used as economical building materials.

Keywords: Hemp, Hemp Tow, Hemp Straw, Hemp Fiber, Structural Element

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1. INTRODUCTION

There are many publications on the use of hemp and its products as building materials. Studies and publications in Turkey are still few and limited. Some published studies are listed below. Beyond the "zero carbon" products, the importance of which is constantly increasing today, the use of hemp products with their "negative carbon" feature has the qualities that will allow the production of materials that can be the "solution of the future". [1], Hemp and its products have many positive features; [2], the superior properties of the building material called "hempcrete" made with hemp-lime; [3], that "houses are built with hempcrete technology" in many places in the world and studies are carried out rapidly, that fibers obtained from hemp are in the main group of "natural fibers", in the subgroup of "vegetable fibers", in the classification of fiber types, "multicellular-simple fiber". is; [4] states that hempcrete is a revolutionary building and thermal insulation material that can be used to build an entire house without bricks or other thermal insulation.

Hemp fiber panels can be shaped into veneers, sheets or even bricks and used in wall construction [5]. First of all, it should be noted that the total carbon emission value is negative [6]. [3], as a result of their work on hemp, generalizes for green and sustainable building "sustainable development, a development model that meets the needs of the present without compromising the ability of future generations to meet their own needs". [7] also concluded that this material also allows the untreated 30 cm thick hemp concrete wall to store 36.08 kg of CO_2 per m^2. [8], Flax and hemp can be mixed together to produce high performance thermal insulation material, the best performing blend material has a thermal conductivity coefficient of 0.033 W/m K, a 32 kg/m^3 made of flax fiber, gravel and a synthetic binder. states that the heat transfer coefficient was determined as 0.043 W/m·K and the water vapor resistance factor as 2.9 in the measurements made on a dense sample. It is stated that the hemp-lime material called hemp concrete is a good thermal insulator [9]. The water absorption, mechanical strength and dynamic strength of the polyethylene film coated hemp composite were investigated and SEM images were taken. The mechanical properties of the composite obtained by using hemp fiber and polyurethane in various proportions were investigated, and based on the results obtained, the critical fiber length of the hemp fiber was tried to be determined [10]. It is natural to obtain results such as the improvement of the water-moisture relationship of polymer-coated hemp. However, the obtained composite materials (composite materials) no longer have the "natural hemp" properties, but have partially or completely lost other positive features that can be expected from hemp. Hemp insulation is used to make high quality acoustic insulation as sandwich (layered) composite materials to reduce airborne sound. The insulation made of hemp fiber has a thermal conductivity coefficient between 0.38 and 0.40 W/m^2K and is among the best products [11]. Considering that in order for a material to be defined as an "insulation material", its thermal conductivity coefficient should be ≤ 0.06 W/m^2K, it is concluded that it is a very good material, based on the idea that if an element of a certain thickness is used, no additional insulation layer is required.

[8], in the study examining alternative materials, mixed hemp fibers produced from jute with polyester fiber and fire retardants, and examined its physical and mechanical properties, taking into account that it is a textile fiber used for building applications. [6] investigated the behavior of lime mortar bonded building blocks (Hempcrete) produced using hemp against temperature. [12] discussed the results by producing materials containing 25% and 40% by weight hemp fiber to measure the effect of temperature on the mechanical properties of polypropylene composites. The physical properties of hemp crumb (splinter)

and fiber were determined by [13]. It should be noted that the use of cement alone as a binder presents significant setting problems in a hemp concrete matrix and does not significantly increase mechanical strength compared to hydraulic lime as other natural binders such as lime and clay cannot compete with other positive material properties [2]. The result that “hemp-lime concrete is 7 times lighter than conventional concrete” [4] turns out to be the most interesting feature of hemp. According to the results obtained in this study, the unit weight of the hemp samples decreased to the level of 0.40 kg/dm^3. Considering that this value is 2.4 kg/dm^3 for concrete, the same value appears as 6 times. However, this value is not general and is valid for some samples. According to the results of this study, the unit weight value that can be generalized can be given as 0.8 kg/dm^3 and it is approximately 3 times lighter than concrete.

[4], it can be taken into account that approximately 120 m^3 hemp-lime (hempcrete) is required for a 100 m^2 detached house with a 50 cm thick hemp wall (it can be taken into account that 84 m^2 hemp cultivation area is required for a 1.2 m^2/m^3, 1 m^2 building), in which case It states that the amount of CO_2 to be captured will be 13 tons (0.65 t/m^3 or 9.23 m^3/t), and that the required production will only be possible over time, that the product in the market is not sufficient in the current situation, construction costs and the expertise (real value) required for the construction of the construction. indicates that it cannot be done. The disadvantages highlighted for real and reliable calculation are also valid for Turkey. Considering the use as a building material, there are no encouraging results in terms of hemp production area.

The average cost of a standard family home is $295300 in June 2020, according to the National Association of Realtors (NAR). The average unit cost of building a house with an average area of 112.5 m^2 is $2625/m^2. It should be noted that prices will vary depending on location, whether special designs are used, and build size. The amount of hemp-lime (hempcrete) material required to build a house depends mainly on the area of the house being built. About 2500 m^2 of hemp is needed to produce enough hemp material to build an average 112.5 m^2 house. It should be taken into account that each project is unique and the installation method will be different. It is also clear that each method for hints will require different amounts of materials and labor. However, it can be assumed that the total material price of the finished building is approximately $706-1059/m^3 (the rest of the unit cost is the sum of costs excluding material supply). The properties that construction materials and insulation materials must have are given in the relevant Turkish Standards. The insulation materials planned to be produced in this study are listed as low heat permeability, high vapor diffusion resistance coefficient, fire resistance, mechanical strength [14] and [15]. However, since the existing facilities do not allow to do all of them, the test results that can be done are given and the necessary evaluations are made.

2. MATERIALS AND METHOD

All conventional binders are intended to be used in addition to binders used in published studies. In this respect, it is aimed that the results to be obtained will contribute to the formation of an important scientific field. The use of clay binder was tried for the first time. Apart from the fact that it is a different study on a world scale, the necessity of renewing the different ratios and amounts of the tested binders with new studies was considered important. From this, it has been understood that there is a need for more comprehensive studies on cultivation and obtaining various products in Samsun, which is a cannabis cultivation and research center.

The produced samples were designed as external wall/bearing element, partition element and insulation element. However, after the trial productions, the production of carrier element samples was abandoned, taking into account the test constraints. Cement, lime varieties, clay, gypsum and water-based glue were used as binders. Prismatic elements are formed by hand compression. Coating and insulation materials are produced by applying pressure in the dimensions of 20x30 cm and 30x30 cm (15 and 20 tons). All the samples produced and the experiments performed are explained in detail below. In order to carry out the experiments, binder and auxiliary materials and broken (manufactured by removing the stem) fiber and tow varieties (Coarse tow-T1, Medium tow-T2, Fine tow-T3 and Dust-T4) were provided as hemp product material. No experimental studies have been conducted on the physical properties of the materials to be used with hemp products, except for cream lime and clay. When necessary, the values on the packaging or specified by the manufacturers are used. The amount of free water was measured for the creamy lime and mud-like clay.

In the production of pressure-applied plate type samples, 25 mm thick steel sample cups that will have sufficient strength other than coating the mold surfaces were used. In order to eliminate the waiting time, inner molds that can be removed manually into the outer mold were also produced, and at the same time, two separate 6 removable inner molds with 30x30 and 20x30 cm surface areas, called large and small, were used. No experimental results were obtained from the samples intended for pre-production. It was used to make literature supported determinations for the determination of suitable compounds. For experimental studies, these determinations were used with some adjustment when necessary.

3. EXPERIMENTAL WORKS

In all of the samples, cube molds with polymer material with a side length of 15x15x15 cm, and custom-made steel containers with a surface area of 20x30 cm and 30x30 cm and a maximum thickness of 6 cm were used (Figure 1). Some connectors used are given in Figure 2.

(a) (b)

Figure 1. Special molds for standard cube and pressure plate, a) Standard cube, b) Special molds

Figure 2. Some binding materials used in sample production

The mixtures prepared according to the composition ratios were mixed with the mixer in the laboratory (Figure 3a). Insertion into cubes and special molds was done manually (Fig. 3b-c). Pressurized specimens were pressurized with a concrete press (Figure 3d). 15 tons of pressure was applied to the samples with a surface area of 20x30 cm, which is generally called small, and 20 tons of pressure was applied to the samples with a surface area of 30x30 cm, which is called large. No pressure was applied to the cube samples. Except for the first studies, plastic products were used instead of aluminum foil separators.

(a) (b) (c) (d)

Figure 3. Placing and removing the mixer and samples from the molds

Figure 4. Storage of samples

The samples produced according to their composition ratios were generally taken out of the mold after 3 days, except for those using cement binders (Figure 4). No special care was applied except wetting in the samples using cement binder and intermittent wetting in the others. No maintenance was performed on the samples using water-based glue. In the samples where the clay is a binder, the free water is kept in a closed environment (at least one day, at most two days) after demoulding, followed by drying in the sun by turning it upside down for two days in the absence of air flow and sun, and then once or twice a day. expected to leave the body. After the free water dried, all samples were processed at 105 ^{o}C for 48 hours, except for the glued ones. The same process was performed for the glued samples at 50 ^{o}C (Ready-to-measure samples are given in Figure 5 and Figure 6).

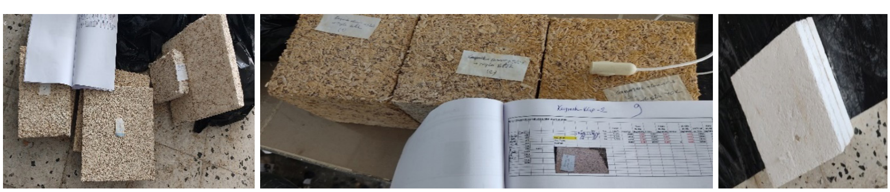

Figure 5. Produced and ready-to-test samples

Figure 6. Various binders used sample sets

In the samples where lime varieties were used, CO_2 application was made in the indoor environment, based on the hardening of the lime as a result of the reaction with carbon dioxide in the air. The application was carried out in the form of giving CO_2 gas to the samples lined up in the oversized bag from the CO_2 tube, immediately closing them and waiting, and repeating this process 2-3 times with 2-3 days intervals. However, it was not possible to measure the effect of this procedure on the results, since the working time is very limited. Since only the pressure test could be performed on the samples, it was not possible to determine the hardness difference with the bending test. In the pressure tests, since no sample was completely broken (destroyed as a result of fracture), it could not be determined how much or in which direction the CO_2 effect was.

4. RESULTS

Water absorption and return of water was the first experiment on hemp products in all produced samples. The water-moisture change measurements obtained from natural hemp products are given in Table 1. The sample unit weights, which show parallelism with the removal of the unreacted part of the water used in the mixture or the water used for workability (free water) on the produced samples, were measured and evaluated for all samples. Compressive strength tests on cube samples produced for all mixtures were performed and evaluated. Thermal conductivity coefficients (heat transfer rate from unit area through unit thickness of the material at unit temperature) (k, W/mK) values were measured on all cube and plate shaped samples.

Table 1. Time-dependent water absorption and water loss values of hemp

Material Type	Natural State, Water Absorption and Drying (g)						Water-Moisture Values (%)				
	Natural	Oven dried	Absorption (48h)	5 Days	7 Days	10 Days	Natural	Absorbed(48h)	5 Days	7 Days	10 Days
Large Splinter	100	90.85	148.22	125.18	113.46	101.86	10.07	63.15	23.16	18.06	9.70
Big Tow	100	87.45	249.42	224.07	194.91	124.87	14.35	181.33	53.41	46.44	17.45
Medium Tow	100	87.82	244.31	217.97	188.47	113.64	13.87	174.74	52.03	44.79	12.09
Fine Tow	100	85.43	306.68	278.96	245.95	167.8	17.05	252.64	61.34	55.60	31.29
Dust	100	83.75	347.37	332.96	276.59	124.01	19.40	306.29	69.70	55.78	11.99
Fiber	100	83.28	194.43	166.13	135.83	94.56	20.08	124.38	38.72	27.08	2.73
Total/ Avg.	600	518.58	1490.43	1345.27	1155.21	726.74	15.80	183.75	49.73	41.29	14.21

Thermal Conductivity Calculation Value (λ, W/mK) expresses how much a material transmits heat depending on its physical and chemical structure. The thermal conductivity calculation value, W/mK unit, is the amount of heat that passes between the 1 m^2 surface of the thermal insulation material at a distance of 1 m perpendicular to each other, when the temperature difference is 1°C, although it is related to k, it can be found if different parameters are known.

Thermal Permeability Coefficient U (W/m^2K) is the amount of heat that passes vertically over 1 m^2 surface in 1 hour when the difference between the temperatures of two parallel surfaces of a material with a thickness of d (m) is 1K=1°C. The U value depends on the thermal conductivity calculation value (λ) of the materials and the thickness in the direction of heat transfer. The smaller the thermal conductivity coefficient, the less the heat loss. In this respect, considering that it would not be realistic to calculate the λ or U value with the measured k coefficient, the same k coefficients were measured and compared as reference values in 10 materials that would reduce the need for thermal insulation or are used directly for thermal insulation.

4.1. Unit Weights

Test samples using cement, clay, natural hydrolytic lime, plaster lime, cream lime, water-based glue and gypsum and hemp products were weighed and recorded at periodic intervals during the planned maintenance operations after they were produced and removed from the mold.

The unit volume weights measured are given in Table 2. Drying in an oven means 105 °C and 48 hours of waiting time. The drying temperature was 50 °C and 48 hours in the sample set, in which only water-based glue was used. The water-moisture status and unit volume weight information of all samples given in Table 1 are summarized and ordered from smallest to largest. When this summary table is examined, it is seen that the unit volume weight is less than 1 in 14 of 15 different experimental sets. The unit volume weight was found to be less than 0.5 in 3 groups of samples where hemp was treated with water-based glue, cream lime and natural hydrolytic lime and the amount of binder was low and the amount of hemp was high. From this, it can be concluded that almost all of the samples produced will be suitable for the production of very light structural partition elements and will be very suitable for research and use in terms of earthquake effects.

Table 2. Unit volume weights of all samples (Averages/ranked)

No	Sample Name	Dry Unit Weight (kg/dm^3)
1	Water-based glue-hemp cube samples	0.33
2	Cream lime-hemp cube samples	0.44
3	Natural hydrolytic lime-hemp cube (1st set)	0.46
4	Clay-hemp (2nd set) plate samples (30x30x3 cm)	0.52
5	Cream lime-hemp (2nd set) plaque samples	0.54
6	Gypsum-hemp cube samples	0.55
7	Cream lime-hemp cube samples	0.61
8	Natural hydrolytic lime-hemp (3rd set) plate samples (30x30x3 cm)	0.64
9	Natural hydrolytic lime-hemp cubes (2nd set) broken cube samples	0.66

10	Natural hydrolytic lime-hemp (3rd set) plate samples (Spare)	0.68
11	Natural hydrolytic lime-hemp (3rd set) plate samples (20x30x3 cm)	0.71
12	Clay-hemp (2nd set) plate samples (20x30x3 cm)	0.73
13	Cement binder-hemp cube samples	0.82
14	Cream lime-hemp (1st set) plaque samples	0.87
15	Clay binder-hemp plaque specimens (1st set)	1.05

4.2. Compressive Strength Tests

Compressive strength tests were carried out with the press in the Civil Engineering Department Laboratories. All of the compressive strength tests were carried out on cube samples. Since there is no longitudinal and transverse strain gauge in the device used, two dial comparators that can measure vertical and horizontal strains were mounted and the measurement was made (Figure 7). Since the longitudinal deformation of all samples exceeded the maximum longitudinal deformation limit of the press used, it was evaluated by measuring up to the limit value (35 mm). For this reason, the compressive strength values obtained are not the ultimate compressive strength, but can be considered as the minimum compressive strength. Since the actual dimensions were taken into account in the evaluation, the mean of the volume calculation was used considering that the transverse deformation measured from only one surface occurs on all surfaces. When the values in Table 2 were examined, it was observed that all the samples continued to deform transversely despite the final length change, the transverse and longitudinal deformations partially returned after the automatic stop due to the press length change, but complete destruction did not occur in any of them. From this, it has been concluded that the energy absorption capacity of the produced samples is quite high and that they show their original strength without being destroyed.

These results mean that when combined with the very low unit volume weights (14 out of 15 types of samples are less than 1 kg/dm^3, and 3 are less than 0.5 kg/dm^3), it will allow to make very light structures. These results should also be understood that there is a need for more detailed scientific, technological and production-oriented studies on our country, 95% of which is under the influence of earthquakes.

Figure 7. Compressive strength test with press and measurement of longitudinal-transverse strain

Table 3. Compression test mean stress-strain and poisson ratios

Cube Sample Name/ Description	Compressive Stress (σ_y-kg/cm^2)	Long. Shape Value (ε_y-cm/cm)	Transverse Shape V. (ε_x-cm/cm)	Poisson Rate
Cement-hemp	24.69	0.1085	0.0377	0.35
Water-based glue-hemp	6.13	0.1552	0.0250	0.16
Natural hydrolytic lime-hemp	5.67	0.1060	0.0406	0.39
Plaster-hemp	8.72	0.1398	0.0337	0.24
Cream lime-hemp	12.11	0.1629	0.0470	0.29
Cream lime and silica sand-hemp	12.73	0.1662	0.0423	0.26
Clay-hemp	18.06	0.2111	0.0554	0.26

Table 4. Pressure test mean size and volume changes

Name of test sample (Dimensions are in cm)	First trans.	First Long.	First High	First Volume	Last trans.	Last Long.	Last High	Last Volume
Cement-hemp	15.0	15.0	15.0	3375.00	16.5	17.0	13.5	3786.75
Water-based glue-hemp	15.0	15.0	15.0	3375.00	15.5	15.7	14.1	3410.43
Natural hydrolytic lime-hemp	14.8	14.8	15.0	3285.60	15.7	15.7	13.5	3316.85
Plaster-hemp	15.0	15.0	15.0	3375.00	15.8	15.9	13.5	3378.83
Cream lime-hemp	15.0	15.0	15.0	3375.00	15.7	15.9	13.5	3357.33
Cream lime and silica sand-hemp	14.7	14.7	15.0	3241.40	15.0	15.0	13.3	2992.50
Clay-hemp	14.5	14.3	14.5	3006.60	16.0	15.1	13.0	3140.80

When the results of the pressure test cube samples are evaluated together, the highest strength (actual stress) was found as 24.8 kg/cm^2 in the set made of cement and hemp products. The lowest stress value is 5.5 kg/cm^2 in the set where natural hydrolytic lime is used. Other sample strengths were found to be 6 with glue, 9 with plaster, 12 with cream lime, 13 with cream + silica sand + brick and 18 kg/cm^2 for clayey samples. It could not be determined whether the difference in the form of an increase of approximately 1 kg/cm^2 between the samples produced with creamer lime and the samples to which silica sand and brick tow were added is due to additional additives. Whether there was any increase in strength in the samples using natural hydrolytic lime and cream lime and CO_2 applied could not be determined due to the lack of necessary equipment and the lack of time to be allocated for the experiments. Additional studies should be carried out regarding the CO_2 effect, application amount and duration in order to establish the strength of the materials that are hardened by the CO_2 effect in the building materials used in historical artifacts and in which the lime is binder. According to the results obtained from the produced samples, it was concluded that it would be appropriate to use as a building material and partition element, considering that the energy absorption capacity is high and the broken samples are not destroyed. It should also be taken into account that the strengths will be found to be approximately 10% higher if the “apparent strength” calculation, which is the traditional method, is made.

Table 5. Rates of pressure test size and volume changes

Test Sample Name (Changes are %)	Transverse Change	Long. Change	Trans-Long. Change	High Change	Volume Change
Cement-hemp	10.00	13.33	11.67	-10.00	12.20
Water-based glue-hemp	7.11	10.00	8.56	-8.89	7.38
Natural hydrolytic lime-hemp	5.33	7.33	6.33	-7.33	4.77
Plaster-hemp	3.00	4.33	3.67	-6.00	1.05
Cream lime-hemp	4.80	5.25	5.02	-7.33	2.20
Cream lime and silica sand-hemp	5.04	5.27	5.16	-8.67	0.98
Clay-hemp	10.34	5.59	7.97	-10.34	4.46

4.3. Thermal Conductivity Coefficient "k" (W/mK)

Thermal conductivity coefficient measurement was made with the KD2 Pro brand device in the Mechanical Engineering Laboratories of the Faculty of Engineering. Since it is not possible to measure the Thermal Conductivity Calculation Value (λ, W/mK), in addition to measuring the thermal conductivity coefficient, measuring the same thermal conductivity coefficient (k) of 10 different materials (Figure 9) whose insulation properties are considered good or directly used as "insulation material" and comparison was made. The average values of the measurement results made on the samples are listed in Table 5 and the material measurements used for reference are listed in Table 6.

When the measured values and the values of the reference materials were compared, one of the 15 different types of samples was found to be called "insulating material" with a value of 0.051 W/mK (cannabis is treated with cream lime, produced by pressing the hemp with less lime content and more hemp content). Four different hemp samples have a thermal conductivity coefficient between 0.065-0.069 and five different hemp samples have a thermal conductivity between 0.072-0.085 W/mK (equivalent to the measured natural pumice) and are considered as materials that can be reproduced as "insulation material". The thermal conductivity coefficient of only five of 15 different hemp samples was found in the range of 0.115-0.243 W/mK. The sample with the highest thermal conductivity coefficient with a value of 0.243 W/mK was the sample produced with water-based glue with the lowest unit weight (0.33 kg/dm^3).

Figure 8. KD2 Pro measuring device used for thermal conductivity measurement

(a) (b) (c) (d) (e)

Figure 9. Materials for which reference measurements are made for thermal conductivity (a: Iso-wall, b: Sandwich panel, c: Pumice hollow block, d: Chipboard, e: PS foam-cement coated)

Table 6. Average thermal conductivity coefficients measured in hemp samples (ranked)

File name	Temp. °C	k=W/mK	r^2
Cream-Plate-Press-1	25	**0.051**	0.9998
Clay-Plate-Press (Small-1)	25	**0.065**	0.9999
Cream-Plate-Press	23	**0.066**	0.9998
Natural Hydraulic Lime Plate-Press (Small)	24	**0.067**	0.9989
Natural Hydraulic Lime-Press (Large)	24	**0.069**	0.9992
Natural Hydraulic Lime-2	24	**0.072**	0.9984
Plastered	25	**0.075**	0.9992
Clay-Plate-Press (Large)	24	**0.083**	0.9986
Cream-Cube-2	23	**0.084**	0.9993
Cream-Cube-1	25	**0.085**	0.9984
Natural Hydraulic Lime Plate-Press (Small)	24	0.115	0.9998
Grass-Cube	25	0.118	0.9990
Hemp-Clay-1	23	0.130	0.9990
Clay-Plate-Press (Small-2)	25	0.133	0.9988
Glued	24	0.243	0.9996

Table 7. Thermal conductivity coefficients measured in selected reference samples

No	File name	Notation with Letters	Temp. °C	k=W/mK	r^2
1	Iso-wall-PS Foam-White	a	26	**0.027**	0.9962
2	Sandwich panel-Foam Filling	c		**0.029**	0.9996
3	PS Foam-Cement Coated	e		**0.033**	0.9961
4	Iso-wall-XPS Foam-Blue	a		**0.034**	0.9967
5	PS Foam-Cement Coated-Intermediate	e		**0.059**	0.9988
6	Iso-wall-Natural Pumice	a		**0.074**	0.998
7	Bims Filler	c		0.104	0.9993
8	Styrofoam reinforced concrete	b		0.143	0.9993
9	Chipboard (2.5 cm)	d		0.152	0.9997
10	Cement Binder Pumice	b		0.172	0.9995

4.4. Baking Experiment on Clay Samples

Based on the knowledge that the flaming temperature of hemp products is in the range of 700 °C, which is a common view, the dry state of the samples produced as a mixture with clay is baked in the oven up to 500 °C and the surface is painted with primers and paints used in ceramic materials, by making use of the possible hardness, or with adhesives used in ceramic materials, in Kavak Vocational School. It is planned to be covered with produced ceramics. However, since it was determined that the prepared samples were charred as a result of flameless combustion at 290 °C, this stage of the experiment was evaluated as "unsuccessful". However, hemp products and clay have the potential to be used together as a building material (as a partition or partition element). No negative results were observed for the use of adobe-like bricks in the old traditional Turkish building style.

Figure 10. Firing and combustion of clayey samples

5. DISCUSSION

In the experiments on water-moisture properties, it was observed that the least moisture in the natural state of hemp products was in coarse splinters (10%), and the highest moisture in fiber (20%). In the water impregnation test (48 hours, mains water, at 20-25 °C ambient temperature), the water absorption amount and rates were found to be very high (Table 1). For T4 (Powder), which is the thinnest sized tow, the water absorption was 306%, the least water absorption was observed in the coarse splinter with the largest size and its rate was 63%. After 10 days of drying in natural environment (mixing once a day and upside down), the remaining moisture amounts were measured as 31% in coarse tow and 17% in fine tow. The moisture content of the hemp product, which was 600 g in its natural state and 518.58 g in dry form, was found to be 14% in the 10-day presentation. According to these findings, hemp products absorb water-moisture very quickly, but give it late, this situation is not suitable for use as a building material in geographical regions with water-moisture effect (additional measures can be taken), and in geographical regions where water-moisture effect is low, it is not suitable for use. can be interpreted as.

According to the results obtained from the experiments on the samples produced from binder-binder and water and hemp products, it was observed that the unit volume weight was less than 1 in 14 of 15 different test sets. Unit volume weights were found to be less than 0.5 kg/dm^3 in 3 groups of samples where hemp was treated with water-based glue, cream lime and natural hydrolytic lime and the amount of binder was low and the amount of hemp was high. From this, it was concluded that almost all of the samples produced would be suitable for the production of very light structural partition elements and would be very suitable for research and use in terms of earthquake effects.

According to the results of the thermal conductivity coefficient (k, W/mK) measurement using the KD2 Pro measuring device, only one of the 15 different types of samples has a value of 0.051 W/mK (produced by pressing the hemp with creamy lime, low lime content, and high hemp content) “insulation”. It cannot be called an insulation material in the current situation, where the thermal conductivity coefficient of four different hemp samples is in the range of 0.065-0.069, and the thermal conductivity coefficient of five different hemp samples is between 0.072-0.085 W/mK (equivalent to the measured natural pumice) concluded that it could be The thermal conductivity coefficient of only five of 15 different hemp samples was found in the range of 0.115-0.243 W/mK. The sample with the highest thermal conductivity coefficient with a value of 0.243 W/mK was the sample produced with water-based glue with the lowest unit weight (0.33 kg/dm^3). It was thought that the dried glue was effective in the formation of this value. When all the results are evaluated together, it can be concluded that if the materials produced with hemp products are used as a building element with sufficient thickness, either no insulation material will be needed, or low-thickness insulation will be sufficient and in this way, it will allow to produce important economic solutions in terms of building materials.

Actual measurements were used in the pressure tests on cube samples. This means that the strength value is found to be smaller. In the measurements made, this difference is about 10%. According to the results obtained, the highest strength is 24.8 kg/cm^2 in cemented samples. The lowest stress value is 5.5 kg/cm^2 in natural hydrolytic lime samples. The actual stress values in the other samples were found to be 6 in glued, 9 in gypsum, 12 in creamer lime, 13 in creamer lime + silica sand + brick and 18 kg/cm^2 in clayey samples. It could not be determined whether the difference in the form of an increase of approximately 1 kg/cm^2 between the samples produced with creamer lime and the samples to which silica sand and brick tow were added is due to additional additives. It could not be determined whether there was any increase in strength in the samples using natural hydrolytic lime and cream lime and CO_2 applied, due to the lack of necessary equipment and the lack of time to allocate for the experiments. Additional studies should be carried out regarding the CO_2 effect, application amount and duration in order to establish the strength of the materials that are hardened by the CO_2 effect in the building materials used in historical artifacts and in which the lime is binder. According to the results obtained from the produced samples, it was concluded that it would be appropriate to use as a building material and partition element, considering that the energy absorption capacity is high and the broken samples are not destroyed. [7] gives this thickness value as 30 cm. It should be noted that the strengths will be found to be approximately 10% higher if conventional and apparent strength calculations are used.

It is necessary to be cautious about the information that the flaming temperature of hemp products is in the range of 700-800 °C. Within the scope of this study, it was determined that the samples were charred as a result of flameless combustion at a temperature of 290 ^{o}C in the firing test performed on clayey samples. [16] gives the flaming combustion temperature as 1800 ^{o}C for 10 minutes and states that the resulting temperature is 165 ^{o}C on the passive surface. In this study, in which the results obtained are evaluated, it should be emphasized that this temperature is an incomplete information, but it may be a limited result for very specific conditions. In this study, it was concluded that hemp products used with hemp or any binder are destroyed by charring below 290 oC, even if it is not flammable.

6. CONCLUSION

Compared to the samples in which the produced hemp products are used, it has a very low unit weight as a structural element. Although there has not been a study of compatibility with the construction of the load-bearing system, it can be said that it is only suitable for the production of partition elements according to the compressive strength values for now. It can be considered as a safe construction material for Turkey, which has a low unit volume weight of 95%, which has an earthquake risk. It is suitable for the production of building materials with very high insulation properties in terms of thermal conductivity coefficient. It would be useful to search for solutions that can be a direct insulation material. No negative results were observed for the use of adobe-like bricks in the traditional Turkish building style.

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EFFECTS OF USAGE OF CANNABIS SATIVA L. AS FIBER REINFORCEMENT IN EPOXY COMPOSITES TO TENSILE AND IMPACT STRENGTHS

Gürkan Kara[1*], Fevzi Şahin[2], Cengiz Görkem Dengiz[3], Mevlüt Gürbüz[4]

ABSTRACT

Composite materials, which meet many of the features expected in almost all engineering fields such as high strength, corrosion resistance, low weight, ease of production and supply, fracture toughness and low cost, are widely used in almost all sectors especially in aviation and automotive. Although a wide variety of materials are used as matrix material in composites, carbon and glass fibers are generally used as reinforcement material. The accuracy of the usage of these reinforcement materials in terms of both their high costs and the negative effects of the production processes to the environment has been intensively discussed recently and this increased the interest in studies on green composite materials produced using organic fibers. In this study, epoxy resin was used as matrix material and long fibers produced from Cannabis Sativa L. fibers were used as reinforcement material. After the fibers were impregnated with resin, they were placed in test sample molds by hand lay-up method, and test samples were prepared in 25% and 35% fiber-matrix ratio by volume. As a result of the charpy and tensile tests performed on the prepared samples; tensile strength increased by 95.6% at 25% fiber aspect ratio, 52.1% at 35% ratio, compared to the unreinforced condition. On the other hand, there was an increase of 193.5% in the 25% ratio and 345.2% in the 35% ratio compared to the unreinforced state in the impact strength.

Keywords: Composite, Organic Fiber, Hemp, Tensile Strength, Impact Strength

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1. INTRODUCTION

Composite materials, which meet many of the features expected in almost all engineering fields such as high strength, corrosion resistance, low weight, ease of production and supply, fracture toughness and low cost, are widely used in almost all sectors especially in aviation and automotive. Although a wide variety of materials are used as matrix material in composites, carbon and glass fibers are generally used as reinforcement material. However, the biggest disadvantages of these fibers can be listed as; being extremely brittle, having a higher density compared to natural fibers (1.75–1.93 g/cm3 for carbon fiber, ≈ 2.6 g/cm3 for glass fiber), more energy consumption (43.3 MJ) while production, high emissions of CO2 (20.4 kg), SOx (8.8 g) and NOX (2.9 g) and extremely high costs [1]. The accuracy of the usage of these reinforcement materials in terms of both their high costs and the negative effects of the production processes to the environment has been intensively discussed recently and this increased the interest in studies on green composite materials produced using organic fibers. The aim of this study is to use hemp fibers in order to eliminate the problems given above and to reduce the amount of carbon or glass fiber used. The density of hemp fibers to be used (0.86 g/cm3) is much lower compared to carbon and glass fibers. Also the lower values of power consumption (3.4 MJ), CO2 (0.64 kg), SOx (1, 2 g) and NOX (0.95 g) emissions for hemp fiber provides a great advantage [1]. In addition, it has been seen in the literature that hemp fibers have a tensile strength close to 1000 MPa, and the elastic modulus has been reported up to 70 GPa [2-3]. In this study; hemp reinforced composite samples with different fiber aspect ratios were produced, tensile and charpy tests were performed on these samples and the tensile and impact strength properties of hemp reinforced epoxy composites were investigated.

2. MATERIAL AND METHODS

SEM, XRD and FTIR analysis results of hemp fibers used in the study are given in Figure 1a-c. The fibrous structure of cannabis is clearly visible from the SEM image, with a rough morphology of 100-300 microns in diameter. From the XRD analysis, 2-theta gave a diffraction of around 15 and 25 degrees, which is compatible with the literature. All vibrations taken from the FTIR analysis are given depending on the wavelength. As seen here, the peaks obtained at wavelengths such as 3336, 2887, 1423, 1317, 896, 662 belong to cellulose, and peaks around 1250, 1506 belong to lignin. All other peaks matches with the cannabis FT-IR results in the literature [4].

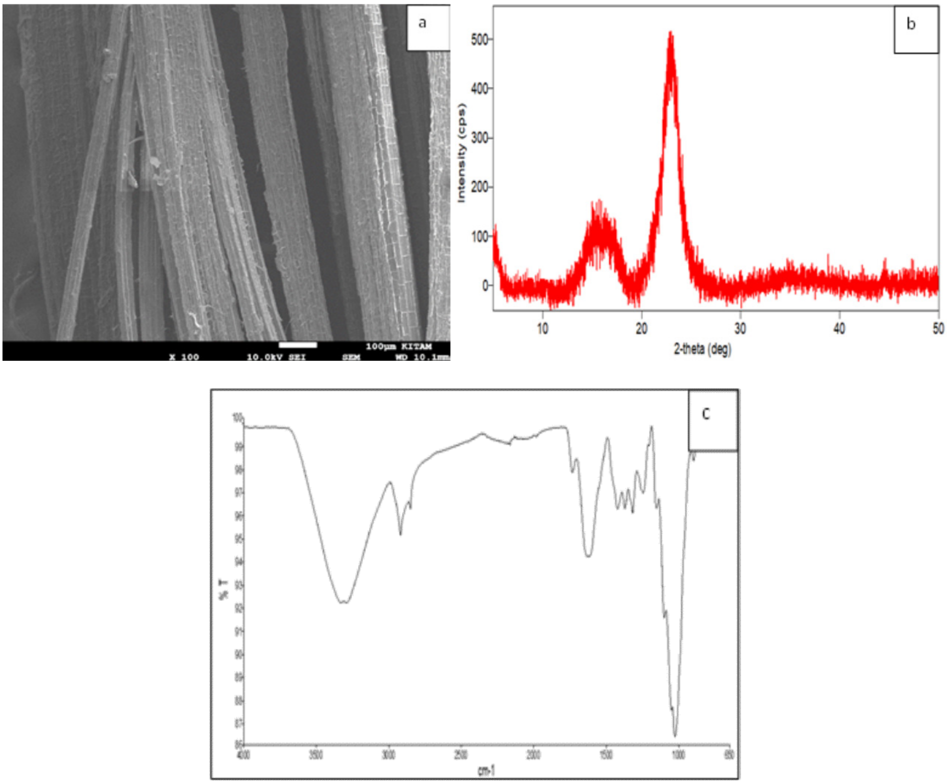

Figure 21. Analysis results of Cannabis Sativa L. a)SEM b)XRD c)FT-IR

In Figure 2, the resin to be used in the production of composites and the oriented hemp fibers cut in certain sizes are given. It is prepared to have a aspect ratio of 25% and 35% by volume.

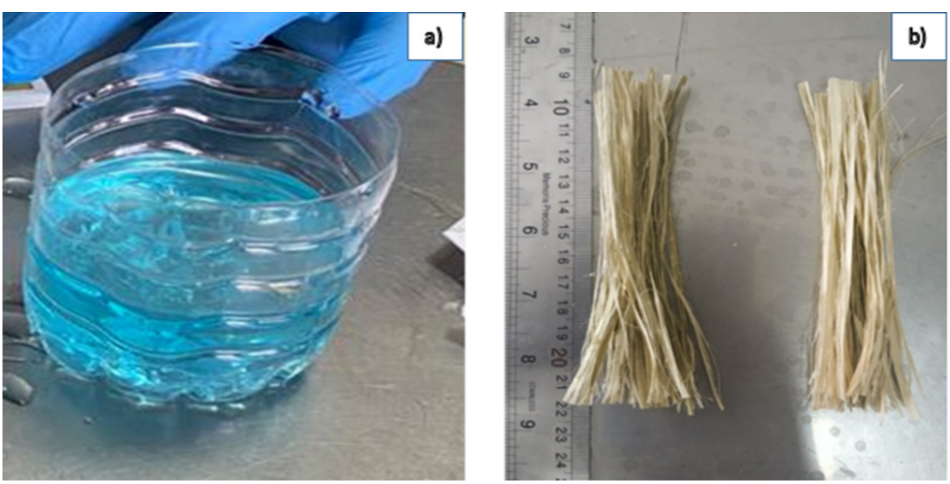

Figure 22. Materials used in composite production a) Epoxy Resin b)Cannabis Sativa L. Fibers

In Figure 3a-b, the preparation of test samples is given. After the fibers were impregnated with resin, they were placed in test sample molds by hand lay-up method, and test samples were prepared in 25% and 35% fiber aspect ratio by volume. The samples in the molds and ready for tests are given in Figure 3c-e.

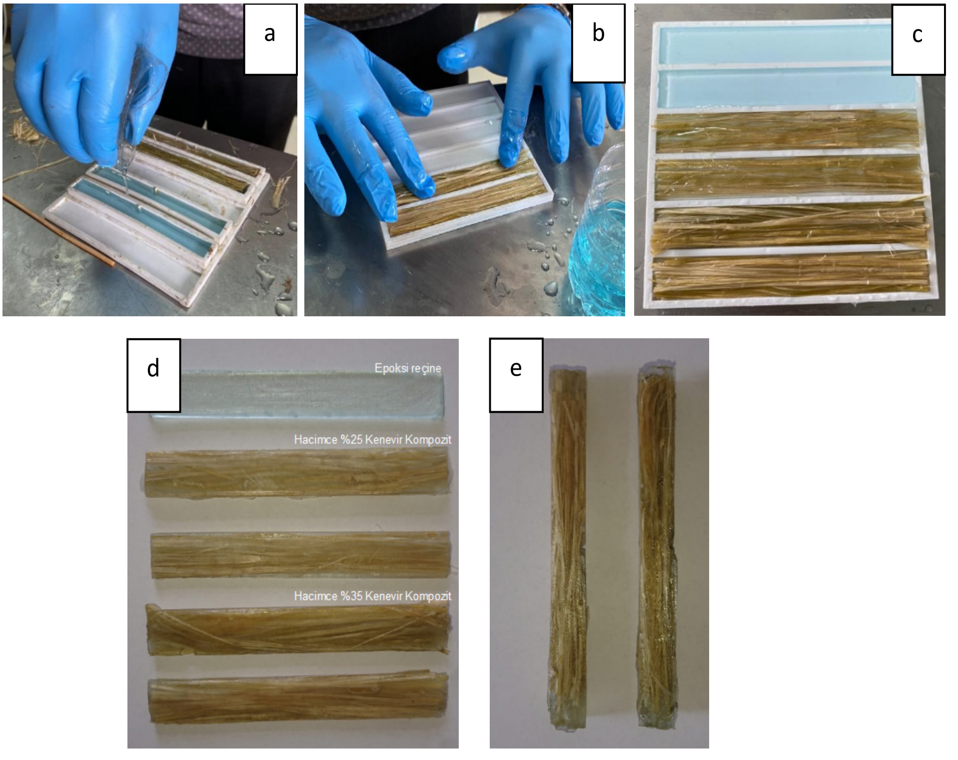

Figure 23. Test samples a)Preparation of Charpy test samples b)Hand lay-up method c)Tensile test samples in die d)Tensile test samples e)Charpy test samples

Dimensions of tensile test specimens are 2 mm-15 mm-125 mm. Tensile tests were carried out with a 10 kN capacity INSTRON brand test device at a test speed of 10 mm/min. The dimensions of the Charpy test specimens are 10 mm-10 mm-125 mm, the notch apex angle is ^{o}90 degrees and the notch depth is 1.5 mm.

3.RESULT AND DISCUSSION

Tensile and charpy tests of the composites produced are given in Figure 3a-b. As given in the figure, the maximum tensile strength of the epoxy was approximately 23 MPa and exhibited a ductile rupture behavior. With the addition of 25% hemp fiber by volume, the tensile strength increased up to 45 MPa and decreased to 35 MPa when the hemp content was 35%. As a result of the charpy test, the impact strength of composites containing epoxy, 25% and 35% hemp by volume was determined as 2.65, 7.78 and 11.80 Joules, respectively. Graphics of tensile and Charpy tests are given in Figure 4a-b.

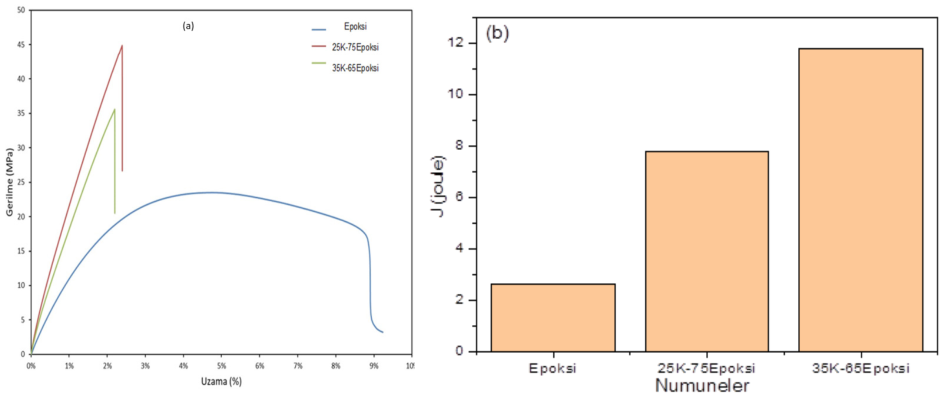

Figure 24. Test results of Composites. a)Tensile Test b)Charpy Test

4. CONCLUSION

Composites which has unreinforced, 25% and 35% hemp fiber aspect ratio by volume were produced by hand lay-up method, and tensile and Charpy impact tests were carried out. The maximum tensile strength of unreinforced epoxy is approximately 23 MPa, and with the addition of 25% by volume hemp fiber, the tensile strength increased up to 45 MPa, and when this value was 35%, it decreased to 35 MPa. As a result of the Charpy impact test, the impact strength of the composites containing pure epoxy, 25% and 35% hemp by volume was determined as 2.65, 7.78 and 11.80 Joules respectively. The reason for the decrease in the tensile stress with the increasing hemp ratio can be considered as air remains between the hemp in the hand lay-up method, and the resin does not completely impregnated the increased hemp. The Charpy impact test also confirms air bubbles formed by increasing hemp absorbs more shock.

ACKNOWLEDGEMENT

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CHAPTER 8

Climate Change and Mitigation

A STUDY ON THE DESIGN AND FEASIBILITY OF AN INNOVATIVE FARM-TYPE BIOGAS PLANT

Elif Cura[1], Yasin Karagoz[2], Alper Bayrakdar[3*], Erkan Sahinkaya[4]

ABSTRACT

The demand for energy has been increasing due to the rapid increase in population and industrialization activities as a result of technological advances. Since existing energy sources cannot meet the demand, renewable energy sources are seen as an alternative. In addition, from an environmental point of view, in managing problems caused by animal waste, anaerobic digestion resulting in biogas production can be considered an alternative solution in terms of energy recovery. Biogas can be shown as an important alternative among renewable energy sources. The heating and electricity needs can be provided by biogas production. Besides, with the anaerobic digestion process, digested organic material can also be used as an organic fertilizer. Hence, the rate of preference is increasing day by day. In the first part of this study, energy needs and resources in the World and in Turkey have been determined and a detailed examination of renewable energy sources has been made. Then, a photo was taken about the amount of biogas that can be produced from animal waste in Turkey. The mobile commercial biogas systems have been examined and compared with the system designed in this study.

In the last part of the study, calculations and designs for the farm-type biogas system have been carried out. The feasibility study of the developed innovative biogas system has been conducted.

Keywords: Biogas, Biogas Plant, Energy

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1. INTRODUCTION

As a result of rapid population growth and industrialization on a global scale, the energy and raw material needs of developing countries have been greatly increasing. With the increase in industrialization and development in industrial areas in recent years, raw material and energy requirement has become an important problem for Turkey. As a result of this need, the use of non-renewable energy resources such as oil, natural gas, and coal is increasing day by day. Hence, Turkey's foreign dependency and current account deficit have been increasing.

In the world and in Turkey, biogas has the potential to be an important source of energy and fertilizer in small settlements (villages, farms, etc.). The amount of animal waste generated as a result of livestock activities is considerably higher. Unfortunately, the potential of animal waste in Turkey cannot be valorized efficiently. A large proportion of these wastes are used as fertilizer after being kept in open areas for a long time without any treatment. Due to this long unattended storage, unwanted bacteria, pathogens, and viruses pass directly to the soil and pollute the soil and water resources. In Turkey, approximately 193 million tons of animal waste is generated annually [1]. Since these wastes cannot be utilized correctly, there are millions of dollars in economic loss in Turkey.

1.1. Animal Waste Amount and Methane Potential in Turkey

When the number of cattle is taken into account in Turkey, it is predicted that the biogas energy capacity originating from cattle is very high. If energy policies are directed correctly, and incentives for biogas energy are increased, Turkey's energy dependence on foreign sources may decreased substantially. According to TUIK data, cattle number was 18,036,117 in 2021 in Turkey [1]. Calculations we made within the scope of this study shows that the daily energy potential of 2021 is 80 million kWh/d, and the potential biogas production is 12 million m^3/d, on average. Details of these accounts are presented below.

Amount of substrate to be fermented daily

Daily manure to be produced by per cattle = 20 kg/cattle/d.

Daily manure to be fermented= 18,036,117 cattle x 20 kg/cattle/d

360,722,340 kg/d manure to be fermented in 2021

Total solid content and total solid (TS) and volatile solid (VS) ratio are accepted as 14% and 0.8, respectively.

Daily solid load = 360,722,340 kg/d x 14% = 50,501,127.6 kgTS/d

Daily organic matter load = 50,501,127.6× 0.8 =40,400,902.08 kgVS/d

Daily methane potential

1 kg of VS of cattle manure produce 0.2 m^3 methane gas (assumption).

Daily theoretical methane production = 40,400,902.08 kg/d × 0.2m^3/kgVS= 8,080,180.416 m^3/d

Energy to be generated

1 m^3 methane gas equals to 10kWh [3].

8,080,180.4 m^3/d × 10 kWh/m^3 = 80,801,804 kWh/d.

1.2. Farm-Scale Biogas Plants

Within the scope of this study, commercial small-scale reactor designs were examined. Since farm-type biogas reactor systems are not widely used in Turkey, foreign commercialized products have been listed below.

Table 1. Farm-scale biogas digesters

Trade Name	Material	Cons	Country
Biogassa	PVC membrane	No mixing and heating	India
Biotech	Fiberglass reinforced plastic	Fixed size, No heating and mixing	India
Sintex	HDPE	Fixed size, No heating and mixing	India
Fenghuo	Steel	No heating and mixing	China
Sistema	Geomembrane	No heating and mixing	Mexico
Puxintech	Plastic	No heating and mixing	China
Teenwin	PVC	No heating and mixing	China
Homebiogas	Plastic	No heating and mixing	Israel

1.3. Purpose and Objectives of the Study

Anaerobic digestion emerges as an environmentally friendly method that has been intensively applied in Turkey in recent years in terms of both the disposal of wastes with high organic content such as animal manure, food waste, domestic organic wastes and treatment sludge and the generation of energy from these wastes. Instead of disposing of organic wastes in an uncontrolled manner, which has serious negative effects on the environment, treating those by anaerobic digestion, which is an environmentally friendly technology, methane gas with high calorific value can be produced and heat and electrical energy can be obtained.

It is known that some animal husbandry enterprises do not have land where they can use the animal wastes as fertilizer, even if they do, wastes are left in uncontrolled way on the land. These uncontrolled applications cause groundwater pollution in terms of nitrate (NO_3^-) and organic matter, greenhouse gas emissions, spread of pathogens and weed problems.

There are different scales of biogas plants to produce combined heat and power generation from agricultural wastes.According to the data of the Ministry of Energy and Natural Resources, there are a total of 61 biogas power plants in Turkey. The installed power of these power plants operating in 45 cities are approximately 229.78 megawatts (MW). However, in terms of energy production from wastes with high organic matter content, the applications in Turkey are still limited and the sector is open to industrial development. The total energy equivalent of Turkey's waste (animal, municipal, agricultural) is 34 MTEP, which corresponds to approximately 395450 GW [1].Considering that the current resources of Turkey are 39 MTEP and 153.5 MTEP is used annually [4], the contribution of the energy to be obtained from biogas will be substantial. A large part of this potential originates from animal waste, other potential sources are industrial waste, municipal waste (garbage) and agricultural residues. The aim of this study is to spread the environment-friendly biogas plants in Turkey, which is foreign-dependent in terms of energy and thus reduce foreign dependency.There are generally small-scale farms in Turkey, which means that the waste produced is not uniformly distributed. One of the main reasons why small-scale biogas plants do not become widespread in Turkey compared to European countries is that the technology is not domestic and accordingly the initial investment costs are too high for small and medium-sized animal farms.In the central biogas facilities, the transportation costs of the wastes bring an additional burden to the business that cannot be underestimated. The main purpose of this thesis is to design and develop a domestic and decentralized (individual) biogas reactor (digester) for small-scale livestock farms (5-100 heads), which is low cost, much easier to operate than large-scale facilities. In decentralized biogas technology, biogas will not only be used as an energy source for cooking and heating but will also help reduce environmental concerns caused by animal manure.

If the use of small-type biogas facilities becomes widespread, the amount of energy to be obtained may have the potential to exceed the amount of energy to be obtained from large facilities because there are too many small facilities in the livestock sector in Turkey and the wastes produced in these small facilities cannot be evaluated unfortunately. Therefore, there is a need for economical, easy-to-operate, innovative design small biogas plants that can be used in small facilities to further evaluate the animal waste produced.

2. FARM-SCALE DIGESTER DESIGN, MANUFACTURE, AND INSTALLATION

2.1. Farm-Scale Biogas Digester

The small-scale biogas plant designed within the scope of this study has a mixing system and can serve different sized farms. In addition, the system can be heated with solar energy, thus producing biogas with higher performance. Liquid and solid fertilizer produced as a result of the process can also be used in agriculture. Thus, wastes can be converted into energy and fertilizer.

2.2. Capacity and Production Potential of the Designed Digester

Amount of substrate to be fermented daily

Daily manure to be produced by per cattle = 20 kg/cattle/d.

For 5 animals = 5 cattle x 20 kg/cattle/d = 100 kg/d

Solid and organic matter load

Total solid content and total solid (TS) and volatile solid (VS) ratio are accepted as 14% and 0.8, respectively [3].

Solid load = 100 kg/d x 14% = 14kg /d

Organic load = 14 kg/d x 80% = 11.2 kgVS/d

Digester Volume

Hydraulic retention time, headspace volume and density of manure are taken 25 days, 20% and 1L/kg, respectively

Total digester volume = 100 kg/d x 1L/kg x 25 d x 1m^3/1000L x 1.2 = 3 m^3 (total volume), 2.5 m^3 (active volume)

Methane gas production (for 5 animals)

1 kg of VS of cattle manure produce 0.2 m^3 methane gas (assumption) [3].

Organic loading rate = 11.2 kgVS/d / 2.5 m^3 = 4.48 kgVS/m^3/d

Theoretical daily methane prodcution = 4.48 kgVS/m^3/d x 0.2 m^3/kgVS = 2.24 m^3/d

Biogas energy to be generated (for 5 animals)

1 m^3 methane gas equals to 10kWh [5].

Energy = 2.24 m^3/d x 10kWh/m^3 = 22.4 kWh/d

Energy (annual) = 22.4 kWh/d x 365 /year = 8.176 kWh/year

Estimated return time

The investment cost calculated for the farm type digester is 35,000 Turkish Liras (1880 USD) when the current dollar rate is taken into account.

Heating value of an 12kg-cooking gas cylinder is 11,000 kcal/kg

Total heating value of a gas cylinder = 12 x 11,000kcal/kg = 132,000 kcal/cylinder

132,000 kcal /cylinder x 1kWh/860 kcal = 153.5 kWh/cylinder

8.176 kwh/year /153.5 kWh/cylinder = 53 gas cylinder /year

A 12kg-cooking gas cylinder is 19 USD (350 TL)

Hence return time = 1880 TL/(19 x53) TL/year = 2 years

2.3. Manufacturing and Installation of Farm-Scale Biogas Digester

Design stages

Within the scope of this study, based on the number of 5 animals, the digester volume and sizing were made as a result of the daily fermentation amount. The system will be installed with a water tank with a capacity of 5 tons to be used as an anaerobic digester. In addition to the animal manure, straw, grass, garden wastes can be fed as substrate. As a result of fermentation reactions, the produced biogas will be stored in a separate biogas collection balloon. The drawing details of the designed bioreactor are presented below (Figure 1)

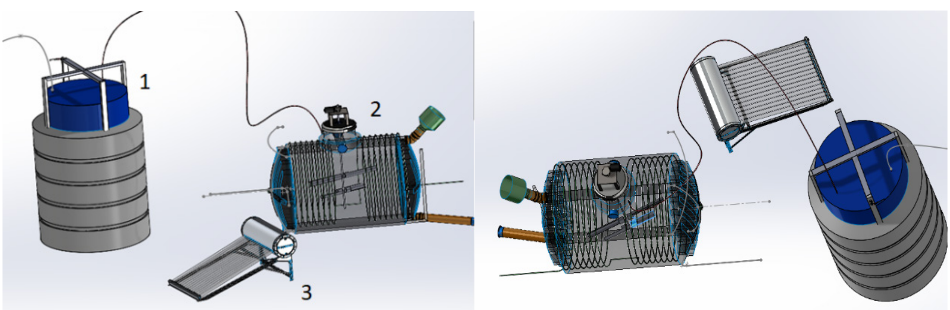

Figure 5. Anaerobic digester overview (Reactor (2), biogas tank (1) and solar energy system (3))

A mixer consisting of specially designed pedals positioned on a shaft will be placed in order to distribute the microorganisms and wastes homogeneously and to perform the anaerobic digestion process efficiently. The mixer will mix for a minimum of 1 minute and twice a day, creating an optimum speed gradient.

Heating of the digester will be provided by the serpentine to be placed in the digester (Figure 2). By passing hot water from vacuum tube solar collector through the serpentine, mesophilic temperature conditions will be provided for the digester.

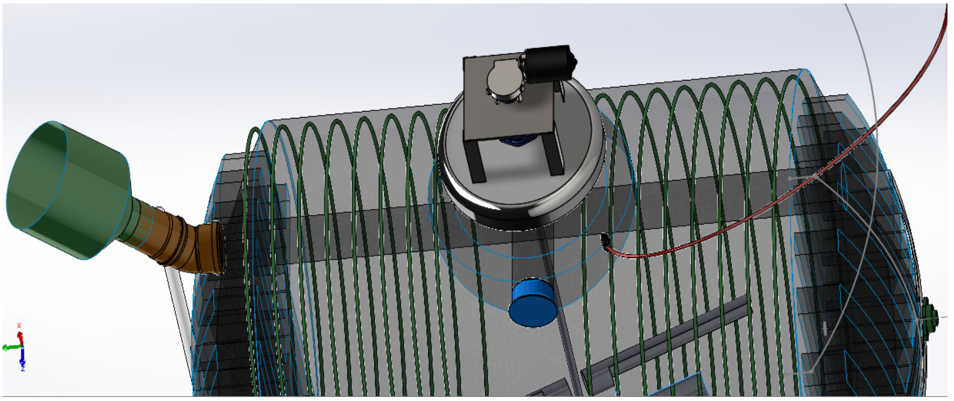

Figure 6. Hose serpentine system inside the digester

Installation stages

The reactor system installation designed within the scope of this study was carried out in the BİLTAM laboratory of Istanbul Medeniyet University and in the small cattle farm in Urla, Izmir. Manufacturing was carried out within the scope of KOSGEB project (02.01.01). A 5m^3 polyethylene water tank was used as the anaerobic reactor (Figure 3). An inflatable water tank was used to store the produced biogas. Connections to which animal manure will be added and fermented manure will come out are mounted to the tank. Water hose connections have been made inside the tank to ensure the circulation of hot water and serve as a serpentine.

Figure 7. Farm-scale 5m^3-digester

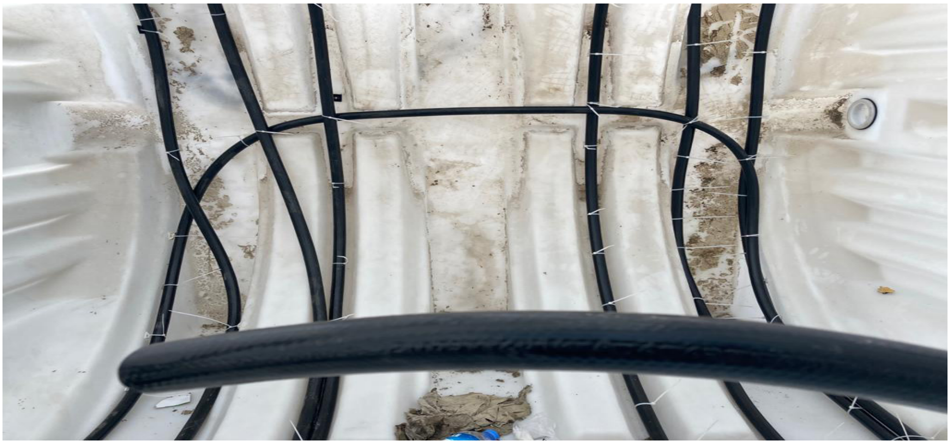

Figure 8. Serpentine system

The reactor was taken to the cattle farm in Urla, Izmir and placed in the ground as half buried (Figure 5).

Figure 9. Digester placed in the cattle farm

2.4. Recommendations for the Widening of use of Farm-Scale Biogas Plants

Compared to the countries in Europe, one of the main reasons why farm-scale biogas plants are not widespread in Turkey is that the technology is not domestic and, accordingly, the initial investment costs are too high for small and medium-sized livestock farms. For farm type biogas plants to become widespread, domestic production should be supported and in addition, farm owners should be made aware.

3. CONCLUSION

The aim of this study is to design a small-scale, low-cost, easy-to-operate, decentralized mobile biogas system for use in cattle farms. The investment cost calculated for the farm type digester is 35,000 TL (1880 USD) when the current dollar rate is taken into account.

Considering that the gas to be produced will be used for cooking, with the designed biogas system, thermal energy equivalent to 5 12-kg-cooking gas cylinders on average will be obtained in a farm with a capacity of 5 animals. Thus, the initial investment cost will be amortized in 2 years, and the depreciation period will decrease if the income to be obtained by drying and selling the fermented fertilizer is also taken into account.

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THE EFFECTS OF ANIMAL MOVEMENTS IN GLOBAL WARMING METHANE EMISSIONS PAST, NOW AND FUTURE

Buğra Genç[1*]

ABSTRACT

Due to the increase in the world population, there is a global increase in livestock movements in line with the increasing demand for quality animal protein. However, ruminants cause a serious methane emission. The methanogen archaea found in the natural flora of the digestive system of ruminants play an active role in global warming as shown by several studies conducted in the last 50 years. The researches on reducing methane emissions from livestock focus on changing the feeding regime, breeding animal breeds, vaccination, use of hydrogen traps, pasture management practices and genetic studies. Up today, there has not been enough success in solving the current problem by using these methods. New researches with advanced genetic methods need to be made to better understand the functions of archaea which are very difficult to detect and be reproduced by in vitro methods. By this way, it is considered that more effective solutions can be reached in reducing methane emissions from livestock. In this study, ruminal archaea, their methanogenic effects and measures to reduce their effects on global warming are discussed. In the light of the findings, it was concluded that the application of new genetic methods, updating animal nutrition and breeding policies and global cooperation are needed to solve the problem.

Keywords: Archaea, methanogens, global warming, animal movement

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1. INTRODUCTION

According to 2011 data of the Food and Agriculture Organization of The United Nations (FAO), the world population is expected to reach 9.2 billion people from 7.2 billion by 2050 [1].This rapid increase in the human population is an important criterion for providing the right protein sources and diversity. Among the protein sources, animal proteins are still considered as essential sources for human nutrition, since they contain essential nutrients. As a matter of fact, the World Health Organization recommends that a healthy person consumes 0.83 g/kg body weight protein daily and that 42% of this protein consumed should be of animal origin [2]. Consumption amounts of animal protein (gr/capita/day) and resources (kg) according to the development level of countries in the World in 2018 given in Table 1.

Table 1. Consumption amounts of animal protein (gr/capita/day) and resources (kg) according to the development level of countries in the World in 2018.

Consumed Food Source	World Mean	Developed Countries	Developing Countries	Less Developed Countries	Türkiye
Animal proteins (gr/capita/day)	32.63	64.65	44.35	13.81	38.14
Eggs (kg)	9.59	12.44	11.17	2.06	8.63
Fish- Seafood (kg)	20.25	26.00	13.86	13.59	4.89
Meat (kg)	42.55	79.68	61.19	13.51	38.97
Milk-dairy (kg)	78.01	188.68	135.29	25.95	165.37

Source: FAO [3]

Ruminant animals are bred for the production of red meat and milk, which have an important place in animal protein sources. In the large stomach (rumen) of these animals, there is a microbial population that is essential for the digestion of cellulose, which is primarily the plant cell wall. There are also methanogenic archaea in this population. The methane produced by these creatures is a gas that can have a greenhouse effect and plays an important role in global warming with its accumulation in the atmosphere [4]. In this study, the formation of methane, which has a greenhouse gas effect in global warming, originating from livestock, and attempts to reduce methane emissions in the past and present, and future approaches are discussed.

2. PROTEIN REQUIREMENTS

Access to adequate amount and quality of protein is essential for meeting physiological needs and maintaining health during the life cycle of all living creatures. The quality of proteins is determined by their nitrogen and amino acid profile [2]. Animal proteins provide all nine essential amino acids, which cannot be synthesized in the living body, in sufficient quantities [5]. According to FAO [6] data, it is seen that more than 820 million people in the world struggle with malnutrition. In the face of this situation, different policies are applied on the breeding of different animal species on a global scale in order to close the animal nutrient deficit.

3. DIGESTION, METHANOGENS AND METHANE EMISSION IN RUMINANTS

Roughage is an indispensable element in the diets of ruminant animals. Cellulose, hemicellulose and lignin in roughage can only be digested by ruminal microbial population in their stomachs. This microbial population consists of bacteria, protozoa, yeast, fungi and archaea. While the rumen bacteria continue to digest the cell wall elements in the roughage consumed by the animal, the carbon dioxide (CO_2) released as a result of digestion is reduced to methane (CH_4) by methanogen archaea. It is a known fact that archaea, which have species that survive even at different pH, extreme temperature, salt density and pressure values, are produced in a laboratory environment even if anaerobic conditions are provided, and most of them cannot be observed even with the most advanced molecular detection methods [7, 8]. Species that have been identified today are listed as Crenarchaeota, Euryachaeota (halophiles and methanogens), Korarchaeota, Nanoarchaeota Thaumarchaeota, Aigarchaeota, Parvarchaeota, Aenigmarchaeota, Diapherotrites, Nanohaloarchaeota and Proteoarchaeota [9,10].Among these archaea species, those found in the digestive system of ruminants are listed as Methanobacteriales, Methanomicrobiales, Methanococcales, Methanosarcinales and Methanomassiliicoccales [11].The gases released as a result of digestion with chemical and microbial activity in ruminants consist of 5% H_2, 40% of CO_2 and 30-40% of CH_4.The volume of CO_2 and CH_4 formed is between 30-50 liters per hour and is expelled from the mouth during the rumination function of the animal. There is a direct proportion between the amount of forage in the ration consumed by the animal and the volume of CO_2 and CH_4 formed. For every 100g of carbohydrates consumed by cattle, 4.5 g of CH4 is formed [12].With the methane formed, approximately 2-15% of feed energy is lost [13]. Enteric methane, which is released from ruminants, constitutes 30% of the methane emitted into the Earth's atmosphere [14].While enteric methane has a rate of 40% in the greenhouse gas formation originating from livestock, this rate is seen as 6% in anthropogenic greenhouse gas emissions [1,15,16]. The formation of methane in the rumen as a result of the digestion of roughage is shown in Figure I.Natural wetland (peatland), animal digestion wastes and paddy (rice cultivation) areas also play a role in methane emissions due to agriculture and livestock movements [14, 17]. Methane gas is also released during the degradation of proteins and carbohydrates in the fertilizers formed as a result of digestion in an anaerobic environment. It has been determined that the amount of methane formed in this way constitutes 5% of the global total methane emissions [18].

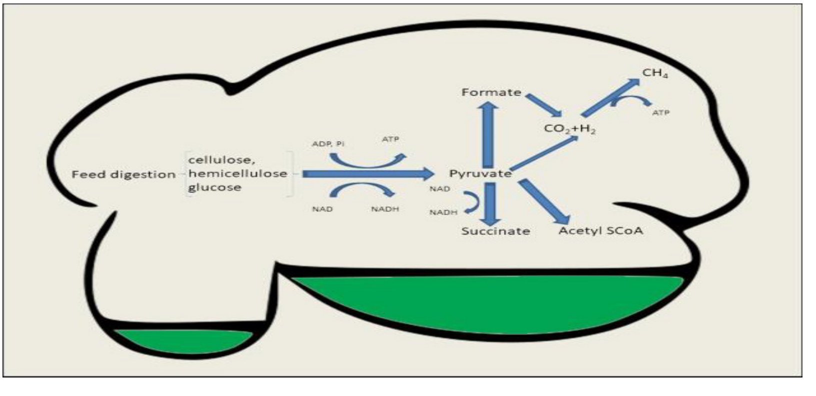

Figure 1. Formation of methane in the rumen as a result of the digestion of roughage[8].

4. THE ROLE OF METHANE IN GLOBAL WARMING

The gases in the atmosphere, which affect the thermal balance of the atmosphere by holding the radiation coming from the sun and reflected from the ground, are called greenhouse gases. With the proportional increase of these gases in the atmosphere, global warming may occur due to more solar radiation retention. The role of greenhouse gases caused by human and animal mobility in global warming has recently been among the most debated issues in the scientific framework.The increase in warming threatens the sustainability of ecosystems and has become a situation that is followed with concern [19]. Methane, which has an important role in global warming, is a greenhouse gas. It is 80 times more effective than carbon dioxide in global warming in the first 20 years as a cumulative effect since this gas, which is released into the nature with the degradation of biomass, is released into the atmosphere. However, CO_2 is 28-34 times less potent than CH_4 as a greenhouse gas over a 100-year timescale [20, 21].Because CH_4 produces more radiative forcing per molecule than CO_2, it is more powerful than CO_2. In addition, more molecules may fill the space since the infrared window is less saturated in the range of wavelengths that CH_4 absorbs radiation [22].Since methane is chemically reactive and affects ozone accumulation in the stratosphere and troposphere and is the main source of water in the stratosphere, it is also effective in global warming with its chemical properties [23, 25].Atmospheric concentrations of CO_2 and CH_4, the main greenhouse gases, have increased from 350 to 410 ppm (28%) and from 1100 to 1875 ppb (70%), respectively, in the last 70 years [26].Researches show that the effect of methane on the warming of the earth existed 2.2-2.8 billion years ago during the formation of the earth. Some modeling studies have also found findings confirming this [27]. Methane chemistry is closely related to CO, as methane oxidation produces 30% of atmospheric CO [28].According to the data compiled from the study of Erdöhelyi [29], the thermodynamic representations of the reactions between CH_4 and CO_2 are as presented in Table 2.

Table 2. The Thermodynamics of the CO_2 + CH_4 Reaction

Reaction	ΔH^0_{298}	Reaction reforming
$CO_2 + CH_4 \rightleftharpoons 2\,CO + 2\,H_2$	ΔH^0_{298} = +247 kJ/mol	Dry reforming
$CH_4 + H_2O \rightleftharpoons CO + 3\,H_2$	ΔH^0_{298} = +206 kJ/mol	Steam reforming
$CH_4 \rightleftharpoons C + 2\,H_2$	ΔH^0_{298} = +75 kJ/mol	Methane decomposition
$CO_2 + H_2 \rightleftharpoons CO + H_2O$	ΔH^0_{298} = +41.2 kJ/mol	Reverse water–gas shift
$CO_2 + H_2 \rightleftharpoons CO + H_2O$	ΔH^0_{298} = +41.2 kJ/mol	Reverse water–gas shift
$CO_2 + 4\,H_2 \rightleftharpoons CH_4 + 2\,H_2O$	ΔH^0_{298}= −164.9 kJ/mol	Methanation
$2\,CO \rightleftharpoons C + CO_2$	ΔH^0_{298} = −171 kJ/mol	Boudouard reaction
$C + H_2O \rightleftharpoons CO + H_2$	ΔH^0_{298} = +131 kJ/mol	Carbon gasification

ΔH^0: Enthalpy change

Furthermore, the abundance of atmospheric NOx affects CH_4 oxidation chemistry, and the CH_4 oxidation chain can also cause ozone production or reduction [28].In case of sufficient NOx, CH_4 oxidation causes ozone production. When NOx is insufficient, the ozone that exists during the oxidation of CH_4 is also reduced by using it.The oxidation of methane,

CO_2 and nonmethane hydrocarbons is the main event that maintains the tropospheric OH level.Thus, increased methane sources can deplete atmospheric OH and contribute, through feedback, to an increase in atmospheric mixing ratios.Unless the global distribution of OH accumulation is more precisely determined and monitored, there is no reasonable way to empirically distinguish between increasing sources of CH_4 and decreasing OH [25].

5. METHODS TO PREVENT METHANE EMISSIONS FROM LIVESTOCK

5.1. Inhibiting Enzymatic Reactions

Halogenated sulfate compounds are effective in inhibiting the activity of Methyl CoM reductase (Mcr), which plays an important mediator role in the steps of methanogenesis, stopping the corrinoid enzyme activity and inhibiting cobamide-dependent methyl group transfer. It is noteworthy that researches using dibromochloromethane, 2 bromoethanesulfonate, carbon tetrachloride, 2- chloroethanesulfonate, choloroform, bromoform, bromodichloromethane, bromochlorormethane, trichloroacetamide, trichloroethyladipate, 3-nitrooxypropanol and 3 bromopropanesulfonate among these compounds [30, 33]. Of the aforementioned substances, 3-nitrooxypropanol (3-NOP) appears to be the most commonly used substance in research and is one of the additives that have the most effective reducing effect on methanogenesis [34].

5.2. Hydrogen Traps

Hydrogen is known as the main substrate in ruminal methanogenesis.In this method, unsaturated organic acids fumarate, sulfate, butyrate enhancers, malate and nitratepropionate e acceptor are used as H_2 traps [30, 35, 37]. Non protein nitrogen (NOP) is needed for the continuation of rumen microbial life.This need can be met from nitrates. During the nitrate reduction reactions, H_2 is used, which is also necessary for the production of methane. Thus, the formation of methane will be competitively reduced [38], but excessive levels of nitrite formed by the reduction of nitrate may cause increased methemoglobin and death.

5.3. Tannin, Saponin, Flavonoid, Essential Oils, Lonofores.

It is known that tannin sources have an inhibitory effect on methanogenesis, but their use is limited by reasons such as high toxic effects and reduced animal productivity [14]. Similarly, saponins may adversely affect animal health despite their reducing effect on methanogenic activity [4]. Polyunsaturated fatty acids (PUFAs) and monounsaturated fatty acids (MUFAs) can be used to reduce methanogen activity due to their ability to selectively destroy cell membranes [39]. Ionophores, which destroy the cell walls of acetate and H_2-producing Gram (+) bacteria, can also be used to reduce methanogenesis with these properties [40]. Another benefit of these materials is that they offer a pathway of microbial selection [14] with the effects of inhibiting methane formation pathways and reducing the archaea population.

5.4. Halogenated Metabolites and Biochar

In the meta-analyses [41, 42] it has been seen that algae can also be utilized to reduce the total enteric CH_4 emissions formed per unit animal and per unit dry matter consumption. With the addition of filamentous tetrasporophytes of red magro (*Asparagopsis taxiformis*) algae living in the seas and containing halogenated metabolites such as bromoform ($CHBr_3$) to the ration at a rate of 3%, it can reduce ruminal methane emission by 80%

with its effect on MCR [43] has been reported.However, it has not been proven that it definitely reduces ruminal methane emissions so far. In addition, due to the high potential of microalgae to be exposed to heavy metal load, the need for a high-cost culture algae production method [34] and the negative effects of these algae on the palatability of the diet are limiting factors.The findings obtained in studies conducted with the *in vitro* method [44-46] on the CH_4 emission reducing effects of biochar products show that there is no sufficient effect.

5.5. Microbes and Fungies

Direct fed microbials (DFM) (*Acetitomaculum ruminis*, *Eubacterium limosum, Ruminococcus productus, Enterococcus faecalis, Mitsuokella jalaludinii, Denitrobacterium detoxificans, Propionibacterium acidipropionici, Wolinella succinogenes*) which are products containing live bacteria and/or fungi. It continues to be used in studies to prevent methanogenesis. The main use of these products in animal husbandry is to protect animal health and increase productivity. Currently, its effects on altering the hydrogen flow and reducing the formation of fumarate, nitrite and nitrite have been demonstrated in in vitro studies, but its effects on methane emission have not been demonstrated *in vivo* [34].

5.6. Dietary Regulation

Concentrated feed and roughage mixtures are used in ruminant feeding. Meadow and pasture grasses, known as roughage, are indispensable elements of the ration for animal health and the continuation of the microbial population. However, rumen fermentation and acetate/propionate ratio increase if the roughage ratio increases due to economic, physiological needs and other reasons [47]. Efficiency of methanogens using acetate for energy and methane production increase accordingly. On the other hand, methods such as reducing the roughage ratio and choosing higher quality roughage in terms of nutrient content can be applied in ration arrangements. However, acidosis [14], other digestive system disorders and uneconomical ration cost that may occur with the increase in the concentrate feed rate constitute obstacles to the effective implementation of this application.

5.7. Genetic Selection

One of the studies to reduce methane emission is the method of applying genetic selection in animals. For this purpose, animals with smaller rumen volume, high digestion rate, high feed efficiency, less rumen fermentation efficiency and high reproductive power are preferred [48]. There are individual differences even between animals of the same breed and consuming the same diet. Since these differences can cause differences in digestive metabolism, different levels of methane emissions can also be encountered. For more successful gene transfer and better preservation of racial characteristics, animal production with embryo transfer, superovulation and artificial insemination methods instead of natural and random selection methods may be beneficial in closing this gap [14].

5.8. Vaccination

In preventing methanogenesis with vaccine, the production of specific antibodies against methanogens and the passage of these antibodies to the rumen through saliva are targeted [49].However, it is seen that there are great differences and inconsistencies between the results obtained from vaccine applications. Although it has been reported that, compared to other methods, two doses of vaccine can be beneficial without affecting the rumen microflora other than archaea, and methane emission can be reduced by 20-69% with this method, it is also known that most of the vaccine studies carried out so far have been unsuccessful [14,50].

5.9. Nitrocompounds

Nitroethane is a substance that can have an inhibitory effect on the methane emission steps in animals. However, when repeated application is made, the information on the effects on preruminal and postruminal methane synthesis function, absorption from the digestive system and accumulation in the animal body is not sufficient yet [51]. Bozic et al. [51] showed that intraruminal administration of nitroethane to Holstein cows with 120 mg nitroethane/kg body weight/day for 4 days temporarily reduced methane synthesis in rumen fluid up to 3.6 times, while increased methane reproductive activity in feces up to 8.8 times. In their research, they concluded that the nitroethane effect is effective in the migration of methanogens from the rumen to the intestines.

6. RESULT AND DISCUSSION

When the studies on rumen methanogenesis in the historical process are examined, it is seen that more than 9000 in vivo and in vitro studies were carried out according to Scopus records between 1960 and 2018. It is noteworthy that the first aim of both in vitro and in vivo studies is that methane formation causes energy loss in animals and affects their productivity [16]. The reason for this may be the fact that in the 1960s and 1970s, approaches to the concern of closing the human food and nutrient deficit were more prominent than the current serious interest in global climate change. Over time, the number of studies focusing more on the effects of rumen methanogenesis on the environment and climate changes has increased [16]. The relevance of livestock movements to global climate change has begun to be better understood, with the increase in research using increasingly high-tech methods and a better understanding of the physiology of living things. The change in the main aims and objectives of the researches in this direction seems to be connected to the development in question. The effect of reducing methanogenesis was classified by Hegarty et al. [34]. According to this classification, values above 25% were accepted as very high, between 15-25% as high, between 5-15% as moderate and below 5% as low. According to these values, it is seen that 3-NOP and Asparagopsis taxiformis are very effective, nitrate is effective, essential oils, saponin, tannins, monensin, microalgae, biochar, bacterial direct feeding microbes and fungal direct feeding microbes are low effective. Studies on methane production have shown that antibiotics [52] and essential oils [53] do not provide a clear benefit in reducing methane production.In addition, with the decision taken by the European Union, the use of antibiotics in livestock except for the treatment of diseases has been prohibited since 2006.There are studies showing that 3-NOP, which is a patented product, can be safe for use in the field of pasture feeding and dose range. However, no official statement has yet been found regarding its use to prevent methane emission.The fact that it causes a decrease in live weight gain in animals [54] is also seen as a disadvantageous aspect.Difficulty in accessing *Asparagopsis taxiformis* products, which are not yet commercially available, consumption of dry matter in dairy cows and low productivity [55] and the ozone-destroying effect of bromoform [56] are seen as limiting factors.In addition, due to the iodine [34] it contains, its use in animal nutrition has a disadvantage that should be considered. In order to prevent methane emission from livestock, it is seen that there is a tendency towards studies that mostly target the modification of animal rations and nutrition methods. The continuity and frequency of application of these methods have the potential to directly and/or indirectly affect the entire livestock policy. Since the applicability of potential solutions proposed globally within the scope of economic, technical and cultural characteristics and competence may have different results for different countries, it may be an obstacle for these methods to be effective and sufficient in preventing methane emissions from livestock.At this point, arranging financial supports that support modification in animal feeding and breeding methods by country governments and implementing incentive financial policies in case these methods are implemented can be a helpful way.Natural and commercial products [34] (Biopremix, cinnamaldehyde, cowbucha, fumerate, glucosinolates, malate, oregano, propolis, statins etc.), which are not frequently used to prevent methane emission and whose in vivo efficiency has not been sufficiently proven, are not considered advantageous due to the varying safe use intervals and high costs.Microbiome and metagenomic methodologies [57, 59] which are also used in understanding the effects of diet regulation studies, are seen as very important choices in investigating the role of rumen microbiota in methane emissions and global climate change.

Nitroethane [51] added to the diet seems to cause a decrease in rumen methanogenesis, but an increase in enteric methane levels. This result suggests that nitroethane has the effect of migrating methanogens to the lower parts of the digestive tract.Although it does not seem like a very effective method in reducing methanogenesis, the potential of this feature to create new opportunities should be taken into consideration.

7. CONCLUSION

In the light of the studies and evaluations, it is seen that many different methods have been applied, especially in the last 60 years, aimed at reducing rumen methanogenesis and preventing the changes it causes.Due to the still unknown genus of ruminal methanogens and the lack of knowledge about their biology and physiological effects, none of the methods applied alone is sufficient.In addition, it is seen that these methods have disadvantages in terms of animal health, economy and applicability.It is seen that the data obtained as a result of the use of *Asparagopsis taxiformis* and 3-NOP can shed light on new researches.It has been concluded that it is necessary to better understand the biological structures and physiological effects of methanogenic archaea, to reveal the unknown species with advanced genetic detection methods, and to struggle on a global scale for a solution.It was concluded that the biological structures and physiological effects of methanogenic archaea should be better understood, unknown species should be revealed by advanced genetic detection methods, and solutions should be sought on a global scale.

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LEGAL DEAL WITH MEAL

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ABSTRACT

The dilemma that we, as human-beings, are in is that; although we are aware that the sustainment of our own living fully depends on the sustainment of the natural-beings' living, on one hand, we want to use (usus), exploit (fructus), and even abuse (abusus) them, on the other. This dilemma has emerged only after the viewing of the natural-beings as "resources" has proved that they are not endless by causing the extinction of many of them. It is an undeniable fact that natural-beings are the only source for the sustainability of all beings' life. However; this, by no means, means that they can be used, exploited, and abused as one wishes. For, there is a miraculous circulation in nature that can be summarized as the "butterfly effect": The planet we live on is like a closed circuit; that is, no being vanishes but just rots, dissolves and transforms into another being.

This change of perspective towards the natural-beings brings us to the point that we are under the obligation of protecting the nature as a whole by protecting every single being therein for the sake of ourselves, if not for the sake of them.

There is an existing and expanding practice of attributing the legal personality status to natural-beings in order to protect them more efficiently than the existing punishment-based system. Pioneered by Christopher D. Stone, this practice leads to a better protection when compared to the previous practices however it also arises the question of: Would this practice end as in the over-protection of them whereby we would need protection against extinction?

In this paper, it will be argued that the deal lies in the middle of over-exploitation and over-protection.

Keywords: Environment, Protection, Legal Personality, Natural Person.

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1. INTRODUCTION

The Nature has its own laws which is basically of two kinds: physical and psychical. The history is full of proofs that there is no such thing as de minimis in the Nature's law of physics as there is in the laws of the States, comparison of the size of an atom to the size of the explosion thereof being the most significant example. This alone is sufficient to change the human-beings' perspective over the Nature, and the beings thereof, towards "besides", instead of "against", themselves which is the Nature's law of psychics.

Environmental protection became an objective of almost all, if not the whole, of the countries which observed to be achievable at the global scale only, as best demonstrated by the "butterfly effect" theory. The disastrous effects of the realization of progress in the reciprocal expansion of industry and science had over the human-beings as well as the natural-beings have made it to be realized that there is also a reciprocality between these two; meaning that the well-being of the latter is the prerequisite of the well-being of the former. Even the anthropo-centric view, albeit with selfish motives, concludes that any harmful action against any natural-being should be prohibited, because the negative consequences of these actions will eventually occur on the human-beings who also are a part of the very same nature.

The inefficiencies of the historical punishment-based approaches led to the emergence of other views offering that natural-beings deserve bona fide protection against all harmful human activities, some of which could be specified as extreme as they may lead to somewhat difficult situations for human-beings. This over-protective approach has also led to the emergence of some balance-seeking views, offering the protection of natural-beings only within the purpose of sustainment of their service to the human-beings. Although seeking for different goals, what these two different groups of views have in common is the offer of using the legal tool of the personality status to natural-beings.

The extreme-protectionists view the natural-beings indifferent than the human-beings, therefore, offering that they should have fundamental rights just like human-beings have human-rights. The sustainment-protectionists, on the other hand, offer a new legal status other than both the things and the persons: quasi-person, non-human living-being, or living object regarding the difficulties that might be faced in the case of attributing "full" legal personality – whatever that might mean to them - to to natural-beings. Both of these views have wrong points as well as the right ones.

The most fundamental wrongness lying within these views is that the consideration that the concept of legal personality comes with a cluster-of-rights within. The truth is, it is like an empty tool-box rather than being a tool like the rights and the obligations which can be put therein. The bare attribution of this status to a being would enable him to have the legal standing only. In order for this legal-personality-attributed-being to claim any right depends on the rights', that this being is been considered to be should be having, thereof to be determined and been thereto attributed. Therefore, it does not only enable a being to have legal standing but also does enable the rights and obligations to have standing within itself. Any right or obligation may not exist to be of any being unless is has the legal personality of its own.

Secondly, the rights and obligations are not a full-set bonded to each other; that is, they may be distributed separately in order to meet the needs of different persons. Exterritoriality, for example, is a right that requires not only the status of the legal personality to be held but also the type of this legal personality to be the kind of belonging to the human-beings. Therefore, even none of the legal-beings might ever have it, not all the human-beings does have it either.

In this paper, we will examine the meaning, the function, the types, and the scope of the legal status of personality and discuss that there exists the need for new legal personality types and offer a new legal personality type, which we define as "legal deal with meal" by analogy with the "social contract" and under the name of "natural personality" by analogy with the "electronic personality", that can be created for and attributed to the natural-beings in order to protect them in a more effective way by enabling them to have their own rights.

2. INSTITUTION OF THE LEGAL PERSONALITY

The objects of the law can be bifurcated as: institutions and beings. Personality statuses, persons, rights, and obligations are institutions of the law and all of the beings are viewed through the perspective of these institutions as either persons or things. At the moment of the State's creation, all of the beings under Her jurisdiction are at the default status of things. The whole purpose of attributing legal personality to a being, whether it be a real or non-real-being, is the incorporation thereof into the "world of persons" of that legal system, which otherwise would remain as a member of the "world of things". This incorporation which is a prerequisite for attributing legal rights and obligations to any being is also an endowment [20, 1] thereto. Through this, any being comes into a status where he may hold the rights and obligations that the legal system of Her jurisdiction that he is under might attribute to him. The material fact of this status is the making of a being right holdable. Without this, the legal system sees and behaves to this being just like any other being even if that being is a human-being. On the other hand; any being, if duly incorporated into the world of legal persons, may have his own rights and obligations on his own name and account, his own standing in front of any public and private institutions, and use his own rights for the sake of protecting his own interests; even thought that being is not a human-being. The law can even, first, imagine a non-physically-existing thing and create it as a legally-existing-being, and second, attribute the legal status of the "personality" thereto. Such an imaginarily-created-object of the law becomes a "potential" subject-of-the-rights over any being lacking this status making "it" an object-of-the-rights. The status of object-of-the-rights may include even a physically-existing-human-being. The relation of a being to the rights, therefore, is the determinative point of that being's status within the law; if he may become the subject of, i.e., hold, them then he is a person; and on the other hand, if it may be the object of them, then it is a non-person, i.e., thing or object. There is the common usage of the terms of "object" and "subject" referring to those beings' selves; which were created in a way of abbreviating the sayings of "object-of-rights" and "subject-of-rights."

Prior to the creation of corporate legal personality; there were only some human-beings, amongst all, who were the only members of this legal status. Although the human-being-members of this status have increased by the subsequential inclusion of some other human-beings like the Roman family members besides the *patria potestas*, the women, the elder, the young, and the malformed members of the societies, it has not been reached to the whole yet due to the still-existing exclusion of the fetuses. Besides these subsequently-added-human-beings, some other non-human-beings were also created and included in the legal status of the “person” like the corporations (C), the associations (A), and the trusts (T): CAT.

Apart from these widely accepted and applied creations and inclusions; there appeared also a practice of attributing legal personality to non-human and human-made-real-beings like the ships [15], and the idols [17], as well as some non-human-natural-beings like the river [19], and the Nature as a whole [8, 11] in some jurisdictions. Such practices have proven that it is possible to protect any being by using the rights held by them as a result of their inclusion into the legal personality status rather than by using the rights held by the persons over them. This personalitylessness of a being results in the dilemma that acknowledging that it has to be protected against harmful actions although it does not have an owner but not being able to protect it because there is no breach of any interest of any personality-holding-member of the law. In order to overcome this dilemma, there are offers like: the rights of the existing persons’ or of the future generations’ to/over the Nature; which seems to us to be the hard way.

2.1. The Meaning of the Legal Personality

The meaning of being a person in the eyes of the law is to determine the beings that are capable of holding [21] rights and obligations [10]. According to this definition, which is formulated in the “legal personality” term; the ability of a being to be the subject of the rights recognized and obligations brought by the legal system in which it is located depends primarily and only on its acceptance as a “person” by this legal system. Although it is perceived to be identical to the human-being, in fact, the existence of the personality of even human-beings is not due to itself, but because the legal system in which he is located recognizes it [9]. That is, it is possible for a legal system not to recognize a human-being as a person, and therefore not to accept him as a subject of rights and obligations, just as it was a fact for slaves in the past and for the fetuses then and now. Same way; it is possible for a legal system to recognize some non-human-beings as legal persons, as well as human-beings.

Today, some beings that do not have any physical existence, but are considered to exist in accordance with the “law”, that expresses the legal system, can be the subject of certain rights and obligations stipulated by this legal system, thanks to the institution called “corporate legal personality” [2]. The point that should be noted here is that although the term “legal” is used consecutively with the concept of “personality”, it does not describe the personality of this being but the being itself. Indeed, the fact that is considered to exist according to the law is not “the legal personality” of a self-existing-being but “the legal existence” of that non-actually-existing-being. Although “it is often thought that the legal life of an individual human being is in some sense natural, and that the legal life of other things, such as corporations, is in some way artificial, even the legal life of a human being is artificial” [21]. In fact, there is no difference in terms of the legality of the personality of a human-being and of a legal person. The meaning of the expression “real”, which is used to distinguish the legal personality of human-beings from that of legal persons, is that the existence of human-beings is based on physical reality rather than a legal one. Therefore; the expression of “legal person” in case of a corporate legal person implicitly means the fact of “a personality belonging to a non-real-being that exists only in the eye of the law”.

2.2. The Function of the Legal Personality

Legal personality should be considered as a mere legal tool rather than a goal that is to be used for the protection of a being's interests via the State-power-using legal institutions. It functions as utilising the legal powers of any given legal system for the interest of any given legal person whether it be a human-being or not and against the interest of any being whether it be a person or not. Without it, any being would exist in fact but not have any right at all; and with it, any being would not even exist in fact but have any right that the legal system wishes him to have. Therefore; there is no bias to state that the legal personality is the base of rights and obligations stipulated by any given legal system. The legal system should first attribute legal personality to any being he wishes, whether it be a real-being like a human-being or a ship or even a non-real-being like a corporation or the God, in order to grant him any legal right or obligation.

Once recognised as a person of a legal system, this being will now on be treated as a potential holder of rights and obligations of his own. Any interest of him will be protected by the institutions of that legal system under the name of "his rights." He will be able to be the plaintiff in front of the court on his own name and account. He will be able to sue for the damages given to himself. The compensation awarded will be utilised to revert back the negative consequences of the wrongdoer [18].

2.3. The Types of the Legal Personality

In most of the current legal systems, there are only two types of legal personality: real and legal – or artificial, or corporate [13]. Real personality is the term used for the legal personality type of human-beings. Although there are different types of real-beings holding legal personality, only the legal personality type of human-beings is called "real personality" and only they are called "real persons". In some jurisdictions, non-human-real-beings such as ships, idols, and rivers do also hold legal personality however their personality type is not called "real personality" and they themselves are not called "real persons".

This may make an impression that the terms "real" and "legal" do not define these persons' selves but the type of their legal personalities. As discussed above and can vividly be seen now; the ship, the idol, and the river are not fictitious-beings that exist only by the stipulation of law. They are just as real as human-beings are. Therefore; it is true that these terms are not used to indicate the existence cause of these beings. However; they are not used in order to differentiate the type of these beings' legal personalities either as there is no difference between being a person, in respect of any given legal system, of human-beings' from of other real and non-real but always non-human-beings'. No one can claim that there is an inequality of degree at the legality of personality of the real persons and the legal persons. The only difference there is that makes the use of different terms necessary and meaningful is the scope of these legal-person-beings' legal personalities. Besides this scope, there is no difference between being a person, in respect of any given legal system, of human-beings from other real-beings. This is the only reason why the terms "legal personality" and "legal person" are used in respect of those non-human-beings although they are as real as, and hold personality as legal as human-beings. When it comes to the non-real and non-human-beings' legal personality: the term "legal" means; first, that their existence is only in respect of the law, second, they are blessed with the personality status of the law by the law, and third, the scope of this status that they are in is not the same as the status that the human-beings are in. Therefore, legal personality in this case means in long: The (legal) status that (legally) makes the (legally created) non-real-beings to be able to hold the (legal) rights not specific to human-beings.

Although there are no different types of real persons, there are different types of legal capacities among human-beings. Legal personality, on the other hand, is the term used for the legal personality type of both non-human-real-beings' and all non-real-beings'. Therefore, there are two main types of legal personality: the first is non-human-real-beings' and the second is of non-real-beings. There are also two sub-types of legal personality of non-real-beings: civil law and common law.

2.4. The Scope of the Legal Personalities

Being a legal person does allow this being of the legal system to hold not every existing but only the stipulated rights and obligations for him by the legal system. Not every legal person has the same rights and obligations neither has every legal personality type. As for the legal personality types: there are human rights available only for the "real" legal personality type and other rights available for the "legal" legal personality types. No being other than human-beings may hold the real personality type as opposed to the legal personality type: the legislator may legislate that any real or fictitious-being become a legal person holding a legal personality.

The scope of the legal personalities differs according to the needs of the legal persons. Civil law legal persons may decide to end their own life while common law persons and real persons may not. Real persons may vote, merry, etc. while neither of the legal persons may not [5].

3. CONTEMPORARY NEEDS

3.1. The Need for New Legal Personality Types

Although it seems simple and efficient to employ these two types of legal personalities also for the new members of this status; they are not even currently sufficient for the current legal persons as discussed above. Naming the non-human-real-beings' personality type as "legal" creates a confusion as making the impression that they exist only by the stipulation of the law which is obviously not true; on the other hand, not naming the human-beings' personality type as "legal" makes the impression that their personality is not based on the law which, again, is not true. There are real-beings holding legal personality and therefore are real persons but not named so; also, there are human-beings holding legal personality and therefore are legal persons but not named so. The need for a new type of legal personality has been seen clearly and approved in the case of AI: the European Parliament has offered a new type of legal personality for it to be named as "electronic". Similarly, if recognised, natural-beings' legal personality type would be named as "natural".

Instead of using a specie name for the private kinds of that species; it is wiser and more useful to use private names for them. The term "legal person" is a name used as the specie name and also the private name under that specie: in its usage as a specie name, it means a being that is recognised as a right and obligation holdable unit within a legal system, which covers human-beings as well; and in its usage as a private name, it means a real or non-real, but always a non-human, being that is recognised as a right and obligation holdable unit within a legal system. This does not mean that human-beings do not have legal personalities or they are not legal persons; on the contrary, they are the first - and to some point, the only - person of law, which is to say, legal person.

The terms "real" and "legal" are, although the latter is confusing as discussed above, accepted and used widely within the legal literature. The confusion will be much greater if there is a new kind of being to be recognised as a person of law, because it will become a legal person just like human-beings, corporations (C), associations (A), and trusts (T): CAT. It might seem practical to keep grouping the newly legal-personality-attributed-beings under the legal persons group. However, this would be no different than naming the human-beings as "living-beings" and the rest of the beings "non-living-beings" which is not true as there are living-beings just like human-beings other than human-beings. Naming the legal personality type of human-beings after the emergence of the CAT as "real" makes sense as the CAT have no real existence while human-beings do. The situation has started to be confusing when real-beings other than human-beings have been recognised as legal persons like ships, idols, rivers, etc. because they also do have existence in the real meaning. These real-beings are not like CAT as their existence is not only in the eye of the law. This becomes weirder when the public international law is the case as for the traditional doctrine in the matter of subjects of international law are only the States and international organizations [12]. Therefore, these two legal persons are in fact the real persons in this field. If the human-beings are included as new actors in this stage, the name of their legal personality type will have to be "legal personality".

This problem of naming, which became to exist with the recognition of legal personality to non-real-beings besides human-beings, will accelerate with further legal personality recognition to non-human-real-beings. Therefore, there exists the need for new legal personality types for the upcoming real and non-real-beings such as natural-beings and AI.

3.2. The Need for "Natural Personality"

It was the concern that full autonomous AIs (FAAIs) would cause harm to currently existing legal persons which sparked the European Parliament to consider recognising them as a new kind of legal person under the name of the "electronic personality." This naming shows that we are not alone in the above-mentioned concern of "using different names for different legal personalities" as it is clear that FAAIs are more real than CAT however, they are still predominantly non-real to be called a "real person." The main difference between CAT and FAAIs is that the former lack the capacity of will while the latter have their own of it.

The situation is the opposite in the natural-beings' case as they are considered to be recognised as legal persons not due to the concern that they may cause harm to the existing legal persons but due to the concern that existing legal persons do cause harm to them but it is not possible to focus on the compensation of the damages occurred on them because they do lack existence in the eye of the law as a being worth to protect the interests of by making them a subject of rights. Therefore, the law considers the collateral damage that occurred on the account of these beings' owners but not the direct damage given to these beings' selves.

This scenario shows the inefficiency of the protection of natural-beings under the current legal personality regime: An owned animal's leg has been cut off while it is alive which is forbidden according to the law. What will be demanded from the court will not be the repairment of the loss of its leg, maybe via a prosthesis leg, but a sum of money to be paid to the owner and maybe another sum of money to be paid to the government as a penalty which might be accompanied with or instead of some to time of imprisonment of the wrongdoer; none of which will help to the animal itself. Even if the cost of the prosthesis leg can be demanded and held through the court decision, the owner is free to spend that money for that goal or not. The only way to ensure the repairment of the loss of such an animal in the most efficient way is to attribute legal personality to it by which it will become the plaintiff in front of the court in his own name and will sue for the damages given to himself.

Such a legal person that is created by attributing a specific legal personality to meet its needs would never empower it with the rights that existing legal persons have. This, we can clearly see in the comparison of the rights and obligations of existing legal persons: CAT do not have the right to vote, health, education, marriage, etc. also do not have some of the obligations that real persons might have such as the military service. On the other hand; they have some rights; such as to open a branch, end their own existence, etc., and obligations; such as to maintain at least one human-being as her representative and a share-holder at all times; which real persons do not. Likewise, natural-beings can also become legal persons by having their tailor-cut kind of legal personality which includes the rights serving for the efficient protection of their own interests.

4. CONCLUSION

Just as the law itself is a tool to maintain and sustain the public order in any State; being a person in the eye of that State's legal system is another tool that enables any-given-being to be able to hold the rights, not every existing but only the legal personality type recognised to him enables him to, for the sake of protecting the interests of his own by using the State's powers. As it is at the discretion of only the States [4, 6, 7, 13, 15] to give that status to any being She wishes, it is the State to decide to which of the beings She wants to attribute legal personality in order to protect the interests by the rights belonging to that being's self.

Natural-beings seem to us to be the most-jeopardised-being and therefore need and deserve such a status amongst all. They have served to human-beings from the beginning till now and will continue to do so until the end of time only if they do not extinct due to the mal-use (*abusus*) of them by the human-beings as a result of insufficient protection of them by the States. A new type of legal personality may serve as an appropriate tool to reach that goal. Including only the tailor-cut-rights together with a special name for this type of legal personality might enable the human-beings to survive along with these beings.

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CHAPTER 9

Climate Change and Monitoring

CLIMATE CHANGE AND ITS EFFECTS ON HIGH IMPACT WEATHER EVENTS

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ABSTRACT

Climate change may be described in terms of spatial scales (e.g., global or regional), in the temporal mean of a given atmospheric parameter (e.g., temperature, humidity, precipitation, wind, pressure) or in its variability. Changes in climate mean and in climate variability may lead to the high impact weather events, which can be unusual and extreme than average weather conditions, such as intense heatwaves, severe droughts, heavy precipitation and flash-floods. Since the warmer atmosphere can hold more moisture, it can pave the way for the extreme precipitation events. As well as extreme precipitation events, heatwaves are also very frequent in recent years. It was reported that the global mean surface air temperature for 2015–2019 was approximately 1.7°C above pre-industrial period and 0.3°C warmer than the previous 5-year period. For example, the global mean temperature of 2019 was noted to be approximately 1.1 ± 0.1°C above the 1850–1900 baseline and noted as the second warmest on record. The mean global surface temperature in 2021 was approximately 1.11 (± 0.13) °C higher than the pre-industrial (1850-1900) levels. The year of 2021 is the 7th consecutive year (2015-2021) where global mean surface temperatures has been over 1°C higher than the pre-industrial levels. The effects of climate variability and change on extreme events were evident in the summer of 2021. Both the eastern and western Black Sea regions experienced high impact flash floods. In Kastamonu, for example, measured rainfall amounts were close to 500-mm in 48-h, causing fatalities, damages and economical losses of EUR 425 million. The eastern Black Sea region experienced severe flash-floods, which led to some casualties and damages. The 48-hour total precipitations were approximately 245 mm in Rize, which were well above its July climatological average (158 mm). Owing to long lasting intense heatwaves, the year of 2021 was the second-worst wildfire season in Europe. Turkey was the most affected country, which accounted for 206,013 ha, which is approximately three times its yearly mean forest fires.

Keywords: Climate Variability and Change, High Impact Weather, Flash-Floods, Black Sea Region

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1. INTRODUCTION

Climate change may be described in terms of spatial scales (e.g., global or regional), in the temporal mean of a given atmospheric parameter (e.g., temperature, humidity, precipitation, wind and pressure) or in its variability in various time-scales. Since the warmer atmosphere can hold more moisture – which is 7% per 1°C according to the *Clausius-Clapeyron* relationship – it can pave the way for the extreme precipitation events.

Extreme swings from one severe weather event to another are sometimes referred as "climate whiplash" or "weather whiplash", because of the climate change induced climate variability. The summer of 2021 can be given as an example in this context, in which various European countries and Turkey went through various severe weather events such as high-impact flash-floods and mega heatwaves, and that some of these events caused deaths and extrensive damage. In July 2021, Austria, Belgium, Croatia, Germany, Italy, Luxembourg, the Netherlands, and Switzerland experienced catastrophic flooding events. It was noted that 243 people died in floods; 196 in Germany, 43 in Belgium, two in Romania, one in Italy and one in Austria [1]. On 13-14 July, intensive rain caused severe flash floods and landslides in Rize in the eastern Black Sea coast of north-eastern Turkey, and 6 people had died and 2 went missing. Recorded 24-hours total precipitations were 213.6 mm in Rize-Güneysu and 188.3 mm in Çayeli. In early August 2021, in the mid-western Black Sea coastal area of Turkey, devastating flood events led to 82 deaths and causing several fatalities, damages and economical losses of EUR 425 million. In late July and early August, extremely dry weather conditions paved the way for wildfires in 39 countries, burning a total of 1,113,464 ha according to the European Commission's Joint Research Centre. The two most impacted regions were Turkey and Italy with 206,013 ha and 159,537 ha burned areas, respectively [2]. This paper aims to give some brief accounts of these extreme weather events.

2. FLASH FLOODS OVER THE EASTERN BLACK SEA REGION: 13-14 JULY 2021

Its geomorphology, topography, physiographic characteristics and location make the Black Sea region very sensitive to extreme weather events, e.g. heavy precipitation, catastrophic flash-floods, high waves and storm surges, which can lead to fatalities, damages and substantial economic disruption. On 14 July, torrents of rain led to flash floods and landslides in Rize, which is located in the eastern Black Sea Region of northern Turkey. Several houses collapsed or had buried under heavy landslides and flood accumulated debris. More than 70 roads in the flood affected region were closed. It was reported that 6 people had died and 2 went missing [3].

The flash-flood events of 13-14 July highly affected Giresun, Trabzon, Rize, Artvin and their provinces. This study focuses on rainfall amounts of Rize stations to bring attention on high precipitation amounts and intensity. According to Turkish State Meteorological Service's (TSMS) 1961-2020 observational records; climate mean of July precipitation is 158.1 mm. Analysing the 48-hour total rainfall for Rize and its provinces indicated that they received extreme amounts of precipitations, which were well above the July climatological mean (158 mm) (Figure 1). Analysing daily total precipitation amounts of 13-14 July indicates that Rize received most of its rainfall on 14 July (Figure 2).

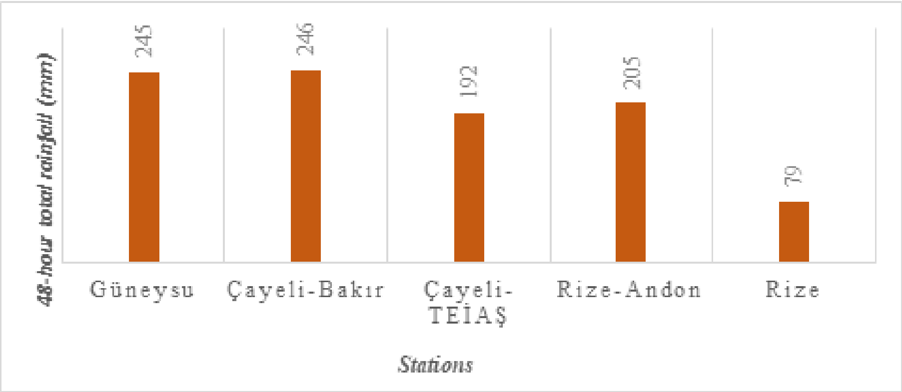

Figure 1. 48-hour total rainfall amounts (in mm).

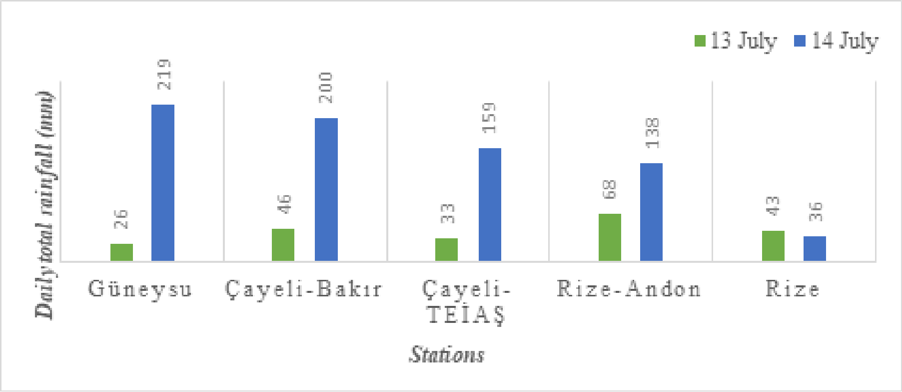

Figure 2. 13-14 July recorded daily total rainfall amounts (in mm).

Analysing in detail daily and hourly maximum rainfall amounts of 14 July for Rize revealed that hourly maximum precipitation amounts were very high (Figure 3). For example, the observed 24-hour rainfall was 219 mm in Güneysu station, and its hourly maximum rainfall was 67 mm, which was approximately 31% percent of its daily total precipitation. Similarly, Çayeli-Bakır station received 200 mm daily rainfall, and its maximum hourly rainfall was 69 mm, which accounted for approximately 35% percent of its 24-hour rainfall. Daily rainfall was 159 mm in Çayeli-TEİAŞ station, and hourly maximum precipitation was 64 mm. It highlighted that 40% percent of daily rainfall was received just in an hour.

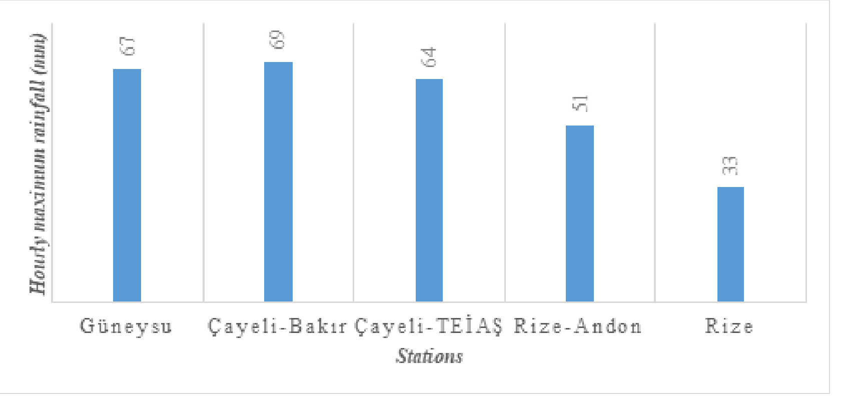

Figure 3. Recorded hourly maximum rainfall amounts (in mm) for 14 July.

3. FLASH FLOODS OVER THE WESTERN BLACK SEA REGION: 10-11 AUGUST 2021

The high-impact flash-flood events of 10-11 August severely affected the Black Sea towns of Bartın, Kastamonu, Sinop, and their provinces. According to Turkish State Meteorological Service's (TSMS) 1961-2020 observational records; average precipitation of August is 31.9 mm for Kastamonu, 42.7 mm for Sinop and 76.7 mm for Bartın [4]. The observed 48-hour rainfall amounts are depicted in Figure 4. The 2-day period total rainfall amounts underline the intensity of flash-flood events. Kastamonu's Mamatlar Köyü, Kuz Köyü and Küre received 420 mm, 356 mm and 382 mm amounts of rainfall respectively. It should be noted that Kastamonu's mean annual precipitation is 482.8 mm [4], and these reported 48-hour rainfall amounts are approximately account for its 79-87% of annual mean precipitation. Sinop's Ayancık station recorded 302 mm, which is almost 50% of its mean annual precipitation.

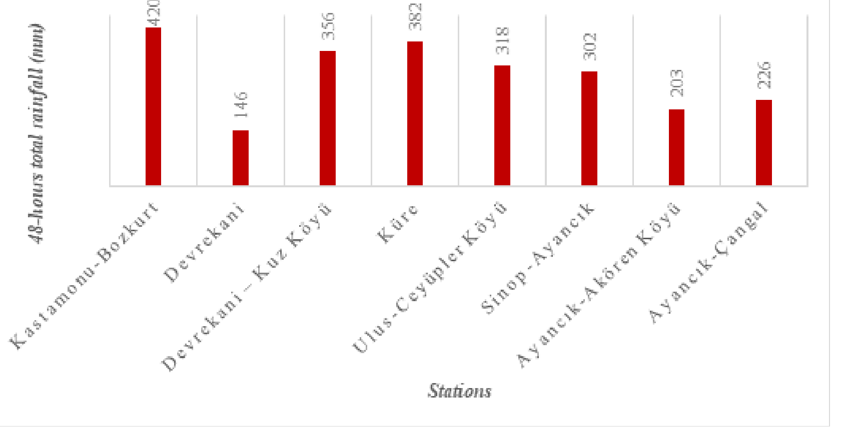

Figure 4. 48-hour total rainfall amounts (in mm) for Kastamonu and Sinop.

Examining daily rainfall amounts for 10-11 August indicates that most of rain fell on 11 August, except for Kastamonu-Ulus and Sinop-Ayancık (Figure 5).

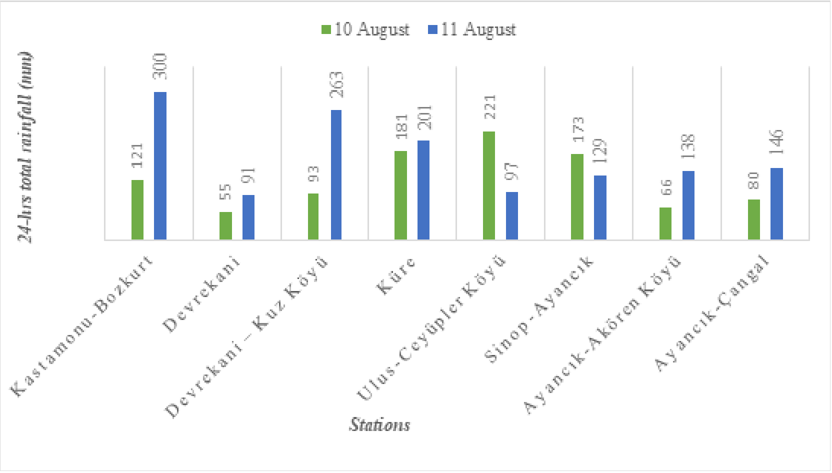

Figure 5. 10-11 August recorded daily total rainfall amounts (in mm) for Kastamonu and Sinop.

Analysing hourly maximum rainfall amounts of 10 August for the area of interest showed that hourly maximum rainfall was very high for Kastamonu-Bozkurt, Bartın-Ceyüpler Köyü and Sinop-Ayancık stations (Figure 6). Hourly maximum rainfall amounts account for most of the daily rainfall amounts, which indicates the intensity of this event. For example, on 10 August, 24-hour total precipitation was 221 mm in Batın's Ceyüpler Köyü station, and hourly maximum precipitation was 126 mm, which is almost 70% percent of its daily rainfall.

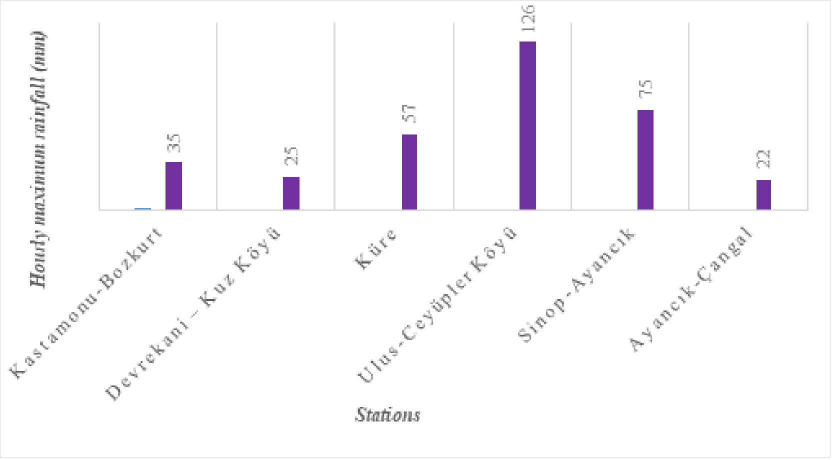

Figure 6. 10 August recorded hourly maximum rainfall amounts (in mm) for Kastamonu and Sinop.

Hourly maximum rainfall amounts of 11 August highlight that hourly maximum rainfall amounts of Kastamonu-Bozkurt, Kuz Köyü and Küre and Sinop-Ayancık stations (Figure 7) account for large part of daily fall. For example, daily rainfall was 129 mm in Sinop-Ayancık, and hourly maximum rainfall was 90 mm. It shows that 57% percent of daily rain fell in an hour, which sheds light on the intensity of the event. Bartın-Ceyüpler Köyü's 24-hour rainfall was 97 mm and hourly maximum was 47 mm, which accounts for 48% of its daily rainfall.

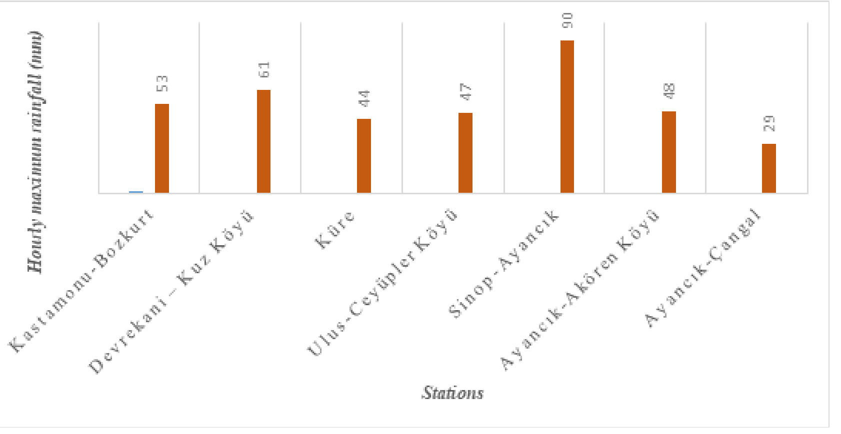

Figure 7. 11 August recorded hourly maximum rainfall amounts (in mm) for Kastamonu and Sinop.

4. THE MEDITERRANEAN FOREST FIRES: 29 JULY – 3 AUGUST 2021

The year of 2021 was the second-worst wildfire season in Europe since 2000 [5]. Forest fires were noted in 39 countries, burning 1,113,464 ha as reported by the European Commission's Joint Research Centre. A record of 1422 fires were reported, which were nearly four times the average of the last 13 years [5]. Among the wildfire effected countries, Turkey was the most affected one, which accounted for 206,013 ha which is approximately three times its yearly mean forest fires, and Italy had 159,537 ha burnt area. Most of the fires took place very near to the Mediterranean and Aegean Sea coastal locations, such as provinces of Antalya, Muğla, and Marmaris in late July and early August. The Moderate Resolution Imaging Spectroradiometer on NASA's Aqua satellite provided images of forest fires in Antalya and Marmaris. For example, the Operational Land Imager (OLI) on Landsat-8 acquired natural-colour imagery of fires near the coastal provinces of Antalya -which are Alanya and Manavgat- are depicted in Figure 8 and in Figure 9. On 3 August, nine wildfires were still underway [6].

Figure 8. Forest fires on the Mediterranean coastal side of southern Turkey for 31 July 2021. (Courtesy of https://earthobservatory.nasa.gov/images/148650/fires-rage-in-turkey)

Figure 9. As in Figure 8, but for the area indicated for detail.
(Courtesy of https://earthobservatory.nasa.gov/images/148650/fires-rage-in-turkey)

5. CONCLUSIONS

A better understanding of extreme events under the changing climate has been stated as one of the World Climate Research Program's Grand Challenges [7]. In a warming world, the risk of having various extreme events, such as mega heatwaves, droughts, and extreme precipitation becomes higher. Various research studies postulate that extreme weather events may occur more frequently in a changing climate [8-9]. The possible role of climate change is questioned, whenever an extreme weather event occurs, but the effect of climate change on the extreme weather is not similar in all parts of the world.

The effects of climate variability and change on extreme events were evident in the summer of 2021. Both the eastern and western Black Sea regions experienced high impact flash floods. In Kastamonu, for example, measured rainfall amounts were close to 500-mm in 48-h. The eastern Black Sea region experienced severe flash-floods, which led to some casualties and damages. The 48-hour total precipitations were approximately 245 mm in Rize, which were well above its July climatological average (158 mm). Owing to long lasting intense heatwaves, the year of 2021 was the second-worst wildfire season in Europe. Turkey was the most affected country, which accounted for 206,013 ha, which is approximately three times its yearly mean forest fires.

High-impact weather events are typically triggered and driven by large-scale atmospheric patterns, while being maintained and sustained by local topography and thermodynamic effects. This study mainly examined observed and analysed atmospheric parameters of the 10-11 August the mid-west Black Sea catastrophic flash floods. Future studies may include predictability of this case well in advance so that with timely warnings central and local authorities can take preventive measures to avoid or lessen possible damages and casualties. By using global climate model input, which is based on the IPCC climate scenarios [10], regional climate models with much higher horizontal and vertical resolutions can provide detailed information on the occurrence of intense precipitation events, mega heatwaves and severe draughts in the future. This may provide guidance to city planners and authorities to consider suitable and sustainable smart constructions for future needs of vulnerable cities in a changing climate.

ACKNOWLEDGEMENTS

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BATHING WATER MONITORING ALONG TURKISH COASTS AND INTERNATIONAL BLUE FLAG AWARD SCHEME

Almila Kından Cebbari[1*]

ABSTRACT

Bathing water quality monitoring is one of key instruments for the protection of public health when they are using bathing waters and coastal areas for recreation. It is different than monitoring surface water quality as bathing water quality directly deals with and main focus is human health. In this study, bathing water monitoring quality criteria constituted originally by European Union Bathing Water Quality Management Directive 2006/7/EC repealing Directive 76/160/EEC, as Blue Flag International criteria is based, is to be explained and bathing water monitoring implementations along Turkish coasts will be presented. International Blue Flag Programme is one of the main data processor of bathing water monitoring results and seeks for excellent bathing water quality framed with 5 different criteria set including sampling, analyzing, assesment standards as well as risk asssesment of bathing areas named as bathing water profiles stated in above mentioned 2006/7/EC Directive adopted to Turkish directive as Yüzme Suyu Kalitesinin Yönetimine Dair Yönetmelik issued in the year 2019. This oral presentation will also include general view of statistical data covering the number of bathing water sampling water points, pollution monitoring points, excellent ones and Blue Flag awarded sites.

Keywords: Bathing Water Quality, Blue Flag

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1. INTRODUCTION

As of 2022, 531 beaches, 24 marinas, 15 tourism boats and 5 individual yachts were deemed worthy of the Blue Flag Award in Turkiye. This international award is valid for one year and is withdrawn when the environmental quality is not maintained and/or the criteria are not met. Looking at the distribution of the number of awards, Antalya, Mugla, and Izmir are followed by Aydin, Balikesir and Samsun with the highest number of beaches.

In Turkey, which ranks 3rd in the world with 531 beaches, it can easily be said that there are more works to be done for sustainable tourism and the protection of coasts due to the density of award-winning areas in certain regions.

Figure 1. Number of Blue Flags by provinces in Turkey-2022.

It is known that the existing infrastructure, sewerage systems, and treatment facilities are insufficient in terms of both capacity and treatment level, especially on the coasts, due to the increasing pressures with the number of visitors during the summer period together with the concentrated resident population.

On the other hand, the fact that environmental education in the marine tourism sector has not yet been fully integrated into operations and the Blue Flag Award is new in boating field can be showed as one of the reasons why the number in tourism boats and individual boatowners category is still low.

Historical Process of Monitoring Bathing Water in Turkey

Bathing water monitoring studies on Turkish coasts started with the cooperation protocol, signed in 1992, between the Ministry of Health and the Ministry of Tourism at the time, which is still valid today, at the level of ministries and prepared to create a base for the implementation of the Blue Flag Program in our country.

Until that time, the samples and analyzes taken irregularly in order to protect public health in the waters used for swimming within the scope of the General Sanitary Law (Umumi Hıfzısıhha Kanunu in Turkish), were brought into an order by harmonizing them with the European Union Directive 76/160/EC with the mentioned protocol.

Today, the 2006/7/EC Directive has replaced the old 76/160/EC with a new method based on basin-based risk assessment, statistical interpretation, public information, and inter-agency cooperation, with only sampling and analysis and arithmetic mean in classification in bathing water monitoring. system has been implemented.

The current directive was harmonized with related EU Directive of 2006/7/EC in our country in 2019 and published in the Official Gazette as Yüzme Suyu Kalitesinin Yönetimine Dair Yönetmelik.

By looking at the Blue Flag and general bathing water quality data of the monitoring points on the Turkish coasts for the year 2022;

• Samples are taken and analyzed regularly (once every 15 days during the summer season) in designated swimming areas at around 1650 points on the coasts of our country.

• Evaluations of the analysis results are made with the statistical analysis of the data of the past 4 years (percentile calculation-excel program) according to the criteria of the EU Bathing Water Directive 2006/7/EC (Regulation on the Management of Bathing Water Quality in our country) for the Blue Flag Program.

• 88 out of 1650 points are closed to monitoring, 43 points have just been added and are not ready for statistical evaluation, 64 points are creek pollution monitoring points, and 400 points are not at perfect levels.

• 531 of the remaining 1055 points in our country in 2022 were entitled to receive the Blue Flag Award. The conditions of other points need to be improved due to various reasons such as treatment status, lack of superstructure, and the risk of bathing water.

<u>• Just because it isn’t perfect doesn’t mean it isn’t good. Water Framework Directive (SÇD) and Marine Water Strategy Framework Directive(DSÇD) consider the ‘good environmental situation’. In the Bathing Water Quality Regulation, ‘good’ and ‘adequate’ classifications are considered sufficient for public health. Bathing Water Profiles are critical.</u>

Causes of Marine and Coastal Pollution

In order to evaluate the status of Blue Flag numbers in the context of marine pollution, it is necessary to list the types of pollution encountered in the field when it comes to marine pollution:

- Marine litter (surface and onshore solid wastes)
- Foaming and mucilage on the sea surface
- Petroleum and derivative wastes, oil, and film
- Pollution from offshore or marine tourism
- Pollution carried by streams and runoff
- Algae
- Microbiological pollution, pathogens

Some of these pollutions are regularly monitored and some are evaluated on a case-by-case basis. The Ministry of Environment, Urbanization and Climate Change, the Ministry of Agriculture and Forestry, and the Ministry of Health, through various regulations and circulars, carry out monitoring or control of pollution sources, some on a project basis and some on a regular and yearly basis. These are stated in Turkish below;

- Kıyı Kanunun Uygulanmasına Dair Yönetmelik
- Yüzme Suyu Kalitesi Yönetmeliği (76/160/AB)
- Su Kirliliği Kontrolü Yönetmeliği
- Kentsel Atıksu Arıtımı Yönetmeliği
- Gemilerden Atık Alınması ve Atıkların Kontrolü Yönetmeliği
- Gemilerden Atık Alınması ve Atıkların Kontrolü Yönetmeliği
- Denizcilik Atıkları Uygulaması Hakkında Genelge 2020/21
- Deniz Çöpleri İl Eylem Planlarının Hazırlanması ve Uygulanması Genelgesi 2019/9
- Marmara Denizi Eylem Planı›nın Uygulanmasına İlişkin Genelge

Although subject-based monitoring and controls are carried out with regulations and circulars, **SÇD** and **DSÇD** approach should be adopted as an exponential title. In these approaches, basin-based and integrated assessment of all relevant regulations is carried out, where all topics that may lead to pollution of water resources are evaluated, basin-based management is addressed and discharges to receiving environments are regulated by identifying sensitive areas, areas and indicators to be monitored are determined and ultimately, it is aimed to achieve good environmental status in the seas.

The main principles of the Water Framework Directive approach are as follows:

- Quality targets are set according to water bodies, not sectors
- Basin-based management approach is essential
- Receiving environment standards and discharge standards should be applied together
- Aimed at achieving good water status
- Evaluation of quality and quantity together is ensured
- The user pays-polluter pays principle is operated
- Participation of all stakeholders in planning studies is ensured

Figure 2. Water Framework Directive
(Ministry of Agriculture and Forestry, General Directorate of Water Management).

SCD, targets “good surface water status” while DSCD targets “good environmental status” in the seas. Based on the necessity of good quality of all surface waters reaching the seas in order to prevent marine pollution and to achieve a good environmental condition in the seas, it should be noted that there is a need for capacity development of coastal residents and public administrations in this regard, with careful and careful handling of both framework directives.

While determining an ecosystem-based management approach in the DSCD’s approach, the seas are handled regionally and all pressures on the seas are taken into account (Beken et al., 2013)

By fulfilling the issues specified in the said directives set forth by the European Union, it will be possible to control and prevent marine pollution at its source.

Monitoring Marine Pollution in the Blue Flag Program

In order to understand how marine pollution is handled and followed in the Blue Flag Program, first of all, it is necessary to examine how it is handled on the basis of criteria.

Looking at the Blue Flag Award criteria on a category basis, it can be seen that there is a broad perspective that includes environmental management criteria, which mainly includes waste management, and environmental education, aiming at the protection of sea water quality;

- Distribution of 33 criteria for beaches
  - Environmental Management-15 criteria
  - Water Quality-5 criteria
  - Environmental Education and Information-6 criteria
  - Safety and Services-7 criteria

- Distribution of 38 criteria for marinas
  - Environmental Management-22 criteria
  - Water Quality-1 criterion
  - Environmental Education and Information-7 criteria
  - Safety and Services-6 criteria
  - Corporate Social Responsibility-1 criteria
  - Public Participation-1 criterion

- Distribution of 51 criteria for tourism boats
  - Environmental Management-22 criteria
  - Environmental Education and Information-8 criteria
  - Responsibility to Wildlife-9 criteria
  - Safety and Services-7 criteria
  - Social Responsibility-5 criteria

- Distribution of 4 criteria and 17 codes of conduct for individual yachts
  - Environmental Management- 1 criteria

- Environmental Education and Information- 2 criteria
- Legal Permission- 1 criteria
- 9 codes of conduct for environmental management, 6 codes of conduct for responsibility to wildlife, 2 codes of conduct for information

Blue Flag Bathing Water Quality Criteria

In addition to environmental and waste management, which have a significant impact on the quality of sea water, and environmental education, which has an important role in ensuring these standards, the level of bathing water quality at the end of these efforts is controlled by 5 of the Blue Flag Criteria for Beaches.

Basically, within the scope of the award program, which requires re-application every year, the quality of bathing water, especially on the beaches, should be at an "excellent" level according to the evaluation of the past 4 years under the EU Bathing Water Directive 2006/7/EC. The 5 criteria determined to ensure this are as follows, respectively:

Criterion 7. The beach must fully comply with the water quality sampling and frequency requirements.

- Samples must be taken in the right place, at the right time and in the right way, and transported to the laboratory correctly.
- Sampling calendars are determined by the Provincial Health Directorates of each province.
- Before the season starts, the sampling schedule should be learned by contacting the Public Health Directorate and the sample results should be followed up by the municipality and the establishments.
- In the event that the sample results are negative, especially during the precipitation periods, it should be ensured that the sample is taken again 3 days after the end of the precipitation, thus determining whether the pollution is temporary or not.
- For negative sample results, research and on-site examination must be done. The EU Bathing Water Directive 2006/7/EC rules are valid for the pollution being temporary and ignoring the said negative sample, and an exemption of up to 15% of the total number of samples is allowed each year. The result of the sample to be replaced is also expected to be confirmed after 7 days (Mavi Bayrak Kriterleri ve Kılavuz Notlar Kitabı, 2019).

Criterion 8. The beach must fully comply with the standards and requirements for water quality analysis.

- In our country, the Ministry of Health is the authorized authority to take bathing water samples and analyze them.
- For this reason, only the samples taken by the Ministry and the results of their analyzes can be used for the Blue Flag.
- The conditions of the European Union Directive 2006/7/EC are provided by the Ministry in the sampling and analysis of the samples (https://hsgm.saglik.gov.tr/depo/birimler/cevre-sagligi/1-su-guvenligi/Kitaplar/Yuzme_Sulari_Rehber_Kitabi.pdf

- In 1992, sampling and analysis in accordance with the Blue Flag criteria on the coasts of our country was given an official status by making a protocol between the Ministry of Tourism and the Ministry of Health, and today the protocol still maintains its validity.

Criterion 9. Industrial, waste-water or sewage-related discharges must not affect the beach area.

- It is recommended that there should not be any industrial, urban wastewater or sewage-related discharges into the Blue Flag area or immediate buffer zone/surrounding area. If there are discharge points in the area of the beach, these must be documented at the time of application.

- For our country and EU member countries, the requirements for the treatment and effluent quality given in the EU Urban Waste Water Treatment Directive (91/271/EEC) are valid.

- A bathing water profile must be compiled for every Blue Flag beach. A bathing water profile includes identification of potential sources of pollution, a description of the physical, geographical and hydrological characteristics of the bathing water, as well as an assessment of the potential for cyanobacteria and algae formation.

- Bathing water profile documents describing the **risk factors for each beach on the coasts** of our country were prepared by TUBITAK MAM in 2014 by the Ministry of Environment, Urbanization and Climate Change, Department of Marine and Coastal Management. The current documents have been updated by Istanbul University Marine Sciences Institute and can be viewed at www.plaj.csb.gov.tr .

- Existing bathing water profile documents can be obtained from the Ministry of Environment, Urbanization and Climate Change. However, beyond the library information, the documents should be carefully examined, especially by the municipalities and beach managers, and the information should be kept up-to-date and handled with the understanding of the management of risk factors.

- The 3 main indicators that are taken as a basis while determining the final risk status of bathing water in profile documents are microbiological status, ecological status and chemical status.

- Microbiological status is determined by the Ministry of Health within the scope of the beforementioned protocol, and "excellent" microbiological classifications that can be nominated for the award are determined within the scope of the Blue Flag Program.

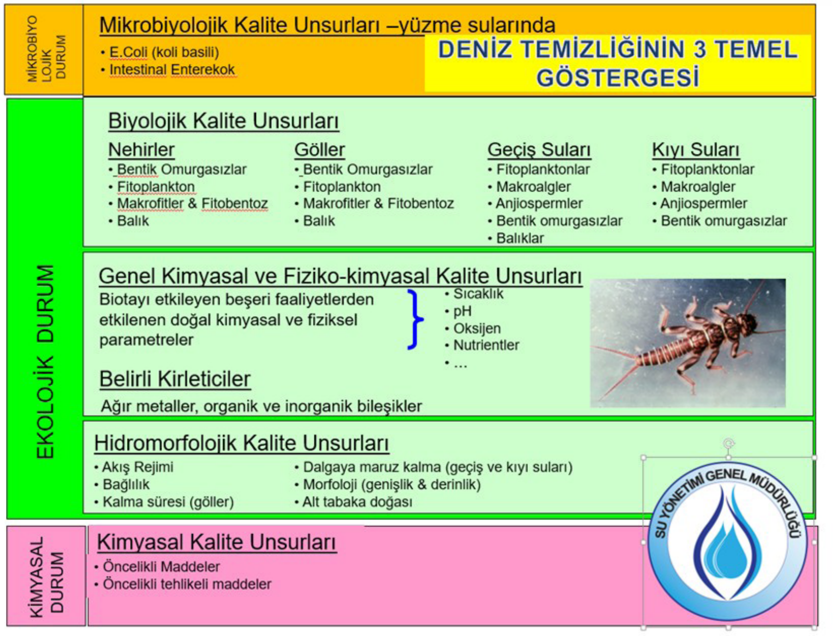


Figure 3. ThreeBasic Indicator Table of Marine Cleanliness, created by combining the Ecological Status and Chemical Status table of the Ministry of Agriculture and Forestry and the table of Microbiological Status.

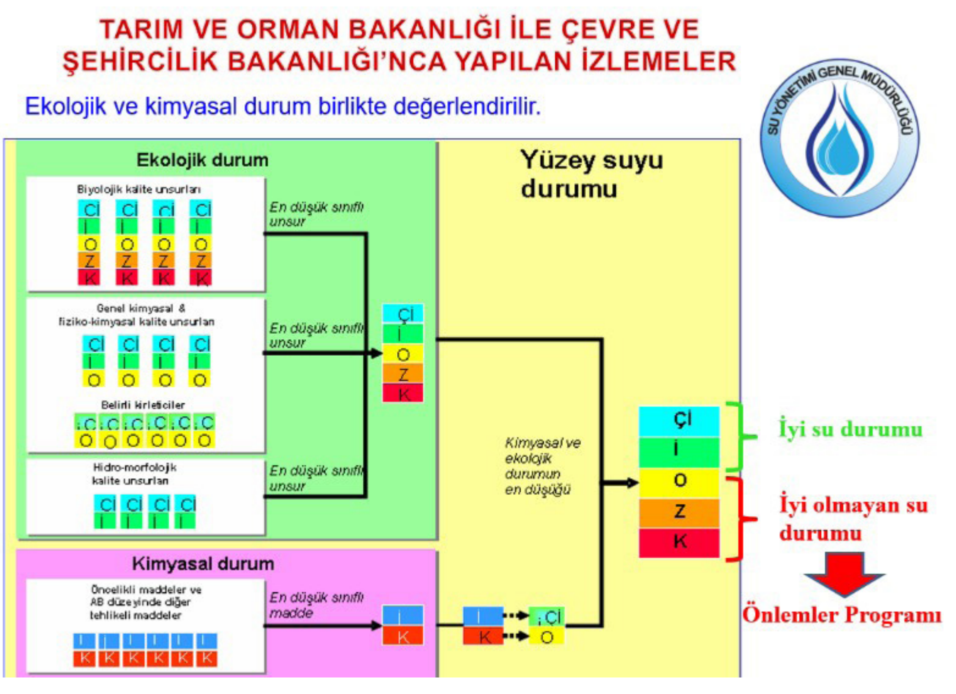
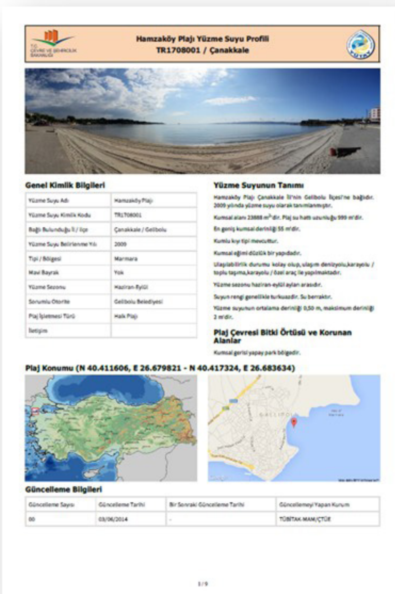


Figure 4. Ecological and Chemical Status Parameters
(Ministry of Agriculture and Forestry, General Directorate of Water Management).

- As a result of all marine pollution indicator data processed in the risk analysis matrix specified in the WHO Guidelines for Safe Recreational Waters document of the World Health Organization, the risk status of bathing water is finally defined and an example of the final report is given in the images below.



Hamzaköy Plajı Yüzme Suyu Profili
TR1708001 / Çanakkale

Genel Kimlik Bilgileri

Yüzme Suyu Adı	Hamzaköy Plajı
Yüzme Suyu Kimlik Kodu	TR1708001
Bağlı Bulunduğu İl / İlçe	Çanakkale / Gelibolu
Yüzme Suyu Belirlenme Yılı	2009
Tipi / Bölgesi	Marmara
Mavi Bayrak	Yok
Yüzme Sezonu	Haziran-Eylül
Sorumlu Otorite	Gelibolu Belediyesi
Plaj İşletmesi Türü	Halk Plajı
İletişim	

Yüzme Suyunun Tanımı

Hamzaköy Plajı Çanakkale İli'nin Gelibolu İlçesi'ne bağlıdır. 2009 yılında yüzme suyu olarak tanımlanmıştır.

Kumsal alanı 23888 m^2'dir. Plaj su hattı uzunluğu 999 m'dir.

En geniş kumsal derinliği 55 m'dir.

Kumlu kıyı tipi mevcuttur.

Kumsal eğimi düzlük bir yapıdadır.

Ulaşılabilirlik durumu kolay olup, ulaşım denizyolu,karayolu / toplu taşıma,karayolu / özel araç ile yapılmaktadır.

Yüzme sezonu haziran-eylül ayları arasıdır.

Suyun rengi genellikle turkuazdır. Su berraktır.

Yüzme suyunun ortalama derinliği 0,50 m, maksimum derinliği 2 m'dir.

Plaj Çevresi Bitki Örtüsü ve Korunan Alanlar

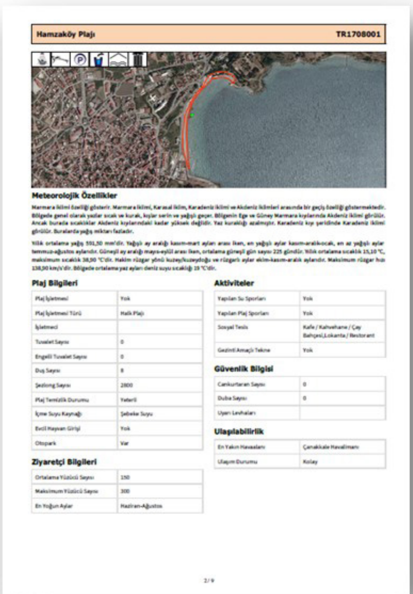
Kumsal gerisi yapay park bölgedir.

Plaj Konumu (N 40.411606, E 26.679821 - N 40.417324, E 26.683634)

Güncelleme Bilgileri

Güncelleme Sayısı	Güncelleme Tarihi	Bir Sonraki Güncelleme Tarihi	Güncellemeyi Yapan Kurum
00	03/06/2014	-	TÜBİTAK-MAM/ÇTÜE

1/9



Hamzaköy Plajı TR1708001

Meteorolojik Özellikler

Marmara iklimi özelliği gösterir. Marmara iklimi, Karasal iklim, Karadeniz iklimi ve Akdeniz iklimleri arasında bir geçiş özelliği göstermektedir. Bölgede genel olarak yazlar sıcak ve kurak, kışlar serin ve yağışlı geçer. Bölgenin Ege ve Güney Marmara kıyılarında Akdeniz iklimi görülür. Ancak burada sıcaklıklar Akdeniz kıyılarındaki kadar yüksek değildir. Yaz kuraklığı azalmıştır. Karadeniz kıyı şeridinde Karadeniz iklimi görülür. Buralarda yağış miktarı fazladır.

Yıllık ortalama yağış 591,50 mm'dir. Yağışlı ay aralığı kasım-mart ayları arası iken, en yağışlı aylar kasım-aralık-ocak, en az yağışlı aylar temmuz-ağustos aylarıdır. Güneşli ay aralığı mayıs-eylül arası iken, ortalama güneşli gün sayısı 225 gündür. Yıllık ortalama sıcaklık 15,10 °C, maksimum sıcaklık 38,90 °C'dir. Hakim rüzgar yönü kuzey/kuzeydoğu ve rüzgarlı aylar ekim-kasım-aralık aylarıdır. Maksimum rüzgar hızı 138,90 km/s'dir. Bölgede ortalama yaz ayları deniz suyu sıcaklığı 19 °C'dir.

Plaj Bilgileri

Plaj İşletmesi	Yok
Plaj İşletmesi Türü	Halk Plajı
İşletmeci	
Tuvalet Sayısı	0
Engelli Tuvalet Sayısı	0
Duş Sayısı	8
Şezlong Sayısı	2800
Plaj Temizlik Durumu	Yeterli
İçme Suyu Kaynağı	Şebeke Suyu
Evcil Hayvan Girişi	Yok
Otopark	Var

Ziyaretçi Bilgileri

Ortalama Yüzücü Sayısı	150
Maksimum Yüzücü Sayısı	300
En Yoğun Aylar	Haziran-Ağustos

Aktiviteler

Yapılan Su Sporları	Yok
Yapılan Plaj Sporları	Yok
Sosyal Tesis	Kafe / Kahvehane / Çay Bahçesi,Lokanta / Restorant
Gezinti Amaçlı Tekne	Yok

Güvenlik Bilgisi

Cankurtaran Sayısı	0
Duba Sayısı	0
Uyarı Levhaları	

Ulaşılabilirlik

En Yakın Havaalanı	Çanakkale Havalimanı
Ulaşım Durumu	Kolay

2/9

Criterion 10: Bathing water values should be within the limits given for microbiological parameters.

Bathing water quality in Blue Flag is evaluated according to the **2006/7/EC Bathing Water Water Quality Regulation of the European Union**.

- This regulation is currently described as the most comprehensive and stringent bathing water regulation worldwide.

- Evaluation is based on statistical evaluation of seawater analyzes of the past 4 years.

- Escherichia coli value indicates direct human sourced sewage waste, while Intestinal enterococcal value indicates sewage and animal/agricultural pollution.

- The duties of beach representatives and municipalities; to follow the analysis results up-to-date on www.mavibayrak.org.tr or www.yuzmesaglik.gov.tr for E.C. (escherichia coli) and I.E. (intestinal enterococcus) values are above the limit values, to ensure that research is done.

- Whether it is at a perfect level according to the limit values expressed in the table is determined by statistical percentile calculation and an excel program is used for this.

EK-1

Tablo 1: İç sular için kalite kriterleri ve kalite sınıfları

	A	B	C	D	E
	Parametre	Mükemmel Kalite	İyi Kalite	Yeterli	Referans Analiz Metotları
1	İntestinal enterokok (cfu/100 ml)	200 (*)	400 (*)	330 (**)	ISO 7899-1 veya ISO 7899-2
2	Escherichia coli (cfu/100 ml)	500 (*)	1 000 (*)	900 (**)	ISO 9308-3 veya ISO 9308-1

(*) Yüzde 95'lik değerlendirmeye dayanmaktadır. Ek-2'ye bakınız.
(**)Yüzde 90'lık değerlendirmeye dayanmaktadır. Ek-2'ye bakınız.

Tablo 2: Kıyı suları ve geçiş suları için kalite kriterleri ve kalite sınıfları

	A	B	C	D	E
	Parametre	**Mükemmel**	**İyi Kalite**	**Yeterli**	**Referans Analiz Metotları**
1	Intestinal enterokok (cfu/100 ml)	100 (*)	200 (*)	185 (**)	ISO 7899-1 veya ISO 7899-2
2	Escherichia coli (cfu/100 ml)	250 (*)	500 (*)	500 (**)	ISO 9308-3 veya ISO 9308-1

(*) Yüzde 95'lik değerlendirmeye dayanmaktadır. Ek-2'ye bakınız.
(**)Yüzde 90'lık değerlendirmeye dayanmaktadır. Ek-2'ye bakınız.

Figure 5. Regulation on the Management of Bathing Water Quality microbiological classification ANNEX-1 table.

Criterion 11: Bathing water must be within the limits given for physical and chemical parameters.

-The physical appearance of the bathing water must be clean, The listed items must not be in the water:

- Solid waste
- Foam and mucilage
- Oil and film layer on the surface
- Petroleum and derivative wastes
- Floating materials such as wood, plastics, bottles, containers, glasses or other items.

- The personnel who take samples on the sampling days also record such pollutions they see in the bathing water.

In unusual physical and chemical pollutions;

- Analysis results cannot show from which stream, facility or boat the pollution comes from. For this, boat traffic and pollution pressures in the surrounding area should be determined and monitored and evaluated together with the analysis results.

- Sampling must also be carried out by authorized persons in accordance with the "Communiqué on Sampling and Biology Sampling from Surface Water, Groundwater and Sediment" published in the Official Gazette dated 21.02.2015 and numbered 29274.

- In the summer period, especially for the pollution seen on the sea surface, the Health Directorate is usually called and the samples are analyzed for the detection of microbiological pollution. Although this determination is important, some additional analyzes may be required.

- For this reason, the Provincial Directorate of Environment, Unbanization and Climate Change Ministry should be called immediately and a study should be requested to determine what the necessary analyzes are and to investigate the source of pollution.

- Samples taken in an emergency should be analyzed in laboratories authorized by the Ministry of Environment, Urbanization and Climate Change. https://elab.cevre.gov.tr/LabSorgu/

Exemption Cases Regarding Deterioration of Bathing Water Quality

Application for exemption;

- Caused by exceptional/extraordinary weather conditions affecting the water quality criteria.

- In order to apply for an exemption, the situation must be documented.

- These documents should demonstrate that the problem has been resolved and that the contamination is unmistakably related to the event in question.

Often, the application for exemption arises due to extreme weather conditions that affect water quality. Accordingly, the documents required for the application are;

- Weather report - official notification that the weather is unusual

- Photos summarizing the situation

- Control sample results (exemption application is not accepted if the control sample proving that the pollution has passed is not taken).

Institutions that should cooperate in order to ensure the quality of bathing water within the scope of all stated bathing water quality criteria:

- Provincial Health Directorate
- Provincial Directorate of Environment, Urbanization and Climate Change
- Related Metropolitan Municipality Water and Sewerage Works
- If it is not a metropolitan municipality, the municipality to which it is affiliated
- Regional Directorate of State Hydraulic Works
- Provincial Directorate of Agriculture and Forestry Ministry
- Universities

- NGOs actively working as Blue Flag Local Responsible, if any, in the region
- Foundations and associations working on marine pollution

TÜRÇEV-European Environment Agency Marine Litter Watching Program implemented under the Blue Flag Program

The criteria for bathing water quality include the absence of solid waste and garbage on the sea surface and on the land part of the beaches. However, one of the most important problems that stand out all over the world is marine litter and it is known that there are 5 large plastic islands identified in the oceans. In addition, according to the United Nations Environment Program-UNEP study, it is stated that approximately 69 billion dollars should be spent every year to clean the accumulated wastes that have accumulated on the coasts consisting of 34 million km all over the world.

The starting point of the necessity to conduct such a monitoring study within the scope of the Blue Flag Program;

- To increase the quality of coastal cleaning campaigns carried out for awareness purposes in accordance with Blue Flag criteria
- Raising awareness of municipalities and campaigners about marine litter and its sources
- To create real data-based information about the state of marine litter on the coasts of our country
- To contribute the scientific studies
- Preparing the ground for the preparation of places without a Blue Flag Award for the Blue Flag Award and the establishment of qualified beach services
- Raising awareness about marine litter and mobilizing the community

Method:

- Under the supervision of Prof. Dr. Ahmet Kıdeyş from METU Erdemli Institute of Marine Sciences and in cooperation with the European Environment Agency-Denmark, the methodology of the European Environment Agency Marine Litter Watching Program is applied
- Selected areas are where municipalities or private businesses are unable to provide regular cleaning services
- Monitoring and cleaning is carried out 4 times a year-4 seasons at the same coordinate intervals at the same location on the same beach
- Only items larger than 2.5 cm are counted, smaller items and microplastics are not included
- The collected waste is categorized and counted in over 200 different categories and where possible, weights are measured. Of these, plastics are the category that is searched in the most detail with over 100 types
- Reports are processed by TÜRÇEV to the European Environment Agency data system under the group name Blue Flag Turkey

- The data of municipalities, operators or NGOs that want to work with TÜRÇEV Blue Flag Program are entered into the European Environment Agency system by writing the name of Blue Flag Turkey and the name of the stakeholders.

The data of all countries can be seen at:
https://www.eea.europa.eu/themes/water/europes-seas-and-coasts/assessments/marine-litterwatch/data-and-results/marine-litterwatch-data-viewer

Municipalities and local groups participating in the Marine Litter Watching Program:

1. Aksu Municipality and KUYAB- Kundu Tourism Investors Association (Antalya)- Çardak Resort Location

2. Kemer Municipality (Antalya) – Kındılçeşme Picnic Area

3. Kocaeli Metropolitan Municipality & Kandıra Municipality. – Kandıra Sardala Bay

4. SARÇED- Sarıgerme Environmental Education Association (Muğla)– Sarıgerme Public Beach

5. Şile Municipality (İstanbul) – Uzunkum Beach

6. Didim Municipality (Aydın) – Fener Bay

7. Kumluca Municipality (Antalya) – Obalar Location

8. Ula Municipality (Muğla) – Kermetur Beach

9. Kuşadası Municipality (Aydın) – Banyolar Beach

10. Alanya Municipality (Antalya) – Galip Dere Beach

11. İzmir Metropolitan Municipality (İzmir)- İnciraltı City Forest

12. Manavgat Municipality (Antalya)- Boğaz Beach

The proportions of total waste found in all study areas for 44 surveys were determined as follows:

- 53025 pieces of plastic (78% plastic) out of 67640 pieces of waste found in a total of 44 monitoring on 13 beaches

- Weight measurement could not be done everywhere and therefore the data is expressed in numerical quantities

Visuals and summary numbers of all monitoring activities can also be seen on @mavibayrakturkiye social media accounts.

RESULTS

The indispensable criterion among all Blue Flag criteria is the “excellent” level of bathing water quality. Therefore, it requires careful examination of all criteria in this category and to be considered together with the necessary management measures. In this context, municipalities, especially the relevant public institutions, have important duties. In any case, capacity building of public institutions and all relevant parties in monitoring marine pollution and seawater quality criteria is important, and the Foundation for Environmental Education in Turkiye-TURCEV, the sole authorized executive of the Blue Flag Program in our country since 1993, undertakes this task.

All relevant organizations participating in the Blue Flag Programme, monitored or located in award-winning places, improve their level of knowledge by participating in national-level trainings organized by TÜRÇEV every year. In addition, with the Beach Blue Flag Representative Training and Certification Program, beach representatives are trained with an exam and their information is kept up-to-date. (http://www.mavibayrak.org.tr/tr/icerikDetay.aspx?icerik_refno=55).

In conclusion, it can be said that those who participate in the activities carried out within the scope of the International Blue Flag Program make an important contribution to the efforts to protect the seas and coasts, especially the European Union legislation.

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SURVEY ON THE CHALLENGES OF REDUCING CARBON DIOXIDE EMISSION USING RENEWABLE ENERGY TECHNOLOGIES IN NIGERIA

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ABSTRACT

Energy is needed to support human social and economic development. Major part of the world population especially those in developing countries like Nigeria, rely on fossil fuel to meet their energy needs. Renewable energy is a great strategy for addressing climate change, but it must be sustainable to meet future generations' energy demands and slow the process of global warming. Therefore, one of the key strategies for achieving the goals established by energy policy in this area is to reduce carbon dioxide emissions. This study examined the challenges encountered in reducing carbon dioxide emission using renewable energy technologies in Hadejia and Gashua towns of Jigawa and Yobe state, Nigeria respectively. Descriptive survey design was used with a structured questionnaire as data collection instrument. The population of the study comprised 271 households who were randomly selected. Simple percentages were used to analyze the demographic information of the respondents, while the hypotheses were tested using chi-square. Findings revealed higher percentage in the use of fossils (firewood, charcoal and kerosene) as against a very low percent for renewable energy (solar plate/batteries and battery cells) use in the study areas. The finding also revealed that availability and low cost are the factors influencing the utilization of fossils in the production of energy. Negative factors such as cost, lack of awareness and lack of trust in the new form of energy production affects the use of renewable energy. The result of the test of hypothesis revealed that the use of renewable energy has an impact on carbon dioxide emission reduction in the study areas. Therefore, it is essential for regulators to adopt motivation in their approach for boasting investments in renewable energy resources, considering the higher percentage of challenges discovered, in order to enhance CO_2 reduction.

Keywords: Carbon Dioxide Emission, Fossil Fuel, Renewable Energy

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1. INTRODUCTION

Climate change is now affecting every country, on every continent, costing lives, disrupting national economies, communities and countries. The attention of the world including academia, policy makers, e. t. c. all geared toward solving this critical issue. Strategies to counteract climate change focuses on reducing emissions of greenhouse gases, the most common being carbon dioxide (CO_2). Deforestation and the burning of fossil fuels are the two main human-caused sources of carbon dioxide emissions that exacerbate the adverse effects on the climate system. Many households in Nigeria are facing challenges of clean, less dangerous and convenient cooking fuel. Studies have shown the sources of cooking energy in Nigeria to include electricity, liquefied natural gas, kerosene, charcoal, firewood, wood waste, and agricultural waste [1, 2]. Rural communities, particularly women and children who spend a lot of time in the kitchen, are more likely to develop respiratory ailments as a result of the traditional way of cooking that involves burning biomass. Conventional energy systems negatively affect human health and are neither economically, socially, nor environmentally sustainable [3]. A few examples of renewable energy technology that have helped rural populations raise their standard of living while adjusting to climate change are solar energy, hydroelectric power, wind power, improved cooking systems, enhanced water mills, and biogas plants. For instance, the UK's carbon emissions were 43% lower than the baseline level from 1990, and this decrease was primarily made possible by the decarbonization of the country's energy-producing sources. In 2018 carbon emissions were reduced by 43% below 1990 levels, but a considerable amount of reduction is still needed to meet the national target of an 80% reduction by 2050. Achieving the national goal of an 80% decrease requires switching to alternative energy sources and reducing energy usage in industries other than large-scale power generation [4]. Controlling the rate at which carbon emissions are increasing and decreasing in intensity are crucial concerns requiring immediate attention. This study involves two towns (Gashua and Hadeja) from different regions of Nigeria, possessing similarities in climatic conditions. Gashua town with about 125,000 persons (2006) lies few kilometers from convergence of River Jama'are and Hadeja. While Hadeja an internationally important ecological and sensitive zone [5] with about 105,628 persons lies to the north of Hadejia River. The study specifically aims at finding out the conduct and attitude of people toward renewable energy, the extent of fossil utilization as sources of energy as well as to investigate the factors influencing the use of fossils and renewable energy sources.

2. METHODS

A descriptive survey design was use to examine the challenges encountered in reducing carbon dioxide emission using renewable energy technologies. The population of the study comprised 271 households who were randomly selected. The instrument for data collection was a structured questionnaire distributed to individuals from the selected households across the two towns. Results were analyzed using simple percentage, while the formulated hypotheses were tested using chi-square.

3. RESULT AND DISCUSSION

3.1. Result

Table 1: Distribution of Responses by Socio-Demographic characteristics

Characteristics	Frequency of distribution	Percentage (%)
Gender		
Male	182	67.2
Female	89	32.8
Age		
21-30 years	78	28.8
32-40 years	103	38.0
41-50 years	65	24.0
Over 50	25	9.2
Years of leaving in Area		
Less than 3yrs	11	4.0
3-6 yrs	40	14.8
7-10yrs	132	48.7
Over 10yrs	88	32.5
Marital status		
Single	28	10.3
Widow	74	27.3
Married	152	56.1
Widower	17	6.3
Occupation		
Civil servants	28	10.3
Trader	109	40.2
Farmer	98	36.2
House wife	36	13.3

Source: Researchers Field Survey, 2022

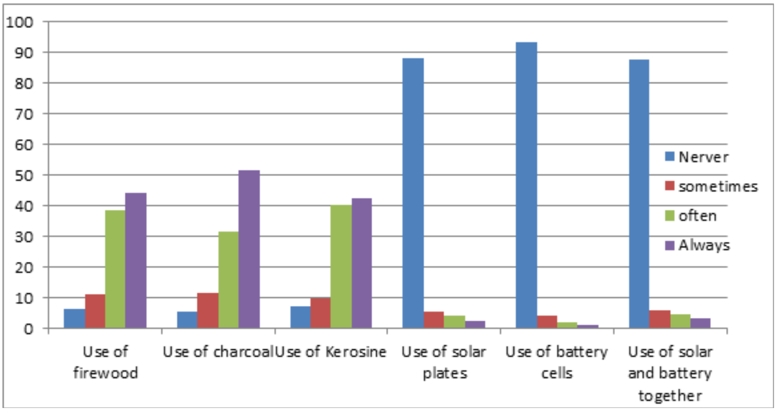

Figure 1. Distribution of responses for use of fossils and renewable energy.

Table 2: Distribution of Responses on factors influencing the use of fossils in the study Areas

S/N	Variable	N	Response			
			Disagree (%)	Don't know (%)	Agree (%)	Strongly Agree (%)
1	Readily available	271	22 (8.1)	24 (8.9)	200 (73.8)	25 (9.2)
2	Low cost	271	8 (3.0)	16 (5.9)	218 (80.4)	29 (10.7)
3	Less technicality in operation	271	0 (0.0)	13 (4.8)	236 (87.1)	22 (8.1)
4	Ignorance of harmful effect	271	3 (1.1)	12 (4.4)	241 (88.9)	15 (5.6)
5	Poor regulatory control	271	5 (1.8)	15 (5.6)	239 (88.2)	12 (4.4)

Source: Field Survey, 2022.

Table 3: Distribution of Responses on factors affecting the use of renewable energy in the study areas

S/N	Variable	N	Response			
			Disagree (%)	Don't know (%)	Agree (%)	Strongly agree (%)
1	Cost	271	77 (28.4)	54 (19.9)	136 (50.2)	4 (1.5)
2	Lack of awareness	271	48 (17.7)	12 (4.4)	179 (66.1)	32 (11.8)
3	Space requirements.	271	21 (7.7)	19 (7.0)	204 (75.3)	27 (10.0)
4	Lack of innovative technology	271	50 (18.4)	59 (21.8)	145 (53.5)	17 (6.3)
5	Poor Policies	271	60 (22.1)	21 (7.8)	164 (60.5)	26 (9.6)
6	Attitude toward change		48 (17.7)	14 (5.2)	189 (69.7)	20 (7.4)

Source: Field Survey, 2022.

Hypothesis Testing

Based on the objectives set out and the research questions outlined, the null hypotheses was developed. The statistical significance of the raised hypotheses was tested at 0.05 significant levels.

H_{o1}: There is no statistically significant relationship between the use of fossils and climate change in the study Areas.

Table 4: Observed frequency (Oi)

Response Variables	Increase carbon emission	Causes river flooding	Fossils affect environment	It leads to desertification	Total
Always	56	52	37	90	235
Often	53	50	42	71	216
Sometimes	112	115	80	101	408
Never	50	54	112	9	225
Total	271	271	271	271	**1084**

Source: Survey 2022

The values were calculated and tabulated using the formula below:

$$Ei = \frac{rt \times ct}{Gt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\text{e.g for always} = \frac{235 \text{ X } 271}{1084} = \mathbf{58.75}$$

Where Ei = Expected frequency, rt = Raw total ct = Column total Gt = Grand total

Table 5: Chi-square $(X^2) = \sum \frac{(Oi-Ei)^2}{Ei} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$

Oi	*Ei*	*Oi-Ei*	*(Oi – Ei)²*	$\frac{(Oi-Ei)^2}{Ei}$
56	58.75	-2.75	7.563	0.129
53	54	-1	1	0.019
112	102	10	100	0.980
50	56.25	-6.25	39.063	0.694
52	58.75	-6.75	45.563	0.776
50	54	-4	16	0.296
115	102	13	169	1.657
54	56.25	-2.25	5.063	0.090
37	58.75	-21.75	473.063	8.521
42	54	-12	144	2.667
80	102	-22	484	4.745
112	56.25	55.75	3108.063	55.254
90	58.75	31.25	976.563	16.622
71	54	17	289	5.352
101	102	-1	1	0.010
9	56.25	-47.25	2232.563	39.690
Total				**137.502**

H_{o2}: Renewable energy has no impact on reduced carbon dioxide emissions in those areas.

Table 6: Observed frequency (Oi)

Response Variables	**Renewable Energy Sources Cause Environmental Degradation**	**Solar Energy are not User Friendly**	**Total**
Disagreed	238	197	435
Don't know	13	17	30
Agreed	11	37	48
Strongly Agreed	9	20	29
Total	271	271	**542**

Source: Questionnaire. Survey 2022

3.2. Discussion

Nigeria's CO_2 emission has been on the increase from 91.7m tones in 2010 to 120.3m tones in 2020 thereby raising the global warming indices and triggering climate change [6]. Renewable energy sources are primary, clean, low-risk, and limitless with low carbon contents and are therefore anticipated to have a less adverse environmental impact [7]. Environmental issues like the exhaustion of fossil fuels and global warming are getting worse, and Resent studies shows that replacing fossil fuels with renewable energy encourages energy conservation and lowers carbon emissions [8]. Transitions to renewable energy are crucial for decarbonizing the global economy and reducing its effect on climate change. The well-being of those who are vulnerable may be jeopardized especially across this area of study, despite the attention of the world on this issue, lack of awareness, poor policies, attitude and less innovative technologies continue to play a significant role and must be quickly addressed for the attainment of global goal of net zero emission. In the first hypothesis **s**ince the calculated value 137.502 is greater than the table value of 16.919, the null hypothesis which states that "There is no statistically significant relationship between the use of fossils and climate change in the areas" is rejected. This therefore translates into accepting the alternative hypothesis which means that the use fossils as a means of energy influence the nature of climate in those areas due to environmental warming which agrees with [9].However, in the second hypothesis the calculated value of 22.654 is greater than the chi-square table value of 7.815; the null hypothesis which states that "There is no statistically significant relationship between the use of renewable energy and reduced carbon dioxide emission in the study areas" is rejected. This therefore translates into accepting the alternative hypothesis which means that the use of renewable energy has impact in reducing carbon dioxide emissions [10].

4. CONCLUSION

In order to enhance human development, which promotes economic growth and productivity, energy is a necessity in our daily lives. Although using renewable energy to reduce CO_2 emission is a great idea, the challenges of cost, awareness, innovative technology and space requirements were identified to be the major obstacles in the study area. Sustainable renewable energy sources are to replace fossil fuel-based energy sources in order to prevent climate change and its effects. However, it is also noted that pricing, political climate, and market conditions have impeded emerging developing countries from fully utilizing their potentials toward the sustainable energy ventures. Therefore, it is recommended that certain motivative approach should be adopted by regulators to improve the production and consumption of this new clean form of energy.

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CLIMATE CHANGE IMPACTS ON EXTREME WEATHER EVENTS: 10-11 AUGUST 2021 FLASH FLOODS OVER THE BLACK SEA REGION

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ABSTRACT

Climate describes the statistics of weather for typically over a 30-year period; it can describe long-term averages or variability of weather over specified temporal and spatial scales. Climate change may be described in terms of spatial scales (regionally and globally), in the temporal mean of a given atmospheric parameter (e.g., temperature, precipitation) or in its variability in various time-scales. Since warmer atmosphere can hold more moisture – which is 7% per 1^0C according to the *Clausius-Clapeyron* relationship – it can pave the way for extreme precipitation events. In 10-11 August 2021, the mid-western Black Sea region of Turkey experienced high-impact flash-floods, which resulted in severe casualties and damages. Examining the 48-hour total precipitations shed light on the scale of devastating flash-floods. Kastamonu's Mamatlar Köyü, Kuz Köyü and Küre received 420 mm, 356 mm and 382 mm amounts of precipitations, respectively. Considering Kastamonu's mean annual precipitation of 482.8 mm, these 48-hour precipitations account for its 79-87%. Bartın's Ceyüpler Köyü received 318 mm, which covers 30% of its mean annual precipitation. Sinop's Ayancık station recorded 302 mm, which is almost 50% of its mean annual precipitation. Analyses of weather maps, satellite and weather radar images and lightning data revealed surface and upper level atmospheric conditions that led to the extreme precipitations. The stationary surface low and the upper level low were located very close to the flood affected area and the prevailing strong northerly winds transported hot and humid air towards the land and led to thunderstorms and heavy precipitation for 2-days. Sea surface temperature (SST) is one of the major climate variables due to its key role for climate variability and change. In recent years, the Black Sea region's SSTs have a warming tendency, and that 10-11 August mean SSTs were 2-3^0C above climate averages, which might have contributed to the extreme precipitations.

Keywords: Climate Variability and Change, High Impact Weather, Flash-Floods, Black Sea Region

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1. INTRODUCTION

Climate change may be described in terms of spatial scales (regionally and globally), in the temporal mean of a given atmospheric parameter (e.g., temperature, precipitation) or in its variability in various time-scales. Since the warmer atmosphere can hold more moisture – which is 7% per 1°C according to the *Clausius-Clapeyron* relationship – it can pave the way for the extreme precipitation events. Extreme swings from one severe weather event to another are sometimes referred as “climate whiplash” or “weather whiplash”, due to the climate change induced climate variability, in this context, the summer of 2021 can be given as an example in which some European countries and Turkey experienced all sorts of severe weather events such as extreme flash-floods and mega heatwaves, some were catastrophic, causing deaths and widespread damage. In July, Austria, Belgium, Croatia, Germany, Italy, Luxembourg, the Netherlands, and Switzerland were affected from severe flood events. It was reported that 243 people died in these floods; 196 in Germany, 43 in Belgium, two in Romania, one in Italy and one in Austria [1]. In 13-14 July, heavy rain caused flash floods and landslides in Rize in the eastern Black Sea coast of north-eastern Turkey, and 6 people had died and 2 went missing. Recorded 24-hours total precipitations were 213.6 mm in Rize-Güneysu and 188.3 mm in Çayeli. In early August, in the mid-western Black Sea coastal area of Turkey, devastating flood events led to 82 deaths and causing several fatalities, damages and economical losses of EUR 425 million. In late August, extremely dry weather conditions paved the way for wildfires in 39 countries, burning a total of 1,113,464 ha according to the European Commission’s Joint Research Centre (JRC). The two most impacted regions were Italy and Turkey with 159,537 ha and 206,013 ha burned areas, respectively [2].

Its geomorphology, topography, physiographic characteristics and location make the Black Sea region very sensitive to extreme weather events, e.g. heavy precipitation, catastrophic flash-floods, high waves and storm surges, which can lead to fatalities, damages and substantial economic disruption. This study examines the high-impact flash-flood events of 10-11 August, which severely affected the Black Sea towns of Bartın Kastamonu, Sinop, and their provinces. According to Turkish State Meteorological Service’s (TSMS) 1961-2020 observational records; average precipitation of August is 31.9 mm for Kastamonu, 42.7 mm for Sinop and 76.7 mm for Bartın [3]. The TSMS’s recorded precipitation amounts is summarized in Table 1 and depicted in Figure 1. Daily and hourly maximum precipitation amounts are very high particularly in Bozkurt, Devrani and Küre of Kastamonu; Ulus province of Bartın and Ayancık province of Sinop.

Table 1. 10-11 August 2021 recorded precipitations (mm)

City	Station Name	Date	Daily Total	Hourly Maximum	Time
Kastamonu	Bozkurt	10 August	109,83	**77**	15:00
		11 August	37,6	12	07:00
	Bozkurt – Mamatlar Köyü	10 August	120,74	35,08	18:00
		11 August	**299,71**	**52,45**	10:00
	Devrekani	10 August	55,2	16	19:00
		11 August	91,2	27	07:00
	Devrekani – Kuz Köyü	10 August	93,23	25,17	16:00
		11 August	**262,92**	**60,25**	09:00
	Küre	10 August	**180,94**	**57**	17:00
		11 August	**201,12**	**44**	08:00
Bartın - Ulus	Ulus	10 August	72	**51,6**	23:00
		11 August	71,4	21,4	07:00
	Ceyüpler Köyü	10 August	**221,28**	**126,39**	23:00
		11 August	96,52	**46,65**	00:00
	Çubukeli Köyü	10 August	14,57	7,81	22:00
		11 August	**122,17**	**40,73**	02:00
Sinop - Ayancık	Ayancık	10 August	**172,92**	**75,26**	23:00
		11 August	**129,17**	**90,28**	11:00
	Akören Köyü	10 August	65,58	13,29	23:00
		11 August	**137,64**	**47,54**	**03:00**
	Çangal	10 August	80,48	22,09	23:00
		11 August	**145,74**	29,14	04:00

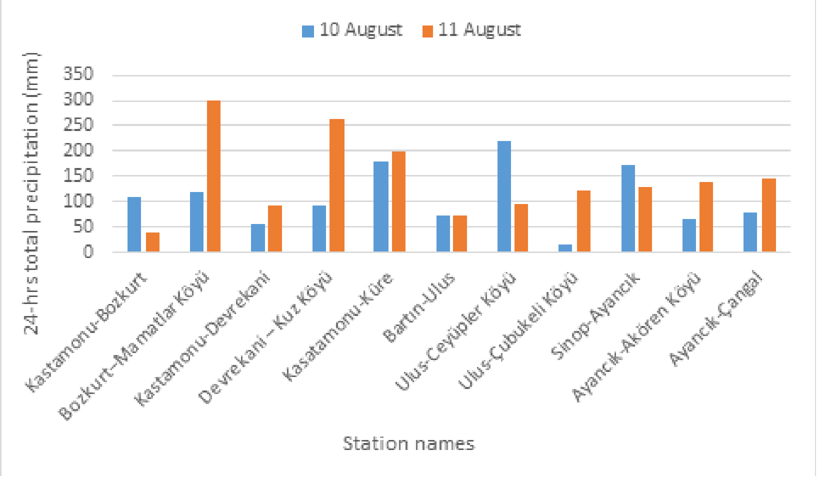

Figure 1. 10-11 August recorded 24-hour total precipitation (in mm) for Kastamonu, Bartın and Sinop, and their provinces.

Examining and comparing daily and hourly maximum precipitation amounts of 10 August for the area of interest revealed that hourly maximum precipitation amounts were very high for Kastamonu-Bozkurt, Bartın-Ulus, Bartın-Ceyüpler Köyü and Sinop-Ayancık stations (Figure 2). Hourly maximum precipitation amounts cover most of the daily total precipitation amounts, which reveals the intensity of precipitation event. For example, on 10 August, 24-hour total precipitation was 221 mm in Batın's Ceyüpler Köyü station, and hourly maximum precipitation was 126 mm, which is almost 70% percent of its daily precipitation.

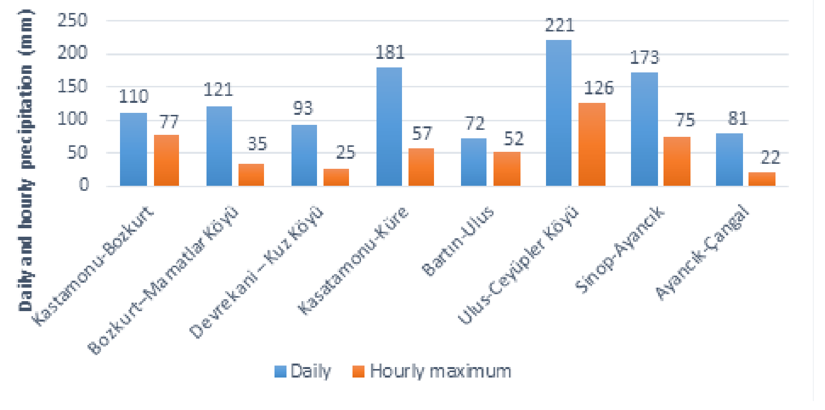

Figure 2. 10 August observed daily and hourly maximum total precipitations (in mm) for Kastamonu, Bartın and Sinop, and their provinces.

11August daily and hourly maximum precipitation amounts indicate that hourly maximum precipitation amounts of Kastamonu's Mamatlar Köyü, Kuz Köyü and Küre, Bartın-Ulus and Sinop-Akören Köyü stations (Figure 3) account for large part of daily precipitations. For example, 24-hour total precipitation was 129 mm in Sinop-Ayancık, and hourly maximum precipitation was 90 mm. It indicates that 57% percent of daily precipitation fell in one hour, which sheds light on the scale of the precipitation event. Bartın-Ceyüpler Köyü's daily rainfall was 97 mm and hourly maximum was 47 mm, which accounts for 48% of its daily precipitation.

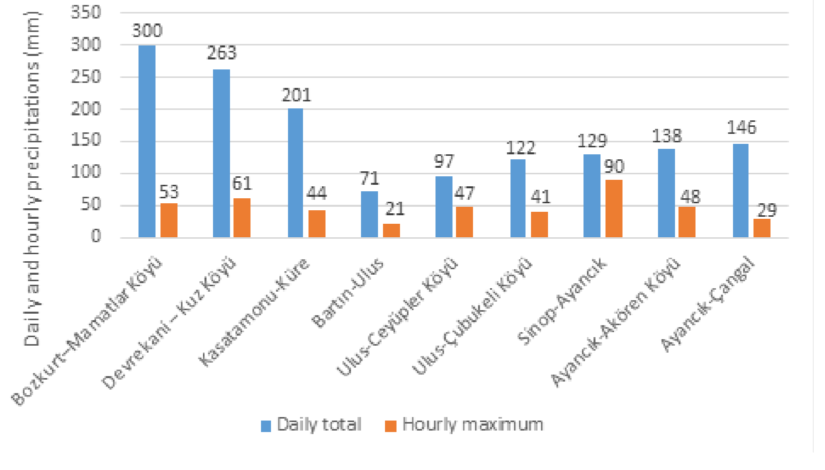

Figure 3. 11 August observed daily and hourly maximum total precipitations (in mm) for Kastamonu, Bartın and Sinop, and their provinces.

The 2-day period total precipitation amounts (Table 2 and Figure 4) underline the scale of flash-flood events. Kastamonu's Mamatlar Köyü, Kuz Köyü and Küre received 420 mm, 356 mm and 382 mm amounts of precipitation respectively. It should be noted that Kastamonu's mean annual precipitation is 482.8 mm [4], and these reported 48-hour precipitations are approximately 79-87% of its annual mean precipitation. Bartın's Ceyüpler Köyü received around 318 mm of rain, which amounts to 30% of its mean annual precipitation. Sinop's Ayancık station recorded 302 mm, which is almost 50% of its mean annual precipitation.

Table 2. Observed 48-hour total precipitation amounts (in mm)

City	Station Name	48-Hour Total
Kastamonu	Bozkurt	147,3
	Bozkurt – Mamatlar Köyü	**420,45**
	Devrekani	146,4
	Devrekani – Kuz Köyü	**356,15**
	Küre	**382,06**
Bartın	Ulus	143,4
	Ulus - Ceyüpler Köyü	**317,8**
	Ulus - Çubukeli Köyü	136,74
Sinop	Ayancık	**302,09**
	Ayancık - Akören Köyü	**203,22**
	Ayancık - Çangal	**226,22**

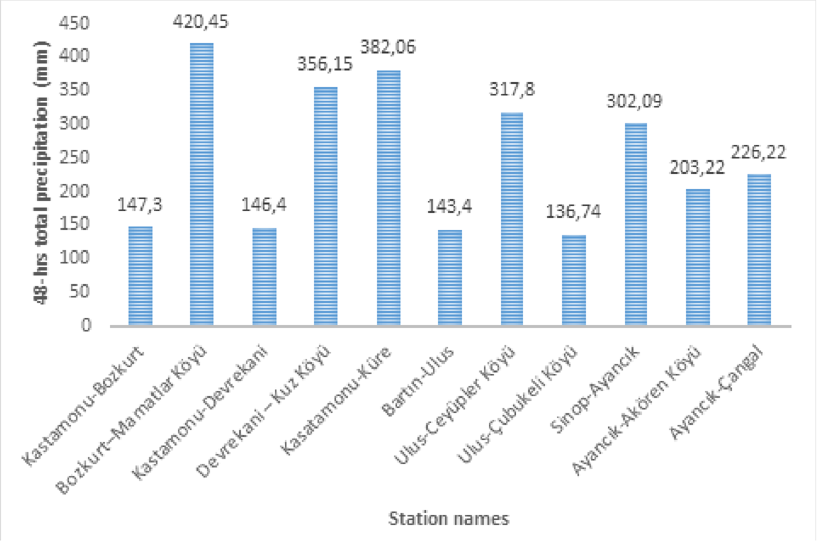

Figure 4. Observed 48-hour total precipitation (in mm) for Kastamonu, Bartın and Sinop, and their provinces.

2. MATERIAL AND METHODS

The National Oceanic and Atmospheric Administration (NOAA) based National Center for Environmental Predictions (NCEP)'s Global Forecasting System (GFS) Model data, which has a 0.25°x0.25° longitude-latitude grid horizontal resolution, is used in this study to analyse surface and upper level atmospheric conditions. The Moderate Resolution Imaging Spectroradiometer (MODIS) instrument aboard the National Aeronautics and Space Administration (NASA) Terra satellite images are from the NASA's Worldview Snapshots application, part of the Earth Observing System Data and Information System (EOSDIS), which has 250 m horizontal resolution, was used for satellite based observational analysis. Lightning data are obtained from Blitzortung and it is used for observational analysis of convective cloud activities. The reflectivity scanning of the Zonguldak dual polarized C-Band Doppler radar, which has a volume-scanning of 1-km horizontal resolution and 6-minute interval in a maximum radar range of 370 km, is obtained from TSMS, and utilized for examining precipitation observations. Sea surface temperature (SST) data is obtained from the NOAA OI SST V2 High Resolution Dataset, which is provided by the NOAA Physical Sciences Laboratory (PSL), is employed for horizontal SST distribution and its relation to climatological anomalies.

3. RESULTS AND DISCUSSIONS

3.1. A Brief Synoptic Overview

At the surface; on 10 August, a surface low was centred over the southern Black Sea, and accompanying precipitation was noted over the mid-west and the eastern Black Sea coastal regions of Turkey (Figure 5(a)). On the following day, the surface low deepened further over the same location and precipitation area extended towards west and south (Figure 5(b)). The low pressure system did not move much due to the quasi-stationary high-pressure system on its east, which helped to maintain its position and continuation of the related weather conditions.

Compared to observed precipitations, the GFS model's performance in simulating precipitation is very poor, this can be attributed to global model's low horizontal resolution and related model physics. A meso-scale event of this type may be simulated better with a regional numerical weather prediction model that may have high horizontal and vertical resolutions and may be equipped well with high resolution geared model physics. Predictability of high-impact weather events well in advance also requires ensemble forecasts, which contains suits of model physics and initial and boundary conditions [5].

At the upper-levels of the atmosphere (the 500 hPa which is around 5000 m above sea level), a north-south elongated low centre was over Turkey with accompanying northerly strong wind (Figure 5(c)). On 11 August, the upper level a north-south elongated trough covered the Black Sea and Turkey, and the strong northerly winds continued to transport hot and humid air from the Black Sea to over the flash-flood ridden towns of Bartın, Kastamonu, Sinop and their provinces (Figure 5(d)).

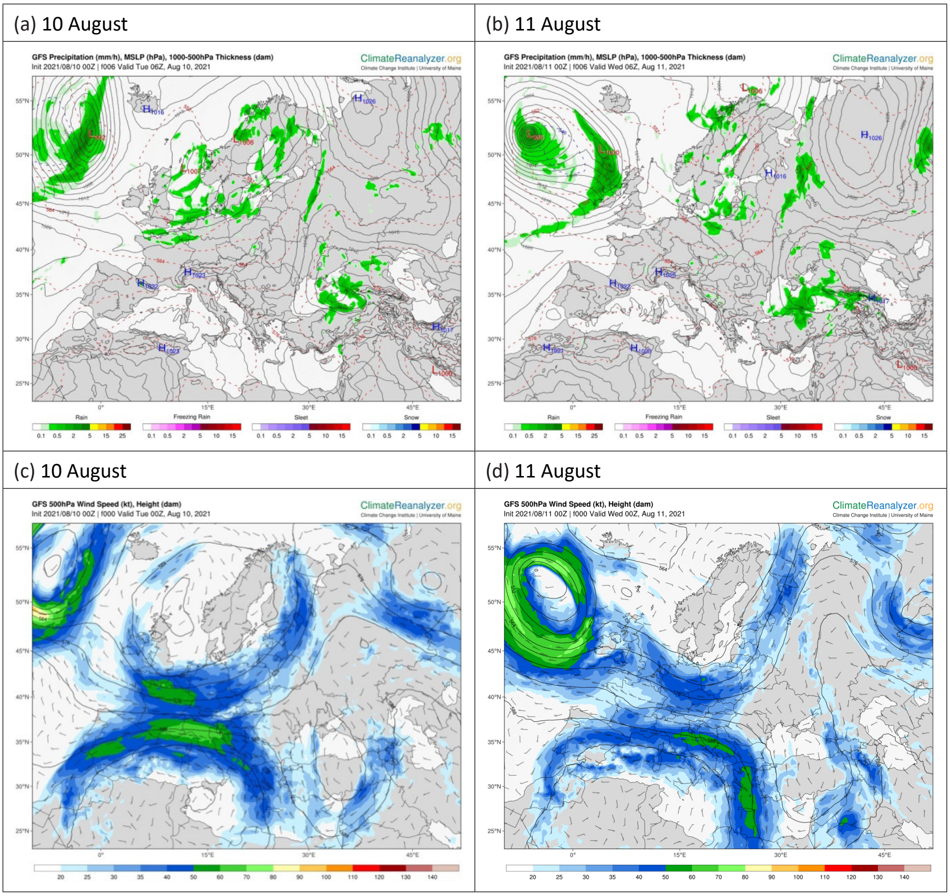

Figure 5. Mean sea level pressure (hPa), precipitation (mm/h) and 1000-500hPa thickness (dam) (a) 10 August; (b) 11 August; 500 hPa geopotential height (dam) and wind speed (knots) (c) 10 August; (d) 11 August; (Courtesy of https://climatereanalyzer.org/) (1 knots is equal to 1 m/s.)

Sea surface temperature (SST) is one of the major climate variables due to its key role for climate variability and change. SSTs play a vital role in extreme rainfall events by increasing or decreasing resulting precipitation amounts [5]. Some research studies indicate that the spatial pattern of the Black Sea SST has a general warming tendency [6-8].Examining the mean SSTs of the Black Sea for 10-11 August period indicated that the southern region had SSTs of 26-27°C (Figure 6(a)). These SSTs are close to tropical SSTs [9]. The SST analysis for the period 10-11 August 2021 indicates an extensive area of seawater being 2–3°C warmer than the August climatological averages (Figure 6(b)). Warmer-than-average SSTs over the Black Sea can be responsible for anomalous sensible and latent heat fluxes, which can act to trigger heavy precipitation conditions at the boundary layer. Considering the strong northerly winds of the quasi-stationary surface low and continuous transport of hot and humid air over the flood affected area for two consecutive days, SSTs warmer than climate mean can play an important role in producing and maintaining large amounts of hourly and daily precipitations.

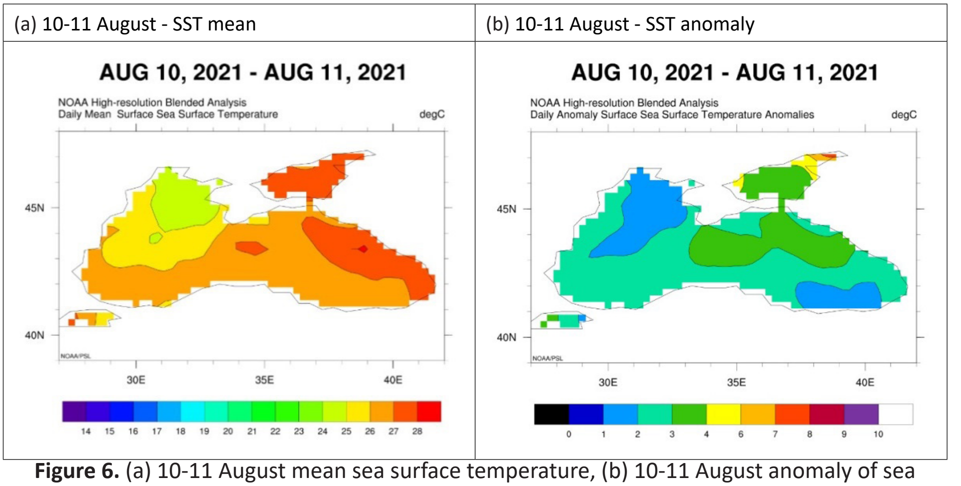

Figure 6. (a) 10-11 August mean sea surface temperature, (b) 10-11 August anomaly of sea surface temperature distribution.

3.2. A Mesoscale Observational Overview

On the satellite image of 10August (Figure 7(a)), the pronounced north-south elongated cloud bands –which were parallel to the prevailing northerly winds (Figure 5 (c))- was noted over the Black Sea region, and led to heavy rainfall in Kastamonu-Küre (181 mm), Bartın-Ceyüpler Köyü (221mm) and Sinop-Ayancık (173 mm) (Table 1 and Figure 3). On the following day, similar cloud bands were still present over the same region (Figure 7(b)). The continuous advection of warm and moist air over the Black Sea sustained heavy daily precipitations in Kastamonu's Mamatlar Köyü (300 mm), Kuz Köyü (263 mm) and Küre (201 mm).

High-impact precipitation events are often associated with mesoscale convective systems (MCS) which are triggered by large-scale dynamics and a surface low transporting warm and moist air [10-11]. MCSs can stay over a place for many hours and lead to heavy rainfall. 10th August lightning events indicated existence of various MCS and their path towards the flood affected region (Figure 7(c)), which was in line with satellite image of the same day (Figure 7(a)). On 11th August, the further intensified lightning activities continued over the same area and revealed effects of highly active thunderstorm clouds. Intense lightening hints deep cumuliform type of cloud formations, which has high potential for intense precipitation.

The reflectivity scanning of the Zonguldak dual polarized C-Band Doppler radar, which has a volume-scanning of 1-km horizontal resolution and 6-minute interval in a maximum radar range of 370 km, is presented in Figure 7(e-f). On 10August, organized radar echoes was noted over Bartın, Kastamonu and Sinop at 1700 UTC (Figure 7(e)). Since the low pressure system was quasi-stationary, on the following day at 09:00 UTC, the same area was again covered by radar echoes (Figure 7(f)). The long stay of the rain producing system led to heavy precipitation on 11 August too (Table 1 and Figure 2). Strong radar echoes hinted large amounts of hourly precipitations, which were supported by measurements from the automated weather observing systems of TSMS (Figure 2 and Figure 3).

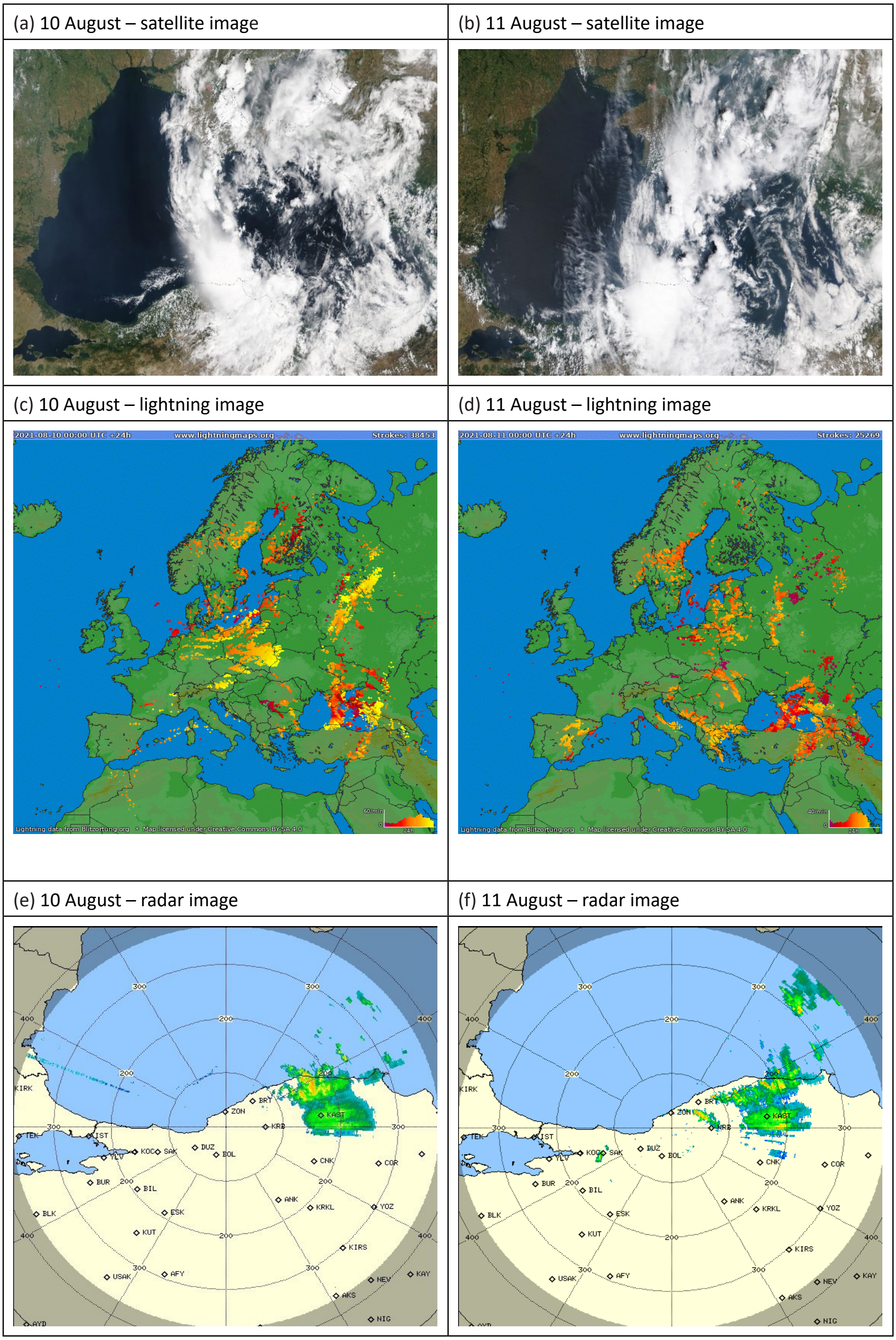

Figure 7. Satellite imageries from NASA Terra MODIS 7-2-1 bands with 250 m resolution for: (a) 10 August and (b) 11 August; lightning images for: (c) 10 August; (d) 11 August; TSMS Zonguldak weather radar images for: (d) 10August; (e) 11 August

4. CONCLUSIONS

In a warming world, the risk of having various extreme events, such as mega heatwaves, droughts, and extreme precipitation becomes higher. Various research studies postulate that extreme weather events may occur more frequently in a changing climate [13-14]. The possible role of climate change is questioned, whenever an extreme weather event occurs, but the effect of climate change on the extreme weather is not similar in all parts of the world. A better understanding of extreme events under the changing climate has been stated as one of the World Climate Research Program's Grand Challenges [12].

In 10-11 August, the mid-western Black Sea region of Turkey experienced the high-impact flash-floods, which resulted in severe casualties and damages. Kastamonu's Mamatlar Köyü, Kuz Köyü and Küre received 420 mm, 356 mm and 382 mm, respectively. Considering Kastamonu's mean annual precipitation of 482.8 mm, these 48-hour precipitations account for its 79-87%. Bartın's Ceyüpler Köyü received 318 mm, which covers 30% of its mean annual precipitation. Sinop's Ayancık station recorded 302 mm, which is almost 50% of its mean annual precipitation. Analyses of weather maps, satellite and weather radar images and lightning data revealed surface and upper level atmospheric conditions that paved the way for the extreme precipitation and resulting catastrophic flash-flood events. The quasi-stationary surface low and the upper level low were located over the flooding area and the prevailing strong northerly winds transported hot and humid air of the Black Sea towards the land and led to heavy precipitation for two consecutive days. In recent years, the Black Sea region's SSTs have a general warming tendency, and that the 10-11 August mean SSTs were found to be 2-3°C above climate averages, which might have contributed to the pronounced hourly maximum precipitations.

High-impact weather events are typically triggered and driven by large-scale atmospheric patterns, while being maintained and sustained by local topography and thermodynamic effects. This study mainly examined observed and analysed atmospheric parameters of the 10-11 August the mid-west Black Sea catastrophic flash floods. Future studies may include predictability of this case well in advance so that with timely warnings central and local authorities can take preventive measures to avoid or lessen possible damages and casualties. With the aid of high resolution numerical weather prediction models, sensitivity studies can be conducted to address the role played by warmer than usual SSTs and the role played by the complex topography. By using global climate model input, which is based on the IPCC climate scenarios [15], regional climate models with much higher horizontal and vertical resolutions can provide detailed information on the occurrence of intense precipitation events in the future. This may provide guidance to city planners and authorities to consider suitable and sustainable smart constructions for future needs of vulnerable cities in a changing climate.

ACKNOWLEDGEMENTS

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CLIMATE VARIABILITY AND CHANGE: THE 2019 SUMMER HEATWAVE EVENTS OVER THE EURO-MEDITERRANEAN REGION

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ABSTRACT

Changes in climate mean and in variability may lead to the high impact weather events, which can be unusual and extreme than normal or average weather conditions, such as intense heat spells, severe droughts, heavy precipitation and flash floods. The Mediterranean basin has been referred as a *'climate change hot spot'*, and the region experiencing intense and frequent heatwaves, prolonged severe droughts, and wild forest fires. It was reported that the global mean surface air temperature for 2015–2019 was approximately 1.7 °C above pre-industrial period and 0.3 °C warmer than the previous 5-year period. The global mean temperature of 2019 was noted to be approximately 1.1 ± 0.1 °C above the 1850–1900 baseline, which is used as an approximation of preindustrial levels. It was reported that the year 2019 was the second warmest on record. The heat-wave indicator -which uses a non-parametric approach to diagnose a spatiotemporally varying maximum temperature threshold- gave an objective account of hot spells of summer of 2019 over the Euro-Mediterranean region. The total number of heatwave days varied from 3 to 48 days for the June-July-August 2019 over the Euro-Mediterranean region, which were resulted from 1-6 major heatwaves. Examining each summer month separately revealed that in June, some parts of south-eastern Europe and the eastern Turkey had approximately 3-18 heatwave days with accompanying 1-2 heatwaves; in July, duration of hot spells varied from 3 to 12 days with 1-2 major heatwaves which were located over the north-eastern Spain, the western Italy and south-east of Turkey; in August, heatwaves lasted 12-24 days over east of Spain, south-eastern France, Italy, the Balkans and Turkey, and the region experienced 3 major heatwaves.

Keywords: Climate Variability and Change, Heatwaves, the-Euro-Mediterranean Region

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1. INTRODUCTION

Climate describes the statistics of weather for typically over a 30-year period; it can describe long-term averages or variability of weather over specified temporal and spatial scales. Climate change may be described in terms of spatial scales (regionally and globally), in the temporal mean of a given atmospheric parameter (e.g., temperature, precipitation) or in its variability in various time-scales. The frequency and intensity of hot spells may change in response to shifts in both climate mean and climate variability. Heatwaves (HWs) are considered to be the most concerning severe weather phenomenon, as they have various impacts; such as human health (e.g. mortality and morbidity), extreme socio-economic and ecological effects, severe wildfires and resulting poor air quality, droughts and increase in energy consumption [1]. Increased need for energy and water during long hot spells may also lead to some difficulties on such supplies [2]. The Mediterranean region is considered to be "the climate change hotspots" [3,4]. In recent years, mega heatwave events have been occurring very often, for example, the 2003 European heatwave [5], the 2006 heatwave of northern Europe [6], the 2007 heatwave of the Balkans and Turkey [7,8], and the 2010 mega heatwave over Russia [9]. In the summer of 2017 mega heatwaves affected the Euro-Mediterranean region and Turkey [10].

It was reported that the global mean surface air temperature for 2015–2019 was approximately 1.7 °C above pre-industrial period and 0.3 °C warmer than the previous 5-year period [11]. It was noted that 2019 was the second warmest year, after the El-Nino affected 2016 [12, 13]). The summer of 2019 caused severe HWs in the Euro-Mediterranean region, which were noted to be exceeding heatwaves of 2018 [14,15]). In June 2019, Vérargues in south-eastern France experienced a maximum temperature of 46 °C on 28th June [14]. Extreme temperature events are led by anomalous large-scale atmospheric circulations.

Heatwaves are usually associated with the large-scale atmospheric flow pattern and dynamics. They are generally noted to be accompanied by quasi-stationary high pressure systems which are also referred as atmospheric blocking [7, 16-20]. High pressure systems are associated with downward motion which leads to clear air conditions and hence positive radiation anomalies, adiabatic warming and advection of warm air [21, 22]. Therefore, they are usually the main drivers of extremely high surface temperatures.

Collocated atmospheric patterns and related climatological anomalies provided necessary ingredients that paved the way for the extremely hot summer of 2019. The underlying atmospheric conditions were dominated by the quasi-stationary anomalous zonal flow, which led to the transfer of hot and dry air conditions to over the Euro-Mediterranean region and Turkey. High pressure systems, which are characterised by downward motion and hence clear-sky conditions, are usually the key triggers of extreme surface temperatures [7]. During the summer of 2019, they paved the way for surface temperature anomalies in the order of 8-12°C. Previous studies highlighted that anomalous sea-surface temperatures (SST) may also enhance and sustain mega heatwaves [23, 24]. Analysis of the 2019 summer SST indicated large anomalies (not shown), which might have positively contributed to the 2019 summer heatwave events.

In this study, we aim to address the combined roles of large-scale atmospheric circulation anomalies and the summer HWs of 2019 over the Euro-Mediterranean region. The underlying atmospheric conditions are examined for June-July-August 2019 summer period and for each summer month individually.

2. MATERIAL AND METHODS

The European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis (ERA5) dataset [25], which has a 0.25°x0.25° longitude-latitude grid horizontal resolution, is employed in this study. The geopotential height at 500 hPa (GH500) is used for computing GH500 anomalies, temperature at 2 meter (T2m) is used for determining T2m anomalies and heatwave diagnostics.

2.1. Computation of Period Means, Climatological Means and Period Anomalies

The followings are computed for the study period (from 1 June to 31 August 2019, hereafter JJA) in order to analyse the hot spells of summer 2019: (i) the period-mean of the 500 hPa geopotential height (GH500); (ii) GH500 anomalies for the JJA 2019 are computed from the difference between the temporal mean of the 1 June – 31 August 2019 and the 1980–2009 base climatological mean; (iii) the period-mean of 2 metre surface temperature (T2m); (iv) T2m anomalies are determined from the difference between the temporal mean of the study period and the climatological mean of 1980–2009 period.

For analysing the summer 2019 hot spells from a dynamical perspective, the time-mean (1 June – 31 August 2019) of GZ500 and T2m were computed as outlined in Equation 1 and Equation 2 respectively.

$$GH\,500_{JJA\,2019\_mean} = \frac{\sum_{JJA=1}^{92} GH\,500_{JJA}}{92} \tag{1}$$

$$T\,2m_{JJA\,2019\_mean} = \frac{\sum_{JJA=1}^{92} T\,2m_{JJA}}{92} \tag{2}$$

For the base climate period, 1980-2009 was considered since it has been commonly used in recent years [26, 27]. The base climate period means of GZ500 and T2m for JJA summer months are computed respectively:

$$GH\,500_{JJA\_1980\_2009\_climate\_mean} = \frac{\sum_{years=1980}^{2009} GH\,500_{JJA}}{(92 * 30)} \tag{3}$$

$$T\,2m_{JJA\_1980\_2009\_climate\_mean} = \frac{\sum_{years=1980}^{2009} T\,2m_{JJA}}{(92 * 30)} \tag{4}$$

Anomalies of GH500 and T2m for the summer of 2019 anomalies (with respect to 1980-2009 climate base) are computed by taking the difference between the time-mean of June-July-August 2019 and the June-July-August 1980–2009 climatological mean.

$$GH\,500_{2019\_anom} = GH\,500_{JJA\_2019\_mean} - GH\,500_{JJA\_1980-2009\_climate\_mean} \qquad (5)$$

$$T2m_{2019\_anom} = T2m_{JJA\_2019\_mean} - T2m_{JJA\_1980-2009\_climate\_mean} \qquad (6)$$

2.2. Heatwave Detection Method and Metrics

Heatwaves may be considered as climatologically, however, considering their short-life span compared to climate time-scale which is 30 years, it is better to consider them as weather events [28]. Spatiotemporal diagnostics of the heat spells of June-July-August (JJA) 2019 were performed by using a non-parametric approach to determine a spatiotemporally changing maximum temperature threshold, which is a 90th percentile (T2mP90) from a 7-day temporal period [7]. This threshold is computed for each respective calendar day (RCD) as the 90th percentile of the climatological distribution of daily maximum temperature at a grid-point in one of the two temporal periods with a ±3-day window centred on each side of the RCD, and then assigned as the maximum threshold temperature.

$$T2mP90_{(latitude,longitude,RCD)} = \bigcup_{y=1980}^{2009} \bigcup_{t=RCD-3}^{RCD+3} T2m_{(latitude,longitude,year,day)}$$

where both ⋃ is used for showing the union of T2m; the first ⋃ on the right is for the base climatology period and the second ⋃ is for the two time-windows of the RCD. Above, $T2mP90_{(latitude,longitude,RCD)}$ represents the 90th percentile maximum 2 meter temperature threshold of the RCD and $T2m_{(latitude,longitude,year,day)}$ represents the maximum 2 meter temperature of a given year and day. An illustrative example may be given in here; T2mP90 of 12th August is determined by considering maximum temperatures from 9th August to 15th August of the base climate period.

Two objective criteria are applied for determining a heatwave; (1) the first criterion is the T2m of an RCD must be equal or higher than the calculated T2mP90; (2) the second criterion is the satisfaction of the first criterion for three uninterrupted days. Then, a heatwave event (HWE) is assigned to the grid-point if metrics defined in (1) and (2) are both concurrently fulfilled. Accordingly, HWE is assigned to 1, otherwise to 0. Thus, HWE = 1 means a heatwave event took place, and HWE = 0 means there is no heatwave event. The three days long temporal duration is considered to be the representative of the period of time that persistent high temperatures may pose hazardous effects [29].

3. RESULTS AND DISCUSSIONS

3.1. An Overview of Climatological Anomalies of June-July-August

June-July-August (JJA) 2019 period and individual monthly anomalies of GH500 are depicted in Figure 1(a). The mean summer of 2019 GH500 indicate that the positive anomaly –which is approximately 50 above the base climatology (1980-2009) was located over the central Europe. This area coincides well with the June-July-August (JJA) 2019 T2m anomaly which were 6-12°C above the base climatology (Figure 2(a)).

Climatological anomalies of each summer month was also examined. In June, the GH500 positive anomaly was large at the order of 100 and covered East of Europe, Russia and most parts of Turkey (Figure 1(b)). This area experienced high surface temperatures which were noted to be 10-12°C above the base climatology (Figure 2(b)). In July, the GH500 positive anomaly was located over the UK and the west of Europe and the negative anomaly was noted over the Eastern Europe, Russia and Turkey (Figure 1(c)). During this period, surface temperatures were higher than climate averages over south-eastern France and eastern Spain and east of Turkey (Figure 2(c)). In August, the GH500 positive anomaly covered East of Europe, Russia and most parts of Turkey and the negative anomaly was located to the west of the UK (Figure 1(d)). During this time, surface temperatures were 6-10°C above the reference climatological means over the Balkans and south eastern parts of Turkey (Figure 2(d)).

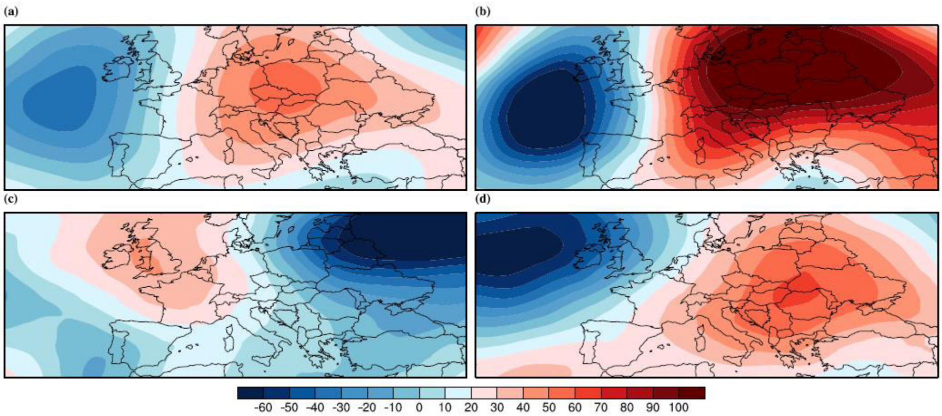

Figure 1. The anomaly of GH500 (in gpm) with respect to the base climate (1980-2009): (a) June-July-August 2019; (b) June 2021; (c) July 2019; (d) August 2019

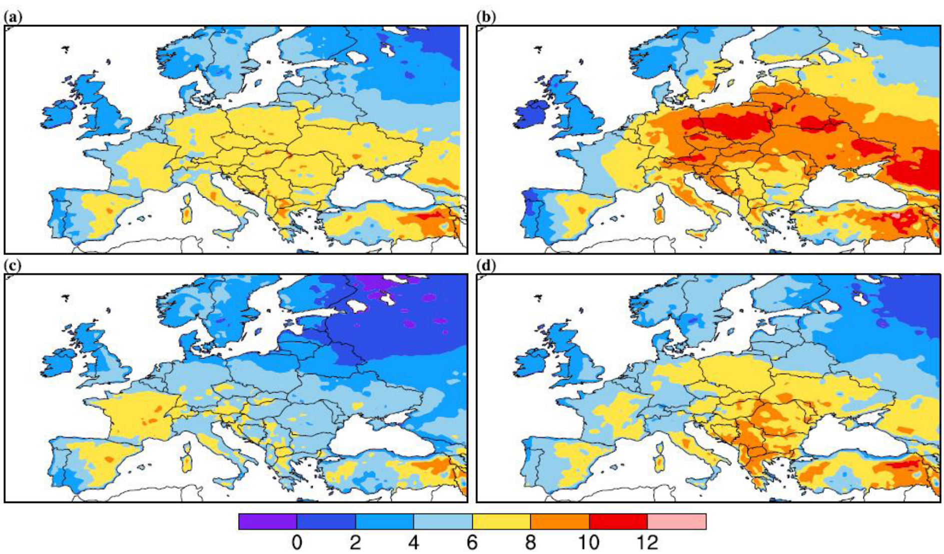

Figure 2. The anomaly of T2m (in degC) with respect to the base climate (1980-2009): (a) June-July-August 2019; (b) June 2019; (c) July 2019; (d) August 2019.

3.2. Summer Heatwave Analysis of 2019

Heatwave method outlined in Section 2.2 was applied on the summer heatwaves of 2019. In our method, the 90th percentile based temperature threshold varies spatially and daily, and therefore it is compatible with microclimatic conditions of the study area. Analysis of the total number of heatwave days of JJA 2019 indicated that the north-eastern part of Spain, the south of France, the west of Italy, the Balkans and the East of Turkey were under hot summer conditions for approximately 25-45 days (Figure 3(a)). Examining every summer month separately gives a detailed account of each month. In June; some parts of southern Europe and the north-eastern Turkey had approximately 3-21 heatwave days (Figure 3 (b)). It is of the interest to note that some of these areas were collocated with the GH500 anomalies (Figure 1(b)) and with the T2m anomalies (Figure 2(b)). Duration of heatwaves varied from 3 to 9 days in July, they were located over the north-eastern Spain, south-eastern France, the north-western Italy, the eastern Greece and south-eastern Turkey (Figure 3(c)). In August, heatwaves with 3-27 days coved over eastern Spain, south-eastern France, Italy, the Balkans and Turkey (Figure 3(d)). This highly affected region was collocated with the positive GH500 anomaly (Figure 1(d)) and the large T2m anomaly (Figure 2(d)).

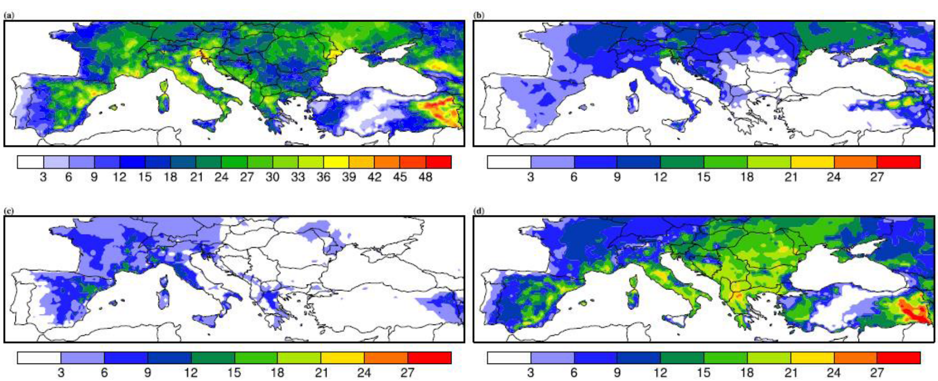

Figure 3. Horizontal distributions of total number of heatwave days; (a) June-July-August 2019; (b) June 2019; (c) July 2019; (d) August 2019.

During the JJA of 2019, the total number of heatwaves varied from 1 to 6. The total number of heatwaves were particularly high over the eastern Spain, the south-eastern Europe, the Balkans and the parts of Turkey (Figure 4(a)). Examination of each summer month individually showed that the most of Europe and eastern Turkey had 1-2 heatwave events in June (Figure 4(b)). In July, the eastern Spain, south-eastern France and north-western Italy and eastern Turkey had 1 to 3 events (Figure 4 (c)). In August, most of Spain, the eastern Italy, the south-eastern Europe and the western and the eastern Turkey had some heatwaves which ranged from 1 to 3 (Figure 4 (d)). These highlighted heatwave regions coincided with the GH500 positive anomalies (Figure 1(d)) and the largest T2m anomalies (Figure 2(d)).

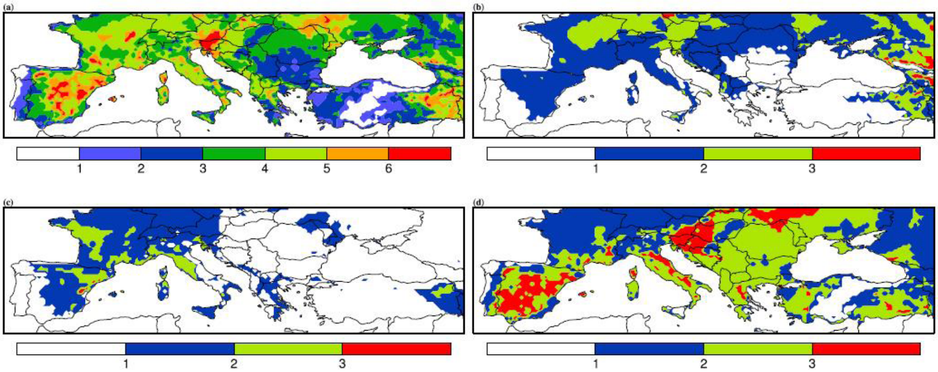

Figure 4. Horizontal distributions of total number of heatwaves: (a) June-July-August 2019; (b) June 2019; (c) July 2019; (d) August 2019.

4. CONCLUSIONS

This study highlighted the association between the extreme temperatures of summer 2019 and the related atmospheric patterns. The location of 500 hPa geopotential height positive anomalies usually have an impact on the magnitude and life-time of heatwave events. Analyses of summer season and monthly anomaly of GH500 showed that the most extreme heatwave occurrences were coincided with these upper-level atmospheric anomalies. Sea surface temperatures also contribute to life span of heatwaves. In this context, it should be noted that both the Mediterranean Sea and the Black Sea had approximately +2°C above climate averages (1979-2000) in July and in August (not shown in here) [30].

The relationship between the anomalous hot temperatures and GH500 positive anomalies are important for both in high impact weather events and in the synthesis of heatwaves in the context of climate variability and climate change. Several climate scenarios project intense, more frequent and long lasting heatwaves for near and extended future periods [31-33]. Since the Mediterranean region is considered to be a "climate change hot spot" [3, 4], therefore it is expected to be severely affected by intense and frequent heatwaves and draughts.

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CHAPTER 10

Climate Change and Philosophy - Intelligent Transportation - Safe Food Supply

PREDICTION OF NUTRIENT LOADS IN AN INDUSTRIALIZED WATERSHED UNDER FUTURE CLIMATE DYNAMICS

Meltem Çelen[1], Mehmet Salim Öncel[1,2], Halil Nurullah Oruç[3*], İsmail Kalafat[4], Sinem Vural[5], Meltem Yağcıoğlu[6]

ABSTRACT

Projection of streamflow and nutrient loads is critical for water resources and the quality of basins that discharge into inland seas like the Marmara Sea, which responds quickly to environmental anomalies. Streamflow and nutrient loads under climate change are generally projected for agricultural basins, while research on industrialized basins are limited. In this context, this research aims to model changes in streamflow and nutrient loads (TN, TP – kg/ha/month) in an industrialized basin under future climatic conditions. Saz Stream (NW of Turkey) consists of two main drainage networks, Saz and Çayırova, within a small-scale basin that is highly urbanized and industrialized (approximately 72%). Saz stream is under pressure from point sources originating from Çayırova tributaries with wastewater characteristics and two Organized Industrial Zones. Because of these characteristics, the Saz Stream can be regarded as a prototype for point pollution sources found throughout the Izmit Bay drainage area. Projections were performed in three main stages, (i) Soil and Water Assessment Tool (SWAT) was set to calibrate streamflow and nutrient loads for 6 sub-basins generated along Saz Stream under the current conditions, (ii) The MPI-ESM-MR projection model's RCP4.5 and RCP8.5 outputs were incorporated into the SWAT between 2018 and 2040, (iii) three reference periods (2025-2029, 2030-2034, 2035-2039) were used to analyze model outcomes and were compared the current conditions. The findings indicate that the streamflow are exhibited only modest increases (3%–6%) across all reference periods. The TN and TP loads, which are already recorded at hazardous levels under the current conditions, are predicted to increase by 2%–40% and 10–60%, respectively for the throughout the basin. The increase in nutrient loads can be constrained in the future to tolerable levels if the study team's suggested nutrient reduction scenarios (particularly for Çayırova drainage network) are put into practice.

Keywords: Nutrient Pollution, Climate Changes, Climate Projection, Water Quality Modelling

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1. INTRODUCTION

In addition to the impact of climate change on the water budget, the projection of the impact on the water quality in the basins discharged to inland seas such as the Marmara Sea, which reacts quickly to the water regime and environmental anomalies, is also very important. [1], [2]. The most recent example of environmental anomalies is the mucilage bloom recorded in the Marmara Sea towards the end of 2020. The reason for such events has been attributed to pollution from neighboring seas as well as nutrient loads from basins flowing into these inland seas [3]. In this sense, quantitative modeling of nutrient reduction strategies that may be implemented based on basin features, as well as the impact of these efforts under future climatic conditions, provides a crucial framework for preventing such disasters.

The main effects of climate change on water availability are droughts and floods. Besides these quantitative effects, surface water quality is also affected by climate change [4]. Variations in air temperature and precipitation are expected to impact streamflow, and consequently the mobility and dilution of pollutants. Especially during the summer, the decrease in streamflow would result in an increase in the residence time of the water, which will enhance the potential for algal development and the rate of sedimentation. Variations in air temperature and precipitation are expected to impact streamflow, and consequently the mobility and dilution of pollutants. Especially during the summer, the decrease in streamflow would result in an increase in the residence time of the water, which will enhance the potential for algal development and the rate of sedimentation. In fact, while the impact of climate change on water quantity is widely known, its impact on water quality is less common [5]. Research on nutrient pollution have mostly concentrated on agricultural source pollution, and there are few studies on industrialized basins [1]. The findings of our previous assessment of the Saz Stream's water quality—the subject of this research—showed that nitrogen and phosphorus for the quality of the stream tributaries symbolize the greatest threat [6].

In the light of aforementioned motivations, this research aims to model changes in streamflow (m^3/s) and nutrient loads (TN, TP – kg/ha/month) in an industrialized basin under future climatic conditions.

2. MATERIAL AND METHODS

2.1. Study Area

Saz Stream is a basin that drains 50 km^2 and runs along the boundaries of Istanbul and Kocaeli, two of Turkey's most significant industrialized and urbanized provinces (Figure 1). Saz Stream consists of two main drainage networks, Saz and Çayırova, within a small-scale basin that is highly urbanized and industrialized (approximately 72%). Saz Stream is under pressure from point discharges of two Organized Industrial Zones (shown in OSB-1 and OSB-2) and other individual industrial activities (Figure 1). Metal (32%), plastic (13%), automotive parts supply (9%) industries are common in these OIZs. Şekerpınar, Gebze, and Darıca are main settlements of the basin. When urban wastewater from these locations enters the Municipal-WWT with a collector, it is treated before being released into the Marmara Sea. The Saz Stream can be used as a pilot for point pollution sources located throughout the Izmit Bay drainage area due to these characteristics. The basin's climate lies in a transitional zone between the Mediterranean and the Black Sea, characterized by cold-rainy winters and hot-humid summers. The average annual temperature is 15 °C, with 720 mm of precipitation (MGM, 2015).

In recent years, research has been conducted to identify the main pollution sources of the Saz stream quality [6], [7]. Additionally, this basin has served as a prototype basin for a variety of method development projects, such as determining the level of hydromorphological alteration and the sensitivity of hydrological model outputs to soil parameterization [8], [9].

2.2. Field and Laboratory Studies

The field campaigns were conducted considering the parameters required in the model's setup and calibration processes. In this way, streamflow and nutrient (TN, TP) measurements were carried out monthly between June 2020 and March 2022 at 6 monitoring stations along the basin. Station locations were selected by considering the condition of the tributaries and pollution sources (Figure 1b).

Streamflow (m^3/s) was measured as the multiply of water velocity (m/s) and cross-sectional area (m^2). Hydrometer 2 JDC was used to measure the velocity of the water. In contrast, the depth of the water section was measured at 20-cm intervals during monthly field campaigns. And so, the cross-sectional area was calculated using the spline method in the AUC package found in R.

Water samples were analyzed for Ammonium Nitrogen (NH_4-N), nitrate nitrogen (NO_3-N), Total Kjeldahl Nitrogen (TKN), Total Nitrogen (TN), and Total Phosphorus (TP). TP was analyzed using the instrument Principle of ICP Optical Emission Spectrometry (ICP-OES) (EPA Method 200.7.). NH_4-N, NO_3-N and TKN were analyzed according to SM 4500 C Titrimetric method, SM 4500 NO_3 B Colorimetric method, SM 4500 N_{org} B method, respectively. TN was calculated as the sum of NO_3-N, and TKN (mg/L).

2.3. Application of the SWAT Model

The Soil and Water Assessment Tool (SWAT) was used to reveal the hydrological and water quality status of the Saz Stream basin. In recent years, SWAT—a continuous, semi-distributed, physically based, open-source model—has been an extensive application for managing water resources and evaluating point and non-point source contamination in basins of various sizes and environmental contexts (Neitsch et al. 2009). Although the nature of SWAT's installation is aimed at revealing diffuse pollution loads, it has increasingly been utilized in industrial and urban regions with the addition of modules like point source, reservoir, and usage circumstances of urbanized basins [10].

Model Construction

In this study, the model structure was formed by watershed delineation, creating the hydrological response units (HRUs), and integrating the meteorological and point sources to the model, respectively. Spatio-temporal data collection and processing needed for the SWAT were detailed in Oruc et al.[8]. In summary, the elevation of the basin was digitized in the GIS environment with a resolution of 5 m. In the watershed delineation section, stream network and subbasin boundaries were constituted. The outlets of the subbasin are characterized in the model according to the locations of the monitoring sites (Figure 1a). The HRUs are determined by a combination of soil physicochemical properties, slope (%), and land use data. In this regard, the CORINE (2018) database was used to obtain the spatial distribution of the digital land use classifications. Generally, the basin consists of industrial areas (UIDU-30%), residential-high-medium-low density (URHD, URMD, URLD-42%) areas. The remaining 28% of the lands consist of unused agricultural lands (Figure 1b). The local soil physico-chemical properties of the basin were visualized as a combination of soil texture and main soil groups (Figure 1c). The main soil groups are rendzinas (16.5%), brown forest soils without lime (10.9%) and brown soils without lime (37.5%), respectively. Soil texture is dominated by sandy-loam (82.6%), silt-loam (13.8%) and loamy-sand (3.6%). Slope groups were classified as <5%, 5%-12%, >12% (Figure 1d).

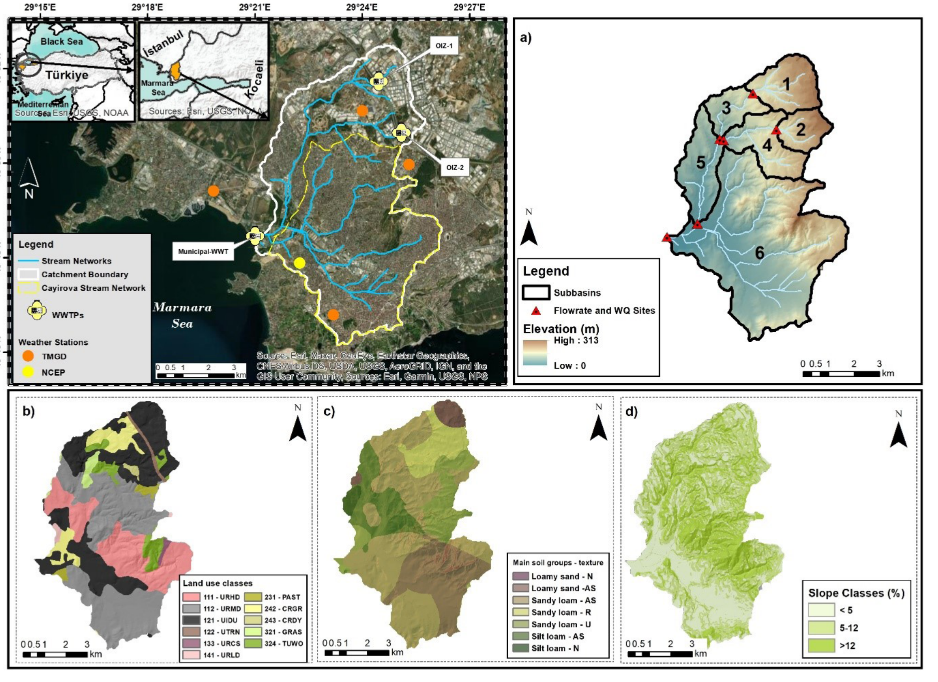

Figure 1. Location map of Saz Stream basin, (a) watershed delineation part of SWAT, (b) spatial distribution of land use classes, (c) combination of main soil groups and soil texture, (d) slope classes (%).

A total of 10 meteorological parameters such as precipitation (mm), minimum/maximum temperature (ºC), wind speed (m/s) are needed for SWAT installation [11]. The Turkish Meteorology General Directorate's (TMGD) measurements and projections parameters from four meteorological stations in and around the Saz Stream basin that reflect the current and future conditions were used (Figure 1a). Additionally, the missing days were interpolated using re-projection data from the US National Environmental Prediction Center (NCEP) station located in the basin's southwest. RCP4.5 and RCP8.5 outputs of the MPI-ESM-MR global climate model configured by the Max-Planck-Institut für Meteorologie Institute were used for climate projections. Other hand, as stated in the previous sections, treated wastewater of OIZ-1, OIZ-2, Municipal-WWT and Çayırova tributaries were integrated to the model as point source inputs (Figure 1a).

__Model Calibration__

The SWAT-CUP automatic calibration tool was used to calibrate the model. It was ran five times (500 iterations per run) for each of the six sub-basins, for a total of 15000 simulations (6 sub-basins x 5 x 500 iterations). A total of 10 parameters were calibrated, taking into consideration academic studies and field studies conducted in industrialized basins, in order to choose sensitive parameters and ensure the most suitable values for the calibration of the streamflow and nutrient loads (kg/ha.month) of the Saz Stream basin. The calibrated parameters for streamflow and nutrients are SCS curve number for moisture condition II, base flow alpha factor (days), groundwater delay (days), soil saturated hydraulic conductivity (mm h^{-1}), Soil erodibility factor in USLE, surface runoff lag coefficient, available water content (mm), soil bulk density (g cm^{-3}), deep aquifer percolation fraction, manning coefficient for the main channel.

The statistical performance evaluation metrics Nash-Sutcliffe efficiency coefficient (NSE), coefficient of determination (R^2), and percentile deviation (PBIAS) were used to test the consistency between the simulation and observation data. Model performance was evaluated by considering the streamflow, TN and TP change criteria determined by Abosbapour (2007).

Table 1. Model performance evaluation indexes

Performance Criteria	NSE	PBIAS	
		Streamflow	TP - TN
Excellent	0.75 - 1.00	< ±10	< ±25
Good	0.65 - 0.75	±10 - ±15	±25 - ±40
Satisfactory	0.50 - 0.65	±15 - ±25	±40 - ±70
Not acceptable	≤ 0.50	≥ ±25	≥ ±75

2.4. Climate Projection with SWAT

Climate projection data were examined in three reference periods (2025-2029, 2030-2034, and 2035-2039). The 20x20 km resolution climate projections obtained from TMGD archives were validated with the station data of TMGD measured between 2015 and 2022.

The variations of TN and TP loads were projected separately using the high (RCP8.5) and moderate (RCP4.5) climate change scenarios of the MPI-ESM-MR climate model. Within the framework of the TUBITAK-1001 (No: 121G066) Project, the two most effective reducing nutrient loads scenarios were chosen. The most efficient scenario represents 100% reduction in Çayırova tributaries, 80% reduction in TP and TN loads from OIZs and Municipal-WWT.

The second most efficient scenario represents 80% reduction of TP and TN loads in all point source discharges. Accordingly, three main strategies for projections were listed as follows.

“PR-0” represents the spatio-temporal variations of nutrient loads (%) in future climatic conditions, assuming current conditions continue.

“PR-1” represents the spatio-temporal variations of the nutrient loads (%) for the three reference periods if the second-best nutrient load reduction scenario is implemented starting today.

“PR-2” represents the spatio-temporal variations of the nutrient loads (%) for the three reference periods if the best nutrient load reduction scenario is implemented starting today.

3. RESULT AND DISCUSSION

3.1. Evaluation of the Calibrated SWAT Model

The calibration results of the observed and simulated streamflow values are visualized in Figure 2. The R^2 values were calculated for the sub basins between Sb-1 and Sb-6 as 0.77, 0.77, 0.74, 0.73, 0.76 and 0.77, respectively. While NSE values were determined as 0.71, 0.71, 0.69, 0.66, 0.72 and 0.75, PBIAS values were varied as -4.2, 14.7, 9.6, 7.5, 5.8 and -5.6 for the sub basins between Sb-1 and Sb-6. According to these results, the overall model performance falls into the "good" category. Despite that the model underestimated Sb-1 and Sb-6, as evidenced by the negative PBIAS values during the calibration period.

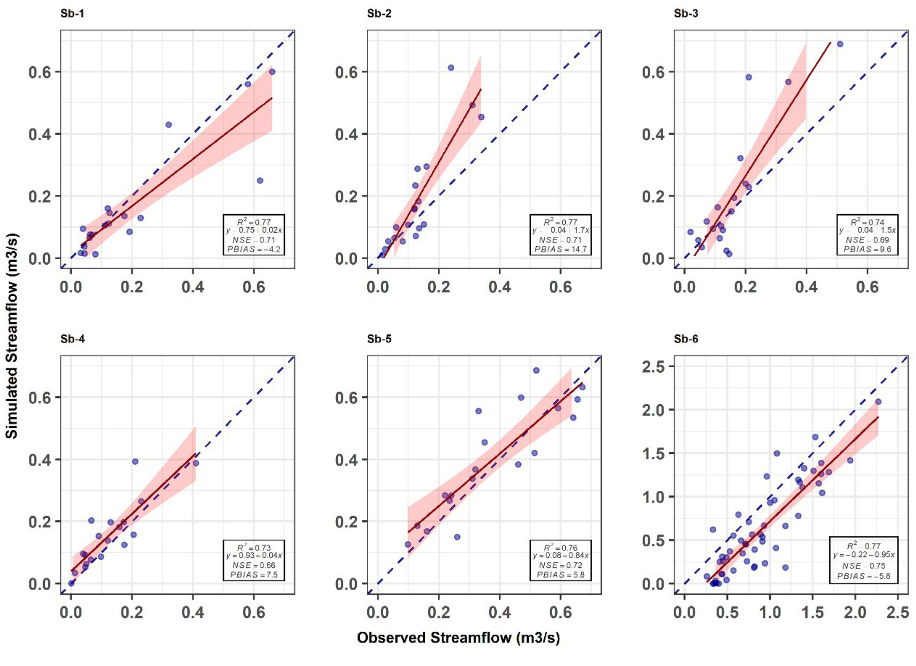

Figure 2. Examination of the model performance in the sub-basins created across the Saz Stream basin.

Comparison of simulated and observed nutrient loads were examined individually between June 2020 and March 2022 representing the measurement period, and between 2018-2022 standing for the projection period (Table 2). The simulated minimum TP loads were overestimated in all sub-basins. The observed and simulated average and maximum TP loads are similar. In the two periods, the dataset representing the observed TP loads had higher internal variability than the simulated ones. In the first five sub-basins, the simulated minimum TN loads are lower than the observation data, but they appear to be rather high at the basin outlet. Irregular nutrient inputs from the Çayırova tributaries can account for this. On the other hand, model performance for nutrient loading was determined to be "satisfactory" (figure not shown).

Table 2. Comparison of observed and simulated nutrient loads with descriptive statistical indicators.

Reference Periods	Descriptive Statistics	*TP (kg/ha.month)*						*TN (kg/ha.month)*					
		Sb-1	Sb-2	Sb-3	Sb-4	Sb-5	Sb-6	Sb-1	Sb-2	Sb-3	Sb-4	Sb-5	Sb-6
Observation (2020-2022)	Minimum	0.02	0.01	0	0.01	0.03	0.02	2.38	3.14	1.13	1.1	3.18	1.82
	Average	0.15	0.71	0.13	0.21	0.11	0.29	3.29	6.52	3.5	1.8	3.84	3.97
	Maximum	0.69	1.9	0.66	0.56	0.65	1.16	4.34	11.64	5.99	2.4	4.49	7.15
Simulation (2020-2022)	Minimum	0.09	0.39	0.04	0.13	0.05	0.34	0.51	2.5	0.19	0.82	0.26	11.11
	Average	0.16	0.51	0.12	0.2	0.12	0.4	0.96	3.14	0.7	1.62	1.04	12.33
	Maximum	0.4	0.89	0.34	0.42	0.31	0.55	2.07	4.46	1.78	4.93	3.35	16.81
Simulation (2018-2022)	Minimum	0.09	0.39	0.04	0.13	0.05	0.34	0.5	2.5	0.19	0.81	0.26	11.11
	Average	0.2	0.57	0.16	0.24	0.16	0.42	1.07	3.19	0.8	1.52	1.01	12.57
	Maximum	0.71	1.46	0.67	0.73	0.57	0.69	2.12	4.46	1.93	4.93	3.35	16.81

3.2. Climate Projections

Table 3 compares the minimum-average-maximum temperature values and precipitation records from TMGD for the current conditions and three future reference periods regulated by RCP 4.5 and RCP 8.5 scenarios. A technical report by TMGD Climatology Research stated that the Marmara Basin will warm by 0.5 to 1.5 °C between 2016 and 2040 as a result of the MPI-ESM-MR model outputs [12]. The temperature increases seen throughout the Saz Stream basin are also among these ranges. The minimum temperatures of RCP 4.5 and RCP 8.5 are the same. Besides, the minimum temperatures for RCP 4.5 and RCP 8.5 are raised by 0.83 °C, 1.1 °C, and 1.3 °C, respectively, for the three reference periods. In turn, the increasing date periods demonstrate increases of 0.49, 0.59, and 0.66 °C for RCP 4.5 and 0.58, 0.87, and 1.09 °C for RCP 8.5, respectively. At maximum temperatures, RCP 4.5 shows an increase of 1.25 °C, 1.17 °C, and 1.2 °C, but RCP 8.5 shows an increase of 1.26 °C, 1.27 °C, and 1.29 °C, respectively.

When compared to the projections of RCP 4.5, which indicate a decrease in monthly average precipitation of 8.24 mm, 3.5 mm, and 5.02 mm for the years 2025–2029, 2030–2034, and 2035–2039, respectively, the RCP 8.5 scenarios anticipate a decrease of 8.59 mm, 4.3 mm, and 8.92 mm. The MPI-ESM-MR model's outputs indicate that from 2016 to 2040, there will be an increase in specific dates when the Marmara Basin's precipitation regime does not vary widely [12]. The irregular increase-decrease precipitation regime determined between the reference periods of 2018 and 2039 is supported by this fact.

Table 3. Average values of precipitation, minimum, maximum, and average temperatures reflecting present and future conditions over four reference periods.

Reference Periods	RCP4.5				RCP8.5			
	Minimum Temp. (°C)	Average Temp. (°C)	Maximum Temp. (°C)	Average Monthly Precipitation (mm/month)	Minimum Temp. (°C)	Average Temp. (°C)	Maximum Temp. (°C)	Average Monthly Precipitation (mm/month)
2018-2022 (Measurement Records)	*10.54*	*15.56*	*20.14*	*28.98*	*10.54*	*15.56*	*20.14*	*28.98*
2025-2029	11.37	16.05	21.39	20.74	11.37	16.14	21.40	20.39
2030-2034	11.64	16.15	21.31	25.48	11.64	16.43	21.41	24.68
2035-2039	11.66	16.22	21.34	23.98	11.66	16.65	21.43	20.06

Figure 3 is visualized with the simulated streamflow values at the interconnected Sb-1 and Sb-3, Sb-2 and Sb-4, Sb-5 and Sb-6 outlets in the same panel (see Figure 1a). Streamflow tends to increase from the upstream to the downstream parts of the basin, as expected. All of the sub-basins appear to have similar temporal changes in streamflow as well as changes in high and low streamflow conditions.

Precipitation-streamflow processes were seen to be compatible for all subbasins. For instance, it can be shown that the daily precipitation was about 70 mm during the high flow conditions in 2034.

Figure 4 depicts the model outputs created in accordance with the RCP 8.5 climate projection scenario. The monthly variations of the streamflow simulated at the subbasin outlets are similar across the basin, similar to RCP 4.5. The high level of interaction between sub-basins is not surprising given the catchment area of 50 km^2. The streamflow-precipitation dynamics appear to be consistent in the comparatively low precipitation conditions observed in July 2037, with the exception of the high streamflow values. Between April 2038 and May 2039, the model outputs established with RCP 8.5 are higher than those established with RCP 4.5.This can be explained not only by the relative decreases in precipitation but also by increases in temperatures.

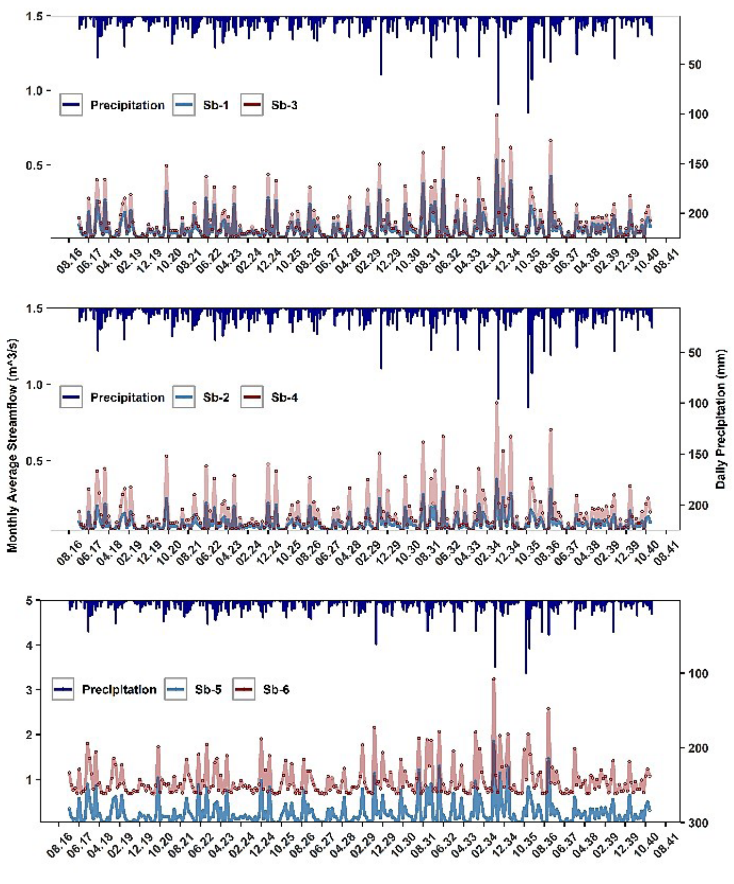

Figure 3. Temporal variation of daily precipitation records derived from the RCP4.5 scenario of the MPI-ESM-MR climate model and simulated streamflow between 2017-2040.

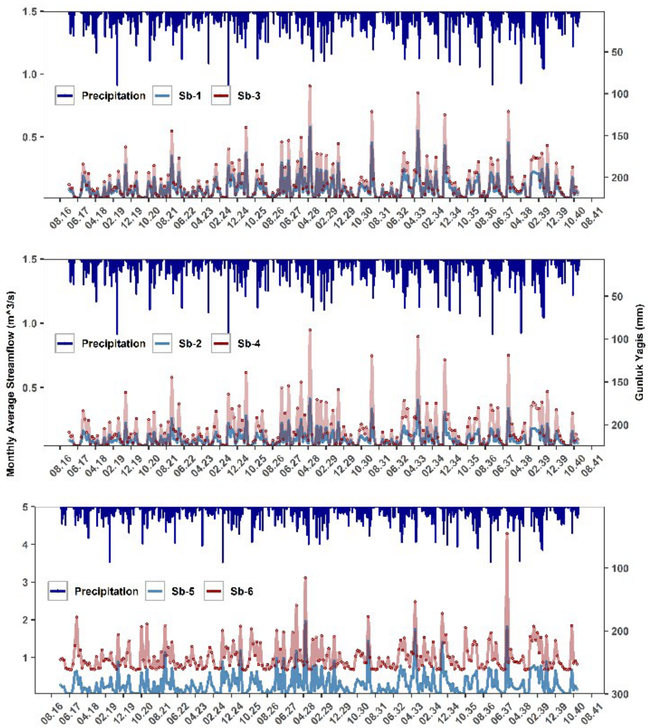

Figure 4. Temporal variation of daily precipitation records derived from the RCP8.5 scenario of the MPI-ESM-MR climate model and simulated streamflow between 2017-2040.

As a result of the projection namely PR-0, the spatio-temporal variations (%) of nutrient loads according to RCP4.5 and RCP8.5 are presented in Figure 5. Examining the model outputs established with RCP4.5 and RCP8.5 reveals that TN and TP loads are typically increasing rise in line with the current condition. TP loads increased by 42% on average over the basin during the three reference periods. TN loads, on the other hand, increased by 40%, particularly between 2035 and 2039.

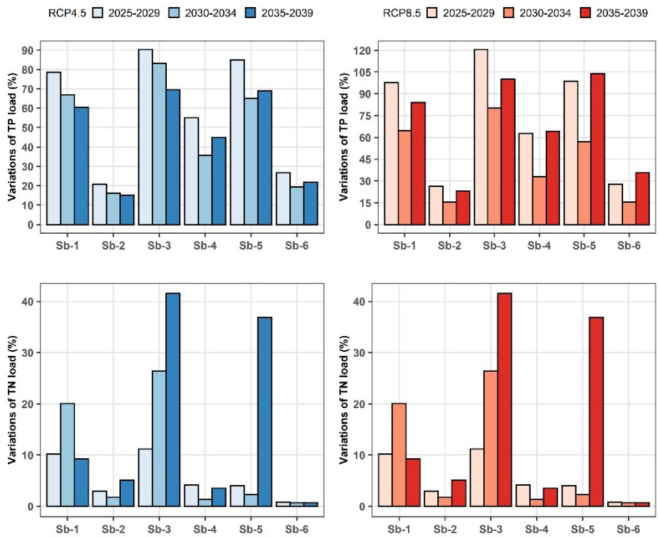

Figure 5. Percentage change of nutrient loads (%) in future climatic conditions, assuming current conditions continue.

As a result of the projection namely PR-1, the spatio-temporal variations (%) of nutrient loads according to RCP4.5 and RCP8.5 are presented in Figure 6. With this scenario, it is seen that current conditions, reduced TN and TP loads, will increase again with climate change. While TP was projected to rise by about %82 in the basin's outlet, TN was predicted to increase by about %80. While the percent increase in TN values for Sb-6 was concerning, significant increases in TP loads were simulated along the basin.

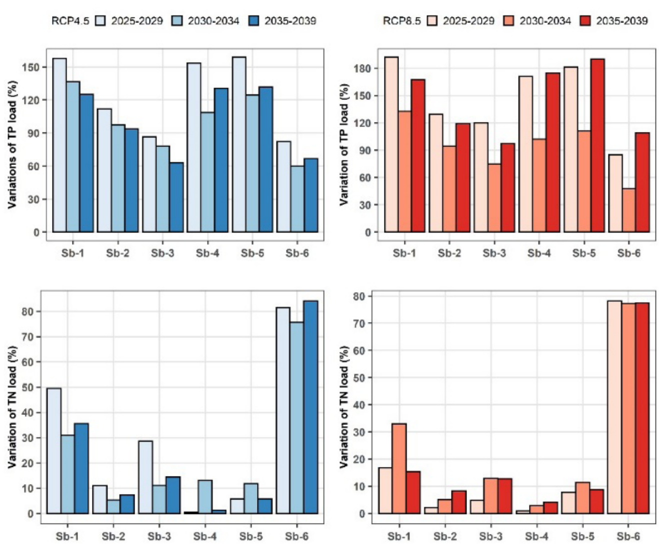

Figure 6. Spatio-temporal variations of the nutrient loads for the three reference periods if the second-best nutrient load reduction scenario is implemented starting today.

As a result of the projection namely PR-2, the spatio-temporal variations (%) of nutrient loads according to RCP4.5 and RCP8.5 are presented in Figure 7. TN and TP loads increased by an average of 8% and 120% at the basin outlet during the three reference periods for RCP 4.5. The TN and TP loads increase by 12% and 155% for RCP 8.5.While the percentage increase in TN loads for Sb-1 were worrying, significant increases in TP loads were predicted for the entire basin.

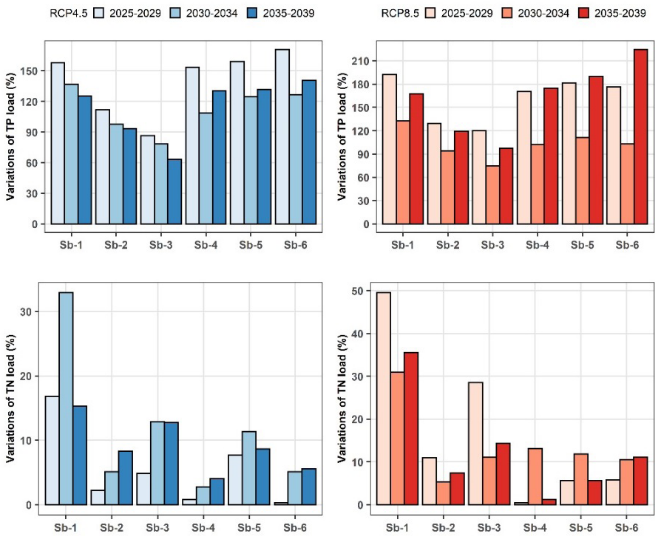

Figure 7. Spatio-temporal variations of the nutrient loads for the three reference periods if the- best nutrient load reduction scenario is implemented starting today.

We should not forget that the reductions in TN and TP loads simulated by the PR-1 and PR-2 meet the limit values of the Turkish Surface Water Quality Management (TSWQM) Regulation. That's why, despite nutrient loads increasing dramatically in the PR-1 and PR-2 estimates, they accounted for around one-third of those expected in PR-0.

4. CONCLUSION

This research has revealed the changes under the climate projections of nutrient pollution, which poses a serious threat in the current conditions of the Saz Stream basin, which is discharged into the Marmara Sea. If present circumstances persist, the increase in TN and TP loads over the basin is projected to be 21% and 35%, orderly. The SWAT was used to execute the nutrient load reduction scenarios in this situation, which was part of the TÜBTAK-1001 project centered on the Saz Stream basin. The outcomes of these scenarios demonstrate that achieving the requirements outlined in the PR-1 and PR-2 projections is the only two methods for the Saz drainage network to achieve the limit values in the TSWQM regulation. Given that, in addition to the Saz Stream basin, several industrialized basins drain into the Marmara Sea, the continuance of current conditions evidence that the pressure on the Marmara Sea will increase day by day. Consequently, the rapid expansion of modeling studies including nutrient reduction scenarios and climate projections for all basins around the Sea of Marmara is critical.

ACKNOWLEDGEMENT

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BLOCKCHAIN TECHNOLOGY IN FOOD SAFETY AND TRACEABILITY

Volkan Arif Yılmaz[1*]

ABSTRACT

There is an unprecedented demand for a smarter, safer food supply for people and also feed supply for pets and livestocks all around the world. Adulterations, safety crisis, diseases and epidemics have increased more than ever in recent times, and people are demanding food they can track, know what's in, and trust. As a result, it is more necessary than yesterday to seek a system that can increase food safety and freshness, protect human health, reveal efficiencies in the supply chain, minimize waste, improve the reputation of brands and directly contribute to their earnings. Nevertheless, globalization of the food sector results in difficulties and chaos in the supply chain. Blockchain technology is considered to have the potential to solve or minimize many of the food safety and traceability issues. Blockchain is a digital record of transactions maintained by multiple unconnected computer networks, and this technology allows data to be processed, transmitted, stored and represented in a readable proprietary software format. Data is shared in encrypted form in data blocks, and each block forms a link in this chain. Thus, without the need for an official validator, information and documents are shared over the network in a trust relationship and time-stamped. Today, various examples can be given to global companies that have taken steps towards implementation in food supply and traceability by making the agreements with the organizations that provide blockchain technology. It is clearly seen that the applications of blockchain technology in the food sector are very promising in increasing food safety and that this traceability has the potential to become widespread in the future with digitalization.

Keywords: Blockchain, Food, Safety, Traceability, Supply

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1. INTRODUCTION

Hundred years ago, the human population of the world is about 2 billion and now it reaches 8 billion in 2022 and is estimated to exceed 10 billion in 2055. With such an increasing population, the need for food is constantly increasing and will continue to increase significantly in the future. In order to meet the food demand of humanity, pets, livestock and aquaculture products, industries of food, agriculture, and livestock must take advantage of to find more efficient, innovative, and less wasteful production ways. However, it can be easily understood from the problems that it is not easy to provide the food demand brought by the population growth in an economical, high quality, healthy and safe. Food-based problems are more on the agenda due to factors such as economic bottlenecks, expectations for more products and profits, commercial immorality, carelessness, lack of education and lack of control. In the last few decades, customer confidence in the food industry has been drastically decreased after many food imitations, irritations, safety risk incidents and scandals, including foodborne outbreaks, mad cow disease, genetically modified foods, toxic (melamine) milk powder and the horsemeat scandals [1, 2]. In addition, about 600 million people around the world get sick, 420 000 people die, of which approximately 125 000 are under the age of 5, due to food related ills every year. Low- and middle-income countries are losing $110 billion annually, due to unsafe foods and related medical spending. [3]. Therefore, ensuring food safety has become a major problem for regulators, governments, and stakeholders in the food business. However, due to the complexity of the food supply chain, it is hard to find an effective regulatory mechanism from farm to fork. [4]. Foods are generally not consumed where they are produced and may contain a wide variety of microbiological, physical and chemical risks depending on the product group. As a result of all these, they have a certain shelf life. In addition, since especially processed foods are produced by the production of many raw materials and auxiliary materials with certain techniques, it is very difficult to retrospectively determine and control whether all the inputs in their content meet the quality and safety standards. Studies show that more than 30% of food is thrown away directly due to food spoilage, and one-third of food is wasted due to mishandling during transportation [5]. Existing food traceability systems have some problems, such as the possibility to manipulate data and the lack of effective methods to analyze the causes of risks. [4]. Today, although there are various information about the contents, production place, allergen warning, storage conditions, production or expiry date on food packages, there is no information about with production techniques and technologies, transportation and storage conditions, and time period, and how long it takes to reaches the consumer after production. This makes it impossible to follow the safety chain and where it might be broken, especially in terms of microbially high-risk foods. The globalization of the food industry also makes food safety and traceability more complex, foodstuffs can travel tens of thousands of kilometers from all over the world, pass through countless hands, increase the number of actors, the result of different food legislation of countries reveals incompatibilities, prolongs the movement of perishable products and increases information disparities in supply chains [6]. Controlling and monitoring whether the foods they will consume in accordance with the belief concerns of the consumers meet the conditions they want is another important issue that needs to be emphasized. The use of artificial intelligence and other tracking and automation technologies to meet food safety with traceability is the new trend to solve the problems in the food sector. Solutions such as Artificial Intelligence (AI), Blockchain (BC), Privacy Preservation (PP), and the Internet of Things (IoT) are the latest technologies that can be applicable for food monitoring, traceability, and analysis of collected data, as well as intelligent decision-making, to help the selection of the best. [5].

2. BLOCKCHAIN TECHNOLOGY

Blockchain technology, which refers to the evolution of algorithms and IT infrastructures, introduced in 2008 by Satoshi Nakamoto in the financial field to monitor and control currency transactions [7]. Today, apart from forming the basis of the crypto money market, it is a method that can find different applications in the fields of logistics, traceability and trade. Blockchain technology connects blocks mainly through cryptography methods. Each data block contains all the data information of the system within a given period of time and generates digital signatures to verify the validity of the information and is linked to the next block of data to form the main chain known as the blockchain. [8] Each of the participating entities using blockchain technology has an identical copy of the entire transaction history known as the ledger. The ledger consists of several blocks, and each block contains a series of transactions. Blocks are linked together using the hash method. A block hash is obtained using a hash function that takes the entire block as an input and returns a fixed length with a value [9]. The blockchain network would break if one of the blocks is attempted to be changed, and cannot be connected to other blocks. Therefore, blockchain is reliable, secure and hard to hack due to its shared, immutable ledger. [6]. Blockchain is classified into three groups; Blockchain 1.0: Digital, programmable currency system, Blockchain 2.0: Digital programmable finance system, including contracts and transactions and Blockchain 3.0: Digital programmable society in other services and industries [8].

Blockchain technology is considered one of the most promising technologies in the field of food traceability due to its decentralization, openness, transparency and immutability. [10].

3. APPLICATIONS OF BLOCKCAIN TECHNOLOGY IN FOOD SAFETY AND TRACEBILITY

With blockchain technology, applications that will help to improve traceability, ensure safety and authenticity, reduce waste, prevent food imitation and irritation, meet buyers' demands, choose options for suppliers, improve inventory management and prevent price fluctuations have started to come to life in the food industry [11].

In 2016, US retail giant Walmart started trials a blockchain-based solution to trace pork products in China. Blockchain systems enabled the details about the farm, factory, batch number, storage temperature, and shipping of products in a few minutes instead of days [3].

In 2018, large quantities of produce had to be destroyed in the United States due to *E.coli* contamination from lettuce. After this incident, Walmart decided to working with IBM (Food Trust) to digitize a system using blockchain technology as a next-generation solution in food safety to track and monitor lettuce supply chains. By collecting information from the farm along various supply chain steps with a handheld system, it can take only seconds rather than a week to track the source of a problem [12].

Walmart is using blockchain in the food chain to track packages of sliced mangoes it imports from Mexico. Mangoes and their derivatives are shipped worldwide and are known to be susceptible to *Listeria* and *Salmonella* contaminations [13]. During production, many problems that may affect the quality such as rotting, surface defects, internal deterioration, cold and heat damage, defects during ripening may be encountered in mangoes, and there is a risk that the producers may produce in uncontrolled environments by employing contaminated fertilizers, workers and child workers in bad conditions. According to the agreements made with blockchain technology, these stages can be followed and problems can be stopped [13]. It is also used to take around six days to track each product package and each step until their stores, now it takes just seconds [11].

Another sample from livestock and meat sector that Chinese retailer Jindong has collaborated with Mongolia-based beef producer Kerchin, to apply blockchain technology to floow informations about farms, batchs, processes and factory, expiration dates, storage temperatures and shipping. The systems allow customers to track information about frozen meat, such as breed of cow, weight and diet, and the location of farms by scanning the QR code on the package [14].

Over time, many companies and producer associations have also taken an interest in this topic, helping blockchain become increasingly popular in food safety and the food industry as a whole [15]. Also French retailer Carrefour is one of the first users of blockchain technology in agreement with IBM and blockchain-enabled QR codes for some of milk products in 2019. They also announced a plan to track their products in France, Spain, and Brazil and noted plans to expand to other countries by 2022 [3]. There are various companies such as Nestle, Anheuser-Busch InBev, Kraft Heinz, Albert Heijn, Plantaze, Bumbble Bee Foods, Tyson Foods and JBS using blockchain to seek milk, beer, orange juice, wines, seafoods, farms and livestock respectively [11]. It is estimated that by 2025, more than 20% of global companies will use blockchain and the application of blockchain technology will increase [11].

Scientific studies that research and propose methods on tracking systems and models on agriculture[16-20] , food [21-36] and livestock [1, 18, 20, 37-40] with blockchain applications are increasing day by day. Salah et al. [18] designed an ethereum-based soybean tracking system that includes the seed company, farmer, grain elevator, grain processor, distributor, retailer and customer, and described and reported the tracking parameters required for each chain (Figure 1). They stated that an application to be planned in this way can also be used for any crop in the agricultural supply chain. However, they reported that blockchain technology still faces significant challenges regarding scalability, governance, identity registration, privacy, standards and regulations.

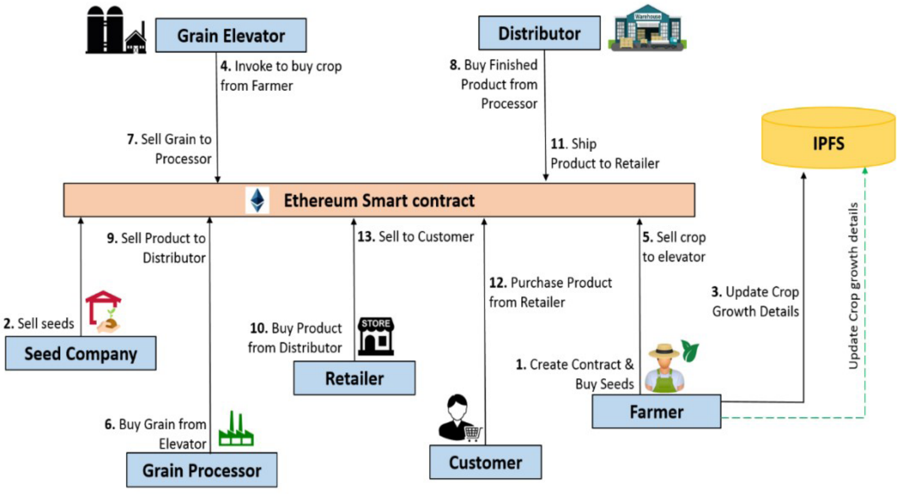

Figure 1. A sample system for automating the soybean traceability using Ethereum smart contracts [18]

Researchers have investigated how innovative methods are perceived by consumers in order to follow the properties of extra virgin olive oil [19]. 94.2% of the participants were interested with tracking systems; on Near Field Communication (NFC); tamper-proof device plus Radio Frequency Identification (RFID) and app; in QR code based blockchain systems. It was reported that 45% of the participants preferred the QR code-based blockchain system. However, only 17.8% of the participants declared that they could pay extra for the product for these tracking systems.

In another study, Guido et al. [7] proposed a framework for tracking and tracing an extra-virgin olive oil supply chain, starting from the results of a market survey, located in Calabria, in South Italy. They schematized the parameters to be followed for the olive grower, carrier, oil factory and subsequent analysis (Figure 2). Researchers stated that the traceability model increases the perceived value of the product placed on the market and can be easily reused by small enterprises.

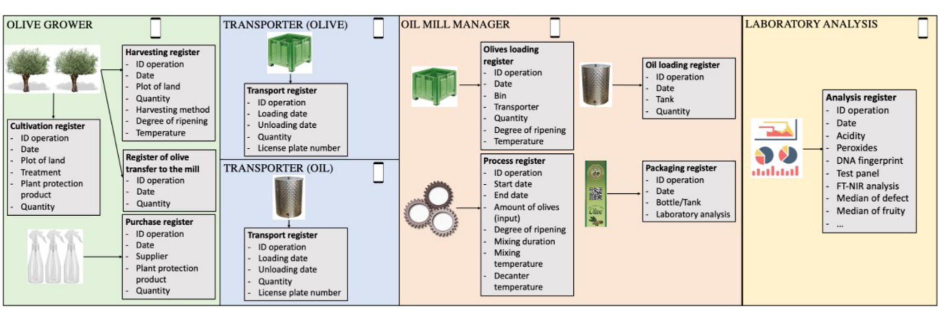

Figure 2. Informations gained for the blockchain database

Miron et al. [41] proposed a platform named as “FOODALERT” to measure, collect and store measurements of food allergens. The platform has been reported to include the design and optimization of a decentralized device based on mobile sensors and a miniature potentiostat for sensitive and selective detection of gluten using blockchain technology. Thanks to the developed device and platform, consumers will be able to detect food products contaminated with allergens, even if the label states otherwise, and at the same time have the opportunity to warn other consumers, organizations and manufacturers.

Blockchain technology also has the potential to be a good tracking system alternative in addition to Halal and Kosher food certificates, in tracking whether foods that can be consumed due to religious beliefs and foods that cannot be consumed are present in the products and whether the way the food is processed is suitable for consumption.

On the other hand, building a blockchain network for traceability and safety needs investment cost. A certain adaptation, time, control and rules are required in order to ensure that the system operates in a healthy way at every stage from the producer to the end consumer. These can also be considered as extra costs at the beginning. Xu et al. [42] reported that blockchain can greatly reduce transaction cost, cost of quality, and cost of activity between major units in the chain and provide additional economic benefits over time. However, the use of blockchain technology initially requires strict control of data sources to ensure the authenticity and accuracy, so the technical flaws of the blockchain also increase the traceability cost [42].

4. CONCLUSION

The World Food Submit is defined the goal of food safety is to enable all people to have safe, nutritious, and enough food for their dietary needs and preferences for a healthy and active life [43]. In order to achieve this goal, there are many tasks that need to be done individually, institutionally and globally. In today's world where everything is digitized, it is unthinkable that food safety and supply should not get a share from it. Blockchain technology is at the forefront of the methodologies that can work both locally and internationally in food safety and monitoring, and it is now starting to enter our lives with the cooperation of large food suppliers and IT companies. It is seen that positive and promising results can be obtained in the applications. Since it is a new application area, it is expected that it will take time for the systems to become widespread. Because today, establishing a monitoring and security system like this is done on a voluntary basis and requires an investment cost. Its spread to international trade, societies and small producers will only be possible with legal regulations, obligations and incentives to be taken in this sense. However, the success of implementation will only be possible if everyone from the smallest unit in the system to the rule makers does their part and, again, with commercial ethics.

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MULTIDISCIPLINARY ENGINEERING EDUCATION: A COMPREHENSIVE STUDY ON INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

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ABSTRACT

The Intelligent Transportation Systems (ITS) applications such as intelligent intersections, park violation detection, red light violation detection and average speed corridor systems in the world are becoming more important day by day with the development of technology. The encountered problem during the development and utilization of these systems is the lack of competent engineers and technical staff in this area and correct utilization of new technologies in transportation planning and management. The current number of ITS applications in urban roads and the opportunity to learn these systems' all application processes from the development to their implementation and operation is very limited. Thus, project-based education (PbE) for undergraduate and postgraduate engineering students on intelligent transportation system applications gains big importance. In this study, project-based education expectations (PbEE) of students were tried to examined and modeled by collecting questionnaire survey data under various effective parameters. Model results show that there is a distinct desire among students to receive a PbE on ITS. Then, the developed project titled "i-gCar4ITS: Innovative and Green Carrier Development for Intelligent Transportation System Applications" for PbEE of students in Turkey and UK were introduced in detail. Developed "i-gCar4ITS" project still ongoing and have a partnership with "Smart City Traffic Safety" project carried out Samsun Metropolitan Municipality in Turkey. Every stage of the project, which is implemented to make Samsun city urban roads more fluent and safer with intelligent solutions, is Turkey's biggest ITS project on ITS. At the end of i-gCar4ITS education project, engineering students in both countries with knowledge and experience in intelligent transportation will be trained. Thus, target stakeholders who had experience in this field will be able to create new R&D projects on ITS, have employment opportunities in this field, and have the desire, knowledge, and experience to take part in international projects for their future carriers.

Keywords: Intelligent Transportation Systems, Traffic Planning, Road Safety, Smart Cities, Intelligent Intersections.

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1. INTRODUCTION

Enhancing the diversity and quality of graduates in transportation field has a great importance regarding to keep up with the developing technological innovations. The disconnection between theory-based learning and real site applications (practical engineering) that most of the engineering students meet only fundamental and introductory engineering courses might further disengage learners from engineering programs [1]. To address these insufficient education problems, a project-based learning (PBL) has been added to engineering education schedule in many universities of the world. Conducted education quality surveys has shown that students have a high motivation and less attrition during the education period [2]. Project-based courses (PbC) and education programs in engineering fields have also been found to help students for learning the relation between theory and application in their field. Thus, they can have both self-confidence and experience in their work life.

The rapid transformation and improvement in industry and technology cause major changes in Intelligent Transportation Systems (ITS) across the world. These new systems aim to supply innovative services relating to different modes of transport and traffic management. They also provide many alternatives to users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. ITS have many intelligent transportation technologies (ITT) and they vary in technologies applied, from simple systems such as car navigation; traffic signal control systems; container management systems; variable message signs; automatic number plate recognition or speed cameras to monitor applications, such as security CCTV systems, and automatic incident detection or stopped vehicle detection systems; to more advanced applications that integrate live data and feedback from a number of other sources, such as parking guidance and information systems; weather information; bridge de-icing systems; and the like. On the other hand, ITS have different predictive techniques which are being developed to allow advanced modelling and comparison with historical baseline data. Unfortunately, many engineering students often struggle to understand the need to frame transportation problems, largely because of the problems that they have typically meet in university, are already framed and can simply be solved. Especially, the significant developments on ITS and the huge demand on to use these new systems in traffic planning and operation process clearly showed the finding qualified staff or experts during the implementation and operation of these systems. Nowadays, it is a big problem for the companies and road agencies. This is mainly resulted from lack of the existing courses and materials at universities. In addition, not seeing the application of such intelligent systems in the field from a technical point of view is unfortunately quite inoperative in terms of having sufficient equipment.

This study focused on important insights regarding the role of project-based education (PbE) in the long-term carrier paths of engineering students. For this aim, project-based education expectations (PbEE) of students were tried to examined and modeled by collecting questionnaire survey data under various effective parameters volunteer engineering students. Then, the proposed ongoing project titled "i-gCar4ITS: Innovative and Green Carrier Development for Intelligent Transportation System Applications" for PbE expectations of students in Turkey were introduced. Many volunteer engineering students have attended to project were exposed to engineering design principles and theoretical knowledge related to assigned projects, as well as product development process, project management and teamwork skills. The study is could be a good example of a project-based introductory course on ITS that contribute to retaining students and supporting subsequent academic success in engineering field. This study also addresses this gap in the research base for introductory engineering courses on transportation. Thus, it will draw attention to the fact that engineering students receive a good PbE in the field of transportation and will be able to update the education curricula according to this situation.

2. BACKGROUND

2.1. Development on ITS

The traffic congestion problem in urban traffic is one of the biggest problems of cities around the world. Currently, peak-hour traffic congestion reflects the behavior of road users, as well as their travel needs, which certainly load the existing road networks and transit systems [3]. This chaos results a huge need on ITS which can effectively control and manage traffic density in road networks. ITS can be defined as a well-organized management tool to improve traffic efficiency in a transportation network. These systems have been started to developed since 1970s [4] and since then, these systems are still considered as the future of transportation. ITS includes many advanced technologies such as electronic sensors, data transmission, and intelligent control into the all-transportation modes [5]. These new technology-based systems aim to supply better services for drivers and riders in transportation activities. They can be applied from simple to complex traffic management systems such as vehicle navigation systems, traffic signals (actuated and pre-timed signals), variable message signs (VMS), highway advisory radio (HAR), automatic number plate recognition, speed cameras, surveillance cameras to make the traffic operations smoother. They can also provide large-scale transportation data such as smart card, GPS, sensors, video detector, social medias, and so on. Thus, they can provide effective data analytics for better service of traffic control and management with ITS.

There exist many data collection components for ITS and they can collect many different types of data from roads and transportation systems to analyze current traffic flow conditions. For example, inductive loop detectors are one of the most used systems to detect presence of vehicles based on the induced current in the loop with passing vehicles. Thus, loop detectors can collect traffic information such as traffic volume and spot speed on current traffic [6]. As well as loop detectors, image processing for video cameras and radio-frequency identification (RFID) scanners are increasingly started to use in traffic data collection with the help of developments on sensing and imaging technology. Utilization of these type new systems supply all traffic related data such as traffic flow, speed, vehicle types, etc. [7]. Especially, latest development on image processing method provides the utilization of automatic license plate recognition which has a crucial importance to determine additional information such as selected paths and travel times of vehicles in a traffic flow [8]. Additionally, radio-frequency identification data (RFID) commonly started to use for different traffic-related information, such as path choice and travel time, through the matching of unique RFID [9]. On the other hand, the technological developments in mobile systems have also caused an increase in utilization of smartphones and advanced communication technologies, global positioning system (GPS) data, media access control (MAC) addresses from Bluetooth and Wi-Fi components, and mobile phone data on traffic information [10]. Today, dozens of new systems different from these systems are used, and all of them provide the collection and processing of data related to transportation. At present, dozens of new digital systems different from mentioned systems are used, and all of them provide the collection and processing of data related to transportation. According to different sources in ITS, some popular IT systems and their technological infrastructure can be primarily categorized into the following types as summarized in Fig. 1.

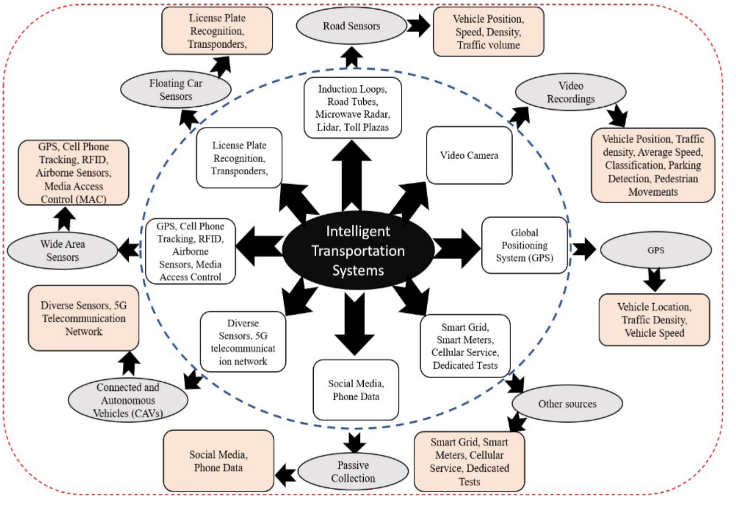

Figure 1. Some popular IT systems and used technologies.

Analysis of obtained data from ITSs aim to supply different information and management/control measures, using collected data from the many used sources. These systems collect data on transportation related all movements regularly and continuously with the help of many technological subsystems. Since these collected data are in large amount, it is necessary to analyze, regularly. Thus, big data analytics should be made regularly from the transportation planners and experts because many IT systems need to handle large amount of data to give instant information or provide decision to manage traffic or public transportation systems. Especially, traffic data which contain different formats from different sources, must be compared with the previous data, then processed within a short time [11]. The data processing must be able to process more complicated and increasingly expanding data. In this point, how to guarantee the process timeliness with so large and fast data is a big challenge and IT systems have a good ability to deal with this problem.

2.2. Affordances of Project-Based Learning in Transportation Field for Engineers

Project-based education (PbE) can integrate all necessary knowledge, practice and ability to engineering students to find a solution to a problem, develop a model or design a product [1]. This education method introduces under and postgraduate engineering students to clear and concise design objectives and problems to develop solution strategies in open-ended and learner-directed tasks [12]. This method also allows students to get necessary knowledge and abilities from various topics and knowledge domains. Thus, they can apply these methods to varied problems in their work life. Courses at engineering faculties are also well suited to incorporate PbE to expose students to core engineering competencies. Additionally, attending PbE courses increase student interest, motivation and skills. For example, [13] compared project and problem-based education methods in engineering and found that relative to students who were exposed to PbE were more motivated and demonstrated enhanced teamwork skills and understanding of engineering problems of practice. In another study, [14] examined student perception who took a first-year PbE program had an overall higher third-year GPA, compared with students who were not in the program. In a similar study, [15] found that attending in an introductory PbE, where students rotated in labs from different engineering disciplines, was associated with a 17% increase in retention in engineering by students' third year. In their study, [1] examined characteristics related to enrolment in the project-based introductory engineering course and subsequent academic performance. Their study results provided that project-based introductory engineering course can support students' academic success in engineering, definitely.

When the existing literature is examined in detail, it is clearly seen that the current studies are mostly focused on the effectiveness of education projects in engineering. They were not focused on a common area that concerns all engineering students and the expectations of the students on this subject in detail. Therefore, in this scope, it has been determined that there is no study that investigates the importance of PbE from the perspective of students and proposes a PbE in this subject. Within the scope of this study, ITS were chosen as a mutual area which covers many engineering departments and the PbEE of engineering students in this field were examined considering different parameters. Again, by starting a project-based education project in this area, the progress of the students was tried to be observed and evaluated in detail. Thus, the importance of PbE has been tried to be revealed and attention has been drawn to this issue.

3. METHODOLOGY

This study aims to examine PbEE of undergraduate and postgraduate engineering students on ITS applications. The scope of the study is restricted to students in Turkey and only related departments (Table 1) on ITS were taken into the consideration for the study. To determine the student expectations, an online questionnaire was prepared and conducted, and then a regression model developed for PbEE in the scope of becoming a descriptive and definitive research.

3.1. Sampling Group

The sample group of the study covers 688 students who are undergraduate and postgraduate students in engineering field. Departments and characteristic properties of the students are given in Table 1. The exact student number statistics of under and postgraduate students were not found correctly from the current statistics. Thus, random sampling has been applied and all the survey were made by sending an electronic questionnaire form.

Table 1. Some descriptive statistics of sampling group.

No	Department	Observation Number (*N*)	Average Age ($\bar{X}$)	Std. Dev. (±σ)
1	Civil Engineering	155	21.7	4.12
2	Geomatics Engineering	108	20.8	2.89
3	Electrical and Electronics Engineering	97	20.6	2.11
4	Computer Engineering	80	21.9	3.45
5	Software Engineering	75	21.1	3.22
6	Industrial Engineering	60	21.7	3.22
7	Environmental Engineering	58	20.3	2.88
8	Mechanical Engineering	55	21.0	2.58

3.2. Variables and Obtained Data

In the scope of the study, a digital questionnaire form developed to collect data for the purpose of the study and has been sent to randomly chosen engineering students for the determined department related on ITS. Then, all completed survey results obtained in digital platform. The used variables in the study are determined as given in Table 2.

Table 2. Variables of the proposed model for PbE level expectations of students.

Variable Type		Notation	Variable Definition
Dependent Variable		*PbEE*	Project-based education expectations of students
Independent	Covariates	Age	Student Age
		I_{ITS}	Interest Level on ITS
		K_{ITS}	Knowledge Level on ITS
		D_{ITS}	Desire to have a job on ITS
	Dummy	Gender	(If student gender is female 1, otherwise: 0)
		Department2	(If student depart. is civil eng.: 1, otherwise: 0)
		Department3	(If student depart. is geomatics eng.: 1, otherwise: 0)
		Department4	(If student depart. is elect. and electronics eng.: 1, otherwise: 0)
		Department5	(If depart. is computer eng.: 1, otherwise: 0)
		Department6	(If depart. is software eng.: 1, otherwise: 0)
		Department7	(If depart. is industrial eng.: 1, otherwise: 0)
		Department8	(If depart. is environmental eng.: 1, otherwise: 0)
		Education_Level2	(If student has undergraduate edu. level: 1, otherwise:0)
		Education_Level3	(If student has M.Sc. education level: 1, otherwise:0)
		Undergradute_Class2	(If student's undergraduate class is 2: 1, otherwise:0)
		Undergradute_Class3	(If student's undergraduate class is 3: 1, otherwise:0)
		Undergradute_Class4	(If student's undergraduate class is 4: 1, otherwise:0)
		Project_Experience	(If student has a project experience: 1, otherwise:0)

Before analysis, natural logarithm of dependent variable and covariates were taken to make skewed original data more normal. Thus, it improves the linearity between dependent and independent variables and boosts validity of the statistical analyses. In the proposed regression model, quantitative and qualitative variables are used which also named as Analysis of Covariance (ANCOVA) models [16]. The obtained equation for the model estimation is given in Eq. (1)

$$\begin{aligned} PbEE = {} & \gamma_0 + \gamma_1\ Gender + \gamma_2\ Department2 + \gamma_3\ Department3 + \gamma_4\ Department4 \\ & + \gamma_5\ Department5 + \gamma_6\ Department6 + \gamma_7\ Department7 \\ & + \gamma_8\ Department8 + \gamma_9\ Education\_Level2 + \gamma_{10}\ Education\_Level3 \\ & + \gamma_{11}\ Undergraduate\_Class2 + \gamma_{12}\ Undergraduate\_Class3 \\ & + \gamma_{13}\ Undergraduate\_Class4 + \gamma_{14}\ Project\_Experience \\ & + \beta_1\ LnAge + \beta_2\ LnI_{ITS} + \beta_3\ LnK_{ITS} + \beta_4\ LnD_{ITS} + \varepsilon \end{aligned} \tag{1}$$

In Eq. (1), γ_0 is the fixed term, γ_x, $x \neq 0$, are dummy variable coefficients and , are covariates' coefficients, and β_y, y=1,.....,4 are covariates' coefficients, and ε is an error term. To determine the model coefficients in Eq. (1), ordinary least square (OLS) estimator was used and Breusch-Pagan/Cook-Weisberg test was made to check availability heteroskedasticity problem. χ^2 value was found as 77.43 and P>0.001. Therefore, null hypothesis of constant variance was rejected and robust standard errors was calculated to correct the coefficients for the presence of heteroskedasticity. On the other hand, possible multicollinearity problem was checked and Variance Inflation Factor (VIF) was computed as 4.12<10. It shows that there is no multicollinearity problem in the model. Lastly, disturbances are accepted normally distributed because of the large sample size based on Central Limit Theorem which proposes a normal distribution for large sample size in the analysis [17].

4. STUDY FINDINGS

According to analysis results, descriptive statistics of all variables are given in Table 3. In the table, scale ranking for I_{ITS}, K_{ITS} *and* D_{ITS} variables are defined as 1: Low and 5: High. It can also be seen from the table, engineering students' "interest" is close the high $(\bar{Y}_{I_{ITS}} = 3.45)$, "knowledge" is close to middle $(\bar{Y}_{K_{ITS}} = 2.67)$ and "desire to have a job on ITS" in the middle $(\bar{Y}_{D_{ITS}} = 3.01)$.

Table 3. Descriptive statistics of continues variables.

Var. Type	Variables		Observation Number	Percentage (%)
Cont.	Student Age	Age	688	—
	Interest Level	I_{ITS}	688	—
	Knowledge Level	K_{ITS}	688	—
	Desire to Have a Job	D_{ITS}	688	—
Discrete	Gender	Female	255	37.1
		Male	433	62.9
	Department (Engineering)	Civil	155	22.5
		Geomatics	108	15.7
		Electric and Electronics	97	14.1
		Computer	80	11.6
		Software	75	10.9
		Industrial	60	8.7
		Environmental	58	8.4
		Mechanical	55	8.0
	Education Level	Bachelor	452	65.7
		M.Sc.	147	21.4
		PhD.	89	12.9
	Class Number for Bachelor Degree Students	1	123	27.2
		2	112	24.8
		3	106	23.5
		4	111	24.6
	Project Experience	Yes	64	9.3
		No	624	90.7

While determining the randomly selected student numbers given in Table 3, the relationship of the departments with the ITS were taken into the consideration. Thus, civil engineering students' percentage in the survey study became higher than other departments because ITS are more related to this field. Similarly, current student ratio for undergraduate and postgraduate students were taken into the consideration to determine the most proper sampling group of the study. Thus, the bachelor degree students were determined as the most crowded group in the survey. Using the sampling group's questionnaire data, a regression analysis was made to examine the effect of student properties on project-based education expectations of students. Obtained coefficients for the proposed regression model, which is given in Eq. (1), are summarized in Table 4. According to analysis results, proposed model is found statistically significant (F= 8965.2; P= 0.000 < 0.01 and R^2=0.84).

Table 4. Proposed regression model for PbEE of students as dependent variable.

Independent Variables	**Coeff.**	**Robust Std. Error**	***t***	**-Value†**
Fixed term	1.48	0.23	5.36	0.000*
Gender	-3.36	3.25	-5.64	0.112
Department2	0.98	0.20	7.88	0.000*
Department3	0.81	0.19	6.31	0.000*
Department4	0.73	0.15	4.60	0.000*
Department5	1.01	0.24	8.15	0.000*
Department6	0.88	0.19	6.44	0.000*
Department7	-0.03	0.06	-0.48	0.632
Department8	-0.14	0.03	-1.34	0.187
Education_Level2	0.09	0.06	1.41	0.091***
Education_Level3	0.14	0.04	2.04	0.046**
Undergradute_Class2	0.01	0.07	1.03	0.306
Undergradute_Class3	0.12	0.06	1.92	0.055***
Undergradute_Class4	0.30	0.03	5.67	0.000*
Project_Experience	0.34	0.07	4.39	0.000*
Ln Age	0.12	0.05	2.40	0.016**
Ln I_{ITS}	0.22	0.04	1.99	0.047**
Ln K_{ITS}	-0.27	0.05	-1.34	0.187
Ln D_{ITS}	0.20	0.06	5.45	0.000*
Obs. Number	688			
F (15; 3985)	8965.2			
> F	0.000*			
R^2	0.84			
Root MSE	0.3244			

† Significant at ***0.1 level, **0.05 level, *0.01 level

Results of proposed model show that three covariates (Age, interest level and desire to have a job on ITS) has significant and positive coefficients. "Interest level" has the highest positive and "age" variable has the lowest positive coefficient. It means that "interest level on ITS (I_{ITS})” variable has the most influential whereas “Age” variable has the least influential on expectation of the students. These positive statistical coefficients for three covariates also indicate that “PbEE” of students increases when student age, interest level (I_{ITS}) and desire to have a job (D_{ITS}) increase. All these three continues variables positively affect PbEE of the students. Unfortunately, model results also show that to have knowledge on ITS (K_{ITS}) does not have a significant coefficient and it means that to have a knowledge on transportation doesn’t have any effect on PbEE of the students.

The model results also indicate, ten dummy variables, five for department of students (Department2,3, 4, 5, and 6), two for education levels (Education_Level2 and 3), two for class no of undergraduate students (Undergradute_Class3 and 4) and to own a project experience have statistically significant coefficients; four dummy variables, two for department of students (Department7 and 8), class no of undergraduate students (Undergradute_Class2) and gender variable doesn’t have significant coefficients as categorical variables. All significant department variables have a positive effect, which means that students at more related departments related on ITS want to work in this area. However, students at engineering faculties’ industrial and environmental engineering departments have not a significant PbEE on ITS. This result may be due to the fact that both departments have less relevance or interest on ITS or undergraduate students may have less knowledge on the importance of ITS in their job. On the other hand, undergraduate students at early classes at universities’ engineering faculties have not a significant expectation on PbE and if the class no of students increase, they earn a consciousness and understand the importance of PbE. According to model output, to own a project experience and to be a member of a project during the education life has a great importance for a student to understand the importance of a project and to want a PbE in the education curriculum of his/her department. The model also clearly indicate that gender variable has not a statistically significant effect and it means that become male or female has not any importance on the expectation.

5. DEVELOPED PROJECT FOR PROJECT-BASED EDUCATION

5.1. Project Aim

In recent years, transportation planners, researchers, and decision makers have taken steps towards the development of ITS the widespread use of e-vehicles instead of fossil fuels to solve all these problems by using developed technology and opportunities. Thanks to the all authorities, significant progress has been made in the utilization of these technologies in traffic and transportation planning. However, the biggest problem encountered at this stage is to find qualified staff or experts during the implementation and operation of these systems because the education for the planning and implementation of such systems, especially in engineering faculties, are limited and insufficient. Current situation showed that non-project-based education does not contribute to the knowledge and experience of students in transportation field. In addition, not seeing the application of such intelligent systems in the field from a technical point of view is unfortunately quite inoperative in terms of having sufficient equipment.

In this context, i-gCar4ITS project aims to contribute to the engineering students of OMU as the pilot university and the lead institute in the study to graduate engineers, young researchers from different universities, academics, and the employees of SMM which is the supporting partner institution to be qualified personnel in the project. The fact that the project is currently one of the most comprehensive projects implemented in this regard in Turkey will provide an opportunity to everyone involved in the project to see ITS and e-Bus applications live, gain technical knowledge and experience, help develop themselves by observing every stage of the project from the beginning to the end, learn the contributions of the systems to the country's economy, and contribute to any report to be prepared about traffic safety and climate change. This project-based education and application project aims to train qualified individuals in intelligent transportation systems and e-Buses and contribute to their self-training to take part in national and international projects, write and execute projects, etc. and reduce the shortage of qualified personnel in the relevant fields. Besides, undergraduate, postgraduate students, academicians, graduates, road authorities, transport students and researchers at Cardiff University, which are foreign partners of the project, will be able to follow the developments in this field in Turkey, exchange information, and develop joint projects. With this feature, the project will provide "equality of opportunity" to all participants in this field, regardless of their religion, language, race, gender, etc. In line with the priority themes and outputs identified in the project call, the objectives and targets.

5.2. Motivation and Infrastructure

The significant increase in the population and the number of vehicles in traffic causes vehicle densities, delays, long vehicle queues, and many traffic accidents on urban and rural roads. This negative situation results an increase in the emission of more CO_2, NO_x, PM2.5, etc. harmful gases to nature from fossil fuel-consuming vehicles and causing climate change. This unmanageable increase in traffic can lead to traffic accidents, aggressive driver behaviors, disobedience to rules, etc., and adversely affect human health. To find a solution to this issue, which is among the top priorities in the United Nations Action Plan, many cities around the world are trying to control and manage existing urban and rural roads with innovative and ITS. In addition to using these intelligent and environmentally friendly systems to relieve traffic, many cities aim to initiate and expand the use of e-Buses or micro-mobility systems such as e-Scooter and e-Bike instead of fossil fuel vehicles in their public transportation systems. Samsun Metropolitan Municipality started to implement "Smart City Traffic Safety" project throughout the city in June 2021 with the biggest technology and defence company "ASELSAN" in Turkey (Fig. 2).

Figure 2. The signing ceremony held in June 2021 between ASELSAN and SMM [18].

During the project, total 78 “Intelligent Intersection Systems” are started to install at signalized intersections, “Average Speed Detection System” in main corridors, “Parking Violation Detection System” in roadside parking areas, “Red Light Violation Detection System” in sections with signalized lights, and initially 20 e-Buses are started to use for public transportation. Thus, the project become one of the biggest ITS project in Turkey. After the contract was signed, the project started to be implemented in July 2021 and still ongoing. Firstly, the geometric and technologic infrastructure transformation of total 78 intelligent intersections started (Fig.3).

Figure 3. An example visual for ITS transformation of a signalized intersection.

As part of the implementation of the project, many intelligent intersection systems and violation detection systems will be implemented to manage traffic and air pollution throughout the city. In public transportation, instead of fossil fuel buses, e-buses developed by ASELSAN, which is a partner in the “Smart City Traffic Safety” project, will start to be used in Samsun city (Fig. 4).

Figure 4. Signing ceremony of e-Buses in Samsun City Public Transportation (URL-1).

To supply a project-based education opportunity to engineering students in Turkey and Transport M.Sc. students in UK, an education project titled “i-gCar4ITS: Innovative and Green Carrier Development for Intelligent Transportation System Applications” was proposed. In the project, Ondokuz Mayıs University (OMU) is the lead institution in Turkey, Samsun Metropolitan Municipality (SMM) is the national partner institution in Turkey, and Cardiff University (CU) is the partner institution from the United Kingdom. During the i-gCar4ITS project, all step of Samsun Metropolitan Municipality’s “Smart City Traffic Safety” project is examined in detail with students. This ongoing project-based education project (i-gCar4ITS) aims to train students, graduates, engineers, and academicians who are experts in smart transportation systems and environmental transportation planning in Turkey, with the cooperation of OMU, SMM, and CU. It is a well-known fact that it is very difficult to find qualified expert in smart and innovative transportation systems, and air pollution management in institutions, universities, and professional organizations in Turkey and many countries.

All process steps from the beginning to the end of "Smart City Traffic Safety" project is examined in detail and continuously monitored, and experts are trained by using the applied learning method. During the implementation, all partners and the target participant of the project are able to follow all phases of the project, regularly. The proposed duration of the project has been planned by SMM as a maximum of two years. According to this plan, the duration of the smart city project overlaps the proposed project in the work plan, and timetable meet almost all the expected outputs.

5.3. Conducted and Ongoing Activities

Application and learning based project "i-gCar4ITS" has started November 2021. As a first step, project opening meeting was conducted in Ondokuz Mayıs University (Lead University) to announce the project to engineering students. Many engineering students, graduates, sector partners and lecturers from the universities have attended to meeting (Fig. 5a). After meeting, all volunteer partners registered to project. Then, project organization and management meeting were conducted between project partners (Fig. 5b).

Figure 5. (a)Project kick off and (b) organization and management meeting.

In the first period of the project, to reach more students and partners and supply project dissemination, project team has attended many conferences, organization and workshops in Turkey and UK as shown in Fig. 6.

Figure 6. Some visuals for the attended activities to develop collaboration.

The most important part of the project is its education method. Project aims to teach all the steps of ITS by using site visits, online and face to face education and analyis methods. During the project, some examples can be seen such as real site visits (Fig. 7a-d), image processing and coding courses (Fig. 7e-g), education for ITS (Fig. 7h-j).

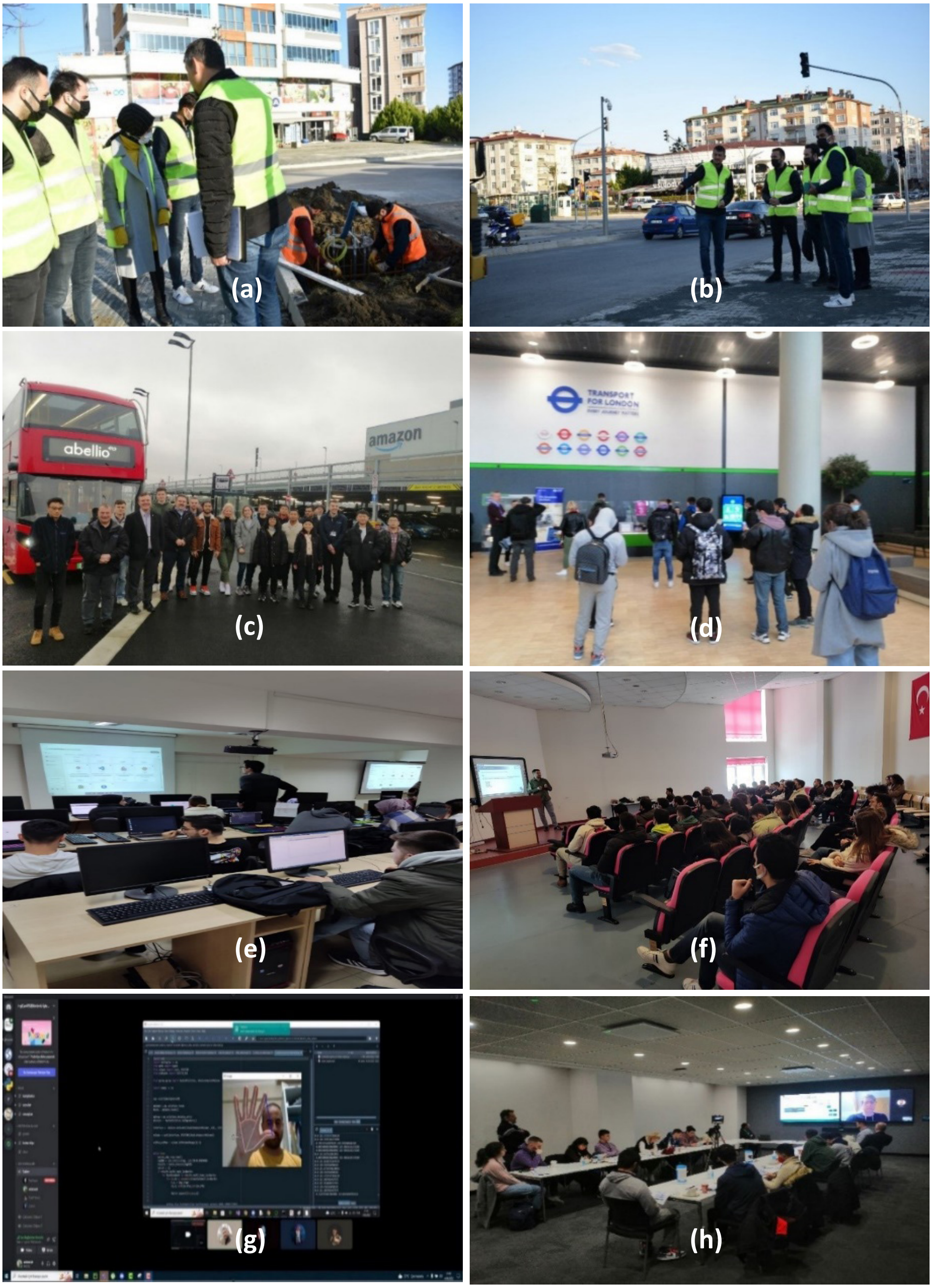

Figure 7. Some visuals for conducted activities for i-gCar4ITS project.

6. CONCLUSION AND SUGGESTIONS

In recent decades, the use of technological developments in transportation has become quite common due to the increasing population in the world, chaos in traffic, exhaust emissions, etc. Especially with the development of artificial intelligence algorithms and sensitive measurement/management systems, ITS applications have come to the fore. The use of ITS-based environmental systems in transportation has also gained importance with the environmental and air pollution problems caused by transportation activities and the climate change. However, the lack of experienced and trained personnel to work in this field draws attention as one of the biggest problems. Thus, PbE for undergraduate and postgraduate engineering students on ITS gain big importance. In the study, project-based education expectations (PbEE) of students were tried to examined and modeled by collecting questionnaire survey data under various effective parameters. Model results show that there is a distinct desire among students to receive a project-based education on ITS. Most of the students have an expectation to get project-based education and to be involved in a project to regarding to his/her working area. In this study, according to project-based education demand of the students, the developed project titled "i-gCar4ITS" for PbEE of students in Turkey and UK were introduced in detail and current activities were shared. In the project, engineering students in both countries with knowledge and experience in intelligent transportation are started to be trained. Thus, target stakeholders who had experience in this field start to get able to create new R&D projects on ITS, have employment opportunities in this field, and have the desire, knowledge, and experience to take part in international projects for their future carriers. Study results are also showed that many students from different departments have huge interest on to develop a project or become a member of ITS-based project and thus, the importance of PbE come to the fore to encourage future projects in this issue.

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CHAPTER 11

Climate Change and Sustainability

THE ROLE AND IMPORTANCE OF CULTURAL ECOLOGY IN COMBATING CLIMATE CHANGE

Cevdet Yılmaz[1*]

ABSTRACT

In the 21st century, one of the most important problems our world faces is global warming and the resulting climate change. In the solution of the problem; reducing greenhouse gas emissions from fossil fuels and saving energy use are the first suggestions that come to mind. In the process of combating climate change, people's actions and choices should be in harmony with nature, practices that harm nature are expected to be reduced. In this study, it is emphasized that cultural ecology and traditional local knowledge can be a guide for achieving a balance in nature-human relations. In this respect, it is aimed to illustrate the importance of sustainable lifestyles and modes of production in rural Turkey by recognizing the local geography. Rural architecture and the cultural ecology of agriculture in Anatolia were selected as two thematic areas, and the data obtained through field studies and face-to-face interviews were interpreted. As a result, it has been concluded that rural architecture examples are rich in functional solutions designed according to climate and seasonal conditions, which contribute to savings in energy use, annual cooling and heating energy demand can be balanced with the use of natural environment characteristics, and traditional ecological knowledge can guide the solution of today's problems.

Keywords: Climate Change, Geography, Cultural Ecology, Energy

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1.INTRODUCTION

Until the 19th century, human beings have survived for thousands of years to the extent that they adapted to the natural environment in which they lived, otherwise their lives were endangered. In the last two centuries, humans have gained superiority over their environment and rapidly changed it through industrialization and the technical means it has brought.

In the meantime, they have used fossil fuels in abundance, created many environmental problems, especially human-induced global climate change, and turned the world into a place with pathological disorders. As a result of the overuse of natural resources and ecosystem destruction, societies and countries face various problems. In parallel with population growth and the development of technology, intervention in natural environments has increased, and resource consumption and environmental pollution have reached a level that threatens living health. One of the biggest problems faced on a global scale is climate change. There are countless research and publication activities related to this problem and new ones are being added every day. In these studies, emissions of gases such as carbon dioxide, methane and nitrous oxide are cited as the main causes of the rising global temperature. The last three decades have been the warmest since 1850, and if emissions continue at current trends, the average air temperature in the period 2081-2100 will be 4.8°C higher than in the period 1986-2005 [1].

Vulnerability to climate change can be broadly defined as "the relationship between the degree to which a community or system (physical geography, ecological system or socio-economic sector) is affected by or vulnerable to climate change stress (stress and pressure), the level of meeting or responding to stress (sensitivity) and the level of adaptation to climate change (adaptive capacity)" [2]. Due to changing climatic conditions, energy demand for heating and cooling in residential buildings may increase, albeit differently in cold and hot climates. In a study [3], it is stated that energy consumption will decrease in Northern and Central Europe due to global warming, while in Southern Europe, the increase in cooling demand will be higher than heating demand. Based on three cities (Curitiba, Florianópolis ve Belém) from different locations in Brazil, it is projected that there will be an increase in annual energy demand between 19%-65% between the three cities in 2020; 56%-112% in 2050; and 112%-185% in 2080. In the coldest city, annual heating energy demand will decrease by 94% in 2080 due to an increase in average temperature and global solar radiation. In another example, in a study on the potential impact of climate change on heating and cooling energy consumption in residential and office buildings in Switzerland, four climate scenarios were evaluated for the period 2050-2100, and energy consumption for cooling in Zurich was projected to increase by 223% and 1050% in 2050 and 2100 respectively, while energy demand for heating was projected to decrease by 36% and 58% in 2050 and 2100 respectively [4]. At this point, how to combat human-induced global climate change and how to cope with new changes is of worldwide importance. Although not on the scale of today, human beings have always encountered natural disasters such as drought, floods, floods, frost, extreme cold, most of which are related to climate, and have learned to cope with these problems in order to survive, and have developed numerous skills and adaptations in this direction. However, today, in rural areas where technology has not yet penetrated with all its elements, people adapt to their environment by using many methods without consuming fossil fuels and polluting the atmosphere, and manage to survive without disturbing the natural balance. At this point, methods that prioritize less energy use, environmental health and ecosystem protection come to the fore. So what is the way to stop the adverse conditions caused by global climate change or to develop strategies to cope with changing climate conditions? The aim of this study is to evaluate the importance of recognizing and taking into account local geographical conditions in the process of adaptation to the effects of climate change, and the unique examples we have identified regarding cultural ecology and traditional ecological knowledge for this process. Architecture, agriculture, food production and related processes, which are among the most concrete human activities, are directly related to climate. Practices based on agricultural knowledge and methods that take into account local geographical conditions such as climate, soil, land structure, do not harm or cause little harm to ecosystems, and where solutions to problems are often found and applied locally can contribute to adaptation to human-induced climate change and reduce the effects of new adverse conditions.

2. METHODS

The approach of this study is based on cultural ecology, which explains the processes that may develop in the case of recognizing the geographical environment in which we live, acting in accordance with it or not. This branch of science, which focuses on how humans benefit from their environment without harming it, can bring some solutions to the problems of global climate change, even if only partially. One aspect of cultural ecology, which is a research approach within the human-environment relationship, is cultural adaptation.

Cultural adaptation is a change in the traditional structure of a group of people over a long period of time in order to respond to and adapt to structural changes in the natural environment, new technologies, political system, etc. [5]. In the context of global climate change, it should be recognized that human-environment relations can be shaped by a range of social and cultural practices, and that local, regional or even global political, cultural and economic systems may be behind any change in the natural environment [6]. Cultural ecology offers an interdisciplinary approach to mobilize a cultural shift and radical decisions for the urgent fight against climate change. Traditional ecological knowledge, which best reflects culture and ecology as well as local geographical characteristics, is a cumulative body of knowledge, practices and beliefs about the relationships of living beings, including humans, with each other and with their environment that develops through adaptive processes and is passed down through generations through culture [7]. The study is based on the ways of life and production that reflect the cultural ecological elements that already exist in our country. In terms of the adaptation process to global climate change, evaluations were made under the following 2 themes with various examples from Anatolia based on local geography:

a) Architecture in harmony with the geographical environment, b) Traditional preservation of food and reduced energy use through traditional ecological knowledge in Anatolian agriculture. Rural dwellings and the relationship between food preservation and energy saving were analyzed based on geographical observations between 2018 and 2022. The data obtained are categorized and interpreted under sub-headings.

3. FINDINGS

3.1. Architecture Compatible with the Geographical Environment

Climate, seasonal conditions, residential architecture and energy conservation

One of the most important characteristics of rural architecture in Turkey is that it is developed in harmony with the geographical conditions in which it is located. Adaptation to the geographical environment seen in traditional architecture is directly related to climatic elements such as temperature, precipitation, humidity and wind, as well as land structure, lithology and vegetation. For example, the front or one of the facades of the house facing the sun; paying attention to the direction in which the crops and animal feed will be dried; taking into account the resistance to climate and precipitation in the selection of trees for the building; measures to protect the house from wind, humidity and blizzards are some examples of adaptation to the geographical environment. This adaptation increases the lifespan and durability of dwellings, and with its functionality, savings can be achieved in the use of time, space and energy, and new costs can be eliminated. Material selection and planning according to climate and seasonal conditions are always important in architecture for an environment suitable for human life. Considering the effects of climate change, energy demand and need for heating, heating and cooling in homes may change over time. Design and applications that will balance the effects of heat and cold will be required to achieve the desired bioclimatic comfort characteristics in the most suitable climate and weather conditions for human life. Looking at the rich architecture of Anatolia, it is seen that whether in semi-arid areas or in rainy, humid regions, dwellings suitable for the natural environment have been developed. This general view can be explained with an example from the Black Sea Region (Photo 1). In the traditional architecture of the Ayancık region, the use of stone and wood together in the humid environment of the Black Sea to provide a technical solution for the rainy climate, and the fact that the production of stone and wood, the source of which is an edible material, requires relatively little energy shows both the design suitable for the geographical structure and sustainability [8, 9].

Location relative to the sun

When looking at examples from Anatolia regarding energy saving in rural dwellings, designs to meet various needs such as solarization of houses, thermal insulation, heat preservation and distribution within the house, and outdoor food drying are observable features. The positioning and shape of houses in relation to the sun affects the amount of energy needed and used. In rural areas, the ways in which families heat their homes or retain heat and prevent cold air from entering the house are often related to a) the use of sun-facing facades in summer and winter, b) the interior layout of the house, c) insulation mezzanines, d) siding and shutters, and e) livelihood types-livestock. In houses, the use of sunlit and non-sunlit rooms is changed according to the seasons to save heat and light. In the winter months, the more sunlit rooms on the south and east sides of the houses are generally used, while in the summer, the summer rooms close to the body wall of the house are used because they are cooler.

Photo 1. Houses with one side facing the sun;
a) Sinop, Ayancık, Armutluyazı village, b) Sinop, Türkeli, Satıköyü

Summer room-floor; winter room-floor application

In today's cities, the amount of energy spent to keep the houses cool in summer and to heat them in winter is quite high. However, with the application of summer and winter floors in traditional Turkish houses, people have lived the most efficient life with the least amount of fuel and have been able to realize a sustainable lifestyle without destroying their environment (Photo 2). In local architecture, simple solutions have been developed to maintain heat balance, provide ventilation and prevent the entry of cold air (Photo 3). For example, in the "Şavşat house" in the Artvin region, the ayvans allow the house to be ventilated naturally. These houses are two-storey wooden structures with the lower floor used as animal shelter and the upper floor as living space. On the living floor, there is a corridor that divides the rooms into two and connects the two opposite sides of the house, and two doors lead to the ayvan. The "ayvan" is a semi-open balcony-like structure that surrounds the house without a partition and is used to pass into the house. In this architectural design, air circulation is possible in the house in all seasons.

Photo 2. Bursa, Cumalıkızık village (HTML-1); houses usually have three floors;
1st floor is entrance, 2nd floor is winter, 3rd floor is summer.

Photo 3. Bursa, Cumalıkızık; middle floor winter floor; narrow, low, easy to heat. Upstairs summer floor; wide, spacious, airy.

Another issue is the function of building windows. Double glazing is used to reduce the effect of outside noise and cold air. Again in rural architecture, houses in cold and high areas have wooden shutters on the windows. By closing the shutters, the effect of the sun or cold air is reduced, depending on the season. Another element is the roof shape and roof covering material of the buildings. Roofs, with their materials and shape, can either reject or retain heat. This can be illustrated by comparing stone and wood roofing with sheet metal roofing in rural dwellings. According to the owners, in the past, when wood (hartama, bedevra) was used for roofing, various foods such as dairy products and dried fruits could be kept in the attic for a certain period of time in hot weather, but this was not possible with the use of sheet metal in the 1980s.

Heat saving with rooms with stove

In the house interior plan, there is a structure embedded in the wall, called a hearth or open fire, which is always located in a room of the house and provides warmth and heating. The room with the hearth is the space used by the family together, especially in the winter months, and heat distribution is provided through passages to other rooms. Most of the hearths are closed and stoves are placed in front of them and many cooking and drying processes are carried out at the same time (Photo 4).

Photo 4. Fireplace and rovine stoves are used to heat homes while cooking and drying at the same time, saving energy.

Another example of doing more than one job at the same time with less energy consumption is to utilize the heat from the stove by opening the living room and kitchen in modern houses. A similar practice has been applied in public institutions to save heat (Photo 5).

Photo 5. A stove system in an old school in Giresun, where a single stove heats two adjacent classrooms.

Utilization of other heat sources; barns, insulation floors

Depending on animal husbandry, animal shelters were built close to the living areas, both side by side or in the form of lower and upper floors. For example, in the Eastern Black Sea Region, in the high and cold regions, the first floor of traditional houses in the high and cold regions was used as a winter room and the side of the house was used as a barn. In winter, the lower floor was warmer than the upper floor thanks to the heat of the barn and the thick logs. Again, especially in wooden houses, a narrow intermediate floor about 20-30 cm high was left between the barn ceiling and the house floor. This area was filled with materials such as soil and ash (Photo 6). Thus, the barn odor was prevented from passing to the upper floor and the heat of the barn and the house was maintained.

Photo 6. The isolation gap between the barn and the living space in two-storey traditional houses.

Architecture compatible with rainfall conditions, geomorphology and reducing the impact of natural disasters

With climate change, seasonal anomalies and sudden precipitation will trigger an increase in floods and landslides. In rural architecture, the land structure, lithological characteristics and the risk of flooding and inundation affect the durability of the dwelling. In areas where the ground water level is high and the slope is far away from the slope value where the rainwater will move away quickly, the houses were built by taking some precautions (Photo 7). For example, in the Çarşamba region of Samsun, old houses on the plain were raised on stilts to keep them away from water and moisture (Photo 8). Since these local conditions are the same, the same technique was taken as an example in the concrete houses built later.

Photo 7. Flood disaster in the Çarşamba Plain - Yeşilırmak Delta on June 22, 2019 (Source: DHA). Two examples of dlta houses built on poles high above the ground, very few of which have survived to the present day in case of similar problems in the past.

3.2. Traditional Ecological Knowledge and Food Preservation and Climate Adaptation in Anatolian Agriculture

Agriculture adapted to local geographical conditions

Agriculture is one of the most important areas to be affected by changing climate conditions. Local climate and agricultural systems in different parts of the world are facing threats such as drought, rising waters and increased erosion. Considering population growth and the provision of food, which is a basic need, a balance between the protection and utilization of agricultural lands and the most reasonable adaptation strategies to new conditions should be determined. Many engineering solutions designed to mitigate climate-related risks, such as early warning systems and crop monitoring, are being developed. However, local solutions developed thousands of years in the past against changing natural environment characteristics and the best of which have survived to the present day should also be discovered and adapted to the present day. Indeed, our country has a rich diversity in terms of both geographical conditions and local dynamics of agricultural activities. Anatolian agriculture, which has reached the present day by experiencing various conditions in thousands of years of agricultural history, contains a memory to be used in solving current problems. Uses appropriate to the quality of land are in themselves a natural protection against the effects of climate change and a method of adaptation to new conditions. Growing crops in accordance with the structure of soils and the availability of irrigation water; protecting the soil by terracing sloping lands and creating planted areas are examples of local methods.

Traditional agricultural knowledge and skills

Traditional ecological knowledge and practices in Anatolian agriculture, which has developed adaptation to its geographical conditions, are of great importance in the process of adaptation to global climate change. These themes can be examined in various ways such as soil recognition, soil protection, soil fertility, planting and planting in accordance with local climate and soil conditions, alternation, multiple planting, seed collection and seed preservation, fallow, natural solutions to plant diseases, traditional preservation methods. With this knowledge and practices, crops can be grown in accordance with climatic elements such as drought, rainfall, humidity or seasonal anomalies. Growing crops in accordance with soil and water availability is important for the sustainable use of soil and water resources. The ability to solve a problem encountered in agricultural production with local possibilities and the use of less energy and chemicals also support adaptation to the natural environment.

Less energy use

In the past, when household appliances based on electrical energy did not vary, there were many items used for similar functions (Photo 8). For attractive reasons such as saving time, being easier and faster, a transformation has begun in households and kitchens. Electrical appliances are now being used more and more for tasks that can be done and prepared by human hands.Do we have to use electricity and consume energy in all of the items we have started to use in the kitchen, almost all of which are electrical. Can't some of these things be done with physical labor as in the past?

Photo 8. Kitchen utensils used in the recent past and recently replaced by electric appliances. The question is, do we do everything with electric tools now, or can we save energy by doing some of it by hand, as in the past?

Energy consumed by freezers and traditional preservation of food

When it comes to using less energy in kitchen appliances, deep freezers undoubtedly attract the most attention (Photo 10). Especially in rural areas, these containers, in which vegetables and fruits are stored as soon as they are available, cause a huge energy consumption, and most of the time, when the value of what is stored in them is compared to the electricity consumed, it is more than a hundred percent. Today, many people store food in electric coolers to extend its shelf life, increasing energy use and incurring heavy bills. However, for thousands of years, our people living in rural Turkey have been able to develop very important methods of preserving and extending the shelf life of their food without utilizing depletable energy resources.

Traditional preservation of food; grain and fruit stores built in rocks and tuffs

Thick layers of tuff formed in volcanic areas and karst caves seen in karst topography have been used for the storage and preservation of various crops since the past. These practices, which constitute one of the best examples of adaptation to the natural environment, are a form of utilizing the physical environment through culture. The most common and well-known of these in our country are the natural warehouses in Nevşehir region. The towns of Kavak and Ortahisar in Nevşehir are an example of food storage by utilizing the natural environment. In the region, naturally cooled underground storages have been widely used since the past. Tuffs on the slopes of river valleys are carved out and used without the use of energy.

Thousands of tons of fresh fruit can be stored in these storages for months without any energy consumption. In these warehouses, ventilation shafts with a diameter of 25-30 cm and a height of 15-17 m are built at 5-6 m intervals. Trucks also enter the warehouses to unload their cargo. For this reason, the height of the warehouses from the ground varies between 4.8-5.5 m and their width varies between 4-6 m. There are more than 500 naturally cooled underground storages in Kavak and Ortahisar towns [10]. Another example of tuff deposits in volcanic areas is the Güzelöz (Kayseri) and Şahinefendi (Nevşehir) tuff deposits in the Middle Kızılırmak Department (Photo 9). Thick layers of tuff were carved out with modern excavators and transformed into warehouses where crops can be stored for 7-8 months. The materials are natural and the structures are artificial, but in terms of storage conditions, the conditions provided by this type of warehouses are close to the room climate in modern cold storages.

The average temperature inside the warehouse in summer and winter is around 5°C, provided that the insulation of the warehouse with the outside is safe [11].

Photo 9. Natural storages formed in tuff layers in Nevşehir region.

Rock cracks and karst caves in karst areas are used for food storage, preservation and ripening in Anatolia. One of these caves, the Peynirini Cave within the borders of Mülayim Neighborhood of Derbent District of Konya Province, has long been used for ripening tulum cheese, as the name suggests (Photo 10). The year-round temperature in this cave is around 6-7°C and the cave air has high humidity saturation (99.6-100%) [12].

Photo 10. Konya / Derbent / Mülayim village / Peynirini Cave (Photo: Ayşe Dağlı)

Cold storages, which are used to protect, store and delay the spoilage of various foods, especially against the heat of summer, are called icebox, "buzhana", "buzhane", "daran", "mahsen" in Anatolia (Photo 11). Although there are refrigerators in homes, some food is placed in ice houses in addition to refrigerators as needed. According to the testimony of those who use the icehouses, they are not worried about power cuts when daily or weekly food is stored there. Therefore, in the event of a power cut, the ice houses are used with peace of mind.

Photo 11. "Icehouses" in the natural environment, in karst areas and around the house.

Storage by storing in earthen wells

One of the ways of preserving some vegetables and fruits in the natural environment is through earth wells (Photo 12). This type of well aims to keep vegetables and fruits fresh throughout the winter. Wells dug in the soil and by human hands are also shaped according to the type of crop.

Photo 12. Different shapes of earthen wells used to keep certain vegetables and fruits fresh; 1. Cylindrical vertical wells, 2. Deep and wide surface wells, 3. Deep and rectangular wells.

Dry storage in warehouses and "serender"s

Warehouses and serenders, which are extensions of the house, are used for drying and storing products such as corn and hazelnuts, as well as some vegetables (Photo 13). Since at least one year's worth of food was to be preserved, the inside of these structures should be away from moisture. For this reason, they were built without windows. Similar to warehouses, there are also vineyard warehouses with two floors, the upper floor of which is used only for grape storage and which, like warehouses, are windowless [13].

Photo 13. Serender and granaries are notable for their versatile functionality by drying or storing food in a dry environment.

Boiling and nature-dried storage.

Increasing the duration of use by transforming the fruit is done by boiling and drying the fruit in the sun or by making "pestil" and "köme". Sun exposure time is important for proper drying of foods based on manual labor and traditional methods. Drying and preserving in nature is usually done in summer and fall. Similarly, another method is to first dry local cheeses and then soak them in water and shred them to make them edible. What is distinctive in this example observed in the Artvin region is that the drying of cheese is done even in January in settlements in the valleys. For this process, cheese drying cabinets were built as a small addition to the open space in the front facades of traditional dwellings called gazebos (Photo 14). The fact that the low-lying settlements in the valley are relatively warm and the valley breezes may have played a role in the development of this method.

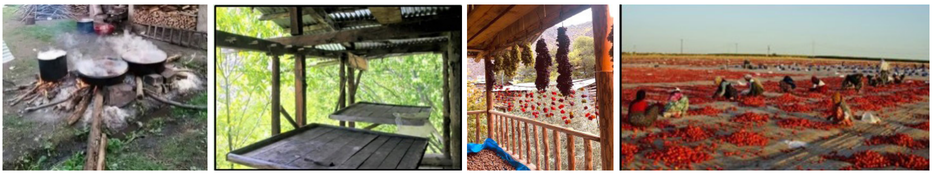

Photo 14. Boiling in cauldrons (Sinop), rotatable food drying greenhouse in the gazebo of houses (Artvin), hanging (Artvin) and drying fruits and vegetables (Şanlıurfa) (HTML-2).

Cool storage in cellars of houses

In the periods when electrical energy was not used, small additional structures were built in or near the house or the ground floors of the houses were used to keep various food products cool and stored for a certain period of time. Thus, various food storage areas, which cannot be considered independent from the house and have an important place in daily life, were created (Photo 15).

Photo 15. The cellars close to the houses and agricultural fields were the storage units for vegetables, fruits and liquor.

4. CONCLUSION AND RECOMMENDATIONS

In this study, examples from the cultural ecology of Anatolia are given to the search for solutions to the causes and effects of global climate change. Especially through the themes of architecture and agriculture, it is conveyed that a life and production style in harmony with nature also saves energy, creates less waste, and that a sustainable life already exists. Traditional knowledge and methods can also be utilized in solving the global problems we face today. The appropriate solutions found by taking lessons from the problems that human beings have experienced and encountered can be adapted to the current processes. While scientists are looking for solutions to the effects of climate change on a global scale, the people who are experiencing these problems themselves, such as those facing the threat of rising sea levels, can be monitored to see what kind of solutions they come up with to survive in their current environment. For all these, the human-nature relationship should be looked at more closely, and solutions identified in the context of cultural ecology should be generalized and developed as suggestions for solving global problems. For example, tuff warehouses, structures called ice houses, and earthen wells can be used as alternatives to modern cold storages and coolers used in homes, which consume a lot of electrical energy. With its 10,000 years of settlement history, Anatolia has countless examples in this regard.

Although this study briefly focuses on agriculture and rural architecture, many areas are waiting to be examined. Our task is to collect this information before the last representatives of Anatolia's ancient culture who live in the rapidly emptying countryside - with internal migration and urbanization - disappear, and to make use of them for the solution of our future problems, including today. Local governments should take the lead, scientists and geographers should explain the characteristics of the place, appropriate house plans should be made, examples should be taken in Anatolia. Climatic changes have a direct impact on traditional agriculture, the types of crops grown, production, the productivity of meadows, the working hours of farmers. Local geographical knowledge is therefore the best guide to understand the current situation. In the face of climatic changes, many local solutions for the construction of new houses, the temperature of the home environment in hot and cold weather in rural dwellings, its suitability for human biology, how ventilation is provided, and how to protect the exterior of the houses from moisture and wind can be a source of inspiration. Many engineered solutions are being developed to mitigate climate-related risks, such as early warning systems and crop monitoring. However, local solutions that have been developed thousands of years in the past against the changing characteristics of the natural environment, the best of which have survived to the present day, should also be explored and adapted to the present day. Solutions to today's problems can be developed by feeding on the countryside. For this, the continuity of local values must be ensured.

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SUSTAINABLE AND GREEN PARTICLEBOARD MANUFACTURING

Aytuğ Tekbaş[1*], Nihal Bektaş[2]

ABSTRACT

From the start of civilization, wood is the most used natural materials for many purposes by different industries such as building, furniture, and packing. There are many benefits in using wood use because it is renewable resource, regenerative fuel, good-looking, low weight, high insulation capacity, extensive availability as well as flexible in applications. Engineered wood products are widely used in home and as exterior furniture in these days and particleboard is the most wood product used in modern woodworking industry since it is low-cost and more uniform than conventional wood. Particleboard is a panel product manufactured from wood lignocellulosic materials by combining with resin and wax, then it is cured under pressure and heat to form into sheets. The particles used to manufacture particleboard include waste wood materials such as flakes, wood shavings, wafers, chips, sawdust, strands, slivers and wood wool.

In this century, there is a huge pressure of the society to reduce environmental effects of all type of production. Climate change will also affect every aspect of our daily lives. Green manufacturing (GM) gives minimal negative impact on the natural environment by using less energy and raw materials.Also, IPCC recommends replacement of energy intensive products such as iron, steel and plastic with the wood-based products with concerns over climate change. Due to these huge demands on particleboard industry, there is an urgent need to develop particleboard production in green and sustainable ways.

In this presentation, particleboard production process will be detailed and green and sustainable option of manufacturing process will also discuss according to principles of sustainability and EU Green Deal to avoid climate change occurs and affects globally.

Keywords: Particleboard, Climate Change, Green Deal, Green Manufacturing (GM) and Sustainability

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1. INTRODUCTION

The environmental effects of wood-based panels, which are in the top priority in consumption habits in our country and in the world, from the production process to the delivery to the end user, have attracted the attention of many researchers [1]. It is obvious that the studies carried out as a result of the life cycle analyses and the environmental effects of the chipboard plants and the evaluation of the environmental parameters are important in terms of sustainability [2].

2. PARTICLEBOARD PLANTS

Particleboard plants have an important place in wood-based chip production. The most common in the forest industry products sector in terms of production technology and usage area is the particleboard industry [3]. Particleboards are large and large-surfaced boards sized according to the purpose of use under heat and pressure by using a synthetic binder (resin or adhesive) of chips and small particles obtained by using wood raw material [4]. Particleboards; although it is used in both interior and exterior floor applications, it is among the materials used in furniture making [5]. The fact that particleboards are resistant to impact due to their density and that their surfaces are smooth cause different usage areas [6] The fact that particleboards are resistant to impact due to their density and that their surfaces are smooth cause different usage areas [7].

Due to the population growth in our country and in the world and the changing needs accordingly, there has been an increase in the fabrication of wood-based panels, as in many production sectors. After the 2000s, our country has become one of the most important producer countries in the world, especially in particleboard (chipboard) production[8]. In Europe, the wood-based board industry accounts for 9% of the woodworking industry. The most important share in the wood-based board industry, and about 70% of this, belongs to the particle board facilities [9].

The most important raw material used in particle board production is lignocellulosic materials. Wood is the leading raw material of lignocellulosic materials used in the preparation of particle boards. In addition, woody parts of annual plants and straw, reed, sugar cane, flax stalk, hemp stalk, sunflower, hazelnut, peanut shells and cotton seed shells can also be used in particleboard production. The best raw material for particleboard production is primarily coniferous woods, although it can also be used in deciduous woods. In the production of particleboard, more than 90% of the weight of the board consists of wood as raw material, and synthetic resins are used as adhesives[10]. About 90% or more of urea formaldehyde in particle board production in the world resins are used. Urea formaldehyde resins cheap, hardening time on pressing glues are short and easy to use. For this reason it is preferred [11]. Basically, three production technologies can be mentioned in particleboard production. These are slanted particleboard production, vertical particleboard production (OKAL TYPE) and moulded particleboard production. Apart from these, Thermodin Method, Collipres Method, Werzalit Method are also known. All production methods are basically the same [11].

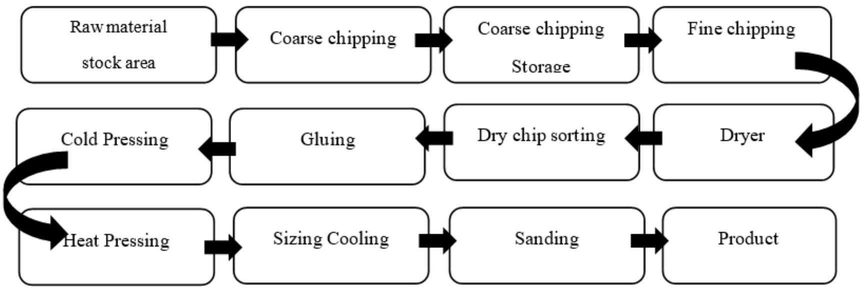

Figure 1. Particleboard production stage [5]

Figure 1 shows the production stages in particle board facilities. In production, drying processes and gluing processes are carried out after coarse and fine chipping processes.

Studies in the traditional industrial production of wood-based panels mostly take into account the physicochemical properties and usage requirements of the products. But a lot of resources are consumed in the production process. Adhesives used and water consumption are another issue to be considered. For this reason, wood-based products can cause environmental pollution [12].

3. CLIMATE CHANGE AND GREEN DEAL

Climate change can be defined as "change in climate as a result of human activities that directly or indirectly degrade the composition of the global atmosphere, in addition to natural climate changes observed over comparable time periods" by United Nations Framework Convention on Climate. Human activities continue to change many things, including climate, from past to present on Earth. Some anthropogenic effects such as fossil fuel use, industrialization, deforestation have huge impact on the Earth's energy balance and are the major drivers of climate change.

There are many international agreements to reduce greenhouse gas emissions and global temperatures. The most important steps taken so far in this regard can be listed as the United Nations Framework Convention on Climate Change (1994), the Kyoto Protocol (2005), and the Paris Agreement (2016). As a continuation of the Paris Agreement, the European Commission has put the European Green Deal on the solution of the problems caused by climate change on its agenda. The Sustainable Development Goals mentioned at the United Nations Conference on Sustainable Development held in Rio do Janerio in 2012 address issues parallel to the European Green Deal. It is the priority of the European Green Deal to create developing and solution-oriented policies. In this context, different greenhouse gas targets have been determined for goals of the green deal include carbon neutral.The European Green Deal set the plan for this transformational change. 27European Union (EU) Members have pledged to transform the EU into the first climate-neutral continent by 2050. For this, it was decided to reduce emissions by at least 55% by 2030 compared to 1990 levels.

Türkiye has created an action plan for the European Green Deal. With this action plan, it is aimed to contribute to Türkiye's move to a resource efficient economy. In the action plan, there are many directives to be done given as follows;

(1) Carbon Regulations at Borders,

(2) Circular and Green Economy,

(3) Green Finance,

(4) Clean, İnexpensive and Secure Energy Supply,

(5) Sustainable Agriculture,

(6) Sustainable Smart Transportation,

(7) Mitigating Climate Change,

(8) Diplomacy, and

(9) European Green Goals determined under the headings of reconciliation information and awareness activities actions to be taken to achieve it [13].

3.1. Green and Sustainable option of Particleboard Manufacturing

World has got several environmental difficulties from the beginning/middle of the last century. Environmental management policy in the past concentrated in pollution control-waste treatment and disposal techniques. These techniques can improve environmental quality, but in general, it can only eliminate a pollutant but also often transfers it from one medium to another. Therefore, there is a need a new strategy to reduce and prevent pollution before it occurs, contrary to conventional pollution control methods. Waste reduction/Pollution prevention approaches can be defined as a strategy to reduce the amount of waste generated and released into the environment and it must be moved to waste management moves from pollution control to pollution prevention.

Clean technology and manufacturing techniques support environmentally sustainability making environment acceptable industrial development. The definition of sustainability "balance economic, environmental and social factors in equal harmony" should be taken further these days to create a complete sustainable world—one in which we are responsible to the needs of all future generations and all living creatures**(Figure 2).** In another word, "Ecology-Environment" is a key perception in struggles to maintain the status of the world. As mentioned before, the three pillars, and "sustainability" are subject to various different interpretations.

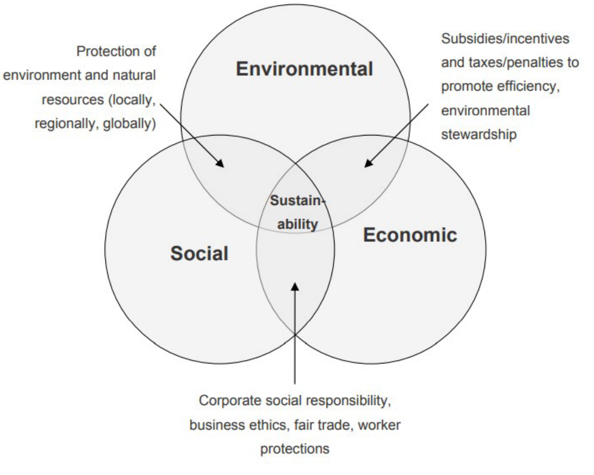

Figure 2. Sustainability as the intersection of its three key part [14].

In weak sustainability, the environmental, social, and economic subjects with equal weighting and seeks to balance them while strong sustainability, presents the three dimensions as placed one inside the other and presents different ranges environment cannot be replaced by any other capital [15]–[17].

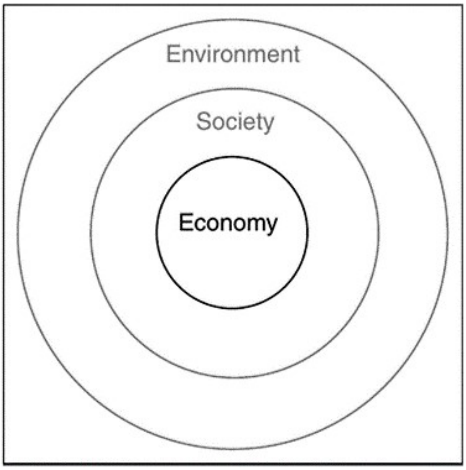

Figure 2. Strong sustainability.

Life cycle analyses are primarily important to assess the sustainability of particleboard plants. [18] It is a controversial issue to determine which sustainability criteria should be given priority in the production of wood-based panels, especially in particle boards. The main reason for this is that there are too many variables in the life cycle.

In order for particleboard facilities to comply with Green Deal, it is necessary to reduce emissions, provide clean, economical and safe energy supply, support sustainable agriculture in the forestry sector, which constitutes a large part of its raw material, turn its production towards green production and review innovations in transportation.

It has become necessary to carry out studies for the development of environmentally friendly technologies by improving technology for sustainability in particle board facilities. Investigation of new alternative raw materials to replace wood in chipboard production from renewable agricultural wastes or different wood wastes is an appropriate strategy [18].

Since particleboard panels are wood-based products, there are studies on ensuring the use of sustainable and environmentally friendly materials, especially with raw material changes.

4. CONCLUSION

Replacing formaldehyde used in particle board production with products that support green production in life cycle analysis, energy supply should be directed to renewable energy sources. In the Türkiye Green Deal Action Plan,Borderline Carbon Regulation Mechanism to our energy-intensive and resource-intensive sectors modelling the effects on the basis of scenarios and working on the basis of the sector and what needs to be done actions are determined. In this context, it has become necessary to conduct situation assessment studies in particle board facilities.

In Türkiye as in all areas, green technologies that will contribute to the production of products with high added value and compatible with the environment Its development is aimed in the turkey green deal action plan.For this purpose, life cycle analyses for particle board plants and the development of new technologies will contribute to the action plan.

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AN ASSESSMENT ON THE POTENTIAL OF GREEN DEAL POLICIES FOR THE WELL-BEING OF CITIZENS

Deniz Can[1*], Serap Kayasü[2]

ABSTRACT

The first two decades of 21st century have marked critical global problems that kept on growing, exceeding the limits of ecological, economic and social thresholds in different scales ranging from individual to societal or to national and global. The conventional systems that tried to relieve the emerging crises, and tackle the problems through de facto policies and planning approaches did not provide sustainable solutions. The unequal distribution of resources, increasing inequalities in accessing urban services (housing, transportation, green infrastructure, social amenities) and the growing gap between different income groups increased vulnerabilities within societies while anthropogenic effects on ecosystem services, environmental deterioration, consumption of non-renewable energy sources, excessive GHG emission and pollution consequently led up to long term problems of climate change (climate crisis). Today, triple crisis of economic, social and environmental problems points out to a potential systemic tipping point, in which new solutions are searched for in political, academic and planning agenda. Under these circumstances European Green Deal emerged as a response to the global challenges and crises that are dominating diverse aspects of current ecological, social and economic systems. While urban areas and people are the main generators of aforementioned crises, they are also the ones that are vastly affected by the consequences. In this framework, this paper aims to analyze transformative paradigm shift that vastly impact urban areas and unravel the parallels between Green Deal policies and citizen well-being. The concept of well-being aims to re-establish a harmonious relationship between society and nature, ensuring a fair distribution of resources and providing prosperous living conditions in flexible communities. In order to sustain well-being; objective and subjective factors, hedonic and eudaimonic approaches, and individual and community levels should be supported. This paper assesses the potential of the European Green Deal to encompass a collective well-being approach through a transformative paradigm shift.

Keywords: Green Deal, Well-being, Crises, Sustainability, Climate Change

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1. INTRODUCTION: ERA OF CRISES

In the first quarter of twenty-first century, global challenges and crises in various contexts has been the prominent agenda of the era. The rapid increase in world population along with fast urbanization that remarked the dominant demographic trend of 20th century, surpassed its era and agglomerated problems and challenges in different scales starting from rural and urban to regional, national and global. These problems and challenges emerged and are still emerging in ecological, economic and social components, impacting different aspects of life, from ecological diversity to healthy environments, distribution of resources to well-being of people, sustainable living environments to unsustainable consumption patterns. The crises of twenty-first century stem from the current growth-oriented system which exceeds the limits of ecological, economic and social thresholds. These crises emerge as climate change, pollution, high carbon-footprint and excessive use of non-renewable resources in ecological sense along with global pandemics (recently Covid-19) and extreme weather events that are ultimate result of the disruption of the balance of the nature. The economic crises appear through unsustainable growth oriented economic models and surface through global financial crises (recently 2007-2008 global financial crisis), increasing individual and sovereign dept. The economic aspects impact social crises through the growing gap between different income groups, which induce unequal distribution of resources and increase inequalities in accessing basic needs and urban services such as housing, mobility, infrastructure and other amenities. Today, triple crisis of financial, socio-economic and environmental problems points out to a potential systemic tipping point, in which new solutions are searched for in political, academic and planning agenda [1]. Projections according to current urbanization rates show by 2050 80% of the total world population will be living in urban areas [2]. Rapid urbanization along with anthropogenic effects on environment, the pressure on natural resources will be exacerbated. Hereby the pressure on ecosystem intensifies major environmental, economic and social challenges in cities. The triple crises also exposed a radical break for the current urbanization paradigms in which cities are the main generators of these challenges, also impacted vastly by them; they carry the potential to provide solutions to tackle these challenges. The crisis that we are in opens the door for new sustainable and transformative development paradigms which could shed light on the reciprocal relation between economic, social and environmental crisis and provide a holistic roadmap. This points to a comprehensive change in current economic growth policies along that goes parallel with urban development structures. It is evident in order to tackle climate crises; multifaceted strategies should be followed that also consider socio-economic transformation which center around well-being of people. The triple-P relationship between profits, planet and people is the foundation of the new economic paradigm; which is backed b numerous international agreements [3,4]. This paper analyzes these relationships through two pioneering green deal policy proposals; Green New Deal of United States and European Green Deal proposed by European Commission and focuses on the critical role of socio-economic transition towards well-being of individuals in order to realize the goals proposed by these legislative and regulatory policy documents.

2. GREEN NEW DEAL

In 2018 Intergovernmental Panel on Climate Change (IPCC) published a report indicating the crucial importance of not exceeding the 1.5°C global temperature increase limit. This meant that a global action should be taken to cut the carbon dioxide emission to 45% by 2030 and “reach net zero greenhouse gas emission by 2050” [5]. In order to achieve the target set by 2030, drastic measures are needed as set by the report that meant; “rapid and far-reaching transitions in energy, land, urban and infrastructure – including transport and buildings - and industrial systems...deep emissions reduction in terms of scale, a wide portfolio of mitigation options and a significant upscaling of investments in those options” [5]. The Green New Deal emerged as a resolution to meet the necessities of the challenges the IPCC report oblige. It was initially proposed in the United States, remarking the country’s disproportionate accountability of greenhouse gas (GHG) emissions and their role in climate change along with the recent economic and social crises that point out to important issues of welfare, well-being and equity [6,7]. The main goal of the GND resolution is to decarbonize US economy through making systematical changes in social and economic arena. It asserts that the social, environmental and economic re-organization would go hand in hand to both reduce economic inequality and GHG emission which are linked to each other [8].Eliminating vulnerabilities in society and, supporting the technological solutions along with reducing economic inequalities would support and allow a sustainable approach for the targeted goals. In the document the main goal is stated as follows: “to achieve net-zero greenhouse gas emissions through a fair and just transition for all communities and workers… and to create millions of good, high-wage jobs and ensure prosperity for all people of the United States” [9].The importance of US’s GND lays in the fact that this is the first time a comprehensive environmental, social, economic and technical package is proposed by a country with major political force, not only to tackle impending climate destruction alone but also to address vulnerabilities in society through socio-economic rights and re-distribution of wealth and power [10,11,12]. The name “Green New Deal” refers to 1930’s “New Deal” which is issued after the 1930 Great Depression by US President Franklin D. Roosevelt. As like the New Deal, GND aims to have a transformative and reorganizational force on society and space by adopting Keynesian interventionist demand-side economic model [13,6,14]. Up until now, the conventional solutions for climate and ecological crisis have been technical and especially carbon-centric approaches that range from carbon taxes, caps and emission trading schemes, which only focus on one side of the problem with opportunity for narrow regulations [15]. Comprehensive and holistic approach GND presents, based upon the Keynesian type proposals which integrates and forms parallel with climate change mitigation and a deep transformation in social and economic systems [16]. GND portrays its objectives for the resolution of climate crisis along with an equitable social order in which economic injustices are eliminated. Along with the technological solutions the policy proposal also emphasizes new job creation and creation of a just society to close the gap of income inequality which will support the mitigation measures for ecological, climate and economic crises. The outlining policy brief brings economic well-being into the focus and together with interrelated issues of social, economic and technical stance aims for; “1. Net-zero GHG emission, 2. Just Transition through job guarantee with a sustaining wage, 3. Investments in sustainable industry and infrastructure, 4. Accessibility to clean air/ water and healthy environment/nature, 5. Equity for all with affordable housing and amenities” [9].

3. EUROPEAN GREEN DEAL

European New Deal proposal like the GND, included environmental, financial and system (transportation, energy, housing etc.) adjustments, covering every sector in economy emphasizing circular economy model [17,18]. In European Commission's (2019) European Green Deal document, Green Deal is defined as; "a new growth strategy that aims to transform the European Union into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" [19]. With the same manner of Green New Deal, European Green Deal emerged as a response to the global challenges and crises that is dominating diverse aspects of the current ecological, social and economic systems. It emphasizes sustainability with its' three dimensions; environmental, economic and social. While the initial base line focuses on green solutions and infrastructure, it is strongly emphasized in the strategy document to have a social development in which "no one is left behind" to ensure a holistic and integrated transformation. This is why the social and ecological nexus are core to the presented framework of EGD [20].

European Green Deal's main aim is to transform the EU's economy for a sustainable future. It outlines the principles of this transition and covers the issues of needed investments, available financing tools. It inquires ways for a just and inclusive transition that progress parallel with green and circular economy. While the main goals concern ecological inputs such as boosting the efficient use of resources, preventing climate crisis, stopping pollution and reverting biodiversity losses, it illustrates a roadmap which include social, economic, technological, institutional and political re-configurations of ongoing growth paradigms [21]. European Green Deal is a program proposed by European Commission in 11 December 2019 to render a "new growth strategy" for the continent, which aims to achieve carbon and climate neutrality by 2050 by decoupling economic growth from carbon emission. This overarching aim extends to diverse sectors including infrastructure, energy, construction, biodiversity, transportation and water, energy and food nexus; in order to become the world's first "climate-neutral block" [22]. Several economic, social and environment challenges that are not just experienced by the continent but the globe marks the need for a transition from a linear economy model to circular/green economy [23]. EU aims to play a pivotal and pioneering role in this transition through creating a comprehensive and holistic transformation in all dimensions of sustainability concept by embracing sustainability development goals (SDGs) for EU's policymaking and actions. It also puts sustainability and well-being of citizens into the center of its proposed economic policies which are aimed to be supported by the digital technologies. While tackling environmental problems and challenges, EGD utilized concepts and instruments targeting economic efficiency along with social justice [20,24]. This approach is rendered in three social-ecological policy tasks; "1. Recognizing and mitigating environmental inequality, 2. Accelerating transition policies by rendering them fair, 3. Aiming to improve present and future human well-being rather than increasing economic growth" [20,22]. The document asserts that in order to sustain transition, a social-ecologically just approach should be embraced which is supported by innovation, digital technologies and green/circular economy [24, 25, 26]. As a transformative approach, European Green Deal acknowledges that the transition is only possible by the active public participation. The shift from unsustainable and polluting sectors to clean, efficient and sustainable practices should be just and inclusive; in which attention should be given to the sectors and workers who will be greatly impacted by these changes. One of its' objectives is to include national, regional, local authorities along with civil society, non-governmental organizations and all citizens to work together with EU's institutions and consultative bodies during the transition.

4. SOCIO-ECOLOGICAL TRANSFORMATION

The main objective of both Green Deal policy proposals, envisions climate neutrality by 2050, which implies a significant acceleration of emission reduction. While documents emphasize just transition, the effects of socio-economic gap and well-being of individuals on carbon emission and climate change are further discussed. Jorgenson et al. (2016) reveals in a study that the poorest half of the global population are responsible for only around 10% of global emissions and the poorest is also the most vulnerable to risks and climate change [27]. On the other hand, the richest 10% are responsible for around 50% of global GHG emission. This study indicates the correlation between socio-economic inequalities and CO2 emission. This is further supported by Chancel and Piketty (2015), which reveal that individual CO2 emission of the wealthiest 1% are up to 20 times larger than average individual GHG emission [28]. These studies show a direct correlation between socio-economic gap and GHG emission rates, and consequently environmental deterioration and climate change. Without reducing socio-economic gap and increasing low-income groups' living conditions, it would be impossible for technical and technological solutions along with the use of renewable clean resources to penetrate to the ever strata of society. To make net zero GHG emission possible, the regional and social inequalities in Europe should be reduced. Carbon neutrality strategy also needs the social and political support, which would not harm the already vulnerable social groups, instead empower them through a socio-ecological transformation [29,30,31]. This points the need to provide tangible improvement of living conditions and well-being of citizens across all regions and social groups. Furthermore, transition to a new growth path should be analyzed in terms of its feasibility, emissions and unemployment and the potential of new green sectors and green jobs [32].

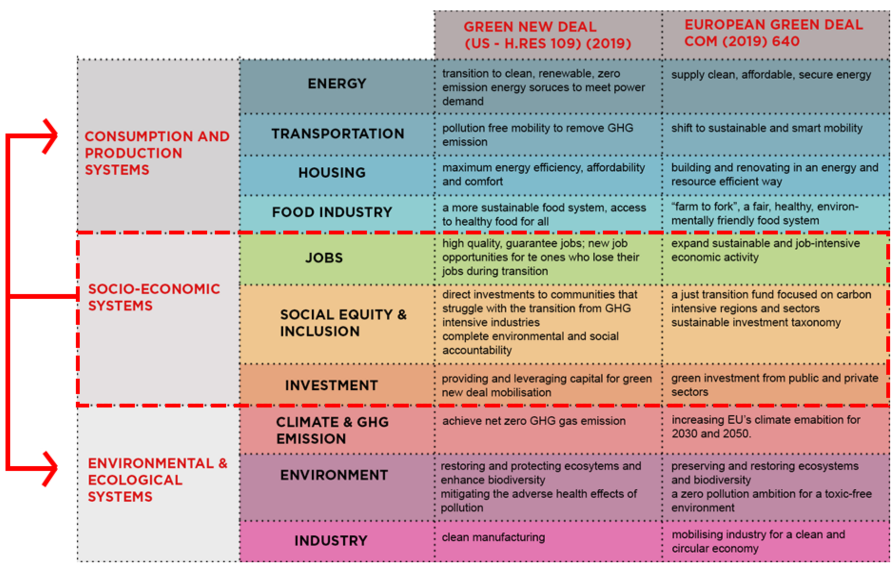

Figure 1. Common Strategies of the Green New Deal and the European Green Deal [9,18,19].

4. WELL-BEING OPPORTUNITIES

Well-being is a positive physical, social and mental state that results from a range of collective relations with people, places and conditions. Well-being is a complex situation and a multifaceted process that has been in constant debate over the years. It embraces personal, interpersonal and mutual needs that affect each other, intertwined elements such as physical, cultural and natural elements. Dimensions of well-being range from community building, lifestyle, awareness and participation to being able to access economic, social and environmental resources. OECD explains well-being in eight basic criteria; "health status, work-life balance, education and skills, social connections, civil engagement and governance, environmental quality, personal security and subjective well-being" [3]. WeALL proposes a more broadscale ten principles in order to achieve well-being economies; "being ecologically safe and environmentally just, protecting environmental standards, green infrastructure, universal basic needs, guaranteed livelihoods, fair distribution, better democracy, well-being economic organization, cooperation and public control of money" [4]. Both instructions address to similar aspects of eudoimonic and objective well-being which cover human needs in terms of economic, social and environmental resources. Hedonic well-being which focuses more on happiness approach and supporting it, subjective well-being that depends on life satisfaction are emphasized with WeALL's focus on fair and just distribution principles. There was a significant commitment to improve wellbeing economics, with a shift towards satisfaction and sustainability in people-planet-profit linkages within the context of Green Deal. The socio-economic transition dwell upon creation of (green) jobs, development of rural communities, reduction of energy poverty and negative impacts on the environment and consequently on human health [33]. In this sense incentives to support the use of clean, efficient and renewable energy becomes a part of well-being economics benefiting social and economic development along with human satisfaction [34]. Well-being of citizens and communities plays a vital role in green deal both as the generator of the process of sustaining a comprehensive and just transition, along with the cooperative basis it creates for a strict net-zero emission. "Leaving no one behind" as it was stated in European Commission's principles of European Green Deal, paves the way to decrease the socio-economic gap, thus addressing vulnerabilities and empowering vulnerable groups, creating resilience in the society and enabling citizens to access to green technologies, jobs and resources. This enables a holistic paradigm change to create a sustainable future, in which different income groups would be actively participate in the process. Well-being based policies carry the potential to support social, economic and subsequently environmental sustainability.

CONCLUSION

21st century has already witnessed radical changes that not only affected localities but had impacts beyond borders. Globalization, digital transition, ever-growing inequalities and uncontained global climate change marked a tipping point for the conventional development systems. In this atmosphere, Green Deal idea emerged as a comprehensive policy proposal to tackle ongoing contemporary problems with a transformative stance point that link socio-economic equity with technology-based solutions for current ecological (climate change), socio-economic and financial crises. Cities and, the social, spatial, political and economic dynamics are the main arena of these problems and they also contain the solutions for the crises through transformative planning approaches. In this framework, an overall holistic framework is needed for 21st century planning agenda that not only focuses on the symptoms of eroding social, economic and ecological resources and treat them with de facto policies and solutions but to have a comprehensive understanding of socio-economic and socio-spatial relations that underlies these symptoms and address them through integrated framework. Well-being notion in Green Deal proposal carry the potential to shift the focus to social and socio-economic problems underlying the triple crises of 21st century. Without tackling the problems such as socio-economic gap, vulnerabilities in the societies, accessibility to efficient and green resources, and just transition, only partial temporary fixes are possible. In order to have a comprehensive and holistic transformation for a sustainable future, the potential of socio-economic transitions and well-being concept should be considered as a focal point of Green Deal policies and action plans.

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UNMANNED AERIAL VEHICLES DESIGN FOR CLIMATE CHANGE AND ENVIRONMENTAL PROTECTION RESEARCH STUDIES

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ABSTRACT

In recent years, The World has come to a tipping point with the side effects of technological developments. Global temperatures continue to rise in parallel with the increasing use of technology, with serious consequences for the sustainability of many things which accept as natural. This study focuses on discussing the advantages of unmanned aerial vehicles (UAVs) on sustainability and renewability, which are important in technological developments. Since unmanned aerial vehicles (UAVs) are at the forefront of the technological revolution, they can evolve to collect data for environmental protection projects. UAVs, which contain technology that can support the work of climate change and environmental researchers, play a key role in the implementation of sustainable solutions, and serve the renewable energy infrastructure, can do all of these better, easier, faster, cheaper and more safely. UAVs can be used in the sky in many areas such as increasing the efficiency of solar power plants or photovoltaics (PVs) and wind power plants (WPP), supporting the use of clean energy, increasing efficiency in agriculture, remotely monitoring endangered animal species, supporting the work of scientists all over the world. It is critical to design and use UAV' provide renewable energy companies with a powerful productivity tool and to help researchers prepare for the complex effects of climate change and environmental degradation.

Keywords: Unmanned Aerial Vehicles, Sustainability, Renewable Energy, Climate Change

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1. INTRODUCTION

Our world is exposed to global climate change day by day. The use of fossil fuels (coal, oil, natural gas) as an energy source for electricity generation, transportation, industry and homes increases the production of human-induced greenhouse gases. In addition, it contributes to the change of land use and the increase of the greenhouse effect in waste. As a result, the world is facing a global danger. The effects of global climate change are increasing every year. It need to benefit from today's technology to find solutions to the crises that will emerge in the coming years. Humanity is developing and becoming conscious day by day thanks to technology. Innovative applications are produced to leave a better world for future generations. Unmanned aerial vehicles can be cited as examples of these innovative applications. An unmanned aerial vehicle (UAV), in short, is a type of flying vehicle that does not physically contain humans [1].

A UAV is a robot type device that operates under remote control or flies independently via flight plans controlled using software. Unmanned aerial vehicle is also known as drone. In the last ten years, Unmanned aerial vehicles have emerged from the concept of science fiction and turned into reality. It was used for military purposes in the first applications, and as the developments continued, UAVs began to take place in daily life by using them as spy and reconnaissance vehicles. In addition, UAVs can monitor and improve power usage, These sensors include orientation and stabilization, chemical, laser or LiDar, time of flight, and distance sensors. With the help of b-sensors, UAVs efficiently monitor and map large areas, conduct environmental surveys, fly to dangerous and inaccessible places and prevent wildlife from forbidden areas. These devices monitor the weather, humidity and soil moisture levels and conduct scientific research. It flies to dangerous and inaccessible places and discourages wildlife from prohibited areas. Figure 1 illustrates of an example of UAV below.

Figure 1: Flighting Uav or drone.

UAVs help the environment in various ways. As this technology advances, its impact on our environment becomes tangible. The various following where drones are helping the environment.

- Transport and delivery,
- Wildlife monitoring and protection,

- Monitoring of renewable energy,
- Developing smart applications in the agricultural sector,
- Rehabilitation of forests,
- Mapping and environmental monitoring,
- Ocean health monitoring,
- Land Management.

The transportation and logistics sector benefits the most from UAV technology. This is because UAVs can access areas that are not easily accessible, such as warehouses, terminals, and shipping container ports. Unmanned aerial vehicles are starting to become an industry that has dramatically changed the shipping industry to deliver commercial packages. Unmanned aerial vehicles consume less energy per package-km than delivery trucks. With this feature, it can be predicted that it can reduce greenhouse gas emissions and energy use.

For example with an product generators; Amazon first successfully tested its drone delivery services in December 2016 and has stated that it plans to continue to pursue this technology. Several companies are developing programs for package delivery using drones, including Amazon [2] , Google [3] , UPS [4] and Deutsche Post DHL [5]. Trucking is responsible for 24% of transportation-related greenhouse gas emissions and accounts for 23% of transportation energy use in the US [6], so changes in the industry are important for the environment and the energy system [7]. As power grids evolve, the scale of the environmental benefits of charging drones with electricity will depend on electricity's life-cycle environmental characteristics, vehicle use, battery materials, and enabling infrastructure. Previous studies have shown that transporting goods per ton-km by conventional aircraft is about four times more carbon-intensive than transporting by truck, which is about 10 times more carbon-intensive than transporting by rail [8]. Using drones instead of trucks to deliver packages can help reduce emissions associated with package delivery. Drone transport enables deliveries to be made quickly and efficiently. Figure 2 shows UAVs for delivering. However, they have a small carrying capacity. Despite this, this mode of transport has a positive effect on the environment.

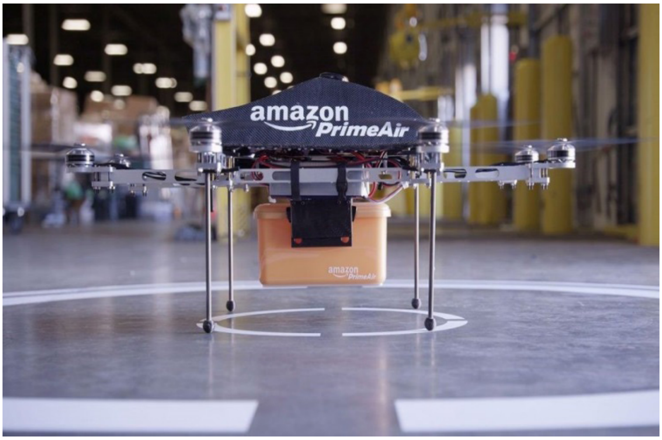

Figure 2: UAV for delivering [2].

Unlike air, rail, road and sea transport vehicles, drones use batteries and therefore no harmful gas emissions into the environment. Another effect of drone transport and delivery is to minimize traffic congestion on our roads. There will be fewer trucks on the road that only carry heavy loads. The biggest disadvantage of this mode of transport is that it only carries less bulky items. However, as the technology develops, it is predicted that the device carrying capacity and the distance covered will also increase. As a result, there will be a significant reduction in the amount of carbon in the atmosphere, especially if the drone's batteries are charged with green energy. However, the rapidly changing climate will slow down and the quality of life of world planet will improve.

2. MATERIAL AND METHODS

2.1. Natural Life Monitoring and Preservation

In addition to providing researchers with data to support conservation efforts, drones are used for emergency environmental missions. In wildlife management, drones help count, study and protect animals. Wildlife and climatic conditions can sometimes be dangerous and challenging. Drones can prevent endangering human life. Thanks to the aerial bird's eye view of the drones, things that cannot be seen from the ground can be seen clearly. Sea Shepherd's whose group application shows in Figure 3, an ocean conservation campaign spanning the Indian Ocean and South China Sea, uses drones to monitor illegal fishing activities. Poachers slaughter 20,000 to 40,000 elephants each year; that is, an elephant is killed every 15 minutes. In the last decade, elephant deaths due to poaching have now exceeded the rate at which they can multiply. Black market ivory smuggling has caused the African elephant population to drop from 1.3 million in 1970 to just 400,000 today [2-8].

In recent years, anti-poaching drones have made a useful and innovative contribution to various methods of combating illegal poaching. Focusing on elephant conservation in the Masai Mara, Kenya, the Mara Elephant Project is an organization that uses conservation drones to reduce poaching. Special onboard thermal cameras on drones transmit live video safely to teams, often miles away, and record images for later analysis. Organization, Since its inception, it has arrested hundreds of poachers and seized more than 1,000 kg of ivory. Thanks to the Mara Elephant Project, the percentage of illegally killed elephants has decreased from 83% to 44% [9].

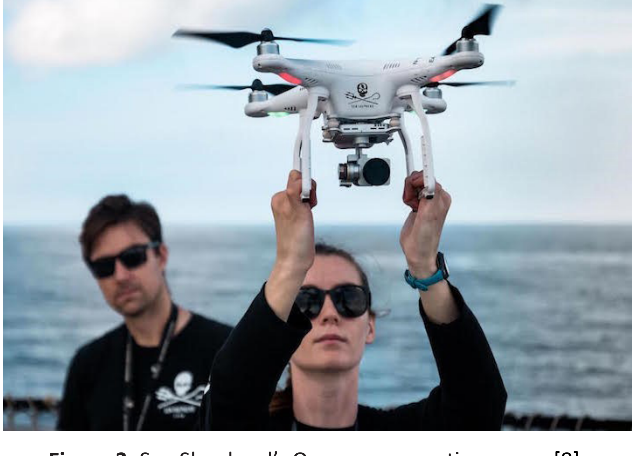

Figure 3. Sea Shepherd's Ocean conservation group [8].

It can be seen with the Mara Elephant Project and Sea Shepherd's Group, unmanned aerial vehicle technology is used to monitor animal species in danger of extinction.

2.2. Renewable Energy Usage Monitoring

The capability of a drone to cover great distances and provide high-resolution aerial images has allowed many companies to optimize their productivity when completing dangerous or time-consuming tasks. By providing accurate data to solar farm managers through new technological developments such as drones and thermal sensors, it enables routine operations to be carried out more efficiently. Companies in the Energy Industry combine cutting-edge technology with drones to improve the efficiency of power plant operations, and drones play a critical role in their quest to provide their customers with reliable and affordable energy. In response to growing concerns about climate change and carbon emissions, many countries around the world are increasing their investments in renewable energy projects. Considering many renewable energy sources, solar energy has been the preferred solution. In the last decade (2009-2019), investments in solar energy reached US$1.3 trillion worldwide, accounting for half of total assets contributing to the growth of renewable energy [10].

One of the reasons for the widespread adoption of solar solutions (Photovoltics) has been the reduction in the overall cost for installation. For example, Solar installation costs drop by nearly 73% from $4,621 in 2010 to $1,210 in 2019 [11]. The goal now is to continue to make solar energy affordable worldwide. To achieve this, solar managers must optimize operations and create value throughout the entire power generation process. To meet their energy demands, solar companies must install thousands of solar panels distributed over large, typically highly irradiated areas. Essentially, a solar farm needs about 2,500 acres to power 100,000 households. [12] Traditional solar field assessments, It involves inspecting each panel with handheld thermal cameras to check for faulty cells or cables. During this process, the worker must manually monitor the positions of the defective panels and perform maintenance later. Given the size of most solar power plants, this method of inspection is inefficient and results in a heavier and sometimes dangerous workload for maintenance and operations teams. Drones are constantly being used in solar farms to improve inspection operations, particularly in areas with high radiation exposure and creating a host of problems for field crews. The use of drones shortens the inspection time of solar farm crews by 70%, providing a significant reduction compared to traditional methods. Figure 4 shows Solar UAV monitoring.

Figure 4. Solar UAV Monitoring [10].

UAVs can be used to collect data or transmit it in real time to teams on the ground. Detailed reports detect turbine blade corrosion and malfunctions, enabling wind farm managers to reduce both efficiency losses and maintenance costs. To overcome key challenges such as low efficiency, high costs and poor inspection data quality, many wind farm operators around the world have started using drones for wind turbine inspections. Tripoli, Greece, a drone services provider founded in Athens, Greece in 2017 "IDS - Industrial Drone Services" Company, together with its customers Eunice Energy Group (EEG), one of the pioneers in the field of renewable energy in Greece, has a total capacity of 34. They used DJI drones from their drone platform to inspect a 5 MW wind farm. With winters providing less than 10 hours of daylight on average, using traditional inspection methods would have been extremely time consuming and therefore expensive.

Normally, a full inspection of a single wind turbine with inspectors working at height can take between 3 and 6 hours. This does not include lengthy security procedures and preparation time. On the other hand, with DJI being windproof, it only takes 45 minutes for RTK drones to fully examine a turbine. This allows the entire 15 turbine farm to be inspected within three days [13].

2.3. Development of Smart Agriculture in the Agricultural Sector

Agricultural drones are unmanned aerial vehicles used to assist conventional agricultural labor and optimize the agricultural process, thanks to their sensor and image tracking capabilities. They have integrated GPS systems, tracking mechanisms, and more suitable for farming. These systems will take weeks for a farmer to assess conclusively. It provides a complete view of fields and crops. This not only increases productivity, but also increases crop yields and overall production. Agricultural drones in smart agriculture obtain a 3D map thanks to ground mapping, can plant crops, are used for spraying crops, obtain result data by monitoring the field, and provide a healthy evaluation of crops by tracking irrigation and fertilizer. Drone technology has recently been used in almost every field of agriculture. There are specially programmed drones used in soil analysis, planting, pesticide spraying, monitoring and many other parts of agriculture and farming. In Turkey, the first AUAV (agricultural unmanned aerial vehicle) sold in the region was delivered by Silivri Agricultural Credit Cooperative affiliated to Tekirdağ Regional Union of Agricultural Credit Cooperatives. While the use of agricultural unmanned aerial vehicles in agriculture makes agricultural life easier, drones that can take up to 30 liters of pesticides are preferred by farmers who want to save time, water and pesticides. With the increase in the use of drones in agriculture, both the country and the farmers are making serious gains in terms of productivity. UAUVs, which spray in a short time without damaging the plants, can spray 30 decares of land by staying in the air for an average of 12 minutes. With pesticides made from the air, pesticides are applied quickly and efficiently in the detected diseased areas [14]. Overall productivity is increasing thanks to agricultural drones. The human workforce is declining. It results in better crop production and higher yields in the long run.

2.4 Improving green areas

Also in the UAE, oil distribution group CAFU has used drones at every stage of an ambitious tree planting project. In March 2021, 10,000 Ghaf trees were successfully planted by drone in the Dubai desert. The process started with drones used to scan potential planting sites and measure the suitability of soil, wind and moisture. Drone was used to determine the best spots for seeds to plant and a map was created with GPS markers for drone-enabled seed drops. Monthly drone inspections are conducted to monitor the progress of each tree [15].

Figure 5. UAE-CAFU Tree Planting [15].

Reforestation is time consuming, costly and labor intensive when relying on human labor. Unmanned aerial vehicles for reforestation, it can map and identify areas where trees need to be planted and make planting faster and more efficient. First, the drones map the space to give a layout for planning and implementation to begin. Second, drones monitor the growth of new trees. Third, they map and drop seeds where they don't germinate. Unlike the natural afforestation method, where animals leave seeds through feces, drone afforestation technology is more advanced.

2.5 Developing With Mapping

Drones are also incredibly good at mapping and tracking. They can gather information from large coastal areas, allowing specialists to use photogrammetric image processing tools to create detailed maps. Poaching and unlawful activity monitoring; change tracking over time; and other types of mapping and monitoring, Protection of plants and river-banks; monitoring of coastal management; evaluation of rivers and floods; management of animals and their habitats; modelling of land and hydrology; and management and monitoring of forests. Drones are equipped with cameras, pressure and humidity sensors, thermometers, wind gauges, and other equipment to effectively gather important environmental data. The good news is that they can enter even dangerous environments.

4. CONCLUSION

UAVs are developing rapidly in parallel with the advances in electronics and software technologies. Although UAVs were developed only for military missions in the early days, their use for civil and commercial purposes has also increased to a great extent. UAV systems have become very useful thanks to their ability to stay on. It can carry a large payload. Thanks to this logistics feature, it has become the choice of many cargo and delivery companies. In recent years, we have come across UAVs in many fields apart from the military field. Scientific research, delivery, and UAVs are used in places where manpower is limited and there is a safety hazard, such as mapping and smart agriculture. Climate change is now becoming a global problem all over the world. This global problem has led technology companies to change their vision and mission. It aims to support technology with green energy resources by making use of sustainable and renewable resources. If the battery and load-carrying capacity of unmanned aerial vehicles are increased, it may be possible to encounter more UAVs in the sky in the coming years. In the coming years, land vehicle use will decrease, and unmanned aerial vehicles with renewable battery capacity will take their place. UAVs will support sustainable agriculture with the help of special sensors, irrigation, spraying, and visual tracking and increase efficiency. Agriculture will develop; animal species in danger of extinction will be protected; the challenging conditions of scientific research will be overcome; the maintenance of renewable resources such as solar and wind power plants will be done by saving time and cost without endangering human life. Many countries, including Turkey, are working on this issue. and leading technology companies also support countries.

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SUSTAINABLE WASTE MANAGEMENT SYSTEM IN IZMIR-KARABURUN PENINSULA

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ABSTRACT

Global solid waste generation is constantly rising, hence the need for management strategies that implement environmental improvements. Among its many components, sustainable municipal solid waste management strategies must not overlook collection and transportation stages. This study aims to model municipal solid waste transportation using Life Cycle Assessment (LCA) software. We used CCalC2 for this study, and the CML2001 methodology was used. To demonstrate how different approaches to waste management through transportation can reduce environmental impacts, LCA modeling was done for the three districts of Urla, Çeşme, and Karaburun, all of which are located at the Karaburun Peninsula. Each district was was evaluated based on three scenarios, with Scenario 0 representing current municipal practices, Scenario 1 representing a 50% reduction in plastic waste, and Scenario 2 representing a 50% reduction in all renewables. Results showed that only plastic separation might not be enough to achieve significant reductions in environmental impacts. It has been demonstrated that in the transportation sector of Urla and Çeşme, Scenario 1 had a CO_2 reduction of 3.7%, and Karaburun had a CO_2 reduction of 3.8%, while Scenario 2 represented at least 20% reduction in carbon footprint in all three districts. The findings of this research will support municipalities in the roadmaps they will choose for their Municipal Solid Waste Management applications.

Keywords: Sustainable Waste Management,Life Cycle Assessment, Carbon Footprint

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1. INTRODUCTION

Environmental issues caused by municipal solid waste (MSW) management include global warming, risks to human health, photochemical ozone formation, stratospheric ozone depletion, ecosystem damage, and the depletion of renewable and mineral resources [1]. Managing solid waste is a major challenge specifically in developing nations. Due to the need for more land to eventually dispose of these solid wastes, disposal issues have become more challenging as the annual waste generation rises in direct proportion to population growth and urbanization [2]. Municipal solid waste management practices in Türkiye need to change and evolve if sustainability is the primary concern. A tool is needed to calculate the environmental impacts of these practices to reduce the dangers that come with them. The life cycle assessment (LCA), based on ISO 14040 and 14044 standards, is the main methodology employed to assess the environmental impact of the various stages of any system in general and MSW management in particular. (ISO 2006a; 2006b) [3].

Municipalities must collect and transport municipal solid wastes as part of their sustainable urban municipal solid waste management (MWSM) strategy (MSWs). However, the collection and transportation of MSWs have consistently proven to be challenging when modeling integrated MSWM systems while taking into account environmental and energy aspects. [4]. In 2020, the global transportation sector generated about 7.3 billion metric tons of carbon dioxide (CO2) emissions, making it one of the worst polluters. After the energy sector, transportation-related activities in Turkey accounted for 22.3 percent of all GHG emissions. Additionally, the processes used to treat agricultural waste were responsible for 28.9% of the methane emissions. [5].

Although waste disposal options have been studied extensively, research on transportation and collection stages of MSW management was mostly ignored. In this study, we investigated each step from the perspective of the municipalities and compute the scenarios using the actual methods for disposing of municipal solid waste in the cited districts rather than hypothetical facilities.

2. MATERIAL AND METHODS

2.1. Case Study

Three municipalities—Urla, Çeşme, and Karaburun—served as the study sites for this research. They are touristic areas due to their geographic location, which results in substantial differences in the summer and winter populations, consequently municipal solid waste generation changing in both quantity and quality. For instance, it is predicted that the summer populations of Çeşme and Urla were roughly three to four times of the ones for winter. Due to yard maintenance, garden wastes also increase in the spring and summer. The survey did not, however, cover garden and yard waste.

2.2. Population and MSW Projections

Due to the data from prior years, linear regression, forecasting, and Bank of Province approaches were used to compare results, and the bank of Province method chose the population projection approach.

The Bank of Provinces

The Bank of Provinces defines the population increase rate based on a factor (P) that is calculated; hence the increase rate is limited (Equation 1). Then the future population is estimated using the P factor (Equation 2). This method is widely accepted and utilized for projects in the public sector.

$$P = \left[\left(\frac{N_{next}}{N_{previous}} \right)^{\frac{1}{\left(t_{next} - t_{previous}\right)}} - 1 \right] * 100 \quad (1)$$

N_{next}: Next census population

$N_{previous}$: Previous census population

t_{next}: Next census year

$t_{previous}$: Previous census year

If P is equal to or lower than 1, it is taken as 1. If P is equal to or higher than 3, then it is taken as 3. If P value is between 1 and 3, then the actual value is used.

$$N_{future} = N_{last} * \left[1 + \frac{P}{100} \right]^{n} \quad (2)$$

N_{future}: Future population projection

N_{last}: Last census population

n: the year difference between the last census and the projection year.

2.3. Life Cycle Inventory (LCI)

The Ecoinvent database, academic literature, and interviews with municipalities were used to get the LCI data. Considering the current MSWM system on Karaburun Peninsula, web tools, research papers, and communication with the municipalities were used to determine the distance between the landfill and the transport station, average travel distances for waste collection, the capacity of a diesel truck, the average amount of waste that is transported daily, the mean truck velocities, and the average truck routes. Locations of the current transfer stations and ramps were determined by on-site visits. Three scenarios that evaluated the environmental and energy impacts of various MSWM scenarios were quantified and compared. CCaLC2 was the program that we employed in this investigation. Based on the rate of MSW generation, a functional unit of 1 ton was selected, and a 10-year system lifetime was taken into account. Based on the scenarios, the system boundary comprised of plastic waste reduction and MSW collection and transportation. Modeling semi-trailers and trucks according to their load capabilities was done using the CCalC2 program. Waste truck counts, average trip counts, empty weights, container capacities, and average trip distances were computed for each district. CCaLC2 contains the User database, Ecoinvent, and CCaLC databases. The CCaLC database is composed of both publicly available data and data generated during tool development. The Ecoinvent database is a part of the CCaLC2 tool. Based on the CCalC2 databases [9], we defined the raw materials as follows:

a. Alkylbenzene sulfonate, linear, petrochemical:

Detergent usage was defined based on unofficial correspondence with the Urla Municipality Cleaning Works Division based on every 1 ton of municipal solid waste. It was assumed to be valid for other municipalities too.

b. Lubricant oil:

Based on our market studies and analysis, the trucks' use of lubricant oil is calculated based on the kilometers they travel in the collection and transportation processes; thus, we calculated the day-to-day trips and, based on the waste generation, obtained the oil lifetime. Regarding our research, the lubricant oil should change every 15000 km; hence the kilometers each truck travels calculated. Based on our evaluation shown below, the lubricant oil usage per functional unit has been calculated.

$$\frac{15000}{D} = N.O \quad (3)$$

N.O: number of days that oil needs changing

D: the roundtrip traveled each day for collection services

$$\frac{MSW\left(\frac{ton}{year}\right)}{365days} * N.O = L.O \; (4)$$

L.O= the amount of MSW collected for the lubricant oil to change

Every 5 liter of Lubricant oil is approximately 4.45 kg

$$\frac{4.45\ kg}{L.O} = kglubricantoilthatwillbeuseperfunctionalunit$$

c. Steel product manufacturing:

Steel consumption per functional unit in the operation was calculated using the number of solid waste containers based on the reports of each district, assuming that 80% of the containers were in use and estimating the lifetime of each container as ten years of service (Eq. 5).

$$Steel\,used = \frac{(theweightofMSWcontainers)*80\%*\ thenumberofcontainers}{MSWgeneratedin\ 10\ years} \qquad (5)$$

d. Water at use in both Door to container and Transfer station stages:

The amount of water used to wash the trucks was calculated based on the type of the truck, and it was constant in all scenarios. Based on the previous studies, the average was assumed and calculated based on the weekly schedule of the cleaning processes.

e. Polyethene bags

The packaging was defined as polythene bags that the household uses to pack the waste and remove it from the containers. In order to calculate the mass of plastic garbage bags, we first calculated the volume of 1 ton of waste (functional unit). The density values of waste varied based on the waste characterization in scenarios. Then waste volume was divided by the capacity of a standard garbage bag with 50 lt volume. The market research indicated that mass of a 50 lt plastic bag was 93 g, which gave us, with a simple multiplication, the total mass of plastic garbage bags per functional unit.

$$\frac{FU}{density} = volume \frac{volume}{capacity} = thenumberofplasticbagsused$$

$$Thenumberofbags * themass = amountofplasticgarbagebag$$

Once the data on raw materials, such as lubricant oil, steel for use in containers, water use, and detergent for cleaning trucks and transfer stations were identified in CcalC2, we calculated the daily trips and derived the oil lifetime based on the waste generation. According to our market studies and analysis, the trucks' lubricant oil consumption was calculated based on the distances they travelled during the collection and transportation processes. In the raw material phase, water was also used for cleaning trucks and transfer stations. The average water consumption was calculated based on the weekly schedule of the cleaning processes and previous studies.

2.4. Scenarios

The business as usual scenario (S0) showed the baseline of each district's current state from the given data, research, or corresponding from the related municipality. Production was the next stage in the scenario model. Polythene bags will be used as garbage disposal bags in the production step, and MSW will be an output of this process that is dumped from households into containers. The first analysis of transportation was from the stage of production to storage, which in this study was assumed to be the transfer stations. On the basis of the provided information, truck models, and capacity, we constructed the daily waste collection routes from containers to transfer stations. The next step was storage; for this step, we added the energy consumption, which was based on an assumption that the transfer stations' average electricity usage. The lighting and hypothetical offices there were considered to be only energy consumers because the entire process is manual. Once more, the output of this step is waste that will be disposed of in the Harmandali landfill. The final transportation was defined from storage to use, which we assume to be the Harmandali landfill. The distance and waste density were calculated based on each scenario. The 22-ton truck with the empty return trip was chosen because it would return from the landfill with no waste.

In S1, we used a new waste management approach and assumed that 50 % of plastic waste had been separated at the source before transportation. The density and volume of waste will change with this proposal because we will reduce the plastic waste weight by 50%, and density will also change in the given models. As a result, the functional unit were adjusted, indicating that there will be less municipal solid waste to transport when compared to S0.

Based on the research and the other two scenarios, an alternative future scenario (S2) was proposed that further improves transportation systems. S2 was formed to reduce transportation and, as a result, the global warming potential. It suggests plastic and a 50% separation of all renewables at the source therefore the composition by weight of the renewables waste characterization was reduced by 50%. The functional unit (f.u.) was decided as 1 ton = 1000kg so the weight and volume of each item adjust based on the f.u.

3. RESULT AND DISCUSSION

Waste management was one of the most significant environmental issues in Türkiye's cities, and Izmir was no exception. The current solid waste landfill in Izmir has reached its maximum capacity. In addition to adopting a model, cutting-edge, and environmentally friendly urban infrastructure approach, the new facility will offer Izmir high-quality integrated solid waste management at a crucial time.

There were 10 transfer stations in total in the districts of Buca (Gediz), Bornova, Konak (Halkapınar), Menemen (Türkelli), Urla, Menderes (Kınık, Gümüldür), Kınık, Selçuk and Seferihisar in İzmir; There are 8 transfer ramps in total in Torbalı, Karşıyaka, Çeşme, Kemalpaşa, Foça, Karaburun, Dikili and Ödemiş districts. The capacity of the transfer vehicles is 27 tons and has a walking-based semi-trailer system. [6]. For the purposes of this study, we were interested in the locations of the Alaçatı, Mordoğan and Zeytinalanı waste transfer stations, since those would be determinative in calculating the fuel consumption and hence associated emissions. Figure 1 provided an overview of the case study region and transportation, including the round-trip travel times for each district and the distance between selected transfer stations and the Harmandali landfill.

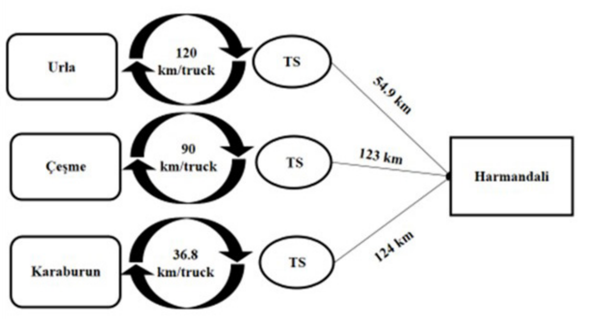


Figure 10. Travel distances for one truck within districts, from district to transfer station and from transfer station to Harmandali Landfill Site.

3.1 Population Projection Results

The Bank of Provinces method was taken into consideration based on the methodology's explanation for the projection processes since this method had been widely used in the projects of the public sector. The trend of each method for the following ten years is shown in Figures 2, 3 and 4 for all three districts.

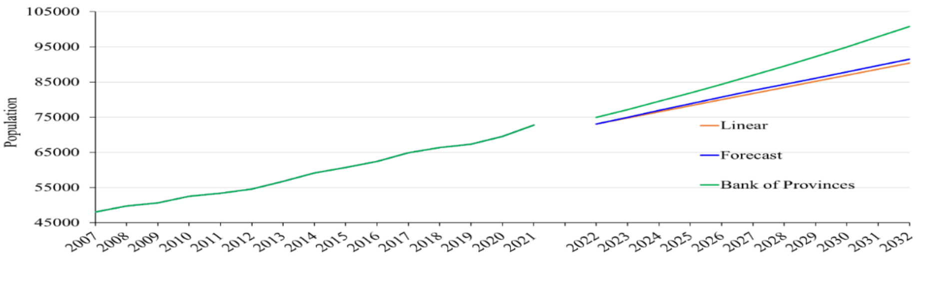


Figure 11. Population data (2007-2021) and projection (2022-2032) for Urla.

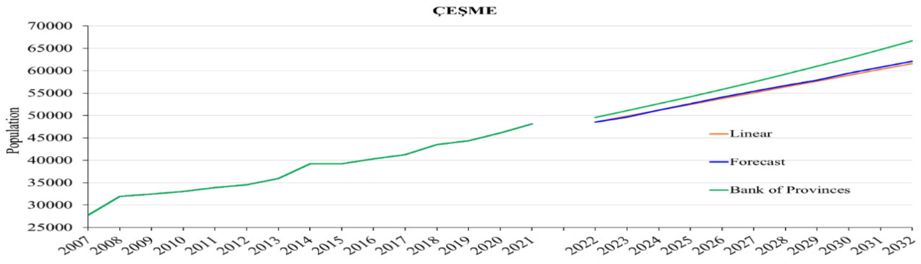


Figure 12. Population data (2007-2021) and projection (2022-2032) for Çeşme.

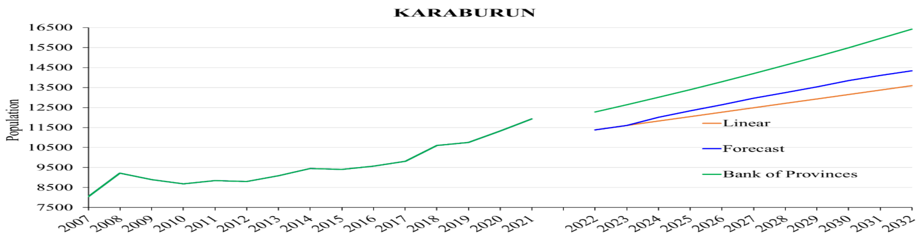


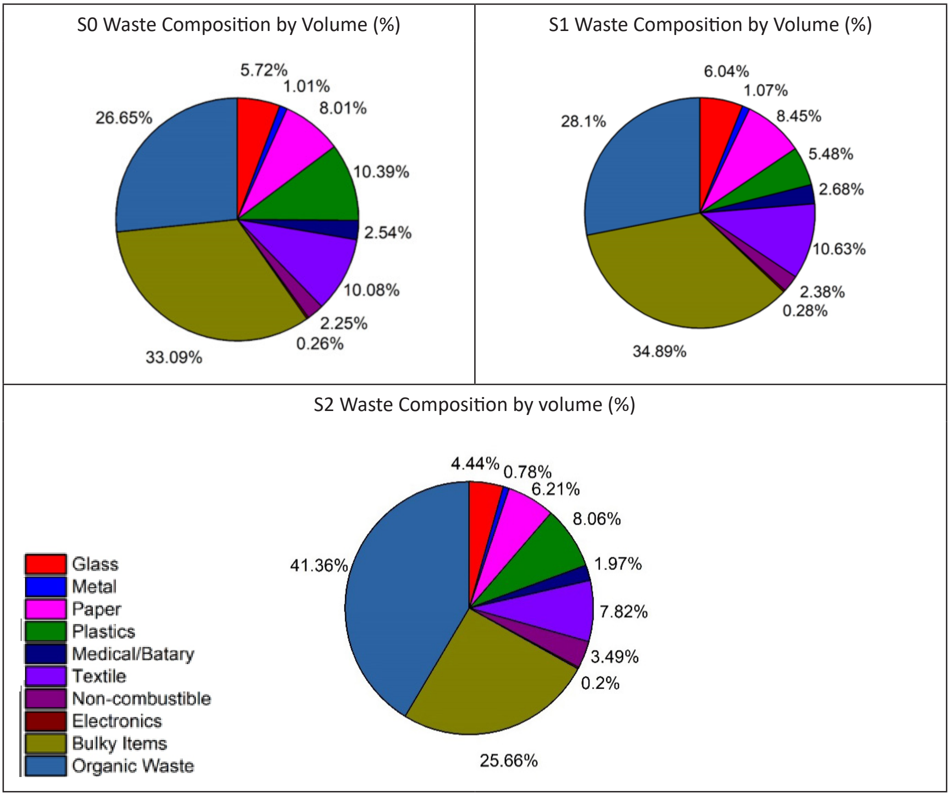
Figure 13. Population data (2007-2021) and projection (2022-2032) for Karaburun.

Based on the projected population and waste generation per capita, a ten-year comparison of waste generation has been done as part of the scenario analysis. The next 10 years' total estimated waste generation values were 1,526,683.5 tons for Urla, 806,984 tons for Çeşme and 199,213,9 tons for Karaburun.

3.2. MSW Density Changes for Scenarios

In calculating the amount of waste that is being handled, the density of the waste shall be taken into account. In order to do that, curent waste characterization data were needed. However, since municipalities lacked that data, we assumed Izmir's waste characterization data for all districts. The composition of the waste handled in S0 was given in Table 1 (a-c). The density of waste was calculated to be 313.1 kg/m^3. As a result of the composition changes in S1 and S2, the density values of the total waste were updated to 318.1 kg/m^3 and 385.15 kg/m^3, respectively.

Table 2. Waste composition by volume for different scenarios.



In scenario 1 of three districts, the numbers decreased on the environmental impacts. Since bulky items, like plastic bottles, have now been separated from waste, it has a direct impact on the collection and transportation of the material.For instance, Urla's data in the transportation sector changed from 39.8 kg/f.u. of CO_2 in the base scenario to 31.49 kg/f.u. in the final scenario. By 2032, the indicated number will result in a reduction in GHG emission of 12,670.4 kg/waste generation.

Scenario 0 is the baseline and current practice in Urla (Table 2). Due to the type of fuel and engine that is diesel the given impacts on Carbon footprint and Acidification were closely monitored in scenarios. We had carbon footprint impact in raw material section, packaging of waste in door to container stage and transport sector. Segregation of plastic in scenario 1 reduced the amount of plastic waste and affected transportation for Urla (Table 3). In scenarios 0 and 1, the carbon footprint decreased from 60,761.9 tons to 58,471.9 tons, corresponding to a reduction of 3.7%. In Scenario 2, where 50% of the renewable waste was separated at the source, the transportation sector's carbon footprint was reduced the most (Table 4). The total amount of CO_2 equivalent decreases by 21% (48,090.5 tons) compared to Urla's current waste management strategy.

Table 3. Results for environmental indicators for Urla-Scenario 0.

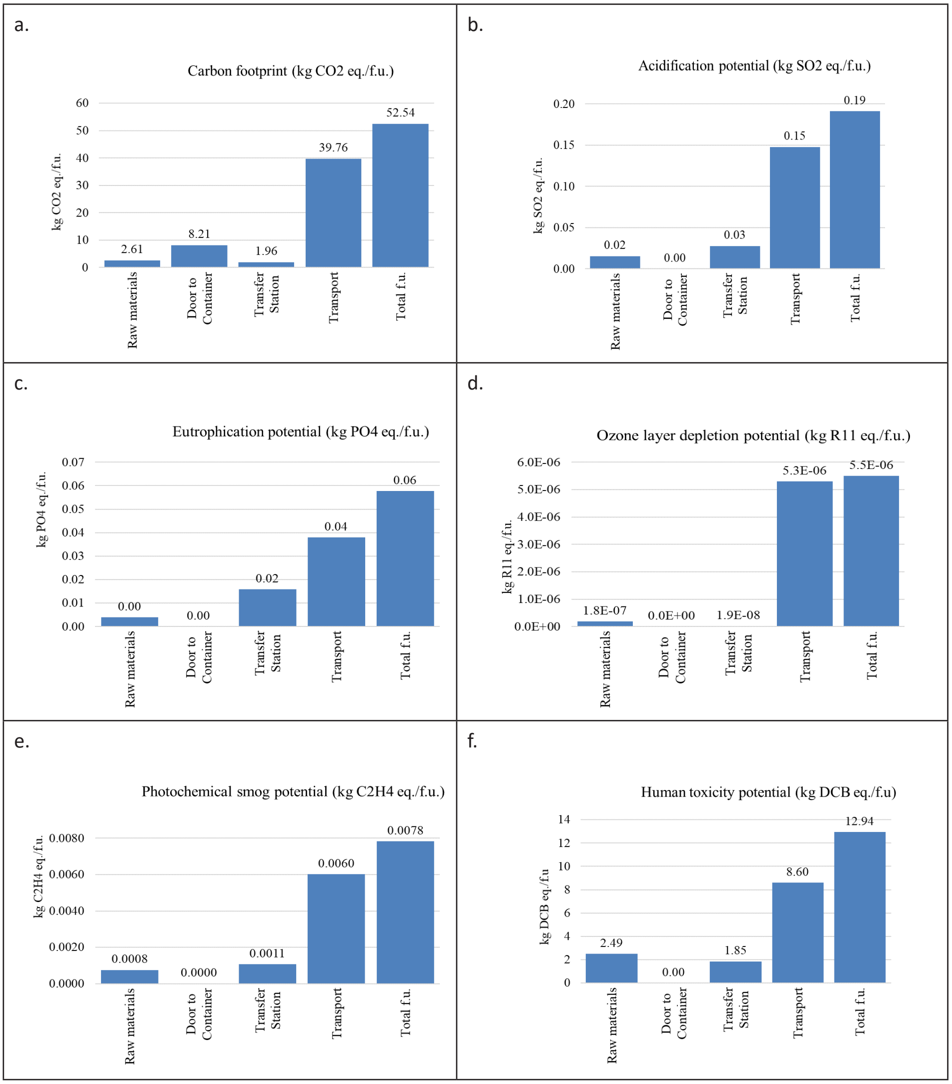
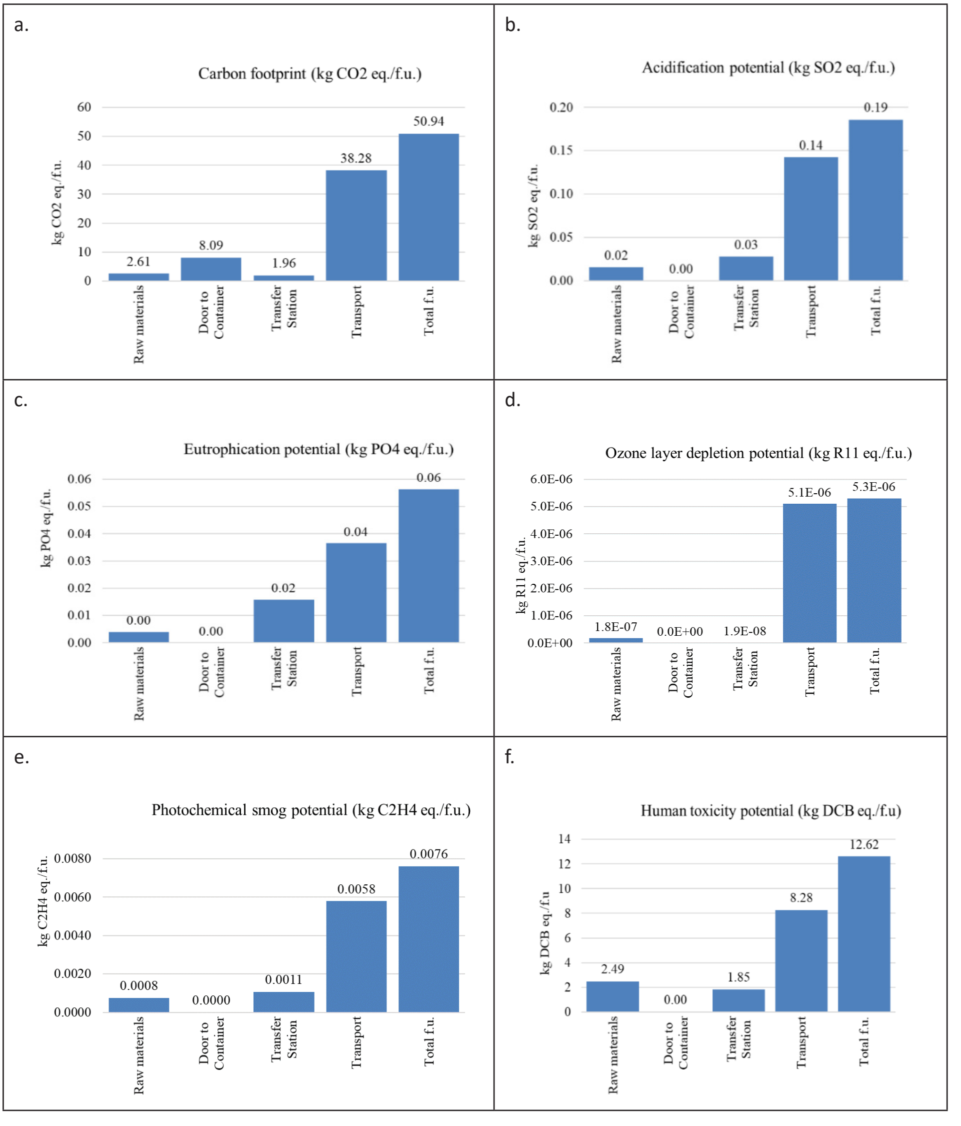
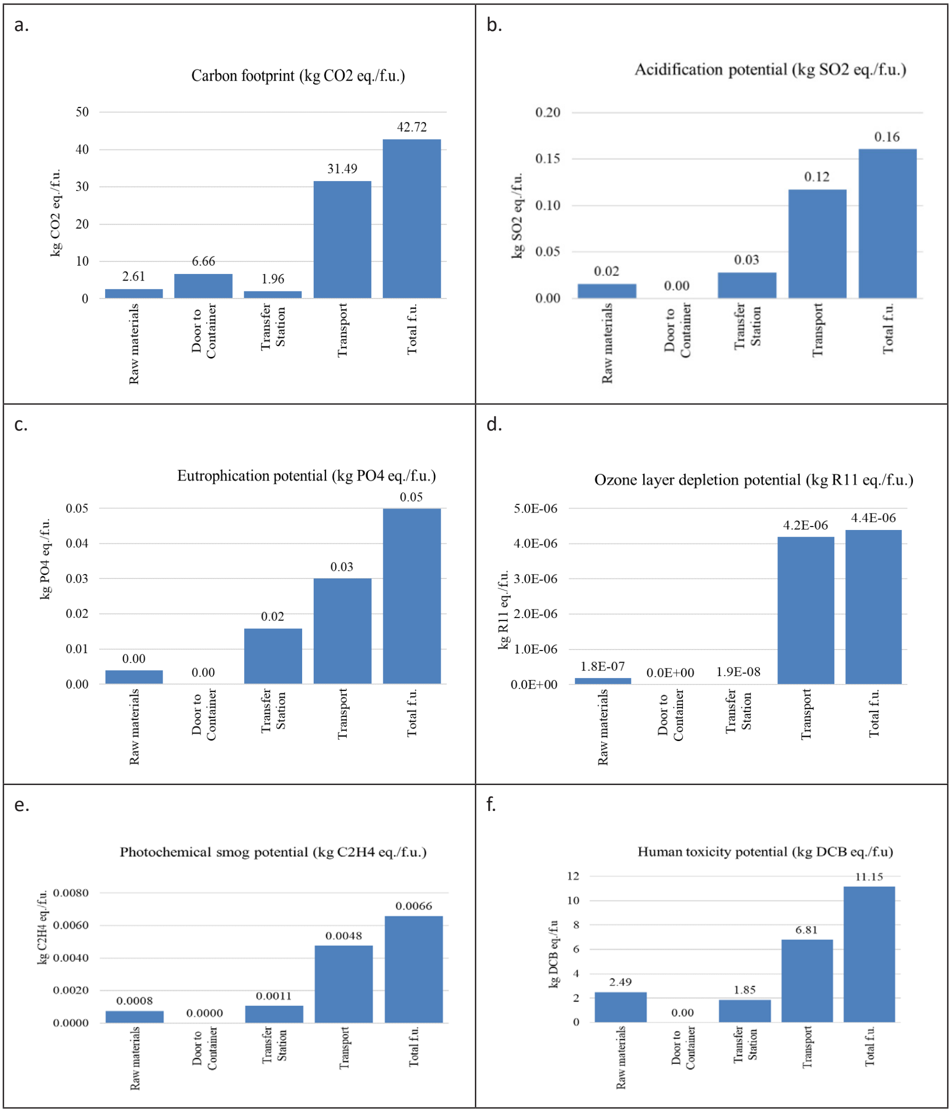


Table 4. Results for environmental indicators for Urla-Scenario 1.



Tables 4, 5, and 6 from Urla's diverse results indicated how the environmental indicators were altered under each scenario.

Table 5. Results for environmental indicators for Urla-Scenario 2.



For Çeşme-Scenario 1, the changes were similar to Urla-Scenario 1 on transportation sector. Carbon footprint has decreased by 3.7% with reduction from 26,146.3 tons of CO_2-eq to 25,177.9 tons of CO_2-eq. Results from Scenario 2 were even more significant, with a 20% reduction calculated in carbon footprint. The results were shown in Table 5, Table 6 and Table 7.

Table 6. Results for environmental indicators for Çeşme-Scenario 0.

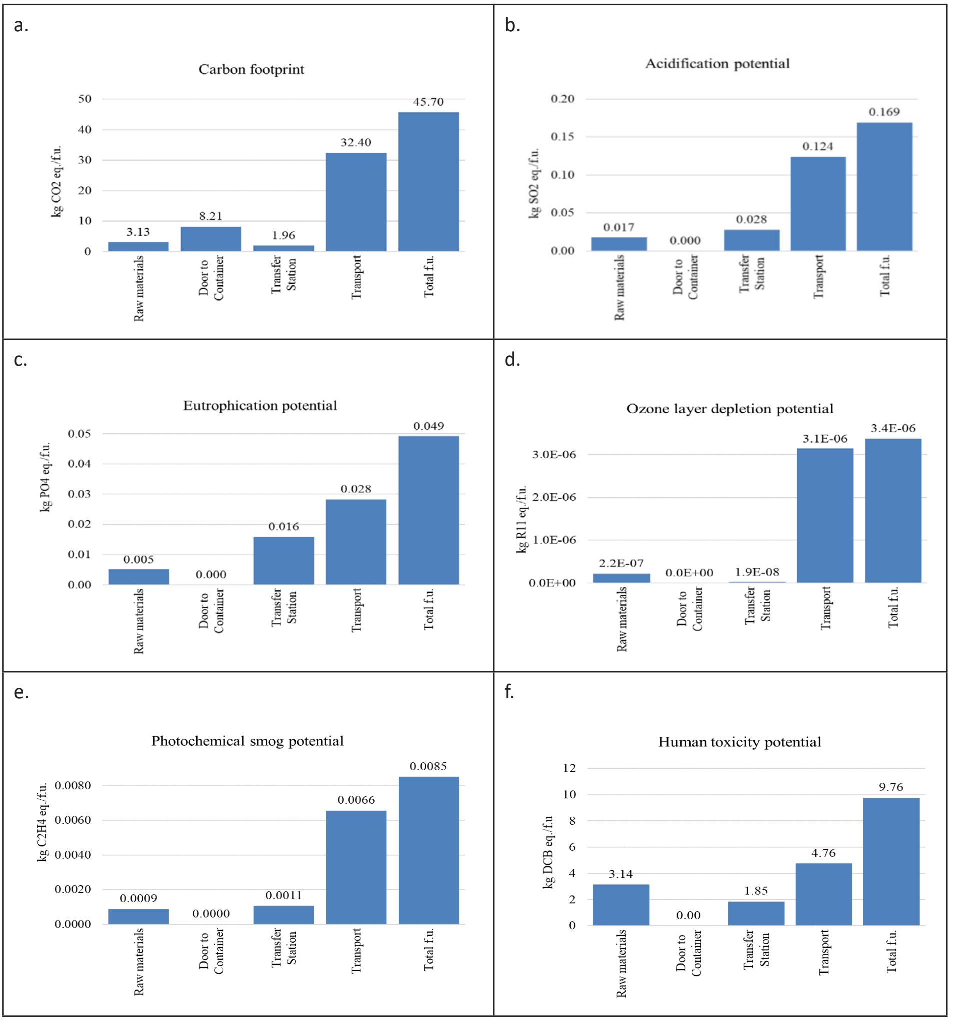


Table 7. Results for environmental indicators for Çeşme-Scenario 1.

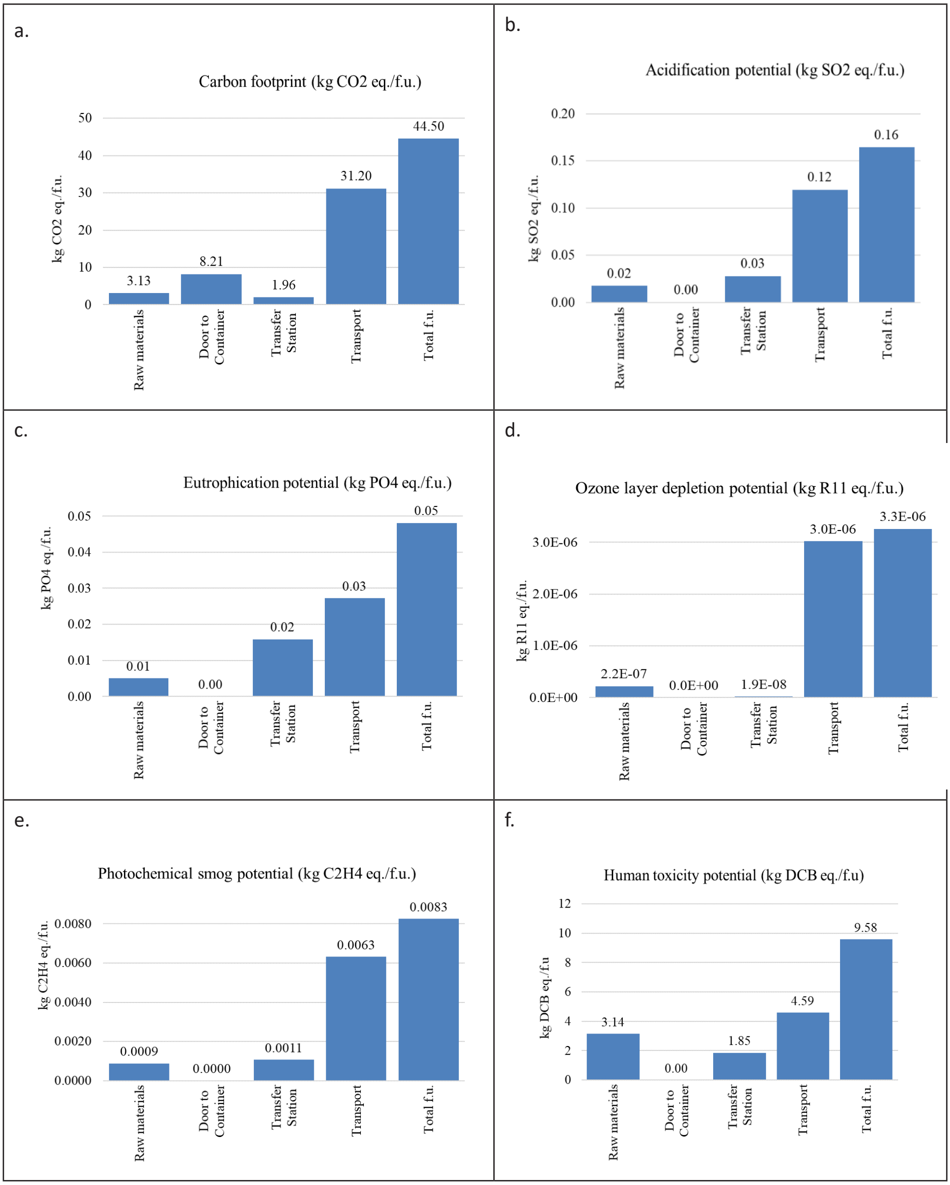
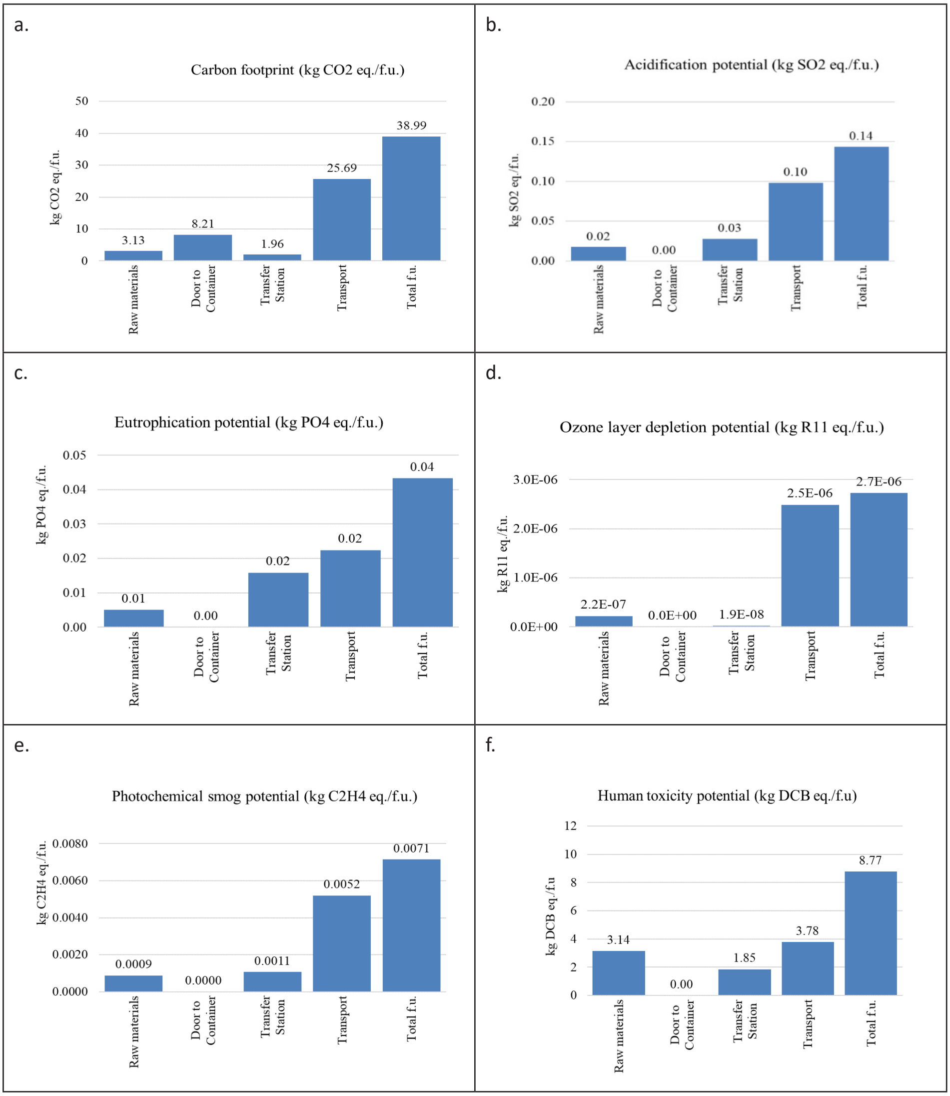


Table 8. Results for environmental indicators for Çeşme-Scenario 2.



Based on (Table 8 and Table 9) the information that the municipality provided, the Karaburun district base scenario was described. Scenario 1's characterization change resulted in a deduction of 219,13 tons of CO_2 being produced. The second scenario, which includes a reduction of 1,195.3 tons of CO_2, has the greatest impact on the numbers.

Table 9. Results for environmental indicators for Karaburun-Scenario 0.

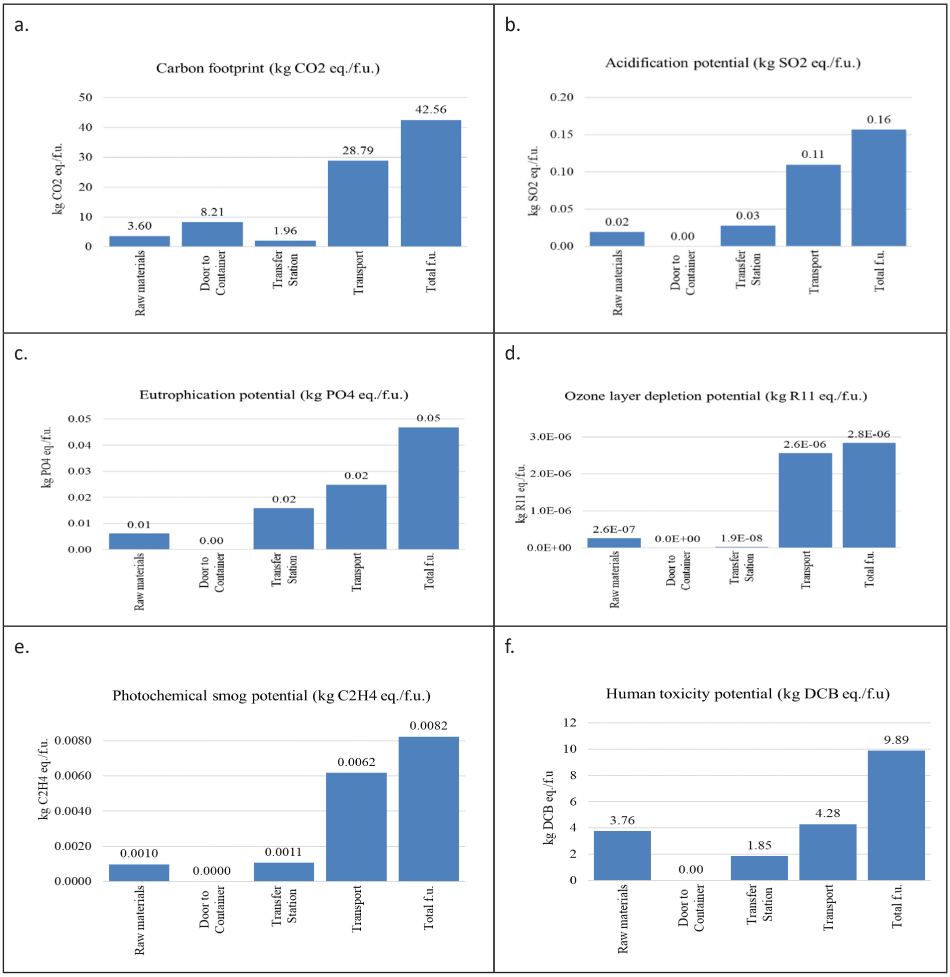


Table 10. Results for environmental indicators for Karaburun-Scenario 1.

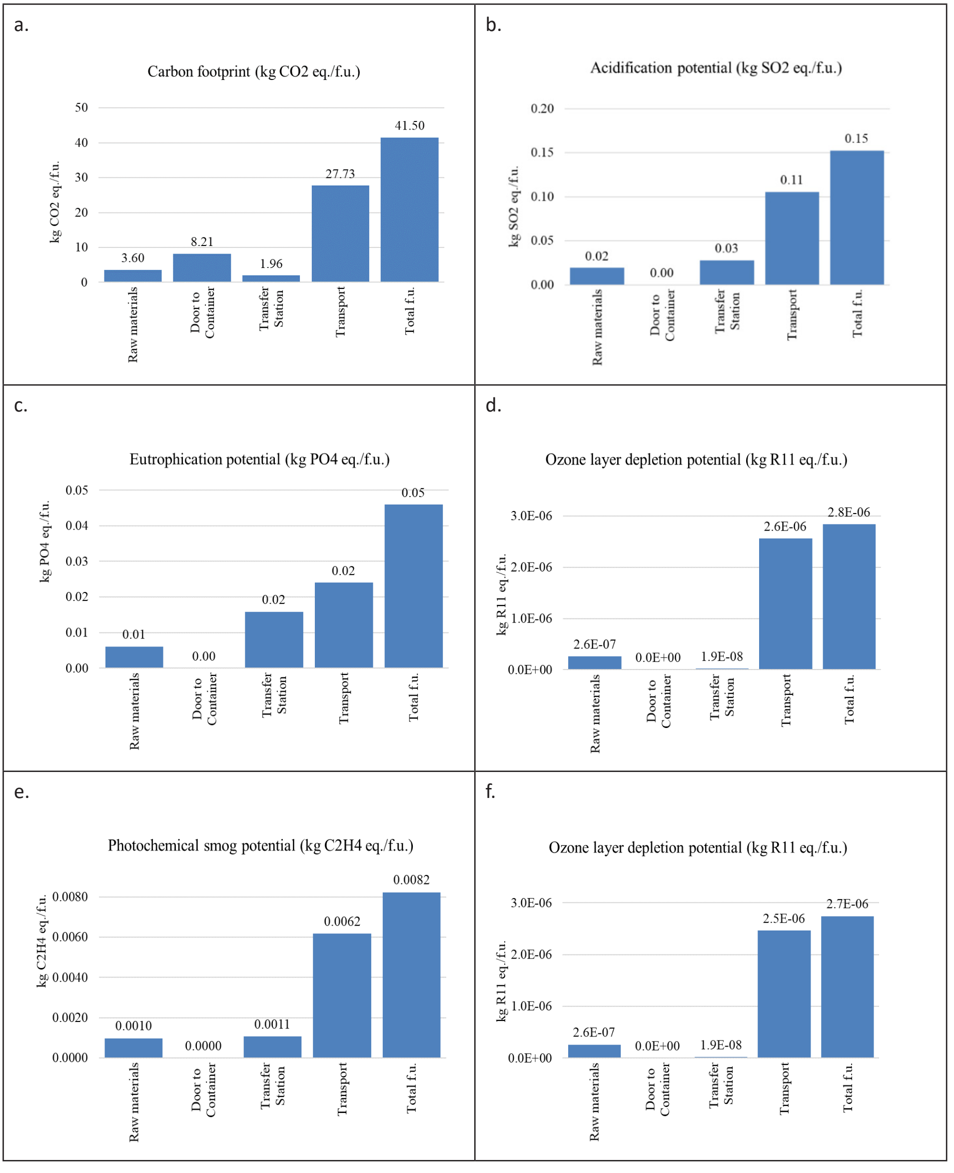
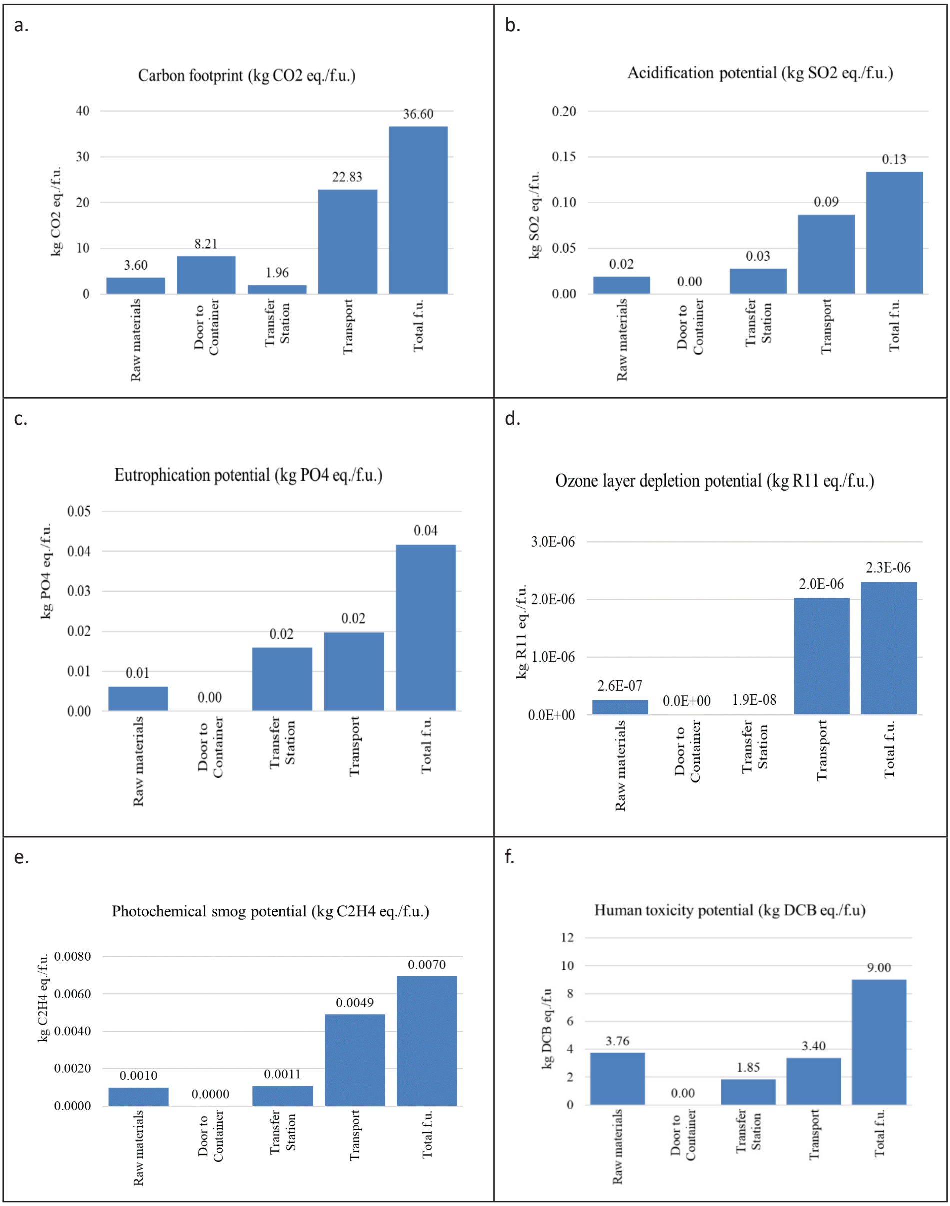


Table 11. Results for environmental indicators for Karaburun-Scenario 2.



Based on (Table 4, Table 7, Table 10) scenario 2 in all three districts has the most significant effect on the environmental impacts of MSW transportation. The table below compares each district's differences regarding the effect of changing scenarios on the Carbon footprint impact and shows that the alteration and reduction of only 50% of all renewable can effect radically on the environmental impacts. The results were summarized in Table 11.

Table 12. Environmental indicator values for different scenarios.

Scenarios	Carbon Footprint (kg CO_2 eq./f.u.)	Acidification Potential (kg SO_2 eq./f.u.)	Eutrophication Potential (kg PO_4 eq./f.u.)	O_3 layer Depletion Potential (kg R11 eq./f.u.)	Photochemical Smog Potential (kg C_2H_4 eq./f.u.)	Human Toxicity Potential (kg DCB eq./f.u)
Karaburun S0	42.56	0.16	0.047	2.84E-06	0.0082	9.89
Karaburun S1	41.50	0.15	0.046	2.74E-06	0.0080	9.73
Karaburun S2	36.60	0.13	0.042	2.31E-06	0.0070	9.00
Çeşme S0	45.70	0.17	0.049	3.38E-06	0.0085	9.76
Çeşme S1	44.50	0.16	0.048	3.26E-06	0.0083	9.58
Çeşme S2	38.99	0.14	0.043	2.73E-06	0.0071	8.77
Urla S0	52.54	0.19	0.058	5.50E-06	0.0078	12.94
Urla S1	50.94	0.19	0.056	5.30E-06	0.0076	12.62
Urla S2	42.72	0.16	0.050	4.39E-06	0.0066	11.15

CONCLUSION

Using LCA modeling of the Karaburun Peninsula, this study assessed the environmental effects of the transportation sector on MSW management. The results implied that merely sorting plastic trash was insufficient and that sorting all renewable waste at the source would have a major influence on reducing carbon emissions. The decrease of carbon footprint and acidification owing to truck types and fuel usage was proposed in three scenarios using various methods.The findings indicate that scenario 1's transportation of MSW with 50% plastic source separation results in an approximate 3% CO2 decrease, while scenario 2's transportation of MSW with just 50% assumed segregation of renewable waste characterisation results in an approximate 20% CO2 reduction. In Izmir, Türkiye, municipalities can use LCA for decision-making processes and evaluation of each sector's environmental impacts. Since one of the major limitations in this study emerged to be repsentative and current waste characterizations, those studies should be done by municipalities regularly.

Karaburun Peninsula, due to its touristic nature, has significant waste generation differences during summer and winter. The accuracy of this project or future research on the management of MSW in this area can be improved with the related waste characterization district. This study showed that despite the importance attributed to the plastics recycling, only plastics recycling did not cause significant carbon footprint reduction.

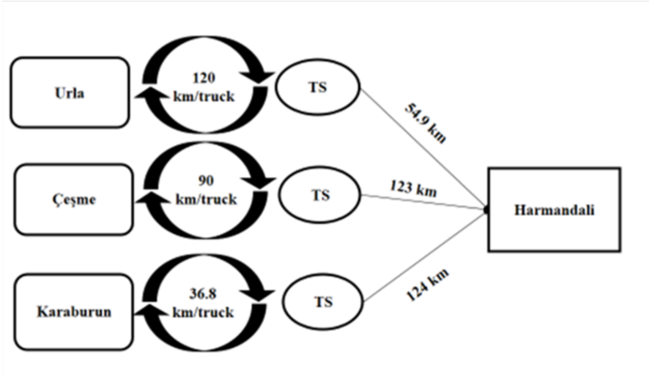


Figure 14. Travel distances for one truck within districts, from district to transfer station and from transfer station to Harmandali Landfill Site.

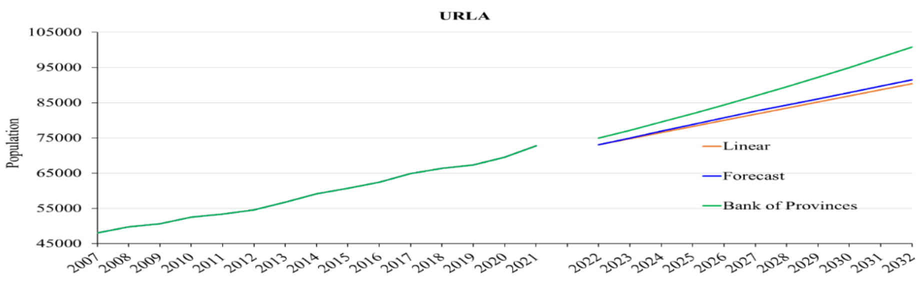


Figure 15. Population data (2007-2021) and projection (2022-2032) for Urla.

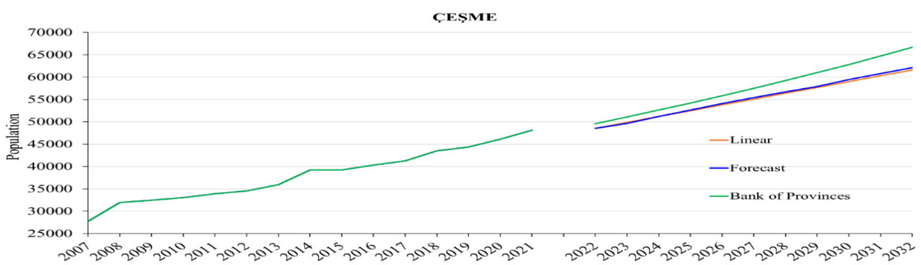


Figure 16. Population data (2007-2021) and projection (2022-2032) for Çeşme.

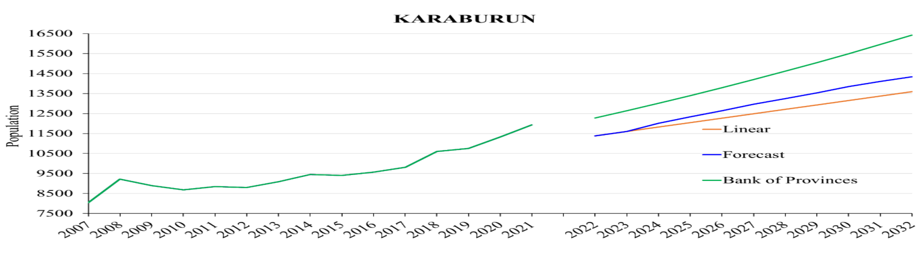


Figure 17. Population data (2007-2021) and projection (2022-2032) for Karaburun.

Table 13. Waste composition by volume for different scenarios.

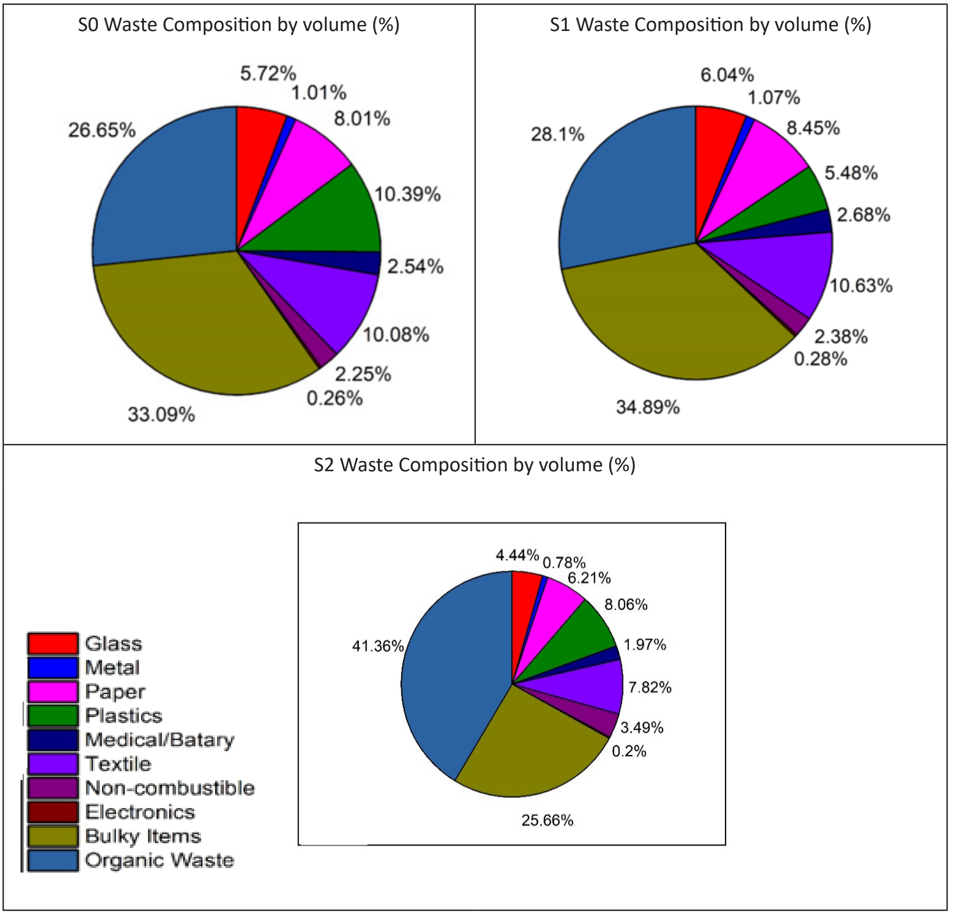


Table 14. Results for environmental indicators for Urla-Scenario 0.

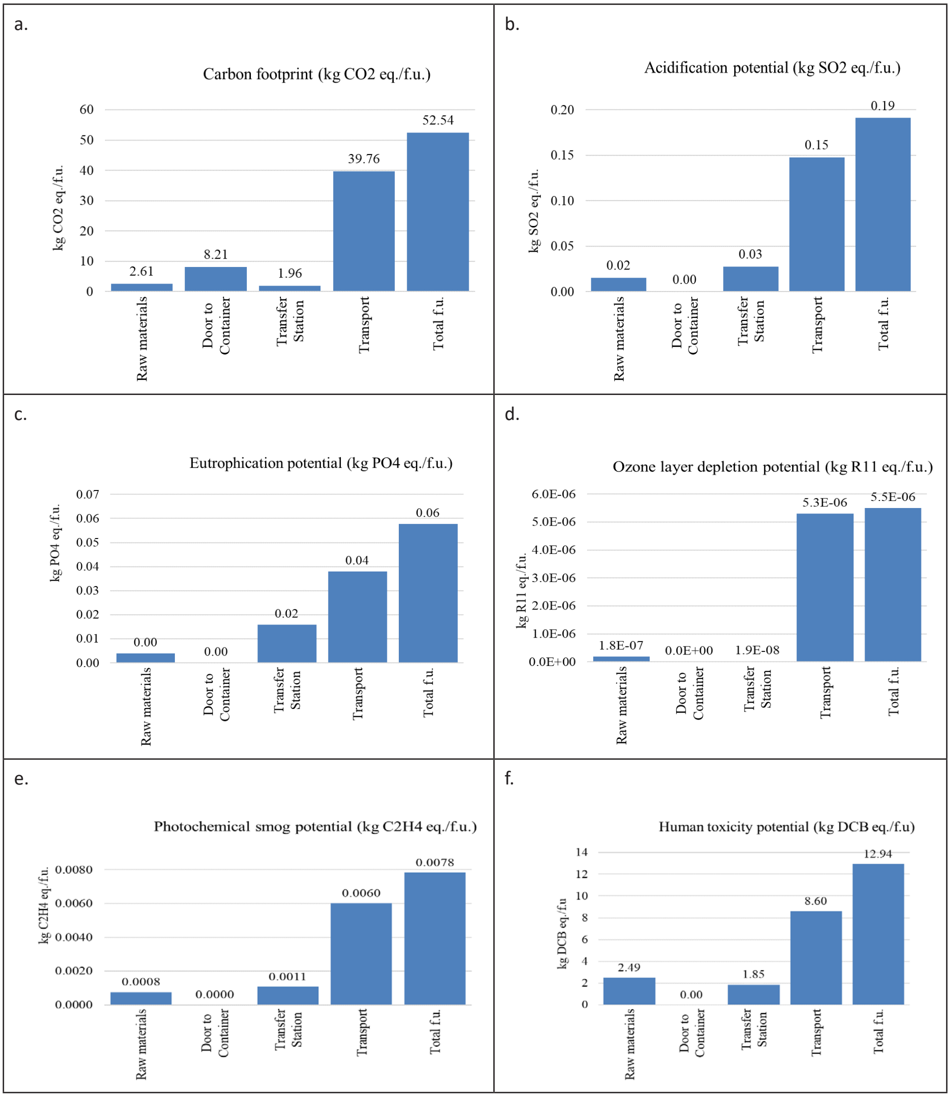


Table 15. Results for environmental indicators for Urla-Scenario 1.

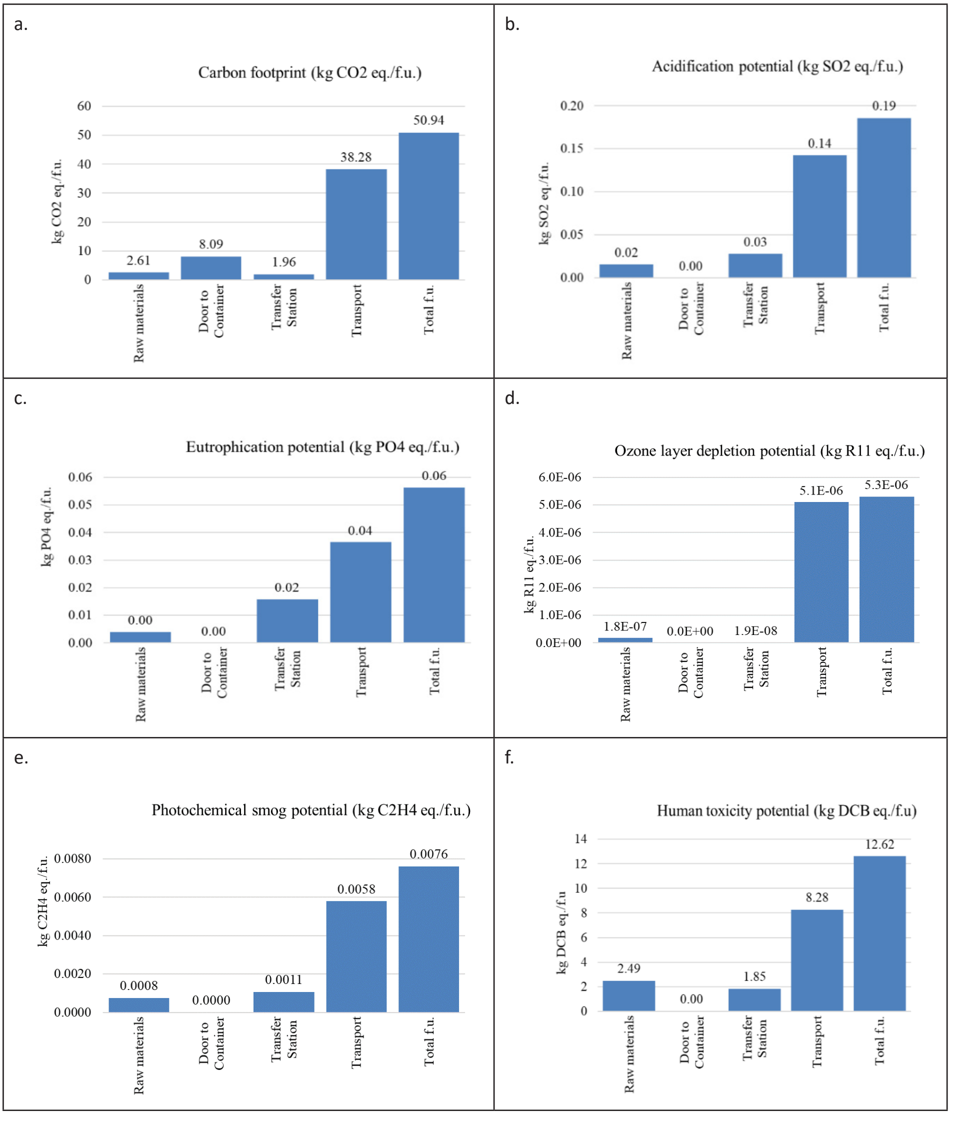


Table 16. Results for environmental indicators for Urla-Scenario 2.

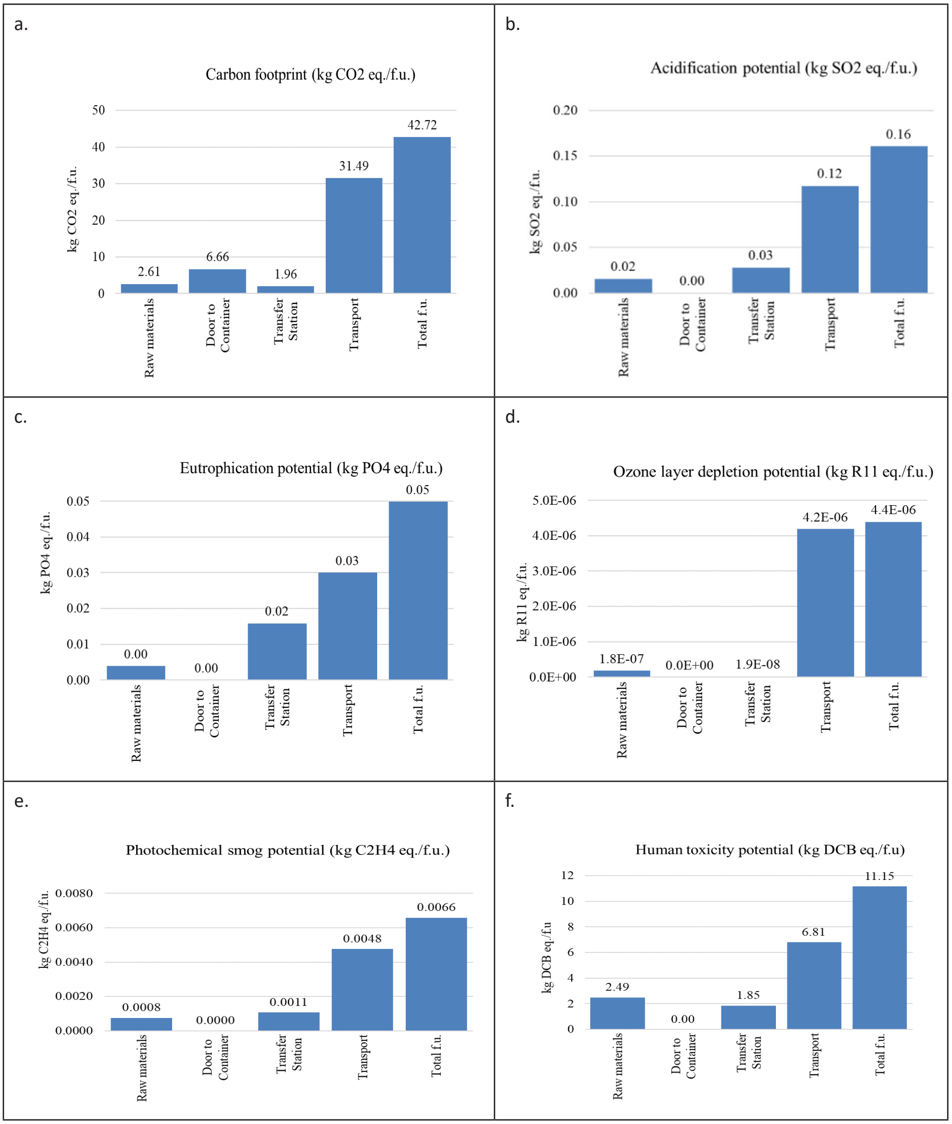


Table 17. Results for environmental indicators for Çeşme-Scenario 0.

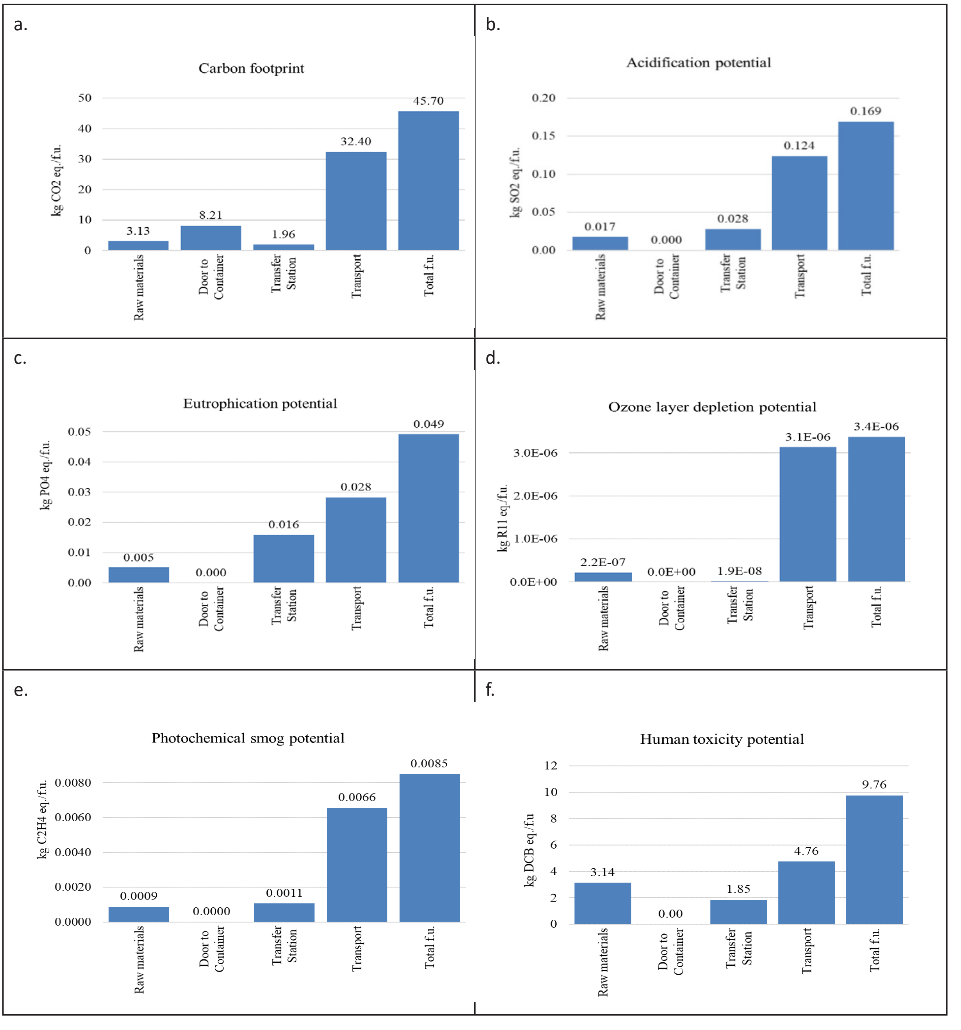


Table 18. Results for environmental indicators for Çeşme-Scenario 1.

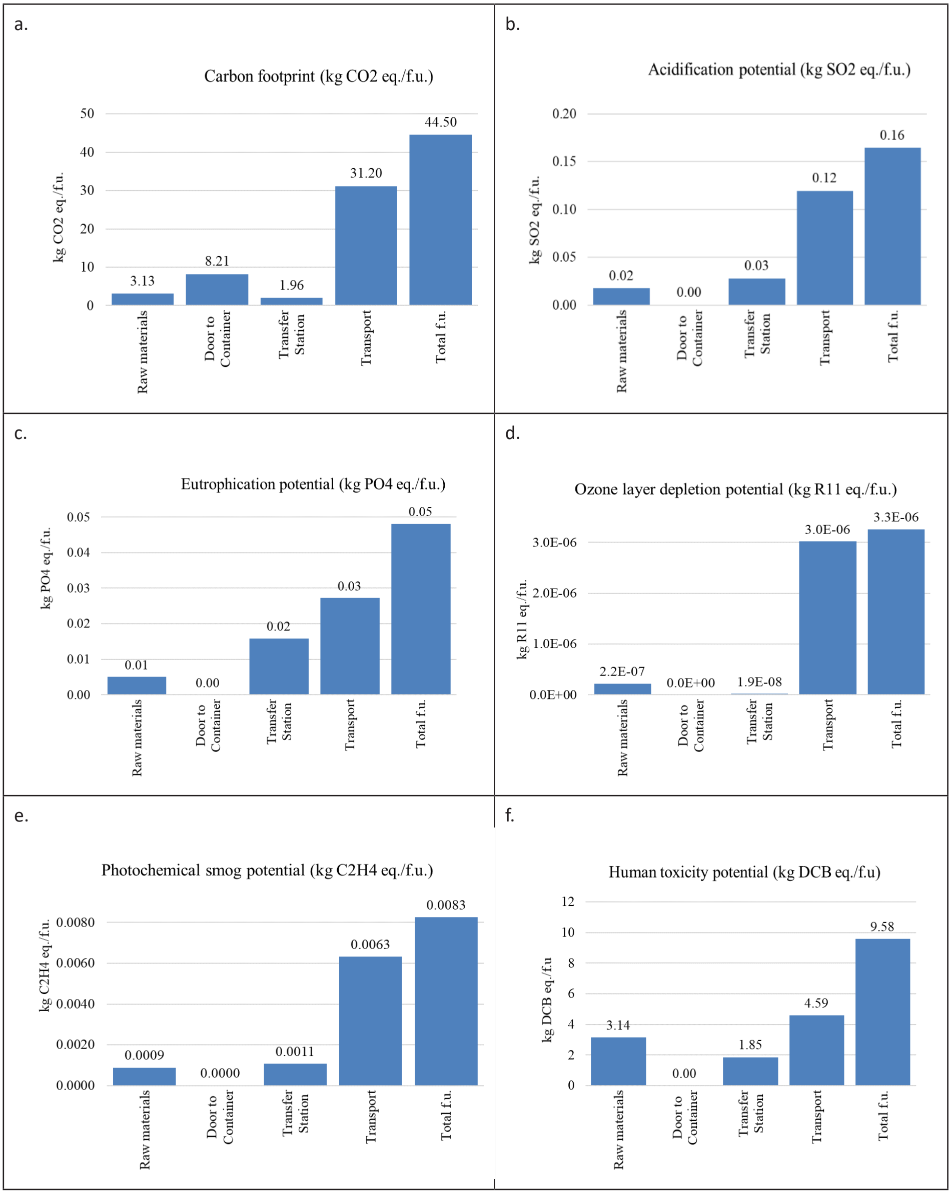


Table 19. Results for environmental indicators for Çeşme-Scenario 2.

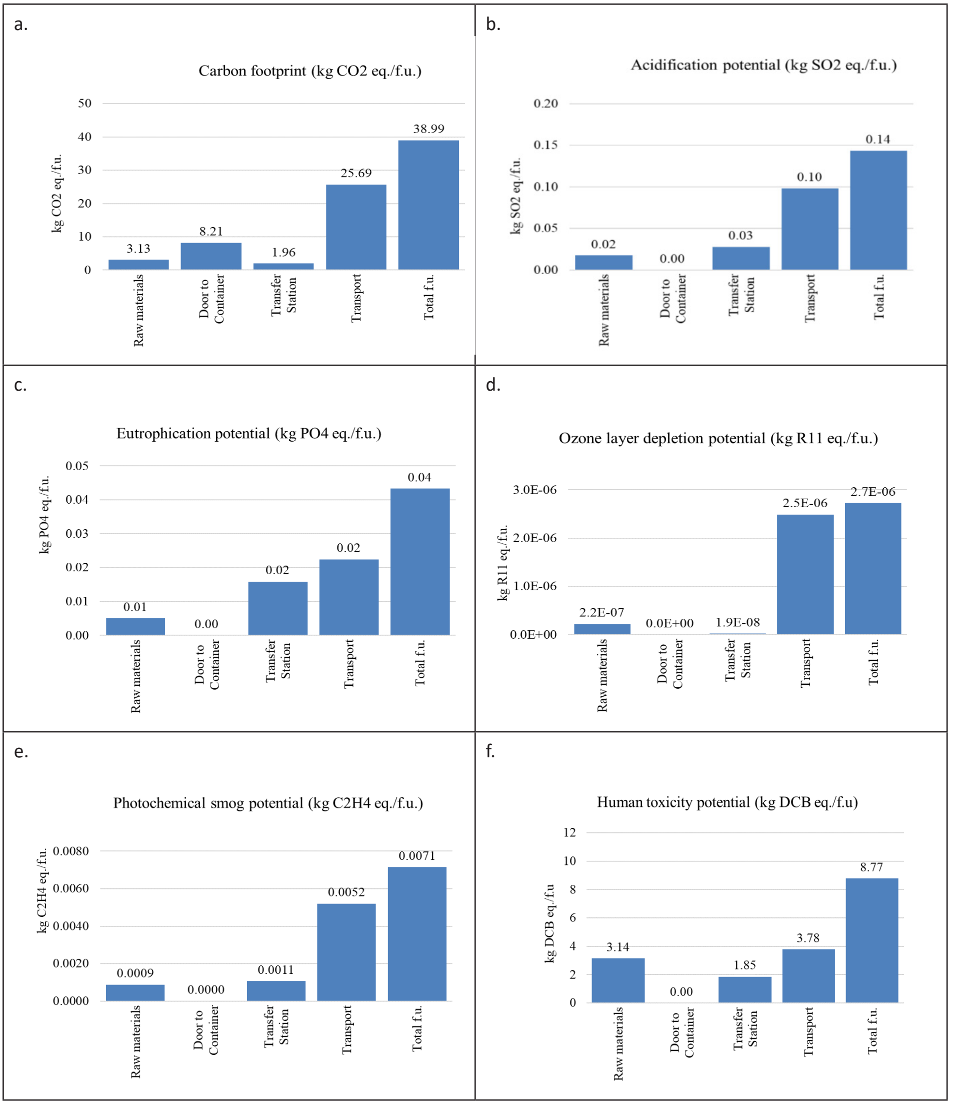


Table 20. Results for environmental indicators for Karaburun-Scenario 0.

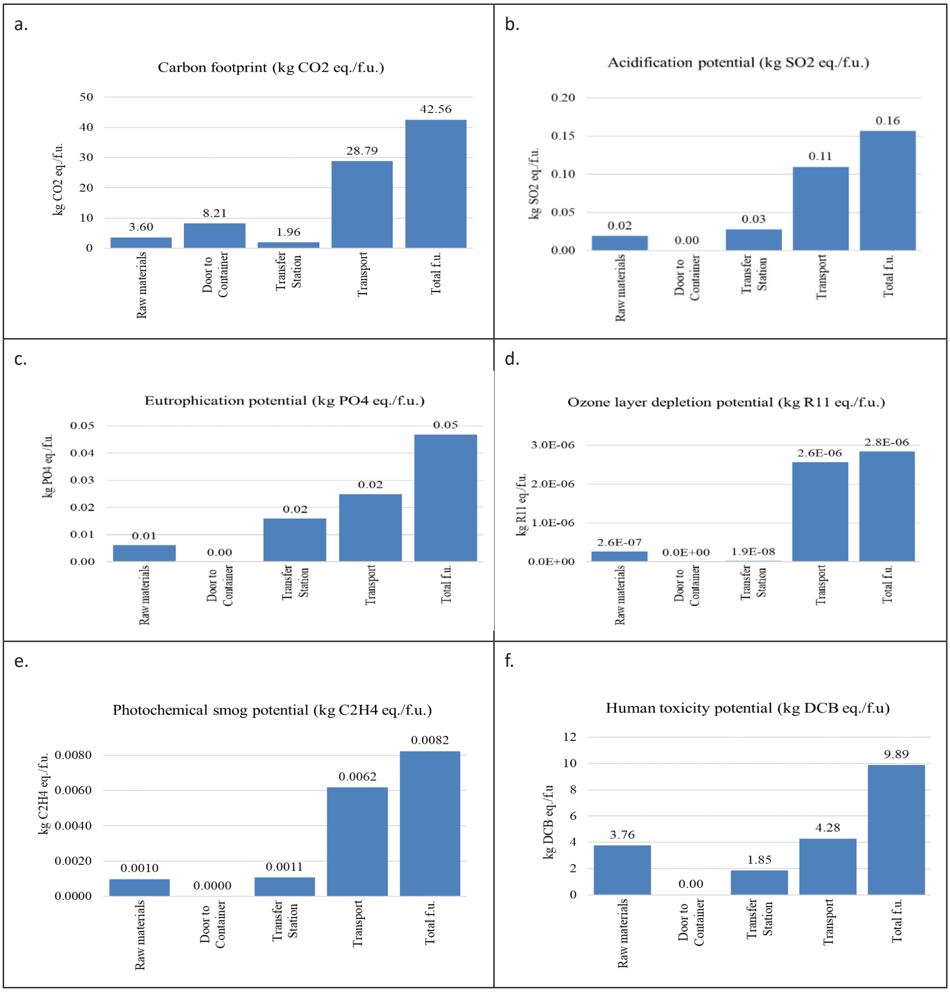


Table 21. Results for environmental indicators for Karaburun-Scenario 1.

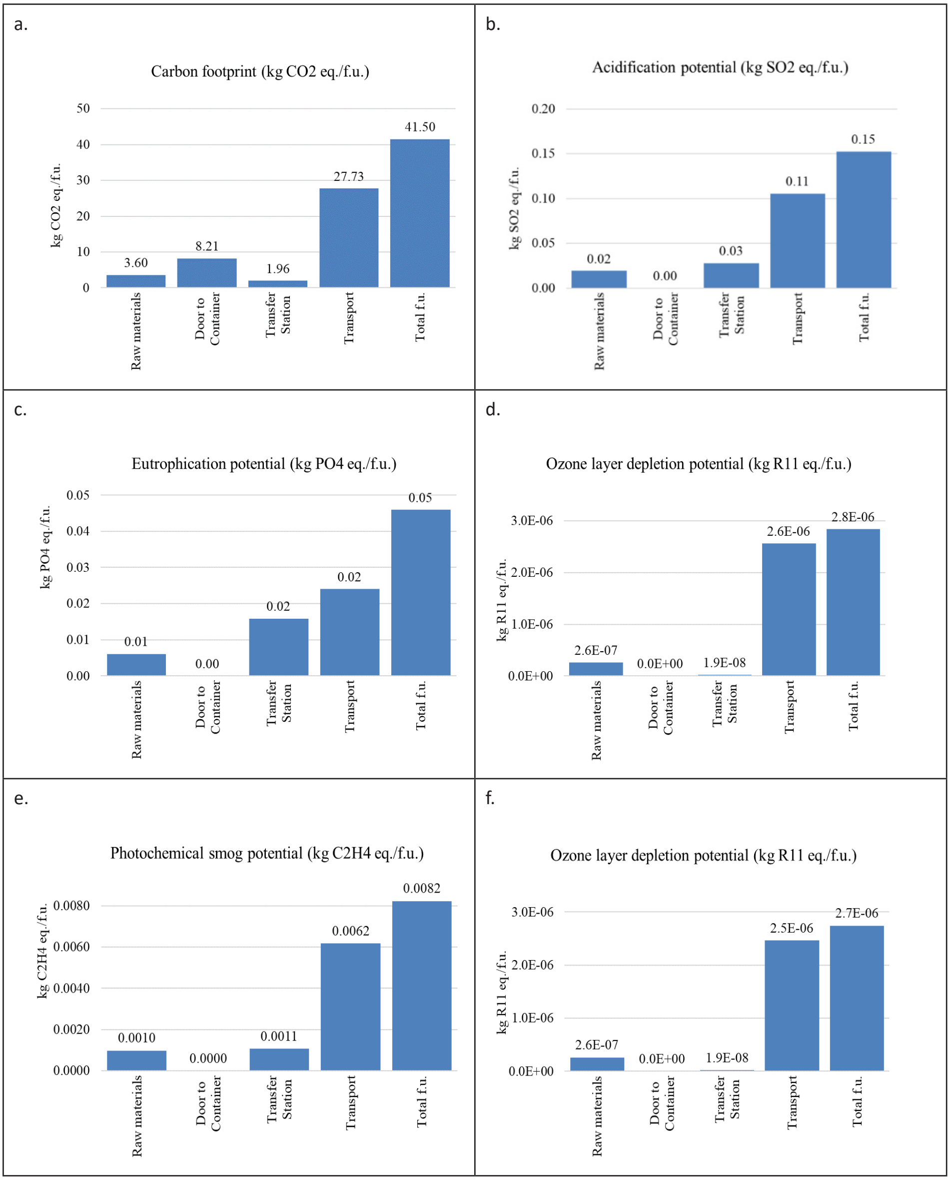


Table 22. Results for environmental indicators for Karaburun-Scenario 2.

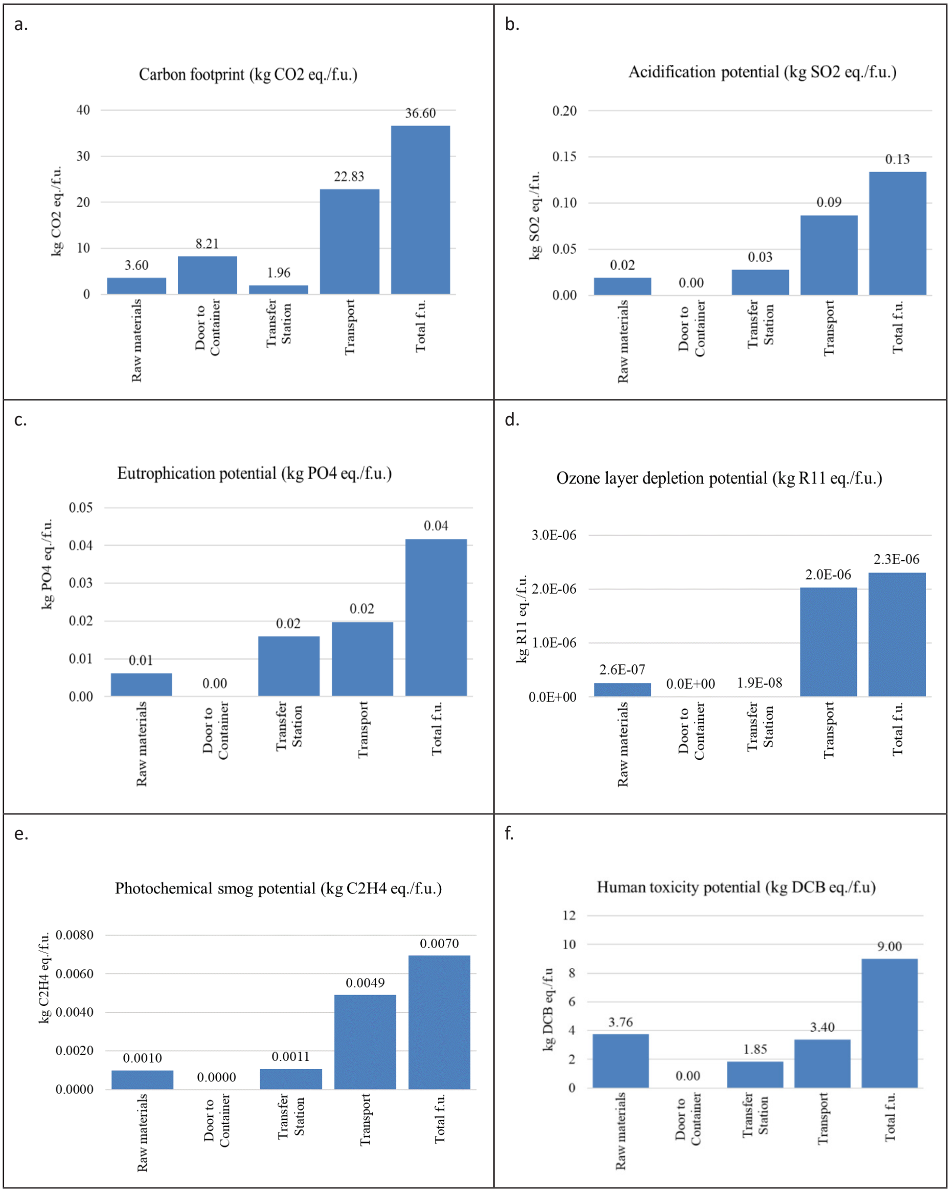


Table 23. Environmental indicator values for different scenarios.

Scenarios	Carbon Footprint (kg CO_2 eq./f.u.)	Acidification Potential (kg SO_2 eq./f.u.)	Eutrophication Potential (kg PO_4 eq./f.u.)	Ozone Layer Depletion Potential (kg R11 eq./f.u.)	Photochemical Smog Potential (kg C_2H_4 eq./f.u.)	Human Toxicity Potential (kg DCB eq./f.u)
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Karaburun S2	36.60	0.13	0.042	2.31E-06	0.0070	9.00
Çeşme S0	45.70	0.17	0.049	3.38E-06	0.0085	9.76
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Urla S2	42.72	0.16	0.050	4.39E-06	0.0066	11.15

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IN THE FUTURE THE THREAT OF CLIMATE CHANGE OF TOXICITY IN WATER RESOURCES! IS IT POSSIBLE NOT TO BE TOXIC TO WATER SUPPLIES AS PROMISED IN THE GREEN DEAL?

Yuksel Ardalı[1*]

ABSTRACT

This study identifies threats to water resources and estimates their impact on water quality as a result of climate change and human activities in the coming years. The main risks to water availability are climate change and variability, water regulation and extraction, human activities and limitation of the use of water resources. Environmental water has had a significant impact on the environment as a result of human activities, in parallel with the decrease in storage levels due to the inability of water to be absorbed by the soil despite high rainfall. Chemicals involved in the water cycle are likely to be found in water sources, and reduced water levels with climate change mean greater exposure to these pollutants. As surface water is at risk, the use of groundwater as a water source and the deterioration of groundwater and water quality will also create problems. As a result of pollution caused by human activities, the availability of water resources becomes difficult. In addition, the decrease in the amount of water with climate change increases the concentration of pollutants, and the disasters caused by the climate crisis and the decrease in the protection of resources will pose a threat to us in the future. It is imperative to act urgently with an integrated approach to the non-toxic environmental-water resources approach promised in the Green Deal. In order to create a non-toxic environment in natural circulation, solutions are sought with circular economy and sustainable development goals, and supported by zero waste-wastewater-emission approach. Continuing with the old order in the new world will cause problems that cannot be solved by both environmental deformation and climate change. The importance of integrated water resources management and the steps to be taken for the future are summarized in this study.

Keywords: Climate Change, Water Resources, Hazardous Wastes, Green Deal, Circular Economy

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1. INTRODUCTION

While 20% of the world's population does not have sufficient access to safe water, it is stated in the United Nations reports that approximately 40% do not have access to healthy water. The increase in surface/groundwater pollution adversely affects both human and aquatic life systems. Although the benefits of industrialization are numerous, they pose a great threat to the environment due to the increasing distribution of various chemicals to nature with the increase in consumption demands.

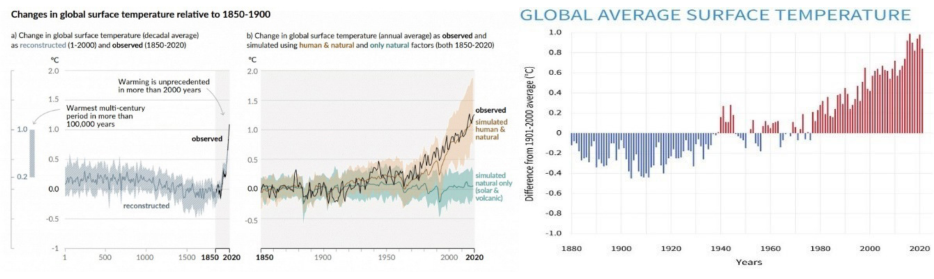

Figure 1. Changes in global surface temperature and global average surface temperature-IPCC-2021

The release of these pollutants into water supplies must be prevented by feasible technical practices.

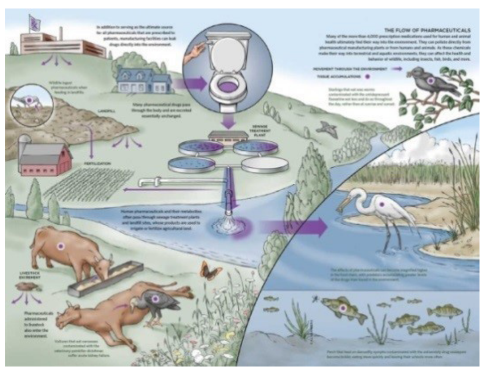

Figure 2. Pharmaceuticals move throughout the aquatic environment. By [Water Science School]

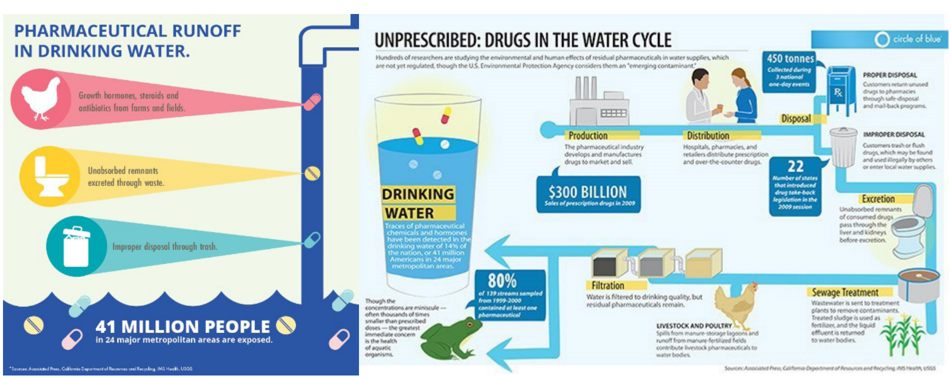

Figure 3. Drugs in the water resources

Today, there are countless hazardous compounds in the environment. Numerous poisonous and dangerous compounds that have an impact on our health, our children's development, and that of future generations are discovered through routine sampling. In addition to pesticides found in our food, solvents and surfactants found in the cleaning and cosmetic products we use every day, and flame retardants found in the toys our children play with as well as the textiles and furniture in our homes, harmful substances also include pollutants from transportation and energy use found in the air we breathe and the water we drink. While the contamination of water resources poses a major threat to humans and the ecosystem, it is expected to exacerbate the problems that exist with the climate crisis. The release of greenhouse gases by human activities and industries, the increase in planetary temperature, contributes greatly to climate change (Figure 1). As emphasized in the sustainable development goals, water pollution prevention techniques come to the fore. Although end-of-pipe treatment to date is seen as a way to prevent water pollution, it is not the right sustainable approach because it is not possible to dispose of many pollutants or because it requires very expensive technology.

1.1. Climate Variability and Change

The conditions that may arise with increasing temperatures [1] can be summarized as more water retention in the atmosphere, faster and more evaporation, increase in the amount and intensity of precipitation, increase in warm seasons and increase in drought.

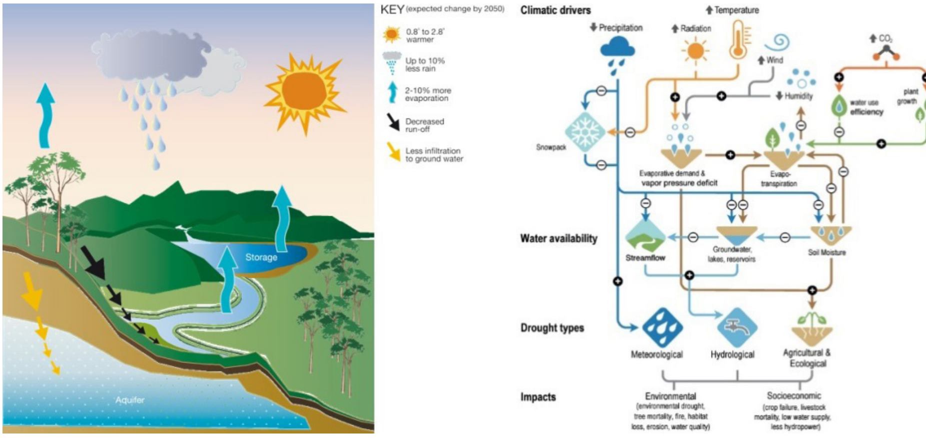

Figure 4. Potential climate change impact on the water cycle by 2050 – Climate drivers of drought, impacts and impacts on water availability (EPA-2022).

Just as climate affects the hydrological cycle, the hydrological cycle affects climate in a variety of ways. Water in the form of liquids, snow, ice, steam and clouds on Earth heats or cools the environment during phase change, and fifty percent of surface cooling occurs by evaporation, while the water vapor generated creates a strong greenhouse effect and causes heat to be kept on the earth [2]. Climate change and changes in the atmosphere cause global and regional water scarcities with temporal and spatial changes in rainfall that are important for the water cycle [3]. In a warming climate, results such as melting glaciers, reduced snow, and permafrost degradation cause changes in the water cycle [4].

Degradation of the environment, a decline in biodiversity, and an increase in climate change are all being brought on by the discharge of poisonous and dangerous chemicals into the environment. Through the melting of glaciers and increased production of air pollution, climate change contributes to the increased discharge of harmful pollutants. Our reliance on fossil fuels and raw materials made from petrochemicals is a major factor in the creation and usage of harmful components, as is seen in the case of plastics.

1.1.1. Water Cycle Change: Possible link between water pollution and climate impact

Climate projections show that water resources will become fragile in this process, adversely affecting societies and ecosystems. While some of the interventions in the environment are tolerable, many harmful human activities exceed the environmental recovery capacity. Considering the accumulations from the past, water pollution will become a problem that cannot be solved by the effects of climate change and will require an urgent integrated approach if the necessary measures are not taken. Possible and ongoing variations in precipitation and air temperature have the potential to influence river flow, resulting in altered kinetics of chemical reactions and a decline in the ecological quality of freshwater.

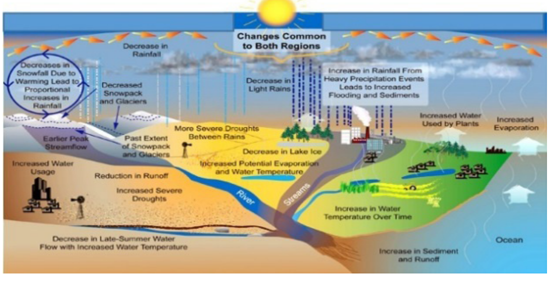

Figure 5. Climate change and water movement

Pollutants can interact with water resources to alter their natural characteristics and have an impact on the environment. This kind of water contamination can result in the production of harmful gases that contribute to global warming as well as more serious environmental dangers. A warmer climate increases the amount of water evaporating from the land and sea, which increases the amount of moisture held in the atmosphere. For every 1 °C increase in temperature, the atmosphere's capacity to hold water increases by about 4%.

1.1.2. Climate Change and Water Pollution

Expected approaches to climate change and water resources can be summarized as follows:

1) Climate change will change the water cycle by affecting the amount of water.

2) Floods and droughts will increase their negative effects as regional and seasonal rainfall patterns change and rainfall increases.

3) In some regions, rainfall and runoff are likely to increase in the winter and spring and decrease in the spring and summer

4) The impact of climate change on surface water quality and groundwater availability

5) Water systems will experience greater stress due to climate change.

6) The measures and practices that were determined for water management in the past are no longer a guide for the future, but our approach should be changed.

1.1.3. Changes in Water Quality

The climatic changes will have an impact on the amount and quality of surface water and groundwater. Increased air temperatures, especially during periods of low flow, lead to higher water temperatures already detected in many streams. Dissolved oxygen decreases in water supplies at high temperatures. Oxygen is an indispensable source for many living things, and the presence of living things at high temperatures decreases due to both the low amount of water solubility and the high respiratory rate. Lower oxygen levels also reduce the assimilation-extraction capacity of water supplies.

Heavy downpours are expected to lead to increased precipitation in the water flow, outbreaks of waterborne diseases and the spread of pollutants. Increases in pollution carried into lakes, estuaries and coastal oceans can cause harmful algae and bacteria growth, especially when coupled with increased temperature. In the past, changes in water quality, changes in pollutants were due to reasons other than climate change.

1.1.4. Climate Stress in Water Systems

Climate change will bring additional pressures to water systems that are already stressed. In many places, aging infrastructure, population growth and farming will bring challenges in managing water resources for municipalities, hydropower, recreation and ecosystems. The current problems with water management will be exacerbated by climate change, increasing vulnerability. Water systems are built to last and have extra capacity. As a result, these systems can adapt to minor changes in typical settings. Today, water resources planning does not take into account a wide range of factors, and it is necessary to decide and implement what measures to take to adapt to climate change and minimize vulnerability.

1.1.5. Changing water demands

With rising temperatures, there will probably be changes in water needs. As temperatures rise, more water should evaporate from water sources. The need for water for irrigation is anticipated to rise as a result of higher temperatures and longer dry spells. This can be somewhat compensated by plants using water more effectively as a result of rising atmospheric carbon dioxide levels. The withdrawal of cooling water by power plants will likely increase as temperatures rise. Additionally, as a result of the increased demand for cooling during the summer, power plants will need to consume more cooling water. Demand in the industrial and municipal sectors is anticipated to marginally rise.

1.1.6. Water Pollution

Pollutants that have become part of our daily lives are mixed in different ways by the water cycle. Although the synthesis of chemicals is not fully known, the production of chemicals has increased from 10 Mton/year to >400 Mton/year in the last 50 years. Therefore, the discovery and synthesis of more than 123 million chemicals in the last decade means new pollutants for us. Pollutants entering the water cycle are increasing and changing shape day by day.

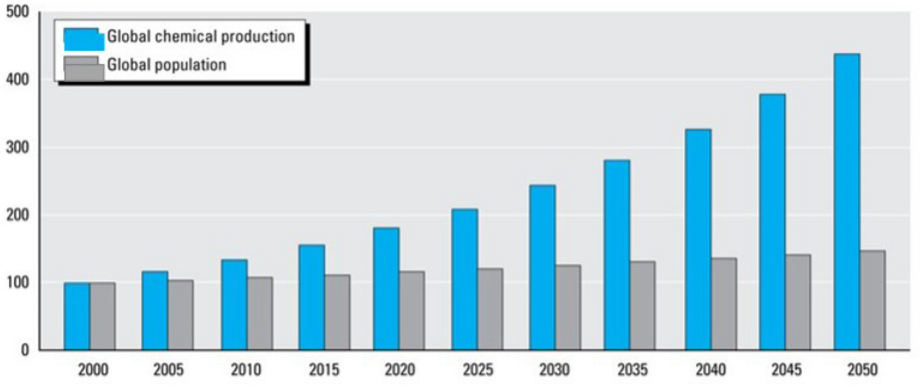

Figure 6. Global chemical production

Priority and Specific pollutants most likely to enter the Water cycle:

1. Very persistent, multi-bioaccumulation-vPvBs
2. Persistent, bioaccumulative, toxic-PBT
3. Carcinogenic, Mutagen, toxic to reproductive-CMRs
4. Endocrine Distruptive Pollutants-EDPs
5. Mikro kirleticiler
6. Persistent Organic Pollutants-POPs
7. Pharmaceutical and Personal Care Products-PPCPs
8. Emerging Pollutants
9. Chemicals Forever-PFAS

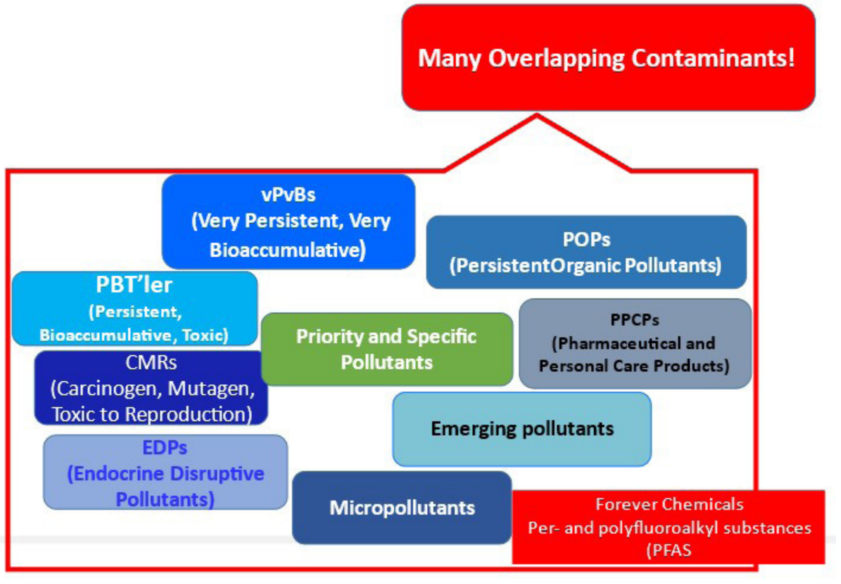

Figure 7. Pollutants most likely to enter the water cycle

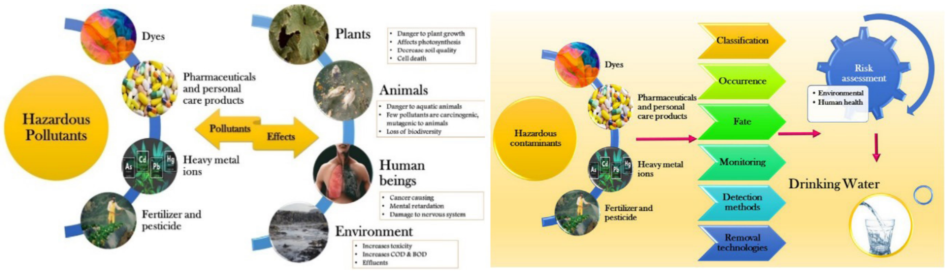

Figure 8. Hazardous Pollutants and Their Effects on the Environment

Recently, per and polyfluoroalkyl substances (PFAS), commonly known as "chemicals forever," have been found in the water cycle. PFAS has been used in a variety of products, from food packaging to waterproof clothing. What these pollutants have in common is that even their low concentrations are effective, not easily found in nature.

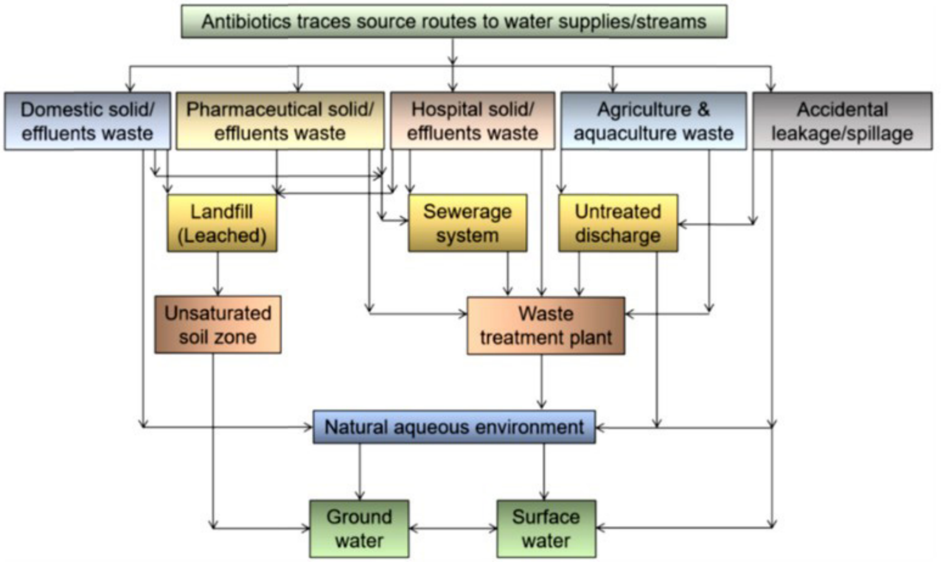

Figure 9. Diagram of the resulting pollutants from the source to the environment

As a result of extreme weather events in water supplies, it can cause the release of toxic substances that were previously immobilized. In general, climate change can lead to increased mobility of chemical pollutants in water supplies. It is believed that rising air and water temperatures change the speed and direction of currents [5], [6] which can change the way toxic substances are transported through the system. Such changes will cause toxic substances to be introduced into previously unexposed habitats in the ecosystem, causing harmful effects on these creatures. Aquatic species may be less able to adapt to climate change as a result of toxic compounds. The success of future populations will be greatly influenced by the capacity of organisms to adapt to new temperature regimes [7]. An organism's tolerance to these alterations may be decreased by chemical additions [8]. Toxic compounds may speed up the rate at which climate change is reshaping the food webs in water supplies, even if recent warming has already outpaced certain species' capacity to adapt.

1.1.7. Green Deal and Non-toxic Environment

In recent years, many ambitious environmental agreements and regulations have been made in the world. Due to the failure to implement regulations, environmental problems continue to increase exponentially every day. The increase in the amount and diversity of chemical substances released into nature is one of the main drivers of this degradation, of which biodiversity loss is an important indicator. published in 2020, the Chemicals for Sustainability strategy in the EU is a framework aimed at addressing chemical pollution in an integrated way. Dechemicalization covers the life cycle of chemicals in production and consumption, including the design of eco-friendly substances to remove them from the environment and the best feasible techniques—cleanproduction. The "non-toxic environment" approach in the Green Deal treaty contradicts the strategy approach. To achieve the objectives of the strategy, it is recommended to harmonize the definition of risk across different chemical legislation, to create a platform for open data and data sharing, and to increase the utility and use of new scientific findings in policy development.

Chemicals legislation has been created in many countries of the world to manage the negative effects of chemicals. In the United States, the first pesticide law was enacted in 1972, and the Toxic Substances Control Act has been in place since 1976. The Basel Convention, the Rotterdam Convention, the Minamata Convention and the Stockholm Convention [9], [10], [11], [12] to regulate chemicals. During the 2002 World Summit on Sustainable Development, it was decided that the safe management of chemicals throughout their life cycle should be carried out by 2020. In addition, all UN Member States have adopted 17 Sustainable Development Goals, including 2030 Sustainable Development. Many of the Development Goals are associated with the chemical cycle SDG2 (Safe food and sustainable agriculture), SDG3 (Good health), SDG6 (Clean water), SDG8 (Safe working environments), SDG11 (Sustainable cities), SDG12 (Sustainable consumption and production), SDG14 (Protection of ecosystems) and SDG15 (Protection of biodiversity).

Figure 10. Chemicals and Waste for All SDGs-Sound management of chemicals and waste as key factors for achieving the SDGs

On the issue of chemical sustainability in the European Commission EU Green Deal [13] has set a target of zero pollution for a "toxic-free environment". The Green Deal defines actions related to a non-toxic environment: measures to prevent and clean up and rectify pollution, restoration of the natural functions of groundwater and surface water, addressing pollution from industrial facilities, and creating a chemical strategy for sustainability.

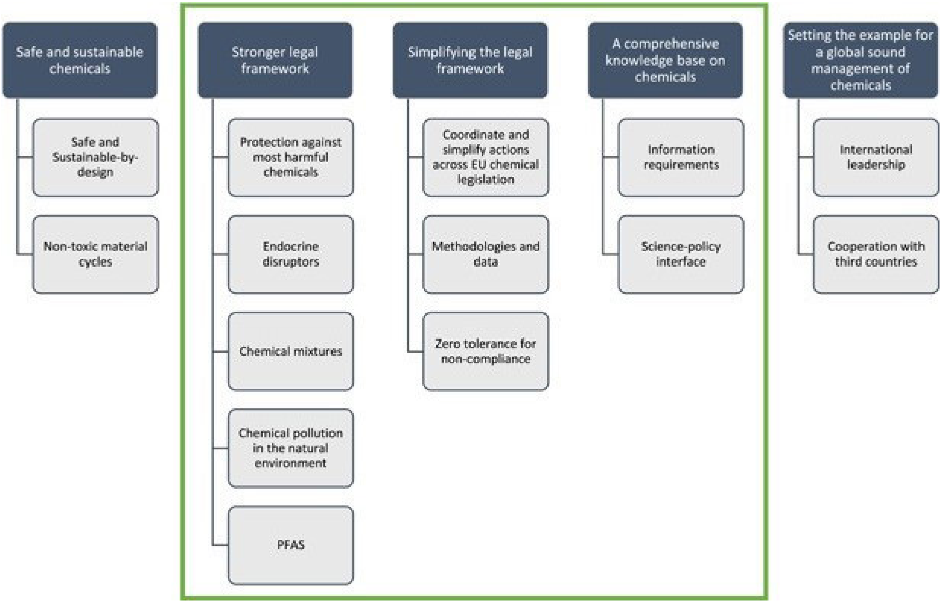

Figure 11. Initiatives for a toxic environment

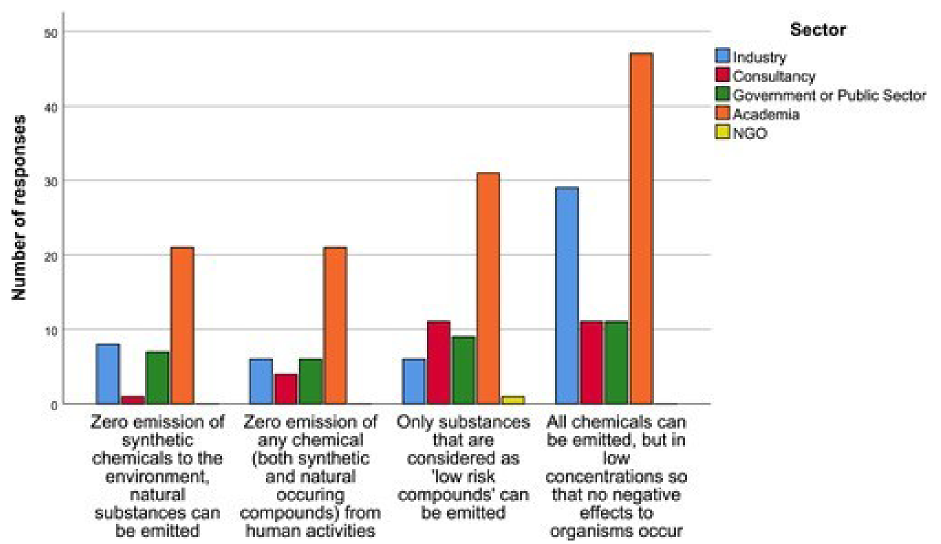

Figure 12. The fate of pollutants mixed with nature

The zero-pollution goal for a non-toxic environment calls for ongoing environmental improvement, yet risk evaluations at this time cannot foresee a chemical's effects in the future. This is crucial because as a result of the buildup of chemicals in the environment and climate change, their fate and behavior may alter and hence rise [14]. To undertake risk assessments that include all uses and enable a “single item assessment” approach, experts concur that there is currently insufficient information on chemical uses, emissions, and environmental fate. Since uncertainties have a role to play in framing what is considered a risk, it will also be essential to understand the different types of uncertainty for each item.

The European Commission supports a circular economy approach to non-toxic environment and water resources. The figure below shows how the growth rate of global chemical production is lagging behind and is expected to continue to exceed global population growth rates in the coming years. These increases in chemical production cause more chemicals to be used in products and more exposure of living things.

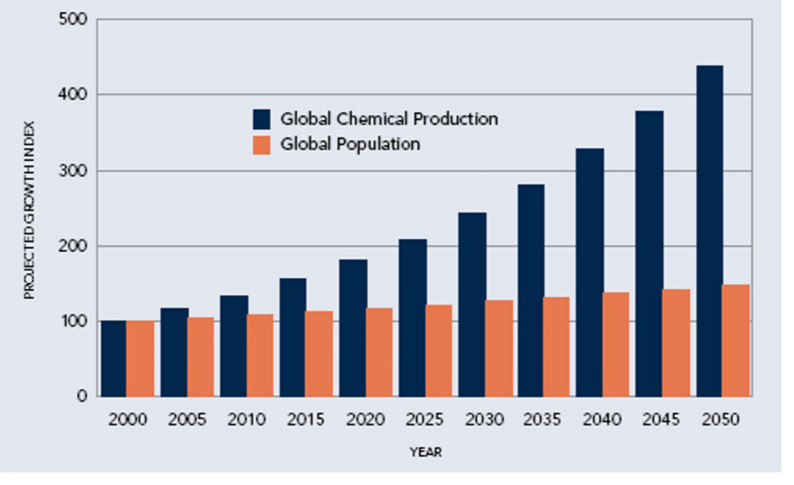

Figure 13. World population against global chemical production

Exposure to persistent organic pollutants (POPs) has been linked to a number of serious health consequences, including damage to the central and peripheral nervous systems and damage to the immune and reproductive systems, as well as certain cancers, birth defects, and immune and reproductive system dysfunction. Additionally, the presence of POPs in the environment is linked to negative consequences including hampered mammalian and avian reproductive. Particularly, PFAS (per and polyfluorinated alkyl compounds), which are particularly persistent and will survive in the environment for hundreds of years, have been found in water sources. Additionally, PFAS has been discovered in drinking water in Sweden, Germany, the United Kingdom, the Netherlands, and Italy. However, as there has not yet been any EU-wide monitoring for PFAS contamination, it is unknown how many EU inhabitants consume PFAS-contaminated water. Within the EU regulatory framework, there are various provisions in scientific programmes supporting the development and use of new (non-toxic/less non-toxic) substances. The following are some of the most significant knowledge gaps and policy and legal gaps found across various emphasis areas:

Information about the hazardous effects of chemicals on human health and the environment is still lacking in some areas;

1. Slow progress being made in the identification of substances of very high concern and the replacement of dangerous chemicals in industrial processes and products

2. Lack of knowledge on chemicals in substances, including imported compounds, and the exposure that results
3. Hazardous chemicals in material flows are not given enough consideration, despite the fact that this is crucial for the circular economy
4. Deficits in the system for protecting children and other vulnerable populations from toxins in goods like textiles, electronics, and other consumer products, for instance
5. Combination effects are still insufficient for managing a number of exposure and toxicity-related issues, including cumulative, low-dose, and long-term exposure, neurotoxicity, endocrine disruptors, protection of children and vulnerable populations, and chemicals in goods, including waste, material recycling, and the circular economy.
6. Lack of understanding of how chemicals originate in the environment and in technology, as well as the resulting societal consequences of exposure.
7. Inadequate strategies for addressing chemical dangers based solely on persistence
8. Lack of monitoring of environmental compartments, particularly water supplies for human consumption, and the accumulation of chemical pollution and health and environmental risks
9. The requirement for stronger incentives to promote the creation of novel, non-toxic and non-chemical solutions
10. The level to which the EU needs to compile monitoring data more thoroughly and set up an early warning system.

More than a billion people worldwide are at danger of negative health effects as a result of drinking water chemical pollution. Communities with limited resources are particularly affected and confront particular difficulties that call for creative approaches to provide safe water. The only way to ensure that water is free of toxic chemicals is to prevent pollution at its source.

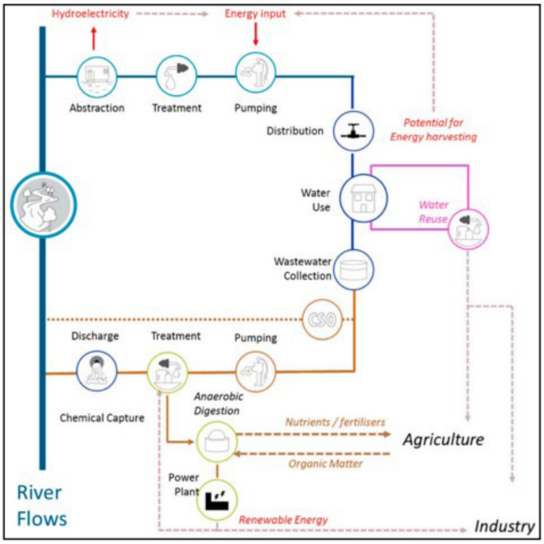

Figure 14. Simplified configuration of water systems with Inter-Sector interfaces

Full circularity is holistic as it applies all 6 R's to shut down water, energy and food source flows by integrating relevant sectors that create mutual benefit along the extended value chain.

Table 1. Definition of water-related 6R's.

Rs	Definition
Reduce	Decrease in water use
Reuse	The usage of untreated wastewater
Recycle	Utilizing cleaned wastewater in the same cycle or procedure
Reclaim	Wastewater treatment and use outside the loop
Recovery	Extraction of precious materials from wastewater
Restore	Replenish water resources with the help of artificial means

Due to their increased potential for water conservation and reuse, increased network resilience, and lower infrastructure replacement costs, decentralized water systems are typically regarded as being more sustainable than centralized systems. As demonstrated by AAT treatment for decentralized water production and circular redevelopment in a metropolitan region, while local treatment of greywater is sufficiently safe, local water production entails greater risks and expenses. The cost of repairing and maintaining water mains, on the other hand, makes different infrastructures more appealing. Green infrastructure tends to be decentralized, and their role in providing water services is well understood, although worthless.

Investing in the vitality of a basin through forest management and wetland restoration are highly successful circular solutions.

Green infrastructure can unlock the potential of the natural environment in providing:

Natural water treatment (through filtration);

Storage (for example, aquifers);

Tamponation (i.e., flood protection through reduced rainwater flow);

Recreation (for example, green areas).

They support a cost-effective, flexible approach to managing the increasing floods and droughts that come with global warming and for which grey infrastructure is not designed to cope.

Digitalization is an important part of circularity, d the term digital water or smart water, Sustainability refers to the water that is sensorized for information about flow, quality, content and temperature, and generates a large amount of data in a wide variety of formats from different sources. That is, real-time SCADA systems, smart meters, smart pipes, flow sensors, quality sensors, pressure sensors, and sensors for flow and quality. The process of digitization begins here. ICT aids in connecting various resources to develop a networked intelligent system based on this (a smart water grid). This link seems to bring numerous benefits:

1. Decrease in energy usage;
2. Avoiding needless water losses;

3. Minimizing the use of resources;
4. Aids in making informed decisions by improving the monitoring and reporting of quality, quantity, water reuse, extreme occurrences (floods, water scarcity);
5. Practice sustainable habits that make it possible for customers to understand how much water they use personally.

Heavy agricultural (pervasive pollution), industrial (spot pollution), and other pollutants carried in the water during flooding all have a negative impact on water quality. In an urban residential setting where there are few options for nature to filter and absorb surplus water, the risk of flooding and the issue of contaminants in the water are both getting worse.

Illustrates the holistic approach to smart water, supported by three dimensions: intelligent design related to the physical and legal infrastructure used to provide smart water; Smart handling is determined by the methods used to minimize and eliminate waste, known as 6Rs (prerequisites of CE), and intelligent control refers to digitally enabled applications that optimize operational efficiency and transform data into information that forms the basis of innovative solutions. In most cases it partially uses some of the 6Rs and some kind of digitalization, but almost none of them embody this holistic approach.

In order to reduce or even eliminate the impact of human activities and climate change on water resources with circular economy, and best applicable techniques (cleaner production) approaches, integrated green approach and digitalization as stated in the Green Deal need to be applied together, and for this, analyses including water, wastewater, emission and raw material efficiency are very important.

CONCLUSION

In the coming years, climate change will change the fate of chemicals in water supplies and could cause irreversible problems. Climate change will alter the interaction of chemicals, increase the uptake of chemicals by aquatic organisms, and reactivate toxic substances in bodies of water. In addition, toxic substances will reduce the capacity of aquatic organisms to adapt to climate change. Uncertainty about the extent of these impacts will create major challenges for scientists, managers and policymakers in developing effective improvement solutions. The current understanding of chemical dynamics must evolve to include the uncertainty and variability of climate change. Climate variability greatly affects the health of living things all over the world. In particular, diversity in rainfall patterns is increasing under changing climate scenarios such as rising temperatures, flash floods, severe droughts, heat waves and heavy rainfall, impacts on surface waters and groundwater resources, and water-related diseases. The water quality of recreational water bodies, such as coastal waters, is significantly affected by extreme weather conditions such as storms and typhoons, which increase drinking water pollution and cause waterborne diseases. Changes in climate have drastically altered and affected water resources, groundwater pollution, health, and subsequently human life. According to the data of the world's most water-scarce countries, Turkey is among the most vulnerable countries and is projected to become a water-scarce country by 2040. Anthropogenic pollutants that enter water supplies in various ways have become a major concern for environmentalists because of the various hazards they pose to the environment. In both the Sustainable Development Goals and the Green Deal, the approach is to prevent persistent, bioaccumulated and toxic chemicals from being present in the nature cycle. This will happen in a certain process, but action must be taken immediately. Zero waste-wastewater-emission and circular economy approach are alternative approaches to the conservation of water resources. Otherwise, we will be less likely to find usable water from water sources due to the effects of climate change. Pollutants, whose negative effects are known to have negative effects on both ecosystem and human health, will cause damage to many living things other than humans, which will adversely affect both environmental deformation and climate change. According to the policy, all industrial chemicals should be used more sustainably and safely, and the most dangerous chemicals should not be employed for non-essential social purposes. The value chain and the chemical industry's transition to a greener economy must also be actively promoted. A toxic-free environment is a goal of the Commission's Zero Pollution for Air, Water, and Land initiative, which will be unveiled in 2021 as part of the Green Deal. Chemical use benefits society in a variety of ways. A huge business potential is to make them sustainable and safe.

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POSSIBLE EFFECTS OF CLIMATE CHANGE ON WASTEWATER TREATMENT SYSTEMS AND ADAPTATION STUDIES IN BLACK SEA REGION

Ayşenur Ayan[1], Yüksel Ardalı[2*]

ABSTRACT

There is a very new awareness of the necessity of wastewater treatment in the Black Sea Region of Turkey. In addition to being a structure that includes many residential and industrial areas from east to west, which is the Black Sea coast, fisheries and marine ecosystem are used. On the other hand, until very recently, only Samsun and Ordu centers have advanced biological treatment and Zonguldak secondary treatment wastewater treatment, other provinces and districts discharge their wastewater into the sea with deep sea discharge systems. There is another danger that awaits the Black Sea region, where such a development is taking place, both deaths and economic losses increase as a result of floods and disasters due to the interaction of both environmental deformation and climate change. In addition, environmental damage will increase with the fragility of infrastructure and treatment systems. Systems for treating wastewater help civilization and make it more susceptible to the impacts of climate change. puts many communities' cleanliness and health at danger. Climate change has a number of effects on wastewater systems that can have a wide range of effects over a variety of timescales.

In this study, first of all, the direct climate-related effects on the wastewater system element (including networked wastewater systems, in-plant wastewater systems and treatment plants) in all cities in the Black Sea Region were examined. Floods and odor problems of the wastewater network, deterioration of water quality and damage to infrastructure due to uncontrolled discharges will be priority problems. More research is needed on specific processes to develop plans for effective adaptation to climate change. Our study is to systematically determine the main effects of climate change on wastewater systems and to determine the direct or indirect social, cultural, environmental and economic consequences. After these studies, infrastructure is generally the development of decision-making principles for local governments. The kind and layout of a WWTP's processes will determine how the characteristics of its effluent alter as a result of climate change. Depending on how they may adapt to changes in the quality of the incoming water (e.g., changing water temperature, water use/conservation measures and nutrient enrichment (eutrophication) and eventual reduction in the receiving environment's capacity to assimilate pollutant loads, it will have potentially adverse effects on the receiving environment.

Keywords: Wastewater, Treatment, Climate Change, Adaptation, Urban

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1. INTRODUCTION

The effects of climate change on wastewater treatment have only been the subject of a few research [3]. The majority of studies focused on problems relating to sewer operation [1, 2]. Water treatment facilities are impacted by climate change in two ways. Climate change therefore affects the activities taking place in a WWTP; more frequent extreme weather events, including floods, will increase the number of untreated sewer overflows. Water use will decrease during a drought, which could have an impact on how well wastewater treatment plants operate. Applying an impact assessment tool, monitoring wastewater treatment facilities, and using vulnerability as an effective way to identify a utility's priority climate change issues can all help to reduce the impact of climate change on WWT processes.

Climate has a big impact on wastewater treatment facilities. In some treatment methods, particularly those that are natural-based and non-mechanical, temperature is a critical factor. Warmer temperatures improve clearance rates and make it possible to use some treatment techniques. Only regions with warm climates can use some treatment methods, like anaerobic reactors, for diluted wastewater, including residential sewage [4, 5]. In areas with lower temperatures, other processes—like stabilizing ponds—might be used, but they take up considerably more space and operate worse in the winter. Due to their greater technological sophistication and level of mechanization, some processes—such as those involving activated sludge and aerobic bio-film reactors—are less dependent on temperature [6]. When WWTPs are installed in coastal or flood-prone areas, greater flooding brought on by more storms can be damaging to infrastructure. One of the most direct impacts of global warming that is already visible in stream flow records over the past several decades is an increase in rainfall frequency and intensity. It is anticipated that storms with greater intensity may result in greater flooding. Inevitably, this will lead to increased water pollution from a wide range of sources. The foremost of these are the systems for treating, storing, and transporting wastewater [5].

Global warming shock conditions, or major changes in a system's boundary conditions that happen quickly, can be used to describe associated effects on wastewater operations. Additionally, it is noted that lowering the hydraulic retention time in the treatment system during a flooding period can worsen the effectiveness of biological nitrogen removal processes and increase the TN concentration in the effluent.

2. MATERIAL AND METHODS

West of Samsun, to the south, is where you'll find Kavak WWTP. The facility was intended to have a daily flow rate of 7000m^3. The information needed to complete this study's goal can be divided into three categories: wastewater quality and quantity metrics; wastewater treatment plant information; and other required data (Layout, design, and operation details). Data on both quantity and quality were directly gathered from the wastewater treatment facility. Through a field visit to the wastewater treatment plants, information about the design, dimensions, and operation of the wastewater treatment plants was gathered.

Figure 1. Plan view of the Kavak(Samsun) wastewater treatment plant (WWTP)

Sewage treatment facilities are built to transform raw sewage into a usable final effluent and to get rid of the solids that were removed during the conversion process. The most popular biological treatment method for large cities' municipal waste waters is the activated sludge process. In order to safeguard the ecosystems that receive the treated effluents, no chemical additions are made during the whole treatment process, which is based on both physical and biological principles. Fig. 1 shows the layout of this WWTP, steps in the wastewater treatment process ; pumping, screening, removing grit and sludge, bio-p tank, aerating and biogical reduction, final sedimention, disinfection.

The values of these sampling points' summary points are displayed in tables1 and 2. Because these data points were monthly data points, a fixed input profile will be employed because we are aware of the precise parameter values.

Table 1. Kavak(Samsun) summary of treatment efficiency of observed sampling points for WWTP

Months/Parameters	COD IN	COD OUT	BOD IN	BOD OUT	SS IN	SS OUT	TP IN	TP OUT	TN IN	TN OUT
June	296	<40	127	<20	108,7	<4	2,6	1,47	29,2	12,9
July	304	<40	127,5	<20	389,4	<4	3,14	0,17	80,9	10,7
August	256	<40	106,5	<20	79,97	3,18	2,74	3,18	51,1	21,9
September	200	<40	86,5	<20	214,5	<4	2,71	1,85	64,1	5,1
October	336	<40	136,8	<20	97,5	<4	2,49	0,07	67,6	12,9
November	432	40	176,9	<20	168,8	<4	1,87	0,16	74,7	8,47
Limits(1)		125		25		35		2		5
Totel	1824	235	761,2	114	1059	27,68	15,55	6,9	368	71,9
Performance %	%87,1		%85,0		%97,4		%55,6		%80,4	

Table 2. Kavak WWTP Avarage Flow, Temperature Values (2021)

Months	$Flow_{IN}$ (Qort)	$Flow_{OUT}$ (Qort)	Temperature (°Cort)
June	1334,4	1503,3	29,5
July	1323,6	1392,2	30,5
August	1214,7	1220,5	29,9
September	1032,2	1492,1	19,4
October	1568,1	1643,0	19,5
November	1863,03	1759,1	18,6

The distinction between seasonal BOD, COD, and SS waste decontamination is shown in Fig.2. The increase in maximum and minimum temperatures where there is no change in precipitation is what is responsible for the improvement in summer removal. In contrast, BOD removal declined throughout the winter due to a decrease in precipitation and an increase in both the minimum and maximum temperatures. This can be attributed by the rise in BOD strength brought on by the decrease in infiltrating water entering the sewer. Less dilution of trash was caused by a decrease in infiltrated water. By itself, raising the temperature improves how well the wastewater is processed by the microorganisms. The pattern resembles to BOD removal with regard to COD removal (Fig. 2). The findings showed that the least impacted process by climate change is TSS elimination.

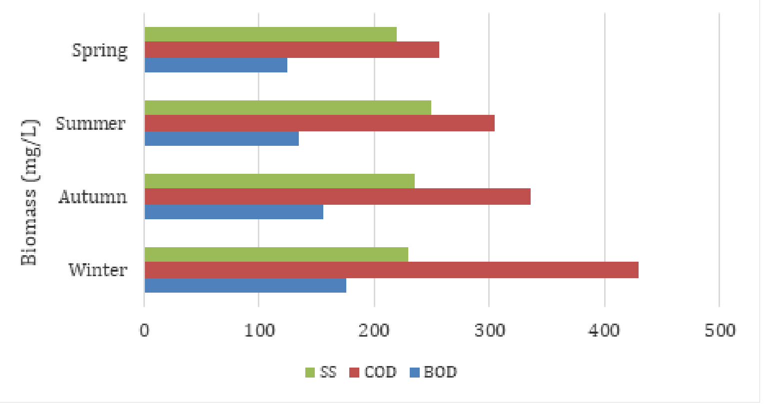

Figure 2. Seasonal variability of biomass density in Kavak (Samsun) wastewater treatment plant

3.RESULT AND DISCUSSION

Lobal climate change and rapidly increasing world population has put pressure on fresh water resources and at the forefront of these sources is treated wastewater [7].Wastewater must no longer be viewed as a problem but as a potential solution that may be used to build resilient infrastructure, increase operator financial viability and environmental quality, and deliver sustainable infrastructure services. “Water resource recovery facilities” should be used instead of “wastewater treatment plants.” Several nations have already started recovering wastewater resources, albeit haphazardly.

In this study, five quality parameters COD, BOD, SS, TN, and TP were used to evaluate the effect of climate change on the efficiency of the WWTP. The criteria that were most significantly impacted were BOD and COD, according to the results. Climate change was determined to have the least impact on SS elimination. The drop in future precipitation during the winter season is what causes the difference in WWTP performance between summer and winter in the future projection. Because less precipitation is getting absorbed into the sewer systems, there will be a high load of BOD and COD. While in the summer, just the temperature has changed as a result of climate change. Increases in temperature alone accelerate biological deterioration. One key recommendation is that urban water drainage and wastewater treatment systems be expanded and strengthened to handle the anticipated challenges brought on by extreme weather (such as floods and droughts) and sea level rise.

ACKNOWLEDGEMENT

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CLIMATIC FACTORS AFFECTING THE CHANGE IN WATER QUALITY OF THE KIZILIRMAK RIVER BASIN

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ABSTRACT

Climate change causes significant changes in the frequency, severity, spatial distribution, length and timing of extreme weather and climate events, regardless of whether they are global or regional. The potential effects of climate change, which are known to have some global and regional effects; it focuses on clean water resources, agriculture, forest, sea level, energy, human health and biodiversity. The decrease in water resources, which is one of the most important results, reaches dimensions that prevent sustainable life. The significance of water and water resources grows as a result of climate change, which has both direct and indirect effects on them. The protection of water resources depends on the establishment of a good water management system. The water management system covers a wide area from the protection and use of water resources, and from pollution after use to the purification of water again. It is also very important to examine the change in water quality while water management is being carried out. While examining the relationships between physical, chemical and biological parameters in water quality, water quality indexes were revealed by monitoring some parameters. The data of the water quality factors were used to create the water quality index. The National Sanitation Foundation Water Quality Index is the most popular and well-known water quality index (NSF-WQI). According to the data collected from the waters, a classification of the water quality is formed, and practical solutions are developed. In this study, temperature, pH, turbidity, dissolved oxygen, biochemical oxygen demand, total phosphate, total nitrate and total solids analyzes were made in surface water samples taken seasonally from the Kızılırmak River Basin between 2013-2014 and NSFWQI (National Sanitation Foundation Water Quality Index) method, the water quality index was calculated and evaluated from an ecological point of view.

Keywords: Water Quality, Climate Change, NSF-WQI, Kızılırmak River Basin

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1. INTRODUCTION

Water and climate are two ideas that are closely tied to one another. Climate change has accelerated recently and begun to manifest its impacts, posing a threat to the environment and natural balance. Rapid population growth and industrialization contribute to global warming, which worsens the balance of precipitation and, in turn, the quality of surface and subterranean water supplies.

The natural and anthropogenic factors have a significant impact on a river's water quality. The most significant human activities include those related to land usage, soil erosion, the use of agricultural chemicals, and the discharge of various wastes (Phung et al., 2015; [2]. A considerable decline in the water quality of numerous rivers throughout the world has been caused by human activities, particularly in the past 50 years [3]. Assessment of surface water quality is highly necessary due to the significance of drinking water quality for human health and raw water quality for aquatic life [4].

Traditional methods used to assess water quality are based on comparison of experimentally determined parameter values with current regulations and/or guidelines [5]. The use of Water Quality Indices, which are based on the approach of expressing different pollutant parameters and values by reducing them to a single number, created by various public and private institutions in the world in determining water quality, can provide easy and understandable results for decision makers, planners and consumers. Water quality indices are methods that significantly reduce the amount of data and make it easier to describe the status of the water quality [6]. In quality index studies, the values of water quality parameters are processed according to certain rules and are generally expressed and classified in the range of 0-100 [7].

Around the world, a variety of water quality indicators have been produced, and these indices reflect water quality in a single value by comparing several criteria in accordance with standards. Although there isn't a globally recognized measure of water quality, several nations use data on water quality to construct their own measures. This method increases the applicability of water quality indices in different regions [8].

In this study, surface water samples were collected seasonally from the Kızılırmak River Basin between 2013 and 2014 and analyzed for temperature, pH, turbidity, dissolved oxygen, biochemical oxygen demand, total phosphate, total nitrate, and total solids. Using the NSFWQI (National Sanitation Foundation Water Quality Index) method, the water quality index was calculated and assessed from an ecological standpoint.

2. MATERIAL AND METHODS

2.1. General Information About Kızılırmak River Basin

Kızılırmak, located in the eastern part of Central Anatolia, is the second largest of the 26 basins in Turkey. It is the longest river that originates in Turkey and empties into the sea in Turkey (Köse et al., 2011) and covers approximately 11% of the country's territory. The longest river in Turkey, Kızılırmak, has a length of 1,151 km and a drainage area of 78,180 km². It arises from Sivas İmranlı vicinity, passes through Samsun provinces and pours into the Black Sea from Bafra Plain [10]. The map of the Kızılırmak Basin is given in Figure 1.

Figure 1. Kızılırmak Basin [11]

A year's worth of precipitation typically falls between 300 and 800 mm, with the average air temperature being 13.7 °C. Kızılırmak is Turkey's second-largest river after the Euphrates in terms of water storage capacity. With a flow of 6.48 billion m^3 per year, Kızılırmak accounts for 3.5% of Turkey's water potential. This river's flow pattern is erratic because it is fed by snow and rainwater. The water regime flows at its lowest water level between July and February, even though its highest level is in April [12], [13].

Turkey's surface water potential is represented by the basin, which is the research region and has an annual average flow of 5,18 x 109 m^3 (2,09 L/s.km^2). By using the average usable surface water rate of 50%, the usable portion of this is calculated to be 2,59 x 109 m^3/year.

2.2. National Sanitation Foundation Water Quality Index (NSF-WQI)

NSF-WQI, developed by Brown et al. (1970), with funding from the National Sanitation Foundation (NSF), is one of the most significant and commonly used indicators [14]. The water quality indices of several seriously polluted water bodies are calculated using this index methodology.

The nine water quality criteria used in this suggested technique to compare the quality of various water sources are temperature, pH, turbidity, fecal coliform, dissolved oxygen, biochemical oxygen demand (BOD_5), total phosphate, nitrate, and total dissolved solids [15]. The weighted effect curve graph is used to transmit the water quality parameter data, from which a numerical Qi value is derived. Equation 1 contains the mathematical expression for NSF WQI [16].

$$NSF\ WQI = \sum_{i=1}^{n} Q_i W_i \quad 1$$

Here, Qi is a sub-index for the water quality parameter, Wi is a weighted average of that parameter's values, and n is the total number of water quality parameters. The charts to read the Qi values are in the book "Field Manual for Water Quality Monitoring," and they match to the concentrations of the nine factors investigated [17]. The values of the weighted effect (Wi) for the water quality parameter indicated in Equation 1 are shown in Table 1[18].

Table 1. Weight Impact Values of the Parameters Used in the National Sanitation Foundation (NSF) Water Quality Index [14]

Parameter	Weight Value (Wi)
Dissolved Oxygen	0,17
Fecal Coliform	0,16
pH	0,12
BOD_5	0,10
NO_3	0,10
PO_4	0,10
Temperature	0,10
Turbidity	0,08
Total Solids	0,07
Σ Wi	1,00

Table 2. Water Quality Values According to the National Sanitation Foundation (NSF) Water Quality Index Method [14]

NSF-WQI	Status	Color
91 – 100	Excellent	
71 – 90	Good	
51 – 70	Fair	
26 – 50	Bad	
0 – 25	Too Bad	

2.3. Study Method

The Kızılırmak Basin's boundaries were used as the basis for this study's analyses of the monthly water quality monitoring data collected from 7 station (Table 3). For the stations/ sampling points (Figure 2) designated within the study's purview, one-year water quality measures (dissolved oxygen, suspended particles, pH, BOD_5, nitrate, total phosphorus, temperature, and turbidity) were investigated. The National Sanitation Foundation Water Quality Index (USV SKI) technique was used to determine the water quality index values for each station in the study basin. The water quality classes were determined by analyzing the average of the one-year data from the stations in accordance with the limit values of the inland water resources of the Water Pollution Control Regulation.

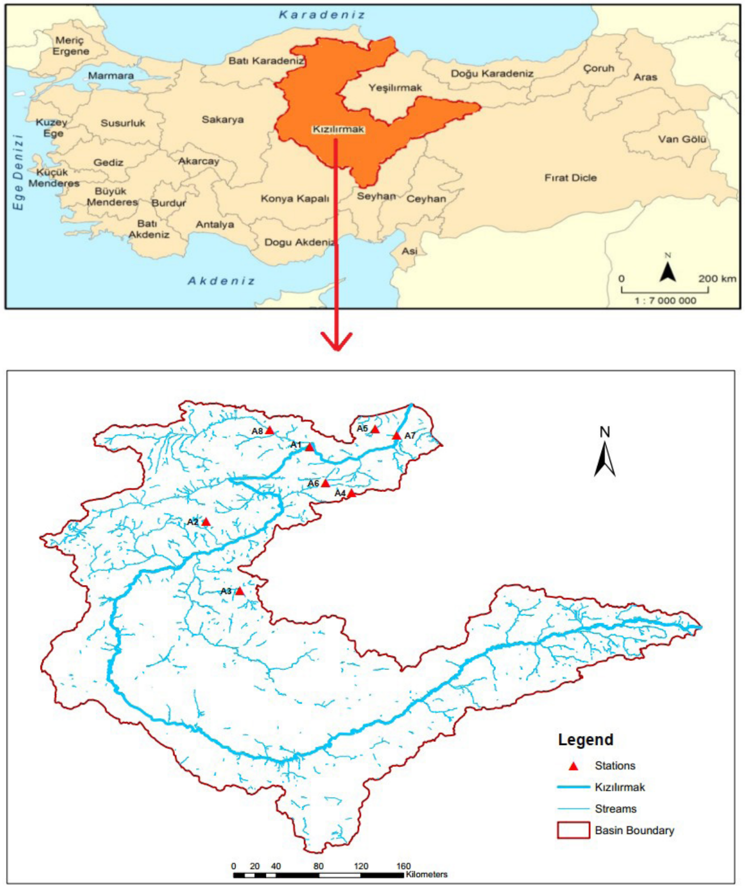

Figure 2. Sample Points and A Study Basin

Table 3. Descriptions and Coordinates of Stations

Station Number	Station Name	Coordinate (X)	Coordinate (Y)
A1	Gökırmak-Boyabat Entrance	646725	4597971
A2	Kuzguncuk Stream Corum Bayat Kunduzlu Pond Axis	602902	4511475
A3	Budaközü Stream Sungurlu Dam Axle Site	628184	4447324
A4	Taskelik Stream - Alaçam Taskelik Pond Axle Place	721130	4601346
A5	Köyiçi Stream Vezirköprü Soğucak Pond	687600	4549702
A6	Kızılırmak-Derbent Dam Outlet	736675	4595421
A7	Boyabat Dam Exit Bridge	675255	4583277

3. RESULT AND DISCUSSION

Since all available water quality data for station points are used in the model, the effects of all parameters are reflected in the results obtained. As a result of monthly monitoring studies carried out for a year, it was concluded that no other parameter exceeded the limit value except for aluminum and iron values.

3.1.NSF-WQI Modification

The National Sanitation Foundation Water Quality Index method evaluated the following parameters: temperature, turbidity, dissolved oxygen, suspended particles, pH, BOD_5, nitrate, and total phosphorus. It was once again modified as a result of the inability to gather the fecal coliform values of the nine parameters needed to calculate the NSF-WQI at the stations.

Table 4. Modified effect values (Wi) for 8 parameters according to USV-SKI

Original Impact Value			Modified Impact Value		
Number	**Parameter**	**Impact Value (W_i)**	**Number**	**Parameter**	**Impact Value (W_i)**
1	Dissolved Oxygen	0,17	1	Dissolved Oxygen	0,20
2	pH	0,11	2	pH	0,13
3	Temperature	0,10	3	Temperature	0,12
4	Nitrate	0,10	4	Nitrate	0,12
5	Total phosphorus	0,10	5	Total phosphorus	0,12
6	Turbidity	0,08	6	Turbidity	0,10
7	Total solids	0,07	7	Total solids	0,08
8	BOD_5	0,11	8	BOD_5	0,13
9	fecal coliform	0,16			
Total		**1**	**Total**		**1**

3.2. Study Results

In this study, a dataset was subjected to the NSF WQI approximation model in order to gauge the basin's current water quality. The WQI types' evaluations and outcomes are displayed in Table 5. The seven stations' WQI values do not agree well with one another. While A1, A3, A6 and A7 imply low water quality, A2, A4 and A5 suggest favorable environmental conditions. With an average WQI of 55, the stream in the intermediate water classification zone is regarded as having fair quality water in terms of average values.

Table 5. Results and Evaluations of Water Quality Index for Kızılırmak Basin

Water Quality Index			
Sampling Stations	WQI_{min}	WQI	Station-Based Evaluation
A1	31	32	Bad
A2	76	77	Good
A3	64	65	Fair
A4	73	74	Good
A5	73	74	Good
A6	31	32	Bad
A7	31	32	Bad
Average	54	55	Fair

4. CONCLUSION

We are forced to manage water resources by limiting them to their natural limits on a basin-by-basin basis, along with other natural resources like soil and air. The integrated management approach ensures accurate assessment of water potential, resource protection and development, and it has accepted the principle of not endangering the hydrological system. Integrated water resources management should be adopted in order to ensure the long-term efficiency and sustainability of existing water resources all over the world and in Turkey.

As a result, the NSF-WQI quality index was used in this study to estimate the water quality index for the Kızılırmak river basin. Since several of the stations' water quality measurements fell into the "bad" category, it was decided that the stations' water quality fell into this category. The results are observed to be compatible and realistic when the data acquired as a consequence of the NSF-WQI model application are compared with the water quality regulations in the national legislation for each parameter. Improvements in water quality can be attained by reducing the pressure on the basin to minimize pollution, reducing the amount of unintentionally and uncontrollably used chemicals in agricultural areas, finding and fixing sewage system leaks in cities, and routinely inspecting the treated water discharged from wastewater treatment facilities. It is essential to take the necessary precautions since it transports the pollutant burden from the research region to the entire basin.

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WATER QUALITY CRITERIA FOR THE EVALUATION OF TREATED WASTEWATER REUSE AS IRRIGATION WATER

Feryal Akbal[1*], Ayşe Kuleyin[2], Emre Burcu Özkaraova[3]

ABSTRACT

The inconsistency of precipitation in some regions due to climate change has put pressure on finding alternative water resources. Especially in draught impacted areas water resources management, reuse of treated wastewaters and alternative irrigation techniques has gained attention. Increasing water availability and sustainable use of fresh water resources are among the primary goals. Thus, wastewater management issues become more important to increase both reuse and recycling of water between sectors (e.g. municipal, industrial and agricultural) especially within the circular economy approach. The urge of wastewater reuse has lead to the development of water quality guidelines with respect to sectoral (e.g. agricultural and industrial) reuse. Especially for the protection of human and environmental health, water quality criteria were published by global institutions like World Health Organization (WHO) and Food and Agriculture Organization (FAO). While WHO primarily emphasis risks from pathogens and some other human health oriented threats in wastewater, FAO concentrates on irrigation water quality to sustain soil and crop health. International Standards Organization (ISO) has also published guidelines for treated wastewater use for irrigation projects (ISO 16075). To sustain crop yield and soil health, major parameters for irrigation water quality are salinity (electrical conductivity), total dissolved solids (TDS), sodium adsorption ratio (SAR), and specific ions like sodium, chloride, bor and bicarbonate. Countries relying on agricultural production have developed additional water quality criteria in order to further reduce the minimum risk level for the protection of national resources. While some countries like Spain defined up to 90 water quality parameters, France defined 6 parameters for reclaimed water with additional parameters on soil. The aim of this study is to present/summarize national and international water quality criteria as the agricultural sector represents the largest share (approximately 70%) in global water consumption.

Keywords: Water Quality Criteria, İrrigation Water Quality

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1. INTRODUCTION

The need for water has increased in the last decades with respect to population growth also driving to higher water consumptions by the agricultural and industrial sectors. It is reported that two third of the world population will face freshwater scarcity by 2025 and, that the global water demand will exceed the supply by 50% by 2050, because of both population growth and climate change [1]. The effect of climate change on water resources is expected to be the most critical one. Water quality and quantity continues to decrease in many parts of the World and concerns about the water availability increase.

New strategies involving water infrastucture and management issues are developed for sustainable water management plans in order to overcome these problems. Besides the protection and conservation of water resources, finding alternative sources such as desalination of seawater, treatment of wastewater and/or brackish groundwater are accepted as primary water management practices. Especially in semi-arid and arid regions alternative water sources are under research to overcome future water scarcity problems. Among the major alternative water sources are the reuse of treated wastewater.

The highest share (approximately 69%) in fresh water requirement is for agricultural irrigation. Thus, besides more efficient water irrigation systems, potential use of treated wastewater as an unconventional water resource is under continuous research. Wastewater has been used for irrigation since ancient times, but health related issues were always of concern. Catastrophic waterborne diseases such as cholera and typhoid fever resulted in an awareness about the need for criterias for both wastewater sanitation and disposal. Even though regulations have been implemented for proper wastewater treatment and disposal, additional criteria have been developed for the protection of soil and groundwater quality. Long term effects of treated wastewater irrigation on soil and groundwater quality have been investigated and countries with higher public concerns has set forward stringer agricultural irrigation water criteria. This paper aims to present national and international water quality criteria.

2. REUSE OF TREATED WASTEWATER FOR IRRIGATION

As freshwater resources became inadequate to meet agricultural irrigation water requirements, especially in semi-arid and arid regions. The use of treated wastewater in agriculture is an alternative practice adopted in different regions facing water scarcity, increasing water demand, and increasing urban population, especially considering the reduction in surface and groundwater resources caused by climate variability and climate change [2]. According to the World Bank (2010) [3] globally approximately one tenth of crops was irrigated with sewage water of which ten percent was reclaimed as required. According to another research more than 20 Mha of land has been irrigated by treated and/or untreated wastewater in the World [4]. This area is assumed to increase in the future. Besides overcoming water scarcity problems in the agricultural sector, irrigation with treated wastewater is also accepted as a natural reclamation technique assumed to decrease pollution in desert environments.

2.1. Environmental Impacts of Wastewater Irrigation

The impact of treated wastewaters is related to the origin (e.g. domestic, municipal and industrial wastewater), composition and treatment level (primary, secondary, tertiary etc. treatment). Various studies have been conducted about wastewater characterisation and its potential influences on receiving environments or reuse areas and purposes [4]. Wastewater constituents such as organic compounds, iron (Fe), manganese (Mn), calcium (Ca), sodium (Na), sulphate (SO_4), chloride (Cl), suspended and dissolved solids (SS and DS, respectively), pH and some toxic micropollutants may contribute to problems in general terms like precipitation, fouling, corrosion, resin blinding, biological growth, gas production [5] in reuse infratructures and deteroriation in soil and groundwater quality [6,7].

Treated domestic wastewater is assumed to supplement essential nutrients for plant growth which enables lower fertilizer requirements in agriculture, leading to a better yield without excessive chemical applications. Thus, agricultural production increases due to improved nitrogen, phosphorus and potassium levels in soil and lower consumption of chemicals. The use of appropriately treated domestic wastewater enhances soil organic matter and soil microbial activity, also leading to lower fertilizer costs. According to a study, the use of 4000 m^3/ha with a treated wastewater containing 18–60 mg/L results to an equivalent 64–248 kg/ha of nitrogen in the soil. Similarly, if the treated wastewater contains 4–66 mg/L potassium and 6–23 mg/L phosphorus results in a build up of 276 kg/ha of potash and 96 kg/ha of phosphorus in the soil [4]. Similarly, appropriately treated wastewater may be seen as potential source of alternative water especially for water-scarce regions.

However, long term direct use of untreated or unproperly treated wastewater for agricultural irrigation has also been reported to cause to impacts such as soil salinity, increased sodium concentration that prompts declining soil structure and restricted plant growth (higher sodium adsorption ratio (SAR), nutritional imbalance), surface runoff and infiltration causing to the contamination of water resources, imbalance in soil microbial communities and influence of pathogenic microorganism to public and environmental health. It should be kept in mind that unsufficiently treated wastewaters containing sewage water may have various excreted organisms like pathogens, bacteria, helminths, protozoa, viruses having the potential for causing diarrhea, cholera, gastroenteritis, arthritis, typhoid fever, hookworm infection and clonorchiasis, dysentery, amoebiasis, giardiasis and many other infectious illnesses. In order to avoid such conseqences wastewater treatments should include desenfection with UV prior to land application. Another concern exist for emerging pollutants, which are generraly not totally removed by wastewater treatment processes. These micro pollutants remaining in wastewater may be initially adsorbed by soil constituents, but released and/or leached down to the groundwater like pathogenic microorganisms especially after long-term application. General impacts of treated wastewater reuse on soil characteristics can be seen in Table 1.

Table 1. The effect of agricultural reuse on soil's physicochemical and microbiological parameters [2]

Parameter	Associated Effects on the Soil and the Environment	
	Physicochemical Properties	Microbiological Properties
pH	Increases the availability of nutrients and metals Mineralization of organic matter Improves the cation exchange capacity	Increases the richness and diversity of the microbial community
Organic matter	Soil structure stabilization Formation of aggregates Water retention Improves nutrient content Buffer Capacity Cation exchange capacity Enzymatic activity Increase in TOC Increases the availability of contaminants	Selection of specific populations and soil microhabitats
Nutrients	Increase in organic soil matter Water retention Leaching to groundwater Improves nutrient content Risk of eutrophication of aquatic environments	Perturbation of the metabolic activity of microbial soil communities
Salinity	Soil salinization or sodification Decreased stability of aggregates Changes in soil structure in the long term Permeability of soil and water retention Increased soil compaction Variation in soil pH Negative impact on soil fertility Dynamics in organic and inorganic compounds Heavy metal leaching	Changes in soil microhabitats and variation in the richness and diversity of the microbial community
Contaminants	Soil toxicity and leaching Accumulation in soils Negative impact on soil fertility Potential contamination of the food chain Mineralization of organic matter Changes in enzyme activity Decomposition of fallen leaves Limiting soil fertility	Increased tolerance to microbial contaminants. Antimicrobial resistance. Reduction of microbial biomass and changes in its structure

Wastewater is generally produced over years and similarly irrigation water requirements continue for agricultural production. Thus, the use of treated wastewater for agricultural irrigation is performed with long-term applications. In order to understand the environmental impact of treated wastewater reuse monitoring for a longer time is very important as influences may show up after environmental buffering capacities exhaust. Therefore, the treatment stage (primary, secondary, tertiary) of wastewater is an important responsibiliy before taking decisions for other strategic plans.

2.2. Wastewater Treatment for Reuse

Most guidelines include recommendations for wastewater treatment levels (e.g. secondary, and tertiary treatments). Considering wastewater characteristics and specific criteria or limit concentrations set for the reuse, required removal efficiencies for each water quality parameter and the sequence of wastewater treatment unit are determined. The wastewater treatment processes, including the primary, secondary, tertiary, and advanced treatments are demonstrated in Figure 1. Primary treatment is generally not suitable for reuse but may be used for low-strength wastewater for the removal of total suspended solids (TSS). Secondary treatment aims organic carbon removal by treatment methods based on biological oxidation such as activated sludge, sequencing batch reactors, membrane bioreactors, and stabilization ponds. The reclaimed wastewater can be used for the irrigation of non-food crops, stream augmentation, and groundwater recharge to prevent saltwater intrusion. Tertiary treatment is used for the removal of nutrients such as nitrogen and phosphorus by biological or chemical methods and suspended solids by coagulation/flocculation and chemical precipitation. The treated wastewater can be used for the irrigation of food crops, unrestricted recreational areas, impoundment, etc. Recent studies demonstrate that secondary and even tertiary treatment techniques are ineffective in removing micropollutants (e.g. pharmaceuticals, personal care products, pesticides, and industrial chemicals, etc.). Thus, wastewaters containing dissolved salts, heavy metals, and micropollutants generally require advanced treatment techniques such as activated carbon adsorption, ion exchange, advanced oxidation processes, and membrane processes. All treatment sequences should eventually end with disinfection to avoid risks from pathogenic microorganisms [8,9].

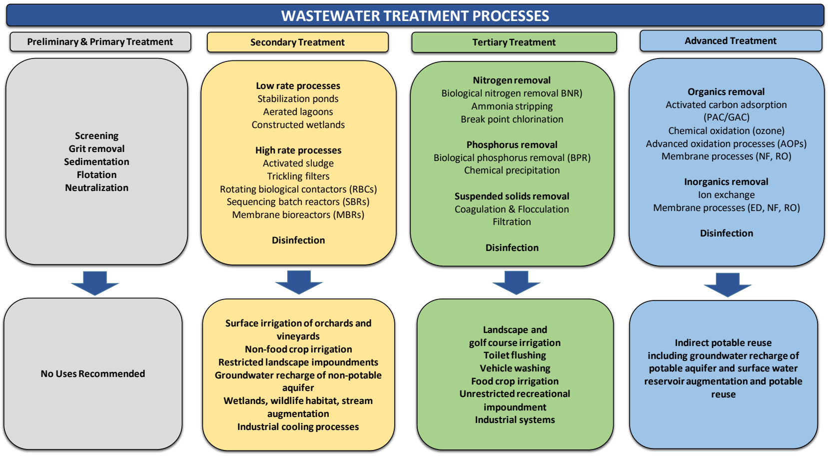

Figure 1. Wastewater treatment for different reuse purposes [10].

2.3. Wastewater Reuse Criteria

The agricultural sector is expected to be the most effected sector by climate change, requiring alternative water resources to meet future needs. Within this regard, wastewater characterization and sufficient treatment to ensure the protection of soil and water resources is most serious. Countries that rely on agricultural production, have therefore developed national guidelines and/or regulations. Some other countries have adopted criteria and standards developed by the guidelines of the World Health Organization [11], Food and Agriculture Organization of the United Nations [12] and International Standard Organisation (ISO) for the reuse of wastewater for agricultural irrigation. The major aim of all guidelines is human and public health while reusing the wastewater for restricted or unrestricted irrigation and raw consumed food crops, processed food crops and non-food crops [10]. The WHO Guideline is based on microbial health risk additionally containing some maximum permissible soil concentrations of toxic pollutants. The FAO Guideline is based on irrigation water specific wastewater quality criteria and limit values for parameters to sustain soil and crop health. The primary criteria of concern of all guidelines and standards is always related to the pathogens. As the WHO guideline includes details about pathogens, other guidelines and standards briefly define *E. Coli* or *Fecal Coliform* as the indicating parameter. Other important parameters related to crop yield and soil health used during the evaluation are salinity (electrical conductivity), total dissolved solids (TDS), sodium adsorption ratio (SAR), and specific ions like sodium, chloride, bor and bicarbonate. Biochemical oxygen demand (BOD), total suspended solids (TSS), pH and heavy metals are also used during the assessment of criteria. Depending on the sensitivity of country and or region the number of wastewater quality parameters is increased for a more detailed investigation by the competent authorities of countries. While Spain defined up to 90 parameters, France defined 6 parameters for reclaimed water with additional quality parameters on soil and sludge [13,14] represented the differences in water quality criteria for wastewater reuse in agriculture in Table 2.

Table 2. Irrigation water quality guidelines and standards for wastewater reuse in agriculture.

Parameters	South Korea [1]		WHO [2]		US EPA		Cyprus [3]		France		Greece		Israel [4]	Italy	Portugal		Spain	
Coliform (/100 mL)	Food Crops	ND TC	Unrestricted	*E. coli* (cfu) ≤ 1000	Food crops	ND FC (median)	Cooked vegetables	FC (MPN) ≤ 100	Unrestricted	*E. coli* (cfu) ≤ 250	Unrestricted	*E. coli* (cfu) ≤ 5 (80%) ≤ 50 (95%)	FC (cfu) ≤ 10	*E. coli* (cfu) ≤ 100 (max) ≤ 10 (80%)	Vegetables consumed raw [(a)]	FC (cfu) ≤ 100	Uncooked vegetables	*E. coli* (cfu) ≤ 100
	Processed food crops	TC (MPN) ≤ 200	Restricted	*E. coli* (cfu) ≤ 10,000	Processed food crops	FC (cfu) ≤ 200 (median)	Crops for human consumption	FC (MPN) ≤ 1000	All crops except those consumed raw	*E. coli* (cfu) ≤ 10,000	Restricted	*E. coli* (cfu) ≤ 200 (median)			Cooked vegetables	FC (cfu) ≤ 1000	Crops for human consumption	*E. coli* (cfu) ≤ 1000
Turbidity (NTU)	Food crops	≤2	–[(b)]		Food crops	≤2 (average)	–		–		Unrestricted	≤2 (median)	–	–	–		Uncooked vegetables	≤10
	Processed food crops	≤5			Processed food crops	–					Restricted	–		–			Crops for human consumption	–
Suspended solids (mg/L)	–		–		Food crops	–	Cooked vegetables	≤15	Unrestricted	<15	Unrestricted	≤10 (80%)	TSS ≤ 10	TSS ≤ 10	TSS ≤ 60		Uncooked vegetables	≤20
					Processed food crops	TSS ≤ 30	Crops for human consumption	≤45	All crops except those consumed raw	Varies [(c)]	Restricted	≤35					Crops for human consumption	≤35
BOD (mg/L)	≤8		–		Food crops	≤10	Cooked vegetables	≤15	–		Unrestricted	≤10 (80%)	≤10	≤20	–		–	–
					Processed food crops	≤30	Crops for human consumption	≤30			Restricted	≤25					–	–
COD (mg/L)	–		–		–		–		Unrestricted	<60	–		≤100	≤100	–		–	
									All crops except those consumed raw	Varies								
Odor	Do not unpleasant		–		–		–		–		–		–	–	–		–	
T-N (mg/L)	–		–		–		–		–		–		≤25	≤15	–		–	
T-P (mg/L)	–		–		–		–		–		–		≤5	≤2	–		–	
Intestinal nematodes (No./L)	–		≤1		–		ND		–		–		–	–	≤1		≤1(/10 L)	
pH	5.8–8.5		–		6.0–9.0		–		–		–		6.5–8.5	6.0–9.5	6.5–8.4		–	
EC (µs/cm)	Food crops	≤700	–		–		–		–		–		≤1400	≤3000	≤1000		–	
	Processed food crops	≤2,000																

ND = not detected; TC = total coliform; FC = fecal coliform; TSS = total suspended solids. [1] Standards for direct wastewater reuse. [2] The most stringent verification monitoring level, which refers to what has previously been referred to as effluent guideline levels, for each irrigation type and arithmetic mean value. [3] For vegetables eaten raw is not allowed and maximum value allowed. [4] Maximum monthly averages for unrestricted irrigation. [(a)] Vegetables whose edible parts are in close contact with the irrigated soil are not included and drip irrigation can be only employed. [(b)] No recommendation. [(c)] In accordance with wastewater treatment standards.

3. CONCLUSION

Deterioration in water quality and reduction in the accessibility to water resources has been accepted as a major problem for a long time. However, high growth in population and consequences of the climate change seems to increase clean water availability problems in future. With respect to the United Nations World Water Developing Report [15], more than fifty percent of world population will face water scarcity in future. The need for alternative water resouces like treated wastewater seems to be unavoidable. The use of wastewater for agricultural irrigation has been carried out since some while. Soil and water quality assessment data reveiled that insufficient treated waters leads to health risk related issues due to pathogens and other unwanted water constituents. So, to protect the human health and the environment (soil and water resources) it is proposed to look intially to the wastewater and soil characteristics and chose the most appropriate wastewater treatment scheme complying national and international water quality criteria.

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INDENTIFICATION OF CLIMATE CHANGE VULNARABILITIES AT LOCAL LEVEL AND ASSEMENT OF ADAPTATION MEASURES

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ABSTRACT

Climate change, which is caused by anthropogenic activities, is the most existential challenge faced by the humankind. It has perpetual effects on ecosystems and living organisms around the world in many ways (i.e. extreme weathers, droughts, rising sea levels and melting glaciers). It has potential for serious economic and social adversities in the medium and long term. Therefore, mitigating effects of climate change and adapting to the change is of outmost importance. Nowadays, building resilient cities are at the heart of adaptation strategies. However, the process is challenging and burdensome for governments and local authorities in developing countries with high urbanization rates, as relevant measures have potential for decelerating economic growth in the short run and exasperating social problems such as unemployment, if not designed inclusively taking account social justice. To build resilient cities with high absorption to future shocks against the effects of climate change and which are inclusive and take into account equity, one of the first steps is identifying urban-specific vulnerabilities considering principles laid out in climate justice paradigm. As an endeavour towards this end, referring to current framework for identification of vulnerabilities, specifically social vulnerabilities, we put forth a preliminary road map for local authorities in Türkiye to identify the social vulnerabilities in their cities.

Keywords: Climate Change, Mitigation and Adaptation Studies, Vulnerability Indicators, Social and Urban Inequalities, Climate Justice

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1. INTRODUCTION

Population growth, industrialisation and technological developments threaten world's resources and environment in various ways. Caused by anthropogenic activities, [1,2] climate change is the most prominent existential crisis for the humankind and ecosystems all over the globe. Greenhouse gasses emitted, especially consequent to burning of fossil fuels, traps sun's heat in the atmosphere creating greenhouse effect which leads tocontinuing changes in world temperature and weather patterns. Climate change manifests itself through extreme weathers, droughts, rising sea levels and melting glaciers etc. Apart from the apparent adverse health and wellbeing effects for individuals and societies, climate change also has both immediate and long run economic and social impacts.

Mitigation and adaptation to climate change is a serious challenge for governments and local authorities specially in developing countries with high urbanization rates because it directly threatens to reduce economic growth in the short run and bring about related adverse social impacts and increase vulnerabilities of the cities [1,2]. Nonetheless, the economic cost of reducing greenhouse gas emissions or adaptation efforts would be much lower than the cost of the damage caused by climate change [3,4].

Cities, as one of the major contributors to climate change [5] and home to more than half of the global population [6] and projected to harbour two thirds of the population by 2050 [7], is at a unique position to be at the forefront in strategies and actions vis-à-vis the climate change. Cities can provide creative solutions regarding mitigation and adaption, serving multiple purposes. For instance, widespread and equitable adoption of green solutions, such as green spaces and city forests [8] in cities would not only decrease greenhouse emissions but also would yield to positive health effects both for the individuals and communities as a whole [9,10], provided that measures to evade gentrification is taken. Similarly, efforts to fight energy poverty with neighbourhood-based retrofitting programs to increase energy efficiency would also serve the aim of mitigation [11,12].

In effect, cities need to build their resilience, while taking into account equity between social groups. They should be able to foresee and be prepared to respond challenges imposed by the climate change. One of the first steps in building resilience and, in general, is to define the urban-specific vulnerabilities in cities, taking also into account social dimensions. Indeed, it will not be the only infrastructure or superstructure that would be harmed from extreme weather conditions, but also whole communities would be adversely affected in various ways. Drawing on the experiences of the Covenant of Mayors, this conference proceeding concentrates on the social dimension of vulnerability and risk assessment and discuss the process within the scope of climate justice paradigm.

1.1. Mitigation, Adaptation and Resilience

Adaptation and mitigation are the two main strategies vis-à-vis climate change. Mitigation refers to all actions and activities relating to the reduction or prevention of emitting of greenhouse gases. Mitigation focuses on the causes of climate change. On the other hand, adaptation concentrates on the impacts and encompasses all efforts for curtailing vulnerabilities imposed by the climate change [2]. On the other hand, resilience refers to the capacity to withstand the effects of climate change and recover with little outside help [13]. Increasing resilience of cities is often taken in hand in the general framework of adaptation to climate change [14-15].

Mitigation is defined as "reduction of climate altering pollutant concentrations" [16]. Mitigation activities involves different low carbon strategies as well as enhancing CO_2 sink for reducing GHG emissions. Some of the activities to reduce GHG are:

- Reduction of all type of anthropogenic emissions of GHG
- Reduce the use of fossil fuels
- Improved energy efficiencies and reduced consumption
- Energy efficient buildings
- Using renewable energy supply
- Reducing the use of private vehicles and increasing public transit, bike, electric vehicles and walking
- Carbon tax [17].

As simply put forward by Fankhauser (1996) adaptation strategies aim to attenuate the negative effects of climate change [18]. In this regard, among many others, adaptation programs and measures involve changing people's attitudes and actions, influence decision making process, developing new technologies as well as lessen exposure. In line with IPCC, adaptation activities can be categorized under three main headings namely, "social adaptation activities", "institutional adaptation activities" and "physical and structural adaptation activities" [19]. Some of the adaptation activities include

- Providing secure facility locations and infrastructures
- Reforestation and landscape efforts
- Supporting and enhancing biodiversity
- Suitable cultivation for extreme events
- Designing favourable agricultural technologies
- Developing cooperatives
- Setting up emergency services [1,2,19]

Terms of resilience can be described as to build a capacity to absorb shocks and recovery in a short time. Therefore, city should strength urban resilience to handle with the future shocks due to climate change resulting successful adaptation strategies in the city [20].

1.2. Definition of Urban-Specific Social Vulnerabilities for Building Resilient Cities: European Experience and Beyond

1.2.1. Climate Adaptation Plans and Covenant of Mayors - Europe

As cities are at the forefront of the mitigation and adaptation strategies vis-à-vis the climate change, bottom-up approach has been gaining importance in adaptation strategies. This has been especially true in Europe. Started in 2008, Covenant of Mayors for Climate & Energy-Europe (CM Europe), has 10962 signatories, of which 51 is from Türkiye as of October 2022 [21]. As voluntary participants, signatory cities (local government/municipalities) made a pledge to exceed commitments made at national level in terms of energy objectives and climate change mitigation and adaptation [22]. The signatories are required to develop local climate action plans [23] within two years of adhesion to the covenant [24]. 15 of signatories from Turkey have prepared local sustainable energy and climate change action plans as of October 22 [25]. The action plans lay out how cities will reach their commitments by 2030 within specified time frames with assigned responsibilities [26]. Through European Climate Adaptation Platform Climate (ADAPT)[27], and guidebooks cities are supported in adaptation efforts and drawing up their action plans. In this respect, Urban Adaptation Support Tool of CM Europe identifies six steps. These are "(1) Preparing the ground for adaptation, (2) Assessing climate change risks and vulnerabilities, (3) Identifying adaptation options, (4) Assessing and selecting adaptation options, (5) Implementing adaptation and (6) Monitoring and evaluating adaptation" [28].

As preliminary steps in plan preparation, cities are to carry out risk and vulnerability assessments, where they are to identify pertinent climate hazards and vulnerabilities at their locality. This assessment is recommended to include sub section such as expected weather and climate events, vulnerabilities, expected climate impacts in the locality as well as assets and people are at risk [26]. These assessments are crucial, as only with sound and inclusive risk and vulnerability assessments, successful plans that do not leave anyone behind can be prepared.

Covenant of Mayors follows IPCC [29] on the definition of risks. In this regard, CM defines risks in the intersection of hazards, vulnerabilities, and exposure. Hazards are adverse physical effects of climate change. Vulnerabilities are taken as "sensitivity to harm" as well as lack of system's adaptation capacity because of occurrence of hazards and relates to biophysical and socio-economic attributes. Exposure is "thepeople, livelihoods, environmental services and resources, infrastructure, economic or cultural assets" that have likelihood to be negatively affected by the hazards [26].

The process of risk and vulnerability assessment recommended has two distinct approaches from which the city authorities to select. The first one rests on spatially impact models and the second one rests on indicator-based vulnerability assessment. Both approaches encompass a participatory approach and establishing of Advisory Group from stakeholders (representatives from civil society organizations, academia and private sector). The first approach is more technically sophisticated compared to the second one. In both approaches, based on expected climate hazards that could hit the cities, cities are to identify the infrastructures, super structures and people to be affected at various scales [26].

While participatory approach in both approaches is central to making sure that social dimension is integrated, it is not sufficient to only invite handful stakeholders to voice their opinions. Both approaches for vulnerability assessment include using of socio-economic data for the analysis. In the first approach the guide makes a specific reference to distinguishing between vulnerable groups considering the way that they are affected from different hazards. In this regard the guide recommends developing vulnerability for each hazard. Income level, population living in slums, education level, health status, age and access to resources and basic services are uttered as some of the indicators for identifying vulnerabilities. Similarly, second approach refers to social vulnerability indexes developed for different climate events and/or hazards [26]. Furthermore, Urban Adaptation Support Tool of the CM includes social wellbeing among urban sectors that are vulnerable. It also specifies impacts of the hazards on "health, workforce, communities and lifestyles" [28]. While the documents give hints of just adaptation, they do not describe in sufficient detail how to achieve it.

1.2.2. Climate Justice and Climate Action Plans

The basic tenant behind climate justice paradigm is that those who contribute the least to climate change is affected the most [30]. The paradigm includes three dimensions, namely distributive justice, procedural justice, and recognition justice. Procedural justice relates to the decision making, its inclusiveness, transparency, and fairness. It concerns that the needs, aspirations, capacities, and characteristics of various groups, including the most marginalized are reflected to the decision making and its outcomes thereof. Distributive justice concerns distribution of burdens, benefits, resources, opportunities as well as evasion of hazards and risks among groups, countries, stakeholders, etc. Recognition justice is about whether certain people, groups and communities are "visible" or "invisible" in the decision framework. [31-33].

As vulnerable communities and groups in the cities are expected to be disproportionately affected by the climate change [34,35], an approach incorporating climate justice is needed in climate action plans. Despite a lack of comprehensive guidance on the social dimension of ensuring just adaptation, the notion of just adaptation in the cities are increasingly gaining importance.

In the early studies cities' climate adaptation plans have been found to be unresponsive to climate justice. For instance, Birsley et. al. (2012) finds that climate justice is not adequately integrated to adaptation plans in the UK [36]. Similarly,McManus, Shrestha and Yoo (2014) provides evidence from Australia that the low-income and disadvantaged groups were not able to provide input to the planning process [37]. In a wider study, analysing data from 100 cities all over the globe, Bulkeley et. al. (2013) finds that while concern regarding climate justice is found to be limited at city level, cities in the global south and global north have differentiated responses to climate justice within the scope of their mitigation and/or adaptation projects and interventions [38]. Those in the north are mainly concentrated on distribution of rights. Those in the south dealt with both distributive justice and procedural justice. Based on the data of 31 cities, Fitzgibbons and Mitchell put forth that the cities in their sample approached equity issues and climate justice unsystematically and that disadvantaged groups were not given enough active voice in their strategies and even some embodied mechanism negatively affecting disadvantaged communities. On the other hand, at a recent study analysing the data of 902 European cities,Yang, Lee & Juhola (2021) put forth that the vulnerable groups, at least old adults, influenced the adaptation plans [39].

1.2.3. Ensuring Strong Social Dimension Within Vulnerability and Risk Assessments That are Just

A just adaptation needs to converse with social factors [40] and take into account inequalities. Foremost, in line with principles of recognitional justice, local authorities should recognize past and present inequalities in the society and should take precautions not to strengthen these inequalities [41,42, 32].

As sound adaptation actions arise from sound risk and vulnerability assessments, these assessments should incorporate strong social dimension. The backbone of this dimension would be strong participatory approach for several reasons, among which are building local ownership of action plans and complexity of issues. Accordingly, only with strong participatory approach and inclusion of diverse experiences, knowledge and views of all social groups a just and comprehensive action plan can be prepared. Specifically, vulnerable groups should themselves be able to identify their needs and map their vulnerabilities [43], as they are in the possessions of best knowledge concerning their own circumstances and capacities.

Inclusion of residents, non-governmental organizations as well as relevant other civil society actors in the planning process from the beginning is a way to move forward with procedural justice [44]. The coverage must be as wide as possible so that all social groups and communities, especially those that are disadvantaged and vulnerable are represented.

The participatory approach to be implemented, has to go beyond sporadic information and consultation [32]. In line with the Pörtner et al. (2022) recommendations, it has to be collaborative and regular [45]. Holland (2017) stresses that vulnerable groups should be able to shape the decisions in line with their interest [46]. In this regard inequalities in the pollical decision making regarding socio-economic divides should be addressed. As the capacity for fair representation of these groups are low, they should be empowered to contribute to the process. Their capacity for meaningful participation should be built and related finance should be supplied. Their access to climate related information and knowledge concerning the process of climate change should be improved [44].

In mapping risk and vulnerabilities, certain indicators are frequently considered, among which are age, ethnicity, gender and socio-economic status [47] are the most frequently used indicators. Based on an extensive review Tapia et. al. (2017) categorizes vulnerability indicators. Those that relate to social dimension of vulnerability assessments at local level are demographic structure, health status, education and skill level, minority/ethnicity composition, gender status, socio-economic conditions, existence of risk transfer skills, housing status, access to technology and infrastructure and their status [48].

Beyond these indicators, a qualitative account of the needs and deficiencies might assist in providing holistic picture. In this qualitative account, the concept of social vulnerability should consider the capacity of various groups to prepare for, respond to and recover from hazards [36,40]. Accordingly, deficiencies in this capacity should be identified. Furthermore, social networks and social characteristics of neighborhoods [40] should be taken account. Moreover, as building resilient cities that are inclusive and equitable requires strengthening vulnerable groups' access to services, infrastructure and livelihoods [49], shortcomings in their effective access should be identified, especially with regards to social services as well as protective infrastructure [50]. Above all, as disadvantages and risks tend to cluster [51] around already vulnerable communities, these disadvantages need to be prioritized [43].

Risks and vulnerability assessments should not be taken as a one-time assessment. As vulnerability is a dynamic process, which changes over time [36], vulnerable group's situation and related assessments should be reviewed periodically [32], so that adaptation plans can respond to changing circumstances.

2. CONCLUSION

Climate change is the prominent existential challenge faced by the humankind and ecosystems all over the world. While mitigation and adaptation plans and programs are underway at national level, cities have been becoming increasingly major agents of mitigation and adaptation. Building resilient cities has become a major agenda item. Many initiatives and networks support and encourage cities in this respect. Covenant of Mayors-Europe is one of the most active and successful networks supporting their members to reach their climate objectives through series of tools.

Recently, discussions regarding climate justice have been gaining importance. With these discussions, social dimension of climate mitigation and adaptation has been becoming an area that the cities try to tackle especially with regards to just adaptation. However, the tools present are not comprehensive enough guiding the cities in building a strong social dimension which considers climate justice. Against this background this conference proceeding tries to put forward a preliminary road map for the cities to integrate strong social dimension to their risk and vulnerability assessment of their climate action plans.

Accordingly, to take a step forward for just adaptation, cities need to recognize inequalities present in the society and take precautions not to exasperate these inequalities. They also need to build a strong participatory approach where vulnerable groups do not only voice their opinions, but also shape the decisions taken. Accordingly, inequalities in the decision making regarding the plans need to be addressed and the capacity of vulnerable group's should be built to guarantee their meaningful participation. In mapping risks wide range of social vulnerability indicators should be used of. However, beyond these indications qualitative account of the needs and deficiencies regarding all social group's capacity and tools to prepare for, respond to and recover from hazards should be prepared. In doing so, social networks and social characteristics of neighbourhoods should be considered. Above all, addressing the disadvantages of vulnerable groups needs to be prioritized. Furthermore, as vulnerability is a dynamic process, vulnerability and risk assessments need to be regularly updated following the strong participatory approach built.

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TREATABİLİTY OF LEACHATES; THE CASE OF SAMSUN

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ABSTRACT

Leachate is a dangerous liquid mixture for the environment and human health, consisting of a high percentage of organic and inorganic pollutants formed from rainwater leaking from solid wastes, natural moisture and biochemical reactions occurring in wastes. This study discussed leachate treatment methods, and experimental studies with leachate samples obtained from Samsun Solid Waste Sanitary Landfill were evaluated within the Water Pollution and Control Regulation framework. The literature research and the results obtained in this study revealed that a single method is insufficient to treat leachate, and several methods should be used together to provide the recommended discharge standards.

Keywords: Hazardous Waste, Landfill, Leachate, Treatment

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1. INTRODUCTION

Leachate waters are characterized by high chemical oxygen demand (COD) and biochemical oxygen demand (BOD), heavy metals and hazardous chemical compounds [1]. Therefore, leachate management gains importance due to the adverse effects of leachate on the environment and the difficulty of treatment. Pollutants in the composition of leachate can be characterized into four main groups. These are dissolved organic substances (DOS), inorganic substances, xenobiotic organic compounds (XOC) and heavy metals. The main components of dissolved organic compounds are parameters such as COD and BOD_5. The dissolved organic matter class also examines compounds such as acids, alcohols, and volatile fatty acids. Ammonium, bicarbonates, calcium, chloride, iron, magnesium, potassium, sodium, carbonates, cyanide, nitrate, nitrite, and sulfate can be counted among the inorganic components. Xenobiotic organic compounds are generally produced by the use of domestic and industrial chemicals. These pollutants include various aromatic hydrocarbons, phenols, pesticides, etc. Arsenic, cadmium, chromium, copper, lead, mercury, zinc and nickel are the most common heavy metals [2].

On the other hand, although there are many toxic components in the leachate composition, ammonia has been identified as the most important. In addition, ammonium nitrogen may continue to occur for many years, even after the landfill is closed. This can initiate algae growth due to excess nitrogen in water bodies. Thus, the amount of dissolved oxygen in the receiving water environment may deplete due to eutrophication [2]. Biodiversity and food chains can be adversely affected if leachate seeps into groundwater. In addition, infiltration of leachate into groundwater can change the pH of groundwater and cause metal dissolution [3]. For all these reasons, the leachate must be treated with appropriate methods before it is released into the receiving environment.

2. TREATMENT OF LEACHATE

Leachate treatment methods vary depending on the age of the leachate and discharge standards. While biological processes are preferred for treating young leachate, physicochemical processes have been found to be more efficient in treating stabilized leachate [3,4].

2.1. Biological Treatment

Biological treatment processes are widely used in the treatment of leachate containing high amounts of organic matter. In case of high biodegradability in leachate (BOD/COD >0.4), biological treatment is recommended. Biological processes can be examined in two groups aerobic and anaerobic processes. Under aerobic conditions, microorganisms reduce organic compounds to carbon dioxide and water, and under anaerobic conditions to biogas [5]. Aerobic and anaerobic processes have advantages and disadvantages compared to each other. For example, while aerobic treatment has advantages such as ease of operation and involvement in the process when necessary, anaerobic treatment has advantages such as landfill gas formation, sludge production and less energy requirement [6].

2.2. Physico-Chemical Treatment

Physico-chemical treatment processes are used in case of low biodegradability. Various pollutants such as suspended solids, colloidal particles, color and toxic compounds can be removed by physicochemical methods [7].

2.2.1. Coagulation-Flocculation

The coagulation-flocculation process is the removal of non-biodegradable organic compounds and heavy metals from leachate by the addition of chemical coagulants. Aluminium sulfate, ferrous sulfate, and iron (III) chloride are the most commonly used coagulants [1]. In the literature, some of the studies carried out by the coagulation-flocculation method from leachate are given below:

Loizidou et al., 1992, obtained 39% COD removal in their study of COD removal from leachate by coagulation-flocculation method (COD entry: 4000-8810 mg/L, BOD/COD: 0.15, Coagulant: $Ca(OH)_2$ + $Fe_2(SO_4)_3$)[8].

Papadapoulos et al., 1998, obtained 42% COD removal from leachate (COD inlet: 6000-8200 mg/L, BOD/COD: 0.11-0.17, coagulant: $Ca(OH)_2$ + $Fe_2(SO_4)_3$) [9].

2.2.2. Chemical Precipitation

Chemical precipitation is a pre-treatment to remove NH_4-N from leachate [1]. This method removes heavy metals, non-biodegradable organic compounds, and inorganic compounds [7]. The method's advantages include its simplicity andlow capital cost, while its disadvantages are sensitivity to pH, low COD removal efficiency and excessive sludge formation.

In the literature, some studies carried out by chemical precipitation from leachate are as follows: Baig et al., 1999, in the study of COD removal from leachate by chemical precipitation (COD inlet: 1585 mg/L, BOD/COD: 0.07, pH: 8.2, chemical precipitator used: $Ca(OH)_2$: 1g/L) obtained 27% COD removal [10].

Ozturk et al., 2003, achieved 50% COD removal in their study (COD entry: 35000-50000 mg/L, BOD/COD: 0.5-0.6, Mg:NH_4:PO_4: 1:1:1) [11].

2.2.3. Adsorption

The adsorption method is a mass transfer process in which a substance is transferred from the liquid phase to the surface of a solid through physical or chemical interactions. It is widely used in the removal of heavy metals and resistant organic compounds from leachate. Powder-activated carbon and granular-activated carbon are commonly used adsorbents [5]. Activated carbon adsorption is effective in removing ammonium nitrogen from leachate samples. It has also been reported that powdered activated carbon increases the biological treatment efficiency of leachate [3]. In the literature, some of the studies carried out by the adsorption method from leachate are as follows:

Kargi et al., 2003, obtained 38% COD removal in their COD removal study (COD inlet: 9500 mg/L, pH: 7, used adsorbent: powdered activated carbon: 2 g/L) by adsorption method from leachate [12]. Heavey, 2003, with a similar study (COD inlet: 625 mg/L, BOD/COD: 0.3, pH: 7.9, adsorbent used: peat) obtained 69% COD and 99.5% NH_4-N removal from leachate [13].

2.2.4. Membrane Filtration

A membrane is defined as a material that can selectively resist the movement of different components of a liquid and create a thin barrier by separating the components. Membrane filtration removes bacteria, viruses, particles and organic matter. Major membrane filtration techniques used in leachate treatment include microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO). Some factors that affect the appropriate membrane selection in leachate treatment are pH, pollutant type and concentration, and temperature [5]. In the literature, some of the studies carried out by the membrane filtration method from leachate are as follows.

Bohdziewicz et al., 2001, obtained 50% COD removal in their study of COD removal from leachate by ultrafiltration (UF) method (COD inlet: 1660 mg/L, pressure (p): 3 bar, velocity: 2.5 m/s) [14]].

2.2.5. Air Stripping

Air stripping is a method used to remove high concentrations of ammonium nitrogen (NH_4-N) in leachate composition [1]. The practical application of this method depends on the following factors: (1) alkaline pH and (2) treating the polluted gas phase with H_2SO_4 or HCl (Renou et al., 2008). Some of the studies carried out by the air stripping method from the leachate are as follows: Marttinen et al., 2002, in the study of NH_4-N removal from the leachate by the air stripping method (NH_4-N inlet: 150 mg/L, pH: 11, temperature: 20^{o}C, experimental time:24 hours) obtained 89% NH_4-N removal. [15] Silva et al., 2004, obtained 99.5% NH_4-N removal in their NH_4-N removal study from leachate (NH_4-N inlet: 800 mg/L, experiment duration: 120 hours) [16].

2.3. Electrochemical Treatment

Electrochemical purification processes are based on transferring electrons between the electrodes and the electrolytic solution by applying an electrical field between the anode and the cathode in an electrochemical cell. Electrochemical processes have attracted attention in recent years due to their versatility, environmental friendliness and ease of use. Electro-Fenton and photo-electro-Fenton methods are among the commonly used electrochemical techniques in leachate treatment [5].

2.3.1. Electro-Fenton Process

Fenton reaction was first discovered by Fenton in 1984 and is based on electron transfer with hydrogen peroxide (H_2O_2) catalyzed by iron (Fe^{2+}) [17]. Basic Fenton reactions are given below [18].

$$Fe^{2+} + H_2O_2 \rightarrow OH^{\bullet} + OH^{-} + Fe^{3+} \tag{1}$$

$$H_2O_2 + OH^{\bullet} \rightarrow H_2O + HO_2^{\bullet} \tag{2}$$

$$HO_2^{\bullet} + Fe^{3+} \rightarrow Fe^{2+} + H^{+} + O_2 \tag{3}$$

$$HO_2^{\bullet} + Fe^{2+} \rightarrow Fe^{3+} + HO_2^{-} \tag{4}$$

$$Fe^{2+} + OH^{\bullet} \rightarrow Fe^{3+} + OH^{-} \tag{5}$$

Besides the basic Fenton reactions, the mechanism of the electro-Fenton process also includes the formation of H_2O_2 at the cathode (Equation 6) and the production of Fe^{2+} at the anode (Equation 7).

Katot: $O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$ (6)

Anot: $Fe \rightarrow Fe^{2+} + 2e^-$ (7)

2.3.2. Photo-Electro-Fenton Process

The photo-electro-Fenton process is based on the ultraviolet (UV) light treatment of the electro-Fenton process to increase the pollutant removal efficiency in wastewater. With the photo-electro-Fenton process, more hydroxyl radicals ($OH^\bullet$) are formed, and the regeneration of Fe^{2+} is accelerated [19]. The essential reactions of the photo-electro-Fenton process are given below:

$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^\bullet + OH^-$ (8)

$Fe^{2+} + H_2O_2 \rightarrow Fe(OH)^{2+} + OH^\bullet$ (9)

$Fe(OH)^{2+} + h\nu \rightarrow Fe^{2+} + OH^\bullet$ (10)

$H_2O_2 + h\nu \rightarrow 2OH^\bullet$ (11)

As seen from the above equations, when wastewater is treated with UV, the amount of $OH^\bullet$ formed in the environment increases. Therefore, more pollutant removal is achieved in photo-electro-Fenton processes than in electro-Fenton.

2.4. Natural Treatment

Another purification method, the use of which has increased in recent years, is the natural purification method, which generally uses plants grown in the field. Although the number of studies on this subject has increased, it has not yet become widespread. It is not possible to treat leachate with this method alone. However, it is possible to apply this method in leachate waters after biological treatment. The method's advantages include low investment cost and high efficiency when used as secondary or tertiary treatment. On the other hand, the disadvantages of obtaining low pollutant removal efficiency in leachate treatment are the inability to use it in cold climates and the toxic effect of leachate on plants [20].

3. THE CASE OF SAMSUN

Samsun Solid Waste Landfill Facility was built in Gürgendağı locality, approximately 10 km from Samsun city centre. The Landfill Site consists of 3 parts, the first part is 5.6 hectares, the second part is 4 hectares, and the third part is 6.9 hectares. Waste acceptance to the site started in 2008, and with this feature, the field enters the middle-aged landfill. An average of 1000 tons of waste per day is stored at the facility, and approximately 350 m^3 of leachate is generated daily. The resulting leachate cannot be treated on-site and is sent to Samsun Doğu Advanced Wastewater Treatment Plant by tankers with a capacity of 30 m^3. The Reverse Osmosis membrane system, which was installed in the field in previous years, cannot be used in the facility for a long time due to its operational problems and disadvantages, such as high cost. All kinds of visuals of the field are given below.

Figure 1. Solid waste landfill site visual

Figure 2. Solid waste landfill site top view

Figure 3. Solid waste dump site

Figure 4. Leachate collection pond

The leachate properties of the Samsun solid waste sanitary landfill are given in Table 1.

Table 1. Samsun solid waste sanitary landfill leachate characteristics

Parameter	**Unit**	**Value**
Temperature	^oC	10-25
pH	-	6-8
Conductivity	mS/cm	20-40
COD	mg/L	8000-25000
BOD	mg/L	5000-15000
NH_4-N	mg/L	3000
SO_4	mg/L	500
Cl	mg/L	5000
Suspended solids	mg/L	1500
Cu	mg/L	5
Pb	mg/L	5
Cd	mg/L	2
Cr	mg/L	10

The leachate composition used in the experiments is as follows: pH: 7.50-8.20, COD: 7150-9000 mg/L, conductivity: 20-40 mS/cm, color: 1887-3596 Pt-Co. All electro-Fenton experiments were carried out in a 74x83x140 mm plexiglass reactor with a useful volume of 860 cm^3. The characteristics of the electrodes used in the experiments are as follows: 45 mm width, 55 mm length, 2 mm thickness, and active anode surface area: 94.64 cm^2. The EF experimental setup is shown in Figure 5.

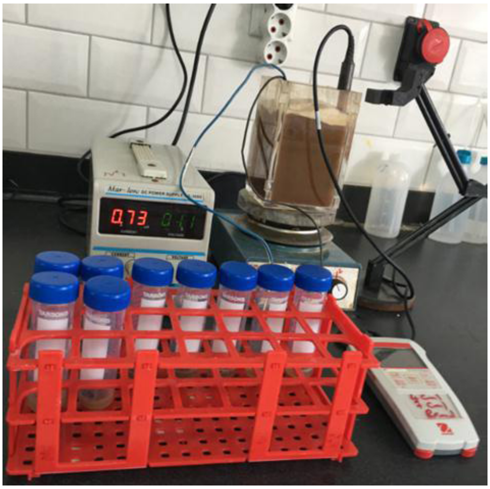

Figure 5. EF experimental setup

Before each experiment, the EF reactor was filled with 750 ml of wastewater and mixed with a magnetic stirrer at 250 rpm. After the pH of the leachate was brought to the desired value, COD and color measurements were made in the raw wastewater for each experiment. Then, the desired amount of H_2O_2 was added to the wastewater placed in the reactor and mixed with a magnetic stirrer. During the experiments, samples were taken at periodic intervals of 2.5, 5, 7.5, 10, 15, 20, 25, 30, 35, 40, and 45 minutes, and after centrifugation at 9000 rpm, COD and color analyzes were performed.

All photo-electro-Fenton experiments were carried out in a cylindrical photo-reactor. The characteristics of the photo-reactor are as follows: inner diameter: 7.70 cm, outer diameter: 8.25 cm, height: 48.5 cm. 16W low-pressure mercury vapour lamp and electrodes consisting of 1 anode and one cathode were placed inside the photo-reactor. The photo-reactor experimental setup is shown in Figure 6.

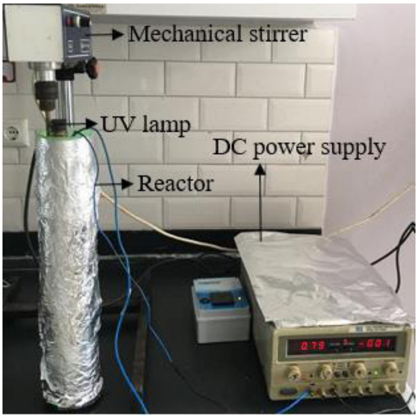

Figure 6. Photo-electro-Fenton experimental setup

H_2SO_4 (Merck) and NaOH (Carlo Erba) were used for pH adjustment in photo-electro-Fenton experiments. pH measurements were made with Thermo Scientific Orion 4 Star brand and model pH meters. After the pH value of the wastewater was brought to the desired value, COD and color measurements were made in the raw wastewater before each experiment. Then, 2.2 L wastewater was put into the photo-reactor, mixed for 1-2 minutes, and then the desired amount of H_2O_2 was added, and the voltage meter and UV lamp were started at the same time. Afterwards, samples were taken at periodic intervals (1,3,5,10,20,30,45,60,90,120,150 minutes) and after centrifugation at 9000 rpm for 10 minutes, COD and color readings were performed in a spectrophotometer (Merck Spectroquant Nova 60A).

All experiments were performed in accordance with Standard Methods for water and wastewater treatment. COD measurements were made according to the closed reflux colourimetric method (5220-D) [21]. COD removal efficiencies were calculated according to equation 12.

$$\text{removal efficiency (\%)} = \frac{C_0 - C_t}{C_0} \times 100 \qquad (12)$$

C_o: initial COD concentration (mg/L)

C_t: COD concentration at time t (mg/L)

Color measurement results were obtained with Pt-Co units in accordance with Standard Methods (2120-B). Accordingly, the absorbance of the samples taken was measured at a wavelength of 340 nm and the color measurement results were determined by multiplying with the required multiplication factor.

In this study, for optimum conditions (COD inlet: 8125 mg/L, pH: 3, current density: 100 A/m^2, H_2O_2: 2000 mg/L, experimental time: 25 minutes) in the electro-Fenton method of COD removal from leachate. It was achieved 68% COD removal. In the color removal study (Color input: 3596 Pt-Co, pH: 3, current density: 75 A/m^2, H_2O_2: 2000 mg/L, experimental time: 7.5 minutes) it was achieved 69% color removal [22].

Some of the other studies in the literature, which have been done with the electro-Fenton method from leachate, are given below.

Atmaca, 2009, in the study of COD and color removal from leachate with the electro-Fenton method (COD-input: 2350 mg/L, pH-input: 3, current: 3A, H_2O_2: 2000 mg/L, experimental time: 20 minutes) maximum 72% It achieved COD and 90% color removal [23].

Cotman and Gotvajn 2010 obtained 70-85% COD removal in their study of COD removal from leachate by Fenton oxidation (COD input: 1396-2455 mg/L, $[H_2O_2]/[Fe^{2+}]$ molar ratio: 10:1) [24]

Carluccio et al., 2020, obtained 82% COD removal from leachate with Fenton oxidation under optimum conditions (pH: 3, H_2O_2/Fe^{2+} :1, $H_2O_2 = Fe^{2+}$ = 3500 mg/L, experimental time: 120 minutes) [25].

In the COD and color removal study of the leachate by photo-electro-Fenton method, under optimum conditions (COD entry: 8150 mg/L, color entry: 1905 Pt-Co, pH: 3, current density: 10 A/m^2, H_2O_2: 1000 mg/L, UV: 16W, the distance between electrodes: 1.0 cm) It was obtained a maximum of 83.84% COD removal at the end of the 90th minute and a maximum of 84.46% color removal at the end of the 45th minute.

After 45 and 90 minutes, 84.46% and 83.84% removal efficiencies were obtained, respectively [26].

Some of the other studies in the literature made by the photo-electro-Fenton method from leachate are as follows:

Altin 2008, in his study of COD and color removal from leachate with the photo-electro-Fenton method, under optimum conditions (pH: 3, current: 2.5A, H_2O_2: 3000 mg/L, UV: 1.4 W/cm^2), a maximum of 94% COD and 97% achieved color removal [27].

Primo et al., 2008, applied the photo-Fenton process to COD removal from leachate and found the following results. For optimum conditions (COD inlet: 3300-4400 mg/L, Fe^{2+}: 2000 mg/L, H_2O_2: 15000 mg/L) they achieved 77% COD removal [28].

Asaithambi et al., 2020, for optimum conditions (COD inlet: 2000 mg/L, current density: 35 A/m^2, pH: 3, H_2O_2: 300 mg/L, UV: 32W, distance between anode-cathode: 0.75 cm) achieved 97% COD and 100% color removal.[29]

In this study, using similar experimental conditions, higher COD removals were achieved. It was thought that the reason for this was that different removal efficiencies could be obtained with different leachates.

4. RESULTS

It has been observed that the efficiency of COD and color removal from leachate with Electro-Fenton and photo-electro-Fenton processes is higher than other physicochemical processes (coagulation-flocculation, chemical precipitation, adsorption, membrane filtration). NH_4-N is mainly removed by air stripping. The advantages of electro-Fenton and photo-electro-Fenton processes over other physicochemical processes are that they provide higher efficiency in removing organic pollutants, exhibit faster kinetics than biological treatment processes, and are environmentally friendly. On the other hand, to solve the problems related to Fenton processes and leachate treatment, the following issues need to be explored: The development of high-efficiency and low-cost chemical oxidants and their large-scale industrial application is required. Another problem is that Fenton systems can often be used with other technologies, as they alone cannot meet leachate discharge standards. It is clear that the efficient integration of Fenton processes and ozonation and biological treatment systems will provide a significant improvement in waste leachate treatment technology studies.

When the study conducted by us in Samsun was examined, it was observed that the discharge standards in the Water Pollution Control Regulation could not be met as a result of the treatment performed with the electro-Fenton and photo-electro-Fenton methods, and it was understood that the photo-electro-Fenton method was relatively more effective. In addition, the significant increase in the biodegradability (BOD/COD) ratio of wastewater from 0.5 to over 1.0 is a significant advantage for biological treatment. The COD value should be used to evaluate the optimum treatment time. Since the color is predominantly composed of soluble iron complexes, it has been estimated that the color can be removed by increasing the pH.

In summary, biological treatment processes can be applied before or after the photo-electro-Fenton process in treating leachate containing high COD and color.

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CHAPTER 12

Green Technology

STUDYING THE DEMAND FOR CLEANER VEHICLES AND CHARGING INFRASTRUCTURE: AN OVERVIEW OF ASSOCIATED FACTORS AND ARISING ISSUES

Dimitris Potoglou[1*], Rongqiu Song[1], Emma Hopkins[1]

ABSTRACT

This paper provides an overview and critical assessment of the published literature in two research areas: demand for cleaner vehicle technologies- with emphasis on electric vehicles- and the emerging stream of studies related to the demand for electric-vehicle charging. Consumer-demand for cleaner vehicles has been based on two approaches: 'psychological measurement of consumer intentions to buy cleaner cars' and 'econometric approaches' looking at the consumers' trade-offs between the purchase price and other vehicle characteristics including the range between recharging. The paper argues for the use of stated choice methods as they allow for the development of 'what if' scenarios and the valuation of a range of vehicle attributes. The paper further discusses choice-based (revealed and stated choices) studies aimed at capturing consumer choices for public charging of electric vehicles focusing on site characteristics, sources of individual taste heterogeneity and potential areas of future research. Finally, the paper defines the concept of 'social equity' in the context of electric-vehicle infrastructure and argues on the importance of social equity on charging infrastructure and considers best practices for its future deployment.

Keywords: Cleaner Vehicle Demand, Electric Vehicles, Electric Vehicle Charging İnfrastructure, Social Equity

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1. THE DEMAND FOR CLEANER VEHICLES: AN OVERVIEW OF APPROACHES

Studies on the demand for electric vehicles (EVs) now have a history of over 40 years. Early studies were motivated by the oil crisis in the 1970s [1, 2]. The majority of these studies were primarily based on econometric models and made an attempt to estimate the demand for EVs based on available market data on vehicle sales [3]. These econometric models were employed in estimating the potential demand for EVs building upon their capacity to 'break down' a car into several related features (or characteristics, attributes) such as: sale price, size, weight, number of seats, acceleration, top-speed, and engine/ motor type (internal combustion, electric) among others.

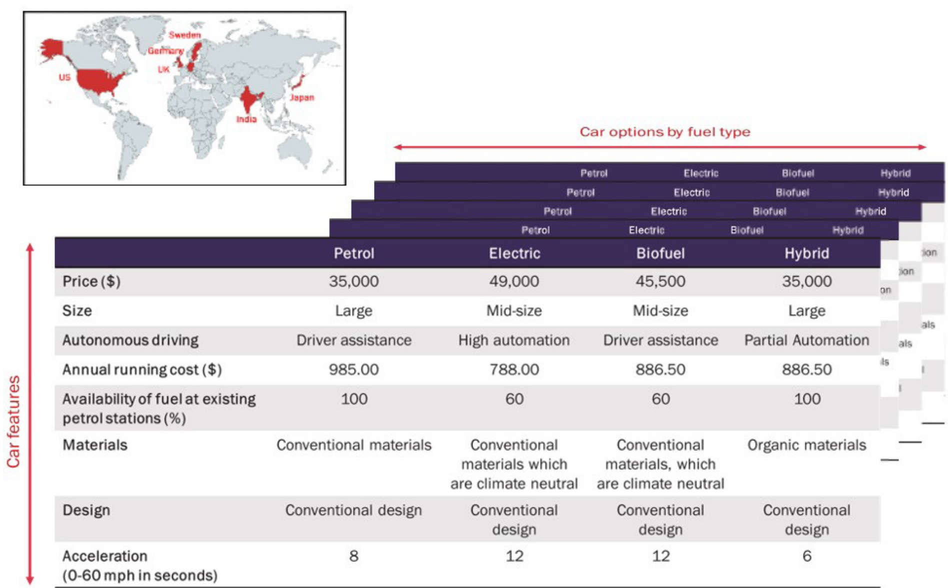
It was soon realised that further information – beyond existing market-sales data – was necessary to account especially for the characteristics of new vehicle technologies. These characteristics (or attributes, features) were not simply a 'projection' of existing vehicle technologies, nor it was a matter of 'presence'/ 'absence' of these features. For example, early models of electric vehicles exhibited new characteristics including significantly reduced range, considerable 'recharging time' instead of refuelling, and a significant difference in the availability and density of charging points relative to petrol stations. These characteristics introduced challenges in assessing the potential demand for and understanding what would drive consumer choices towards these car technologies.

These challenges also created a data paradigm shift from market-sales data (revealed preferences) to survey-based data paradigms including psychometric-based 'intentions to buy' [e.g. 4] and econometric-based 'stated preference discrete choice experiments' (SPDCE) [e.g. 5, 6]. The 'intentions to buy' studies represent the psychological perspective, in which the focus is on the study of individual psychological antecedents and demographic factors, which are likely to influence electric vehicle (EV) purchase intentions. These studies, more specifically, are aimed at capturing consumers' motivations and 'map' the process of decision making (attitudes, intentions, behaviour). Normally, intentions are expressed on a Likert-scale statement – for example, "I intend to buy an electric car next time I buy a car" [4]. It is worth noting that the consideration of other vehicle options (e.g. petrol cars) is absent as the primary focus is to link purchase intentions with a number of psychological antecedents. The underlying theories to test hypotheses across intentions to buy electric cars, psychological antecedents and socio-economic factors include but are not limited to the Theory of Planned Behaviour (TPB) [7], the Theory of Reasoned Action (TRA) [8], and the Technology Acceptance Model (TAM) [9].

SPDCE is a well-established approach, which has been applied across many fields [10]. An SPDCE in the context of electric vehicle demand enables to create hypothetical though realistic market situations and asks consumers to choose among different vehicle technologies (e.g. conventional vs. electric vs. hydrogen, etc.). Each vehicle technology is described by a varying set of features such as price, charging time, vehicle availability. The SPDCE, as a data collection paradigm and the subsequent analysis of the data using discrete choice analysis based on Random Utility Theory (RUT) [11-13], establishes the behavioural links across individuals' vehicle choices, vehicle characteristics, attitudinal factors and individual/household related socio-demographic and economic factors. This analytical approach leads into the estimation of the probability of selecting an EV over other vehicle technologies under the RUT assumption that consumers choose the car technology that maximises their utility.

The SPDCE approach enables researchers to elicit consumer preferences for different car options with varying vehicle characteristics. This means that respondents can provide more than one observation as the different car features can each time take different values. In other words, the researcher is in control of the 'data design' process and respondents only provide their choices. This approach also allows the incorporation of several infrastructure and policy-relevant attributes thus making it a useful tool for governments and car manufacturers. These attributes can be either defined as qualitative or quantitative variables. Previous studies have used a range of such policy levers including pricing (e.g. one time discount, exceptions from purchase tax, reduced usage cost, exceptions from road tax) [6, 14], free parking [6, 15], reduced tolls [14], access to high occupancy vehicle lanes [6], use of priority lanes and bus lanes [16, 17].

A recent study, which employed the SPDCE approach was conducted by Potoglou et al. [18]. The alternative car options included conventional petrol, battery electric, biofuel, and hybrid cars. The characteristics describing each car option are shown on the left-hand size of the choice card in Figure 1. The vehicles' purchase price was introduced within a range relative to respondents' budget, which was elicited via a question prior to the experiment. Autonomous driving levels were in line with the Society of Automotive Engineers' levels of automation [19], Other vehicle characteristics included size, annual running costs, availability of stations, materials used to make the car and acceleration performance. The feature 'materials' comprised conventional and organic materials, which could also be sustainably sourced or fair trade.



	Petrol	Electric	Biofuel	Hybrid
Price ($)	35,000	49,000	45,500	35,000
Size	Large	Mid-size	Mid-size	Large
Autonomous driving	Driver assistance	High automation	Driver assistance	Partial Automation
Annual running cost ($)	985.00	788.00	886.50	886.50
Availability of fuel at existing petrol stations (%)	100	60	60	100
Materials	Conventional materials	Conventional materials which are climate neutral	Conventional materials, which are climate neutral	Organic materials
Design	Conventional design	Conventional design	Conventional design	Conventional design
Acceleration (0-60 mph in seconds)	8	12	12	6

Figure 1. An example of a stated choice card involving different car technologies [18]

The data collection was conducted across Germany, India, Japan, Sweden, the United Kingdom, and the United States and targeted approximately, 1000 respondents per country. The collected data were analysed using Latent Class Discrete Choice Models (LCDCM) [e.g. 12]. These models allowed the estimation of the sensitivity (weight) respondents placed upon the attributes describing each car technology and can account for unobserved heterogeneity in the choices respondents made by assigning them to different groups (clusters) and estimating different attribute weights for each cluster. An example of the qualitative interpretation of the LCDCM model coefficients and the identified groups of respondents in the German sample is shown in Figure 2.

	Class 1	Class 2	Class 3
Members	• Have university degree or higher • Have children	• Have university degree or higher • Self-identify as green and being innovative about cars	Reference class
Preferences	• Very sensitive to purchase price • Insensitive to running costs • More likely to choose electric and petrol vehicles (vs. electric or biofuel) • Less likely to choose cars with Autonomy Level 5 (Full Automation)	• Sensitive to price and running costs • Prefer increased acceleration and fuel availability • Medium sized cars • Unique design • More likely to choose Autonomy Level 3 (Conditional Automation) • Electric cars (vs. Petrol, Hybrid, Biofuel) • Cars made of climate-neutral and ethically-sourced organic materials	• Sensitive to price and running costs • Increased fuel availability • Prefer medium sized cars • Prefer Petrol over electric or biofuel • Indifferent to different Levels of Autonomy

Figure 2. Qualitative interpretation of the latent class discrete choice estimates [18]

2. PUBLIC ELECTRIC VEHICLE CHARGING INFRASTRUCTURE CHOICES

The deployment of public charging infrastructure and the study of the associated choices to use them are very important aspects towards the wider adoption of EVs, the potential decarbonisation of road transport and the improvement of air quality in cities. Understanding public-charging choices is important as there is a significant proportion of existing and potential EV private users who cannot have access to home charging primarily because they lack access to driveway or a private parking space. Public-charging behaviours are significantly different from charging at home or workplaces, so understanding these behaviours would help service providers to better plan and invest in future infrastructure.

There are several open questions regarding the study and understanding of public charging choices. These include:

- How have empirical studies been conducted in terms of research design, data collection and the subsequent analyses?
- What are the drivers (factors) likely to determine choices for public charging?
- To what extent do choices differ between potential or existing EV users and how are these differences captured in empirical studies?
- What are the potential areas for future empirical work to enhance understanding of public-charging choices?

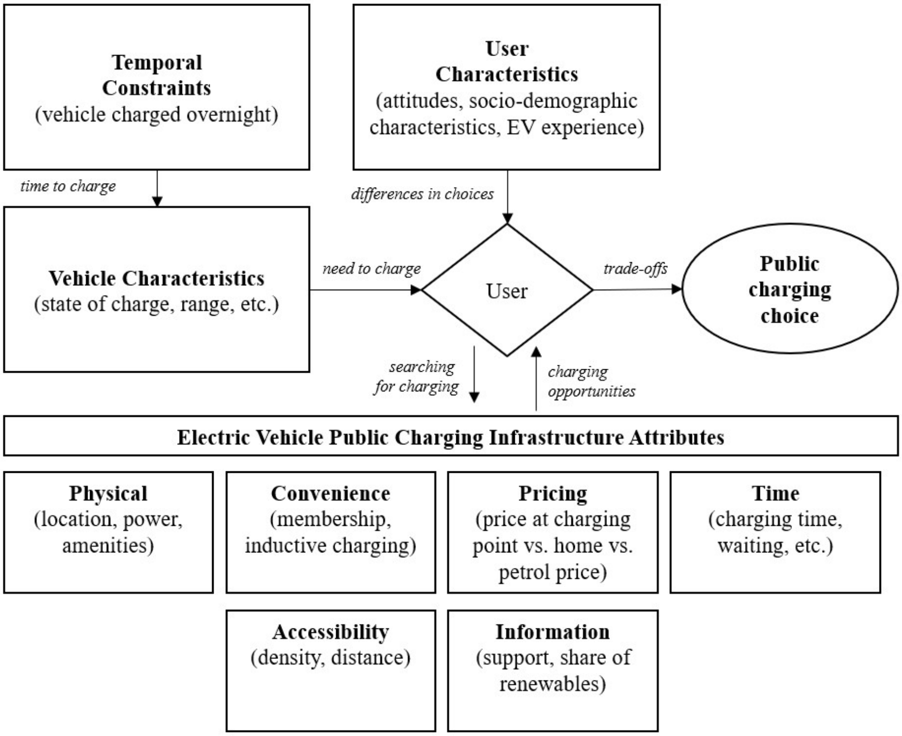


Figure 3. Summary and interrelationship of factors associated with public charging choices (Source: the Authors)

From a critical review of academic publications, we found that public-charging choices - as the key outcome variable across empirical studies - focused on the 'choice-to-charge': (a) at a given destination; (b) across different locations/charging points and (c) at home vs. a workplace vs. a public location or a mix of locations. The study of choices in some cases has been combined with the choice of type of charger such as regular (22 kW), fast charging (50kW) and ultrafast charging (>350 kW).

As shown in Figure 3, the factors related to the EV public-charging choices can be generally classified into four groups: (1) temporal constraints [20], (2) vehicle characteristics including its available range or state of charge of the battery [21], (3) factors related to public-charging infrastructure such as accessibility [22] and (4) user characteristics including attitudes, perceptions, and their socio-economic characteristics [23]. Public infrastructure factors can be further grouped into physical, convenience, pricing, time, accessibility, and information. The temporal constraints limit the length of a charging event to a public charging point. EV users first become aware of the necessity to charge when the EV does not have enough range to complete a journey, or its battery is at a critical level where the driver perceives a strong sense of range anxiety. This, however, does not mean that they will immediately charge at a public charging station, as they will look for available charging opportunities and make trade-offs between these opportunities and not charging. Different user attributes, such as socio-economic characteristics and psychological parameters may be used to explain the differences in users' charging choices including the decision not to charge [24].

There are several opportunities for future work on public charging choices. These include but are not limited, for example, to the evaluation of:

- different types of public charging point locations and the density of charging points. The former refers to the different types of public areas suitable for public charging such as street parking, supermarket parking spaces, and on-street car parks with different vehicle-security and personal-safety related features
- choices for different nearby amenities where EV users could spend their time while charging, and
- which payment models would be more attractive to users of public charging points such as monthly subscriptions, unit (kWh) based, flat feed, or a flat fee per range.

3. SOCIAL EQUITY, ELECTRIC VEHICLES AND CHARGING INFRASTRUCTURE

The sales of EVs across many countries mark year-on-year record sales. For example, in the UK, between the second quarter (Q2 – April to June) 2022 and 2021, there was 21% increase in battery electric vehicle registrations whereas during the same period registrations of petrol and diesel cars decreased by 25% and 45%, respectively [25]. While these are positive news, EV owners normally earn more, and have higher education qualifications [e.g. 26]. There is also an uneven geographical uptake of the EV Homecharge Scheme (EVHS), which provided subsidies for the installation of home chargers across the UK [27]. The number of EVHS units and the number of units per 100,000 were the highest in the South East of England and the lowest were in Northern Ireland [27]. An assessment of the Scheme by the Department for Transport [27] found that the uptake of the Scheme was dependent on users' access to off-street parking, nature of home tenancy (freehold, leasehold), rurality and income. A similar picture is seen regarding the number of public charging devices and the number of rapid chargers across the UK (see, Figure 4). This is some of the evidence suggesting that social equity in the context of electrification of road transport may be under threat.

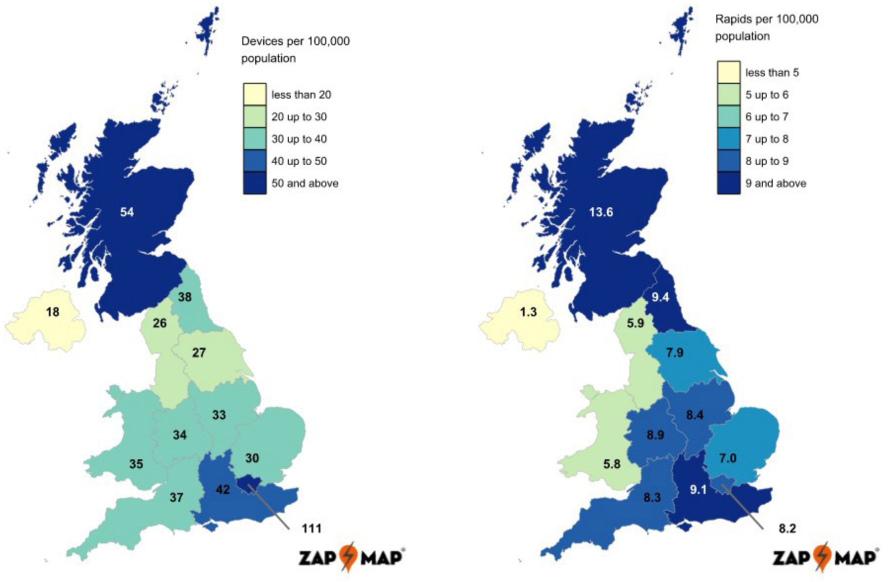


Figure 4. (a) Number of devices and (b) number of rapid chargers per 100,000 population [28]

Social equity regarding electrification may be defined as: "an uneven opportunity for individuals, households, commercial entities and other groups to benefit from electrification of the road transport due to lack of provision, affordability or useability of charging infrastructure". Thus far, electric vehicle charging infrastructure investment has targeted early adopters. Investment on charging point provision and related infrastructure should take a different direction as not all people would benefit from the potentially reduced transportation cost gains and improved local air quality [29], and those living in rural areas and/or cannot afford an electric car [30].

The above issues further expand to several cross-sectoral challenges, which are related but are not limited to:

- **Parking**: there are significant challenges for potential EV owners who do not have access to overnight parking or are unable to install a charging point. Charging infrastructure is currently market led and progresses faster in areas of EV high uptake thus leaving others behind. Also, government-led opportunities for the installation of public charging points currently discourages shared use schemes.
- **Electricity prices**: There are pricing disadvantages for EV users who cannot charge at home. For example, there is a significant difference between the value added tax (VAT) on the electricity price between public charging points (20%) and home charging (5%), whereas those charging at home may also benefit from lower unit prices during off-peak charging.
- **Use of information systems and pricing**: Currently, those who have a membership with a charging-point provider via a smartphone app pay lower charging prices than those who charge on a pay-as-you-go basis.

- **The EV and the second-hand EV market**: While EV prices are becoming more affordable the cost of purchasing an EV remains high and there are high proportions of the population who cannot afford a new electric car whereas subsidies are not available for second-hand EVs.
- **Conventional fuel market**: Increases in petrol prices and high road tax for conventional vehicle owners disbenefit those who cannot afford an EV.
- **Accessibility and usability**: There is an increasing debate on the accessibility and usability of charging points by users with special needs.

Potential solutions related to EV affordability and availability of charging infrastructure include wider implementation of grant schemes to support landlords and multi-unit dwellings to install charging points. This is particularly important for taxi and van users who are more likely to rent and/or live in flats. For example, the UK government is currently offering an 'electric chargepoint grant at £350 or 75% off the cost to buy and install a socket for those who own or rent a flat' [31]. Smart chargers, dynamic tariffs and vehicle-to-grid solutions would also incentivise users to charge during off-peak hours and benefit from lower prices. New business models such as e-car sharing, and peer-to-peer car rental would help address issues around the affordability of owning an EV [32].

Equitable delivery of public charging infrastructure may be materialised via a 'concession business model' between the public and private sectors [33]. Under such model, access-based targets and relevant funding via subsidies would help reach a minimal coverage of charging points at local or regional level. Another flexible solution involves the deployment of 'mobile charging stations', which allows providers to quickly set up charging points and use them for location testing and optimisation exercises [34]. Finally, accessible charging specifications are necessary to ensure that requirements to support useability and access-for-all are satisfied.

There are open questions remaining regarding the issues of equity and EV-related charging infrastructure:

- How can we better understand and capture issues of social equity in the context of EV uptake and charging infrastructure so that we can better address the issues arising?
- How can equity be facilitated so that potential benefits of the transition to EVs remain accessible to all people without being an impedance to innovation of this still emerging market?

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ECO-FRIENDLY AND NATURE-BASED POLYMER COMPOSITES

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ABSTRACT

Recently, climate change and environmental pollution have become a big problem and therefore the demand for natural and environmentally friendly products has increased. The green production and development of materials have been an important issue. Plant extracts have recently been used in areas such as cosmetics, health, energy and food, and products have been provided with more natural content. Apart from this, carbon emissions can be reduced by increasing the production and use of plants. Similarly, the production and use of bio-containing, biodegradable and non-toxic polymer materials have also increased. PVA (Polyvinyl Alcohol) has started to be used in many fields such as filaments, plasters, coatings and photocatalytic materials as a biocompatible, water and nature-soluble polymer with low toxic effects. Accordingly, in this study, PVA composite films were modified with natural plant extracts. The produced composite films have Shore-D hardness values higher than neat samples. The presence of elements, such as K, Mn, Ca and P in the films were determined by Scanning Electron Microscope (SEM) and Energy Dispersive Spectroscopy (EDS) analyses. With these composite films, it will be possible to produce high-strength products with natural content, harmless to the environment and human health, and low carbon emissions.

Keywords: Plant Extracts, Bio-Based Composite, PVA, Composites

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1. INTRODUCTION

The use of toxic products and raw materials with high carbon dioxide emissions has created a great threat to human health, the environment and the climate. Initiatives to fight against climate change and environmental pollution have started on a global scale. In this direction, the demand and interest in renewable and natural energy sources have increased around the world [2,15]. The use of plants and plant extracts, which are renewable and natural resources, is increasing day by day. Plants are very important raw materials as they can be produced easily and at low costs, do not cause carbon dioxide emissions, and are not a threat to human and environmental health [5,10,17]. Hemp and rosemary have been plants that have been used frequently in the production of health, cosmetics, food, building materials, membranes and filters in recent years. In particular, it has increased research on materials that can be produced with hemp, as it reduces carbon dioxide emissions, is easy to grow, has many health benefits, and has high-strength fibers. Another popular raw material with plant extracts is Polyvinyl Alcohol (PVA). PVA is a low-cost, high mechanical strength polymer that can absorb carbon and does not produce toxic releases. It is very popular in biomaterials, food packaging and hydrogel production [8,9,16]. Due to the superior properties of PVA, its place in production and research has increased. In many studies, successful results have been obtained by producing materials such as band-aids, air and water filtering membranes, nano fibers and packaging film using PVA [1,3,4,14,18].

In this study, the microstructure and mechanical properties of PVA composite films produced using hemp seed and rosemary extracts were investigated. The distribution of plant extracts in the PVA matrix structure and the strength they add to the composite were investigated. The films produced are referred to as environmentally friendly and nature-based composite films. With the use of natural plant extracts and PVA, alternative materials have been produced to other composite films with similar properties. With the use of renewable energy and raw materials, no toxic effects, low cost production, low energy consumption and easy production, it is the most suitable material to be used in the fight against climate change. Apart from this, it is not harmful to human health and the environment.

2. MATERIAL AND METHODS

PVA average molecular weight Mw = 90,000 g/mol, 99% hydrolyzed purchased from Sigma–Aldrich Germany was used without further treatment or purification. Hemp seeds and rosemary were collected from the local market and all plants were washed adequately with DI water. After cleaning, plants were cut into fine pieces and dried in the oven. Their properties and names of plant types used in the process are shown in Figure 1.

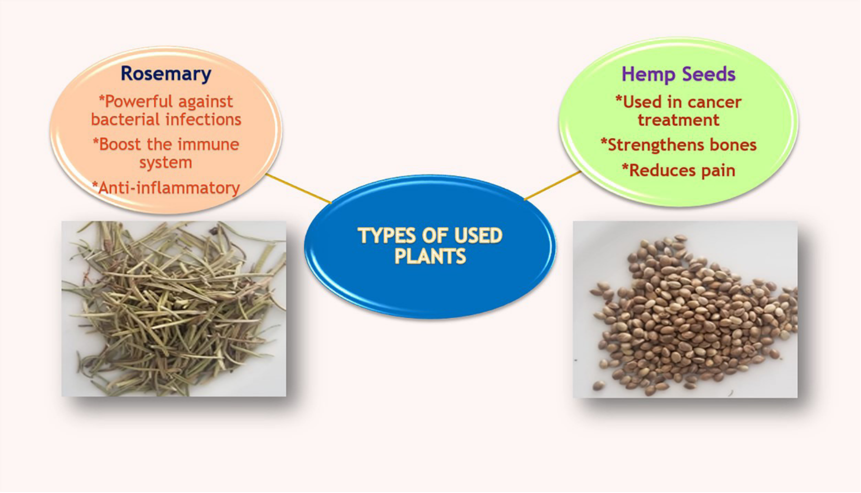


Figure 1. Properties and names of plant types used in the study.

In order to prepare the plant extracts, 20 g of dried herbs was added in 150 ml of DI water and heated for about 30 minutes at a temperate of 95 ◦C and then filtered. The production of plant extracts (hemp seeds, rosemary) modified PVA composite films was carried out by solvent casting method. The first step in the production of polymer nanocomposite films was to prepare the PVA solution. 4 g of PVA powder was dissolved in 40 ml DI water in a beaker at 90˚ C for 1 h by constant stirring to form homogeneous solution. After the PVA was dissolved in water, 15 ml of plant extracts (Hemp seeds-Rosemary) were added in 40 ml PVA solutions and the resulting mixture was stirred for 1 h at 90˚ C. Stirring was continued for 1 hour under 90˚ C temperature until all the combined ingredients were homogeneous. After perapering the solutions, the polymer mixtures were poured into petri dishes to form as the thin films and kept in an oven at 37˚C for 24 hours. Figure 2 shows the polymer nanocomposite films. These films are termed as plant extract-PVA composite films. The reference sample, seen as the lightest color in Figure 2, is the PVA thin film without plant extracts and the light brown film is polymer composite film containing plant extracts.

Figure 2. Plant extracts added and reference PVA composite films.

3. RESULT AND DISCUSSION

The microstructural and chemical characterization of nanocomposite film samples were observed by a JEOL 7001F Field Emission (FE) Scanning Electron Microscope with an EDS attachment which has an $80mm^2$ X-MAX detector. Semi-quantitative chemical analysis on samples was performed by energy dispersive spectroscopy (EDS). Shore-D hardness indicates the resistance of a material to the penetration of a needle under applied load. At least ten measurements were performed for each film and Shore-D tests were conducted at room temperature.

3.1. Microstructure Analysis

SEM images of the reference and plant extract modified PVA composite films are given in Figure 3. It can be seen in Figure 3(A) that the PVA film poured as a reference sample dissolves homogeneously and the film has a smooth surface. On the other hand, in the Figure 3(B) films with plant extract added, it can seen that there are plant extracts particles homogeneously dispersed in the film.

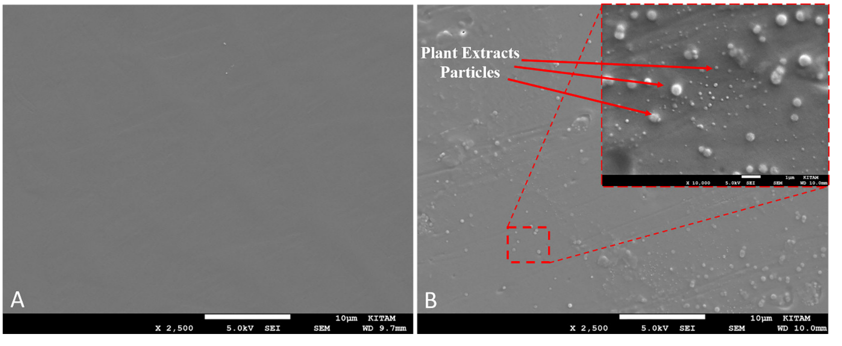
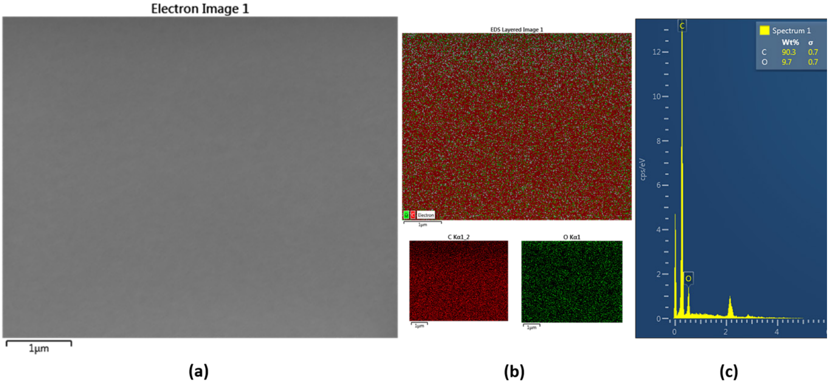


Figure 3.SEM images of (A) Reference sample, (B) Hemp seed and Rosemary extracts added PVA film.

Figure 4 shows the EDS analysis results of the reference sample. Figure 3 shows (a) the SEM image of the reference sample, (b) the mapping analysis result, and (c) the spectrum analysis result. Looking at the EDS results, there are C and O elements in the reference (PVA) film. These elements are present in the chemical compound of PVA and therefore appear as a result of the analysis. Other studies also support these results [11,12].



(a) **(b)** **(c)**

Figure 4.SEM image (a), EDS mapping analysis results (b) and EDS spectrum analysis results (c) of PVA reference sample.

EDS analysis results of PVa composite samples prepared with hemp seeds and rosemary plant extracts are given in Figure 5. Figure 5 (a) is the SEM image of the sample and shows the particles from the plant extracts for which the spectrum was analyzed. Spectrum analysis was performed on 2 different particles and the results are given in Figure 5 (b). In the spectrum analysis results, it is seen that there are minerals from many different elements such as K, P, Mg, Ca, Cl and Al in the plant-based composite sample. There are also C and O elements from PVA. These minerals in the sample are thought to come from Hemp seeds and Rosemary plant extracts. It has been proven in the literature that the mentioned minerals are present in the plant extracts used in the study [6,7].

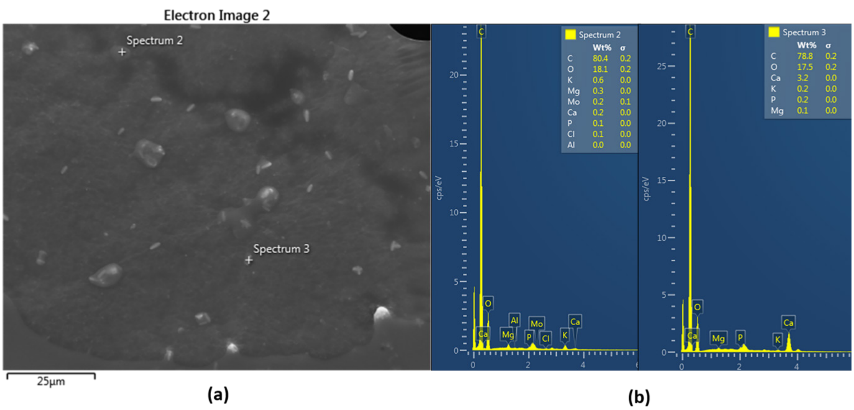


Figure 5.SEM image (a) and EDS spectrum analysis results (b) of plant extract prepared by using Hemp Seeds and Rosemary.

3.2. Shore-D Hardness Tests

Shore-D hardness test was applied to 5 different reference and plant extract modified samples. Measurements were took from each samples 10 different regions. Shore-D hardness values for reference and plant-based PVA composite films were determined by averaging all the obtained values and are shown in Figure 6. The samples modified with plant extracts had 41.45% higher hardness values than the reference samples. Factors such as homogeneity and chemical bonding affect the mechanical strength of polymer composites. It is also known that the additives in the polymer matrix have a strengthening effect. Mineral particles from plant extracts were homogeneously dispersed into the polymer matrix, making the structure more robust. Apart from this, since the plant extracts have hydrophilic properties, it provides stronger bonding by providing wetting with PVA [6,13]. Therefore, higher settness value was obtained than the reference sample.

Figure 6. Shore-D hardness of reference and plant extract modified composite films.

4. CONCLUSION

In this study, polymer composite material was produced using natural and renewable raw materials. By using hemp seeds and rosemary extracts, a material of natural origin, free of toxic content, environment and human health friendly, and no carbon dioxide emission was produced together with PVA polymer. Composite material produced using plant extracts has almost 2 times higher mechanical strength than reference PVA films. Apart from that, it contains many useful minerals such as K, Mn, Ca, P and Cl. These produced nature-friendly and nature-based composites can be used in many different areas such as food packaging, biomaterials, coatings and membranes.

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INVESTIGATION OF PLASTIC WASTE FOR ELECTROCHROMIC WINDOWS FABRICATION

Özge Akpınar Sarıhan[1*], İbrahim İnanç[1,2]

ABSTRACT

Plastic waste is a big problem for our health and environment. Plastic waste will need for hundreds or even thousands of years for degrading so plastic disposal technologies must be improved. By using electrochromic window (EW) energy saving can be achieved. EW consists of polymer electrolyte and electrochromic layers. As electrochromic layer, WO3 solution prepared and this solution spin coated on Indium tin oxide coated polyethylene terephthalate films (PET-ITO). For preparation of polymer electrolyte, purchased polymers and salts are used. In this study, instead of purchased polymers plastic wastes were used. ABS and PMMA plastic wastes were solved with DMF solvent. Homogeneous solutions were obtained. These homogeneous polymer electrolyte solutions were coated on PET-ITO films. By sandwiching WO3 and polymer electrolyte coated PET-ITO films, EWs were fabricated. Results shows coloring of EWs obtained from plastic waste as well as coloring of EWs obtained from purchased polymers. EWs from ABS and PMMA waste were achieved switching times 1, 5 sec (coloration), 2, 6 sec (bleaching) respectively.

Keywords: Recycled Polymer, Polymer Electrolyte, Electrochromic Windows

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1. INTRODUCTION

At present, plastic waste accumulation is a big problem that effects life, economy and environment. Plastic waste increases due to increasing human population and plastic production. [2] Most of plastic waste is burned in open field so they release chemical substances and particles that may pose serious risks to public health and environment. In order to have a cleaner and healthier environment, waste disposal methods must be developed. [3] We are rapidly depleting our resources. Most of the demand for energy falls on the use of traditional fossil fuels. [1]

Buildings are responsible for 30-40 % of our energy consumption. In buildings energy is lost through windows. In cold weather heat escapes straight out of window. In hot weather heat air coming through windows. In addition letting visible light reduces usage of lighting and not let visible light reducing glare. [2] EWs are energy-efficient solutions. Their optical properties can be controlled by applying small voltage.

The basic structure of EW consists of two electrochromic layers separated by an electrolyte layer. As electrochromic layer WO_3 is the most used electrochromic material. Electrolyte layer consists of polymer and ion salt. Applying a low voltage, ions transfer from one electrochromic layer to another; so EW is colored. Reversing voltage polarity ions returns to their original layer and EW is bleached [7]. In addition nanostructures generally increase ionic conductivity in EWs. [8]

In this study plastic waste is used for preparation of polymer electrolyte instead of purchased polymers. By solving Poly(methyl methacrylate) (PMMA), poly(acrylonitrile–butadiene–styrene) (ABS) wastes with DMF solvent, polymer electrolytes were fabricated. For cathode of electrochromic layer WO_3 nanoparticles were used.

Haq et al. reported the PET waste to synthesize a new poly(ethylene oxide)–DST polymer electrolyte [3] Kadam fabricated EC device using PMMA polymer.[4] Arcana et al. prepared polymer electrolyte using Styrofoam waste. [5] Hou et all. fabricated polymer electrolyte composed of a blend of poly(acrylonitrile–butadiene–styrene) (ABS) and poly(methyl methacrylate) (PMMA) as a host polymer.[6] Na et all. fabricated a novel egg white gel polymer electrolyte from egg and rice waste. [9]

2. MATERIAL AND METHODS

2.1. Preparation of Polymer Electrolyte From Plastic Waste

Herein Acrylonitrile butadiene styrene (ABS), Poly(methyl methacrylate) PMMA waste were solved with DMF. In Figure 1. These homogenous solutions can be seen. LiTFSI and hBN nanoparticles were added to solution.

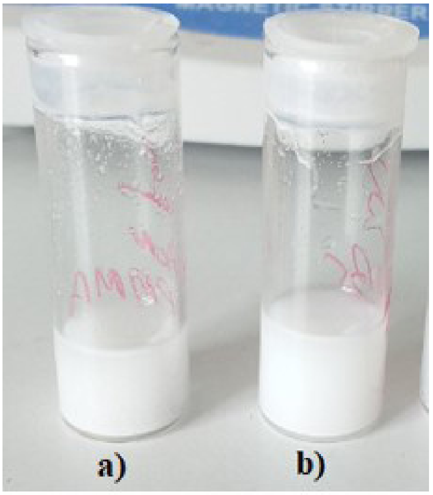

Figure 1. Images of a) PMMA b) ABS polymer electrolyte solutions

2.2. Preparation of WO_3 Solution

To prepare the WO_3 solution, WO_3 nanoparticles were solved with isopropanol (IPA) and deionized (DI) water (1:1:1 ratio) and solution was mixed with magnetic stirrer for 4 h at room temperature.

2.3. Development of Electrochromic Windows

Indium tin oxide coated polyethylene terephthalate film (PET-ITO) were cleaned with IPA, distilled (DI) water and ethanol in ultrasonic cleaner for 5 min in sequence before use. WO_3 solution was spin coated on PET-ITO and thin films are annealed at 80 °C for 10 minutes. Polymer electrolyte was dip coated on another PET-ITO and then annealed at 80 °C for 10 minutes. These films on PET-ITO substrates were sandwiched together.

Figure 2 and 3 shows images of fabricated electrochromic devices from ABS and PMMA polymer waste respectively. EWs from ABS and PMMA waste, when -3V was applied, the WO_3 film is colored, when +3V was applied WO_3 film is bleached. By applying between -3V and +3V the color switches from dark blue to yellow respectively.

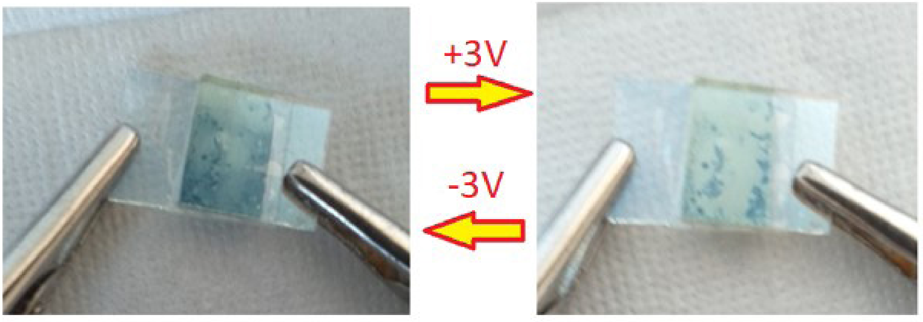

Figure 2. Images of the WO_3/ABS waste electrolyte at 80°C based EW in two states (a) in its bleached state at +3V b) in its colored state at -3V

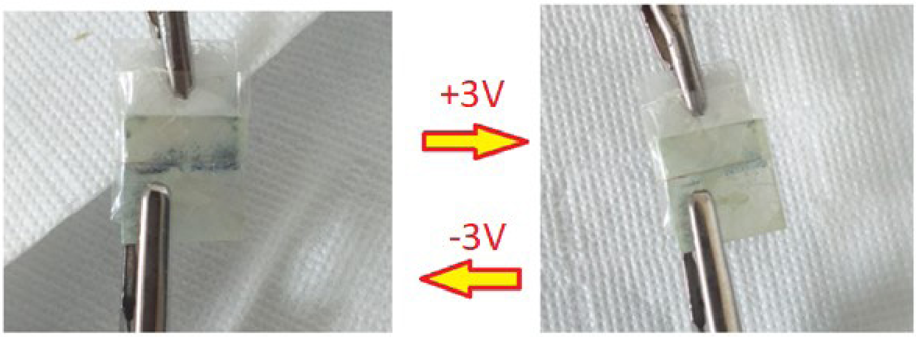

Figure 3. Images of the WO_3/PMMA waste electrolyte at 80°C based EW in two states (a) in its bleached state at +3V b) in its colored state at -3V

3. RESULTS AND DISCUSSION

For characterization of the EWs, Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Spectroscopy (EDX) methods were used. Figure 4 shows cross-sectional SEM images of polymer electrolyte with ABS coated on PET-ITO. Thickness of polymer electrolyte calculated from this image as approx. as 10 µm.

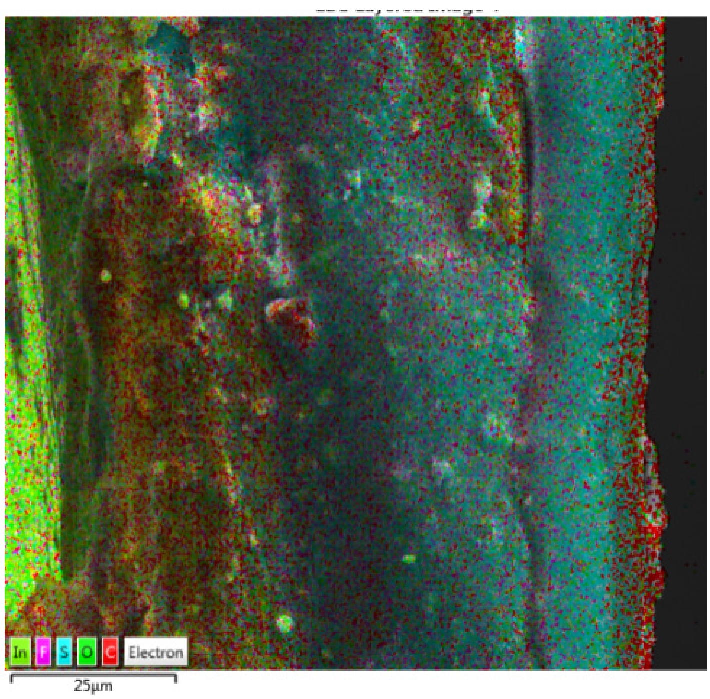

Figure 4. SEM Images of Polymer electrolyte with ABS coated on PET-ITO

Figure 5 shows elemental mapping of polymer electrolyte thin film. In this figure C, S, O, F, In and B elements are seen.

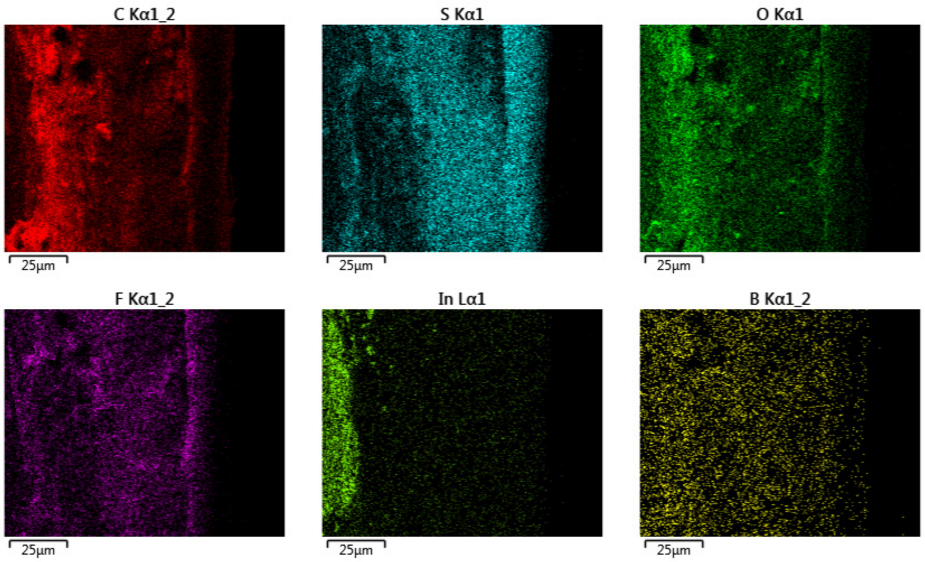

Figure 5. Elemental mapping of polymer electrolyte thin film

In figure 6. we can see S, F, O elements from LiTFSI, C and O elements from ABS waste, Au element from conductive coating for SEM, B element from BN nanoparticles and In element from PET-ITO.

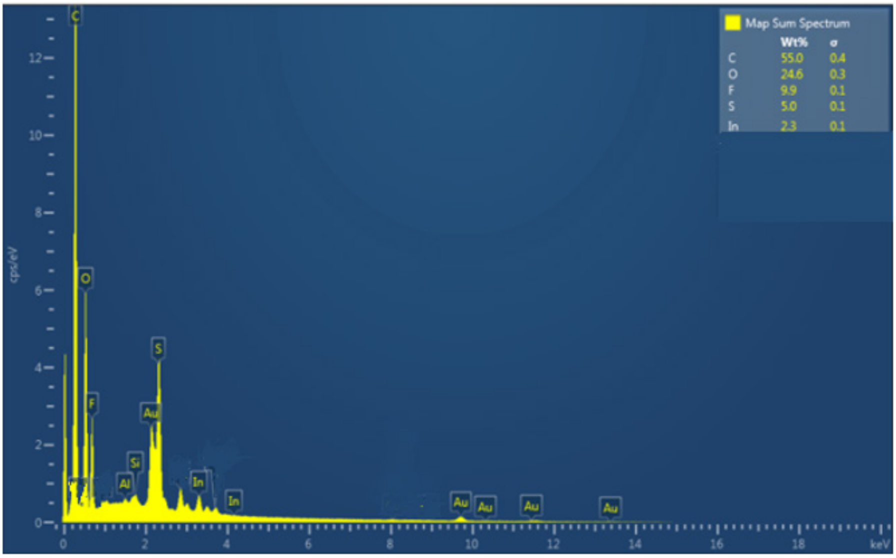

Figure 6. Edx images of polymer electrolyte with ABS waste coated on PET-ITO

Figure 7, 8 shows SEM images of polymer electrolyte from ABS waste thin film at 500 x and 5 Kx magnification respectively. We can see smooth surface and clumps of BN nanoparticles. BN nanoparticles are mostly well-dispersed except these small aggregates. This smooth morphology is obtained due to amorphous nature of ABS polymer and complete dissolution of the lithium salt.

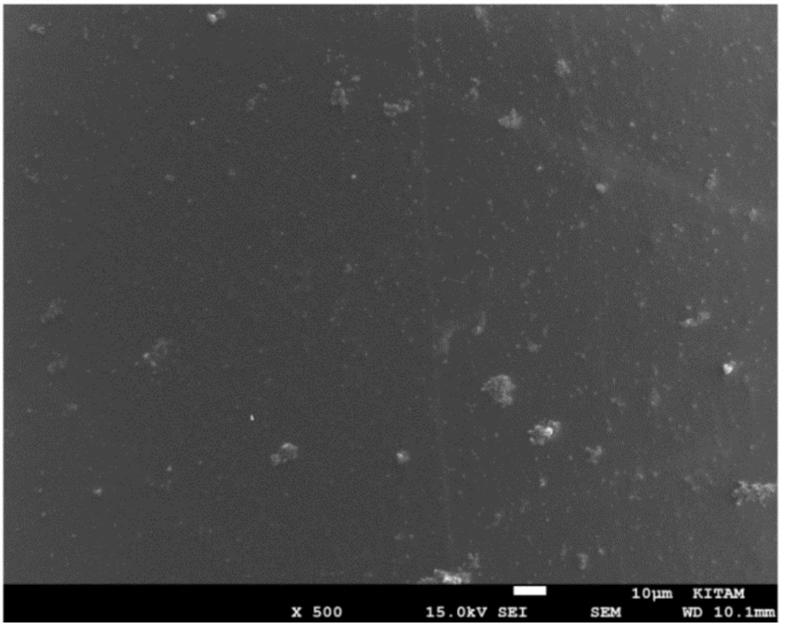

Figure 7. SEM Images of ABS polyelectrolyte thin film at 500 x magnification 15 kV

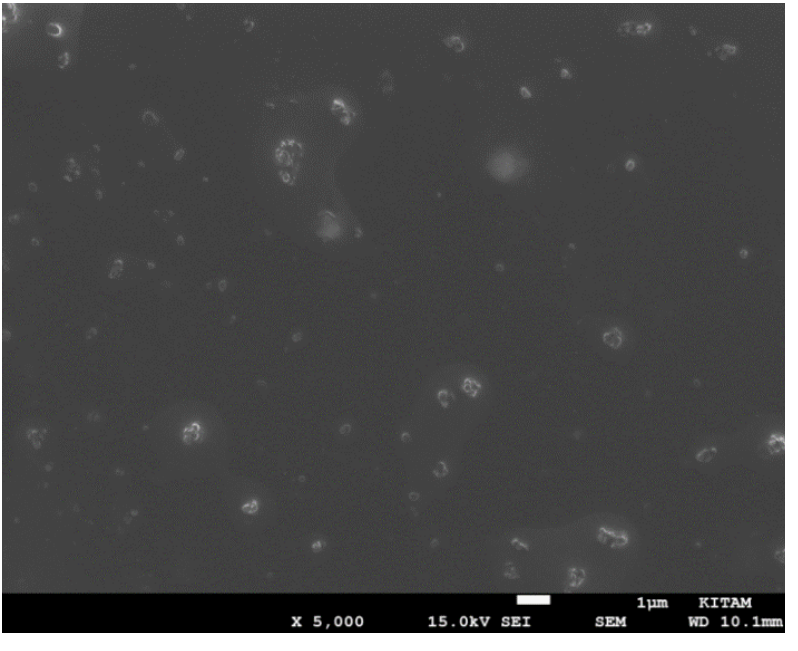

Figure 8. SEM Images of ABS polyelectrolyte thin film at 5 Kx magnification 15 kV

Figure 9, 10 shows SEM images of polymer electrolyte from PMMA waste thin film at 500 x and 10 Kx magnification respectively. We can see less smooth surface with respect to ABS-based polymer electrolyte and also bigger clumps of BN nanoparticles. From this result, it is understood that PMMA polymer is less soluble than ABS polymer with DMF solvent.

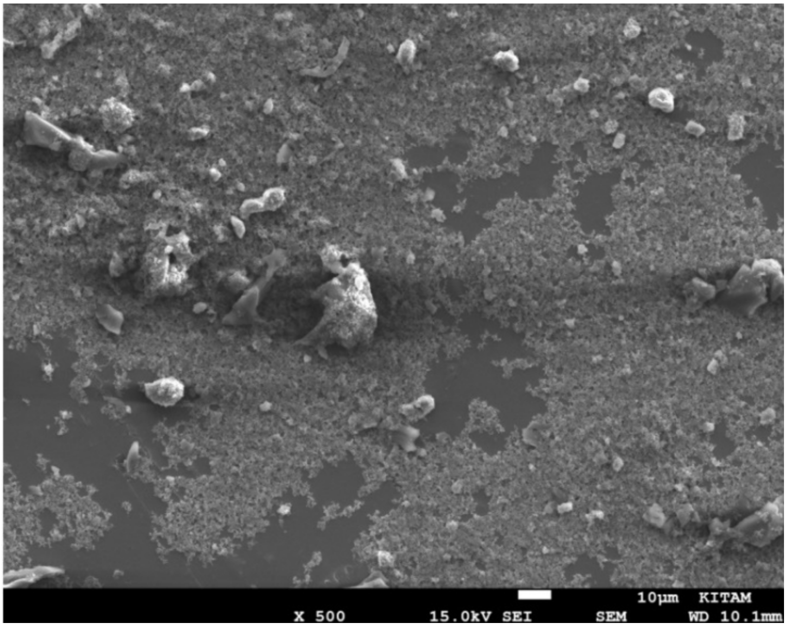

Figure 9. SEM Images of PMMA polyelectrolyte thin film at 500 x magnification 15 kV

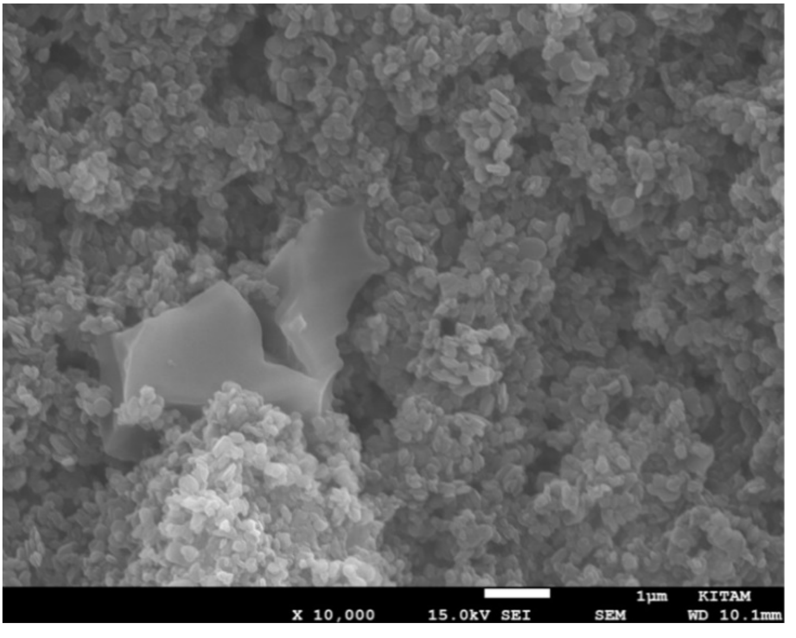

Figure 10. SEM Images of PMMA polyelectrolyte thin film at 10 Kx magnification 15 kV

4. CONCLUSION

Polymer wastes were successfully solved in DMF solvent and homogenous solutions were obtained. LiTFSI and hBN nanoparticles added to this solution. Polymer electrolytes were successfully obtained from plastic wastes. WO_3 solutions were prepared. Polymer electrolyte and WO_3 solutions were spin coated and annealed respectively on ITO-PET substrates successfully. After annealing, WO_3 and polymer electrolyte thin films were sealed with silicon so humidity that affects device was prevented. Fabricated electrochromic window coloured and bleached at -3V and +3V.

Plastic wastes were used as the electrolyte of EWs for the first time. Colouring of EWs with the new electrolyte are as well as purchased polymers.Overall, plastic wastes were used instead of purchased polymers so plastic wastes were disposed and fabricated EWs were cheaper than the others. Coloration time of the electrochromic windows form ABS and PMMA waste is 1 , 5 sec and bleaching time is 2 , 6 second. Quite good response times are obtained compared to the coloration and bleaching times obtained with respect to other studies in the literature.

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APPLICABILITY OF LIGNOCELLULOSIC MATERIALS IN THE STRUCTURE OF FOOD WASTE IN ADSORPTION

Hakan Çelebi[1*], İsmail Şimşek[2], Tolga Bahadır[3], Şevket Tulun[4]

ABSTRACT

During the food life cycle, large amounts of food waste and by-products containing valuable lignocellulosic (cellulose-lignin-hemicellulose etc.) structures are released. Minimizing food waste, avoiding environmental problems, helping the economy and society are the most important goals. Although the first option seems to be the energy sector today, the management of food waste is important. In recent years, successful and promising results have been obtained in the use of these wastes in wastewater treatment. For this reason, recycling of different food wastes resulting from domestic, agricultural and industrial uses instead of throwing them into the garbage cycle is of great importance both for the protection of the environment and the minimization of other environmental pollutants, and is an innovative approach in terms of eliminating waste with waste. A wide variety of treatment techniques are available to remove different types of pollutants from receiving environments such as water, air and soil. Among these treatment techniques, adsorption is accepted as one of the best techniques in treatment due to its simple working principle, high removal efficiency and low cost. However, the most important negative aspect of this method is the cost and efficiency of the adsorbent type. For this purpose, different types of adsorbents are tried in researches, and the most important one is food waste. In recent years, there are many scientific studies focusing on adsorbents of natural origin, which do not cause pollution as a result of their use. The use of waste material in pollutant removal and keeping this concept in the foreground is increasing day by day. Considering the near-zero cost and simplicity, the use of food waste in treatment is both economical and efficient. In this study, the applicability of food wastes containing lignocellulosic materials in the treatment was evaluated.

Keywords: Adsorption, Adsorbent, Food Waste, Non-Toxic Environment, Waste Management

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1. INTRODUCTION

Air-Water-Soil are the basic elements of the environmental life cycle, and in particular, water is an indispensable resource for health. Today, it is a problem to find quality and potable water worldwide. Factors such as rapid population growth, industrial development rate and urbanization, climate change cause significant pollution in air-water-soil ecosystems. Toxic pollutants, heavy metals, metalloids, pesticides, personal care products, drugs and dyes in the wastewaters released into receiving water environments are mostly of anthropogenic origin. It is a known fact that these different pollutants cause serious health problems (types of cancer, cardiovascular and nervous system, circulatory system, kidney, liver and lung problems, etc.) [1, 2]. The effect levels of these pollutants vary depending on the type, duration and level of exposure [3-5]. In particular, due to their bioaccumulation properties, they reach living things through the food chain. Heavy metal interference originating from metallurgical activities, heavy metals from different industrial sectors, paint etc. release of pollutants and pollutants from waste incineration and landfills come from anthropogenic activities [6]. Different types of pollutants released as a result of these activities must be removed from the receiving environment in accordance with sustainability, one health and other approaches. For this reason, many treatment methods are applied in the literature to reach the discharge limits determined by World Health Organization (WHO). Among these, adsorption is an important treatment technique used to increase pollutants with toxic and bioaccumulative properties in different receiving environments. Because it is more applicable and provides ease of operation. In addition, high quality (pollutant removal rate around 90%) water is produced after treatment [7]. Although there is a wide variety of adsorbent materials in the literature, the use of food and agricultural waste materials, which are classified as waste, is a specific approach in terms of both treatment and removal of pollution with waste. The use of waste in pollutant removal and keeping this concept in the foreground is increasing day by day. For the production of new generation bio/adsorbents, raw lignocellulosic materials have come to the fore in recent years (see Figure 1). Lignocellulosic materials are low cost and easy to modify chemically and therefore their use for the production of next generation bio/adsorbents could be advantageous [8, 9]. In this review, bibliometric analysis of recent studies and current approaches on the use of lignocellulosic materials as biosorbent for the removal of heavy metals from aqueous systems due to their harmful properties and intense presence in receptive environments has been made.

Figure 1. A summary of the lignocellulose-based biosorbents for different pollutant (adapted from [10])

2. MATERIAL AND METHODS

"Web of Science Core Collection; Science Direct, Springer, Wiley, Taylor & Francois, Scopus" (Clarivate Analytics®, Boston, USA) and "Google Scholar" (Googleplex, Mountain View, California, United States) were the databases used in this study. Bibliometric analysis was performed based on these databases. First, a general search was performed using the keywords *"adsorption", "biosorption", "adsorbent", "biosorbent", and "different pollutant"* in the basic search tool. For this research, the search has been narrowed down to specific keywords. In this context, the keywords *"lignocellulosic", "lignin", "lignocellulose biomass", "agricultural waste", "food waste", "cellulose", "hemicellulose"* were researched to cover the last 4 years. 50 articles were evaluated according to the field of interest of this review. Figure 2 shows the stages of the literature review of this study.

Figure 2. Flow chart of literature research.

3. RESULT AND DISCUSSION

Lignocellulosic materials are the most abundant and renewable resources in the world [11]. They are especially preferred in the energy sector and the treatment of pollutants. Since they are suitable for modifications (liquid form, chemical treatment), they are seen as raw materials for the "Green Chemistry" of the future [12, 13]. Lignocellulosic material is a complex matrix consisting of three different types of polymers such as cellulose, hemicellulose and lignin [14]. In the last decade, different biosorbents have been prepared from crude lignocellulosic materials and tested in adsorption and biosorption [15]. Lignocellulosic materials can be considered as a new energy source due to their high energy levels [16, 17].

3.1. Separation of Lignocellulosic Materials

Lignocellulosic materials are based on the co-existence of three covalent or hydrogen bonded biopolymers [18]. Different pre-treatment processes are applied to ensure the separation of these matrix forms [10]. They are classified into four categories according to their purpose: physical, thermal, chemical and biological pretreatments [19, 20]. Physical separation includes processes that disrupt the cell wall of lignocellulose material, reduce particle size, and activate the surface structure according to use [21]. Forms are separated at high temperatures by thermal processes such as steam explosion and hydrothermolysis=autohydrolysis [20]. In the chemical separation stage, cellulose, lignin and hemicellulose, which form the building blocks of lignocellulosic material, are left to dissolve with different chemical solvents (acid, base, oxidative processes). Biological processes are preferred because of their advantages (low energy, low chemical consumption, environmentally friendly and no inhibitor formation) (Figure 3).

3.2. Lignin

Lignin ($C_{18}H_{13}N_3Na_2O_8S_2$), which is second only to cellulose in the biopolymer ranking, is a three-dimensional amorphous polymer. Three major cinnamyl alcohol (p-coumaryl alcohol, sinapyl alcohol, and coniferyl alcohol) monomers combine to form the lignin matrix [22, 23]. The monomer structure and content are variable, mainly consisting of carbon-carbon bonds, ether bonds (β-O-4, 4-O) and other types of cyclic bonds (arylisochroman, dibenzodioxine and spirodienenone) [24]. The most common type of bond is β-O-4 ether bonds, accounting for 50-62% of the total reaction bonds [25]. Ethers lack the hydroxyl groups of alcohols. Without strongly polarized O-H bonds, ether molecules cannot hydrogen bond with each other. Ethers have non-bonding electron pairs on their oxygen atoms and with other molecules (alcohols, amines, etc.) that have O-H or N-H bonds can form hydrogen bonds (Figure 4). In recent years only lignin has attracted great attention due to its easy availability, abundant availability, eco-cost and its ability to bio/adsorb different heavy metals due to its biodegradability. The presence of hydroxyl groups provides effective adsorption surface points [26]. Effective adsorbing or biosorbing capacity can be achieved with modifications due to its heterogeneous structure. Since there is no modification, the adsorption capacity in the raw form remains at low levels. However, other matrix elements can partially compensate for this situation [14]. Basically, coniferyl alcohol, sinapyl alcohol and paracoumaryl alcohol, shown in Figure 4, play an active role in lignin. In particular, bonding and attachment responses are intense with these species.

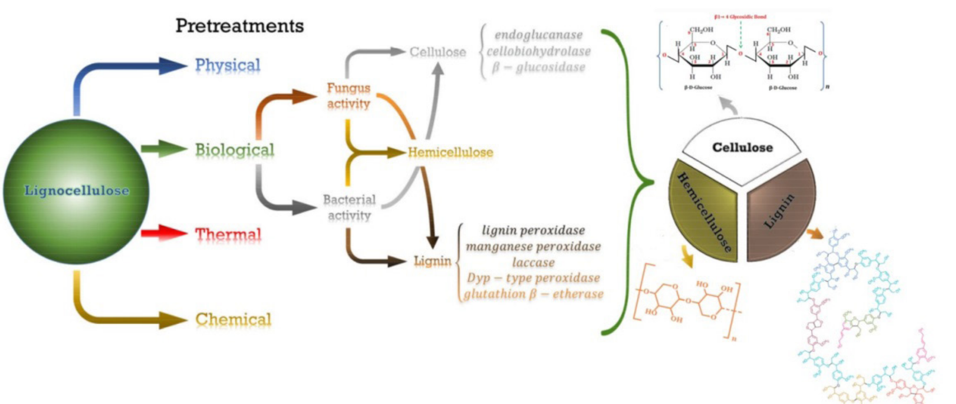

Figure 3. The main pretreatments of lignocellulosic material and the resulting products (adapted from [20])

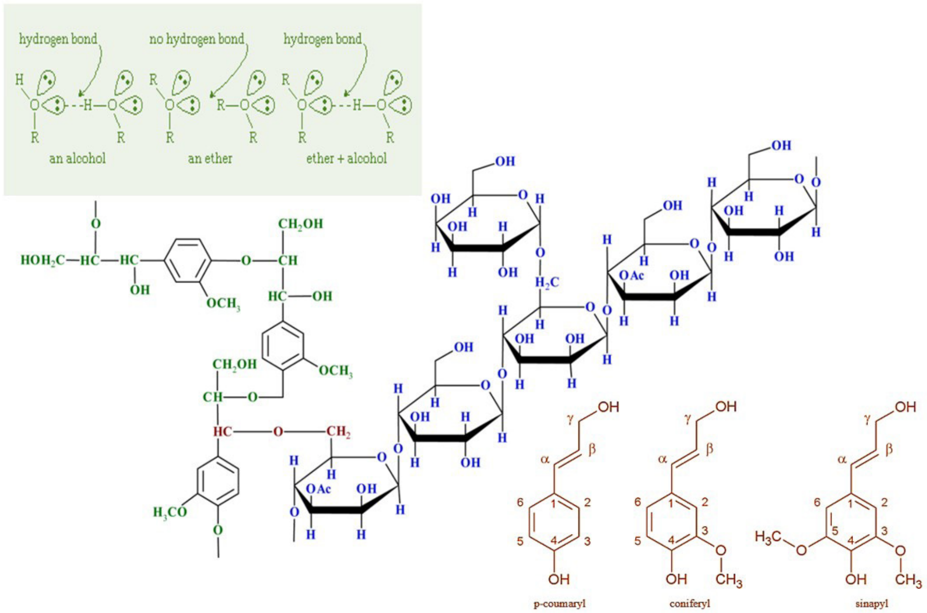

Figure 4. Lignin and hemicellulose and lignin monomers linked by ether bonds (adapted from [14, 20])

3.3. Cellulose, Hemicellulose and Pectin

Cellobiose (the smallest repeating unit of cellulose) is a linear biopolymer and is the most abundant monopoly saccharide in the world [27]. It consists of β-1, 4-glycosidic bonds. Cellulose with its chemical formulation $(C_6H_{10}O_5)_n$ has "n" degree of polymerization (see Figure 5) [28]. Cellulose is a semi-crystalline fibrous and amorphous structure that is difficult to hydrolyze or decompose [23]. Cellulose and hemicellulose are materials with important applications in food, personal care products, explosives, and paper manufacturing [29-31]. Hemicellulose $(C_5H_{10}O_5)$, on the other hand, does not have a specific structure compared to cellulose and lignin. Because, various monomers such as D-xylose, D-mannose, D-galactose, L-arabinose, D-galactose and 4-0-methyl-D-glucuronic acid bound to lignocellulosic material in hemicellulose structure came together to form a combination. Hemicellulose is cross-linked with cellulose and consists of different units such as xylan, xyloglucan, galactomannan and galactoglucomannan [20, 32]. Cellulose and hemicellulose have lower heat resistance than lignin, and this property is beneficial in the modification (such as biochar, activation, hydrochar) stages [32]. The hemicellulose structure has a role in lignocellulosic materials that allows the bonding between cellulose and lignin (see Figure 5). Xylane (xylose building block) is the main material of hemicellulose and reveals small amorphous chains [33]. Pectin $(C_6H_{10}O_7)$ is an acid-based hydrocolloid polysaccharide. Its basic structure consists of α-1, 4-glycosidic bonds and d-GalA residues. By-products or chain bonds are composed of l-arabinose, d-xylose, d-galactose and l-rhamnose molecules. Pectin is divided into two groups as high ester or methoxyl and low ester or methoxyl [34]. Food wastes with pectin content generally exhibit amphoteric structure. In other words, it behaves like a base in an acid medium and like an acid in a basic medium. Amphoteric structures behave differently depending on the type of substances being added to them. Fruits such as bananas, citrus fruits, apples and grapes, which are widely consumed in the world, have a large amount of pectin (approximately 1%-30%) [35].

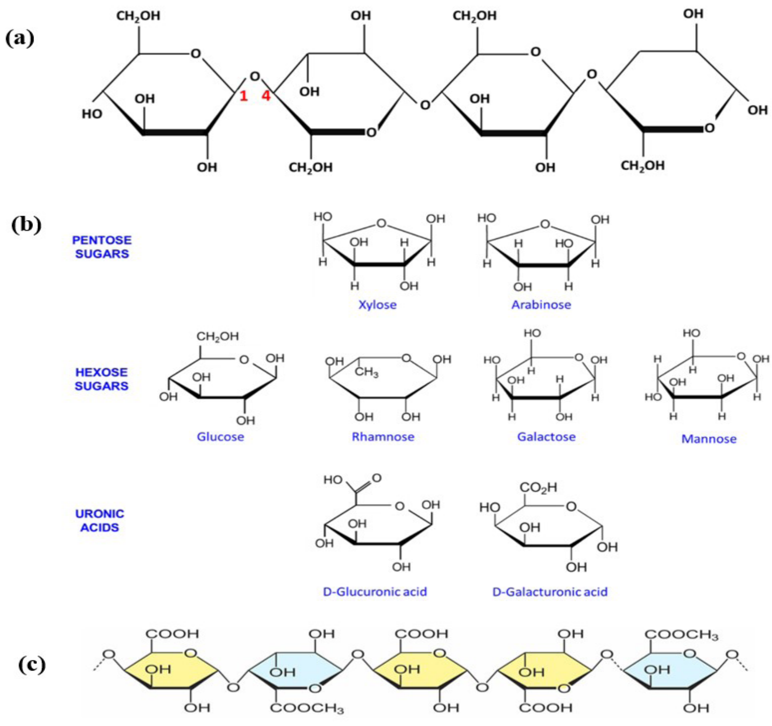

Figure 5. Cellulose (a), hemicellulose (b), and pectin (c) (adapted from [35, 36])

3.4. Biosorbent Usage

Today, a wide variety of industrial enterprises produce large amounts of waste of organic and inorganic origin, which is toxic and carcinogenic. The release of heavy metals into the aquatic environment caused by developing industrial sectors and technological approaches causes both water pollution and carcinogenic effects. At concentrations above the permissible discharge standards, these ions are not biodegradable and remain in the receiving environment. In recent years, there have been many scientific studies focusing on adsorbents of natural origin that do not cause pollution as a result of their use [37]. The use of waste material in pollutant removal and keeping this concept in the foreground is increasing day by day [38, 39]. Although there is a wide variety of adsorbent materials in the literature, the use of food and agricultural waste materials, which are classified as waste, is a specific approach in terms of both treatment and removal of pollution with waste. In line with this approach, wastes with lignocellulosic material structure (especially food and agricultural wastes) have started to be used in the adsorption method [40]. Since the adsorbent has a key role in adsorption, it is important to choose effective, economical and high efficiency adsorbents. At this point, food wastes are evaluated due to their lignocellulosic structure. In particular, such wastes are garbage and are thrown directly into the garbage. This situation, on the other hand, causes not only a valuable waste to be evaluated, but also extra environmental problems (leakage water, odor, fly formation). Approximately 90% of the forms found in dry and raw lignocellulosic material are composed of cellulose (35-55% by weight), hemicellulose (20-40% by weight) and lignin (10-25% by weight) (Figure 6) [9, 14, 23, 24, 36].

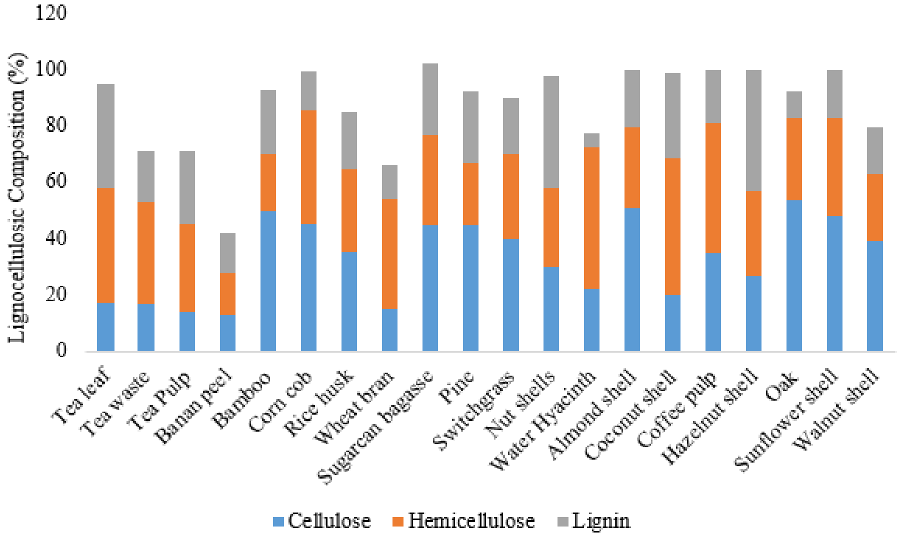

Figure 6. Composition of some lignocellulosic Materials (adapted from [9, 14, 23, 24, 36])

Table 1. Various studies researched to analyze the adsorptive capacity of lignocellulosic materials

Adsorbent/Biosorbent	Efficiency %	q_e (mg/g)	References
Tea wastes	76	7.61	[41]
Walnut shell	87	3.54	[42]
Banana peel	82	92.59	[43]
Orange peel	97	7.14	[44]
Kernel shell	80	6.81	[45]
brewed tea pulp (black)	88	9.14	[46]
brewed tea pulp (green)	83	8.56	
brewed tea pulp (red)	73	5.12	
Pumpkin seed hull	88	12.61	[47]
Walnut shell	99	9.91	[48]

Recently, intense levels of environmental pollution have been attributed to sectoral developments and population density. As both parameters continue to evolve, alternative treatment methods and alternative materials are being researched to reduce environmental pollution. Especially due to the decrease in quality water resources, the treatment and reuse of wastewater comes to the fore. For this reason, economical and highly efficient adsorption process has been preferred in recent years. Scientists have turned to alternatives to increase the efficiency of the adsorbent/biosorbent material in adsorption and reduce its cost. However, instead of conventional adsorbents such as activated carbon and clay, fruit and vegetable wastes are preferred because they are easily available and their cost is equal to zero. The main reason for the preference of especially food wastes is due to their structural (porosity, surface area, active substances, etc.) properties. In addition, in adsorption studies using different food wastes, both the adsorption capacity of food wastes and the pollutant removal efficiency were investigated in different waste waters. Table 1 contains data from adsorption studies of some lignocellulosic adsorbents.

4. CONCLUSION

In recent years, there are many scientific studies focusing on adsorbents of natural origin, which do not cause pollution as a result of their use. The use of waste material in pollutant removal and keeping this concept in the foreground is increasing day by day. Considering the near-zero cost and simplicity, the use of food waste in treatment is both economical and efficient. In addition, the evaluation of food wastes with the existing waste management system causes some problems. Therefore, the existing waste management system needs to be revised according to environmental pollution and the principle of sustainability. The lignocellulosic materials evaluated in this study are not only used for adsorption, but also used as raw materials in the energy, food, cosmetics sectors, animal nutrition, and evaluated as an active ingredient in the pharmaceutical industry. In the adsorption process, the intensive use of food waste as an adsorbent in recent years has given successful results in the treatment of heavy metals, dyes, hazardous chemicals and other polluting groups. With their renewable, active ingredient content and biodegradable properties, lignocellulosic materials are low-cost, easily available and highly efficient potential raw materials for the treatment of different types of pollutants. They are very effective in removing heavy metals from water and wastewater, especially when they can be reused in various adsorption-desorption cycles. Lignocellulosic materials are a promising raw material for fuel production, sustainable production of chemicals and nano-materials in the energy sector, due to their seasonal and socio-economic advantages.

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SUITABILITY PREDICTION OF SOME DIPHENYLAMINE DERIVATIVES FOR APPLICATION IN DYE-SENSITIZED SOLAR CELLS (DSSCs) USING DENSITY FUNCTIONAL THEORY (DFT)

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ABSTRACT

The suitability of the photosensitizer dyes has to be taken into consideration prior to the synthetic process for application in dye-sensitized solar cells to avoid waste of resources, therefore, Density functional theory and time-dependent density functional theory DFT-TD-DFT modeling techniques are used to conduct a computational study of the electronic structure of some Diphenylamine organic photosensitizer dyes (IM1-IM6) using the Gaussian 09 program. The calculation was optimized by means of the Becker three parameters hybrid functional with Lee-Yang-correlation functionals (B3LYP) with 6-31G (d,p) atomic basis set. The solvation effect was taken into account in the TD-DFT calculations in dichloromethane with the nonequilibrium version of the C-PCM model. This study provides a basic understanding of the impact of molecular design on the performance of some diphenylamine derivatives in dye-sensitized solar cells (DSSC).

Keywords: Diphenylamine, Organic Dyes, TD-DFT, Molecular Design, Optimization

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1. INTRODUCTION

The widespread commercialization of the photovoltaic (PV) cells is still limited mainly because of their high prices as compared to the amount of energy produced from them. Recent scientific research conducted for power conversion-efficiency reaches up to 24.2% [1], but is still non-competitive to the conventional electricity production sources. This relatively high cost is mainly due to the complex and expensive production process. Moreover, the need of highly purified silicon and use of toxic chemicals in their manufacturing, limits its use. These constraints encourage the scientists and researchers to divert their attention towards more efficient, economical and environment friendly solar cells. In this regard dye-sensitized solar cells (DSSCs) have received widespread attention in recent years because of their easy processing and low cost [2–5]. The major component of the DSSCs is a sensitizer. Its function is to adsorb an incoming sunlight and produce excitons. It is chemically bonded to the porous surface of the semiconductor. An efficient photosensitizer should: (i) possess intense absorption in the visible region (400 nm to 700 nm); (ii) adsorb strongly on the surface of the semiconductor; (iii) possess a high extinction coefficient; (iv) stable in its oxidized form,thus allows its reduction by an electrolyte; (v) stable enough to carry out ~108 turnovers, which typically correspond to 20 years of cell operation [6].

Photosensitizers are categorized into the metal complex and metal-free organic sensitizers. But metal free organic photosensitizers are preferred over ruthenium-based sensitizers because of their low cost and good transport properties. The basic structural unit of metal-free dyes are donor-pi-spacer-acceptor (D-π-A). The photovoltaic properties of such dyes can be finely tuned by selecting suitable groups within the D-π-A structure [7] This D-π-A dipolar 137 configuration creates an effective intramolecular charge transfer from donor to acceptor during electron excitation. Instead of this charge transfer from donor to acceptor, the performance of DSSCs significantly depends on the conjugated bridging system [8]. Organic dyes based on thiophene, oligothiophene moiety [9], 3,4-ethylenedioxythiophene (EDOT) [10], thieno (3,2-b) thiophene (TT) [11] and dithieno (3,2-b:2`,3`-d) thiophene (DTT) [12] have been reported as efficient pi-bridging moities, exhibits high values of the solar conversion efficiency. Thiophene, has been appeared as an attractive pi-bridging segment for the development of PV materials due to its rigid conjugation structure and facile introduction of alkyl chains. Thiophene based photosensitizers are expected to improve the overall efficiency of DSSCs [13,14]. In this research work, DFT is used to calculate the structural and optical properties of three dyes. Eventually, we compared the theoretical results with the experimental data available [14]. Kohn–Sham DFT/TD-DFT is an effective tool to investigate the ground and excited state properties of photosensitizer complexes compared to other high level quantum approaches, since the computed orbitals are appropriate for typical molecular orbital-theoretical studies and elucidations. Many theoreticians have successfully applied this approach [15,16].

Inorganic silicon based solar cells are being currently used for the conversion of photo energy on a commercial scale because of their high efficiency [17]. However, the need of highly purified silicon, use of toxic chemicals in their manufacture, and the high cost has restricted their worldwide use. These constraints encouraged the search for low cost and environmentally friendly solar cells. In this context, dye-sensitized solar cells (DSSCs) have received widespread attention in recent years because of their ease of processing and the low cost [18]. Dye is the major component of DSSCs, which absorbs incoming sunlight and produces excitons [19]. The photosensitizer, which is chemically bonded to the porous surface of the semiconductor, can be a metal complex or a metal-free organic sensitizer. But metal-free organic photosensitizers are preferred over ruthenium-based sensitizers because of their low cost and good transport properties. The basic structural unit of metal-free dyes is the donor-pi-spacer-acceptor (D-π-A) unit and the photovoltaic properties of such dyes can be fine-tuned by selecting suitable groups within the D-π -A structure [20]. These results suggest that the donor groups to form efficient sensitizers should be selected from the electron-rich aryl amines family including phenylamine, amino-coumarin, indoline, and (difluorenyl) triphenylamine [21]. Many organic groups have been used as pi-spacer to tune the electrical and optical properties of light-sensitive materials.

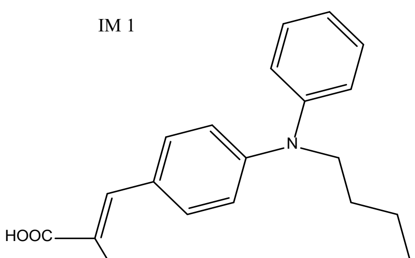
The density functional theory (DFT) and time-dependent DFT (TD-DFT) can provide a deeper understanding of the relationship between molecular structure and properties of compounds. Thus, theoretical calculations are important to design new and efficient dyes for DSSCs [23]. DFT is used because it is the only ab initio method able to do the calculation at a cost acceptable for routine use. Here, the aim is to study the theoretical and experimental studies of novel diphenylamine-based organic dyes and establish their structure-performance relationship for application in DSSCs.

2. MATERIALS AND METHODS

2.1. Design of organic Photosensitizers

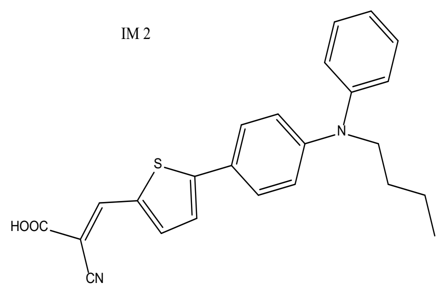
Six organic photosensitizer dyes (IM1-IM6) were designed for the simulation using Gaussian 09 software program. each dye has elecron donor group which is diphenylamine moiety, thiophen and furan as pi-bridge parts and cyanoacrylic acid as electron donor group as shown below;

IM 1



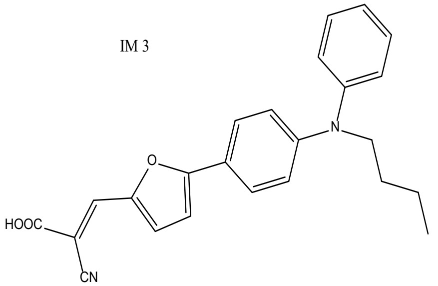
(*E*)-3-(4-(butyl(phenyl)amino)phenyl)-2-cyanoacrylic acid
Chemical Formula: $C_{20}H_{20}N_2O_2$
Molecular Weight: 320.38

IM 2



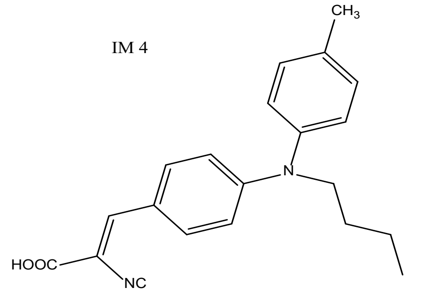
(*E*)-3-(5-(4-(butyl(phenyl)amino)phenyl)thiophen-2-yl)-2-cyanoacrylic acid
Chemical Formula: $C_{24}H_{22}N_2O_2S$
Molecular Weight: 402.51

IM 3



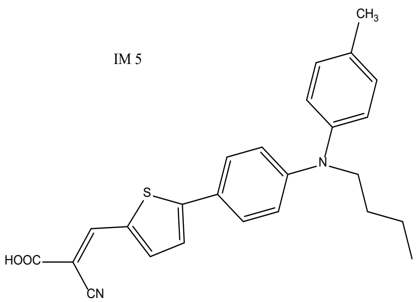
(*E*)-3-(5-(4-(butyl(phenyl)amino)phenyl)furan-2-yl)-2-cyanoacrylic acid
Chemical Formula: $C_{24}H_{22}N_2O_3$
Molecular Weight: 386.44

IM 4



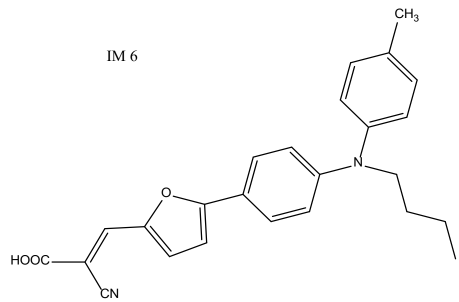
(*Z*)-3-(4-(butyl(*p*-tolyl)amino)phenyl)-2-isocyanoacrylic acid
Chemical Formula: $C_{21}H_{22}N_2O_2$
Molecular Weight: 334.41

IM 5



(*E*)-3-(5-(4-(butyl(*p*-tolyl)amino)phenyl)thiophen-2-yl)-2-cyanoacrylic acid
Chemical Formula: $C_{25}H_{24}N_2O_2S$
Molecular Weight: 416.54

IM 6



(*E*)-3-(5-(4-(butyl(*p*-tolyl)amino)phenyl)furan-2-yl)-2-cyanoacrylic acid
Chemical Formula: $C_{25}H_{24}N_2O_3$
Molecular Weight: 400.47

Figure 1. Structure of organic Dyes

2.2. Computational Details

The ground state geometries of six dyes (IM1-IM6) dyes were optimized by Becke's three-parameter nonlocal-exchange functional with the nonlocal correlation of Lee–Yang–Parr method (B3LYP) [23] using a standard 6-31G(d,p) basis set on all atoms. The frequency was evaluated at the same level to confirm that all the optimized geometries correspond to the true minima on the potential energy surface with none imaginary frequency. To include the solvent influence on the geometries, all the molecules were investigated at the B3LYP/6-31G (d,p) level in dichloromethane (DCM) solvent by using the polarized continuum model (PCM).

3. RESULTS AND DISCUSSION

3.1. Photosensitizer Design

The structures and names of a new class of dyes are shown in Fig 1. In these units' diphenylamine and 2-methyldiphenylamine were used as the electron-donating moieties, carboxyl and cyano functional groups were inserted as the acceptor moiety, and the anchor group owing to their good electron-extracting capability and strong adhesion to metal oxide. thiophene and furan moiety was used as the π-conjugation spacers, which bridges the donor-acceptor systems. Thiophene/furan as a pi-bridge reduces the tendency to aggregate, but resistance to charge transfer between donor and acceptor increases. However, the insertion of thiophene moiety as a pi-bridge causes the red shift in absorption spectra.

3.2. Energy Levels

The HOMOs, LUMOs, and the band gap energies of the photosensitizers play an important role in providing the driving force for the electron injection. For efficient charge transfer, the LUMOs of dyes must be more negative than the conduction band of the semiconductor while HOMO levels must be more positive than the redox potential of electrolyte. The electron distribution of the HOMOs and LUMOs of IM1, IM2, IM3,…IM6 are shown in Table 2.1. Clearly, the HOMOs of these compounds are the highest electron density located at the nitrogen atoms of the diphenylamine. The LUMOs are located in the anchoring group through the pi-bridge. Thus, the HOMO-LUMO excitation induced by light irradiation could move the electron distribution from the diphenylamine segment to the anchoring unit through the pi-bridge segments.

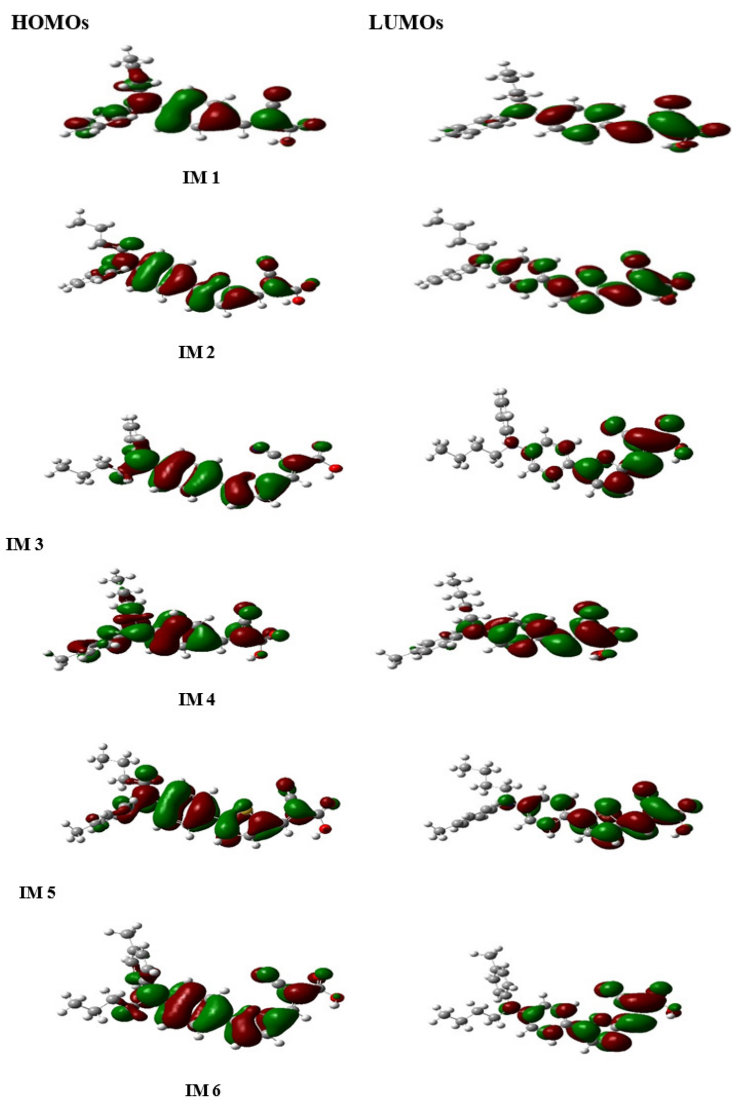


Figure 2. Simulated HOMOs and LUMOs of dyes

Table1. Simulated HOMOs, LUMOs (eV) and H-L gap energies of dyes

Dyes	HOMO (eV)	LUMO (eV)	H-Lgap (eV)	Wavelength (nm)	f
IM 1	-5.6657	-2.2135	3.4522	403.63	1.0211
IM 2	-5.3655	-2.5360	2.8295	506.07	1.0043
IM 3	-5.2284	-2.3938	2.8346	469.50	0.5969
IM 4	-5.6151	-2.1873	3.4278	406.29	1.0040
IM 5	-5.3225	-2.5255	2.7970	510.00	1.0240
IM 6	-5.1971	-2.3761	2.8210	496.09	0.8261

Table 1. shows that the HOMO levels of the dyes are in the order of IM6 (-5.1971) >IM3 (-5.2284) >IM5(-5.3225) > IM2 (-5.3655) > IM4 (-5.6151) > IM1 (-5.6657) While, LUMO energy levels are in the order of IM4 (-2.1873) > IM1 (-2.2135) > IM6 (-2.3761) > IM3 (-2.3938) >IM5 (-2.5255) > IM2 (-2.5360). The insertion of thiophene and furan units as the π-conjugation unit significantly affects the HOMO and LUMO energy levels of the dyes. Similarly, the $H\text{-}L_{gap}$ of the dyes are in the order of IM5 (2.7970) < IM6 (2.8210) <IM2 (2.8295) <IM3 (2.8346) <IM4 (3.4278) <IM1 (3.4522) These results suggest that dyes 1-6 can inject electrons to the conduction band of titanium oxide as seen from figure 3. below the conduction band of titanium dioxide is -4.2eV all the LUMO values of the simulated dyes are more negative than that of $TiO_{2.}$

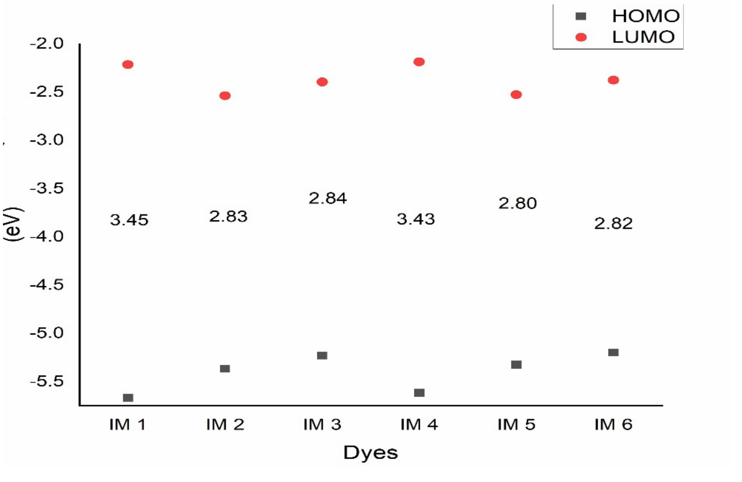


Figure 3. HOMOs, LUMOs and Bandgap of IM1-IM6

3.2 Optical Properties

The UV-Vis absorption spectra of the dyes in dichloromethane are shown in Fig 4. IM5 (510.00) >IM2 (506.07) >IM6 (496) >IM3 (469.50) >IM4 (406.29) >IM1 (403.63). we can see from table 1. and figure 3. that all the dyes occupy visible regions between about 300nm to near-infrared 800nm, this is an indication that if the dyes are to be used in dye-sensitized solar cells, they will give good efficiency. Two distinct absorption bands of all dyes in dichloromethane can be observed: one relatively weak bond is in the region (300-400 nm) corresponding to the π-π* electron transitions of the conjugated molecules and the other is around 400-800 nm that can be assigned to an intramolecular charge transfer (ICT) between electron-donor and electron acceptor anchoring moieties.

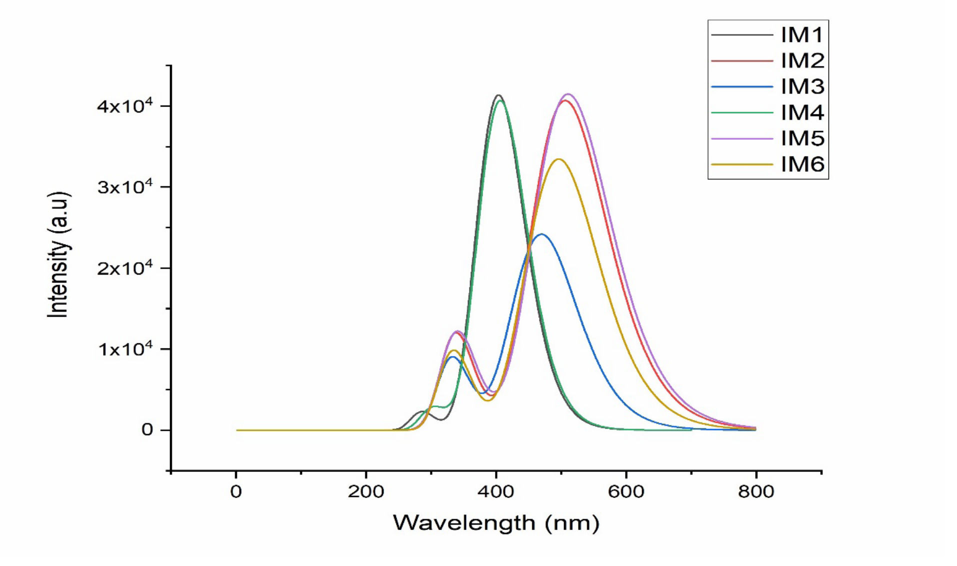


Figure 4. Showing Absorptions of dyes

4. CONCLUSION

In this study we have designed a series of six organic photosensitizers based on diphenylamine derivatives containing thiophene/furan moieties as the conjugated spacers. We theoretically study these compounds by the DFT and TD-DFT methods to investigate their electronic properties and to assess the possibility of their use as sensitizers in the organic solar cell. In the framework of this study, we can draw the following conclusions: The alkyl chain on diphenylamine has no effect on the EHOMO, ELUMO, Egap, and λmax of the designed dyes, extending the π-conjugation by introducing a thiophene or furan moiety between diphenylamine donor group and anchoring group enhances the performance of the studied dyes. The IM5 and IM2 dyes in which thiophene was used as spacer showed the best values of EHOMO, ELUMO, Egap, and λ max parameters, The designed dyes are expected to be efficient sensitizers for DSSCs. Further structural modification of the π-conjugated bridge based on the series of sensitizers to improve the photovoltaic performance is ongoing. The results shows that the LUMO of all of the dyes is greater than the conduction band of TiO_2 indicating that a full charge transfer from these dyes into the conduction band of TiO_2 is allowed.

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CONVERSION OF SO_X AND NO_X TO THE FERTILIZER

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ABSTRACT

Pollutant emissions from developing countries continue to increase. Many of these countries also suffer from social problems such as poverty, food shortages and unemployment.

In addition, other problems developing countries face can be listed as agricultural development, better crop production, and the solution to the food shortage problem. These problems are an important key to job creation and income generation for developing countries.

In particular, when the concentration of fossil fuel air pollutants exceeds specific atmospheric values, it causes serious health problems such as respiratory diseases and lung failure. In addition, pollutants turn into secondary pollutants in the atmosphere, causing severe problems such as acid rains deteriorating the natural structure of vegetation, soil, and water resources, and even erosion of calcareous building exterior materials. Due to such problems, emissions from industrial activities, heating and traffic need to be controlled to protect human and environmental health. In order to control these pollutants, emission limits have been introduced to combustion systems by legislation and regulations.

For this reason, using more efficient and economically environmentally friendly technologies is necessary than the flue gas treatment systems used today. Depending on the use of fossil fuels in different areas, the conversion of harmful gases into the atmosphere into useful products and the sustainability of resources are important. In addition, it is possible to use these products as fertilizer in agricultural areas, considering environmental and soil pollution. This compilation study will give technical information about converting SO_X and NO_X in the flue gas into fertilizer, a product with high-added value. In this way, it is of great importance in contributing to the environment, public health and economic development (especially agriculture) of pollutants from flue gas.

Keywords: NO_X and SO_X Removal, Waste Flue Gas, Fertilizer, Fossil Fuels, Friendly Technologies

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1. INTRODUCTION

Many countries, especially developing regions, are faced with environmental and social problems arising from rapid population growth, industrialization and poverty. As these issues become more prominent, it is essential to consider pollution control strategies that can also deliver social benefits. Sulfur dioxide (SO_x) and nitrogen oxide (NO_x) emissions from thermal power plants and fossil fuel-burning industrial plants are the most contributors to acidic aerosol pollution [1]. In addition, NO_x is also released from the automobile exhaust. While SO_x emissions decrease in industrialized countries, they increase in developing countries. With the burning of low-quality coals, a high concentration of sulfur trioxide (SO_3) emission from the flue gas is released into the atmosphere. In addition, SO_3 has more than ten times the toxicity of sulfur dioxide (SO_2) and is a highly corrosive gas [2]. These pollutants can harm the natural environment and affect human health away from the emission source [3]. These pollutants enter the human body through inhalation, skin exposure and ingestion and cause adverse effects on the lungs and are an aggravating factor for many respiratory diseases such as asthma, lung cancer and chronic obstructive pulmonary disease [4–11]. In addition, these pollutants are the main substances that cause harmful effects on the natural environment as well as acid rain, greenhouse effect, photochemical smog and human health [12–14]. Nevertheless, the most severe effect it has is the destruction of vegetation and forests with acid rains, the deterioration of the natural structure of the soil and water resources, and even the deterioration of buildings. [3, 15–17].

Many countries apply strict environmental regulations, standards and legislation regarding the discharge of these pollutants into the atmosphere to combat the potential health problems and environmental effects of air pollution [18–23]. In this direction, flue gas treatment systems have been developed to reduce flue gas emissions (SO_2, NO_x, CO_2) from fossil fuel use. These systems have been used for many years. However, the energy and natural resource crisis caused by factors such as rapid population growth, industrialization and poverty in many countries cause a focus on the sustainability of resources. For this reason, according to the flue gas treatment systems used today, it has been of great importance to transform the harmful gases emitted by fossil fuels into the atmosphere into valuable products and ensure the beneficial use of an industrial facility treatment waste for another sector with symbiotic sharing.

In this study, flue gas desulphurization technologies, flue gas denitrification technologies and various technologies aiming to remove SO_x and NO_x were examined to control atmospheric pollution due to the harmful effects of NO_x and SO_x on human health. In addition, the treatment of these wastes without harming the environment is important for the environment, and the evaluation of the obtained product is of great importance in terms of the sustainability and economy of the technology used. For this reason, in the continuation of the study, the transformation of harmful gases released into the atmosphere by fossil fuels into fertilizer is discussed, taking into account the environmental and soil pollution.

2. SO_X and NO_X Removal Methods and Conversion to Fertilizer

Among gaseous pollutants, sulfur oxides are the most well-known primary air pollutants. SO_2 gas constitutes the most important share of the sulfur oxides formed due to the high-temperature combustion of sulfur-containing fossil fuels. [24].

Some of the SO_2 is converted to SO_3 as a result of catalysis by solid particles or sun rays in the air or oxidation on water droplets by some reactions [25]. Then it is separated from the atmosphere by wet or dry precipitation, causing soil and water pollution. When the SO_2 concentration in the atmosphere reaches certain values, it can cause fatal diseases such as respiratory system diseases and lung failure.

Another pollutant among gaseous pollutants is NO_x. This pollutant consists of a mixture of NO and NO_2 by various reactions during combustion. NO gas usually accounts for more than 90% of NO_x in the typical flue gas [26]. The sources of NO_x formation can be listed as natural sources, such as the production effects of industrial facilities, flue gas emissions from fossil fuel use, soil microbial activities, and atmosphere lightning events. Atmosferik ortamda NO_x (NO_2, NO, N_2O) ve SO_x (SO_2, SO_3) gibi asidik gazlar H_2O, O_2 ve diğer maddelerin birlikte reaksiyona girmesiyle sülfürik ve nitrik asitlerin oluşmasına neden olur [10, 27, 28]. Conversion reactions of NO_x and SO_x to secondary air pollutants in the atmosphere;

$2SO_2 + O_2 \rightarrow 2SO_3$ (Sulfur trioxide) (1)

$SO_3 + H_2O \rightarrow H_2SO_4$ (Sulfuric acid) (2)

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$ (Nitric acid + Nitrogen oxide) (3)

In addition to such reactions, NO_x is among the main factors forming photochemical fog. Also, NO_2 has a direct toxic effect on both human health and vegetation [29]. Because of these effects, establishing environmentally friendly and economically viable disposal systems is very important.

2.1. SO_x Removal Methods and Conversion to Fertilizer

Flue gas desulfurization (FGD) techniques are used to remove sulfur dioxide (SO_2) from flue gas. FGD is applied in many parts of the world to remove SO_2 from flue gas produced by burning fossil fuels. These processes are classified in two different ways: wet and dry, depending on whether the substance used comes into contact with the gas in powder or solution form (Table 1). Wet flue gas desulfurization (WFGD) is one of the leading methods for SO_2 removal in most industries [30, 31].

Table 1. Flue Gas Desulphurization Processes

Wet Processes	Dry Processes
• Alkaline Earth Metal Processes	• Spray Drying Process
• Alkali Metal Processes	• Alkaline Injection Process
• Ammonia Processes	• Adsorption Process with Activated Charcoal
• Aluminum Sulphate Processes	• Catalytic Oxidation Process
• FeS Processes with Thermal Regeneration	
• Chiyoda Sulfuric Acid Process	
• Thermal Regeneration Amine Process	
• Seawater Process	
• Physical Solvent Processes	
• Molten Salt Process	

Fertilizer production by wet lime/limestone process

The most common FGD process applied in thermal power plants is the wet lime/limestone process. In this process, SO_2 gases are reacted with alkaline absorbent materials such as slaked lime and limestone, and a mixture of slaked lime and fly ash is used to spray them into the flue gases. The most widely used method is the process of producing calcium sulfide hemihydrate ($CaSO_3.0.5H_2O$) or calcium sulfate dihydrate ($CaSO_4.2H_2O$-gypsum) by reacting limestone as a sorbent with SO_2 gases to form a calcium compound [17]. Pure gypsum produced from these processes and finely ground limestone are used to reduce acid precipitation in the atmosphere. At this stage, FGD gypsum sludge formed in the storage tank can be used as FGD gypsum by filtering and dewatering processes.

$$SO_2 + CaCO_3 + 0.5H_2O \rightarrow CaSO_3.0.5H_2O + CO_2 \quad (4)$$

$$SO_2 + CaCO_3 + 2H_2O + 0.5O_2 \rightarrow CaSO_4 \cdot 2H_2O + CO_2 \quad (5)$$

FGD gypsum ($CaSO_4 \cdot 2H_2O$), which is formed as a by-product after the dewatering process, can be used for many purposes. It can be used for soil improvement and soil conditioning for agricultural purposes or fertilizer production. It can be used to make gypsum wallboard. It can be used in cement making by blending with fly ash or shale. It can be used in anhydrite floor screeds, building plasters, and road construction [32–34]. Powdered gypsum can also be used as fertilizer by throwing it directly into the soil [35].

FGD yaş proseslerinden biri olan amonyak prosesi, sulu amonyak solüsyonunda SO_2 adsorpsiyonuna dayanır. Ayrıca bu işlem sayesinde FGD arıtma atıklarından suni gübre üretimine olanak sağlanmaktadır [25].

Another building material containing sulfur is calcium sulfate, also known as gypsum. The FGD process removes SO_2 from the flue gases of coal power plants. It is caused by sulfur in the coal and must be removed by a cleaning system. The reaction that takes place in the washer produces Calcium Sulfite by consuming lime and then Calcium Sulphate through oxidation [36].

Fertilizer production by thermal regeneration ammonia process

The thermal regeneration ammonia process removes SO_2 in the flue gas. In this process, a reversible reaction is achieved in the absorption column with ammonium sulfide solution. Thermal stripping is performed to convert this retained solution into sulfur and H_2SO_4 to recover SO_2[37].

$$2NH_4HSO_3 \leftrightarrow (NH_4)_2SO_3 + SO_2 + H_2O \quad (6)$$

In this process, problems include oxidation of the absorbent $(NH_4)_2SO_3$ into $(NH_4)SO_4$ and the loss of ammonia by evaporation [38].

Fertilizer production with the cominco process

With the Cominco process, SO_2 in the flue gas is removed. In this process, flue gas is washed with dilute NH_3 solution and then reacts with H_2SO_4. After this process, the by-product ($(NH_4)_2SO_4$) formed by evaporation of the solution can be crystallized and used as fertilizer. The main problem of this process is the loss of NH_3 from the system. It is generally used for cleaning furnace gases in metallurgy[39].

Fertilizer production by ammonia absorption-ammonium bisulfate regeneration process

In the ammonia absorption-ammonium bisulfate regeneration process (ABS), SO_2 in the flue gas is washed with an aqueous ammonia solution in an absorption column. Then, a solution of ammonium sulfide ($(NH_4)_2SO_3$) and ammonium bisulfite (NH_4HSO_3) is obtained [25]. This solution obtained reacts with ammonium bisulfate and SO_2 gas, a salable product, is separated from the liquid medium. To reuse ammonium bisulfate and ammonia, the ammonium sulfate solution is evaporated and the remaining crystals are thermally decomposed [40].

$$NH_3 + H_2O + SO_2 \leftrightarrow NH_4HSO_3 \quad (7)$$

$$2NH_3+H_2O+SO_2 \leftrightarrow (NH_4)_2SO_3 \quad (8)$$

$$(NH_4)_2SO_3+2NH_4HSO_4 \leftrightarrow 2(NH_4)_2SO_4+H_2O+SO_2 \quad (9)$$

$$NH_4HSO_3+NH_4HSO_4 \leftrightarrow (NH_4)_2SO_4+H_2O+SO_2 \quad (10)$$

$$(NH_4)_2SO_4 + \text{heat} \leftrightarrow NH_4HSO_4 + NH_3 \quad (11)$$

This product obtained is of quality that can be used as fertilizer and this is the biggest advantage of this system [41]. Ammonium sulphate, which has commercial value as nitrogen fertilizer, does not require the disposal of the absorbent. In addition, it does not require additional costs for the process as the oxidation process is carried out in the washer [42].

Fertilizer production with the walther process

With the Walther Process, SO_2 in the flue gas is removed. After the dust in the flue gas is removed by the pre-treatment process, NH_3 solution is sprayed into the hot flue gas. The gas is then passed through a dryer and electro filter to the washing towers. The cleaned gas from the washing towers is heated with the incoming hot gas and thrown into the atmosphere. The resulting solution is oxidized with air oxygen to Ammonium sulfate ($(NH_4)_2SO_4$) in an oxidator, and then evaporated in a spray dryer. Here, ammonium sulfate and ammonium carbonate ($(NH_4)_2CO_3$) in the environment are decomposed into ammonia (NH_3), SO_2 and CO_2. Ammonium sulfate is obtained as a solid by-product. Ammonium sulfate artificial fertilizer is produced with the Walther process, an aqueous ammonia FGD process. The advantages of this process are the production of dry ammonium sulfate fertilizer and the high retention efficiency in the inlet flue gas SO_2 concentration. On the other hand, remaining harmful chemical substances in the fertilizer are the disadvantage of this process [37].

Fertilizer production with Sodium bicarbonate ($NaHCO_3$)

Sodium bicarbonate ($NaHCO_3$) and SO_2 in the flue gas are removed from the hot flue gas (120°C and 175°C) using sodium bicarbonate injected into the flue gas duct [43]. As a result of the reaction of sodium bicarbonate with SO_2, ammonium sulfate, which is a useful source of sulfur fertilizer, is formed. In addition, the resulting ammonium sulfate fertilizer is generally suitable for products such as wheat, corn, rice, cotton, sweet potato, sesame seeds, fruit trees and vegetables [44].

$$2NaHCO_3 + SO_2 \rightarrow Na_2SO_3 + 2CO_2 + H_2O \quad (12)$$

$Na_2CO_3 + SO_2 \rightarrow Na_2SO_3 + CO_2$ (13)

$Na_2SO_3 + SO_2 + H_2O \rightarrow 2NaHSO_3$ (14)

$2NH_4OH + SO_2 + H_2O \leftrightarrow (NH_4)_2SO_3 + 2H_2O$ (15)

Fertilizer production by ammonium-calcium pyrophosphate process

SO_2 in the flue gas is removed by the Ammonium-Calcium Pyrophosphate Process. In this process, SO_2 is absorbed from the flue gas in two absorption towers with calcium and ammonium pyrophosphate solution and this solution is neutralized with ammonia. Then, after the precipitated $CaSO_4$ and $CaSO_3$ are separated, Tetraammonium diphosphate ($(NH_4)_4P_2O_7$) is crystallized from the solution. A fertilizer with market value is obtained with the by-product obtained. The remaining solution is sent back to the absorption columns. The disadvantage of this process is that the obtained fertilizer may contain dangerous chemicals [37].

2.2. NO_x Removal Methods and Conversion to Fertilizer

Processes such as selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR) for NO_x removal are used in large incinerators such as various boilers, refineries and solid waste incineration plants [20, 29, 45]. In addition, for NO_x removal, removal is provided by absorption, adsorption and biological treatment processes. With ammonia injection, SCR is carried out by injecting NO_x in the flue gas into a catalyst bed at 350˚C [46]. In SNCR, a reducing compound such as ammonia or urea is injected into the waste gas [47]. Since this process does not use a catalyst, it consists of a process that reduces NO_x to water using nitrogen gas under high temperature (850-1100°C) conditions. Biological treatment of NO_x takes place under aerobic conditions, in the form of oxidation of NO_x to nitrate by nitrification and chemical oxidation processes. With nitrification, NO_x compounds become nitrates, and appropriate disposal of nitrate in water should also be considered. On the other hand, under anoxic conditions, the NO_x denitrification process is reduced to harmless nitrogen gas with a high efficiency. In its oxidized form, Nitrogen acts as an electron acceptor in the presence of organic carbon and is reduced by heterotrophic denitrification to nitrogen gas. Facultative heterotrophic bacteria (nitrate, nitrite reductase, etc.) convert oxidized nitrogen forms into nitrogen (N_2) gas in the absence of oxygen by using nitrate reductase, nitrite reductase, nitric oxide reductase, and nitrous oxide reductase enzymes, respectively [29].

$NO_3 \rightarrow NO_2 \rightarrow NO \rightarrow N_2O \rightarrow N_2$ (16)

2.3. Simultaneous Removal Methods of NO_x and SO_x and Conversion to Fertilizer

Separate removal of NO_x and SO_x by conventional methods causes many problems, although the level of purification achieved in treatment systems is high. The wastes produced in these processes (gypsum, wastewater, and spent catalyst) both cause twice the cost of removing pollutants and have problems such as high space requirements that make modernization of retrofit plants difficult [48]. Therefore, recently, new technologies have been developed for its simultaneous removal. These new technologies are being investigated by researchers in flue gas treatment systems such as absorption, advanced oxidation processes (AOPs), non-thermal plasma (NTP), and electron beam (EB) to replace existing integrated systems [14].

Fertilizer production with electron beam flue gas treatment processes

Electron Beam Flue Gas Treatment (EBFGT) Processes is a hugely promising industrial application technology, constantly evolving in the field of simultaneous $DeNO_x$ and $DeSO_x$ from coal-fired power plants, fossil fuel combustion chambers, and diesel engines [49–57]. In this process, both SO_2 and NO_x can be removed simultaneously in a single dry process with high efficiency. The only by-product produced in the process is a mixture of ammonium sulfate and nitrate, which can be used and sold as fertilizer [48]. Figure 1 shows the schematic diagram of the EBFGT process. Here, flue gas containing air and water vapor is irradiated with an electron beam (EB), and oxidative radicals OH, HO_2 and $O(^3P)$ are produced from the radiolysis of O_2 and H_2O molecules. NO_x and SO_2 are oxidized to HNO_3 and H_2SO_4 via radical oxidation reactions [14, 58, 59]. In addition, NH_3 gas or NH_4OH gas is injected together with the flue gas before the EB irradiation chamber. This injected gas reacts with HNO_3 and H_2SO_4 produced under EB irradiation to form the final solid phase by-products of ammonium nitrate (NH_4NO_3) and ammonium sulfate ($(NH_4)_2SO_4$). SO_3, which is directly present in the flue gas, reacts with ammonia to form ammonium sulfate without the effect of free radicals [60]. In the process, in the case of unreacted SO_2 and NH_3, most of these compounds form ammonium sulfate due to thermal reactions [59]:

$$N_2, O_2, H_2O \text{ (vapor)} + e^- \rightarrow \text{free radicals (e.g. } OH\cdot, HO_2\cdot\text{), ions and exited ions} \quad (17)$$

$$SO2 + OH\cdot + M \text{ (third body molecule)} \rightarrow HSO_3 + M \quad (18)$$

$$(4)HSO_3 + O_2 + H_2O \rightarrow H_2SO_4 + HO_2\cdot \quad (19)$$

$$NO + O(^3P) + M \rightarrow NO_2 + M \quad (20)$$

$$NO + HO_2\cdot + M \rightarrow NO_2 + OH\cdot + M \quad (21)$$

$$NO_2 + OH\cdot + M \rightarrow HNO_3 + M \quad (22)$$

$$H2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4 \quad (23)$$

$$HNO_3 + NH_3 \rightarrow NH_4NO_3 \quad (24)$$

$$SO_3 + 2NH_3 + H_2O \rightarrow (NH_4)_2SO_4 \quad (25)$$

$$2SO_2 + 4NH_3 + 2H_2O + O_2 \rightarrow 2(NH_4)_2SO_4 \quad (26)$$

By-products that can be used as quality fertilizer are finally collected after the EB irradiation chamber with the help of ESP or bag filters. In this way, the EBFGT process enables the efficient treatment of flue gas and the production of high-quality by-products as fertilizers.

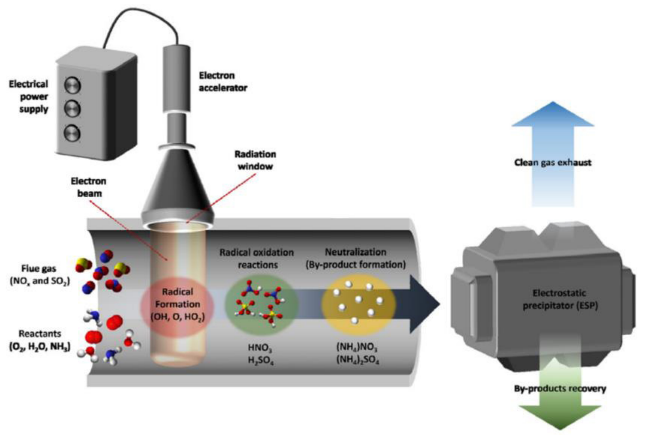

Figure 1. Electron beam flue gas treatment process [14]

Fertilizer production with pulsed corona discharge process (PCDP)

Pulsed corona plasma and energetic electrons are generated by a high voltage electrical power supply within a reactor to remove NO_x by the pulsed corona discharge process (PCDP). Here, most of the NO reacts with NO_2 and then NH_3 and is converted to HNO_3. The particles (NH_4NO_2, NH_4NO_3) formed in the reactor grow by coagulating between the particles and allowing them to be used as fertilizer later [61].

Fertilizer production with NH_3 and O_3

NH_3 and O_3 are used for the simultaneous removal of NO and SO_2 from an industrial flue gas stream. After this process, compounds such as NH_4NO_3 and $(NH_4)_2SO_4$ can be directly converted into fertilizer [23]. The following reactions can explain the reaction mechanism for SO_2 conversion and $(NH_4)_2SO_4$ formation [23, 62–66].

$$SO_2 + O_3 \rightarrow SO_3 + O_2 \quad (27)$$

$$SO_3 + O \rightarrow SO_2 + O_2 \quad (28)$$

$$SO_2 + O \rightarrow SO_3 \quad (29)$$

$$SO_3 + H_2O \rightarrow H_2SO_4 \quad (30)$$

$$SO_2 + HO \rightarrow HSO_3 \quad (31)$$

$$HSO_3 + O_2 \rightarrow HO_2 + SO_3 \quad (32)$$

$$HSO_3 + OH \rightarrow H_2SO_4 \quad (33)$$

$$HSO_3 + OH \rightarrow SO_3 + H_2O \quad (34)$$

$$2H_2O_2 + 2SO_2 \rightarrow 2HSO_3 + O_2 \quad (35)$$

$$HO_2 + SO_2 \rightarrow SO_3 + OH \quad (36)$$

$$H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4 \quad (37)$$

The following reactions can explain the reaction mechanism for NO conversion and NH_4NO_3 formation [23, 61, 62, 65, 67–70].

$$NO + O_3 \rightarrow NO_2 + O_2 \quad (38)$$

$$NO_2 + O_3 \rightarrow NO_3 + O_2 \quad (39)$$

$$NO_3 \rightarrow NO + O_2 \quad (40)$$

$$NO_2 + NO_3 \rightarrow N_2O_5 \quad (41)$$

$$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3 \quad (42)$$

$$H_2O + N_2O_5 \rightarrow 2HNO_3 \quad (43)$$

$$NO + NO_2 + H_2O \rightarrow 2HNO_2 \quad (44)$$

$$NO_2 + OH \rightarrow HNO_3 \quad (45)$$

$$H_2O + O \rightarrow 2OH \quad (46)$$

$$NH_3 + OH \rightarrow H_2O + NH_2 \quad (47)$$

$$NH_2 + NO \rightarrow H_2O + N_2 \quad (48)$$

$$NH_2 + NO_2 \rightarrow N_2O + H_2O \quad (49)$$

$$HNO_3 + NH_3 \rightarrow NH_4NO_3 \quad (50)$$

Simultaneous removal of NO_x and SO_x provides a suitable solution as it provides higher removal efficiency in a single reactor system with added economic benefits to fertilizer production and NH_3 removal. [14, 23, 27, 71].

3. RESULT AND DISCUSSION

Many countries, especially developing regions, are faced with environmental and social problems arising from rapid population growth, industrialization and poverty. As these issues become more prominent, it is important to consider pollution control strategies that can also deliver social benefits. NO_x and SO_x emissions from thermal power plants and fossil fuel-burning industrial plants need to be removed. They were considering the environmental effects of the wastes (gypsum, wastewater and spent catalyst) produced during the removal of these emissions, more effective flue gas cleaning systems should be installed and operated. If these by-products are not used, they become waste and cause environmental problems. It is crucial to ensure the beneficial use of the treatment waste of an industrial facility with symbiotic sharing for another sector. As important as the treatment of waste without harming the environment is in terms of the environment, the evaluation of the obtained product is of great importance regarding the sustainability and economy of the technology used. Care must be taken to avoid a process that reduces one pollutant but emits another.

4. CONCLUSION

Industrial facilities cause a certain cost in flue gas treatment and disposal of by-products. Thanks to this by-product, both additional costs and profits will not be incurred in industrial facilities. Systems used to remove emissions such as NO_x and SO_x from flue gas are not directly related to agriculture. However, it can be stated that it is a way of converting air pollutants into agricultural fertilizers. It is an indisputable fact that the environment and agriculture are essential factors for human survival in ensuring global stability. From this point of view, the symbiotic sharing of by-products formed in the removal of flue gas emissions and their beneficial use and the realization of environmentally friendly use have an important role in the energy sector, global environment and social development.

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CHAPTER 13

Monitoring of Climate Change in Wetlands

CLIMATE CHANGES AND THEIR IMPACTS ON THE KIZILIRMAK DELTA

Ali Uzun[1*]

ABSTRACT

This study has been prepared to examine the possible effects of global climate change and related sea level rise on the Kızılırmak Delta. While preparing the study, the effects of future climate changes were tried to be estimated based on the results of past climate changes. In other words, from the known to the unknown, an inductive method of reasoning was followed. Climate refers to the long-term (30-40 years and above) average weather conditions that prevail in a region. The climate, which is formed under the control of local and global factors, changes with the change of these factors. In the geological past, there have been significant climate changes due to natural causes. Traces of climate changes in the Quaternary have survived to the present day. In the future, the climate is expected to change due to natural reasons. The problem is human-induced climate change caused by fossil fuel consumption and the associated increase in greenhouse gases after the Industrial Revolution. In the absence of adequate measures, it is predicted that global climate change will accelerate gradually. As a matter of fact, according to the pessimistic scenarios prepared for situations where States cannot fulfill their responsibilities under international agreements, the sea level may rise by 2.5 m in 2100 and by 5 m in 2300. Therefore, more than half of the Kızılırmak Delta (370 km2) will be underwater, similar contractions will be seen in the Yeşilırmak Delta and other low-lying areas. In addition, rising sea waters will invade coastal wetlands and cause changes in ecological characteristics. For this reason, it is vital to consider these issues in long-term planning and to control and reduce national and individual carbon footprints.

Keywords: Climate Changes, Sea Level Rise, Kızılırmak Delta, Türkiye.

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1. INTRODUCTION

Climate refers to the long-term (30 years and above) average weather conditions prevailing in a place; climate change refers to the long-term changes in average weather conditions. A climate system has been formed on the earth that is related to the climate and interactions with each other. This system consists of five main components, which are defined as the Atmosphere, Hydrosphere, Cryosphere, Lithosphere and Biosphere [1]. When the climate changed, the climate system also changes. In other words, climate change effects precipitation and flow conditions, sea and lake levels, snow and ice covers, landforms, soil properties, live species and their communities, humans and human activities. This study is prepared in order to discuss how past climate changes have affected the Kızılırmak Delta, and what kind of changes await the delta in the future based on climate change scenarios.

The atmosphere is the natural greenhouse of the earth. There are various greenhouse gases in the atmosphere such as Carbon Dioxide (CO2), Water vapor (H20) and Methane (CH4). The greenhouse effect of the atmosphere was first discussed by Joseph Fourier in 1824 and measured by Svante August Arrhenius in 1896 [2]. Studies have shown that the amounts of greenhouse gases in the atmosphere changed during the climate changes in the Quaternary; hot periods have been high, and cold periods have been low [3-5]. In the geological past, there have been numerous climate changes due to natural causes. After the Industrial Revolution, the amount of greenhouse gases in the Atmosphere increased with the increase in fossil fuel consumption, which led to an increase in global temperatures [6]. This situation has brought up the problem of human-caused climate change in addition to the climate change caused by natural causes. In the 6^{th} Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), it was stated that human-caused climate change causes widespread negative effects on nature and people [7].

The Kızılırmak Delta is located in the Central Black Sea Subdivision of Black Sea Region and within the borders of Samsun Province. The Kızılırmak, which forms the delta, receives its first sources from mt Kızıldağ to the east of Sivas. After the stream draws a wide arc in the Central Anatolia Region, it cuts the Black Sea Shore Mountains and flows into the Black Sea from at Cape Bafra. Its length is 1263 km, and the catchment area is 82,221 km^2. The Kızılırmak Delta is the third widest delta in Turkey after the Çukurova and Yeşilirmak deltas. However, in the literature on the subject, different values related to the area of the delta are encountered [8-12]. The reasons for these differences include the use of different criteria in determining the boundaries of the delta on the land side, the fact that the map scales on which measurements are made are different, and different measurement methods are used. In this study, the boundaries of the Kızılırmak Delta are defined in detail and its surface area is recalculated. According to this, the area of the delta, together with lakes and swamps (21.7 km^2), is 731 km^2 and the coastal length is 86 km (Figure 1).

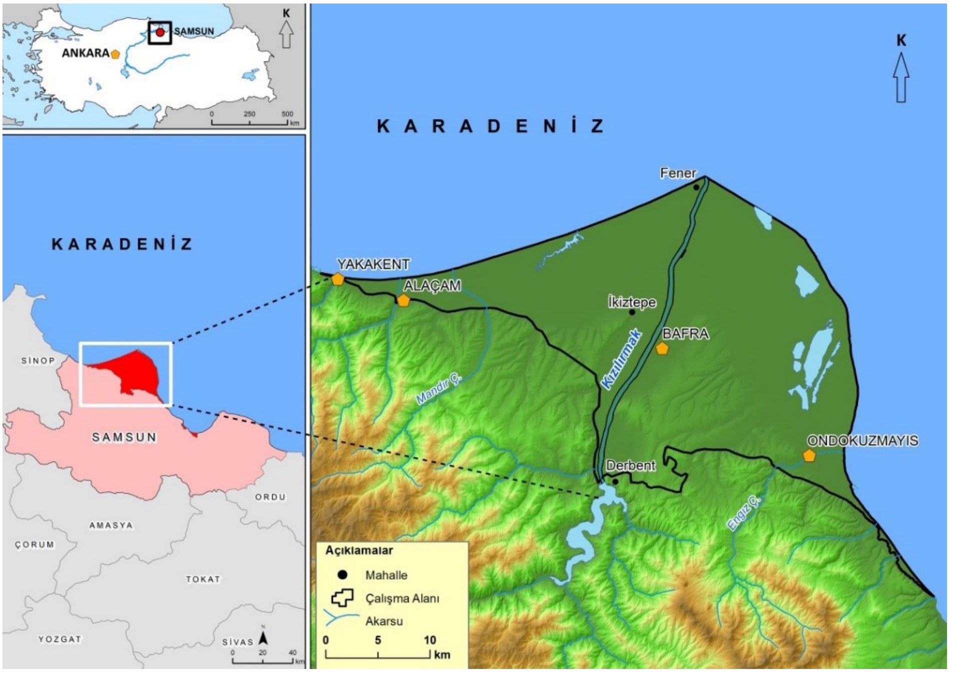

Figure 1. Location map of the Kızılırmak Delta.

2. METHODS

This study is prepared based on relevant literature and field observations. During the preparation of the study, it was tried to predict the possible impacts of future climate changes based on the results of past climate changes. Geographical Information Systems (GIS) and Remote Sensing (UA) methods are used for the collection and processing of data, and induction and analogy methods are used in the interpretation of the data. The boundaries of the delta area were determined according to the distribution of quaternary alluvium.The area and length measurements of the delta were made with the GoogleEarth Pro program. For the prediction of areal changes for in the future, the temperature changes and related sea level rises in the global climate scenarios contained in the IPCC reports was considered [13, 14]. In this context, the three most used scenarios (optimistic RCP2.6; normal RCP4.5 and pessimistic RCP8.5) are preferred.

3. RESULTS AND DISCUSSION

3.1. The Impacts of Quaternary Climate Changes on the Kızılırmak Delta

The Earth has been the scene of climate change for many times by natural reasons throughout the geological ages. Especially the traces of the Quaternary climate changes have survived to the present day. The total length of the Quaternary is 2.58 million years and divided into two sub-periods as Pleistocene and Holocene [15, 16]. Of these, the Pleistocene is represented by glacial and interglacial periods. During the Pleistocene, there occurred glacial periods called Biber, Donau, Günz, Mindel, Riss and Würm from old to new in the Alpine belt, on which our country is located, and interglacial periods between them [16-18]. After the last glacial period, temperatures increased again and 11,700 years ago, was entered to Holocene [19].

The level of the Black Sea fallen to -125 m in the Last Glacial Period [20, 21]. During this period, the length of the Kızılırmak River increased, and the delta area expanded. In parallel with the increasing temperatures in the Holocene, the sea level rose, and during the Climatic Optimum (G 7000-5000) it rose to 2-5 m above the present level [22, 23].During this period, the sea waters go forward along the riverbed towards the land and formed a natural harbor at the mouth of the stream. The sea level fell to its present level about 2000 years ago and has not changed much since then, except for minor oscillations.

The Kızılırmak Delta was affected by the climate changes and young tectonic movements in the Quaternary and gained a stepped appearance [12, 24, 25]. Today, due to the dams built on Kızılırmak, the sediment budget of the delta is decreasing, and the delta area is shrinking [26-28]. In addition, due to DSY (Sea Level Rise) due to global warming, the coastline is receding towards land the delta area is shrinking.

Impacts of Climate Change on Population and Settlements: Increasing temperatures in the Holocene supported the increase of population of the region, and the Ikiztepe settlement was established on the western side of the mouth of the Kizilirmak River. Ikiztepe, which grew as a port city over time, had been a continuous settlement area between the years of 6500-3700 (4500-1700 BC) [29]. About 2000 years ago, the sea level retreated to the present level and has not changed much since then, except for small oscillations. [22, 23]. With the regression, the stream lengthened again, and the delta area expanded. Thus, Ikiztepe, which lost its harbor feature, was extinguished over time and abandoned in the 1700s BC. On the other hand, with the improvement of climatic conditions, the population has increased in the Kizilirmak Basin, and this situation has caused deforestation and erosion.Thus, the amount of alluvium carried by the stream increased, the delta expanded and Ikiztepe remained about 15 km away from the coast.

Impacts of Climate Change on Vegetation: The last glacial period in the Quaternary (Wurm) began about 115,000 years before the present and ended 11,700 years ago [19]. During this period, a relatively cold and arid climate prevailed on the shores of Samsun [30]. In contrast, the Mediterranean coast had a more humid and temperate climate. For this reason, some plants of Black Sea origin such as *Alnus glutinosa, Fagus orientalis, Carpinus betulus* and *Buxus sempervirens* migrated to the Mediterranean coast via the Marmara Region. With the increase in temperatures in the post-glacial period, some Mediterranean plant elements such as *Phillyrea latifolia*, *Pistacia terebinthus*, *Arbutus unedo,Laruris nobilis, Spartium junceum* and *Olea eurepaea* came to the Black Sea coasts via the Marmara Region and settled on the Kızılırmak Delta.

The dams built on the Kızılırmak River cause a deficit in the sediment budget of the delta and retreat in the coastline [26-28]. In addition, global temperatures are increasing, and sea level is rising due to anthropogenic greenhouse gas emissions [1, 13]. For this reason, the coastline is retreating, and the delta area is narrowing.Especially in the coastal zone of the Kızılırmak Delta, the lakes and marshes, which occupying a large area (21.7 km^2) are threatened by the rising salty sea waters. For that reason, it is expected that the living elements of the wetland ecosystem and especially the plant species will be adversely affected by this change (Figure 2).

Figure 2. A view of the Kızılırmak wetlands.

3.2. Expected Areal Changes in the Kızılırmak Delta According to Some Climate Change Scenarios

Global warming causes melting of glaciers and thermal expansion of seawater. Thus, it causes sea level rise. Indeed, since the beginning of the 20th century, the sea level has risen by about 20 cm [31]. The rate of sea level rise continues to increase and the seriousness of the problem compels the international community to take an action [31]. Especially after the 1992 Rio Conference, international solidarity on climate change and its effects has increased and countries are trying to fulfill their responsibilities with some exceptions. However, since countries' ability to fulfill their responsibilities is closely related to their socioeconomic and sociopolitical internal dynamics, the implementation of the measures also differs from country to country. For this reason, different climate scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5) are given in IPCC reports [13]. The SLR forecast is different for each scenario. As a matter of fact, at the end of the 21st century, the SLR is expected to be 0.5 m according to the optimistic scenario, 1 m according to the normal scenario, and 2.5 m according to the pessimistic scenario[32]. Longer-term forecasts are also made in this regard. For example, according to the US Fourth National Climate Assessment Report, the results of the SLR will be between 2.3 and 5.4 m in 2300 [33, 34].

Knowing how the Kızılırmak Delta will be affected by SLR scenarios is important for planning the future. The SLR will exceed 5 m after 1000 years according to the normal scenario (RCP4,5) and 300 years according to the pessimistic scenario (RCP8.5). Therefore, sea waters will move towards land, and more than half of the Kızılırmak Delta (370 km^2) will be submerged under sea waters (Figure 3b).

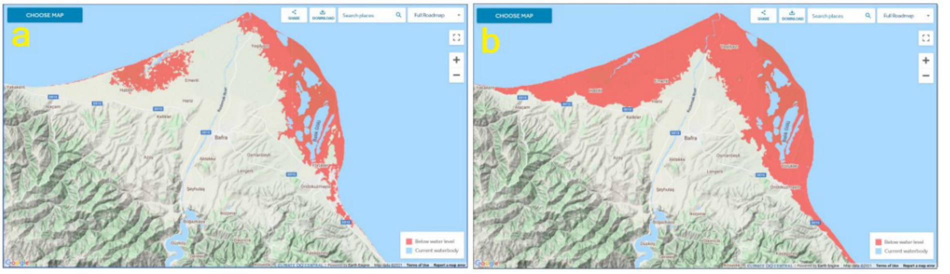

Figure 3. Possible effects of SLR on Kızılırmak Delta: a. Areas that will be submerged if the sea level rises by 1 m. b. Areas that will be inundated if the sea level rises by 5 m[14].

4. CONCLUSION

In the geological past, the sea level has changed many times due to natural climatic changes. During glacial periods, the sea level decreased and increased during interglacial periods. Today, besides natural causes, also humans cause global warming. Global warming causes SLR, both through the thermal expansion of seawater and the melting of glaciers. SLR threatens all low coastal areas and settlements, especially delta plains. Turkey has a coastline of 8333 km and wide coastal plains such as Çukurova, Yeşilırmak Delta and Kızılırmak Delta. Therefore, it is one of the countries affected by SLR.

The Kızılırmak Delta was affected by the climate changes and young tectonic movements in the Quaternary and gained a stepped appearance [12, 24, 25]. Today, due to global warming, the sea level is rising, and the delta area is shrinking. In addition, due to the dams built on Kızılırmak, the sediment budget of the delta is deficit, and the delta area is shrinking [26-28]. In this study, the boundaries of the Kızılırmak Delta were defined in detail and its current area (2022) is calculated.Accordingly, the coastal length of the Kızılırmak Delta is 86 km, and its area is 731 km^2, including lakes and marshes (21.7 km^2). These values can be used as reliable reference data in both current management studies and future planning studies.

According to the normal scenario (RCP4.5), the SLR can exceed 1 m after 100 years and 5 m after 1000 years. According to the pessimistic scenario (RCP 8.5) prepared for situations where states cannot fulfill their responsibilities under international agreements, the rate of sea level rise will gradually increase and exceed 2.5 m in 2100 and 5 m in 2300. In other words, between 300 and 1000 years, the sea level will rise up to +5 m, and more than half of the Kızılırmak Delta (370 km^2) will be lost.For this reason, it must be considered that +5 m elevation in the art structures on the coastline and in the selection of new settlements. Our proposal is to establish the newly planned settlements will be above the +10 m level. On the other hand, the wetlands in the coastal belt will be invaded by the sea and their ecological characteristics will change. Therefore, these issues should be taken into account in long-term delta management plans. It should be everyone's duty to control and, if possible, reduce the national and individual carbon footprint so that the problem would not get worse.

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EFFECTS OF CLIMATE CHANGE ON WETLANDS IN DIFFERENT GEOGRAPHICAL ENVIRONMENTS: GEDIZ DELTA (IZMIR) AND LAKE MARMARA (MANISA)

Mehmet Kaya[1*]

ABSTRACT

Climate change can be defined as changes that occur in the average state of the climate, which may be short-term or may last for many years. Regardless of the duration and causes of these changes, they have some effects on the earth. Although these effects do not show a homogeneous distribution over the entire earth, different results are seen in different geographical environments.This study is aimed to monitor and determine the surface water changes in two wetlands in two different geographical environments, coastal and terrestrial environments, over the years. The boundaries of the Gediz Delta Key Biodiversity Area and the Lake Marmara Key Biodiversity Area were used as the boundaries of the study area. Landsat satellite image data and remote sensing and geographic information systems methodologies were used to detect changes in these areas. By obtaining the relevant images, the water surfaces were determined with the modified normalized difference water index (mNDWI), and the changes in these water surfaces over the years were examined. As a result of the studies, it was observed that between 1985 and 2020, the sea waters encroached on the shores of the Gediz Delta Key Biodiversity Area for an average of 1.5 km and in places 3 km, and the Gediz Delta lost coastal area. In the Lake Marmara Key Biodiversity Area, Lake Marmara, which had an area of approximately 4400 ha in 1985, completely disappeared in August 2022. The effects of climate change on different geographical environments are different. While the sea level rising in Gediz Delta; in Lake Marmara, which is located in the interior, drought and drying have occurred. In addition to climate change, human factors such as inaccurate agriculture and water policies and urbanization accelerate the negative effects of climate change; It damages wetlands at least as much as climate change.

Keywords: Wetlands, Key Biodiversity Areas, Remote Sensing, Geographical Information Systems.

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1. INTRODUCTION

Climate change can be defined as changes that occur in the average state of the climate, which may be short-term or may last for many years. In the narrow sense, the climate is usually defined as average weather, or more precisely, the statistical definition in terms of the mean and variability of quantities over a period of time ranging from months to thousands or millions of years. Climate change is a change in the state of the climate that can be identified by changes in the mean and/ or the variability of its properties and that persists for an extended period, typically decades or longer [1]. Climate change is a natural event in terms of its formation and changes in climate are seen from time to time in geological periods [2]. Climate change can affect wetlands through the direct and indirect effects of increased temperature, changes in precipitation intensity and frequency, extreme climate events such as droughts and floods, and the frequency of storms [3]. However, the effects of climate change are not the same for every geographical environment. Especially coastal areas and wetlands are among the areas that are adversely affected by climate change.

This study is aimed to monitor and determine the surface water changes that have occurred over the years in two wetlands located in two different geographical environments, coastal and terrestrial. For this purpose, Gediz Delta and Lake Marmara, which are two of Turkey's 305 key biodiversity areas, were chosen as the study area.

Key biodiversity areas are areas of proven international importance and are selected through standard scientific criteria based on a set of globally applicable thresholds based on the distribution and populations of species in need of protection.These criteria emphasize two important points while revealing the area conservation priorities; vulnerability and irreplaceability. Key biodiversity areas that meet the vulnerability criterion are areas that contain important populations of endangered species. The irreplaceable criterion, on the other hand, is used to determine areas of importance for narrowly distributed species and biome-specific species [4, 5].

The Gediz Delta is one of the largest wetlands in the entire Mediterranean Basin. The Gediz Delta is a large wetland system formed on the western coast of the Gulf of Izmir at the point where the Gediz River meets the sea. Yamanlar Mountain borders the east and southeast of the delta, Dumanlidag borders the northeast and Foca Hills borders the north. The key biodiversity area includes the western part of the plain, which the Gediz River reaches after passing through a narrow strait, the wetlands on the coast, and the low hills on the plain. In the south of the place where Gediz flows into the sea, there are lagoons (Homa, Cilazmak, Kirdeniz), salt marshes, and salines, separated from the sea by long thin and parallel cords to the land. There are three hills (Lodos, Orta, Poyraz) with heights ranging from 50-100 meters on the coast of Kirdeniz and Tasli Hills in the region behind it. The Gediz Delta includes salt, fresh and brackish water ecosystems. Most of the delta–sea boundary consists of sand bands covered with Salicornia and seashells. Lagoons and extensive saline coastal meadows lie behind the sand belts. Arthrocnema-Halocnemetum strobilacea association is seen in the coastal parts of salt meadows, while Tamarix and Limonium sp assemblages are seen in the inner parts. In areas with high freshwater inflow to the saline area, there are small reeds and Juncus-covered temporary wet meadows. The hills are often covered with garigue. Additionally, there are large agricultural areas, afforestation areas, and gardens in KBA. Well-preserved gallery forests stretch along the Gediz River. One of the most important agricultural areas on the Aegean coast, the part of the delta known as the Menemen Plain, particularly, has extremely fertile agricultural land [5].

The Lake Marmara Key Biodiversity Area is located to the east of the province of Manisa and north of the Gediz River. It is a freshwater lake whose deepest place is 3-4 meters that have been converted into a reservoir, fed by the Gordes Stream and underground waters. There are villages called Sazkoy in the north, Tekelioglu in the south, and Kemerdamlari in the east around the lake. To the west of the lake, there is the 1034-meter-high Cal Mountain, and to the north, there are large and small hills ranging in height from 250 to 700 meters. The south of Lake Marmara is surrounded by agricultural fields and gardens, and the north is surrounded by Turkish pine (Pinus brutia) and oak forests. There are reeds, wet meadows, and mudflats lying in areas closer to the lake. Although the water level of the area changes almost every year, the lake regularly contains large reed areas on the northern shores, and these reeds are a feeding and breeding ground for very high numbers of water birds. The key biodiversity area is an important breeding, migration, and wintering area for water birds. The Dalmatian pelican (Pelicanus crispus), the spur-winged lapwing (Vanellus spinosus), the ferruginous duck (Aythya nyroca), and the squacco heron (Ardeola ralloides) are important water birds that lay eggs in the area. The lake hosts important wintering populations of the Eurasian wigeons (Anas Penelope), the common pochard (Aythya ferina), the pied avocet (Recurvirostra avosetta) and the Dalmatian pelican (Pelicanus crispus). Also, Ladigesocypris mermere, endemic to Turkey, and Kripowitschia mermere, endemic to the lake, are other fish species that have gained the status of key biodiversity area to the lake [5].

2. MATERIAL AND METHODS

In this study, the boundaries of the Gediz Delta Key Biodiversity Area which is approximately 261500 ha, and the Lake Marmara Key Biodiversity Area which is approximately 6900 ha were used as the boundaries of the study area.

Landsat family satellite images which have 5-year intervals from 1985 to 2020 and the current year were used to determine the surface water change in the key biodiversity areas. All satellite images were atmospherically corrected surface reflectance images that were received from USGS (Landsat Collection 2 Level-2 Science Products) and covering the months of June, July, and August. This period was especially preferred due to the minimum amount of cloudiness and precipitation. 41 satellite images were used for the Gediz Delta, and 34 satellite images were used for Lake Marmara (Landsat 5 TM for 1985, 1990, 1995; Landsat 7 ETM+ for 2000, 2005, 2010; Landsat 8 OLI/TIRS for 2015, 2020 and Landsat 9 OLI 2/TIRS 2 for 2022). In addition, 3 Sentinel-2 L2A images were also used to examine the change in Lake Marmara over the last 3 years.

There are various indices are applied to distinguish water pixels on the satellite image. The most commonly used one is the mNDWI index proposed by Xu [6]. The mNDWI index is a modified version of the NDWI index proposed by McFeeters [7]. This index is aimed to separate the water surfaces from the soil and vegetation on the satellite image. The mNDWI index is calculated by Eq. (1).

$$mNDWI = (\rho Green - \rho SWIR) / (\rho Green + \rho SWIR) \quad (1)$$

where ρGreen represents the green band, and ρSWIR represents the SWIR band. The mNDWI values range from -1 to +1. Values above 0 represent water while values of 0 and below indicate the absence of water [6].

In this study, first, mNDWI values for each year of the images were calculated (Figure 1), then Otsu's thresholding [8] was used to calculate optimal thresholds for each mNDWI image for water bodies extraction. Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels that either fall in the foreground or background [9].

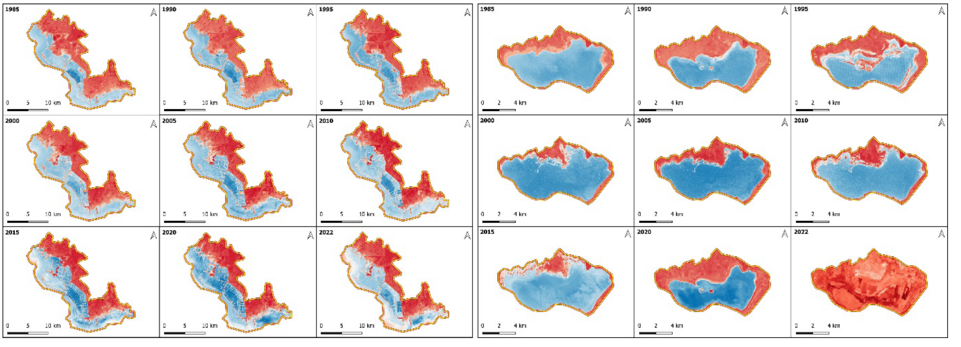

Figure 1. The Results of the mNDWI for each year (1985-2022)

3. RESULT AND DISCUSSION

Surface water changes in the Gediz Delta KBA and Lake Marmara KBA were examined by processing Landsat satellite images from 1985 to 2020 and the current year. The surface water bodies of each image were determined with mNDWI, extracted using Otsu thresholding, and then the surface water body areas of each year were calculated. Then the ratio of these surface water body areas to key biodiversity areas was calculated for each year.

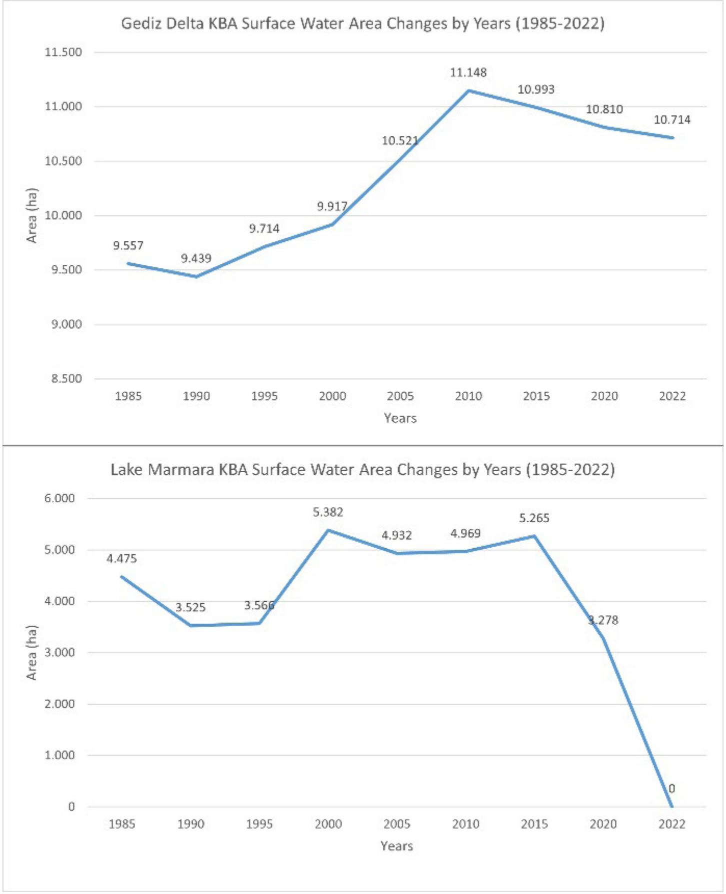

Figure 2. Surface Water Area Changes in Key Biodiversity Areas by Years (1985-2022)

It was found that the sea level generally increased on the shores of the Gediz Delta KBA between the years 1985-2022. Sea waters encroached on the shores of the delta for an average of 1,5 km and in places 3 km. The surface water area in 1985 was calculated at 9557 ha, which accounted for 36.54% of the 26157 ha in Gediz Delta KBA. In 2022, the surface water area was calculated at 10714 ha, and it accounted for 40.96% of the same area. Due to the variability of the presence of water in the saline areas (~3968 ha) which are located within the boundaries of the Gediz Delta, the surface water area of the salt pans was not included in the calculations (Figure 2,Figure 3). On the other hand, the surface water area of Lake Marmara was calculated at 4474 ha in 1985, which accounted for 64.74% area of 6911 ha in the Lake Marmara KBA. There were several changes seen in the lake's surface water area from 1985 to 2020. However, it was seen that from August 2020 to August 2022, Lake Marmara completely dried up in two years (Figure 2, Figure 4, Figure 5).

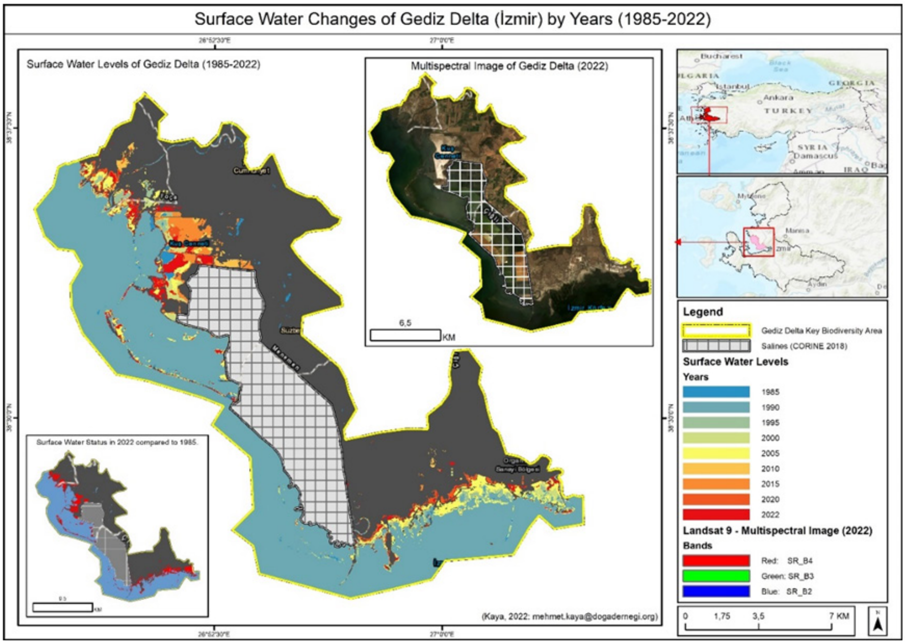

Figure 3. Surface Water Changes of Gediz Delta Key Biodiversity Area by Years (1985-2022)

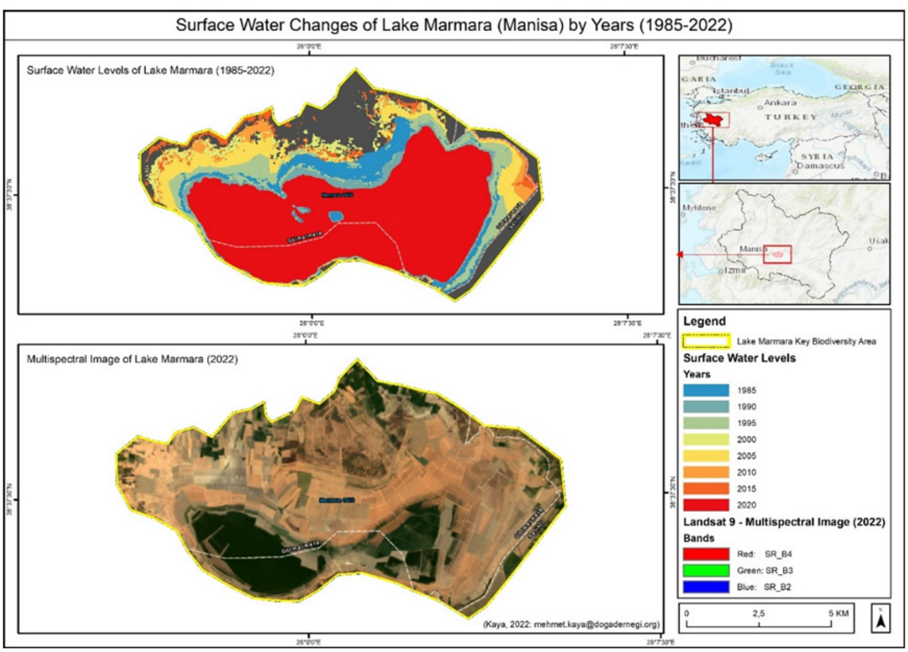

Figure 4. Surface Water Changes of Lake Marmara Key Biodiversity Area by Years (1985-2022)

4. CONCLUSION

In this study, the surface water changes of the Gediz Delta Key Biodiversity Area and the Lake Marmara Key Biodiversity Area were examined with Landsat satellite images using geographical information systems and remote sensing techniques in five-year periods between 1985 and 2022. In order to determine the water surface areas, mNDWI was used and the optimal threshold value was calculated for each year using the Otsu method, and the temporal changes of the water surface areas were calculated.

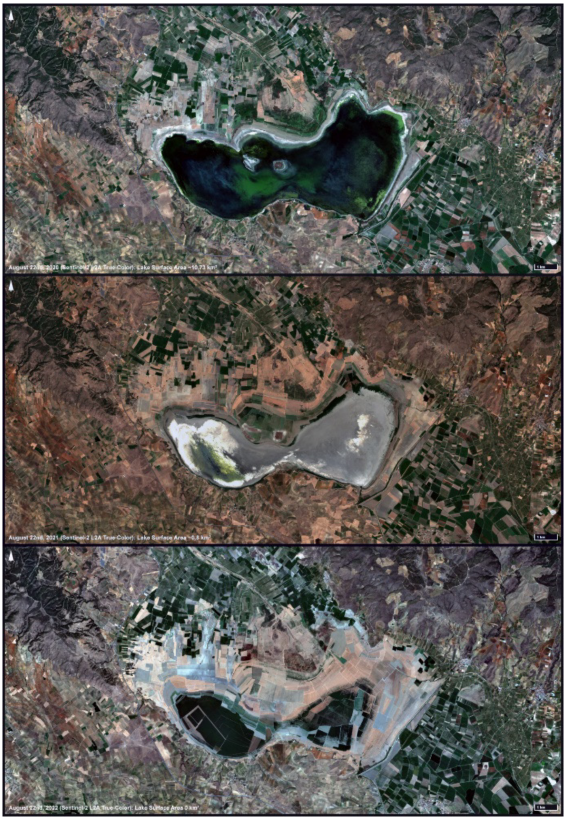

Figure 5. Changes in Lake Marmara over the last 3 years (Sentinel-2 L2A Images from August 2020, 2021, 2022)

As a result of the study, it was seen that the changes in climate had different results in wetlands in different geographical environments.

The sea water level rises within the boundaries of the Gediz Delta KBA, which is a coastal wetland. Due to the rise of sea waters, coastal erosion has increased and Gediz Delta has lost its coastal lands of approximately 1250 hectares in 37 years. The intrusion of seawater on the delta shores might create some crucial issues on the delta plain, which is an important *Indigenous Production Landscape* and agricultural area for the region. For instance, seawater might mix with groundwater, and agricultural areas which are using this water for irrigation can be harmed. Also, the loss of habitats might have a negative effect on the delta's biodiversity.

On the other hand, Lake Marmara, which is a terrestrial wetland area, within the boundaries of the Lake Marmara KBA, has dried up and completely disappeared in just two years. It has been an extremely specific example in terms of showing the anthropogenic effects of climate change. Human activities like the overuse of water, unplanned agricultural activities, urbanization, and inaccurate agricultural and water policies are as harmful as climate change to the wetlands area, which is important for mitigating climate change.

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ANALYSIS OF DROUGHT IN KIZILIRMAK DELTA WITH THE HELP OF DIFFERENT INDICES

Yasemin Balka Çağlak[1*], Murat Türkeş[2], Tamer Özlü[3]

ABSTRACT

Drought, which is one of the negative effects of climate change, poses a serious threat to both human and natural systems in the Mediterranean basin and in our country, as it is in the whole world. Drought has a transformative and destructive negative impact on human activities, socioeconomic sectors, and the natural environment/ecosystems. Therefore, many drought and/or precipitation efficiency indices have been developed to detect, monitor and predict drought. Wetlands are rare areas in the world that host terrestrial and aquatic ecosystems together. Studying, observing and investigating the effects of climate change and drought is therefore important for wetlands. The Kızılırmak Delta, which is the largest delta in Turkey whose natural features have not been preserved, is one of the most important deltas and wetlands of Turkey. There are many lakes, swamps and flooded forests in it. At the same time, it is important to determine the level of being a habitat for more than 350 bird species, the level of impact of the Kızılırmak Delta from climate change and drought, the duration and severity of drought and how it will be in the future. In this study, total precipitation, average maximum and average minimum temperature time series of Bafra Meteorology station between 1964-2020 were used to determine drought in Kızılırmak Delta. These data were analyzed using the Standardized Precipitation Index (SPI) and Standardized Precipitation and Evapotranspiration Index (SPEI) drought methods. Droughts of varying severity were observed in the Kızılırmak Delta for 355 months, from exceptionally dry to mildly arid, with a month SPEI (SPEI-1). While-0.0065 is the smallest drought value, it is extraordinarily dry with the most severe drought value of-3.65. According to SPEI-24, from 1964 to the end of 2020, 14 years and 2 years were uninterruptedly dry. According to the results of the analysis, even in the Kızılırmak Delta on the Black Sea coast, drought has been effective from past to present. Therefore, in addition to the determination and monitoring of drought in the Kızılırmak Delta, which hosts an important wetland ecosystem with a very rich biodiversity in Turkey, it is important in terms of measures to be taken against drought and regional geography implementation plans that take nature into account.

Keywords: Climate Change, Drought, SPEI Index, SPI Index, Wetland, Kızılırmak,Samsun

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1. INTRODUCTION

Drought is a natural disaster that develops the slowest in the context of climate change and its possible effects, but affects the most. In this context, drought has a wide variety of definitions according to different sectors. As in the United Nations and generally accepted field sources, it is expressed as the situation where the median is below the average due to the lack of precipitation or the shift of precipitation in a dry place. There are different types of drought as well as different definitions of drought. Drought is divided into 4 different types, taking into account the period when precipitation is not effective. These are meteorological drought, hydrological drought, agricultural drought and socioeconomic drought. Drought starts as a meteorological drought and comes to the last stage as a socio -economic drought. Socio -economic drought is also known as famine. The drought situation varies according to the area where it is effective. For example, the absence of precipitation for a few days in a place where it rains almost every day is considered as a drought, while the absence of precipitation for a few days or even a few months in places where precipitation is very low is not considered as a drought at first. For this reason, various indices have been developed by many researchers or organizations around the world to detect drought. The most commonly used indices today are Palmer Drought Index, Aridite Index (AI), Precipitation Anomaly Index (RAI), Standardized Precipitation Index (SPI) and Standardized Precipitation and Evaporation Index (SPEI) . The vast majority of these indices are calculated on the basis of precipitation. However, the most important parameter other than precipitation in drought is evopotranspiration . Evopotranspiration refers to evaporation and transpiration on plants. In addition to precipitation, the effect of evopotranspiration reflects the severity of drought more accurately when performing drought analysis. For this reason, in 2010 Vicento The SPEI index was developed by Serreno et al. The most up-to-date one among these indices is SPEI. Climate change and its associated drought affect all life on earth. Drought is effective on physical geography elements such as rivers, lakes, dam lakes, energy production, product yield, and human factors. Wetlands and delta ecosystems are also drought-affected areas in the world. As an example for these areas, Kızılırmak Delta, which is one of the 3 largest deltas in Turkey and the majority of it in Bafra District of Samsun province, is an example. More than 300 bird species, subasar (Galleric forest), lagoon and other lakes in the Kızılırmak delta have an important place in terms of other fauna and flora living in the delta. Kızılırmak delta attracts attention and is important as the only wetland on the Black Sea coast. Due to these and similar reasons, the lack of precipitation and drought problems that will occur in the Kızılırmak Delta may cause significant problems in areas with high vulnerability to climate change and drought. For this, it is important for wetlands that are resistant to sustainable climate change to determine and monitor factors such as drought severity, frequency and distribution area for a highly resilient wetland, delta ecosystem. In this study, the change in the severity and frequency of drought in the Kızılırmak delta over time depending on climate change and the situation of drought were analyzed.

2. MATERIAL AND METHODS

The most important factor in drought analysis is that the data sets are long-term and uninterrupted. For this reason, in this study, precipitation, maximum temperature and minimum temperature data between 1963 and 2020 belonging to Bafra meteorology station with station number 17622, which has long annual uninterrupted observation data, were used. Two different drought indices were used to determine drought severity. These indices are the Standardized Precipitation Index (SPI) and the Standardized Precipitation and Evaporation Index. These indices were analyzed using R Studio and R programming language and drought intensities were calculated. Then the graphics were created.

Standardized Ya is a wetland and includes physical elements of the wetland ecosystem. There are many large and small lakes in the delta. Only one of these lakes has a connection with the sea, and the other lakes do not have a connection with the sea. During the rainy seasons, the lake area takes on an appearance resembling a single lake , depending on the level rises in these other lakes . Precipitation Index (SPI) is an index developed by McKee et al. in 1993 [1]. This index basically uses precipitation. It adapts the distribution of precipitation to the gamma distribution (normal distribution). It is divided into drought severity classes in various classes between -2 and +2. -2 denotes extremely dry conditions, + 2 denotes extremely humid rainy conditions. A value of 0 is considered a normal value. Standardized Precipitation and Evaporation Index in 2010 It was developed by Serrano et al. as an alternative to the SPI index. Evopotranspiration values are also used in this index, different from the SPI index [2]. Because in order to determine the severity of drought, knowing the level of evaporation as well as precipitation also affects the severity of drought. The severity classes of the SPEI index are the same as the SPI. The SPEI index is one of the most recent drought indices.

2.1. Location and Boundaries of the Research Area

Kızılırmak Delta is one of the largest delta plains of Turkey, located within the borders of Samsun province in the Black Sea Region. Although most of the Kızılırmak Delta is located in Bafra, the delta continues in Alaçam and Ondokuz Mayıs districts. Most of the delta has wetland status and is under the Ramsar Conservation area. It is between the coordinates 41 ^{o} 36’ North – 36 $^{o\,05'}$ East. It covers an area ofapproximately 560 km^2. 116 km^2 is wetland and includes physical elements of the wetland ecosystem. There are many large and small lakes in the delta. Only one of these lakes has a connection with the sea, and the other lakes do not have a connection with the sea. During the rainy seasons, the lake area looks like a single lake, depending on the level rises in these other lakes. The vast majority of lakes are located on the eastern coast of the delta. The Kızılırmak Delta is also an important bird watching spot. Birds migrating from different countries come to the Kızılırmak Delta, rest here and continue. There is also a bird watching center in this bird watching area, and by making bird rings, the routes of migrating birds are followed and it is monitored whether the species comes back here. Kızılırmak Delta also ranks first in terms of the number of wild buffaloes in Turkey. It is an important tourism center for Samsun and the Black Sea, as it hosts a wide variety of flora and fauna and different ecosystems. For this reason, it is extremely important to monitor the changes occurring in the Kızılırmak Delta and to prevent the delta’s degradation.

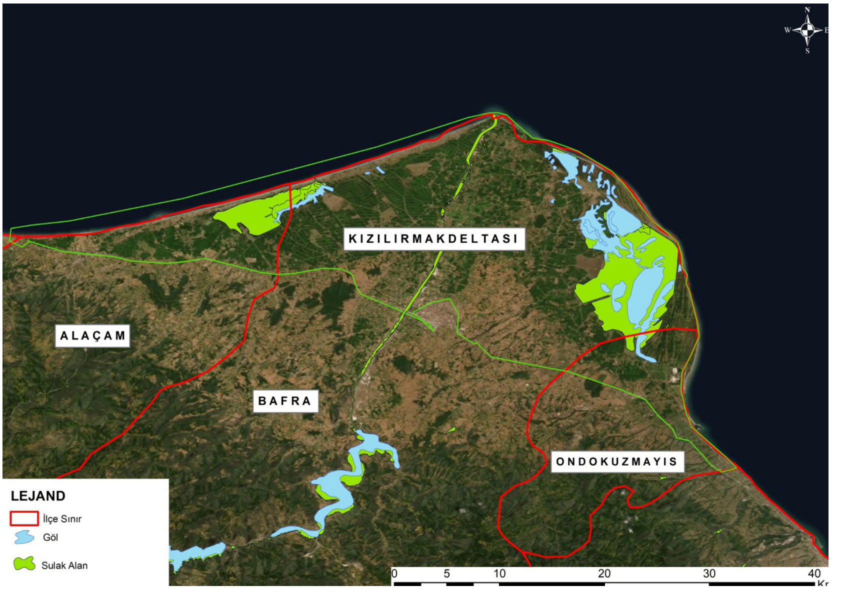
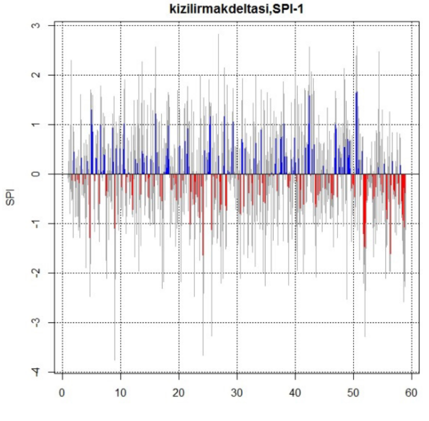


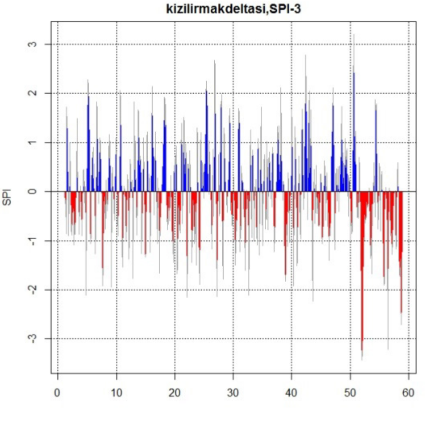
Figure 1. Location of the Kızılırmak Delta.

3. RESULT AND DISCUSSION

3.1. Standardized Precipitation Index Analysis Results

According to the results of the Standardized Precipitation Index analysis, the dry periods in the Kızılırmak Delta were analyzed as 1, 3, 6, 9, 12, 18, 24 months, taking into account various drought types. Then, as a result of the analysis, the dry periods were graphed as 10-year periods. The drought in the Kızılırmak Delta started as a meteorological drought and continued as an agricultural drought. According to the SPI analysis results, when only precipitation is taken as a reference, the frequency of extraordinary arid conditions with an intensity of -2 and above is higher in the Kızılırmak Delta, according to the results of the 12 and 24-month agricultural drought analysis. According to the SPI analysis, extreme and exceptionally dry (-2 and above) conditions are observed in the delta among all drought types.





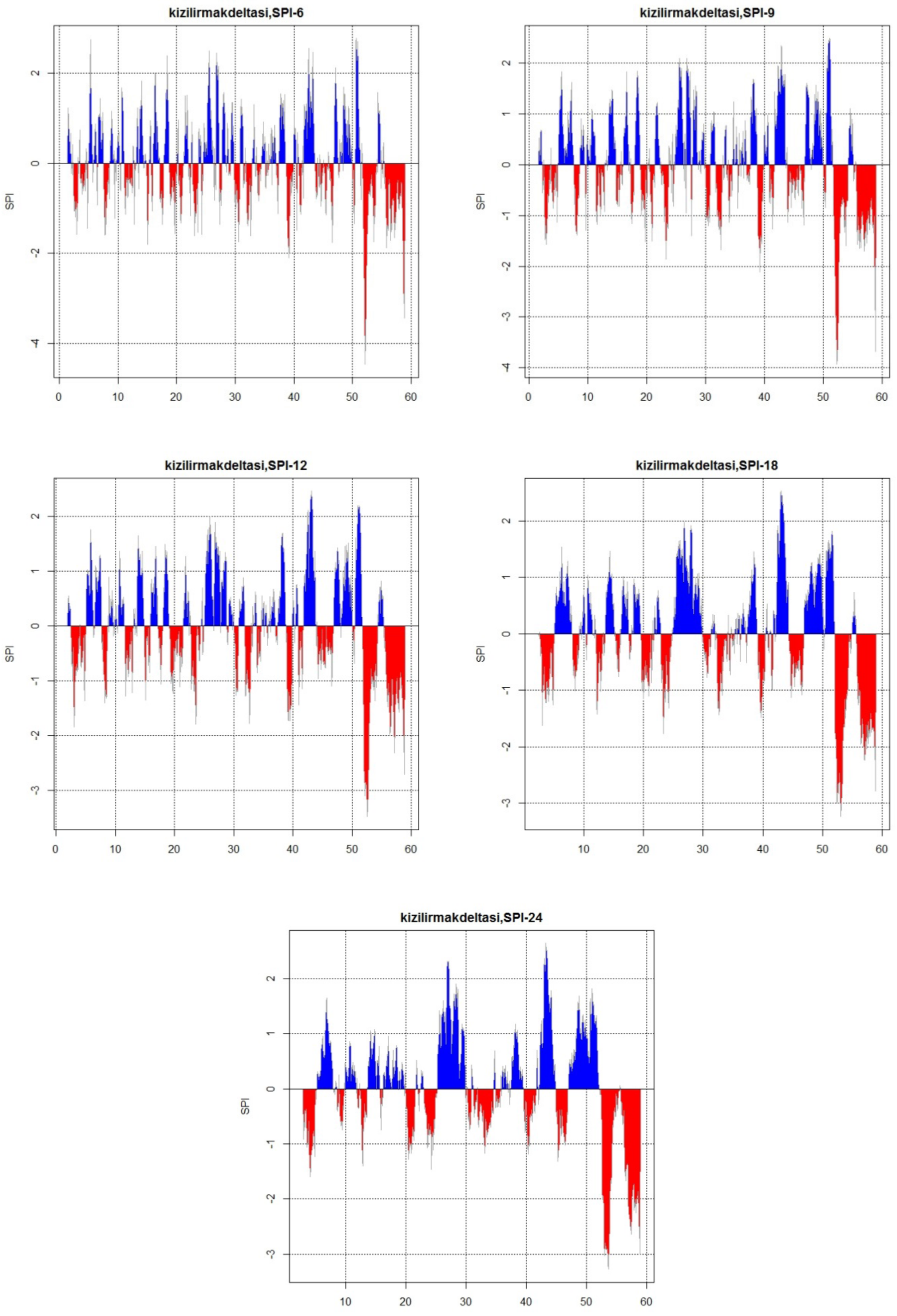
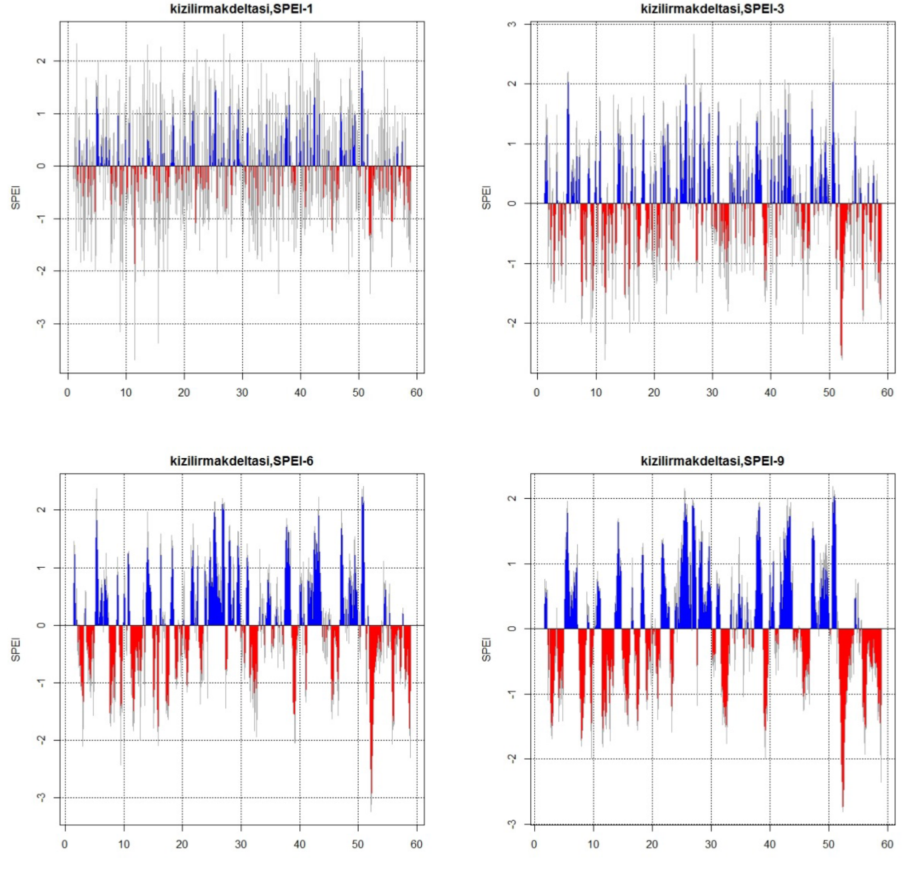


Figure 2.SPI analysis results.

3.2. Standardized Precipitation and Evaporation Index Analysis Results

According to the results of 1-3 month meteorological drought analysis, drought is more effective in the delta as meteorological drought. This situation also depends on the fact that the delta is in the Black Sea coastal belt. Between 1963 and 2020, a drought of 355 months was observed in the Kızılırmak Delta, ranging from extreme drought to mild aridity, with a 1-month SPEI (SPEI-1). While -0.0065 is the smallest drought value, it is extraordinarily dry with the most severe drought value of -3.65. According to SPEI-24, from 1964 to the end of 2020, 14 years and 2 years were uninterruptedly dry. According to the SPEI analysis, the 24-month drought in the Kızılırmak Delta has been exceptionally dry only in the last 10 years. The period between 1970-1980 was generally humid in the delta. After 1980-1990, the frequency of experiencing arid conditions in the delta began to occur. This situation shows that even if it is in the Black Sea coastal belt, drought can be a threat in the Kızılırmak Delta in the coming years with climate change.



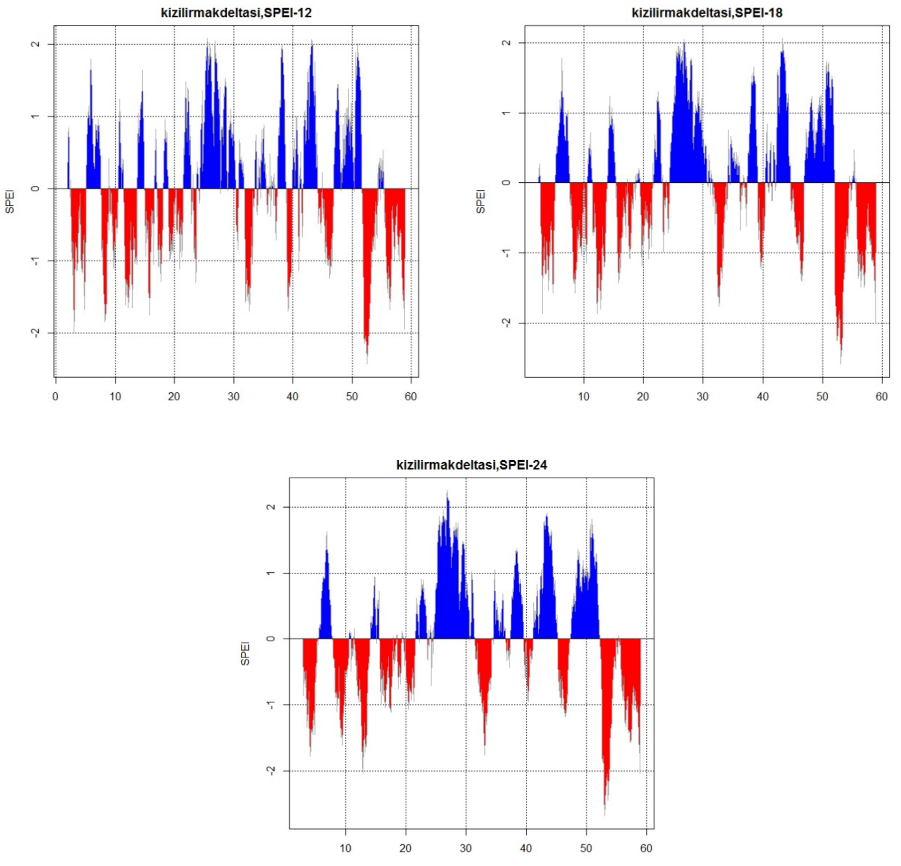


Figure 3: SPEI analysis results

4. CONCLUSION

According to the results of the drought analysis, even in the Kızılırmak Delta on the Black Sea coast, drought has been effective from past to present. Therefore, in addition to the determination and monitoring of drought in the Kızılırmak Delta, which hosts an important wetland ecosystem with a very rich biodiversity in Turkey, it is important in terms of measures to be taken against drought and regional geography implementation plans that take nature into account. Drought will be an important problem for the ecosystem in the Kızılırmak delta, especially considering the precipitation conditions and the decrease in precipitation in the future (based on the prediction that the precipitation will decrease in Turkey and the temperatures will increase). Since the Kızılırmak delta is also an important agricultural area, the agricultural sector will also be affected by the drought, apart from the ecosystem in the delta. For this, the management plan of the Kızılırmak Delta should be reviewed and the vulnerability on the ecosystem as a result of the drought analysis should be analyzed on the basis of species and the vulnerability and risk situation should be added to the management plan. With such an arrangement, only Kızılırmak Delta and other wetland ecosystems can become more resistant to the negative effects of drought and climate change [4].

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PLANT BIODIVERSITY WATER AND DROUGHT RESISTANTTO GLOBAL CLIMATE CHANGE IN THE BLACK SEA REGION AND THEIR EFFECT MECHANISMS

Fergan KARAER[1*]

ABSTRACT

The aim of this study is to determine the water and drought resistant (W&D) plant biodiversity in the Black Sea region (BSR) to be used in Sustainable ecological applications (SEP) against Global climate change (GCC) and to explain their mechanisms of action. According to the researches, it was determined that 834 taxa (558 species and 212 subspecies and 64 varieties) belonging to 91 families and 345 genera could be resistant to GCC (W&D). 171 of them are endemic and 16 of them are rare plants. Endemic and rare plants are highly affected by adverse environmental conditions such as GCC. The IUCN recommends that endemic and rare plants be protected by classifying them according to their endangered status. Accordingly, 19 taxa are critically endangered (CR), 22 taxa endangered (EN), 25 taxa vulnerable (VU), 29 taxa near threatened (NT), and 71 taxa are in least concern (LC) category. 5 taxa are data deficient (DD). At the national scale, rare water and drought resistant 16 plants are in the IUCN category of 12 taxa VU, 1 taxa NT and 3 taxa DD. In addition to these, there are 19 taxa that are resistant to GCC (W&D), which are protected by Bern (2 taxa) and CITES conventions (17 taxa).

GCC resistant plants in the BSR are classified phenologically. 96 taxa are trees, 198 taxa are shrubs, and 541 taxa are herbaceous. These plants are classified according to the Raunkiær life forms. These are 96 taxa phanerophytes, 203 taxa chamaephytes, 90 taxa geophytes, 11 taxa cryptophytes and 434 taxa hemicryptophytes. Of the 19 gymnosperm trees and shrubs in the BSR, 13 taxa are resistant to cold, 14 taxa to drought, 3 taxa to salinity and 14 taxa to air pollution. Of these, 1 taxon is resistant to cold, drought, salinity, and air pollution. 4 of 86 angiosperm tree and shrub taxa in the BSR are evergreen. They have the characteristics of resistance to cold, drought, salinity and air pollution. Of the 82 deciduous tree and shrub taxa, 16 are resistant to cold, 14 to drought, and the others to only air pollution.

Keywords: Global Climate Change (GCC), Plant Biodiversity, Water and Drought Resistant (W&D) Plant

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1. INTRODUCTION

Earth originated from the Milky Way galaxy and solar system about 4.5 billion years ago. It has maintained its balance against the deterioration of its balance in different periods (Natural Global Climate Change-NGCC) due to the events in the internal dynamics of the world. As a matter of fact, the world got rid of these diseases in the last 8000 years with the seasonal imbalances (diseases) consisting of climate, ice ages and hot periods in the last 400 thousand years [1].

In the beginning people lived a better life according to the laws of nature. However, developments in technology and industrialization in the last century have caused the rules of nature to change. The main reason for the deterioration of this balance; It is man's inability to understand the ecological balance of nature. The activities of people to realize their own goals (industrialization, rapid population growth, unplanned construction and urbanization, wrong land use, deforestation and rapid destruction of the natural environment, etc.) have caused the imbalances in the internal dynamics of the world to increase. In other words, these events caused the world to become cancerous.

Thus, human activities, temperature, precipitation, humidity, air pollution and increased greenhouse gas emissions, extreme conditions, cause more spread of Artificial global climate change (AGCC), which is the cancer disease of the world. The AGCC affects plant biodiversity and its components, which are the lungs of the earth. As a matter of fact, the devastating effect of AGCC causes forest fires, storms and tornadoes, and increasing diseases turn into pandemics. It also leads to extinction of vulnerable species, mass migration of people, animals and plants, reduced food and water supplies, and increased warfare. In this case, necessary measures should be taken quickly to prevent further deterioration of the balance between the artificial environment and the natural areas. In this context, it is necessary to rehabilitate degraded areas and manage natural resources in an ecological balance. Thus, it is very important to know the characteristics of plants, which are the keys to life, in order to better understand the effects of humans on nature. For this reason, it is very important to carry out studies on sustainable ecological practices (SEP), protection of natural resources and improving the quality of life of societies.

The aim of this study is to determine the water and drought (W&D) resistant plant biodiversity in and around the Black Sea region (BSR) to be used in the SEP against AGCC and to explain its mechanisms of action.

2. MATERIAL AND METHODS

The material of this study consists of plants collected by the author during his studies in the Black Sea Region [2-20]. In addition, studies on plant biodiversity of the BSR were used [21-26]. Endemic and rare plants are responding the fastest to GCC. The rules for the protection of endemic and rare plants are determined by the IUCN. According to IUCN, endemic and rare plant species are evaluated in seven categories. These categories are: critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC) data deficient (DD) **[27]**. In addition, taxa in CITES and BERN were also determined [28-29].

2.1. Types of GCC and Potential Impacts

Natural physical, chemical, geological and geomorphological events in the structure of the world affect the climate events in the world. These natural interactions are generally effective in regular and local areas. However, the damage done by humans to nature (AGCC) causes problems reaching global dimensions [30-31].

GCC occurs in two ways, NGCC and AGCC. NGCC arises in four ways. These are the influence of the Sun, the precession motion of the Earth, systems of hot and cold-water currents, large-scale atmospheric natural events, and El Niño (EÑGS). Generally, long wave rays are emitted from the hot surface of the earth. These rays are absorbed and re-emitted by a large number of natural greenhouse gases in the upper atmosphere before they are emitted into space. Thus, the natural temperature balance is regulated [32-34].

Excessive use of energy (25%), industry (21%), deforestation (14%), agricultural activities (24%), etc. cause an excessive increase in greenhouse gases. This resulted in an average 0.7°C increase in the world's temperature (0.95°C increase in Europe). This situation also caused an increase in other climatic events (precipitation, humidity, air movements, etc.).

AGCC, together with NGCC, are changes in climate caused by human activities that directly or indirectly degrade the composition of the atmosphere. AGCC, atmospheric window, negative and positive feedback and greenhouse gases emerge from the middle of the 19th century. Although the climate changes in the last 1000 years have been enormous, the temperature changes that took place in the 1990s are very important. As a matter of fact, this period caused it to be the hottest ten years. According to various climate models, the average global surface temperature in 2100 is estimated to be 1.4-5.8°C higher than the levels in the 1990s [35-37].

GCC significantly affects abiotic (topography, climate, soil) and biotic (plant, animal, human other biodiversity) factors in the food chain. GCC, which has a chain effect in social and economic life, causes negativities in globally and regionally sensitive ecosystems with its changes in critical temperatures compared to the pre-industrial period [38]. The most devastating effect of GCC is seen with the increase in the frequency or severity of extreme climatic events. The melting of the polar ice caps that started in the 1980s, the heat wave that affected Europe in the summer of 2003, and the EÑGS seen in 1990 and 1997 were highly effective in tropical regions [39]. GCC has the greatest effects on the mainland between 40°N and 70°N latitudes, including Turkey; atmosphere, glaciers, snow, ice, sea, terrestrial ecosystems and biodiversity, water, agriculture, economy, human health, etc. It shows itself with increases and decreases in indicators (Table 1).

Table 1. Potential impacts of GCC [36].

	ABIOTIC				BIOTIC			
Topographic	Climate			Soil	Interspecies	Intraspecies		
Rise of Seawater Level	Energy	Temperature Rise	Water Resources	Agriculture	Natural environment and species	Plant	Animal	Human
The Floods Changes in energy policies		Rainfalls irregular	Decrease in water supply	Crop losses	Habitat losses	Affected forest vegetation	Impact on invertebrates	Climate-related deaths

Erosion on beaches	Change in energy consumption	Fire increase	Decrease in water quality	Irrigation problem	Biotope losses	Change in geographical distribution	Effects on vertebrates	Epidemics
Protection Costs on Coasts	Energy cost change	Storm, wind increase	Competition for water	Agricultural land change	Decrease in species diversity	Decrease in forest health and productivity	Extinction	Decrease in air quality

2.2. GCC (Water and Drought) Resistant Plants and Mechanisms of Effect

Plants have developed the ability of water deficiency and drought stress to survive in unfavourable abiotic and biotic conditions. Water stress is effective on the morphological, physiological characteristics, yield and quality of plants. Water stress varies according to the type of plant, the degree of stress, its continuity and the development status of the plant. Water stress occurs most prominently with drought. Drought is the long-term dehydration of the soil that causes a noticeable decrease in the water content of the soil and plant growth. Depending on the water holding capacity of the soil and the rate of evapo-transpiration by the plant and soil, the rate of drought is also affected. Plants have developed morphological and physiological resistance mechanisms against water and drought stress [40-41]

2.2.1. Morphological and Mechanical Effects: Water stress causes the growth and division of plant cells to decrease significantly and the above-ground organs to shrink proportionally. The increase in root length (1.5-3m) causes the development of different organ structures (stolon, rhizome bulb, corm, tuber, etc.). In addition, the stiffness, thickness, reduction of the surface area of the leaf, the spiny of the edges, leaf curl, hairiness, leaf movement or reducing the radiation effect by increasing reflection are other important mechanisms that prevent water loss. The tolerance of plants to water loss is related to the structure of the cell membrane, enzyme activity, disruption of the membrane structure of the cells by mechanical injury and denaturation of proteins in the cytoplasm. Plants morphologically or mechanically avoid, escape and fold, etc. It provides resistance to drought with its mechanisms [42].

Avoidance (promoting root growth), escaping from drought and folding or elastic structure of tissues: Plants carry the assimilates they produce to their roots, causing the root to extend up to the water layer. Cactus etc. xeric plants absorb surface moisture with their dense superficial root systems. Thus, they minimize water stress by storing water in their bodies. Therophytes, or short-lived plants, complete their life cycles quickly without a lack of water in the soil. Thus, they are protected from the summer heat by passing to the seed period. The folding or elastic nature of tissues is particularly effective when the protoplasm water potential (PSP) of xerophytes is below 75-50% [42].

Physiological Effects: Low water ratio decreases chlorophyll formation, photosynthesis rate and turgor pressure of leaf cells. This situation disrupts the cell membrane structure (the interaction of hydrophobic and hydrophilic amino acids with water and the location of proteins). In addition, it causes abscisic acid (ABA) accumulation in the cell, closure of stomata, slowing of respiration, minimizing assimilation transport and CO_2 assimilation. Excessive accumulation of assimilate in leaves prevents the regular functioning of photosynthetic mechanisms. Along with these, nitrate reductase, phenylalanine ammonium lyase (FAL) etc. metabolic events slow down with the decrease of the effect of enzymes [43].

Physiologically, one of the important effects on water stress of plants is oxidative stress (OxS), which is free oxygen radicals. OxS is available in 4 forms. These are the formation of unpaired electron-containing molecules of superoxide (O_2-), singlet oxygen ($^1O_2$), hydrogen peroxide (H_2O_2) and hydroxyl (OH.). OxS occurs mostly in vegetative organ tissues, in the chloroplast with light-chlorophyll interactions. Plants have antiOxS defence systems against OxS. Some of them are: vitamins E, C, glutathione and carotenoids (beta-carotene and zea xanthin), Superoxide dismutase (SOD), ascorbate peroxidase (APoX), glutathione reductase (GLR), catalase (CAT) etc. [44].

Plants generally perform four events in increasing their water stress resistance (WSR). These are [1] Reducing water loss, [2] High water use efficiency, [3] Making the most of the humidity of the environment, [4] Regulation of osmotic pressure.

[1] It causes the leaf surface area to decrease, the number of stomata to decrease and the stomata to be more concentrated in the lower epidermis. While this situation differs according to the plant species, in extremely hot regions the plants regulate the opening and closing speed of the stomata daily [45].In addition, the thickness of the cuticle layer, the number of palisade and sponge parenchyma layers regulate the rate of photosynthesis and water economy [46].

[2] Some plants store the water they take in their tissues and undergo morphological changes, ensuring high water use efficiency [47].

[3] Salty plants secrete salt from their leaves using morning dew. Salt absorbs moisture from the air and makes the best use of the humidity of the environment. It uses the water that other plants use for germination by using the moisture it absorbs in some plants, preventing the germination and growth of other plants with the substances it secretes [48].

[4] Some plants take advantage of the difference between the soil pressure and the root pressure and the retained water to produce sugar, organic acids (especially proline) and K+ etc. in the cell. is produced. Osmotic pressure is regulated by increasing the resistance of the ions with increasing concentrations [49].

2.2.2. Changes in Plants and Responses to Water Stress

In general, changes and responses occur in two ways in plants water stress. These are **1.** Morphological, physiological, cytological changes **2.** Biomolecular, hormonal and genetic changes [50, 51].

[1] Morphological, physiological and cytological changes: Drought stress during the flowering period causes sterility in the plant. In the early stages of drought, plants accelerate root development to reach water sources. On the other hand, body development slows down. Drought conditions that last longer than expected damage the plant. In this case, the root and stem growth and the number of leaves decrease at the same time in the plant. As a result, yellowing and shedding of the leaves are seen. Cell division and growth slows down in plants under stress. The structure and functions of the cell membrane and cell metabolism are disrupted, enzyme activities decrease. The stomata close to reduce water loss. The competition for water between the cell and its organs increases. This situation causes deterioration of the balance and turgor structure between organs. Thus, stomatal movements become irregular, photosynthesis and respiration are affected. The cell membrane ruptures and cell death begins. In these cases, the plant either escapes the drought or activates other mechanisms to regulate it.

[2] Biomolecular, Hormonal, Genetic Responses: In drought stress, the plant's carbohydrate metabolism (CHM) is affected and betaine etc. the effect of "osmolyte" biomolecules consisting of various groups increases. Similarly, the effect of "osmolyte" biomolecules consisting of proline, glycine and asparagine amino acids and organic acids increases. The cell synthesizes or collects soluble substances to keep the turgor balance at the same level. They increase the continuity of photosynthesis by increasing stomatal conductivity. Cell metabolism is rearranged by increasing proline, dehydrin, LEA (Embryo formation protein), water channel and heat shock proteins (chaperone) [50].

In particular, water stress in the leaf increases the amount of H2O2 and lipid peroxidation, while the ABA concentration decreases. On the other hand, while antiOXS enzymes increase with SOD, CAT, APX, GR and ion accumulation in the cell, the cell membrane is damaged. While inhibiting the formation of these enzymes disrupts the structure of proteins, DNA and RNA are destroyed and fragmented [51].

The rate of ABA increases in the xylem and acts as an important signalling molecule. Thus, it protects the plant against adverse conditions by closing the stomata. Early (ECG) and late (GCG) responding genes are involved in drought stress. ECGs, which are also involved in the synthesis of factors that will activate GCG, respond very quickly. While GCG plays a role in the regulation of genes and signal transmission of osmolyte biomolecules, it acts slowly and continuously.

3. RESULT AND DISCUSSION

3.1. W & D Resistant Plants and Their Ecological Characteristics in the BSR:

Native plants are more likely to survive and adapt because they are constantly present in their habitats. Therefore, they are less affected by the adverse environmental conditions that occur with GCC. In addition, natural plants irrigation, maintenance, pruning, etc. require less processing. The use of natural plants in sustainable ecological practices (SEP) is very important ecologically and economically, together with the preservation of ecological balance.

In the evaluation of the studies conducted in the BSR, water and drought (W&D) resistant plants consist of 834 vascular plant taxa (558 species and 212 subspecies and 64 varieties) belonging to 92 families and 345 genera. 171 of these taxa are endemic. 19 taxa of endemic plants are in "CR", 22 taxa "EN", 25 taxa "VU", 29 taxa "NT", 71 taxa "LC" and 5 taxa "DD" category. In addition, there are 16 rare taxa in the category of 12 taxa "VU", 1 taxon "NT" and 3 taxa "DD". Apart from these, there are 2 taxa in the Bern convention and 17 taxa in the CITES list. In the BSR, there are 26 families with 11 or more taxa with water and drought (W&D) resistance. Of these families, Rosaceae (84), Poaceae (73) and Crassulaceae (52) have more taxa (Table 2).

There are 33 genera with 7 or more taxa resistant to W&D in the BSR. Sedum (19), Sempervivum (16) and Festuca (15) are the genera with the most taxa (Table 3).

Water and drought resistant plants were determined phenologically in BSR. Of these, 96 are trees, 198 are shrubs, and 541 are herbaceous.

Table 2. Families with 11 or more taxa resistant to water and drought in the BSR

Family	Taxon	%	Family	Taxson	%	Familya	Taxon	%
Rosaceae	84	10,07	Ericaceae	25	3,00	Amaryllidaceae	11	1,32
Poaceae	73	8,75	Ranunculaceae	20	2,40	Betulaceae	11	1,32
Crassulaceae	52	6,24	Iridaceae	18	2,16	Boraginaceae	11	1,32
Asteraceae	42	5,03	Apiaceae	15	1,80	Oleaceae	11	1,32
Fabaceae	38	4,55	Asparagaceae	15	1,80	Plantaginaceae	11	1,32
Lamiaceae	35	4,19	Fagaceae	15	1,80	Plumbaginaceae	11	1,32
Brassicaceae	34	4,07	Liliaceae	15	1,80	Rhamnaceae	11	1,32
Amaranthaceae	27	3,24	Caprifoliaceae	13	1,56	Sapindaceae	11	1,32
Caryophyllaceae	27	3,24	Saxifragaceae	12	1,44			

Table 3. Genus with 7 or more taxa resistant to water and drought in the BSR

Genus	Taxon	%	Genus	**Taxon**	**%**	**Genus**	**Taxon**	**%**
Sedum	19	2.28	*Allium*	11	1.31	*Anemone*	7	0.84
Sempervivum	16	1.91	*Rubus* *	10	1.20	*Alchemilla*	7	0.84
Festuca	15	1.80	*Crocus*	10	1.20	*Atriplex*	7	0.84
Sorbus *	13	1.56	*Draba*	9	1.07	*Astragalus*	7	0.84
Quercus *	13	1.56	*Rhododendron* *	9	1.07	*Aethionema*	7	0.84
Acer *	13	1.56	*Silene*	8	0.95	*Rosularia*	7	0.84
Saxifraga	12	1.44	*Rhamnus**	8	0.95	*Prometheum*	7	0.84
Rosa *	12	1.44	*Pyrus**	8	0.95	*Iris*	7	0.84
Acantholimon	12	1.44	*Juniperus**	8	0.95	**(*Bush)**		

These taxa were evaluated according to the Raunkiær life forms. Accordingly, there are 96 phanerophytes, 203 chamaephytes, 90 geophytes, 11 cryptophytes and 434 hemicryptophytes. Ecological characteristics of GCC resistant plants were determined in BSR, and only the characteristics of trees and shrubs and their Turkish names were given (Table 4).

According to these evaluations, there are 19 gymnosperm trees and shrubs. Of these, 13 are resistant to cold, 14 to drought, 3 to salinity and 14 to air pollution. *Ephedra major subsp. procera* is a shrub species that has all of these features. Four of the 86 angiosperm trees are evergreen (*Arbutus andrachne, A. unedo, Laurocerasus officinalis, Laurus nobilis*) and are the taxa most resistant to air pollution.

Table 4. Ecological characteristics of trees and shrubs resistant to water and drought in the BSR

H: High, M: Medium, L: Low		Ecological Tolerance											
(*) Shrub (x) Endemic, (**) Evergreen		Cold			Drought			Salinity			Air Pollution		
Taxon	Turkish	**H**	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**
Gymnosperms (All evergreens)	**Açık Tohumlular**												
Abies nordmanniana subsp *nordmanniana*	Karadeniz Göknarı	+					+			+		+	
Abies nordmanniana subsp *equi-trojanii*	Kazdağı Göknarı	+				+				+		+	
Cedrus libani var. libani	Sedir	+		+					+	+			
**Ephedra major*subsp. *procera*	Yaban üzüm	+			+			+			+		
**Juniperus communis* var. *communis*	Ardıç		+		+					+	+		
**Juniperus communis* var. *saxatilis*	Bodur Ardıç		+		+					+	+		
Juniperus excelsa subsp. excelsa	Boz Ardıç		+		+					+	+		
Juniperus foetidissima	Kokar Ardıç				+					+	+		
Juniperus oxycedrus subsp. *macrocarpa*	Deniz Ardıcı				+				+		+		
Juniperus oxycedrus subsp. *oxycedrus*	Katran Ardıcı		+		+					+	+		
Juniperus sabina	Saç Ağacı		+		+				+		+		
Picea orientalis	Lâdin	+					+			+		+	
Pinus brutia var. *brutia*	Kızılçam		+			+			+			+	
Pinus nigra subsp. *pallasiana*	Karaçam	+			+					+		+	
Pinus pinaster subsp. *pinaster*	Sahil Çamı		+		+			+			+		
Pinus pinea	Fıstık Çamı		+		+			+			+		
Pinus sylvestris var. *hamata*	Sarıçam	+			+					+		+	
Taxus baccata	Porsuk	+					+			+	+		
Angiospermae	Kapalı tohumlular												
Acer negundo	İsfendan		+			+			+		+		
Acer platanoides	Çınar akçaağacı		+				+		+		+		
Aesculus hippocastanum	Atkestanesi			+			+		+		+		
Ailanthus altissima	Kokarağaç			+		+				+	+		
***Arbutus andrachne*	Sandal Ağacı			+	+				+		+		
***Arbutus unedo*	Kocayemiş			+	+				+		+		
Betula litwinowii	Düzük	+					+			+	+		
Betula medwediewii	Moşi	+					+			+	+		
Betula pendula	Huş ağacı	+					+			+	+		
Carpinus betulus	Gürgen					+				+	+		
Carpinus orientalis subsp. *orientalis*	İstiriç					+				+	+		
Celtis australis subsp. *caucasica*	Kaf Çitlenbiği			+	+				+		+		
Cerasus mahaleb var.*mahaleb*	Mahlep			+			+			+	+		
Cercis siliquastrum subsp. *siliquastrum*	Erguvan			+	+					+	+		
Cornus sanguinea subsp. *australis*	Kansiğdiren			+			+			+	+		
Cornus sanguinea subsp. sanguinea	Kiren			+			+			+	+		
Corylus avellana var. *avellana*	Fındık			+			+			+	+		

Corylus avellana var. *pontica*	Doğu Fındık			+			+		+	+
Corylus colurna	Türk fındığı			+			+		+	+
Diospyros kaki	Trabzon hurması			+			+		+	+
Diospyros lotus	Hırnık			+			+		+	+
Euonymus latifolius subsp. *latifolius*	İğağacı		+				+		+	+
Euonymus verrucosus	Benli iğcik		+				+		+	+
Ficus carica subsp. *carica*	İncir			+	+				+	+
Fraxinus angustifolia subsp. *angustifolia*	Sivri dişbudak			+		+			+	+
Fraxinus angustifolia subsp. *oxycarpa*	Ana dişbudağı			+			+		+	+
Fraxinus excelsior subsp. *excelsior*	Dişbudak			+			+		+	+
Gleditsia triancanthos	Gıledıçya			+	+			+		+
***Laurocerasus officinalis*	Karayemiş			+		+			+	+
***Laurus nobilis*	Defne		+		+			+		+
Magnolia grandiflora	Manolya		+		+			+		+
Malus sylvestris var. *orientalis*	Ekşi elma			+			+		+	+
*xM. sylvestris var. microphylla**	Amasya Elması			+			+		+	+
Ostrya carpinifolia	Firek			+	+				+	+
Platanus orientalis	Çınar		+			+			+	+
Prunus x domestica	Erik			+			+		+	+
Pterocarya fraxinifolia	Yalankoz			+			+		+	+
Pyrus communis subsp. *caucasica*	Kaf armudu			+			+		+	+
Quercus cerris	Saçlımeşe	+				+			+	+
Quercus hartwissiana	Istıran meşesi	+				+			+	+
Quercus macranthera ssp. *macranthera*	Kafkas meşesi	+				+			+	+
xQuercus macranthera subsp.*syspirensis*	İspir meşesi	+				+			+	+
Quercus petraea subsp. *iberica*	Ballık meşesi	+				+			+	+
Quercus petraea subsp. *petraea*	Sapsız meşe	+				+			+	+
Quercus pontica	Yayla peliti	+					+		+	+
Quercus pubescens subsp. *pubescens*	Tüylü meşe	+			+			+		+
Quercus robur subsp. *robur*	Saplı meşe	+					+		+	+
Robinia pseudoacacia	Yalancı Akasya			+		+			+	+
Sorbus aucuparia	Kuş Üvezi			+			+		+	+
Sorbus caucasica var. *caucasica*	Dilburan		+				+		+	+
Sorbus graeca	Cinav		+				+		+	+
Sorbus kusnetzovii	Ufa			+			+		+	+
Sorbus persica	Eyvaz		+				+		+	+
Sorbus torminalis var. *pinnatifida*	Üvez		+				+		+	+
Sorbus torminalis var. *torminalis*	Pitlicen		+			+			+	+
Sorbus umbellata	Geyik elması		+				+		+	+
Tilia rubra subsp. caucasica	Felamur			+		+			+	+
Ulmus glabra	Dağ Karaağacı		+			+		+		+

3.2. Effects of GCC on Biotic and Abiotic Factors in BSR

In terms of plant biodiversity, one of the three plants is endemic (34.4%) and with the discoveries made in recent years, the number of taxa is more than 12.000, and it shows the characteristics of a small continent. Therefore, sustainable use of biodiversity, which is an important source of wealth and power for Turkey, is very important. The effects of GCC on BSR are evaluated in 3 ways. 1. Threats to plant biodiversity (biotic), 2. Habitat loss, fragmentation, impact on distribution areas (abiotic) 3. Impact on ecosystem (abiotic)

1. Threats to Plant Biodiversity (Flora): Biodiversity is a dynamic feature thatprovides resistance and stability to ecosystems, gives strength and vitality, increases the flexibility of living things to adapt, and ensures the continuity of their generations. The effects of GCC on the biodiversity of the Black Sea Region can be evaluated in 3 ways. These are [a] overuse of resources and phenological changes [b] extinction of species and increase of invasive-alien species, [c] spread of diseases and rapid population movement/increase[52-54].

[a]Excessive resource use and phenological changes: People meet many of their needs from plants, from use as food to shelter. This situation causes the deterioration of the natural balance. GCC causes different responses in plants during flowering and fruiting periods [55-56].

[b] Extinction of species and increase of invasive alien species (IAS): The narrowing of the distribution areas of endangered species, especially endemic species, causes great problems. These problems are more effective with GCC. As a matter of fact, water resources and forests will be more adversely affected in semi-arid and semi-humid regions (Central Anatolia, Southeast Anatolia, Aegean and Mediterranean) that are more exposed to GCC in Turkey. **[57-58].** These conditions related to GCC cause deforestation in Turkey and change the adaptation (adaptation and modification) periods of plants. Thus, it is predicted that wetland, sea, lake, mountain and steppe plant biodiversity will be affected more than other countries. Hurricanes, floods, droughts, etc. caused by global climate change. climatic events cause IAS to move to new regions and change the balance of the ecosystem. In this case, native native species are rapidly disappearing in a short time. While these losses are felt quite intensely in BSR, the number and intensity of IAS is increasing. For example, Bur-cucumber (*Sicyos angulatus*) is an invasive species first found locally in Artvin. Today it is distributed as far as Ordu province. Another example is Japanese knotweed (*Reynoutria japonica*), which is among the world's 100 most invasive plants detected in Samsun [59].

[c] Spread of diseases and rapid population movement/increase: GCC is among the stress factors for agricultural crops and affects the quality and quantity of agricultural products, thus global food security. However, plants with reduced resistance become very sensitive to diseases and other foreign plants. GCC will increase the use of pesticides while playing a role in the transmission of plant diseases that pose serious problems.

2. Habitat loss, fragmentation, change of distribution areas and environmental pollution: The most important effect of the irreversible loss of biodiversity is seen in habitat and biotope losses. Especially urbanization, agriculture and industrialization cause the loss of natural vegetation. These conditions cause habitat and biotopes to shrink, fragment and become insufficient for organisms. While some creatures adapt to GCC, especially animals migrate and change their habitats rapidly. Plants migrated to the south during the ice ages in Turkey and to the north during the interglacial ages. The change in the distribution of plants are the Mediterranean enclaves located in the coastal and inland valleys in the BSR and the Black Sea enclaves located in the local areas in the Mediterranean region [18]

3. Impact on Ecosystems: GCC is slowly, irreversibly destroying ecosystems. This situation changes the structure and functions of ecosystems(Figure 1).

[a] Impact on aquatic ecosystems: GCC's impact on aquatic ecosystems is more rapid than on land ecosystems. According to the climate models, it is estimated that the average air temperatures of Turkey will increase by 2-3oC throughout the country, but will be between 3-4oC in the eastern regions. It is expected that the increase in summer average temperatures will be higher than other seasonal increase trends. While the temperature increases observed in the spring are effective in the Mediterranean, South-eastern Anatolia and Marmara regions, the weak warming and cooling trends observed in the autumn will adversely affect the water cycle in particular[60-61].

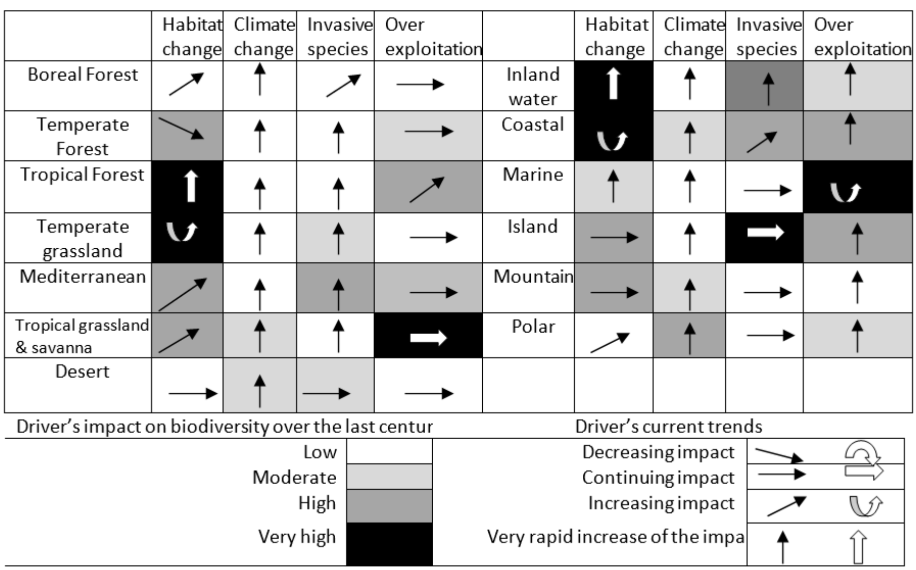

Figure 1. Trends of the factors affecting biodiversity and ecosystems in the last century and today **[62]**

In addition, with the melting of the glaciers, the rate of sea level rise between 1990 and 2100 will be 2-4 times higher than today. This situation will carry the salt water to the land by huge waves caused by the storm. Thus, since ecosystems and wetlands in coastal areas will be more affected, it will cause the displacement, migration or extinction of habitat-specific species in wetlands [63].

[b] Impact on terrestrial ecosystems: In terrestrial ecosystems, plants will be most affected by GCC. While the destruction of plants from the ecosystem is often caused by improper land use and habitat destruction. In this case, estimated that GCC will cause the extinction of mainly endemic plant species with narrow tolerance and limited migration capabilities. A temperature increases of 3°C expected in 2100 will cause the distribution of the species to shift to altitudes of 300–400 km North or higher in temperate regions[64].Recently, it has been determined that the increase in populations of many plant species in the North is closely related to temperature increases. As a matter of fact, an increase was observed in the populations of thermophilic plant species in NW European countries compared to 30 years ago. Decreases in precipitation with GCC may cause more frequent forest fires, increased soil erosion, extinction of endemic species, and an increase in the proportion of more competitive species in the long run. [65]. For this reason, it is expected that by 2050, the species composition of 1/3 of the world's forests will change with the GCC, and new species compositions will lead to the formation of new forest ecosystems. Today, 8% of tropical forests are lost due to human influence, while thousands of species are facing extinction or migration [66].While the growth of plants is directly related to temperature, precipitation and the concentration of CO2 in the atmosphere, the responses of species to climate changes occur in different ways. For example, some trees need low temperatures in winter to sprout in the spring, so an increase in temperature in winter due to GCC will adversely affect these trees. While some trees require high temperatures to bloom, this temperature increase will positively affect the species. Therefore, GCC, tree, shrub and herbaceous plant species are expected to greatly influence the adaptation conditions and growing season, and the native species to be replaced by new species better adapted to higher temperatures or increased drought stress [67].

Changes in the soil structure due to GCC will affect the biotic diversity of the soil, causing many beneficial organisms to disappear or adapt to new conditions. In this case, the emergence of new species, etc. may have consequences that will affect all living systems. Changes in the macro and microorganism diversity in the soil may cause changes in the food chain and the spread of toxic substances that cause disease [68].

3.3. Use of Water and Drought Resistant Plants:

The use of water and drought resistant plants can be applied in 5 ways. These are 1-Plant growth regulator and osmotic preservatives application, 2-Nutrient application 3- Soil processing applications, 4-Mycorrhizal fungi and rhizobacteria that promote plant growth 5- C4 and CAM

Plant growth regulator and osmotic preservatives, nutrient application, inoculation with mycorrhizal and plant growth promoting rhizobacteria (PGPR), tillage applications. Cytokinin, ABA, proline, glycine betaine, polyamine and salicylic acid, gibberellin, brasinolide are growth and osmotic preservatives with an important potential to increase drought tolerance. While growth regulators regulate the protein and oil content of plants and increase growth, they increase water use efficiency by closing stomata. Thus, while increasing the root rate, it leads to the accumulation of antioxidants and protects the plants against stress.

Potassium (K), drought resistance by providing water balance in plants, Zinc (Zn), Nitrogen (N), Boron (B) and Phosphorus (P) etc. cause an increase in productivity. While Calcium (Ca) increases leaf aging and drought resistance with endogenous polyamine, Silicon (Si) improves the damage caused by drought. It also reduces water losses by reducing the cuticular transpiration rate. Selenium (Se) has an important potential to regulate plant water content in water stress. Manganese (Mn) and Molybdenum (Mo) significantly increase drought tolerance, while iron (Fe) improves the seed's nutrient content and its deleterious effects on growth.

While the change of plant species affects the change of soil structure, the microorganisms that suffer the most from this effect or their extinction can cause differentiation of the living world and ecosystem cycle. While the use of SEP in the protection and use of biodiversity provides important contributions to countries, it also imposes important responsibilities. Among these responsibilities, there is a need for concrete steps that will transform ecological wealth into economic interests by taking the steps of the SEP. For this reason, it is necessary to determine plant species resistant to drought stress, to explain tolerance mechanisms, to protect drought-resistant plant gene resources and to increase researches in the direction of contamination. These situations will play an important role in preventing GCC from becoming a major problem for all living things in the future.

4. CONCLUSION

Osmotic preservatives to be applied externally to plants, nutrient application or mycorrhizal fungi (AMF) and rhizobium bacteria (PGPR), which support plant growth, dissolve the phosphorus that the plant cannot use in the soil, while reducing the effects of drought stress and transforming it into the form that the plant can take. In addition, soil and water erosion will be prevented by using protective tillage methods instead of traditional tillage in semi-arid and arid regions, and production costs will be reduced by keeping the moisture in the soil longer. Although it is very important to predict the stress that will occur during the plant growth period, appropriate nutrient (N2, K, Mn, Zn etc.) and microbiological (rhizobacteria that support plant growth) applications play an important role.

The use of natural plants in the SEP, adaptation of natural plants to the area, low maintenance costs, compatibility with the region where the water requirement is located, etc. has important features. For this reason, the richness in flora and vegetation types and ecosystem diversity in our country will provide diversity and economic benefits in terms of plant use in SEP and designs.

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CHAPTER 15

Zero Pollution And Non-Toxic Environment

UNDERSTANDING BIOFILM STRUCTURE ON ANTI-BIOFOULING COATING FOR CHLORELLA VULGARIS

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ABSTRACT

Biofouling is a nuisance because it creates a surface problem for the photobioreactor (PBR) system. Biofilm layer on PBR surface causes damage reducing light penetration, decreasing photosynthetic activity, and cutting backing lifetime of the reactor material. In this study, we investigated the Ormosil coating glasses having anti-biofouling properties to overcome this problem. For investigation of biofilm attachment, glass with $HETAV_{60}$ and $TAV_{2,5}$ coating was studied for the *Chlorella vulgaris* (freshwater green algae) strain. $HETAV_{60}$ Ormosil coating included HEMA, TEOS, AA, and VTS, while $TAV_{2,5}$ included TEOS, AA, and VTS. The water contact angle values of flat $HETAV_{60}$ and $TAV_{2,5}$ Ormosil coating were found as 60 and 42°. The rough surface was produced using hydrophilic silica nanoparticles (10.4 and 12.2 % wt) to produce the superhydrophilic surfaces. For investigation of biofilm attachment, glass with $HETAV_{60}$-10.4; $HETAV_{60}$-12.2; $TAV_{2,5}$-10.4; $TAV_{2,5}$-12.2 coating was studied for the *Chlorella vulgaris* (freshwater green algae) strain. First, coating glasses were pulled out of the reactor at the end of harvesting time (14 days). Then, the light penetrations of coating glasses and the biofilm layers on the coating surface were examined using a light meter and a fluorescent microscope, respectively. These results suggest that superhydrophilic $HETAV_{60}$-10.4 and $HETAV_{60}$-12.2 Ormosil coating glasses would be a more useful candidate than $TAV_{2,5}$-10.4 and $TAV_{2,5}$-12.2 coating glasses for light penetration *Chlorella vulgaris* strain aspect.

Keywords: Biofouling, Algae, Biofilm, Photobioreactor, Chlorella Vulgaris

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1. INTRODUCTION

Microalgae have the potential to be converted into commercial products with the high added value of polysaccharides, lipids, enzymes, and vitamins throspecifictain processes. It is also used to produce various biofuels, reduce ammonia in wastewater, or remove CO_2 in the air[1], [2]. With its high photosynthetic capacities and growth rates, *Chlorella vulgaris* is a promising source of biomass in algae cultivation and possess approximately (>20%) oil content and protein, amino acid, and vitamin content which can be used in different areas [3], [4]. A photobioreactor (PBR) is a closed, enlightened culture vessel for controlled biomass production. According to studies, biofouling, which can be described as a phenomenon composed of the aggregation and adherence of cells onto its inner walls, is one of the essential disadvantages of PBRs. Reactors are supposed to be closed for cleaning and sterilization purposes considering the pollution occurring within them. This pollution causes reduced light transmission of walls, which plays a vital role in biofouling [5], [6]. This study aims to investigate the Ormosil coating glasses having anti-biofouling properties to overcome biofilm problems. For investigation of biofilm attachment, glass with $HETAV_{60}$ and $TAV_{2,5}$ coatings were studied for the *Chlorella vulgaris* (freshwater green algae) strain.

2. MATERIAL AND METHODS

2.1. Algae Cultivation

Thefreshwater green algae *Chlorella vulgaris* (CCAP 211/11B) was obtained from the Culture Collection of algae & protozoa and was inoculated in sterilized (121 °C, 40 min) Bold 3N Medium. Schott glass bottles with a capacity of 2.8 L, each containing a 2L medium, were used for strain growth. The incubated strain at 26 ± 2 ° C under the illumination of LED and cold white fluorescent provides an approximate irradiance of 110 µmol photon/m^2/s and 25 µmol photon/m^2/s, respectively. The reactors were fed with air at the flow rate of 400 mL/min, constituting0.5% carbon dioxide passed through a 0.2 µm filter. The reactors' pH levels were maintained at 7 ± 0.5. Once the algal biomass concentration reaches 1g/L, coating glasses are immersed in each reactor column, and coating glasses are pulled out of the reactor at the end of harvesting time (14 days).

2.2. Experimental Methodology

The first part of the experiment starts with the immersion of six glasses (2 glasses with $TAV_{2,5}$-10.4 coating, two glasses with $TAV_{2,5}$-12.2 coating, and 2 glasses without coating) simultaneously into each of three reactors (R1, R2, R3) for a period of 14 days (Fig. 1). For comparison purposes, fluorescent images are taken as a representative. In the second part of the experiment, the same procedure conducted in the first part was repeated for coatings $HETAV_{60}$-10.4 and $HETAV_{60}$-12.2 instead of $TAV_{2,5}$-10.4 and $TAV_{2,5}$-12.2.

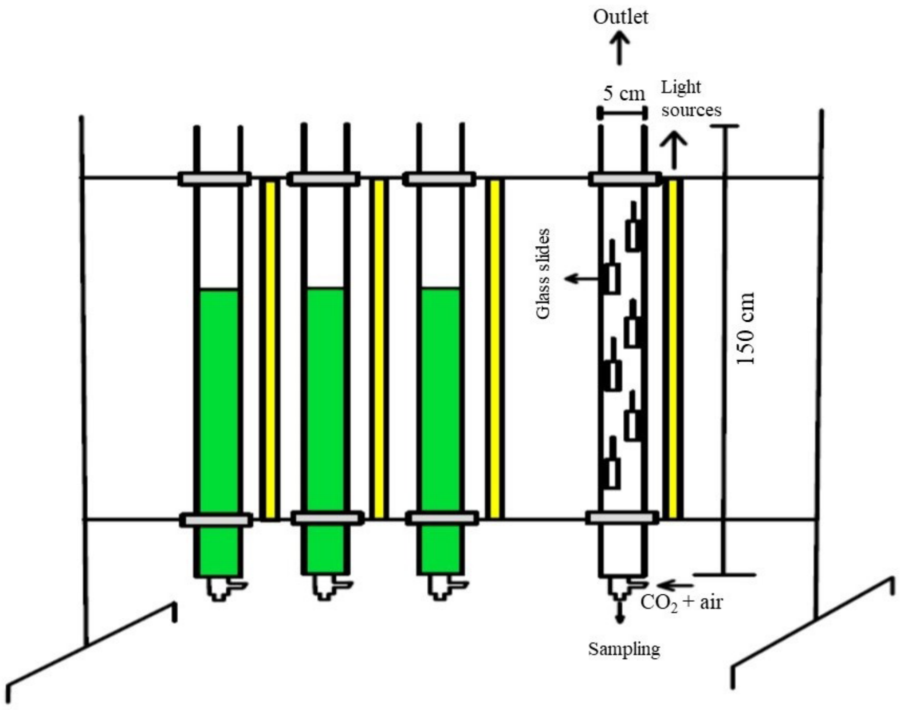


Figure 2. Experimental setup for microalgae cultivation in column reactors

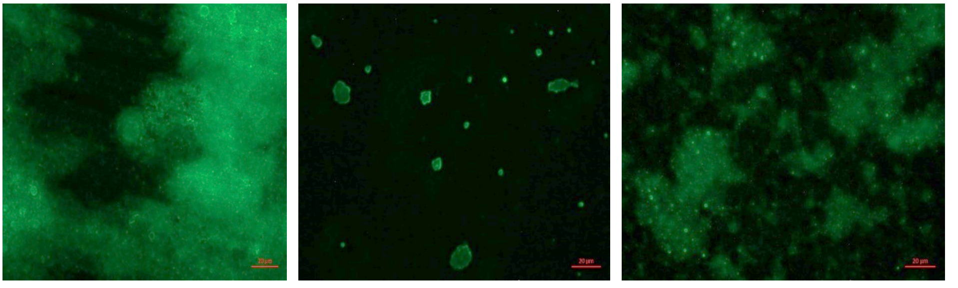
2.3. Measurement of Light Penetration and Biofilm Structure

The microalgal biofilm structure and light penetration were determined after 14 days of cultivation. Biofilm structure was observed with a fluorescent microscope (Zeiss Observer Z1). The biofilms on the coating glasses were observed using an x20 lens. The biofilm images in this work were represented in the results section. A power meter, light meter, lux meter, and photometer are special equipment that can be used to measure light transmittance. Another method to identify light transmittance in practice is establishing an electrical circuit with a photoresist or light-dependent resistor (LDR) [7]. LI-COR/ LI-250A-Lightmeter (photometer) device used in project work can give measurement results up to 1999 µmol/m2/s with a resolution of 0.1 µmol/m^2/s[8]. During the measurement, reference air and sample data were recorded in an isolated environment under an artificial light source. The data set was created by taking the measurements for different samples under the same environmental conditions with average values of 15 seconds (LI-250A, user manual).

3. RESULTS AND DISCUSSION

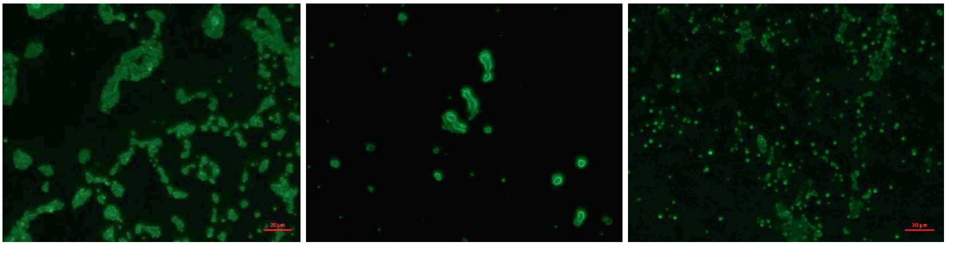
3.1. Biofilm Structure

To understand biofilm structures on different coating glasses, the *Chlorella vulgaris* biofilms were observed with a fluorescent microscope. Figures 2. and 3 display fluorescent microscope images of biofilms on different coatings, which demonstrated significant variations in the microstructures of the biofilms. According to the fluorescent microscope image results, it is seen that the adhesion of microalgae on the non-coating glass slides is in the form of particles. No thick biofilm layer or colony-forming structure among microalgae was observed on the non-coating glass slides. It was observed by looking at the way of adhesion on glass coated with $TAV_{2,5}$-10.4 that particle adhesion is not similar to $TAV_{2,5}$-12.2 coated glass slides. Overall, when compared, it is observed that pieces/particles adhere to the non-coated surface firmly. It can be said that adhesion of microalgae is in the denser and homogeneous form in $TAV_{2,5}$-12.2 coated glass in comparison to $TAV_{2,5}$-10.4 coated glass, which is an undesirable situation for light penetration.



(a1) (a2) (a3)

Figure 2. Experiment results: fluorescent microscope images of biofilms on glasses without coating (a1); with coating $TAV_{2,5}$-10.4 (a2); with coating $TAV_{2,5}$-12.2 (a3)



(b1) (b2) (b3)

Figure 3. Experiment results: fluorescent microscope images of biofilms on glasses without coating (b1); with coating $HETAV_{60}$-10.4 (b2); with coating $HETAV_{60}$-12.2 (b3)

The attached cells on the non-coating glass slide are located in bigger and denser particles. Biofilm layers of b1 and b3 show quite similar density in contrast to b2, which has a completely different characteristic. The surface adherence displays sparse dispersion. Considering all the images, we expected b2 light penetration to be the best.

3.2. Light Penetration

The outcome of measured light penetration of non-coating and coated glasses pulled out of reactors at the end of the harvesting period of 14 days has been demonstrated in Table 1. Moreover, average light penetration value results for all coated and non-coating have been compared, too. In compliance with the derived results, the light penetration results in non-coating glasses are greatly close to $HETAV_{60}$-12.2. On the other hand, when looking at the outcome of glasses coated with $TAV_{2,5}$-10.4 and $HETAV_{60}$-10.4 it is evident that light penetration is better than of non-coating glasses although the result of $TAV_{2,5}$-12.2 is negatively different. To summarize, glass coated with $HETAV_{60}$-10.4 provided the best light penetration aspect.

Table 1. Comparison of average light penetration values of non-coating glasses and glasses with coatings $TAV_{2,5}$-10.4, $TAV_{2,5}$-12.2, $HETAV_{60}$-10.4, and $HETAV_{60}$-12.2for each of the three reactors.

$TAV_{2,5}$-10.4	$HETAV_{60}$-10.4
12.58833	8.151667
$TAV_{2,5}$-12.2	**$HETAV_{60}$-12.2**
14.165	13.27667
Non-coating	
13.42166	

4. CONCLUSION

In the current study, we examined anti-fouling glasses for the photobioreactor (PBR) in which the *Chlorella vulgaris* was grown. Glasses with different coating properties were kept with microalgae for 14 days. The light transmittance test, which is an important parameter in reactor design, was performed at the end of 14 days. The process of adhesion on the coatings was examined by means of a fluorescent microscope. According to the results, the $HETAV_{60}$-10.4 coating demonstrated the best light transmission result.

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SUSTAINABILITY ASSESSMENT OF REMEDIATION ALTERNATIVES FOR SOILS CONTAMINATED BY POLYCYCLIC AROMATIC HYDROCARBONS

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ABSTRACT

Contaminated soils have been recognized as a globally important environmental problem since they pose a significant risk to human health and the ecosystem. To reduce this risk, several remediation techniques can be applied. However, not all the remediation techniques are sustainable, considering the environmental, social, and economic aspects of the application. The aim of this study is to evaluate remediation alternatives for contaminated soils from a sustainability perspective. This study focuses on polycyclic aromatic hydrocarbons (PAHs) contamination of soils nearby an industrial region. Sustainability assessment was then performed using the SiteWise Tool for Green and Sustainable Remediation Version 3.2, developed by US Navy, USACE, and Battelle. The indicators used in the tool were greenhouse gas emissions, energy use, air emissions, water and resource consumption, and worker safety. The remediation alternatives compared using this tool were soil washing, bioremediation, and in-situ chemical oxidation. The results revealed the footprints of each remediation alternative at every stage of project implementation. Therefore, the results of this study are deemed to provide useful information for policymakers when selecting the remediation technology to apply to soils contaminated by PAHs.

Keywords: Contaminated Soils, Polycyclic Aromatic Hydrocarbons,Remediation, Sustainability

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1. INTRODUCTION

Human activities, such as industrial, agricultural and domestic, result in the release of contaminants into the environment via unsustainable and extended use of synthetic chemicals, improper waste/wastewater management, and unintentional production of contaminants. Most contaminants end up in the soil environment due to direct discharges and dry and wet deposition of particles. Soil contamination is a serious global concern since it poses a significant risk to human health and the ecosystem. According to the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP), soil contamination is, directly and indirectly, related to 15 of 17 sustainable development goals (SDGs) identified by the United Nations [1]. Production of safe and sufficient food and drinking water for all people everywhere and maintaining the terrestrial biodiversity are interrelated to the economic and social growth of all countries in the world. Hence, to achieve the SDGs in all aspects, soil contamination should be reduced and prevented. The actions to reduce the risk to human health and the environment posed by the contaminated sites are defined as remediation. These actions involve physical, chemical, and biological mechanisms to reduce, remove or transform soil contaminants. However, not all actions are sustainable as they may result in other environmental problems or create economic and social concerns. Therefore, the green and sustainable remediation concept was introduced by Sustainable Remediation Forum (SuRF) in the USA and widened in other countries [2]. Sustainable remediation is defined as implementing remedial actions using the least amount of resources, generating the least impact while maximizing environmental, economic, and social benefits [2-3]. Within this context, remedial actions are evaluated in terms of environmental, economic, and social aspects [4]. Each aspect has five indicators: i) environmental aspect includes emissions to air, soil and ground conditions, ecology, use of resources, and production of waste; ii) economic aspect involves direct, indirect, and induced costs and benefits, project lifespan, employment; and iii) social aspect includes the safety of workers, neighborhoods, ethics, community involvement and uncertainty about the project [4].

Sustainability assessment of remediation alternatives has become the focus of research in the last 15 years [5-6]. However, to the author's knowledge, there is a little attempt on the sustainability assessment of remediation of contaminated sites in Turkey[7]. For assessing the sustainability of remedial actions, several decision support tools (DSTs) developed by governmental organizations, research institutions, and the private sector are available. These tools are designed to include the sustainability indicators identified by SURF-UK [4] as much as possible [8-9]. Huysegoms and Cappuyns [9] provided a comprehensive review and comparison of DSTs regarding the inclusion of all indicators and their user-friendliness. Based on this comparison, amongst the freely available tools, HVS[10], SiteWise [11] and SRT [12] gave very similar scores [9]. SiteWise calculates the environmental footprint of remediation alternatives. It is a Microsoft Excel-based tool containing a series of sheets where the user enters the information on the use of materials and equipment, transportation of personnel and equipment, waste management, and resource consumption. As a result, SiteWise provides a comparison of remediation alternatives in terms of greenhouse gas (GHG) emissions, other air pollutants emissions, water and energy consumption, and accident risks [11]. Previous studies used SiteWise to assess the environmental footprints of remediation technologies [13–15]. Hence, SiteWise was selected to be used in this study by generating a hypothetical case based on the measurements of persistent organic pollutants (POPs) in an industrial region in Turkey [16–19].

One of the hot spots for POPs in Turkey is Aliağa industrial region in Turkey. Polycyclic aromatic hydrocarbons (PAHs) were repeatedly measured in air, soil, sediments, water, and biological matter in the region [18–20]. PAHs are generally produced as by-products of incomplete combustion reactions; hence they are emitted from fossil fuel combustion, vehicle exhaust, incineration, and industrial processes such as petroleum refining and power plants [21]. PAHs are reported to have adverse effects on the reproductive and immune systems of humans and to be carcinogenic, mutagenic, and teratogenic [22-23]. Hence, the risk posed by PAH-contaminated sites is considered significant. Several remediation alternatives are available for PAHs, e.g., soil washing, in-situ chemical oxidation (ISCO), bioremediation, in situ thermal desorption, etc. [24]. Soil washing of PAH-contaminated soil can be accomplished by synthetic and bio-surfactants, humic acids, cyclodextrins, and vegetable oil [25]. ISCO for PAH-contaminated soil is generally achieved by persulfate, peroxide, and ozone [26-27]. Another technique for PAH-contaminated soils is bioremediation, where biological mechanisms are used. Bioremediation of PAHs can occur by native microbial population, their enhancement via the addition of nutrients, the addition of non-native microbial species, or with the help of plants [21]. All three alternatives include materials added to soil (i.e. soil amendments), hence requiring resources and energy. Therefore, this study aims to generate a hypothetical remediation case for PAH-contaminated soil in an industrial region and assess the sustainability of three remediation alternatives.

2. MATERIAL AND METHODS

2.1. SiteWise Tool and the Assumptions for the Hypothetical Contaminated Site

A hypothetical remediation site was generated in the Aliağa region, where several industrial activities are known to emit PAHs. The remediation site was assumed to be 7,500 m^2 with a depth of 1 m. Our previous tests revealed that soil in the hypothetical region had a silt loam texture with an average moisture content of 3.4%.

SiteWise separates remediation projects into mainly four components and allows the users to assign different phases of the project to these components. In this study, components were divided into 1) remedial investigations and feasibility studies (RI & FS), 2) remedial action constructions (RAC), 3) remedial action operation (RAO), and 4) long-term monitoring (LTM) [11]. RI & FS phase includes sampling of the contaminated media and bench-scale experiments performed to test the efficiency of the remediation alternative. During the RAC phase, any construction activity, such as excavation of soil, drilling of wells, and heavy equipment transportation, took place. RAO phase was considered as the phase when the contaminated soil was treated by physical (soil washing), chemical (ISCO), and biological (bioremediation) mechanisms. Lastly, the LTM phase involved sampling, analysis, and waste removal from the site. Transportation of personnel and equipment in all phases was assumed to be from İzmir to Aliağa (~70 km). Electricity usage and corresponding GHG and air pollutants emissions were taken as US average values, set as default in SiteWise. Apart from the analysis costs, the costs related to material production and use were not considered in this study. Additionally, no footprint reduction technologies were considered to be employed in any of the remedial alternatives.

2.2. Remediation Scenario 1: Soil Washing with Vegetable Oil

To reduce transportation costs and emissions, the soil washing process was considered to be performed at an appropriate place close to the contaminated site. Hence, a temporary facility would be constructed at a maximum distance of 1 km from the site. The facility would include three washing tanks where vegetable oil and soil were mixed for four days. Then, the mixture was taken to sedimentation tanks where clean soil was taken from the bottom and transferred to floatation tanks to remove oil from the soil completely. The used vegetable oil was then mixed with activated carbon (AC) to sorb PAHs dissolved in oil onto AC so that VO can be recycled back to the washing tanks. The AC was then regenerated by thermal treatment. AC regeneration was assumed to be conducted twice; hence AC was destructed by incineration when it was no longer reused. Using this treatment scheme, a total of 7500 m^3 of contaminated soil could be treated in five separate treatment cycles. Each washing tank provided 500 m^3 of soil to be treated in each cycle; hence 645 L of VO was needed for each tank in one cycle, considering the 1:1 (v:dw) ratio suggested by Yap et al. [28]. Accordingly, 430 kg of AC would be needed for the complete treatment of soil [29]. Clean soil was collected at the facility, transported back to the site, replaced to the original place, and paved. The tanks in the treatment facility were assumed to be made of concrete and stainless steel; hence, these materials were also added to the RAC phase.

2.3. Remediation Scenario 2: In-situ Chemical Oxidation

For the chemical injection into the subsurface, a well network should be established based on the hydraulic conductivity of the media. Since no such data exists for this hypothetical case, a system of 200 wells was assumed for this case where H_2O_2 and $FeSO_4$ would be injected. The number of injections was calculated based on the experimental conditions given by Jonsson et al. [30]. Injections were considered to be performed by pulsed injections within five days with the help of pumps and a pipe network. Since SiteWise does not include $FeSO_4$ as a default material, it was added as a low-impact material. The materials used in wells, pipe networks, and chemical tanks were entered for the RAC phase. Finally, well decommissioning was included in the LTM phase.

Table 1. Remediation scenarios and input parameters in SiteWise*

Phase	Soil washing	ISCO	Bioremediation
RI & FS	Materials production VO used: 1 L AC used: 111 g Transportation Distance: 140 km # of trips& personel: 1 &3 Vehicle: light truck using diesel Equipment use Excavated soil: 1 kg Excavation equipment: Shovels Experimental equipment: 1 mixer 600 W power operated for 75 hr + 1 orbital shaker 500 W power operated for 24 hr Operator labor: Construction laborers working for 5 hr, Operating engineers working for 7 hr, scientific staff working for 40 hr Lab analysis: 200$ Residual handling: Waste transported to HW landfill: 0.01 tons Vehicle&trips: Gasoline using vehicle, 25 km per 1 trip Water consumption: 20 L	Materials production H2O2 used: 1 kg Iron sulfate used: 3 g Transportation Distance: 140 km # of trips& personel: 1 &3 Vehicle: light truck using diesel Equipment use Excavated soil: 1 kg Excavation equipment: Shovels Experimental equipment: 1 mixer 600 W power operated for 75 hr Operator labor: Construction laborers working for 5 hr, Operating engineers working for 7 hr, scientific staff working for 40 hr Lab analysis: 200$ Residual handling: Waste transported to HW landfill: 0.01 tons Vehicle&trips: Gasoline using vehicle, 25 km per 1 trip Water consumption: 20 L	Materials production HA used: 2 g SMS used: 3 g Transportation Distance: 140 km # of trips& personel: 1 &3 Vehicle: light truck using diesel Equipment use Excavated soil: 1 kg Excavation equipment: Shovels Experimental equipment: 1 mixer 600 W power operated for 75 hr Operator labor: Construction laborers working for 5 hr, Operating engineers working for 7 hr, scientific staff working for 40 hr Lab analysis: 200$ Residual handling: Waste transported to HW landfill: 0.01 tons Vehicle&trips: Gasoline using vehicle, 25 km per 1 trip Water consumption: 40 L
RAC	Materials production: stainless steel and general concrete Transportation Distance for personnel: 140 km # of trips & personel: 2 & 5 Vehicles: light truck using diesel for personnel transport Equipment transport: 2 trips in 5 km's with 40 tons of equipment Equipment use Excavated soil: 7500 m3 Earthwork equipment: Excavator (diesel), backhoe (diesel) Installation of washing equipments: crawler crane (diesel) Operator labor: Construction laborers working for 40 hr, Operating engineers working for 16 hr	Materials production Well materials: PVC wells with gravel and typical cement fillings # of injection wells: 200 H2O2 & FeSO4 tanks: stainless steel Well network pipes: PVC Transportation Distance for personnel: 140 km # of trips & personel: 2 & 5 Vehicles: light truck using diesel for personnel transport Equipment transport: 2 trips in 5 km's with 1 ton of equipment Equipment use Drilling equipment: hollow stem auger (diesel) Operator labor: Construction laborers working for 200 hr, Operating engineers working for 16 hr Residual handling: 1 tons of non-hazardous waste sent to landfill	Materials production Well materials: PVC wells with gravel and typical cement fillings # of injection wells: 200 HA & SMS tanks: stainless steel Well network pipes: PVC Transportation Distance for personnel: 140 km # of trips & personel: 2 & 5 Vehicles: light truck using diesel for personnel transport Equipment transport: 2 trips in 5 km's with 1 ton of equipment Equipment use Drilling equipment: hollow stem auger (diesel) Operator labor: Construction laborers working for 200 hr, Operating engineers working for 16 hr Residual handling: 1 tons of non-hazardous waste sent to landfill

RAO	Materials production VO used: 1935 L AC used: 430 kg Transportation Distance: 140 km # of trips& personel: 6 &3 Vehicle: light truck using diesel Equipment operation: Washing tank pump: 7.5 kWh x 3 Water reservoir pump: 1.5 kWh x 3 VO recycle pump: 3 kWh Mixers: 3 x 7.5 kWh motor power, 1 x 5 kWh motor power Thermal regeneration of AC: 800 °C, 1 hour, 1.65 L/min gas flowrate Clean soil transportation: truck (diesel), paver (diesel) Operator labor: Construction laborers working for 20 hr, Operating engineers working for 40 hr Residual handling: Waste transported to HW landfill: 0.4 tons Vehicle&trips: Diesel using vehicle, 25 km per 1 trip Water consumption: 10 m3 for floatation tank (sent to WWTP)	Materials production H2O2 used: $6*10^6$ kg FeSO4 used: 3000 kg Transportation Distance: 140 km # of trips& personel: 5 &3 Vehicle: light truck using diesel Equipment operation: H2O2 tank pump: 1.5 kWh x 3 FeSO4 pump: 1.5 kWh x 2 Operator labor: Operating engineers working for 40 hr Residual handling: Waste transported to HW landfill: 0.4 tons Vehicle&trips: Diesel using vehicle, 25 km per 1 trip	Materials production HA used: $2*10^4$ kg SMS used: 30000 kg Transportation Distance: 140 km # of trips& personel: 5 &3 Vehicle: light truck using diesel Equipment operation: HA tank pump: 1.5 kWh x 3 SMS pump: 1.5 kWh x 3 Operator labor: Operating engineers working for 40 hr Residual handling: Waste transported to HW landfill: 0.4 tons Vehicle&trips: Diesel using vehicle, 25 km per 1 trip Water consumption: 1 m^3
LTM	Transportation Distance: 140 km # of trips& personel: 3 &3 Vehicle: light truck using diesel Equipment use Excavated soil: 1 kg Excavation equipment: Shovels Operator labor: Operating engineers working for 7 hr, scientific staff working for 40 hr Lab analysis: 200$ Residual handling: Waste transported to HW landfill: 0.01 tons Vehicle&trips: Gasoline using vehicle, 25 km per 1 trip Water consumption: 20 L	Well decommissioning: 200 PVC wells filled with soil Transportation Distance: 140 km # of trips& personel: 3 &3 Vehicle: light truck using diesel Equipment use Excavated soil: 1 kg Excavation equipment: Shovels Roller use for decommissioning (diesel) Operator labor: Operating engineers working for 7 hr, scientific staff working for 40 hr Lab analysis: 200$ Residual handling: Waste transported to HW landfill: 0.01 tons Vehicle&trips: Gasoline using vehicle, 25 km per 1 trip Water consumption: 20 L	Well decommissioning: 200 PVC wells filled with soil Transportation Distance: 140 km # of trips& personel: 3 &3 Vehicle: light truck using diesel Equipment use Excavated soil: 1 kg Excavation equipment: Shovels Roller use for decommissioning (diesel) Operator labor: Operating engineers working for 7 hr, scientific staff working for 40 hr Lab analysis: 200$ Residual handling: Waste transported to HW landfill: 0.01 tons Vehicle&trips: Gasoline using vehicle, 25 km per 1 trip Water consumption: 20 L

*AC: activated carbon, FS: Feasibility studies, HA: humic acid, HW: hazardous waste, ISCO: In-situ chemical oxidation, LTM: Long-term monitoring, RI: Remedial investigations, RAC: Remedial action constructions, RAO: Remedial action operations, SMS: spent mushroom substrate, VO: vegetable oil, WWTP: wastewater treatment plant

2.4. Remediation Scenario 3: Bioremediation

Biostimulation, i.e., the addition of nutrients to enhance the native microbial population, would be the last alternative to be compared in this study. To enhance the microbial activity for PAH bioremediation in soil, nutrients such as carbon, nitrogen and phosphorus, and other organic matter, which also increase the bioavailability of PAHs, are added [21-31]. Based on the bench-scale studies of Liu et al. [24-32], spent mushroom substrate

(SMS), which provided necessary nutrients and organic matter, and humic acid (HA), which increased the bioavailability of PAHs, were assumed to be injected into the subsurface environment. However, these substances are not present as default in SiteWise. Both HA and SMS can be considered a low-impact-material. For HA, a 0.2 g: 100 g soil ratio was used, while that of SMS was 0.3 g: 100 g [24-32]. The remaining application details, such as well network, pipe system, and pumps, were the same as ISCO.

3. RESULT AND DISCUSSION

SiteWise calculated the footprints of three remediation scenarios in terms of GHG emissions, total energy used, water consumption, electricity usage, onsite, off-site and total NOx, SOx and PM10 emissions, as well as accident risk fatality and injury. Figure 1 represents the comparison for total GHG, NOx, SOx and PM10 emissions. As can be seen from Figure 1, all remediation scenarios emitted air pollutants on the same order of magnitude with soil washing seemingly performing better than ISCO and bioremediation scenarios. Nearly 100% of the emissions resulted from the production and use of consumables. On the other hand, the emissions due to equipment use were very similar in all remediation scenarios. In soil washing, a recycling process for vegetable oil and reuse of activated carbon were designed, hence RAO phase emitted less air pollutants compared to ISCO and bioremediation where soil amendments could not be reused. At this point, more data on site characteristics such as hydraulic conductivity would be needed to make better assumptions on the required soil amendments. Consumables also included bulk materials required for construction, such as stainless steel, concrete for constructing tanks and operation units, and PVC for injection wells.

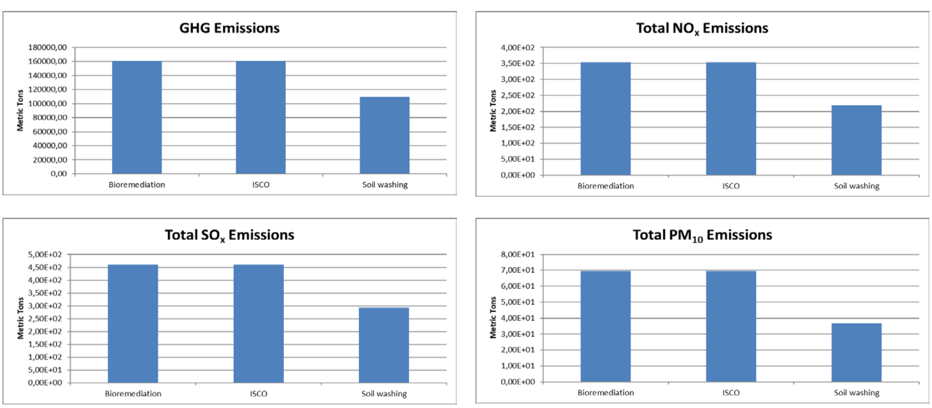

Figure 1. Emissions of air pollutants during all phases of remediation scenarios

SiteWise also allows the user to compare the footprints during various phases of remediation scenarios. Most of the GHG emissions occurred during RAC phase of all remediation scenarios (>100 000 metric tons), while RAO phase also emitted GHG in ISCO and bioremediation (~8100 metric tons). Furthermore, the total energy used reached up to 293 000 MWh in all scenarios, RAC phase being the highest energy using phase. The sources of total energy used are compared amongst the phases of remediation scenarios in Figure 2. In RI&FS phases of all remediation scenarios, the highest energy use was due to equipment use followed by transportation of personnel. RAC phase for all scenarios used energy due to consumables. This situation was observed also in RAO phase of ISCO and bioremediation. However, the energy use in RAO phase of soil washing was mainly due to equipment use. In LTM phase of soil washing, transportation and equipment use were the main sources of energy use, while transportation dominated in ISCO and bioremediation. This comparison provides decision makers to have an understanding of the phase having highest impact and the source with highest contribution. In this study, RAC phase had the highest impacts in all remediation scenarios, and the production and use of consumables was the highest contributor. If any of these remediation scenarios were to be implemented, the required amount of soil amendments and bulk materials such as stainless steel, cement, PVC, needs to be calculated correctly.

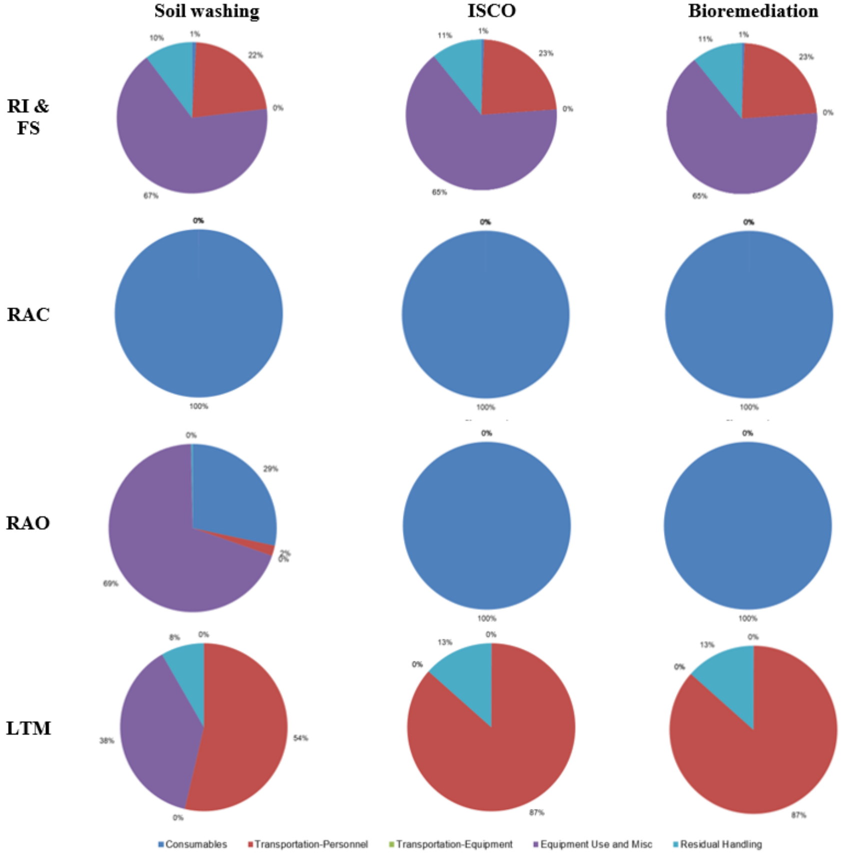

Figure 2. The sources of energy consumption in four phases ofremediation scenarios

The highest contribution to the water consumption and electricity usage was from equipment use in all of the remediation scenarios. In terms of both footprints, soil washing performed the worst. Totally, 32 m^3 of water was consumed in soil washing, which was two orders of magnitude higher than that in other scenarios. Furthermore, during soil washing, electricity usage was calculated to be 11.3 MWh, three orders of magnitude higher than that in other scenarios.

Accident risk fatality and injury were also estimated in SiteWise with regards to the social aspect of sustainability assessment. They were estimated by using statistical data from governmental organizations such as Bureau of Labor and U.S. Department of Transportation, etc. These data represent fatality and injury rates of workers in various positions (e.g. construction, operating, technical) and due to transportation. As a result, all remediation scenarios posed the same level of fatality risk, while soil washing scenario posed higher injury risk.

When all footprints calculated by SiteWise were taken into consideration, none of the remediation scenarios appeared as the most sustainable option. Soil washing resulted in less air pollutant emissions, however water and electricity consumptions were higher than in other scenarios. Additionally, in terms of worker safety, soil washing had higher risks. Generally, bioremediation is considered as a more sustainable remediation technique than physical and chemical processes. But in this study, it performed the same as ISCO, although the type of soil amendments differed. Further runs of the SiteWise tool with proper assumptions would provide more specific results.

4. CONCLUSION

This study provided a comparative evaluation of three remediation scenarios in terms of sustainability using SiteWise tool. By using the results of this study, the remediation technique with lower impacts on specific indicators can be identified. Although none of the scenarios evaluated in this study appeared as the most sustainable option, we are now able to propose solutions to improve these remediation techniques towards sustainability. For example, in ISCO and bioremediation techniques, the soil amendments should be used carefully not to exceed the required amounts. In soil washing, water consumption should be prevented as much as possible. In all techniques, the materials with low impacts used should be selected. Furthermore, site characteristics should be determined for better estimation of required materials. Since a hypothetical contaminated site in Aliağa, İzmir was generated in this study, some assumptions, such as the required soil amendments and number of wells might have resulted in the overestimation of footprints.

SiteWise tool proved useful to guide decision makers before the implementation of remediation projects. However, it has some limitations. There is no consideration for the achievement of remediation objectives, such as reduction percentage in contaminant concentration, or reduction in the risk level. A remediation technique might seem to be more sustainable, but it might be inapplicable if it cannot reach the remediation objective. Additionally, not all the sustainability indicators are included in the tool. Environmental indicators such as air pollutant emissions, resource usage, waste management can be estimated but soil and ground condition and ecology are not considered. Also, among the social indicators, only worker safety is included. Further studies to improve SiteWise tool, or simultaneous application of similar tools might provide more detailed results on all the sustainability indicators.

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IMPACT OF CLIMATE CHANGE ON WATER SUPPLY: TREATMENT AND REUSE OF GREYWATER

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ABSTRACT

Due to population growth and pollution of water sources, water demand is increasing in all over the word. Technological developments with climate change and industrial and agricultural activities are causing significant water demand problems. Therefore, wastewater treatment and reuse of them in different goals such as irrigation, cleaning of surfaces, car, are very important for sustainable water management strategy. Several physical, chemical and biological treatment processes can be used based on raw greywater characteristics and water quality standards.Conventional physical, chemical and biological processes individually are not sufficient to required water quality standards. technologies. Greywater including organics, solids and surfactants treatment considering parameters of turbidity, TSS, TDS, total coliforms and COD removal can be achieved using advanced treatment systems. In this study greywater removal processes and use of treated greywater in Turkey and Europe will be discussed.

Keywords: Greywater, Climate Change, Reuse, Advanced Treatment, Sustainability

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1. INTRODUCTION

Water is a basic and indispensable need for human and living environment to survive. Reasons such as rapid population growth, excessive and unconscious consumption habits after the industrial revolution, climate change and the late formation of environmental awareness have put usable water resources in the world in danger in terms of both quality and quantity. The fact that the consumption habits of developed countries and the natural desires of developing countries that raise their living standards cannot be restrained require the creation of new solutions for the sustainable use of water resources or raising awareness about existing solution proposals. One of the prominent methods among the current solution proposals is the reuse of wastewater. Treating and reusing waste water not only saves water, but also prevents the pollution of existing water resources through discharge. However, the costs incurred in the treatment of wastewater at a reusable level constitute an obstacle to the widespread use of these methods. For this reason, the treatment and reuse of greywater, which has a lower pollution rate compared to industrial wastewater and other domestic wastewater, is much cheaper and easier to treat [1,2].

The part of domestic wastewater that is not mixed with faeces from sources such as showers, baths, sinks, washing machines and dishwashers is defined as greywater. The remaining sewage water originating from the toilet is defined as black water. Black water contains high concentrations of nitrogen and phosphorus, pathogenic bacteria and pharmaceutical residues [3]. For this reason, it is quite unfavorable compared to greywater in terms of reuse by treatment. Greywaters can be divided into two groups according to the level of pollution. Of these, slightly polluted greywaters consist of wastewater from bathrooms and sinks, and highly polluted greywaters consist of wastewater from kitchens, dishwashers and washing machines [4]. About 75-80% of domestic wastewater by volume is greywater. The fact that it is relatively low in pollution and high in volume makes it important to collect greywater separately. Although the concentrations of pollutants and pollutants in greywaters vary according to living standards, social and cultural habits, generally the pollutants and their sources are given in Table 1. There are many studies proving the feasibility of reusing greywater as non-potable water such as irrigation, toilet flushing, development and protection of wetlands, recharging of groundwater, firefighting and washing water after appropriate treatment [5,6,7]. If the advantages of reusing greywater are listed;

- Reuse without the need for treatment or with a simple treatment,
- Decreased use of drinking water as utility water,
- Reduction in the amount of waste water discharged to natural water resources,
- Reduction of the density in the mains water distribution lines,
- Creating a source for irrigation water, especially in arid regions,
- Providing hygienic conditions easily, can be listed as [8].

Table 1. Pollutants in greywater by source [9]

Washing machine	Suspended solids (SS), Organic Matter, Oil, Salinity, Sodium, Nitrate, Phosphorus, pH
Dishwasher	SS, Organic Matter, Oil, Salinity, pH, Bacteria, Detergent
Bathtub-Shower	Bacteria, Hair, SS, Organic Matter, Oil, Soap and Shampoo
Sink	Bacteria, SS, Organic Matter, Oil, Soap and Shampoo

2. TREATMENT METHODS OF GREYWATER

Greywater makes up about 50-80% of the water used in a home. It comes from the sinks, kitchen, bathtubs, washing machine and bathroom. It contains up to 30% organic matter which is less organic matter and harmful pathogens than sewage wastewater. However, its content may vary according to the characteristics of home users. While there is shampoo, soap and etc. in the greywater coming from the bathrooms, there may be a high amount of detergent in the greywater coming from the washing machine. Soap and toothpaste come from the sink greywater. All of them contain nitrogen, phosphate and surfactants. Oil, grease and food residues come from the kitchen sink which has balanced COD: N: P ratio [6, 10, 11].

Although it varies with people's lifestyles and the quality of the water used, greywater is generally at natural pH and has a total suspended solids (TSS) content above the standards. High TSS values are due to kitchen wastes consisting of beverage and food leftovers. Although it is lower than sewage wastewater, there is organic matter in greywater. Chemical oxygen demand (COD) and biochemical oxygen demand (BOD) parameters of greywater are much higher than clean water. The high organic matter content is affected by detergent waste and the amount of water used during the washing process [12]. The pollutant parameters coming from different greywater sources are given in the Table 25.

Table 2. Pollutant parameters coming from different greywater sources [13]

Greywater source/type	pH	Conductivity (µS/cm)	TS (mg/L)	TSS (mg/L)	VSS (mg/L)	COD_t (mg/L)	BOD_5 (mg/L)
Bath/shower	7.5 ± 0.1	318 ± 30	325 ± 55	73.5 ± 38	69.2 ± 35	390 ± 125	263 ± 83
Hand basin	7.6 ± 0.2	318 ± 278	373 ± 96	90.5 ± 68	58.9 ± 48	427 ± 192	305 ± 129
Kitchen	6.9 ± 0.4	449 ± 341	883 ± 426	319 ± 209	314 ± 205	1119 ± 476	831 ± 358
Laundry	8.3 ± 0.8	653 ± 423	1085 ± 608	169 ± 96	139 ± 90	2072 ± 1401	1363 ± 950
Dish washer	10 ± 0.2	2199 ± 753	2535 ± 1053	11 ± 1.3	10 ± 0.5	411 ± 59	184.6 ± 24

Considering the increasing global water scarcity, the reuse of relatively less polluted greywater with on-site separation and treatment is emerging as an attractive approach. The easier control and treatment of greywater makes it possible to use it for non-potable purposes. It can be used in toilet flushing, agricultural irrigation, garden irrigation, car washing, firefighting and discharge into water bodies [10].

Generally, greywater treatment is done to remove or minimize components that can harm human health, disrupt land and aquatic ecosystems, and pollute irrigation systems. The treatment method to be selected according to different parameters such as the size of the water to be treated, the area where the water will be used, economic and social factors, and cost should also be sufficient to treat the greywater, which has pollutants in constantly changing concentrations, in a safe and sufficient quality [14].

Greywater treatment technologies consist of physical, chemical and biological systems. In most of these systems, solid-liquid separation is performed as a pre-treatment purposes. Septic tanks, sieves, filter bags and other filters are among these pre-treatment processes to prevent clogging in the treatment stages. Similarly, microbiological requirements are fulfilled by applying disinfection as post-treatment [6].

2.1. Physical Treatment

Soil based filters, sand filters and membranes are applied in greywater treatment at pilot scale or full scales. Usually, these treatment methods are accompanied by storage tanks, filters and pumps. The volumes of the tanks are large enough to cover the water of one or more houses. TSS and turbidity are removed from sand filters by adsorption of negatively charged colloids and ion exchange mechanisms. Although these filters can highly remove TSS and turbidity, they cannot effectively remove organic matters, some dissolved minerals and microorganisms. To increase organic matter removal, sand filters are often used with an activated carbon filter or pre-treated by coagulation and sedimentation [6,12,15].

In March's study [16] with a nylon stocking type filter (0.3 mm mesh and 1 square meter filtration area), it was stated that it is suitable for use in toilet flushing by precipitating the greywater for 48 hours after filtering and then disinfecting it by adding >1 mg/l choline.

Since conventional filter treatment requires chlorination or disinfection with UV radiation to be safe, there has been an increased trend towards processes that require simpler operation and maintenance. Ultrafiltration membranes may be a suitable process for this. It gives excellent results in terms of E. coli, suspended solids and turbidity and in addition, it provides about 80% TOC removal [17]. Some studies on the physical treatment of greywater are given in the Table 26.

Table 3. Physical methods used in greywater treatment [14]

Process	TSS (%)	Turbidity (%)	COD (%)	BOD (%)	TN (%)	pH	TP (%)	References
Filtration (rock filter)	59,5		51,3	26,5		7.1	6,5	[18]
Filtration (sand and rock filter)	65,1		47,7	16,9		7.2	9,4	[19]
Filtration (sand filter)	55,6	53,8	31,4					[19]
Filtration (nylon sock type filter)	56,8	15,0	54,4		37,7			[16]

2.2. Chemical Methods

There are very few studies on the treatment of greywater by chemical methods. Used methods for treatment of greywater includes coagulation, electro-coagulation, photo-catalytic oxidation, ion exchange and granular activated carbon. In a system reported where disinfection is applied after electrocoagulation, the COD, BOD, turbidity and SS removal efficiencies are 60%, 61%, 91% and 69%, respectively. In addition, total coliform was not determined in the treated greywater [20].

In a study in which activated carbon, which is effective in removing many pollutants by adsorption, was used for the treatment of greywater [21]. Mohammad produced activated carbon from the palm kernel shell and the COD, TDS, TSS removal efficiencies were determined as 56.44%, 57.81% and 42.11%, respectively.

In a study [22] in which coagulation and ion exchange resin were applied, ferric and alum were used as coagulants and supplemented with magnetic ion exchange resin (MIEX). In a study in which coagulation and ion exchange resin were applied, ferric and alum were used as coagulants and supplemented with magnetic ion exchange resin (MIEX). Separate results are given for each scenario. It was determined that magnetic ion exchange resin is not good in turbidity and BOD removal. Both coagulation and magnetic ion exchange resins cannot achieve TN and PO_4^{3-} removal. While the magnetic ion exchange resin failed in total coliform removal, it was reduced to <1 with ferric, alum and MIEX used together with these coagulants. In general, it has been stated that they are effective in the treatment of low organic strength greywater.

[23] reported that turbidity, COD, phosphate and surfactants could be removed between pH 5-9 in their studies where electrocoagulation and electroflotation system was applied to treat laundry wastewater. Laboratory results showed over 70% COD removal and over 90% turbidity and phosphate removal.

Table 4. Chemical methods used in greywater treatment [14]

Process	TSS (%)	Turbidity (%)	COD (%)	BOD (%)	TN (%)	pH	TP (%)	References
Alum Coagulation		90,82	63,72	88,78	12,78		94,58	[22]
Ferric Coagulation		88,84	63,59	85,37	0,56		96,39	[22]
Electrocoagulation and electroflotation		90	70			5-9	90	[23]
Activated carbon from the palm kernel shell	42,11		56,44					[21]
Al + ion exchange resin		93,54	68,77	86,83	15		93,37	[22]
Fe + ion exchange resin		92,92	67,89	85,85	3,33		92,17	[22]

2.3. Biological Methods

Biological treatment processes of greywater can be categorized as aerobic, anaerobic and combination of anaerobic-aerobic technologies but they are also separated within themselves. Aerobic treatment methods can be divided into attached growth, suspended growth and hybrid technologies. In attached growth, the microorganism grows attached to a plastic material, stones, discs, and similar interfaces. The material may be submerged or suspended in water. Examples are systems such as rotary biological contactors (RBCs), moving bed biofilm reactors (MBBRs), or the MBBR-MBR combination. Among the suspended growth technologies, sequential batch reactor (SBR) and membrane bioreactors (MBR) stand out. Since the mechanism is known in domestic wastewater treatment, they have a great use in the biological treatment of greywaters [6,14,24].

On the other hand, anaerobic treatment technologies gain importance due to the low operating cost and the ability to remove nitrogen. UASB, anaerobic filter and anaerobic biofilm reactors are used for these purposes. However, despite the high removal efficiencies, the inhibition of anaerobic microorganisms emerges as a problem due to the presence of high concentrations of surfactant in the greywater. Personal care products (PCPs) can be removed from greywater in all biological treatment methods. However, not all detergents and surfactants are suitable for removal. For example, dodecyl benzene sulfonate isomers (DBS) cannot be degraded by bacteria even after a week. The ingredients in many shampoos and bath gels require a 10-day degradation. Finally, wetland treatment attracts attention in greywater treatment due to its low cost, low maintenance and energy consumption, and environmental advantages. rhizosphetic bacteria, using the oxygen carried to the roots of the plants, break down the impurities in the greywater [24] Some studies on the biological treatment of greywaters are given in Table 28.

Table 5. Biological methods used in greywater treatment [24]

Process	TSS (%)	Turbidity (%)	COD (%)	BOD (%)	TN (%)	pH	TP (%)	References
RBC- Light greywater	63	94	71	89				[25]
RBC- bathroom greywater			60	53				[26]
MBBR- Domestic greywater			94,5	99,4	63		14	[27]
SBR - Household greywater	84,0-100,0		66,0-94,0					[28]
SBR - Household greywater			82		26		31	[29]
MBR- Light greywater	87	99,7	86	98				[30]
MBR - Showers and bathroom sinks		98	90	95				[31]
Anaerobic UASB -			52-64		22-30		15-21	[32]
Anaerobic filter - Bathroom sinks, showers etc.	77	88	71	73				[33]

3. LEGAL LEGISLATION ON TREATMENT AND REUSE OF GREYWATER IN TURKEY

There is no specific legislation regarding the reuse of greywater in Turkey. In the seventh chapter of the Wastewater Treatment Plants Technical Procedures Communiqué, under the title of Recovery and Reuse of Treated Wastewater, a legal arrangement has been made for the treatment and reuse of all wastewater, including greywater. In the communiqué; There are regulations regarding usage areas of treated wastewater, location of wastewater recovery facility, storage of treated wastewater, technology selection for wastewater recovery and irrigation water usage criteria of treated wastewater. In the use of wastewater treated according to the Communiqué; There are usage alternatives such as agricultural irrigation, reuse as process water in industry, charging of groundwater, fire extinguishing, using in toilet flushes and recycling as drinking water. The processes to be selected and the technology requirement in the recovery of wastewater depend on the purpose for which the water to be treated will be used. Disinfection process gains importance in the case of treating urban wastewater to be used in irrigation of agricultural areas or urban green areas. In cases of direct or indirect recovery, advanced treatment techniques such as membrane technologies, activated carbon and advanced oxidation are required [34].

The regulation regarding the use of treated wastewater as irrigation water is contained in Article 22. In Annex-7, criteria for irrigation waters are given. In Table E7-1, treated wastewater to be reused in irrigation is divided into two classes as Class A and Class B. Class A waters are waters that are not commercially processed, irrigated by surface and sprinkler irrigation, and used for the irrigation of food products that can be eaten directly as raw, and for irrigation of all kinds of urban areas. Secondary treatment, filtration and disinfection units are needed. Class B water, on the other hand, is used for the irrigation of commercially processed products such as orchards and vineyards, for irrigation of areas where public access is restricted such as grass production and aquaculture, and for irrigation of non-food crops such as pasture irrigation. Secondary treatment and disinfection units are needed. The quality parameters and monitoring periods required by Class A and B reclaimed waters are given in Table 29 [34].

Table 29. Quality parameters that reclaimed water should provide [34]

Class A		**Class B**	
-pH=6-9 -BOD_5< 20 mg/L - Turbidity < 2 NTU -Fecal coliform: 0/100 mL - In some cases, specific virus, protozoa and helminth analysis may be requested. - Residual chlorine > 1 mg/L	-pH: Weekly -BOD_5: Weekly - Blur: Continuous -Coliform: daily - Residual chlorine: continuous	-pH=6-9 -BOD_5< 30 mg/L -Suspended solid < 30 mg/L -Fecal coliform < 200 pcs/100 mL - In some cases, specific virus, protozoa and helminth analysis may be requested. - Residual chlorine > 1 mg/L	-pH: Weekly -BOD_5: Weekly -AKM: daily -Coliform: daily - Residual chlorine: continuous

4. LEGISLATION FOR THE REUSE OF GREYWATER IN EUROPE

As in Turkey, there is no specific legislation for greywaters in the European Union. However, on 25 May 2020, the Regulation of the European Parliament and of the Council on the minimum requirements for the reuse of water came into force. The regulation will be effective from 26 June 2023. The regulation in general; It includes the water quality parameters and values that treated urban wastewater should be provided in order to be used in agricultural irrigation, the minimum periods that the parameters should be monitored, risk management provisions for environmental and health risks, permit requirements and provisions for making the basic information of reuse projects available to the public. In the regulation, reclaimed water to be used for irrigation is divided into four classes. These;

- Class A; Plants that can be consumed raw and unprocessed, the edible part of which comes into contact with water,
- Class B; non-food products, including food products that are not in contact with reclaimed water and are consumed raw, processed food products and products used to feed dairy or meat producing animals,
- Class C; Used for irrigation of plants that can be irrigated with Class B, with drip irrigation or other irrigation methods that prevent direct contact with the edible part of the crop,
- Class D; It represents water used for industry, energy and seed plants.

According to the regulation, the parameters to be provided by treated water to be used in agricultural irrigation are given in Table 30 [35].

Table 30. Parameters that treated water must provide for use as irrigation water [35]

	E. coli (number/100ml)	BOD5 (mg/l)	TSS (mg/l)	Turbidity (NTU)	Other
A Class	≤ 10	≤ 10	≤ 10	≤ 5	Legionella spp.: < 1 000 cfu/l where there is a risk of aerosolisation Intestinal nematodes (helminth eggs): ≤ 1 egg/l for irrigation of pastures or forage
B Class	≤ 100	In accordance with Directive 91/271/EEC	In accordance with Directive 91/271/EEC	-	
C Class	≤ 1 000			-	
D Class	≤ 10 000			-	

5. CONCLUSION

Several physical, chemical and biological treatment processes were discussed in this study based on raw greywater characteristics and water quality standards.Conventional physical, chemical and biological processes individually are not sufficient to required water quality standards. technologies. Greywater including organics, solids and surfactants treatment considering parameters of turbidity, TSS, TDS, total coliforms and COD removal can be achieved using advanced treatment systems.

Because of water stress in Turkey and Europe, ıt needs wastewater reuse alternatives such as greywater treatment and reuse of it in different area mostly in irrigation, house and car cleaning so on. Treated greywater should be used in cities and rural areas and directives needs upgrading for wastewater reuse such as greywater.

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INTEGRATION OF STORMWATER CAPTURE AT FLOOD MANAGEMENT RESERVOIRS WITH MANAGED AQUIFER RECHARGE

Emre Burcu Özkaraova[1*], Robert Kalin[2]

ABSTRACT

Managed Aquifer Recharge (MAR) is enhancement of natural groundwater replenishment and has become more important in recent years to conserve groundwater resources and ensure integrated and sustainable water resources management. MAR sources includes excess surface water, such as surface run off and/or flood water, and treated water (wastewater or desalinated water). MAR can be effective for sustaining groundwater levels and preventing saltwater intrusion at coastlines, and through injection methods has some potential to reverse trends in confined aquifer piezometric decline thereby reducing land subsidence. Given groundwater is 98% of the available freshwater on the planet, MAR may be a substantial tool for climate change adaptation and resilience. Key knowledge needed to implement MAR are hydraulic properties of the aquifer and its natural flow regime, water quality (including variability of both recharge and underground water), and time-scales (e.g. available time-dependent volume of surface water resource for recharge, and/or groundwater injection and abstraction management). Aquifer systems range widely in storage coefficient (depending on porosity and permeability) but in general offer substantial reservoir space with minimal evaporation and wide distribution. Appropriate groundwater recharge zone determination with respect to potential flood risk zones and surface runoff harvesting locations is critical. Geophysical investigations, such as aeromagnetic survey and vertical electrical sounding, are used to understand hydrogeological properties of subsurface structures. Remote sensing (RS) and Geographic Information Systems (GIS) are helpful tools to model the conceptual understanding of surface water and groundwater interaction, and provide predictions of target sites where MAR can be linked to flash flood and landslide control. This paper describes the potential of Flood-MAR to reduce flood risks and replenish aquifer systems.

Keywords: Managed Aquifer Recharge (MAR), Flood Risk Management

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1. INTRODUCTION

The variability of the hydrologic cycle is expected to increase due climate change, exacerbating flood and drought severity. Flood water related hazards include loss of human life, residential destruction, agricultural production losses, and greater economic damage. Early warning systems as a flood risk management tool reduce the impact of natural disasters through preparation, but requires tremendous disaster risk information (inventory about past events) and infrastructure. The management of flood water (routing and infiltration) combined with early warning systems are a more integrated and adaptive measure for climate change adaptation and resilience.

The effects of population and economic growth has reduced natural aquifer recharge, resulting in a global decline in groundwater levels. This is a risk for surface water systems as groundwater provides substantially to rivers through base-flow discharge to rivers and interaction of groundwater with lakes and wetlands, and is becoming increasingly vital for nature based solutions for climate change adaptation. Within this scope, managed aquifer recharge (MAR) has been accepted as a tool for the replenishment of aquifers with lower yields, and where groundwater is impacted by salt water intrusion and land subsidence [1]. MAR can be briefly defined as the augmentation of surface water movement into underground formations using surface construction and subsurface systems [2]. Aims of MAR are to reverse the decline in groundwater level, to reverse or avoid salt water intrusion by increasing underground freshwater pressure along coastlines, and to store surplus water (e.g. river water, flood water, reclaimed water). Subsurface water storage has the advantage of minimum evaporation and pollution, when compared with surface reservoir structures. Besides the lower construction costs, subsurface formations are wide-spread unlike limited suitable sites for dam construction. Besides these primary advantages, the quality of water for artificial recharge determines its potential use and purpose for MAR, as minimum risk of groundwater pollution is among the main criteria.

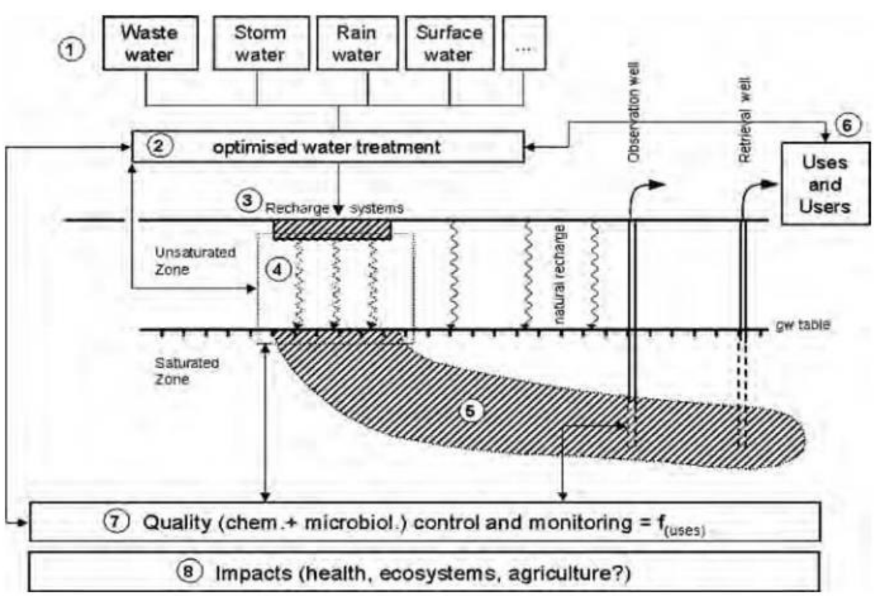


Figure 1. Concept of Managed Aquifer Recharge and Points of Consideration [3]

2. ARTIFICIAL RECHARGE TECHNIQUES

Artificial recharge relies on the modification of the natural groundwater flow and recharge pattern for more infiltration. Recharge techniques are classified as direct and indirect techniques. Direct surface techniques are flooding, ditch and furrow systems, basins, stream-channel modifications, stream augmentation and over-irrigation, while direct subsurface techniques are natural openings, pits and shafts, reverse drainage and injection wells. Indirect techniques include induced recharge from surface water resources and aquifer modifications. The type of recharge technique is selected according to the source of water and climate class, with respect to the geological and hydrogeological formation. The source of water generally used for groundwater recharge is surface water (e.g. stream or river water), storm water and treated wastewater. Figure 2 represents the occurrence of recharge techniques with respect to different water sources. The use of water source for MAR in different climate classes can be seen in Figure 3.

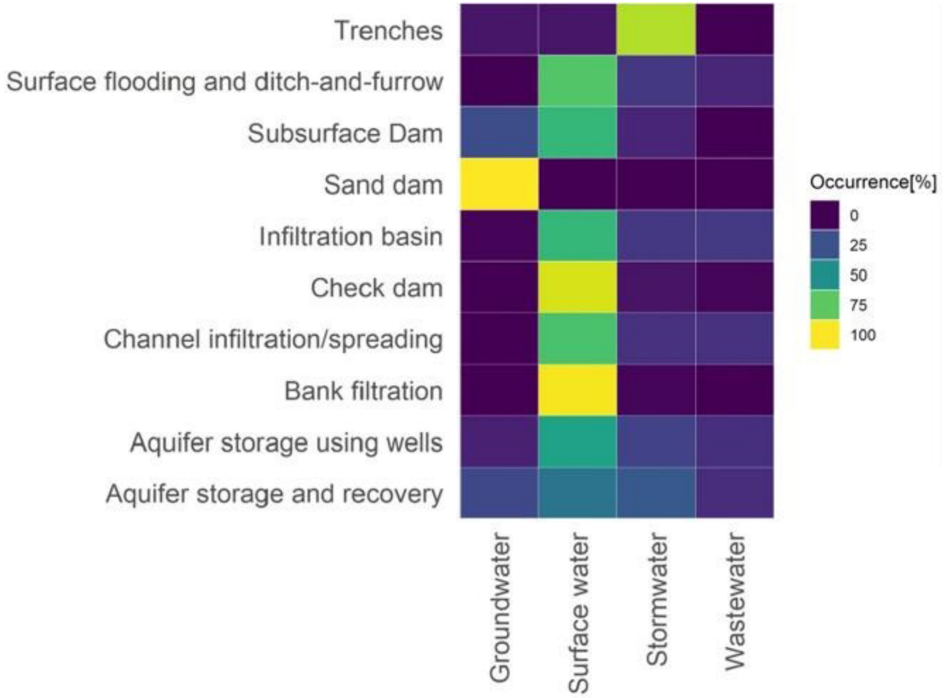


Figure 2. Source Water for MAR Categorised According to MAR Type [4].

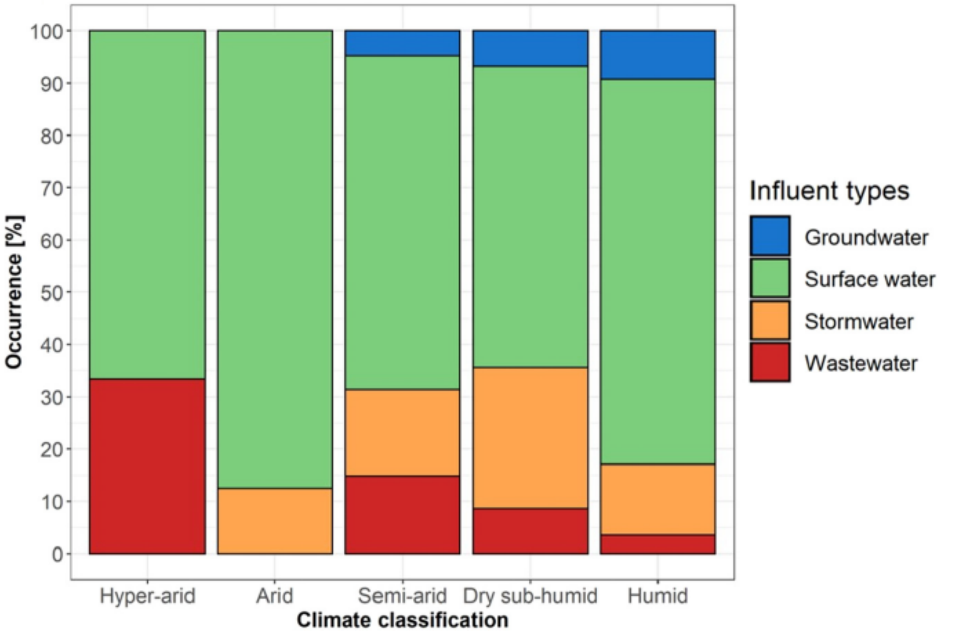


Figure 3. Source Water for MAR Categorised According to Climatic Region [4]

2.1. Direct Surface Techniques

Direct surface techniques basically rely on the same principle as natural percolation through the soil with higher 'managed' infiltration rates. These techniques require aquifer systems that have high permeability, vadose zones without restricting layers that produce excessive perched mounds, and unconfined aquifers of sufficient transmissivity to prevent undue occurrence of groundwater mounds [5]. Flooding, infiltration ponds and basins, unlined ditches and canals are the most often used techniques due to their low cost and ease of operation. Primary factors for all surface technique are amount of water to enter the subsurface, the water quality, the overall recharge area, and the length of time for water-soil contact [6].

Flooding Recharge: This technique is the most basic, simply relying on providing area for surplus water to infiltrate at a potential MAR site, often with 1-3% slope. The water is spread to the land from different points allowing even application with minimum velocity to avoid soil cover disturbance and increased infiltration during down gradient flow (Figure 4). Excess water may be recovered with a recovery canal at topographical low point to minimize evaporation.

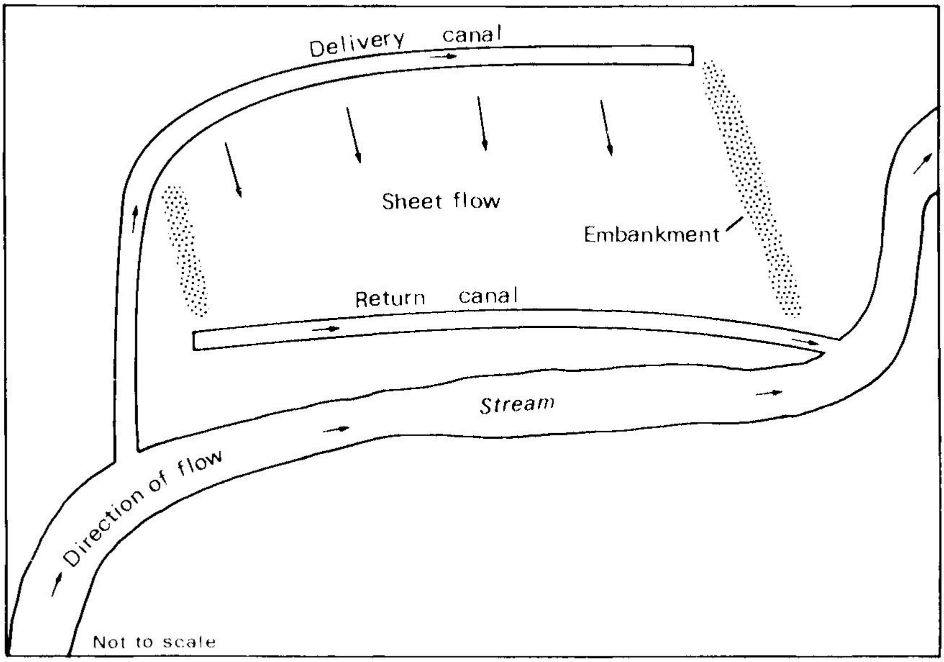


Figure 4. Recharge by Flooding [2]

Basin Type Recharge: Aquifer recharge using infiltration basins is another favoured technique as the construction of dikes or levees is rather easy. The size of basin is relative depending on the source of surplus water (river/stream or storm/flood water), but it is important to consider the impact of evaporative enrichment of salts and reduced water quality of the recharging water. Multiple basins can be easily interlinked, allowing bypass regimes for easy maintenance of basins with higher sedimentation and thus restoration of water infiltration.

Figure 5. A Series of Recharge Basins for Recharge [2, Dillon Sixty years]

Unlined Ditch/Canal Type Recharge: Initially intended for irrigation water distribution, unlined furrow, ditches and canals enable active groundwater recharge. Surplus water is distributed to the recharge area using closely placed, shallow and unlined ditches or canals constructed as lateral, dendritic and contour systems [2]. Structural modifications can slow down water movement and increase infiltration.

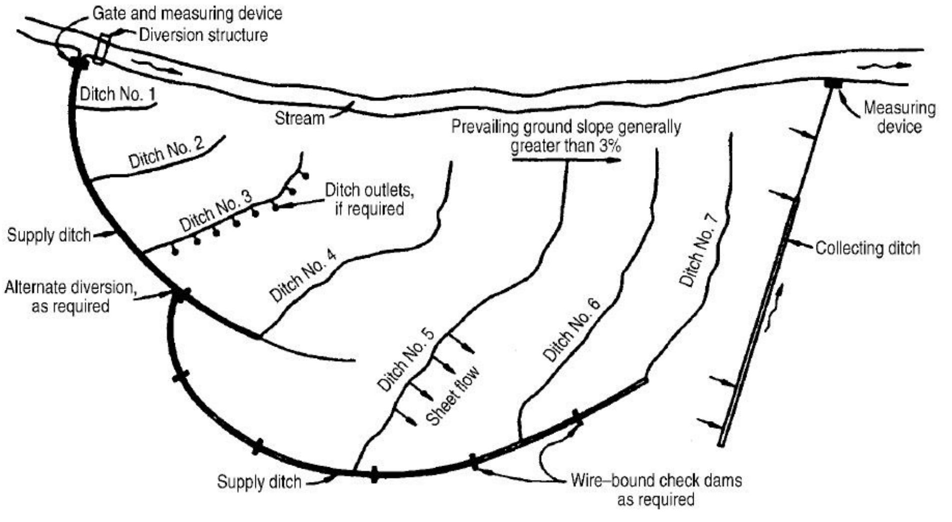


Figure 6. Recharge by Unlined Ditches [7]

Bank Filtration Type Recharge: The natural process of bank infiltration is induced with the construction of gabions, drains, galleries and a line of vertical and/or horizontal wells. The distance between the surface water source (e.g. stream, river etc.) and filtration area and sediment/soil characteristic will determine the percolating water quality.

Modified Stream Channel Type Recharge: Through dredging, levelling, widening, construction of check dams and temporary dikes within the stream channel infiltration rates can be increased by increasing infiltration area and time.

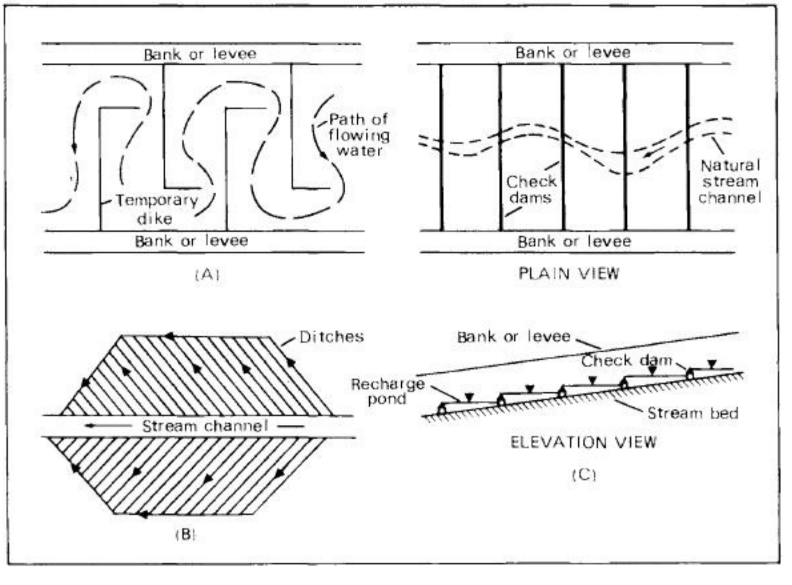


Figure 7. Recharge by stream channel modification [2]

2.2. Direct Subsurface Techniques

As implied by its name, surplus water is directly introduced into the subsurface, to both unconfined and confined aquifers, using natural opening, pits, shafts, wells and drainage pipes. Injection wells are very sensitive to porosity reduction due to clogging by colloids, sediments and mineral precipitates. Thus, the quality of surplus water needs to be monitored and reclaimed to assure the criteria.

Natural Openings for Recharge: Natural fractured formations, limestone caverns or sinkholes may be a good opportunity for aquifer recharge, but again it is important to monitor water quality as it is poor integrated water resource management to introduce a water of poorer quality into a water of higher quality. These may act like a natural drain, that needs to investigated for their appropriateness regarding structure, location and size before use.

Recharge wells: Injection wells are used for many purposes. As borehole drilling enables connection with deeper aquifer systems, recharge of deeper confined aquifer is generally observed using injection wells. The oil and gas sector has considerable experience with injection wells for production, and therefore injection wells are an option for sites unsuitable for direct surface recharge (e.g. lack of land). Injection wells can be constructed to supply water to two or more aquifers simultaneously and where hydraulic conditions permit, can be used as passive connectors between adjacent aquifers separated by impermeable layers [2].

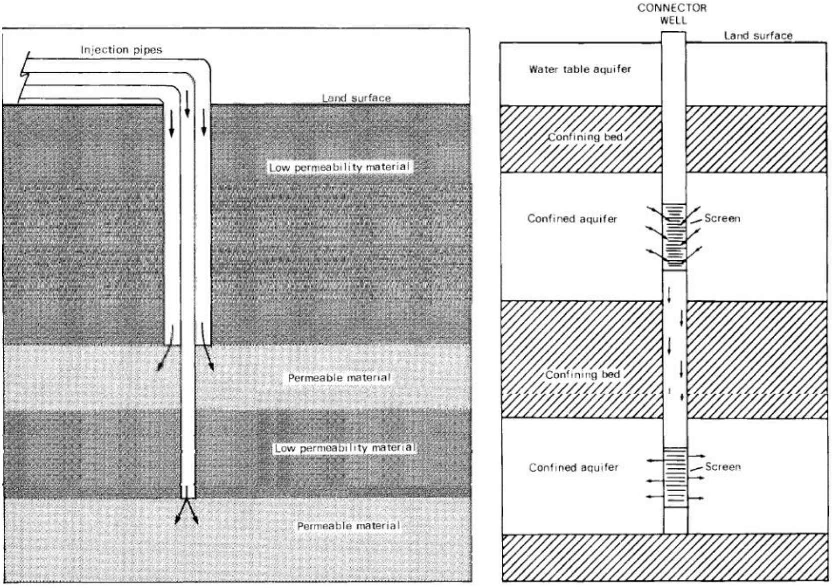
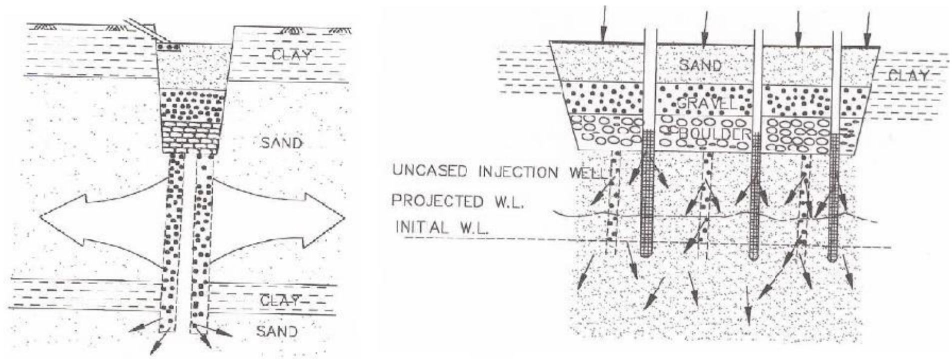


Figure 8. Recharge Using Injection Wells [2]

Pits and Shafts for Recharge: Semipermeable surface layer generally require the use of injection wells, pits or shafts for aquifer recharge generally increasing costs. The depth generally depends on the thickness of impermeable surface layer. Shafts are deeper and narrower than pits, selected according to site specific conditions. Recharge shafts may be applied laterally and vertically with or without injection wells (Figure 9). Gravels are suitable as filling materials, allowing good infiltration and low clogging.



(a) (b)

Figure 9. (a) Vertical and (b) lateral recharge shafts with injection wells [8]

3. AQUIFER PROPERTIES

The aim of MAR is to store large quantities of water in the aquifer to reverse trends in groundwater table declines, or for storage and future use as a climate change adaptation tool. MAR can be designed for unconfined or confined aquifers. MAR therefore should be considered within the wider integrated water resource management planning and investment cycle, possibly as a positive outcome of sustainable urban drainage systems (SUDS) and flood-water management. For flood-risk management MAR should be designed to quickly store large amounts of water with no direct functional use in unconfined aquifers e.g. bank infiltration. However, if land subsidence is to be controlled or avoided, injection into confined aquifer seems more suitable [9]. Additionally, confined aquifers enable the protection of water quality by the confining layer. The heterogeneity in aquifer formations needs to be well characterized prior to MAR projects. Characterization of aquifers with surface hydrogeologic techniques such as resistivity and electromagnetic methods, ground-penetrating radar, seismic reflection and refraction may narrow down large sites for investigations with standard borehole logging techniques.

The capacity of the aquifer to store storm or flood water is one of the determining issues/criteria to investigate. Thus, key parameters to evaluate are hydraulic conductivity, transmissivity, storativity / storage coefficients, subsurface structure (fracture flow, primary and secondary porosity, hydrostratigraphic units), water quality and aquifer mineralogy, for natural and pumped groundwater flow regimes. Hydraulic conductivity reflects the easiness of fluid transport through soil and sediment with respect to fluid density and viscosity and pore size. Transmissivity represents the amount of aquifer available for fluid transmission over the thickness of the hydrostratigraphic unit, and is obtained by detailed pumping tests of the system. Pumping tests and monitoring allows calculation of the aquifers water storage capacity, and routine water quality monitoring provides information on natural water chemistry and contamination sources. Ideally one would wish MAR to be implemented where there is high storage volume (high thickness) in the range of 315 to 430 m^2/day was reported as suitable for MAR/ASR [10]. The hydraulic gradient is the loss of energy over distance in a groundwater system so a lower gradient (less resistence to flow) is preferable. High (steep) hydraulic gradients result in lower recovery, while lower (gentle) gradients enable higher recoveries [9].

Hydrogeological site evaluation requires (among other things) the following technical issues to be considered with supplemental investigations [11]:

- stratigraphy (geologic cross-sections included)
- areal extent, thickness and depth of aquifer formations (confining layers or aquitards)
- lithology of aquifer formations
- hydraulic properties (transmissivity, storativity, conductivity, porosity)
- structure
- mineralogy of clays, sands and other constituents
- geophysical logs
- water table level and hydraulic gradient
- groundwater flow rate and direction
- water quality of each aquifer (compatibility of native and recharge waters)

4. FLOOD CONTROL WITH MAR (FLOOD-MAR)

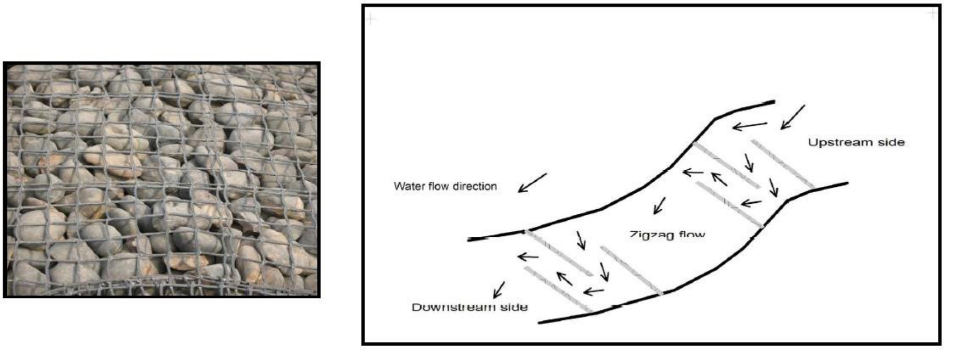
MAR techniques used upstream or within flood risk regions are known to avoid flooding by reducing peak flows. The first step is to determine flood hazard levels and geological and hydrogeological conditions in each region. Various models exist that enable the prediction of rainfall, subsequent run-off. Some other models like the storm flood disaster risk zoning technique helps to determine potential impact of the storm flood related disasters [12] and determine the area requiring solutions. To determine the appropriateness of MAR for disaster management, water retention of geological formations and water storage capacities of aquifer systems in risk areas needs to be investigated in detail. Geophysical investigations, such as aeromagnetic survey and vertical electrical sounding, are used to understand hydrogeological properties of subsurface structures. Remote sensing (RS) and Geographic Information Systems (GIS) are accepted as helpful tools in better understanding surface water and groundwater interaction and assessing locations of flash floods and landslides, respectively. The complexity of the subsurface requires multi-disciplinary team work and professionalism to investigate the depth of Flood-MAR for proper implementation.

Infiltration ponds are often first considerations for MAR investment, however trenches, dry wells, drainage wells, injection wells are techniques also used for storm water management [13]. Storm water contains high level of sedimentary materials which tend to clog pores and reduce infiltration within time. Thus, regarding local conditions media filtration, green infrastructure, constructed wetlands and pre-sedimentation basins are used as pre-treatment to overcome quality problems of storm water [13]. Natural or induced dissolution of minerals and subsequent precipitation or air entrainment may also decrease the downward movement of water. Besides reduction in total suspended solids in water, pH adjustment is also used to prevent the clogging problem during MAR application [12]. Mineral clogging problems in injection wells are easily solved by periodic back flushing or redevelopment with airlifting [13].

5. CASE STUDIES

Solutions to flash floods and draught hazards in semi-arid to arid regions require continuous evaluation and investigation with regard to countries local conditions, and there is a wide range of case studies in the literature to consider. MAR in general has been under-utilised as a solution for urban storm water management. Managed aquifer recharge has also been under-utilised for the mitigation of floods and draughts, but flash flood and groundwater recharge potentials has been investigated and implemented in countries like Egypt, India, USA, Australia, New Zealand and Italy [14].

In a study conducted in Egypt four hydrographic wadi basins, subdivided to 45 sub-basins, were investigated for a relationship between flash flood occurrence and groundwater recharge potential. Remote sensing and GIS techniques were used for satellite image and topographic data analyses. Sub-basin parameters such as length, area, perimeter, sinuosity, bifurcation ratio, stream density, drainage frequency, circularity ratio, shape index, relief ratio, ruggedness number, gradient, texture ratio, valley length and other geologic data were evaluated, and it was found out that only two sub-basins have low potential of flooding and high potential of groundwater recharge and some few sub-basins have moderate potential of groundwater recharge and flooding [15]. For the mitigation of flood hazards retardation dams formed by loose heaps of boulders were proposed to reduce runoff velocities (Figure 10 (a)). An additional proposal was the construction of incomplete embankment dams forming zigzag path along appropriate flood courses between upstream and downstream areas (Figure 10 (b)).



(a) (b)

Figure 10. (a) Diagrams showing (a) loose boulders embankment dam fortified by wire-netting and (b) zigzag path formed by spur dyke dams.

In a pilot scale demonstration study of Flood-MAR in Uttar Pradesh India an unused village pond of 2625 m^2 area and 2 m depth with 10 recharge wells was used to transfer flood water up to 62000 m^3 during the monsoonal rainfall season (62-85 days) [14]. Chinnasamy et al. [16] showed that under different scenarios, capturing between 10% and 50% of excess flow can reduce the flood inundation area with a return period of 5 years by 5.1% to 27.1% for the Ramganga basin.

Figure 11. Infrastructure of a Flood-MAR (UTFI) demonstration at Jiwai Jadid village, Uttar Pradesh İndia [14].

6. CONCLUSION

Groundwater is 98% of the global available fresh water resource, and as climate change enhances climate variability, groundwater will be relied upon more and more as surface water are less available or suitable in quality and quantity. Within the scope of water resources management, MAR is an important tool for integrated water resources management and to reduce the impact of climate change through mitigation and adaptation, however future strategies require conjunctive planning for both. Sustainable management for both surface water and groundwater resources require conjunctive planning for all surplus waters (e.g. flood water, reclaimed water).

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DECOLORIZATION AND NEUTRALISATION OF LOCAL DYEING EFFLUENTS USING PHYTO-ADSORBENT MATERIALS

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ABSTRACT

Access to clean water is among the most critical issues for global health and development. According to the United Nations Development Program, 2.6 billion people lack access to clean water, and around 40 developing countries provide clean water for less than 70 % of their population. Access to clean water that can be used and consumed without risk of acute or long-term impact on health and the environment is important for sustainable development and poverty reduction. The environmental issues associated with untreated dyeing effluents that are discharged directly to waterways are aesthetic and can also disturb photosynthesis and affect aquatic life. Adsorbents are substances that attract other materials or particles to their surfaces, the extent of adsorption depends on the nature of the adsorbent, especially its porosity and surface area. In this research, cost-effective and environment-friendly adsorbents were used to decolorize and neutralized the local dyeing effluent, thus; managing the effluent to save our environment. The maximum percentage decolorization and neutralization of the local dyeing effluent by different adsorbents (un-powdered) were obtained at an optimum contact time of 48 hours and 72 hours with an optimum adsorbent dosage of 15g and 20g. The powdered adsorbents were obtained at an optimum contact time of 12 hours and 18 hours with an optimum adsorbent dosage of 5g and 7.5g. The result shows that Phyto-adsorbent materials can be used to pre-treat effluents from the dyeing process prior to discharge into waterways to save the environment.

Keywords: Effluents, Adsorbents, Environment, Water Treatment, Decolorization

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1. INTRODUCTION

Water as a finite resource is necessary for human existence, agriculture and industry. Inadequate quantity and quality of water supply have serious impact on water resources management and environmental sustainability. Problem of this nature have been increasing in scope, frequency, and severity because the demand for water continues to increase [1]. Dyes are attached onto the textile fibres by Vander Waals forces, hydrogen bonds and hydrophobic interactions (physical adsorption). The uptake of the dye in fibers depends on the dye nature and its chemical constituents. Water polluting substances in effluents from textile dyeing can originate either from the dyes themselves or from other chemicals used in the dyeing process, these chemicals can be auxiliaries in the dye formulation, alkali, salts, reducing and oxidizing agents and auxiliaries used in the dyeing process, or contaminants such as pesticide residues already present on the fibre when the dyeing starts [2]. The discharge of dye-containing effluents in particular, into the water environment is undesirable, not only because of their colour, but also because many of the dyes released and their breakdown products are toxic and carcinogenic, mainly because of carcinogens, such as benzidine, naphthalene and other aromatic compounds [3]. Without adequate treatment these dyes can remain in the environment for a long period of time. For instance, the half-life of hydrolyzed Reactive Blue 19 is about 46 years at pH 7 and 25°C [4]. The main parameters identified in the textile industry are pH, electrical conductivity (EC), chloride, sulphate, phenols, total dissolved solids (TDS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) and other substances [5]. Wastewaters from the textile industry therefore, have to be treated before being discharged into the environment [6].

Adsorption can be defined as the accumulation of dissolved substance on a solid surface through chemical bonds of different strength [7]. In the case of water treatment between a liquid and a solid phase, the molecule adsorbed at the interface is called adsorbate and the solid at which the adsorption occurs is called adsorbent, the strength of the adsorbate-adsorbent interaction varies and depends on properties of the system. Adsorbents are substances that attracts other materials or particles to their surfaces, the extent of adsorption depends on the nature of adsorbent especially its porosity and surface area. A better adsorbent is the one with large surface area and which requires less time for adsorption equilibrium.

Scientists are recently giving considerable attention on the use of biological-based materials and their bye-products as the bio adsorbent for the removal of pollutants from different wastewaters. This is true of the fact that carboxyl, hydroxyl and amino groups over the surfaces of the bioactive compounds of these plants, are capable of binding with dye compounds, microbes and other particulate matter [8]. Bio-based materials such as agricultural waste, biomasses are cheap and easily obtainable in considerably substantial quantities. Adsorption is one of the most promising decolorizing techniques in dyeing wastewater treatment; it has become more popular in recent years owing to their efficiency in the removal of pollutants. Adsorption is influenced by many factors such as dye/adsorbent interaction, adsorbent surface area, particle size, temperature, pH and contact time [8].

Sivakumar *et al.* (2013) reported that the pH, Electrical conductivity, Chloride, Sulphate, Phenols, Biological Oxygen Demand, and Chemical Oxygen Demand was removed from textile industrial effluent in a constructed wetland using aquatic macrophytes, *eichhor-*

nia crassipes. It was found that the maximum percentage reduction was obtained at an optimum nutrient dosage of 60g, dilution ratio of 10, pH of 8, and contact time of 6 days. The maximum removal percentage of various parameters like Electrical conductivity, Total Dissolve Solids, Chloride, sulphate, phenols, Biological Oxygen Demand, and Chemical Oxygen Demand in a textile industry effluent is about 87.2, 90.2, 82.6, 86.8, 78.5, 91.3 92.8% respectively.

A research by Soudani *et al.* (2011) reported that some pollutants were removed from raw waste water using dried carpobrotus edulis plant as a new cheap adsorbent; the results showed that the uptake of nitrate, phosphate and some heavy metals ions from waste water by *C. edulis* increased with increasing contact time. The percentage uptake of heavy metals from industrial waste water by edulis particles was about 94% for Cd(ii) 91% for Cu(ii),99% for Pb(ii)and 98% for Zn(ii). The removal percentage of phosphate and nitrate ions from municipal waste water by dried *C. edulis* was found to be 96% and 97% respectively. The results indicate that the chemical oxygen demand values decreased after contact with micro-particles of dried *C. edulis* plant.

2. MATERIALS AND METHODS

2.1 Instruments

In addition to common laboratory glassware, apparatus and instruments used are UV-Vis Spectrophotometer (Model: Jaykay 4010), Fourier Transform Infrared Spectrophotometer (Model: Carry 630), pocket size pH meter (Model: HI 96107).

2.2 Effluent and Plant Collection

The dyeing effluent was collected in an air tight sterilized bottle from Local Dyeing Industry at Rijiyar Lemu Area, Kano State. Nigeria. The dyeing effluent was then kept in a refrigerator for preservation. Color intensity and pH of the dyeing effluent were analyzed and recorded. Three aquatic plants were used in this research work. All the plants were taken to the Herbarium Section, Plant Biology Department, Bayero University Kano for identification. The identified plants were given accession numbers as follows: 1-Hippo Grass (Vossia cuspidata) - BUKHAN0299, 2-White Lotus (Nymphaea lotus) - BUKHAN0356, 3-Southern Cattail (Typha domingensis) - BUKHAN0358

The aquatic plants were collected from Botsotsuwa pond, Mai'adua Area. Katsina State. Nigeria. The collected aquatic plants were washed several times with tap water to removed dust and soluble impurities. Stems and leaves of the plants were used, rinsed with distilled water, cut into smaller pieces, and then weighed. The fresh adsorbents were kept in a refrigerator to avoid their decomposing. For the dried samples, the adsorbents were kept for drying at room temperature in a laboratory for 14 days and then heated in an air oven at 60°C for 6hours, then crushed and sieved.

2.3 Treatment Process

Different adsorbent dosage (10, 15, 20 and 25grams) and different contact time (24, 48, 72 and 96 hours) of both the fresh and dried adsorbents were employed. Each of the samples was immersed into a separate flask containing 150ml of the dyeing effluent. The samples were kept at room temperature for adsorption process. Aluminum foil has been used to prevent air from entering. The samples were finally analyzed to detect the change in pH and colour. For the powdered adsorbents, different adsorbent dosages (2.5, 5, 7.5 and 10grams) at different contact time of (6, 12, 18, 24hours) were used. Each of the samples was immersed into a separate flask containing 150ml of the dyeing effluent. The samples were kept at room temperature for adsorption process.

3. RESULTS

Leaves and stems of the plants were used to decolorize and neutralizes the local dyeing effluent. Two process parameters, i.e. contact time and adsorbent dosage have been selected for conducting the adsorption studies.

The % decolourization of each sample was calculated by using the following relationship.

$$\% \text{ decolourisation} = \frac{\text{Initial absorbance - finalabsobance}}{\text{Initial absorbance}}$$

Initial absorbance of the local dyeing effluent= 0.737

% neutralization of each sample was calculated using the following relationship.

$$\% \text{ neutralization} = \frac{\text{Initial pH - final pH}}{\text{Initial pH}}$$

3.1. Results of Powdered Adsorbents

Effect of particle size was studied on powdering the dried plants parts. Results obtained are shown below.

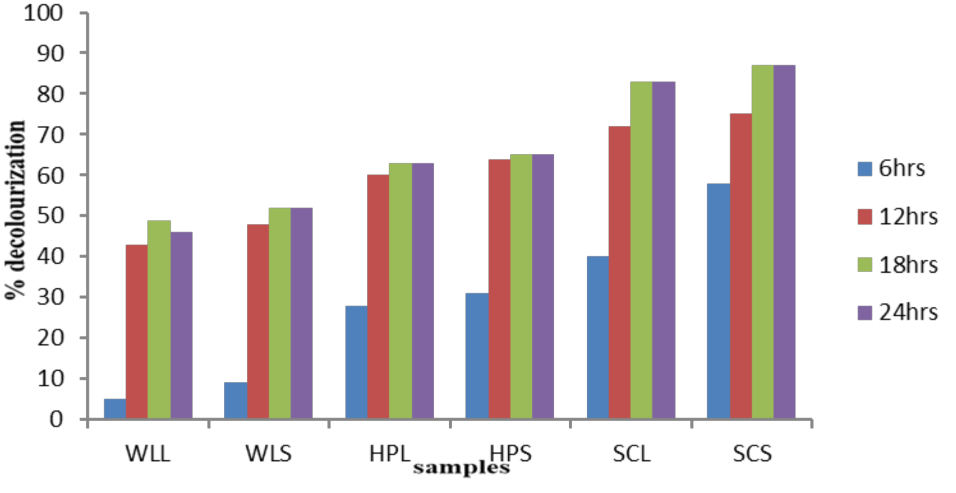

Figure1 . Effect of Contact Time on % Colour Removal at Constant Adsorbent Dosage of 2.5g.

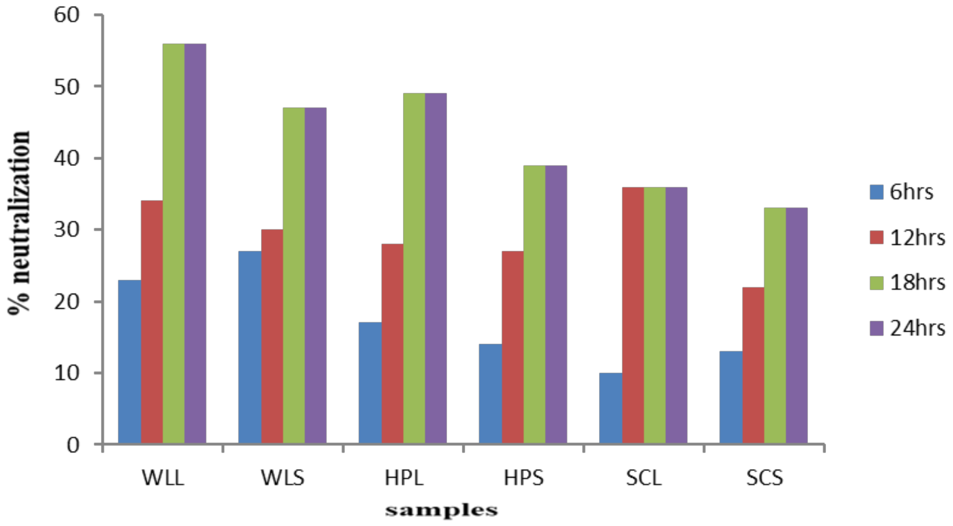

Figure 2. Effect of Contact Time on % pH neutralization at Constant Adsorbent Dosage of 2.5g.

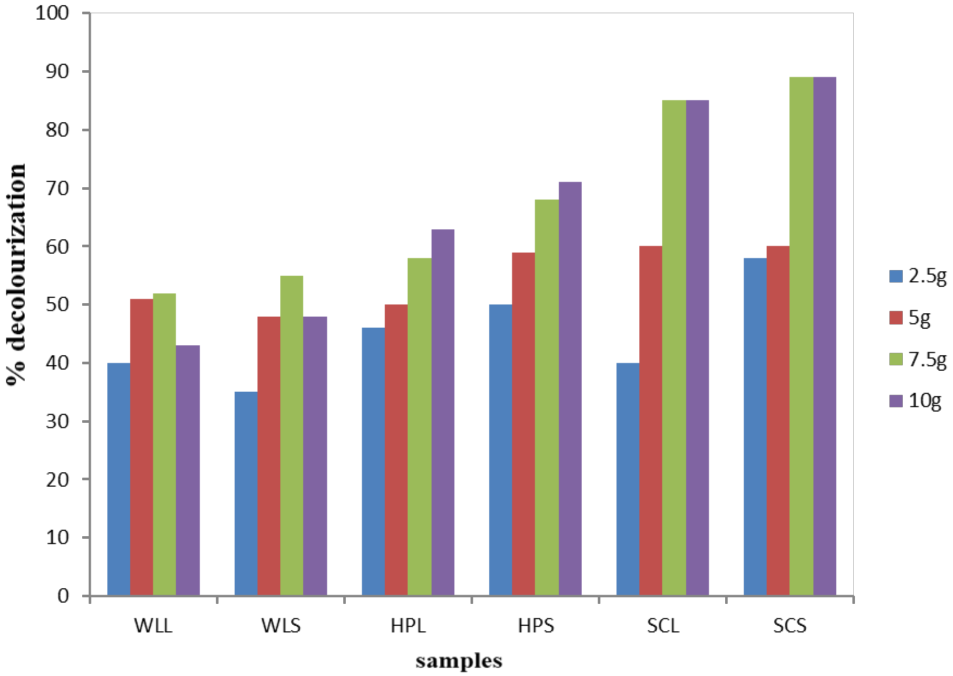

Figure 3. Effect of Adsorbent Dosage on % Colour removal at Optimum Contact Time

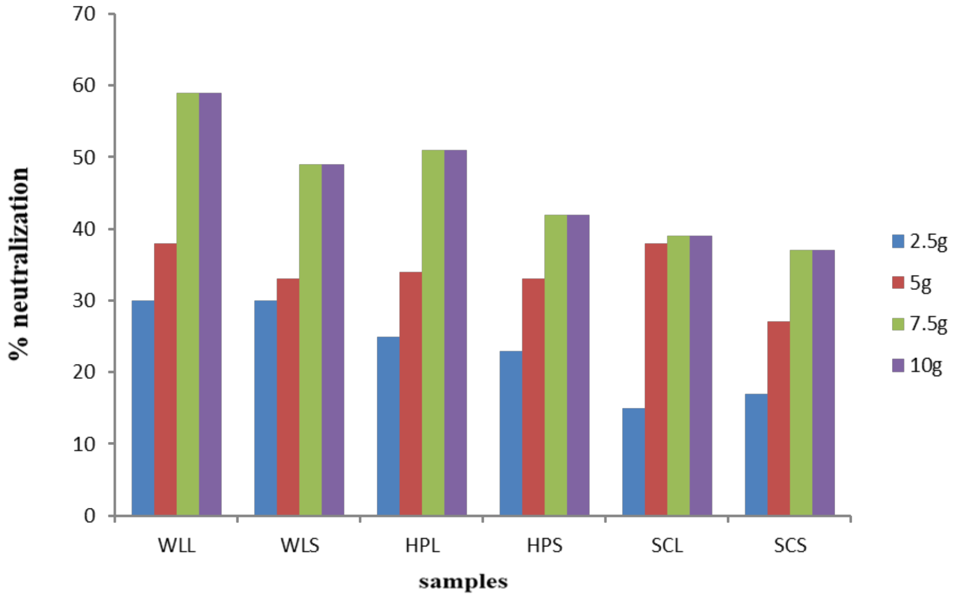

Figure 4. Effect of Adsorbent Dosage on % pH neutralization at Optimum Contact Time

4. DISCUSSION

4.1. Effect of Contact Time on Un-Powdered Adsorbents

Experimental investigations were conducted by changing the contact time from 24hours to 96hours with an increment of 24hours using both fresh and dried adsorbents at a constant adsorbent dosage of 10g to determine the optimum contact time. From the results obtained, Fig. 4.1.1 and 4.1.2 revealed that percentage decolourisation and neutralization are lower at the beginning of the experiment; this is probably due to insufficient contact time between the surface area of the adsorbents and the local dyeing effluent. However, as contact time is increased, the percentage decolourisation and neutralization also increased. Similar phenomenon was earlier reported by [10][16]. The maximum percentage decolourisation and neutralization of the local dyeing effluent by different adsorbents were obtained at optimum contact time of 48hours and 72hours.

4.2. Effect of Adsorbent Dosage on Un-Powdered Adsorbents

Experimental investigations were conducted by changing the adsorbent dosage from 10g to 25g with an increment of 5g using both the fresh and dried adsorbents at an optimum contact time. The results from fig. 4.1.5 and 4.1.6 revealed that the percentage decolourization and neutralization is low at the beginning by both the fresh and dried adsorbents, and then increases with increase in adsorbent dosage, after attaining equilibrium, no further adsorption were noticed. The increase in the amount of colour adsorbed and pH neutralizes was due to the increase in the available surface sites [8]. Adsorbent dosages were playing an important role on adsorption process, this is similar observation by [11-12]. The maximum percentage decolourization and neutralization of the local dyeing effluent by different adsorbents were obtained with adsorbent dosage of 15g and 20g. Dried adsorbents were observed to perform better than the fresh adsorbents in deolourizing and neutralizing the local dyeing effluent; this is because the dried adsorbents have high affinity to the dyeing effluent than the fresh adsorbents, similar observation reported by[8]. Effect of particle size was studied on powdering the dried plants parts.

4.3. Effect of Contact Time on Powdered Adsorbents

The effect of contact time on decolourization and neutralization of the local dyeing effluent was determined by changing the contact time from (6hours, 12hours, 18hours and 24hours). From the experimental results obtained in fig. 1 and 2, the effect of contact time on the percentage decolourisation and neutralization of the local dyeing effluent indicates that contact time played an important role in the adsorption process which made the adsorption of colour and neutralization to increase with increase in contact time [10].

4.4. Effect of Adsorbent Dosage on Powdered Adsorbents

The experiments were conducted to check the effect of adsorbent dosage on the adsorption process by varying the mass of adsorbent (2.5grams, 5grams, 7.5grams and 10grams). The results from fig. 3 and 4 clearly indicates the effect of adsorbent dosage on the percentage decolourization and neutralization of the local dyeing effluent by different adsorbents, the results showed that the percentage decolourisation and neutralization of the local dyeing effluent is low by different adsorbents at lower adsorbent dosage, then increases with increase in adsorbent dosage, this is because the adsorption sites of the adsorbents increases with increase in adsorbent dosage [13]. Lower decolourization and neutralization with adsorbent dosage of 10g might be due to aggregation of the adsorbents at high dose which leads to the blockage of binding sites on the surface of the adsorbent, Similar results have been reported by [18][15]. From the experimental results all the plants can be used for decolourization and neutralization, the results showed that the powdered form of the adsorbents had been proven to have better performance in terms of decolourization and neutralization. This is due to adsorption is proportional to the available surface area within pores that are accessible to the adsorbate [16]

4.5. Mean and Interaction Effect of Contact Time and Adsorbent Dosage

Figure 4 (a & b) showed the mean and interaction plot respectively. Minitab software was used to investigate the mean effect of each parameter graphically. It can be seen that increase in each of the contact time or dosage of the adsorbent the percentage decolourization increases similar phenomenon was observed using the neutralization data. The interaction plot also obtained by Minitab version 17 showed that highest absorption efficiency is obtained by increasing both parameters at the same time. Thus each parameter is affected by the other.

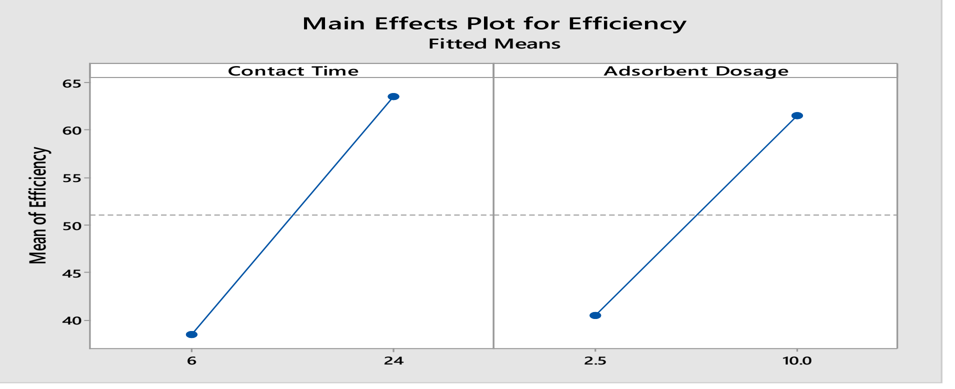

Figure 4.a Mean Effect of Contact Time and Adsorbent Dosage. @minitab 17 software

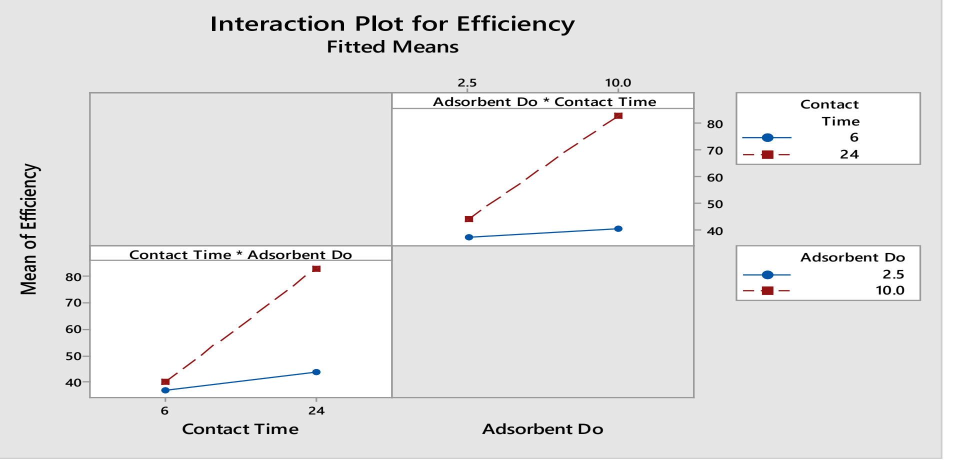

Figure 4.b Interaction Effect between Contact Time and Adsorbent Dosage @minitab 17 software

5. CONCLUSION AND RECOOMMENDATION

5.1. Conclusion

In the present study, the batch adsorption study was conducted to find out suitability of bio-adsorbents for decolourisation and neutralization of the local dyeing effluent, the study showed that, aquatic plants used are essential agricultural by- products for the decoulorizing and neutralizing the local dyeing effluent, with high percentage decoulorization by SCS (89%), SCL (85%), HPS (71%), HPL (63%), WLS (48%) and WLL (43%) powdered and (34%), (36%), (32%), (31%) un-powdered respectively. While high percentage of neutralization was obtained by WLL (59%) (Powdered), HPL (51%) (Powdered), HPS (49%), (42%) (Powdered and un-powdered) and SCL (39%) (Powdered), SCS (37%) (Un-powdered). Experimental investigations were conducted by changing the adsorbent dosage from 10g to 25g (un-powdered) and 2.5g to 10g (powdered) with an increment of 5g (un-powdered) and 2.5g (powdered) for different adsorbents, against different contact time from 1 day to 4 days (un-powdered) and 6hours to 24hours (powdered) with an increment of 1 day (un-powdered) and 6hours (powdered). The adsorption was also found to increases with increase in adsorbent dosage and contact time.

The maximum percentage decoulorization and neutralization of the local dyeing effluent by different adsorbents (un-powdered) were obtained at an optimum contact time of 48hours and 72hours with optimum adsorbent dosage of 15g and 20g. For the powdered adsorbents they were obtained at an optimum contact time of 12hours and 18hours with optimum adsorbent dosage of 5g and 7.5g. In this research, cost effective and environment friendly adsorbents were used for removing colour and pH from the local dyeing effluent. As a result, dyeing wastewater could be managed properly saving our environment in one hand; on the other hand, useless material (adsorbents) can be converted into usable resources.

5.2 Recommendation

I recommend that after adsorption, the poisonous adsorbents should be employed in bio-gas generation by anaerobic digestion instead of dumping them.

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CHAPTER 15

Zero Waste, Recycling and Waste Management

RECOVERY OF ENDUSTRIAL WASTES FROM THE PRODUCTION OF PORCELAIN TABLEWARE

Ozlem Ozcan Durdag[1*], Dilek Yasar[1], Baris Celtikci[1], Alpagut Kara[1]

ABSTRACT

Fine Porcelain belongs to the vitreous porcelain group called “Vitreous China”. In general, the production of these porcelains uses clay, kaolen, quartz and feldspat raw materials. While it is aimed that the amount of waste generated from these raw materials during the production processes does not exceed 3% of the total production, many studies were started on the ability to recycle all waste created for a sustainable world. In this study, industrial treatment wastes were recycled and turned into a product. In addition to providing the physical and mechanical properties expected from vitreous china products, the shapeability of the product is also provided. The biggest limitation of this study is that industrial wastes do not have a continuous standard chemical analysis due to coming from different production points and the chemicals used in settling pools create shaping constraints. For this reason, in this study, it has been studied on the complete use of industrial waste cakes with additives that will provide the process conditions and minimum TSE10850:2021 properties of vitreous china in the final product and stoneaware product output has been obtained.

Keywords: Sustainability, Vitreous China, Recycling

[1] Bonna Porcelain , Bilecik, Türkiye

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1. INTRODUCTION

Fine porcelain products are products with very low water absorption, hygienic use, semi-transparent and high impact resistance. To ensure this durable structure, a hard, non-porous type of porcelain, “vitreous china” composition is used. Its general composition includes 17-31% quartz, 15-23% feldspar or other fluxes, 20-28% clay and 25-35% kaolin by weight. According to TS 10850 standards, porcelain is required to have a water absorption of less than 0.3%, an impact strength of 0.22 N.m, and a thermal shock resistance of more than 150 °C [1].

Significant amounts of cake material and baked ceramic material waste occur due to the imperfections that occur during the porcelain production processes. These wastes can cause adverse effects such as storage and environmental pollution. In our country, as of 2022, a minimum production of 192 tons is carried out with a capacity of 480 million parts. An optimistic estimation, if 5% of them are assumed to be defective, approximately 9600 tons of ceramic waste is generated per year. To save on natural raw materials used in production, to reduce production costs and for a more environmentally friendly policy, the recycling and reuse of porcelain waste as raw materials carries great environmental and economic added value. There are many studies in the literature about the use of industrial waste in the ceramic industry. Use of fly ash from thermal power plants [2], the use of waste such as granite, marble and quartz that are released during natural stone production [3] and in addition, reuse of fired defective vitrified products in the ceramic industry [5],[4] can be given as examples. The raw material waste produced in porcelain production can be grouped under three main topics.

- Slurry and glaze preparation processes
- Glazing processes
- Firing processes

2. MATERIAL AND METHODS

Clay and kaolin used in porcelain body formulation are supplied from Ukraine and feldspar is supplied by local suppliers. The raw material composition of the newly developed body composition is given in Table 1. The chemical analyzes of the raw materials and industrial waste used are shown in Table 2. Chemical analyzes were measured with the Rigaku brand ZSX Primus model XRF device by preparing the samples according to the appropriate method.

The solids obtained in the industrial treatment facility are dehydrated using a filter press to create the waste cake. The improved body composition has been prepared considering that the wastes to be recycled will occur in different periods and there will be no stability in the chemical composition of the waste cake.

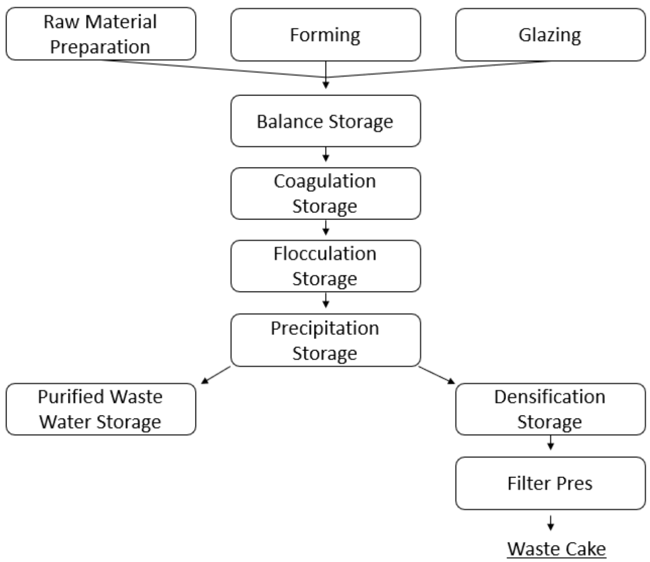

Figure 1. Waste water treatment plant flow chart

Table 1. Raw material composition of the waste body.

Raw Material	Amount (%)
Quartz	5-7
Alumina	5-10
Kaoline	15-25
Clay	5-10
Industrial Waste	40-50

Table 2. Analysis results of raw materials.

Raw Material	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	ZnO	A.Z.
Quartz	99,20	0,50	0,03	0,02	0,02	0,02	0,10	0,02	0,00	0,15
Alumina	0,03	99,60	0,03	0,00	0,00	0,00	0,30	0,00	0,00	0,05
Kaoline-1	54,00	28,00	2,60	1,15	0,45	0,60	0,60	2,25	0,00	10,00
Clay	63,50	23,50	2,45	1,20	0,20	0,55	0,05	2,25	0,00	7,50
Industrial Waste	54,60	23,20	0,45	0,22	5,85	1,12	3,58	1,47	1,05	8,42

The developed body composition was homogenized by mixing for 2 hours in a laboratory type mixer according to the raw material percentages given in Table 1, then taken out of water and plasticity tested using the Pfefferkorn device. Some of them were dried in the FN 500 oven at 110 °C and the dried powder was sieved through a 1 mm sieve and moistened with 3%. Rectangular samples (100x50x10) were shaped by compression pressure of 270 kg/cm^2 in a laboratory type Gabbrielli Press 30T. The prepared samples were fired in Bonna Porcelain firing ovens at 1230°C for 360 minutes. The results of the developed waste structure are shown in Table 3.

3.RESULT AND DISCUSSION

TSE 10850 test results of the developed waste structure are shown in Table 3. The general acceptance for Stoneware products is that these products may have water absorption values of up to 2% [6]. It is seen that this value is 0.15% in the body where we use our wastes. As be seen, the total shrinkage values are equivalent to our standard values and make production possible with our existing molds. The determination of plasticity and kneading water investigates the suitability of products for the shaping management, which is referred to as plastic forming [7]. According to this method, the plasticity and kneading water data obtained from the prescription for the constitution prepared with waste can remain within the limits of which the shaping can be performed.

Table 3. Some physical properties of a new waste body recipe and STD body.

Property	Waste Body	STD Body
Water Absorption (%)	0,05	0,02
Total Shrinkage (%)	10,95	10,54
Deformation (mm)	58-60	58-60
Thermal Shock Resistance (°C)	180	210
Crack Resistance (N.m)	0,34	0,37
Plasticity	32,95	32,41
Kneading Water	31,25	31,85

4. CONCLUSION

The product family, which provides 100% of the technical specifications for the tableware horeca sector, has been provided with the ability to recycle 600 tons of waste. The Prints collection, developed with this body, was launched in cooperation with WWF-Turkey. This collection was drawn attention to to the fact that wildlife is in danger.

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ZERO WASTE MANAGEMENT IN UNIVERSITIES

Mesut Tekbaş[1*], Nihal Bektaş[2]

ABSTRACT

Rapidly developing technology and new consumption habits can cause the differentiation and increase in the amount of waste produced. Many studies on waste management in our country in recent years adopt the management of recyclable wastes in a way that will contribute to the national economy. At the same time, ensuring the proper disposal of non-recoverable wastes is another issue that needs attention. Considering the diversity of wastes and the density of recyclable wastes, it is very important to manage and control the wastes generated in universities.

The subject of waste management and zero waste is carried out in our country within the framework of the legislation enacted by the Ministry of Environment, Urbanization and Climate Change. Our university works with the goal of zero waste philosophy, which adopts the idea of explaining waste management to people not only with legal regulations, but also with a waste management philosophy. Zero waste is a target defined as a waste management philosophy that includes preventing waste, using resources more efficiently, preventing or minimizing waste generation by reviewing the causes of waste generation, and collecting and recycling waste separately at the source in case it occurs. In our university; waste management and control of waste management is done by the waste management unit of Gebze Technical University. In this study, studies carried out within the scope of waste management and zero waste at Gebze Technical University will be presented.

Keywords: Zero Waste, Waste Management

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1. INTRODUCTION

Waste management is an essential step of the circular economy[1]. Waste management: It is based on a closed-loop system intended to prevent resource depletion and reduce the impact of waste generated by the linear economy model [2]after USA, with 1.5 million tones generated annually. However, the absence of adequate system for e-waste reverse logistics are a reality in most of the Brazilian cities. Concerning this hypothesis, we proposed a scenario analysis to support decision-making in e-waste management. This study analyzed the e-waste amount generation, the location of the recycling companies of this segment and the collection routes in the metropolitan region of Rio de Janeiro (MRRJ Therefore, environmental policies come to the fore in our world. Environmental pollution and, accordingly, climate change are becoming more important day by day and people's awareness is increasing. In this context, many environmental policy statements such as the World Conservation Strategy and agenda 21 [3] have been created in the last forty years. It has been emphasized that education has a critical importance in environmental attitudes, social understanding and action, which are believed to be essential to take part in change and influence the masses [4], [5].

Environmental pollution and sustainability education were first seen on the international programs at the Human Environment Conference in Stockholm, Switzerland in 1992. Now, the acceptance of the concepts of environment and sustainability has started to take place in the management and events of universities with the growing population.

In many declarations on environment and sustainability, such as the Kyoto Declaration (1993), the special significance of universities in stimulating sustainable development has been emphasized. As environmental and sustainability policies, it is desired to encourage environmental courses on the academic programs of many universities in the world and to include environmental concepts in the course content more broadly. It can be achieved with an environmental management system approach for the implementation of environmental policies in a beneficial way in universities. The establishment and implementation of these policies requires the commitment of top management. Frameworks should be determined for the implementation of environmental policies in universities and can be achieved by acting according to environmental management system (EMS) approaches.

In this study, how the zero-waste project was implemented at Gebze Technical University, and what difficulties were encountered, the meaning of the zero-waste approach today, in the context of circular and linear economy and zero waste hierarchy are deeply discussed.

2. ZERO-WASTE APPROACH

The zero-waste action is a project initiated by the Ministry of Environment, Urbanization and Climate Change in order to ensure that the waste issue is a problem in the world and in our country, waste causes waste and our resources are depleted, and the concepts of recycling, recovery and reuse, which are missing in the society, find a place in the society (Figure 1). In the zero-waste linear economy model, universities, as well as all education units, have important duties in terms of turning waste into a value-added product and turning to zero waste approach and transferring it to future generations. The driving force that motivates societies to move towards zero waste is the environmental problems and solution proposals that have begun to make their effects felt since the second half of the 20th century.

T.C.
KOCAELİ VALİLİĞİ
Çevre ve Şehircilik İl Müdürlüğü

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Figure 1. Basic level zero waste certificate

In the management of waste, first of all, a waste management plan should be created in order to evaluate the current situation, define the objectives to be achieved, formulate appropriate strategies and determine the necessary implementation tools. In the design of the waste management plan, it is necessary to consider criteria such as equipment, human resources and budget, as well as different stages in waste management such as separation, collection, transportation, storage, treatment, destination. These requirements will be a guiding map during the design process and how the plan will be implemented, monitored and reviewed. In the context of universities, the steps in the waste management plan can represent several challenges and opportunities for the environmental management team [6].

3. WASTE MANAGEMENT IN UNIVERSITIES

Environmental management in our country comes to the force with the zero-waste project of the Ministry of Environment, Urbanization and Climate Change. Waste management units and/or environmental commissions of the universities in our country were started to be established with the zero-waste project, primarily in the public sector.

The establishment of these units enabled the increase in the corporate culture, the single management of all the wastes of the school and the creation of waste management plans. These units are responsible to the rector, who is the first-degree school's civil chief. The steps included in the directive issued by the zero-waste project for educational institutions such as educational institutions proceed under the coordination of the environmental management unit, and if deemed appropriate after the inspections, a basic level zero waste certificate is obtained from the local directorates.

In terms of environmental management, the most important parts of our country's universities in terms of waste management are finance and personal resistance. Zero waste approach can be defined as the recycling of packaging waste from our universities, the conversion of organic wastes into value-added products, and the management of all other hazardous and non-hazardous wastes. The main difficulties experienced financially in the management of zero waste and hazardous wastes from laboratories and medical waste are to buy plastic materials such as bins, open or closed IBCs, which are consumable items. Another problem is the inability to make appropriate packaging because laboratories or departments cannot generate finance for these materials [7].

Many different factors can cause universities to slow things down financially such as not to have a budget under the name of waste management. The activities related to zero-waste activities, e.g. providing of zero waste bins, printing of brochures, construction of temporary waste sites, establishment of 3rd class waste collection centres are becoming difficult to task to do. The basic solution of this problem can be solved by allocation of budget from the central government budget each year.

4. WASTE MANAGEMENT IN GEBZE TECHNİCAL UNIVERSITY

Gebze Technical University is a university with 8312 students and 800 academic and administrative staff in 64 buildings in Çayırova Campus, Gebze, Kocaeli (Figure2). In addition, GTU Technopark is also included in our system. Gebze Technical University, like other universities in our country, carries out education, training and R&D activities for the development, dissemination and sustainability of knowledge. Gebze Technical University started to manage the hazardous wastes originating from its laboratories in the early 2000s. At the beginning of the administration, waste management was implemented within the framework of laws and regulations, and problems were experienced from time to time regarding the functioning and continuity of the system. The work of managing the waste generated at the university started as of 2015 and a waste management commission was established to cover all departments. As of 2020, the environmental management unit has been established at the university.

Figure 2. Gebze Technical University (www.gtu.edu.tr)

In our country, the legislation on waste management and zero waste practices is carried out by the regulations created by the Ministry of Environment, Urbanization and Climate Change within the framework of the Environment Law. Waste Management Regulation, which came into force by being published in the Official Gazette dated 02.04.2015 and numbered 29314. It aims to determine the general procedures and principles regarding the:

a) Ensuring the proper management of solid waste from generation to disposal without harming the environment and human health,

b) Reducing the use of natural resources and ensuring waste management through ways such as reducing waste generation, reuse, recycling and recovery of waste,

c) Production of products within the scope of this Regulation, which have certain criteria, basic conditions and characteristics in terms of environment and human health, and market surveillance and inspection,

In this context, various studies are carried out at our university to collect wastes primarily at the source, on the basis of classification and collection of different types of wastes at their source/where they are produced, without mixing with other wastes.

University's waste management program was divided into two division:

1) Management of hazardous wastes

2) Municipal solid waste management according to the scope of Zero-Waste Regulation.

Hazardous wastes from university laboratories are kept in closed areas in accordance with the legislation by the designated waste responsible, and then regularly transported to hazardous waste disposal companies by hazardous waste transportation vehicles. In addition, trainings given to waste managers; These are important trainings to warn students and employees about the management of hazardous wastes and to raise awareness of proper management (Figure 3).

Figure 3. Training for students and staff

As already mentioned before, Universities are obliged to obtain a basic level zero waste certificate according to Zero Waste Regulation. In order to obtain this document following road map was created:

a) Determination of the Working Team: Working teams are formed with the responsible person or persons who will follow the process from the establishment of the zero-waste management system to its implementation and monitoring.

b) Planning: In order to configure the zero-waste management system to be implemented in the most effective way, a planning is made regarding the things to be done before the implementation. In this context:

1) Current Situation Determination: The current situation is determined regarding the source, type, amount of all wastes, waste collection, collection and transportation methods, temporary storage areas, places where the wastes are delivered.
2) Needs Analysis: Collection equipment and temporary storage area needs are determined for the wastes to be collected separately.

c) Training/Awareness, Raising Activities and Implementation: Training/awareness-raising activities are carried out to increase awareness and the system is started to be implemented.

d) Monitoring, Record Keeping and Improvement Activities: Monitoring studies are carried out on the implementation of the implementation at regular intervals. Measures are taken for the issues that fail, and updates are made if necessary. The outputs related to the application such as the amount of separately collected waste and the gains obtained are recorded. It is in the form[8].

The Waste Management Unit, which was established by forming a working team within the university, determined each building responsible and provided training on Zero Waste. Areas where zero waste bins can be placed in the buildings were determined and placed in the buildings. Then, monitoring and follow-up processes are carried out with the Zero Waste Information system. An example of collection boxes made according to the zero waste regulation is shown in Figure 4.

Figure 4. Example of collection bins made according to zero-waste regulation.

CONCLUSION

Gebze Technical University has established the waste management system required by the legislation. The problems we have faced during to installation of the system given as follows:

1) Lack of sufficient knowledge about waste management, resistance of practitioners,

2) Lack of belief in the subject
3) Students do not pay particular attention to zero waste categories,
4) In the management of hazardous wastes, due to the fact that the waiting periods in the temporary waste storage area are the same as the production facilities in the legislation, sufficient amount of waste is not generated,
5) Due to the rapid development of the university, the problems experienced in the inclusion of previously unplanned areas into the system
6) Financial problems have arisen due to the fact that universities cannot have a budget related to this issue.

These problems can be solved as follows:

1) Providing trainings will regularly increase the faith of the practitioners, and good practice examples may prevent the practitioners from resisting. The trainings to be made should also be planned as trainings to increase the zero waste awareness of the students. It would be beneficial for student societies such as environment and sustainability clubs and their peers to increase their awareness on this issue.
2) Waste management legislation for universities should be different from the general regulations.
3) Having a waste management budget in the annual budget item transferred to universities will eliminate the financial problems of waste management in universities and ensure a sustainable waste management.

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THE IMPORTANCE OF NUTRIENT RECOVERY FROM WASTE IN CLIMATE CHANGE ADAPTATION AND THE CIRCULAR ECONOMY MODEL

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ABSTRACT

The biosphere supports a complex but recoverable system in nature for the sustainability of all living things in their basic habitat. Access to clean air, clean water, food, and environmentally safe living spaces is the most fundamental right of every living thing. However, the population growth of human beings makes natural ecosystems vulnerable due to various ecological dynamics such as migration and competition and creates inefficient by-products in the form of waste behind it. Besides these; the Consumption of carbon-based natural resources, climate change and inefficient use of resources, and unsustainable agriculture and food productivity is the main challenges humanity is currently facing. In the face of these challenges, the natural ecosystems of the Biosphere become vulnerable, and there is a need for ecological designs that can cope with the problems of urbanization and industrialization sustainably and effectively. At this point, waste-fed refinement systems should be developed, and maximum efficiency and zero waste philosophy should be created by ensuring cyclicity within the system. Food recycling is a promising strategy for reducing the environmental impact of depletion of non-renewable resources and the production of these resources. Such systems would have the potential to mitigate climate change. At the same time, with the strong aspects that can strengthen the global economy, adaptation to the circular economy model will be achieved. In this study, the cyclicity, climate change, and environmental impact of nutrient recovery from nutrient-rich wastes will be examined by establishing the Environment-Agriculture-Food connection as a nature-based solution.

Keywords: Climate Change, Nutrient Recovery, Circular Economy

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1. INTRODUCTION

From the existence of the world to this time, there have been different geological periods in which the climate has changed over time, where extreme climatic conditions have been experienced. During the Holocene, environmental changes remained constant and self-renewed with interdependent natural systems. However, by laying the foundations of modern life, the Anthropocene period started with the industrial revolution and climate change changed as a result of human activities [1].

With the linear economy model, although the raw materials were limited, it progressed in the form of build-use-throw. With this economy model, the innovation approach was used as a production tool to create economic value instead of reducing the impact of the industry on the biosphere and drawing attention to sustainability. Thus, no innovation in manufacturing focused on being environmentally friendly or sustainable [2].

With the linear model adopted by the countries of the world, the waste flow resulting from production and human activities and the dependence on fossil fuels, the climate is changing and the natural regulatory capacity of the environment is currently being exceeded [1]. Moreover, it is known that the linear economy model is responsible for the climate crisis. The global outcome of this economic model and the resource utilization index are parallel to each other.

While the linear economy model of the adopter focuses on eliminating wastes that pose a risk to the environment; The circular economy model aims to minimize the effects of climate change as well as providing economic benefits by recovering valuable resources from waste. It is necessary to switch to new technologies that focus on the reduction and/or recovery of pollutants within the framework of circular economy principles of waste and wastewater generated as a result of production activities [3].

With the increasing popularity of the circular economy model, it is aimed to switch to a new economy model order, where waste/waste water can be included in production, new product production and valuable resources will be recovered [4].

In this context, the reuse of high amounts of recyclable resources contained in waste and wastewater in the economy is a circular economy model. In this way, waste/wastewater will not be considered a waste but a source of nutrients such as recovered water, energy, nitrogen and phosphorus [5].

Nutrient recovery from waste/wastewater is important for the circular economy model and climate change. As a result of various production and uses, most of the nitrogen (N) and phosphorus (P) reaches the receiving environments. Excessive accumulation of N and P in receptive environments causes anoxia and eutrophication. Currently, methods of physical, chemical and biological recovery of N and P from waste/wastewater are being investigated.

Nutrient recovery from waste should be integrated into industrial production facilities, wastewater treatment plants and many production sites. Because N and P recovery from wastes will not only prevent eutrophication but also create a circular economy-based development model. In this way, clean production and resource recovery can be achieved by switching to a production system where there is no waste. In addition, recovery of nutrients from waste is a safe natural capital, and adaptation to climate change will be strengthened by reintroducing them into the biosphere. In this study, the role of climate change adaptation and circular economy model in the recovery of N and P from wastes has been discussed and a new perspective has been given to the model.

2. THE ROLE OF N AND P NUTRİENTS İN THE CİRCULAR ECONOMY AND CLİMATE CHANGE

When N and P are released into nature after anthropogenic activities, their reactive forms are changed [1]. As a result of agricultural production, intensive use of fertilizers and high N and P binding capacities of cereal crops, they have negative contributions to natural environments. It is recovered by converting the N2 gas released after production into N-reactive forms with combined tertiary processes. However, this is only a quarter of the N2 gas released into the atmosphere, that is, 35 million tons are recovered annually. As is known, N2 gas released into the atmosphere is a polluting parameter in the air and is effective in global warming. Unlike N, the P nutrient is obtained from phosphate rock mining. About 20 million tons of P are mined each year and used in a wide variety of applications. Since phosphorus resources are limited and non-renewable, it is predicted that they will be depleted in the next 60-80 years. Phosphorus is an essential nutrient for all living organisms and has an irreplaceable role in agriculture and industrial production [6]. The depletion and non-renewal of mineral resource reserves for the production of phosphorus create difficulties in meeting the increasing P requirement [6,7]. As a matter of fact, P was included in the European Union Critical Raw Materials list in 2017 due to its supply risk and economic importance. Phosphorus (P), which is an essential nutrient for all organisms, needs to be recovered urgently due to the increasing demand for natural resources, climate change and uncontrolled use and resource scarcity.

In this context, for the sustainability of P resources, P recovery from wastes with sustainable raw material potential is among the remarkable issues in recent years [8–10] Another reason for giving importance to the recovery of P is its use as a fertilizer in agriculture. This situation indicates that the demand for food will not be met in the coming years due to the decrease in agricultural production efficiency. When restriction of P limits food production; Global famine creates a risk for countries whose economy depends on agriculture. While looking for an alternative solution for all this P shortage, developing eco-friendly approaches instead of chemical fertilizers that we are currently dependent on is related to combating climate change.

3. CONCLUSION

Globally increasing population and rapid development of technology create the need for especially food demand, energy and efficient waste management. While the food demand of the increasing population points to the sustainability of agricultural production, recycling activity, which is the step of effective waste management, is required so that the wastes from industrial productions and daily life activities do not pose an environmental problem.

With nutrient recovery;

- To meet the waste nutrient levels required by the legislation,
- reduce eutrophication problems and

- To provide a potential fertilizer with agricultural and economic value,
- reduce dependence on inorganic fertilizers from phosphate rocks

An overview of nutrient recovery processes in the circular economy perspective reveals the existence of considerable potential for nutrient recycling. However, there is no single optimal technological solution for all situations. Moreover, while recovered nutrients can improve the economics of these processes, government policies and regulations must also take care of the environment when there are insufficient economic incentives or social awareness for nutrient recovery. A new level of policy coherence is needed in this area. In addition, nutrient recovery is an issue that should be included in climate change policies and given priority.

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ANALYSIS OF THE DESIGN'S ROLE FOR ZERO WASTE IN THE CASE OF PRODUCT DESIGN EXAMPLES

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ABSTRACT

The world has faced with the waste problem in the last decades. Especially environmental issues and the risk on the life of species are main problems occurring due to this waste. People mostly ignore these issues, and they prefer the products that are easy for them. Besides these people, there is an increasing group that are interested in waste reduction and zero waste which is the term used recently much more. Even zero waste has 'zero', the term has five levels to achieve that. There are products that can not be refused in daily life, it is possible to reduce them or to find alternatives. While consuming, environmentally friendly products have begun to increase in markets and preferred by people concerning the world. On the other hand, there are other roles to create these 'zero waste' products. In the last decades, designers are seen as responsible for consumption, and they have a new role for a sustainable world. Many designers and producers have focused on creating products called green, sustainable etc to reduce plastic consumption and provide reachable alternatives for them. The aim of this study is to discuss the roles of product designers for zero waste and to show that there are possibilities for the consumption via mentioning the existing products designed. For this study, literature review is used to see the connection between designers and zero waste, also the sustainable world and the products designed for this reason. The data collected from literature has been analyzed and discussed.

Keywords: Zero Waste, Industrial Design, Sustainability

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1. INTRODUCTION

After industrial revolution, people faced with increase of population, urbanization and also increase of the cheaper serial production by using huge of raw materials, natural resources and energy [1,2]. Consumption culture that accompanies this industrialization and urbanization created a community that prefers cheap single use products that make easier their life and throw them away [1]. Then, the increase of waste concept has become inevitable. Also, creating too much waste has brought the use of natural resources intensely and the thread of their extinction [2]. The extraction and process of natural resources need energy and during all these processes too much waste occur, sand and water pollution causes the harm of ecosystem, generates CO2 and other gas emissions that cause the increase of global warming [3]. To decrease the damage on the earth, the concept of waste began to be discussed and many professions have started to bring this issue to their agenda and made it a part of their practices. In this paper, design and the role of the designer on zero waste are discussed. Then, inferences were made by examining the design examples on zero waste.

2. ZERO WASTE

Waste can be defined as anything that is not needed anymore, that is wanted to dispose of [4, 5]. It is supposed valueless and inevitable to be created when the product's life phase finishes [6]. The increase of cost of waste storage, environmental controls force communities, manufacturers and governments to examine the management systems. Unsustainability of waste creation, disposal and the need of the applications of sustainable development's ecologic dimension, the strategies of waste reduction have generated [7]. As a result of these issues and environmental problems like global warming and depletion of resources, waste has begun to be defined as a valuable resource that needs to be collected, dissociated, managed and recycled [2].

On the other hand, zero waste has a challenge against waste assumption and looks for the way to use this "waste" [6]. Zero waste is a design philosophy that lies on the elimination and reduction of waste at source during all processes to prevent the negative effects of the burn or storage of waste instead of waste management [8]. For the zero waste, waste means a resource recirculated within the system unlike the traditional waste management [6].

UNEA also defines Zero Waste concept as a solution for the solid waste issues [9]. In this concept, the resource supply is reshaped, and products and materials are recycled or reused [10]. Before zero waste, wastes were disposed by burning or stored. Burning the waste causes gas emissions while decreasing the waste. Storage also has disadvantages about the mixing of leachate from wastes to soil and water [11].

According to Murray [12], there are three reasons of zero waste to come to fore: increase of the concern of disposal of waste, increase of ecologic concerns about the global environmental problems like global warming and depletion of natural resources, new opportunities technological progress created for waste management. For zero waste approach, a categorization called 5R can be mentioned to define consumers' behavior [13]. Refuse, Reduce, Reuse, Recycle and Rot called as Zero Waste Hierarchy. To achieve the ideal zero waste, a hierarchy guides to know the most preferred method is shown on the top and the least preferred method is shown at the bottom [14]. While Refuse is about denying things that people don't need, reduce defines the reduction of things that cannot be refused. Reuse, the third step of the hierarchy, is the usage of products in a new way, choice of the new life of things. Recycle means the return of the material to a new material. Rot means compost of organic waste [3, 13, 15].

3.DESIGN'S AND DESIGNERS' ROLE

Every day, many materials including clothes, food, any goods are packaged and consumed and due to them, too much waste generates and collected by trucks to take to the waste stations. Finally whole process results in pollution and the decrease of quality of life. But design transform this system, and these materials can be seen as resource instead of discarding [16].

Due to that environmental effects are related to materials and energy flows which are connected to products, it seems urgent that manufacturers should include products and product development in their management systems [17]. In the 90s, interest in the environmental issues grew and it was started to be one of drivers to redesign existing products and also to create new products like decreasing material intensive or increasing the efficiency of energy [18]. On the other hand, the conscious of consumers about zero waste has increased and this topic has entered in their daily life. They have begun to follow sustainability and the community has started to be involved in a sustainable society rather than throwaway [3].

Even the zero waste has recycling and compost at the center, it has a bigger project and is more related to industrial redesign and it can be said that zero waste means a new way of seeing and analyzing the waste [19]. For zero waste, it is important to pay attention to products' whole lifecycles. There are reasons for products to return to waste like one-use products, being unfashionable, turning to outdated. And also, energy use of products is important to define their product lifetime. If the created products become durable, it provides the waste reduction due to using longer time and less consumption. The reduction of waste is related to lifespan expansion. If a product can be used for 10 years instead one year, waste generates 10 times less [10].

Producers make investments to produce products having short lifecycle, but to create more durable, they need to change their business models. On the other hand, that will affect the purchasing power of customers to get these products [10]. Producers' responsibility changed to decrease the waste through product and process innovation, waste is assumed to be the failure of industrial design and needs a different perspective [19].

Producers and industrial designers are staying more center about materials' technical and economic recyclability and to decrease the material use and production needs in the first hand [19]. Design has been one of the fields that has started to discuss the waste concept in the framework of sustainability [20]. Design concerns about the environmental issues and different fields generate in design literature and applications like green design, eco-design, sustainable design, ecological design [for ex; 20, 21, 22, 23]. Design can help people to change consumer behavior and as a result, people can reuse, reduce [16].

It is obvious that environmental issues have been the concern of the profession of industrial design [24]. Victor Papanek [25] who is a design educator created a challenge for designer to provide social ethics and environmental responsibility instead of unwarranted resource consumption and endurable products. After years, he found designers to be involved in useless, wasteful product creation, to be slaves of marketers' and advertisers' capricious works [26]. Papanek [26] found design profession as deformer and misinform instead of being reformer and informer those days. Besides that, designers should be seen a potential course to create solutions rather than being responsible for current unsustainability conditions [27]. In 2000s, Industrial Design Society of America [28], which is the organization with a huge member of designers, defined designers as creator of helpful solutions to reduce ecological problems, to provide people to be beneficial for environment and quality of human lives [28].At that time designers explained their profession that doesn't think apart the environment and follow the way of the sustainable development by the way of coordinating economy, culture, technology, environment that affect the sustainability 29]. According to Margolin [30], to overcome problems humankind face, industrial designers should review profession individually and also collectively.

Looking at the world, United Nations Sustainable Development Goals announced 17 goals for the world [31]. One of these goals is called 12 including Responsible Consumption and Production. World Design Organization, which is an international organization, related to profession of Industrial design accepts this goal as particularly relevant to the industrial design community [32]. When the problems of material and products' lifecycle are taken together with product design's function, opportunities generate for design innovation related to material productivity and zero waste [19].

4. DESIGNED FOR ZERO WASTE

These days, there are designers, manufacturers and brands focusing on zero waste to eliminate ecological problems and gain environment sensitive customers. Adidas, H&M, Fuji Xerox are brands using zero waste practices for their sustainability discourses and they have partnership with non-governmental organizations [6]. There are also some products designed especially for zero waste approach. In this section of the research, the eight products designed for zero waste and shared on the well-known websites which are related to industrial design will be shown.

Eco-Friendly Coffee Capsule

The eco-friendly coffee capsule machine uses coffee balls that can be turned into compost [[33] (Figure 1). This product was designed by CoffeeB and it's figured that coffee capsule machine since it's quick and easy to use but it's not the most environmentally friendly as the single-use coffee capsules are pretty wasteful and cannot be recycled or upcycled. And Swedish coffee brand designed eco-friendly single-serve Coffee Balls. It'd work similarly to the coffee pod machines but it has recyclable packaging and compostable capsules after use.

Figure 1. Eco-Friendly Coffee Capsule

Groundfridge

A sustainable underground fridge designed by Floris Schoonderbeek [34] (Figure 2). The trick used by Groundfridge is by utilizing the natural insulating capacity of the ground and the cooler night air temperatures. This design allows to store vegetables, fruits, cheese etc. throughout the year. Ventilating this project uses a fan with a timer that replenishes the cool air during the night. The Groundfridge is dug in and covered with the excavated soil. This covering layer of soil is about 1 meter thick and has good insulating properties for the core temperature within the Groundfridge to barely vary.

Figure 2. Groundfridge

Volta Zero

Volta Zero is Europe's first all-electric commercial cargo bus is manufacturer to have a proprietary e-axle electric drivetrain made from renewable biodegradable resins flax fibers [35] (Figure 3). Zero's body panels are crafted from renewable biodegradable resins and flax fibers to make it sustainable right from the manufacturing process to have a bigger impact. CEO of Volta Trucks Rob Fowler says that "Commercial vehicles form the lifeblood of commerce and livelihoods in cities, but today's large trucks dangerously impose themselves on our streets and dominate their surroundings. With the launch of Volta Zero, we are changing the face of road transport,"

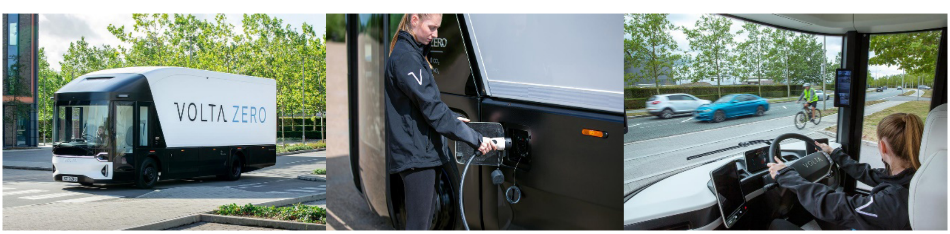

Figure 3. Volta Truck

Biodegradable Takeaway Containers

Biodegradable takeaway containers designed by PriestmanGoode are molded from recycled cocoa beans [36] (Figure 4). Created as a part of the Wallpaper Re-Made project, these bio-composite containers are modeled to look like bento-boxes with a modular design that stacks up as your order increases, resulting in one larger box rather than multiple smaller boxes. The bio-composite polymer used to mold the containers themselves are made from cocoa-bean shells.

Figure 4. Biodegradable Takeaway Containers

Bruto Seating

Bruto seating designed by 812 Creative Design. Bruto designed as an urban furniture and more than 40% of its composition is industrial waste [37] (Figure 5). By incorporating industrial waste into their work, the design studio hopes to encourage the creation and conscious consumption of products that are eco-friendly and sustainable. Not only are they using industrial waste to create the product, but they are also reducing manufacturing waste. By cutting it into a block, they're ensuring no material is going to waste, and all of it is used in its entirety.

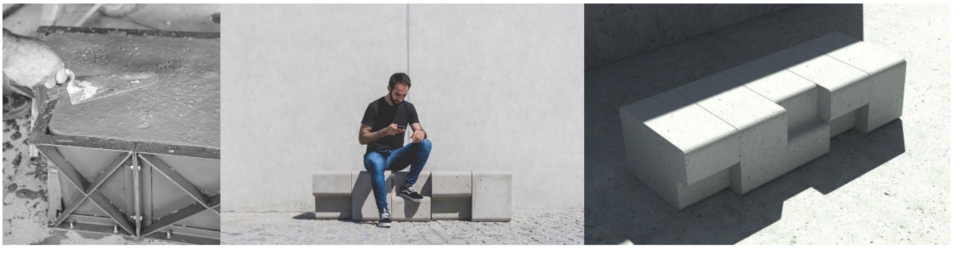

Figure 5. Bruto Seating

3D-Printed Street Furniture

Rotterdam-based research & design studio The New Raw has further expanded its 'print your city' initiative with the Zero Waste Lab in Thessaloniki, Greece [38] (Figure 6). The project invites citizens to bring their plastic household waste in the lab, design their own custom street furniture, and 3D-print it with the help of a robotic arm and on-site recycling facilities. Besides transforming waste into furniture, citizens can learn more about the recycling process of plastic, read about the circular economy, and design new items of furniture for their neighborhoods.

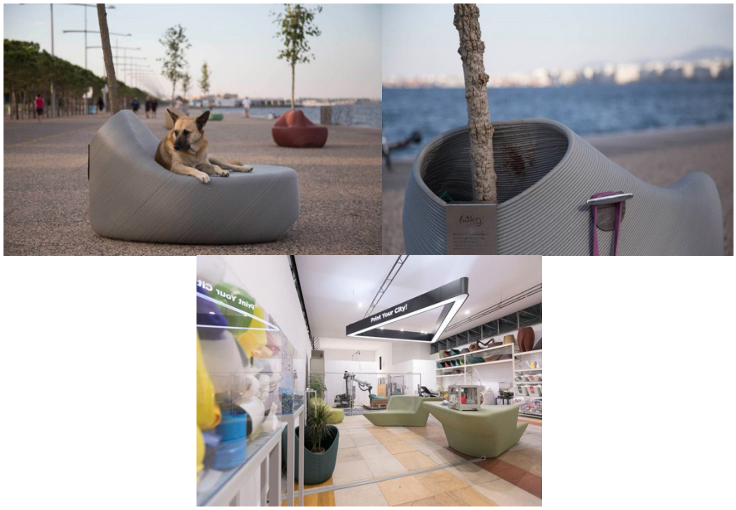

Figure 6. Print Your City

Plastic-Free Toothpaste

Canadian company ‘change toothpaste’ which is founded by Damien Vince and Mike Medicoff has created a zero-waste, plastic-free toothpaste and its packaging [39] (Figure 7). The plastic-free toothpaste contains mostly natural ingredients as well as some of the familiar elements found in traditional toothpaste like dicalcium phosphate and xylitol.

Figure 7. Change Toothpaste

Zero Waste Economical Chair

Zero Waste Economical Chair designed by Seungji Mun (Figure 8). The chair is produced from a single piece of international standard plywood with no scrap material. The simply shaped seats are created using plywood bending processes, allowing for inexpensive and low waste mass production [40].

Figure 8. Zero Waste Economical Chair

5. CONCLUSION

As it is seen that the zero-waste approach is accepted in the world context, it also gets importance in the design environment. According to designers, there are several levels of approaches to zero waste. While some design approaches have the motto of not generating waste in the entire life cycle of the products, on the other hand, the absence of material waste in the process of the production has been evaluated by different designers. Along with this, it is observed that products use clean energy sources and that the unused materials, which are considered as waste, are reused in the production process again. These approaches are handled at different stages, from the level of generating no waste to the level of evaluation of existing wastes. In particular, sustainability approaches and sensitive approaches to waste have begun to be adopted more and more in design circles.

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NEW DEVELOPPMENTS IN CARBON CAPTURE TECHNOLOGIES

Bahtiyar Öztürk[1*], Hülya Aykaç Özen[2], Sevtap Tırınk[3]

ABSTRACT

Global warming, climate change, extreme weather events, ocean warming, sea level rise, narrowing of the north pole and increase in the acidity of the oceans and seas as a result of the increase in atmospheric CO2 concentration due to human activities have become one of the most important problems that the world has to deal with in the 21st century. In this regard, carbon capture and storage (CCS) seems to be a promising technology in reducing atmospheric carbon dioxide concentration. There are three methods for CCS: pre-combustion capture, oxy-fuel process and post-combustion capture. Among them, post combustion capture technology is the most widely used technology today, due to its flexibility in application, easy installation in older plants, and lower initial investment and operating costs. Absorption, adsorption, cryogenic distillation and membrane separation can be applied as post-combustion carbon capture technologies. In this article, technologies used to reduce carbon emissions will be discussed comparatively.

Keywords: Carbon Capture, Pre-Combustion, Oxy-Combustion, Post-Combustion

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1. INTRODUCTION

From the first world climate conference held in Geneva in 1979 to the Climate change conference held in Glasgow in December 2021, many meetings were held on climate change in the world. These meetings have become the most widely attended conferences organized by the United Nations organization today. The main objectives of these conferences are: to draw attention to the changing climate, the consequences of climate change and human-induced factors that change the climate. In recent years, international meetings have focused on how to reduce carbon emissions, one of the most important factors causing climate change. Approximately 80% of the energy produced today is met by fossil fuels [1], and the energy sector accounts for 75% of CO_2 emissions [2]. It is considered that two important activities such as capturing the carbon dioxide at its source and utilizing renewable energy sources can be effective in reducing carbon emissions. But, over the longer term, carbon capture and storage (CCS) could be effective and beneficial to reduce emissions from its sources such as energyintensive industrial processes, natural gas cleanup, hydrogen production, fossil fuel refining, petrochemical industries, and steel and cement manufacturing. CCS consists of four successive phases. These are CO_2 capture, compression or liquefaction of CO_2, transport of compressed CO_2 to its storage location, and isolation of the storage location from the atmosphere (Figure 1). Technologies exist for the implementation of CCS, but today, especially the high cost of carbon capture and the uncertainty about how long the stored carbon can remain stable are the most important factors limiting the application of this process. Although the separation of carbon from the gas mixture by absorption has been used for a long time, especially in the natural gas sector, today the carbon capture constitutes 90% of the cost of the CCS process [3]. Therefore, researchers mostly work on more efficient and less costly carbon sequestration technology.

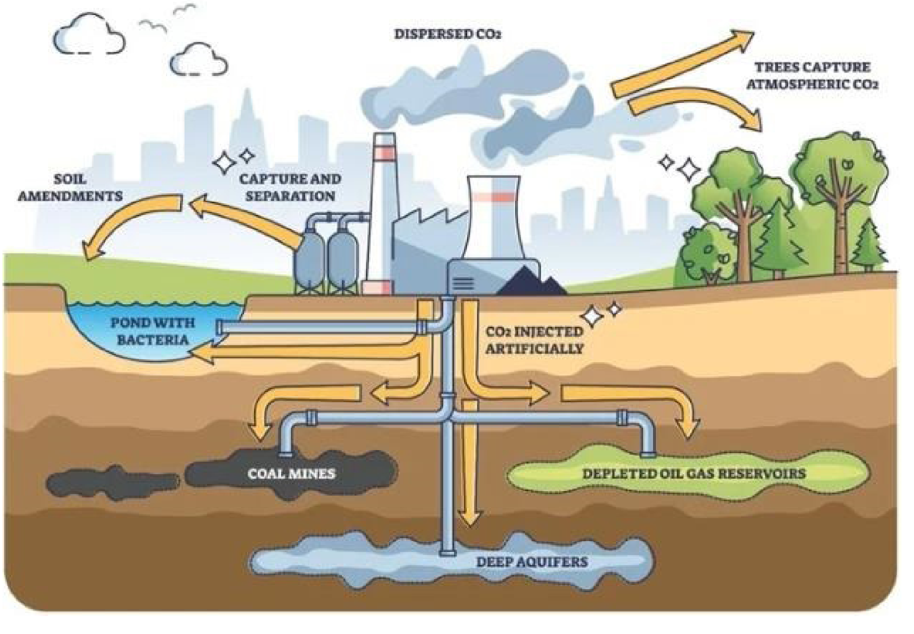

Figure 1. Depiction of carbon capture-compression-transportation and storage [3]

2. REDUCTION OF CARBON EMISSION

CO_2 can be separated from a gas mixture by absorption, adsorption, chemical looping combustion, membrane separation, and cryogenic liquefaction. However, in power plants there are three main technology options to capture CO_2 namely; pre-combustion, oxy combustion and post-combustion.

In the pre-combustion technology, the oxygen of the air is separated from the nitrogen in the first stage, then the fuel is reacted with pure or enriched oxygen to produce syngas. In general, syngas consisting of CO and H_2 is reacted with water vapor at high temperature to produce H_2 and CO_2. Finally, the separated CO_2 is either directly burned to produce electricity or used as fuel in vehicles (Figure 2).

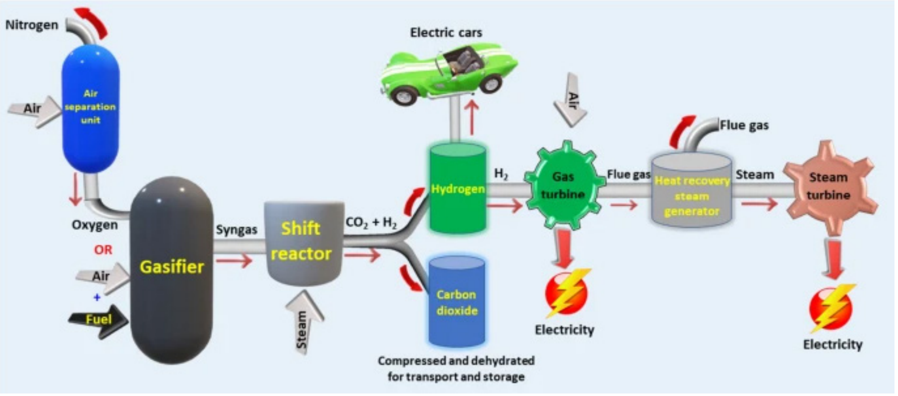

Figure 2. Pre-combustion technology for CO_2 capture [4].

In oxy combustion, after the air separates the oxygen from the nitrogen, pure oxygen is mixed with the flue gas returned from the combustion system's outlet and fed to the combustion system, and the fuel is burned with this oxygen. Finally, the CO_2 separated from the particulate and sulfur dioxide is cooled, compressed, dewatered and transported to the storage site (Figure 3).

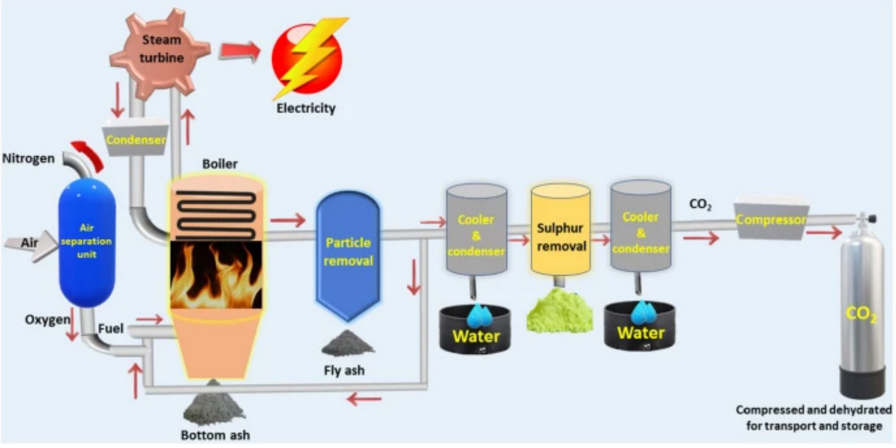

Figure 3. Oxy combustion for carbon capture [4].

In post-combustion technology, the fuel is burned directly with air, the particle in the flue gas is removed, the hot flue gas is cooled and CO_2 is separated from the flue gas in an absorption tower. The CO_2 rich absorption liquid coming out of the absorption tower is sent to the desorption unit. The CO_2 separated from the liquid is separated from the moisture and then compressed and sent to the place where it will be stored (Figure 4).

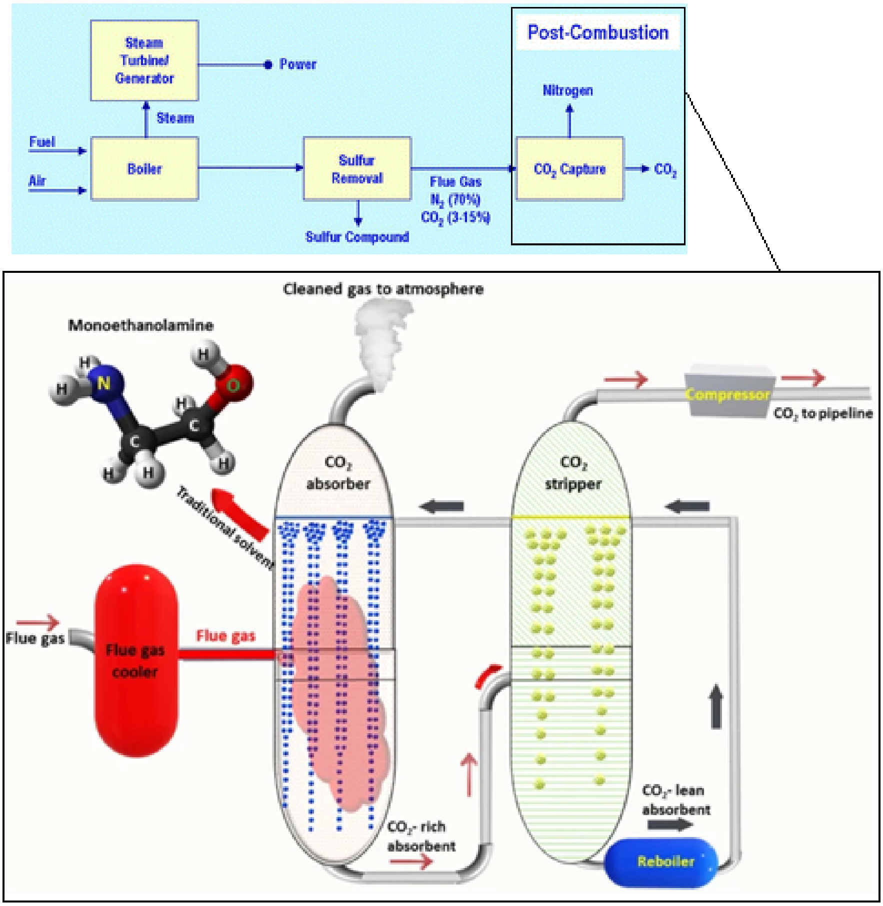

Figure 4. Post combustion CO_2 capture [4].

Of these technologies, pre- and oxy-combustion technologies are not yet in the full-scale application and are more expensive than post-combustion technology. Even though post combustion technology is the most mature and widely used, it could increase electricity generation prices by 60-70% if implemented in new plants [5].

The processes in which these technologies can be applied easily and efficiently differ. The processes in which these technologies can be applied easily and efficiently differ. For example, pre-combustion capture technology can be better applied in natural gas purification, biogas purification, hydrogen purification and synthetic gas purification, while post-combustion technology is easier to apply to CO_2 removal from flue gas of industries such as power plants, iron/steel industry, and cement industry. The choice of technology depends on the type of process, the concentration of CO_2 in the mixture, the expected purity of the separated CO_2, and the degree of carbon sequestration.

3. EMERGING TECHNOLOGIES AND FUTURE PERSPECTIVE IN CARBON CAPTURE

Figure 5 and 6 show the research studies conducted for post combustion carbon capture and the distribution of interest in these studies. Although the technology of capturing CO_2 by absorption applied for natural gas treatment has been used for a long time, there is a need to develop more efficient and cost-effective capture technologies for CO_2 removal from other processes gases. Figure 6 shows the research areas that researchers are working on in post combustion CO_2 capture, and Figure 7 shows the potential benefits and approximate commercialization times of these research results.

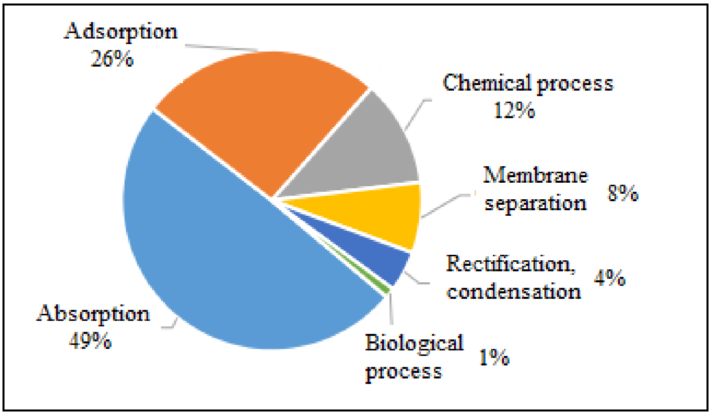

Figure 5. Carbon capture methods distribution in post-combustion technology [6]

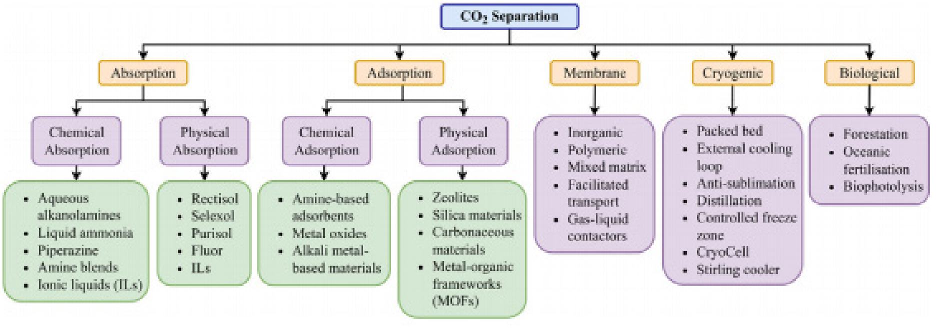

Figure 6. Commonly used and emphasized research areas for post-combustion CO_2 capture [7,8].

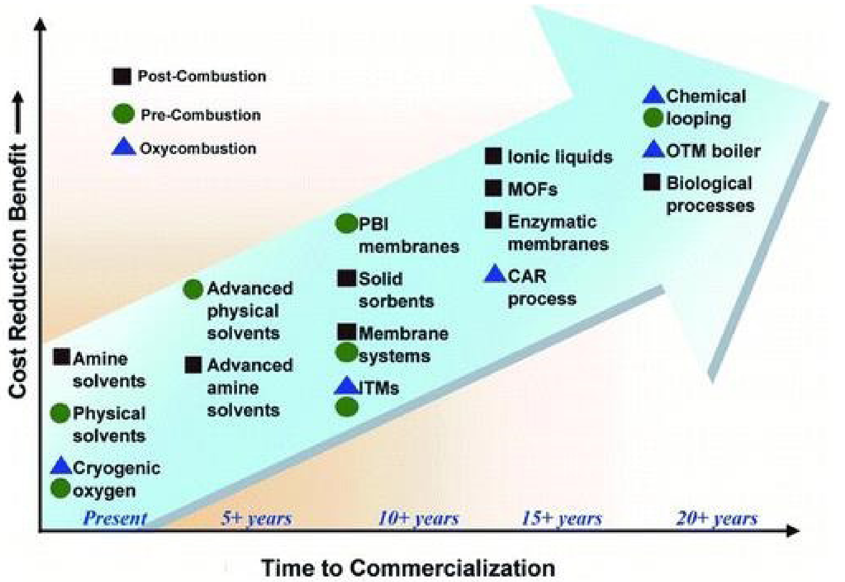

Figure 7. Cost reduction benefits and vs estimated time of emerging carbon capture technologies [9].

Although the flue gas flow rates of power plants burning coal or natural gas are very high, the CO_2 concentrations in these gases vary as approximately 7-14% and <4%, respectively. This requires building large volumes of CO_2 capture systems. In addition, since the flue gas pressure of combustion systems is low, it is not economical to separate CO_2 by adsorption or membrane. This also needs to be taken into account when developing new adsorbents or membranes.

CONCLUSION

There are many mature and researched technologies and methods for CO_2 removal from flue gas or process gas. However, there are some difficulties in the implementation of these technologies. It is possible to collect these in three groups as process-related difficulties, method-related difficulties and economic difficulties. Although many research centers are trying to develop more efficient and economical methods for CO_2 capture or CO_2 separation, the progress made shows that it will be difficult to reach the net zero emission target for 2050. In addition, although fossil fuel resources and reserves are decreasing day by day and renewable energy sources are being used more and more, fossil fuel consumption is still increasing.

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BIOGAS USAGE AS A SUPPLEMENTARY FUEL IN SOLID WASTE COMBUSTION

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ABSTRACT

Rapid urbanization and unmanaged human activities generate a considerable amount of Municipal Solid Waste (MSW), which is extremely difficult to manage in emerging and impoverished nations. Solid waste is gathered at the source and disposed of in many impoverished countries by open dumping. In open dumping, there is little treatment and human monitoring. Open dumping is also harmful to the environment and takes up a lot of space as a garbage disposal site. As a result, a more efficient solution to this problem is required. Various alternatives, including bioreactor sites, have proven effective in many impoverished countries, but they need a large amount of land and a significant degree of running and maintenance expenditures. Furthermore, because these technologies are concentrated, they face substantial transit costs. Incineration is used efficiently in several nations throughout the world. The high heat values of waste materials are utilized to generate thermal energy, which may then be converted into electricity. Recent trends in MSW composition have revealed a drop in the amount of organic material and an increase in the material that may be utilized to investigate combustion possibilities in various nations across the world. The goal of this study is to use biogas as an extra fuel in a combustion system to increase the heat value of municipal solid waste. The experiment is divided into three sections: the fundamental features of MSW are specified, and the heating value of MSW in various proportions after the combination of biogas and air is calculated. To ensure improved efficiency in the combustion system, biogas has been blended with the waste to be consumed in various percentages, as well as a prediction for the needed area and years after utilizing biogas and air as supplementary fuel in the solid waste combustion system.

Keywords: Solid Waste, Biogas, Supplementary Fuel, Calorific Value, Landfilling

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1. INTRODUCTION

Since the 1980s, fossil fuels have been the main factor in the world's tremendous increase in energy consumption. About 33%, 27%, 24%, 7%, and 4% of the world's principal energy supply came from oil, coal, natural gas, electricity, nuclear power, and renewable sources in 2018. In 2018, fossil fuels provided over 85 percent of the world's primary energy demand [1] [2].

Climate change, decreasing energy prices, an increase in distributed generation, and other environmental considerations have led to a doubling of biomass conversion from 65 GW in 2010 to 120 GW in 2019. Anaerobic digestion, landfills, and digestion conversion technologies are better suited to high-moisture wastes. Around 19.5 gigawatts of power were generated by biogas plants around the world as of the end of 2019. Residential wastes (food, fruit, and vegetable scraps) and public moist wastes (cafés and restaurants, daily markets, and companies' biological wastes) are the most common feedstocks for biogas production because of their high degradability and high moisture content, respectively. Organic materials from MSW are what go into the process [2] [3].

The biogenic chemicals that make up biogas are there by design. These biogases naturally diffuse into the atmosphere, and their principal component, methane, contributes significantly to global warming [4]. Methane has been converted into energy, fuel for automobiles, and home heating in recent decades. Bio-methane production has increased dramatically thanks to advances in waste recovery techniques, yet natural gas still accounts for the vast bulk of methane consumption and use. Over the previous decade, it has seen a 4 percent growth in its output potential (from 2010 to 2018). Therefore, a sustainable industry that generates bio-energy from renewable and environmentally favorable natural resources can be built and run [4].Only industrialized countries have the technological capacity to produce biogas on a large enough scale to use current biogas facilities. Biogas is commonly used as a fuel source for thermal and electrical production. Several commercial applications are under development, including its usage in biogas facilities as a replacement for natural gas. The study of the data shows that the production of biogas has increased consistently as a result of worldwide policies and programs. Biofuel generation is seen as the key source for this plan in many parts of the world because the transportation sector is estimated to contribute 0.5% of renewable energy by 2020 [5], or roughly 12.8 GW. Particularly, expanding biogas generation would be disastrous for farming. As a result, cellulosic and lignin wastes account for the vast bulk of biofuels [6] [7] [8].

Many countries have made significant strides in recent decades to develop the international biogas market. Furthermore, domestic or international supportive rules, such as RD&D financial funds, subsidies, and guaranteed electricity purchase contracts, have been implemented to promote the development of cutting-edge biogas production technologies in an effort to level the playing field with traditional energy suppliers [9] [10]. Figure 1.1 shows how biogas technology can be used in a variety of contexts to provide a flexible solution for meeting the energy demands of the commercial and public sectors. The most common use for biogas are in CHP plants, hydrogen generation plants, and other high-tech energy systems like fuel cells.

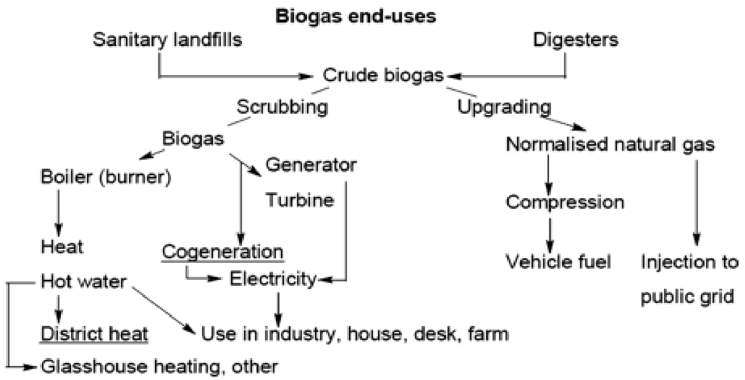

Figure 1. Overview of biogas utilization

Biogas facilities have been developed more rapidly in the EU and North America during the past 40 years than on any other continent. Industrial scale, energy efficiency, and high complexity are the key advantages of the units located in the aforementioned areas. Biogas production was explored by universities and governments because of its potential to solve multiple international problems. It's also worth noting that businesses can reduce their carbon footprint and the pollution caused by waste disposal by adopting biogas technologies, all while benefiting from the wide array of renewable energy applications that biogas can provide, such as for heating, powering electronics, and powering vehicles.

Throughout the world, people have developed a wide variety of methods to produce biogas from agricultural byproducts. Biogas facilities in Germany, for example, are fueled by the production of low-cost agricultural items that require just rudimentary processing (with no outcomes for customers). The new regulations encourage using local resources such as crops, plants, wildlife, and landfill [11]. The following are examples of the use of bigas in different contexts:

1.1. Electricity Generation

Biomass power generation is the most popular and fastest-growing market in the world right now because of technological breakthroughs, decreased dependency on fossil fuels, and reduced greenhouse gas (GHG) emissions. Internal combustion engines (ICEs) and gas turbines (GTs) are the two most common methods of generating electricity in power plants, and biogas has the potential to be employed in these applications. Micro gas turbines are useful because they can meet a wide range of load requirements while producing fewer harmful emissions of nitrogen oxides (NOx). It is possible to meet low and medium power load requirements with a combination of microturbines ranging in size from 70 kW to over 250 kW. The adjacent commercial and industrial establishments can get the power they need from the electricity. The utilization of power for e-vehicles by a networked car-sharing group is a cutting-edge application, especially in developed countries like Germany [12] [13]. The key benefit of on-site energy generation is avoiding transit losses and enhancing reliability because it is not dependent on a centralized infrastructure primarily powered by traditional fossil fuels. Supplying the right amount of electricity and selling the excess creates additional revenue [14] [15].

1.2. Heat Generation

To generate heat, biogas can only be burned directly in boilers. Biogas may be used in natural gas boilers with a few tweaks. Biogas produced from farm biomass can be utilized for a variety of purposes, including but not limited to: heating digesters; warming pig/sty housing; heating greenhouses and aquaculture facilities; cooling and refrigerating agricultural products; and drying crops. Dried agricultural products like digestate, woodchip, grain, herbs, and spices are a big part of the agricultural industry and the farm economy as a whole [16] [17]. Nearly 30%-50% of surplus heat can be sold to a neighboring region for district heating/cooling applications, such as heating swimming pools. An absorption chiller could be a good candidate for increased heat consumption through CHP not just because of its cooling power capabilities (tri-generation). An impressive 70% efficiency in heat-to-cooling power conversion has been reported [18] [19].

1.3. The Present Research is Organized as Follows:

Worldwide, solid waste management is a major issue, particularly in urban areas where landfill waste management poses significant challenges. While there are a number of technologies that help manage solid waste, especially at landfills and other open dump sites, one of the most effective methods is to burn the waste to generate electricity. Although this technique has gained worldwide recognition among scientists, it does not come without limitations, particularly when it comes to the combustion system. It has been found that the efficiency of a solid waste combustion decreases most often due to higher moisture content. This research suggests a method by which waste products already present in the system can be burned off more thoroughly and thus more energy can be generated; this would be an important step toward the development of a high-efficiency combustion machine. Utilizing the most effective method of local energy sources, the use of Biogas in a solid waste combustion plant adds a new dimension to an efficient waste treatment process. Utilizing diverse additive materials in a combustion system is not a novel concept; however, the addition of bio gas with air and other additive materials increases the calorific value of the combustion system, making a treatment plant more energy-efficient. As we all know, creating power from natural gas is already a viable option, but if a treatment plan can manage its waste to produce additional biogas from its existing waste, it will be of great assistance to the treatment plant. Particularly in landfill zones As if there were any doubt, landfilling is a major concern, especially in heavily populated and developing nations. Open dumping could emit a great deal of CH4 gas, which has already been observed in Bangladesh, Lahore, Delhi, Thailand, and countries such as Indonesia. Therefore, managing them is an excellent option for the environment, and utilizing them might be a significant success for the global environment and energy sectors. This study presents a hypothesis and a comprehensive examination of biogas as a sustainable energy source for both production and applications. The review of the evolution of this technology could lead to new commercial opportunities and the exploration of innovative concepts in the environment and energy sectors. In addition, this article will discuss how the usage of varied percentages of existing solid waste extends the lifespan of landfill sites. By reviewing recent international regulations relevant to biogas management are examined on the basis of foreign policy based on international norms and agreements.

2. METHODOLOGY

The methodology discusses the processes or activities that were carried out in order to attain the aims and goals of the study. It is the most crucial aspect of any study since it determines the quality of the research and the findings that are anticipated, and a methodology that has been carefully devised makes it possible for the researcher to easily reach their goals and objectives. This is a research project whose focus is on explanation, and it has a significant quantitative component. To create this quantitative approach, specific data sources were utilized. In this particular instance, information is obtained by utilizing secondary data sources. For the purpose of conducting the study in a methodical fashion, data were gathered from a variety of sources, such as published works, the websites of various levels of government, international organizations, local groups, and so on. In order to determine the optimal biogas-to-air ratio for combustion, the goals of this study include doing an analysis, calculating, and comparing the acquired data. In order to make it possible to propose discovering values as a further improvement to the solid waste combustion process. Because temperature is such a significant problem on a worldwide scale, it is essential that combustion systems have temperature controls. This research also calculates an estimated lifetime for a landfill area after using biogas by obtaining values from the Municipality of Samsun for the biogas production rate of the current Samsun landfill area that can be useful in global landfill modeling for the municipalities.

The municipalities in the city center of Samsun gathered over 900 tons of municipal solid waste (MSW) per day in 2014, according to the Sevda E. Akkaya & Osman N [21]. "Ergun they say. This estimate does not include strong waste generations of settlements of the village type with over 500,000 rural inhabitants owing to a lack of collecting systems".The way in which the Waste is generated per capita in urban municipal districts with collection activities vary from 0.9 kg/capita a day to 1.4 kg/capita/day, due to lifestyle, economic condition and seasonal changes.

Table 1. Solid waste characteristics in Samsun.

Solid waste characteristics in Samsun				
No.	Solid Waste Components	Percentage (%)	Avg. calorific value	Avg. moisture Content (%)
1	Organic	57	2300 Kcal/kg	45-60
2	Plastic	19		
3	Paper/Cardboard	5		
4	Metal	3		
5	Others	3		

In Samsun, the usual mix of municipal solid Waste collected is about 57% organic, 19% plastic, 13% paper and carton, 5% glass, 3% metal and 3% more. Due to the same reasons mentioned above, the makeup differs from district to district. The average heat value of MSW collected is around 2,300 Kcal/kilograms, whereas the mean heat content of municipal solid waste collected in the urban metropolitan area is between 45 and 60% according to Sevda E. Akkaya and Osman N [22].

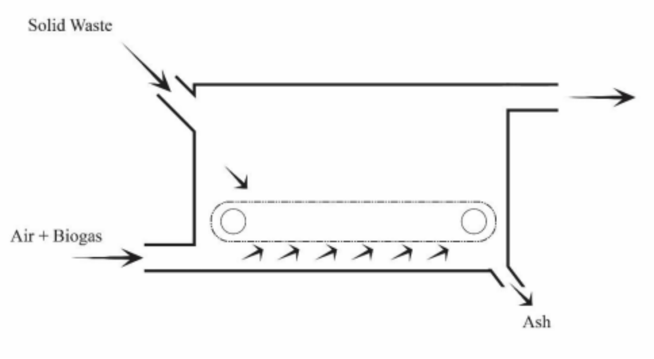

Figure 2. Conceptual model of solid waste combustion for using Biogas as a supplementary fuel.

Biogas includes CH_4 and CO_2, and therefore a combustion system reacts to the Biogas.

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

In Table 6, a different percent of CH4 and a different percentage of air is shown to have the major influence on the burning combustion system. We discover that the ratio has varied calorific value for every percent of CH_4 in the system. Where CH_4 is constant in the system, the real CV is 12000 Kcal/kg. Where the CH4 is constant. After computation, the calorific value is larger for CH4 than for all other additives. Therefore, we discovered 5,292 kcal/kg, 4,536 kcal/kg, 3,780 kcal/kg, 22,224 kcal/kg, 1512 kcal/kg, 765 kcal/kg at 70%, 60%, 50%, 40% and 30%, 20%, 10% of the CH4. But because we know that we have numerous types of waste in a combustion system which we generate every day in our lives, all these products have their individual calorific value. But for our study we use an average heat value of 2300 kcal/kg of solid waste (see table1). Thus, collectively we have a new CV = CV1+CV2 calorific value. Solid Waste + Biogas + Air is determined by CV. The following is a simple example. -

Amount of CH4 = 60% = 0.6

Amount of O2 = (100-60) = 40% = 0.4

So the ratio (Biogas: Air) = 0.7/0.3 = 1.5

Actual calorific value of CH4, H_u = 50000 kJ/kg,

= 0.24 x 50000

= 12000 Kcal/kg

Here,

Standard density of CH4, pCH4 = 0.72

Where, Pressure ambient Pa = 950 mbar

Pressure in biogas plant Pp = 20 mbar

So, actual pressure assumed, Pact = (950 + 20) = 970 mbar

Standard pressure for CH4, Pstd. = 1013 mbar

Temperature actual Tact = 25 degree C = 25+ 273 = 298 K (room temp.)

Table 2. Calculation of Calorific value of Biogas + Air + SW in a combustion system.

(%) of CH4	(%) of O2	Density of CH4 at standard condition	Actual CV of CH4 (Kcal/kg)	Actual Calorific Value of CH4 (Kcal/kg)	Average Solid Waste Calorific Value for Turkey (Kcal/kg)	Ratio (Biogas: Air)	CV1 + CV2 (Kcal/kg)
70	30	0.63	12000	5292	2300	2.3	7592
60	40	0.63	12000	4536	2300	1.5	6836
50	50	0.63	12000	3780	2300	1.0	6080
40	60	0.63	12000	3024	2300	0.7	5324
30	70	0.63	12000	2268	2300	0.4	4568
20	80	0.63	12000	1512	2300	0.3	3812
10	90	0.63	12000	756	2300	0.1	3056

Temperature standard Tstd. = 273 K

So, pCH4act. = pCH4std x [(Pact/Pstd) x (Tstd/Tact)]

Density of CH4 = 0.72 x [(970 mbar/1013 mbar) x (273K/298K)] = 0.63

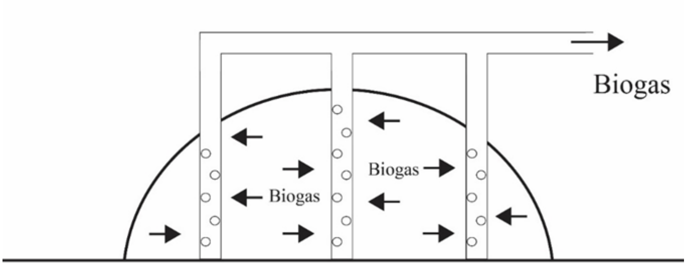

Figure 3. Biogas production system

So, the actual calorific value of CH4 is -

= %CH4 x pCH4act x Actual Calorific Value of (CH4 + O2) Biogas

= 0.7 x 0.63 x 12000 = 5292 Kcal/kg

As we know the average calorific value of Solid waste (for samsun)

= 2300 kcal/kg

So, the calorific value for (Biogas + Air) + Solid waste in a combustion is –

= 5292 + 2300 = 7592 Kcal/kg

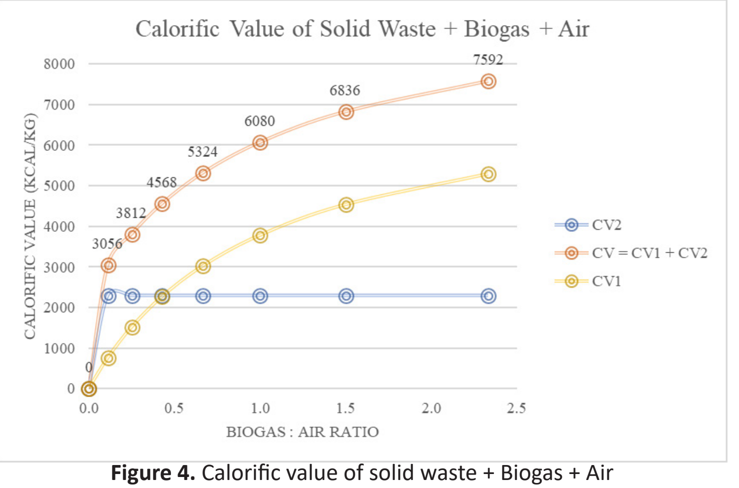

Figure 4. Calorific value of solid waste + Biogas + Air

The heat value of a combustion of solid waste is clearly displayed in Figure 3. As we know, the optimal temperature of these particular materials is therefore defined by calorific value, which implies it is possible to increase the temperature in a solid waste combustion process [20] [21]. Since this study seeks a specified amount of CH_4 that might be utilized in the air burning system, our investigation found that after feeding, the residual percentage of CH4 in combustion. In addition to this quantity of CH_4 we may determine for our uses the calorification value. For instance –

Table 3. Calculation of %CH4 in the mixer and calorific value of that CH4.

Air (m3)	Biogas (% CH4 + %O2) m3	Initial (Biogas + Air) m3	%CH4 in the mixer	Calorific Value of %CH4	Inside the combustion (Biogas + Air) m3
100	100	200	35.00	2646.00	70
100	90	190	31.58	2387.37	60
100	80	180	27.78	2100.00	50
100	70	170	23.53	1778.82	40
100	60	160	18.75	1417.50	30
100	50	150	13.33	1008.00	20
100	40	140	7.14	540.00	10

We feed 100 m^3 of air and 90 m^3 of biogas with a total of 190 m^3 of Biogas and Air. Therefore, we have the real CH_4 content in the system which is still available after the first feed. We obtain in the system 60 m^3 CH4 from 190 m^3 of biogas and air mixer. Therefore, we obtain a calorific value of 2387,37 kcal/kg for that quantity of CH_4. So,

= 0.63 x 0.32 x 12000 Kcal/kg = 2387.37 kcal/kg

Here,

Actual Density $pCH_4act = 0.63$

% of CH4 inside the combustion = 32% = 0.32

Actual calorific value of CH4 = 12000 kcal/kg

A formula which includes a specific production rate, weight and solid waste compaction ratio is used to establish the necessary volume. -

“[V1 = d [R/w + Cv]

in which V1: required landfill volume per one person per year (m3/capita.year)

R: specific solid waste production rate (=1 kg/capita.day)

w: volumetric weight of solid waste after compacted (=800 kg/m3)

Cv: “specific required volume for isolation layer at the bottom, covering layers between solid waste beds and final upper covering layer (=0.0004 m3/capita.day)”

d: 365 day/year ec: efficiency of collection from SW (=0.85)

3. RESULT AND DISCUSSION

In this graph, our research shows that biogas is one of the greatest ways of boosting the temperature in combustion as an additional material. As you can see Wood coal at varied percentages has a high calorific value, however coal is a fossil fuel and it’s bad for the environment. It creates a great deal of carbon, the cause of global warming. However, we may use biogas instead of wood coal and others that will make the system as efficient as possible. We also need biogas that are created from recovered or current garbage to be used for our study. Since the usage of solid waste is an issue for several days already and cannot be dumped at a resort once the area is fielded. There are, therefore, more effective two-fold uses of solid and organic waste. This diagram shows clearly why the use of biogas as a supplemental fuel is crucial in combustion.

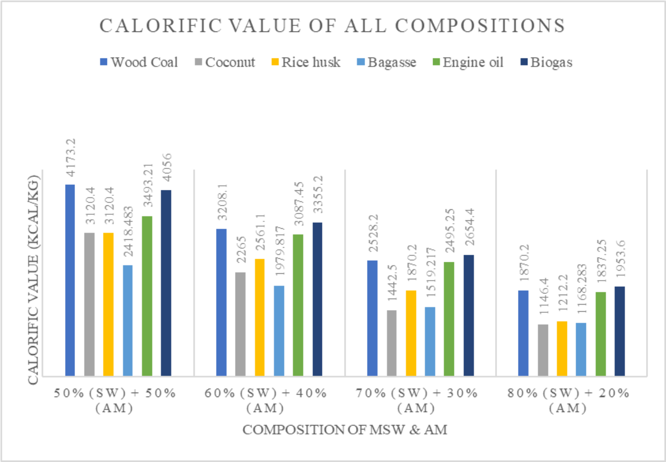

Figure 5. Comparison between the calorific value of Biogas and other additive materials.

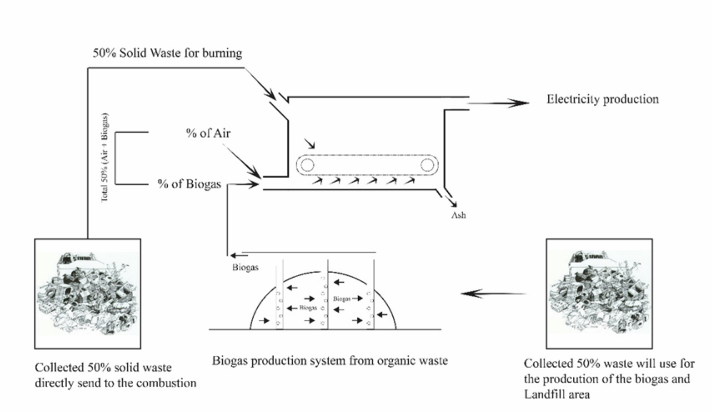

Figure 6. Conceptual diagram of the total system for high efficient solid waste combustion.

As an example, A total of 900 tons of waste are divided into 2 groups: S.W. (Solide Waste) = 450 tons are burnt directly, with O.W. (Bio-Waste) = 450 tons being shipped for biogas production to a landfilling site. The O.W. is separated from the artificial neural network prior to burning the S.W. and delivered directly to the land-filling location to produce Biogas. The biogas produced is combined with air and sent into the system. It means that 50 percent (air+biogas) solid waste will be feed into the system for enhanced efficiencies and the production of more power in our suggested combustion process, therefore raising the temperature in the combustion and enabling it to function at optimum moisture content (percent) We used different ratios/mixtures of Air for the determination of the highest calorific value: Biogas in our study.

Alternative I:

V1 = 365 [1/800 + 0.0004] = 0.60 m3/capita.year

Required landfill volume for the year 1991,

V1991 = V1.N1991 = 0.60 m3/capita.year x 2,775,613 capita

V1991 = 1,671,613 m3/year

After settlement and decomposition :

V1991 = (1,671,613)x0.8 = 1,337,290 m3/year

Alternative II :

V2 = 365[(1/800)0.85 + 0.0004] = 0.50 m3/capita.year

Required landfill volume for the year 1991,

V1991 = V2.N1991 = 0.50 m3/capita.year x 2,775,613 capita

V1991 = 1,481,657 m3/year

After settlement and decomposition :

V1991 =(1,481,657) x 0.8 = 1,185,326 m3/year

“Required volume for solid waste beds could be calculated using the following equation”.

V = (p.e.c.k)/dc

in which V: required volume for solid waste beds (m3/year)

p : “population of the region” (capita)

e : “coefficient of ratio between covering material volume and solid waste beds volume”

dc : “volumetric weight of compacted solid wastes” (kg/m3)

ec : “efficiency of collection from” SW (=0.85)

k : 365 days/year

c : 1kg/capita.day]”

“Required volume for solid waste beds for the year 1991”,

Alternative I:

V1991 = (2,775,613 x 1 x 1.20 x 365)/800

V1991 =1,519,648 m3/year

After settlement and decomposition:

V1 = 0.80 x (1,519,648) m3/year = 1,215,718 m3/year

Alternative II :

V2 = 0.85 x (2,775,613 x 1 x 1.20 x 365)/800

V2 = 1,291,701 m3/year

After settlement and decomposition:

V2 = 0.80 x (1,291,701) m3/year = 1,033,361 m3/year

Population density, solid waste generation rates, additional volume for material covering, and filling time are all factors that must be taken into account while settling the settlement site. For the filling area Harmandalı, the land profile and the height after completion were estimated using 1/1000 scale maps. In order to avoid the waterproof clay layer and achieve minimum reinforcement, natural slope was explored. In principle, the maximum road slope is intended to be 10% for automobiles [22] [23]. Connection to the main road was made using a 3:1 path. The average filling height is 20 m. Although three alternatives have been made, including filling and ultimate heights, ultimate levels are hard to reach.

“The following are fictitious estimates of the Harmandal sanitary landfill’s potential capacity.”:

- Case 1, 7,934,371 m3,
- Case 2, 11,190,396 m3,
- Case 3, 17,596,131 m3.

In light of Izmir's waste production and the volumetric weight of compact solid waste at Harmandal, the average time of usage of the landfill area has been calculated and is presented below, 1940 tonnes/day and 560 kg/m3, respectively:

- Case 1, 7,934,371 m3/1,261,308 m3/year = 6.2 year
- Case 2, 11,190,396 m3/1,261,308 m3/year = 8.9 year
- Case 3, 17,596,131 m3/1,261,308 m3/year = 13.9 year

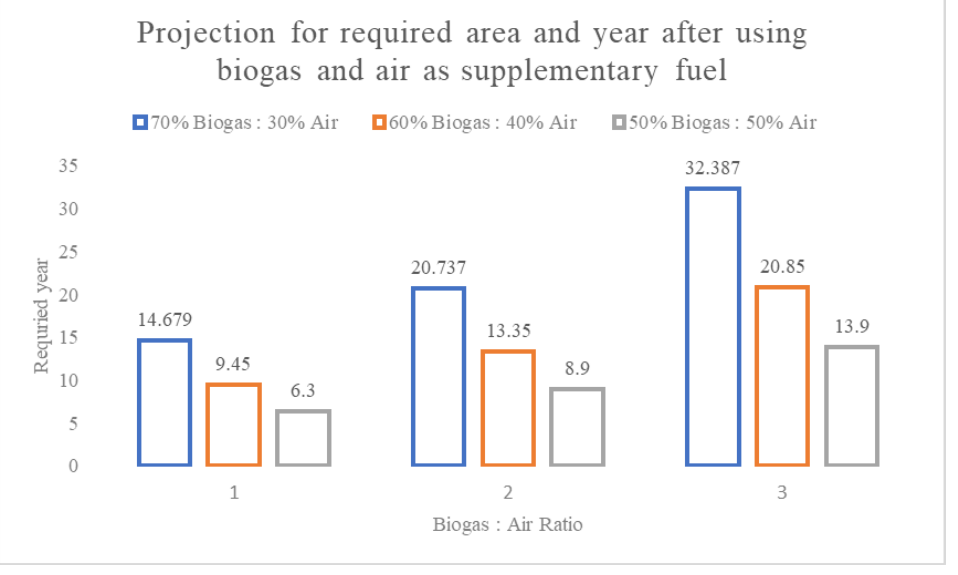

Figure 7. Projection for required area and year after using biogas and air as supplementary fuel.

So, after using 70% of biogas and 30% of air for this combustion system and their landfill area it increases its lifetime of the land fill area almost 2 times. Where the amount of solid waste and volume are the same.

Table 3.4. Calorific value calculation of CH4 after adding the extra air for CH4 burning.

%CH4	CH4 (m3)	Feeding air (m3)	Feeding Biogas (m3)	Biogas+Air (m3)	Calorific value of Biogas + Air
70	0.7	10	1	21.00	5292
60	0.6	10	1	19.70	3723
50	0.5	10	1	18.14	2743
40	0.4	10	1	16.70	2104
30	0.3	10	1	15.30	1652
20	0.2	10	1	13.86	1310
10	0.1	10	1	12.43	1044

3. CONCLUSION

Globally, as a result of a variety of variables like COVID19 and the stability of political power, world leaders are employing energy as a weapon, despite the fact that it ought to be a human right. But now, in the year 2022, we have witnessed how the energy crisis drags down the global economy and causes people all over the world to suffer. Therefore, any nation ought to be able to stabilize itself through its own energy resources, where solid waste might be a significant source of turnover that is virtually completely regenerable. As humans, we produce waste on a daily basis, and putting that waste to use through solid waste combustion through a variety of processes will be an excellent way to mitigate the current global energy crisis.Waste disposal facilities are used by local governments to manage their solid waste disposal, however finding an appropriate disposal site can be challenging. It is important to use more fuel because of the high humidity of solid wastes. In most cases, local governments rely on fossil fuels as a backup source of power. According to the findings, using biogas instead of fossil fuels is more practical. It is possible to reduce waste at disposal sites by using biogas, a fossil fuel substitute. This idea focuses on the use of biogas as an alternative to fossil fuel. The aforementioned benefits will be achieved as a result. Biogas may also be used in the burning of solid waste at higher temperatures to generate energy. With this method, prices for combustion may be reduced as well as waste production. In addition, less pollution will be released into the sky. Biogas with the potential to be burned in order to enhance its performance. Biogas may be generated from half of a district's solid waste, and it can also be used to burn the other half. Biogas might be utilized to provide electricity and heat for local homes.

5. RECOMMENDATIONS

In this study, biogas is being used as an extra fuel in the burning of solid waste in an attempt to obtain a set temperature. Consequently, we may maximize energy generation through improved combustion efficiency. Using biogas as an additional fuel to raise the combustion system's calorific value, this research shows that we can achieve the ideal temperature for high energy output. A disposal may be made more cost-effective for all towns throughout the world, as we showed in our survey. There are certain theoretical limits on the majority of the topics we examine, though. Thus, the findings of this investigation —

1. Biogas can be used with other additive materials as an extra fuel to raise the temperature of the combustion system that will ensure an environmentally friendly solid waste management plant.

2. This study also found that during the combustion process there are some losses because the biogas produced on the site was used directly for combustion and mixed with the air quickly. To prevent that issue, use of artificial intelligence tools will be helpful to eliminate human errors throughout the biogas generation and waste separation operation might be a significant milestone for the incineration facility and losses.

3. In order to better handle supplemental fuel, the European Union requires a minimum combustion temperature of 800°C and a maximum combustion temperature of 1200°C that could be followed and our research finds and proposed an 1100°C temperature for a combustion system by using biogas as a supplementary fuel.

4. According to the findings, use of different (%) generated biogas onsite to the combustion system, will increase the lifetime of a landfill area (see figure 1.2).

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OPTIMIZING WASTE MANAGEMENT WITH GEOGRAPHICAL INFORMATION SYSTEM (GIS) WITHIN THE SCOPE OF ZERO WASTE: THE CASE IN ATATURK UNIVERSITY

Şahin Korkmaz[1*], Elif Tuna Pulaş[2], Cemal Sevindi[3], Zeynep Ceylan[4]

ABSTRACT

In order to meet human needs, many wastes are generated during production, logistics, storage and consumption. It is important that these wastes are properly separated at the source, collected separately, recycled and disposed. Reducing both the production amount and the economic cost of waste is possible with recycling, reuse and circular economy. The "Zero Waste" policy, which covers the prevention of waste, the more efficient use of resources, the prevention or minimization of waste generation by reviewing the causes of waste generation, is becoming widespread locally and nationally.

In this study; In the main campus of Atatürk University (central campus, west campus, lodgings) located in Erzurum, 4 campuses in the city center (botanical park, hobby gardens, guesthouse 3, yoncalık education faculty campus) in a total of 7 campuses; the waste collection system has optimized with the help of GIS in order to manage solid wastes (recyclable, non-recyclable and organic, bio-degradable wastes) in accordance with the zero waste triple separation system, taking into account the optimal conditions and current conditions.Blue containers for recyclable wastes, black containers for non-recyclable wastes, and brown containers for organic and biodegradable wastes have placed at the points determined by considering the number of buildings in the campuses, human circulation in the buildings, waste type and quantity density.Data sets have created by calculating road standards (road width, number of lanes, etc.), type and amount of waste according to seasonal conditions, waste collection hours, road networks belonging to the collection system, demographic structure of the study area, waste amounts.With the help of the data sets created, temporary storage areas where different types of collected waste are optimally created. By evaluating the data, minimum cost systems have studied for the collection and transportation of waste in an efficient and regular manner.

Keywords: Zero Waste, Waste Management, Collection and Transport System, Container, GIS

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1. INTRODUCTION

Solid waste in cities is one of the most striking environmental pollutants. Waste from houses, gardens, parks and picnic areas, public places, industrial areas creates a large amount of waste. In Turkey, an average of 1 kg of domestic solid waste is generated per person per day. The amount of solid waste production per person per day varies depending on factors such as population characteristics, geographical location, seasons, human habits and income level.The collection and transportation of solid wastes in Turkey is given to the Provincial-District Municipalities within the provincial borders. Solid wastes collected within the provincial borders are taken directly to the landfills. In districts that are close to each other, wastes are generally transported to use the same landfill with the establishment of intermediate stations. Due to the lack of data-based optimization in the provinces, collection and transportation operations are not efficient and costly due to the scattered nature of the regions served. A large part of urban solid waste consists of domestic solid waste.

As a result of rapid and unplanned urbanization, solid waste management is becoming a problem, especially in big cities. Therefore, within the scope of zero waste; the effective, efficient and regular collection, transportation, storage and disposal of solid wastes become important [1].

Optimizing waste management systems will reduce transportation costs and enable the savings to be used in different areas. In addition, since the air polluting gases emitted from the vehicles during the collection and transportation of solid wastes will be reduced with the optimized transport system, it will positively affect global warming, climate change and improvement of air quality [2].

The vast majority (65% to 80%) of domestic solid waste management system costs are allocated to collection and transportation operations [3]. A more systematic working system and efficient solutions are needed in collection and transportation operations that require quite a large amount of cost [4]. This need has led to many studies on the subject in Turkey [5-10]. In a study conducted in Erzurum city center on the subject, the current collection/transportation system of domestic solid wastes produced in Palandöken district has examined; solid waste collection vehicles have accompanied, container locations have numbered, collection routes have determined on the satellite map and a data have created on which analysis could be performed. Ergonomic solution proposals have developed by making route optimizations in the system used [11]. In another study conducted in Erzurum; A mixed integer programming model has been developed to support decision making in the planning and operational efficiency of the reverse distribution system related to the recycling of packaging waste. The model has solved with the LINGO optimization program for six different scenarios [12].

The first step of Solid Waste Management in the waste hierarchy is to reduce the amount of solid waste generated. On the one hand, the most advanced smart technologies for waste collection, transportation and disposal are developed, on the other hand, necessary studies are carried out to reduce the waste generated.

Zero waste is defined as a system that allows people to create the least amount of waste with a conscious consumption, collect the existing wastes separately and ensure the recycling of wastes. It creates a new structure by affecting not only the management of wastes, but also the production, design and distribution methods.

The parameters that directly affect the creation of waste management plans are generally waste amount and waste characterization data. These two parameters are guiding in all planning processes from waste collection to transportation, recovery to disposal.

In the classical waste collection system, all types of waste are transported to the disposal facility in a mixed form in a single type of waste container. For this reason, wastes cannot be separated and valuable wastes (such as glass, plastic, paper, metal, etc.) cannot be recovered. In the zero waste system, these wastes can be collected separately in different containers and recycled or recovered.

2. MATERIAL AND METHODS

The place where the study has carried out is the Atatürk University campus and additional campuses in the city center of Erzurum. Erzurum city is surrounded by Artvin-Rize from the north, Bingöl-Muş from the south, Gümüşhane-Erzincan from the west and Ağrı-Kars from the east in the east of Turkey, and is located on 39-55 north latitude and 41-16 east longitude. At Atatürk University, which has a large main campus in the city center of Erzurum; In the 2021-22 academic year, approximately 68000 students are studying in total. As of 2022, a total of 2760 academic staff, including 641 professors, 329 associate professors, 596 doctors, 305 lecturers and 889 research assistants, are working within the scope of the university. Atatürk University campus, located 1.5–2 km from Erzurum city center, has an open area of 6.5 million m² and a closed area of 1 million m². The university land, which covers most of the Erzurum plain, is Turkey's second largest campus. It has the feature of being the first planned campus of Turkey (Figure 1).

Solid wastes in Erzurum are collected regularly every day by Erzurum Metropolitan Municipality and district municipalities (Aziziye-Yakutiye-Palandöken Municipalities). The solid wastes of the university are collected by the Yakutiye municipality. The university campus, where the application is carried out, has a significant amount in the city in terms of the amount of solid waste.

In addition to many decision support systems, Geographic Information Systems (GIS) have used in the management of solid waste within the scope of zero waste within the university. Geographic Information Systems, which have many application areas, are designed to assist users in decision-making processes based on space/location for the solution of complex problems. It is the whole of hardware, software, personnel, geographical data and method that provides the collection, storage, processing, management, spatial analysis of large volumes of geographical data.

Containers were placed at the designated points, taking into account the number of buildings in the campuses, the human circulation in the buildings, the type and amount of waste. Optimization studies were carried out for the wastes accumulated in the containers located at the determined points. In this context; data sets have created based on road standards (road width, number of lanes, etc.), type and amount of waste according to seasonal conditions, waste collection hours, road networks belonging to the collection system, demographic structure of the study area and the amount of waste.

ArcGIS and Google Earth Pro software have used in the creation of maps in order to determine the locations of the containers to be placed at the university. GPS device has used to determine the location information of the containers. Google Earth Pro software has used to create the base maps, to check the accuracy of the road data and to correct the positioning errors caused by the data of the GPS device.

In this study, the zero waste regulation has examined in detail, then the location and number of containers containing different types of waste were determined in order to manage solid wastes in accordance with the zero waste system, taking into account the optimal criteria and existing criteria. The obtained container locations have marked in the Google Earth program, and the waste management system was completed by assigning numbers to the containers.

3. RESULT AND DISCUSSION

This study has carried out in the main campus of Atatürk University (Central Campus, West Campus, Lodgings) located in Erzurum city center and 4 campuses in the city center (Botanic Park, Hobby Gardens, Guesthouse 3, Yoncalık Education Faculty campus). Considering the optimal conditions and current conditions, the waste collection system has optimized with the help of GIS in order to manage solid wastes (recyclable, non-recyclable and organic, bio-degradable wastes and other wastes) in accordance with the zero waste quadruple separation system.

In the study, many existing parameters have evaluated for the optimization of the system. First of all, the optimum points where the containers can be placed have tried to be determined by considering the number of buildings in the campuses (Table 1) and the building locations. The properties of the containers have determined by considering the floor-corridor characteristics inside the building and by evaluating the road networks-road standards outside (Figure 2-3). The number of academic and administrative personnel in the buildings, the number of students and the total population, the density of container use, the change in the content and type of waste according to seasonal changes, education level parameters are some of the evaluation criteria. With the field studies carried out, the locations and numbers of the containers to be placed at the university have been determined within the scope of the current conditions. The locations of the containers are marked on the Google earth program. At the marked points, mostly double, triple and quad container systems have used. Containers have placed at 58 points in total, 25 in the central campus, 31 in the West campus, and 2 in the Yoncalık campus (Table 2-3-4). The map showing the locations of the containers in the study area is given in Figure 4.

All of the wastes taken from the points whose locations are determined are collected by the Yakutiye Municipality between 08.00-16.00 and taken to the 1st Class Waste Retrieval Center of the municipality.

Containers placed in regions according to need can be used as an indicator that gives information about the pollution status in the area. The spatial solid waste distribution maps drawn using the data obtained from the field can be created in a way to show the pollution areas of the regions and the intensity of the pollution. In other words, it will be possible to obtain information about the places where solid waste is more common in the campus borders. Thus, it will provide an important alternative in terms of providing serious convenience for the cleaning, waste collection and transportation processes to be carried out, without the need for any work or calculation.

4. CONCLUSION

Within the scope of this study, solid waste management has carried out with the solid waste collection and transportation system realized within the scope of zero waste at Atatürk University. Studies on the characterization, amount and projection of solid wastes were carried out. The most suitable container location has selected using the Google earth program. A minimum cost system has been developed in order to collect and transport waste in an effective, efficient and regular manner. With the help of data sets, temporary storage areas where different types of waste are collected are optimally created.

The following results were obtained in this study:

A waste balance sheet has prepared within the university by taking the daily amount of waste produced per capita in 2022 as 1.13 kg from the 2020 TUIK (Turkish Statistical Institute) data. [13]. Annual waste amount in Atatürk University central campus is calculated as 74725 kg/day (Table 5). These wastes can be classified as 29890 kg/day (40%) organic, biodegradable waste, 25650 kg/day (35%) recyclable waste and 18681 kg/day (25%) non-recyclable waste.

An average of 74 tons/day of domestic solid waste produced on the Atatürk University campus is transported to the disposal facility at the end of the collection and transportation operations carried out using the fixed container system. In this process, approximately 56 tons/day of total solid waste is recyclable waste. Within the scope of zero waste, it is aimed to bring these wastes to the national economy.

Within the scope of this study, waste containers have placed at 58 points through the Google earth program, taking into account the physical conditions. In addition, the locations and features of the numbered containers in the program has added to improve the communication and working conditions among the personnel.

With these results, the most effective way to reduce the cost in the solid waste collection and transportation system is to reduce the amount of solid waste generated and to ensure recycling. In addition, the most efficient management of waste has ensured in order to create green campuses within the scope of smart cities, circular economy and utilization of wastes as renewable raw materials.

ACKNOWLEDGEMENT

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Tables and Figures

Table 1. Number of buildings in Atatürk University campuses

Building	Number
Administrative building	13
Faculties	23
Vocational Schools	4
Institutes	8
TOTAL	48

Table 2. West campus container properties

Code	Container Point	Blue Container	Black Container	Brown Container	Steel Container
BY1	Ziraat Campus	1	1		3
BY2	The Food Engineering.1	1			2
BY3	The Food Engineering.2	1			1
BY4	Farm Plants	1	1	1	2
BY5	Seafood	1			2
BY6	DAYTAM	1	1	1	
BY7	Communication Faculty	1			2
BY8	Faculty of Veterinary Medicine.1	1			2
BY9	Faculty of Veterinary Medicine.2	1			2
BY10	Faculty of Veterinary Medicine.3	1			1
BY11	Faculty of Veterinary Medicine.4	1			1
BY12	Fish Facilities				1
BY13	Administrative Financial Affairs 1				1
BY14	Administrative Financial Affairs 2				2
BY15	Administrative Financial Affairs 3				2
BY16	Administrative Financial Affairs 4	1			2
BY17	GHUAM 1	1			3
BY18	GHUAM 2				1
BY19	GHUAM 3				1
BY20	Faculty of Letters, Gate B	1			2
BY21	Faculty of Letters, Gate aA	1			2
BY22	Turkish Music State Conservatory	1			2
BY23	Architecture and Design	1			2
BY24	Darülfünun Mosque	1			2
BY25	Faculty of Law.	1			2
BY26	Distance Education Faculty	1			2
BY27	Faculty of Arts 2	1			2
BY28	Faculty of Arts 1	1		1	2
BY29	Faculity of Pharmacy	1	1		1
BY30	CineTekno Cinema 2	1			2
BY31	CineTekno Cinema 1	1			2

Table 3. Central campus container properties

Code	Container Point	Blue Container	Black Container	Brown Container	Steel Container
MY1	Rectorate	1			2
MY2	Rectorate backyard	1			1
MY3	Faculty of Engineering Annex Building	1			3
MY4	Faculty of Engineering Student Entry	1	2		
MY5	Faculty of Engineering Library	1	1		3
MY5-A	Atapark			1	
MY6	Morphology	1	1		1
MY7	Faculty of Medicine Lectures	1	1		2
MY8	Between Faculty of Engineering and Faculty of Foreign Languages	1			3
MY9	Faculty of Nursing	1	1	1	3
MY10	Between Classrooms	1	1		3
MY11	Faculty of Dentistry	1	1	1	2
MY12	Next to the Faculty of Dentistry	1			4
MY13	Between Department of Mathematics and Faculty of Science	1	1	1	2
MY14	Research Center	1	1	1	2
MY15	BAUM	1	1		3
MY16	Mediko	1	1	1	3
MY17	Reading rooms	1	1		3
MY18	Ata-Hotel	1	1	1	2
MY19	Faculty of Science Entrance	1	1	1	
MY20	Construction Works Technical Department	1			4
MY21	In front of Nenehatun Cultural Center	1			2
MY22	Environmental Regulation Unit	1	1		1
MY23	Central Mosque	1			1
MY24	Sports Science Faculty	1			2
MY25	Vocational School of Health	1	1	1	1

Table 4. Yoncalık campus container properties

Code	Container Point	Blue Container	Black Container	Brown Container	Steel Container
YY1	Faculty Member Login	1			2
YY2	Students' Entry	1			2

Table 5. Atatürk University total waste balance

Population (Person)	Amount of Daily Total Waste (kg/day)	Amount of Organic, Biodegradable Waste (kg/day)	Amount of Recyclable Waste (kg/day)	Amount of Non-Recycled Waste (kg/day)
66129	74725	29890 (%40)	25650 (%35)	18681 (%25)

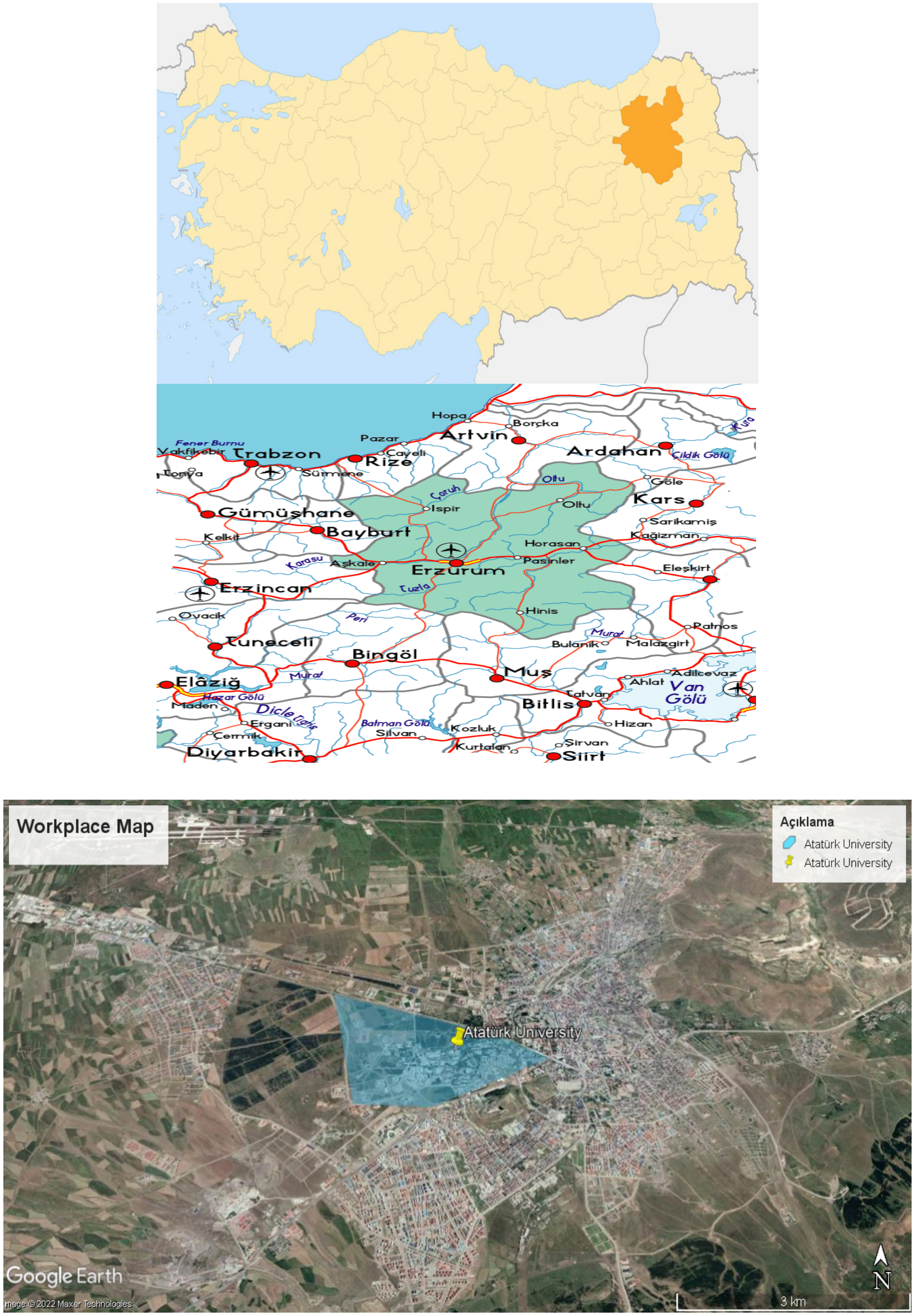

Figure 1. Workplace map

Figure 2. In-Unit Zero Waste Management Boxes

Figure 3. Outdoor Unit Zero Waste Management Containers

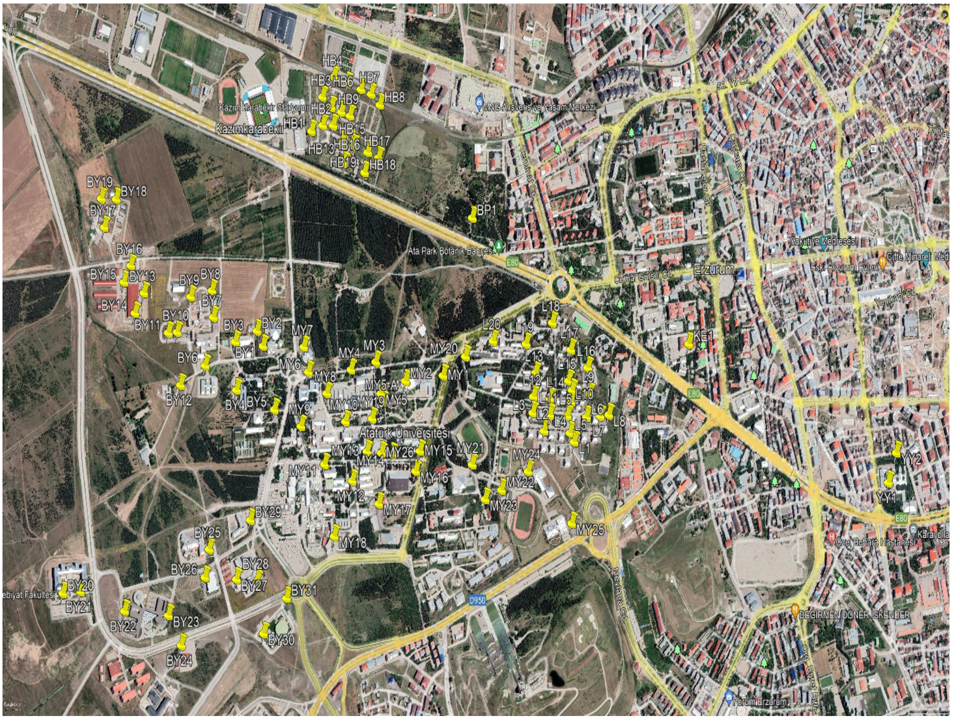

Figure 4. Positions of containers in the study area

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IMPROVEMENT OF THE HYDROPHOBIC PROPERTY OF PET POWDER MADE FROM WASTE

Emine Özlem Dengiz[1,2*] , Mevlüt Gürbüz[2]

ABSTRACT

Polyethylene terephthalate (PET), one of the plastics that we encounter the most in our daily lives and that we use the name the most, constitutes 18% of the plastic production in the world. With a relatively high melting point, PET has a hard and rigid chain backbone that is difficult to bend. For this reason, it has high strength, high toughness, and high resistance to fatigue up to 150°C. PET, which has low specific gravity, can be either ground-hard or full-hard depending on the thickness from which it is produced. PET, which is durable plastic, is also resistant to impact. Besides having good mechanical properties, it is a good barrier to gases, solvent chemicals, and alcohols. Therefore, textile, food and beverage packaging, industrial filtration, photography, electrical industry, automotive, etc. It has a wide range of uses such as fields. Having such a wide usage area, PET has an easily recyclable structure.

Hydrophobic surfaces are surfaces with high water repellency. This property of the surface is measured by the magnitude of the contact angle of the water to the surface. If the contact angle is greater than 90°, the surface is hydrophobic, if the contact angle is between 150-180°, the surface is superhydrophobic. The liquid droplet stays on the surface in a spherical structure. Thus, it is possible to prevent wetting and fogging on the surfaces and create self-cleaning surfaces. Studies carried out to impart hydrophobic properties to surfaces aim to increase the contact angle. Such applications have taken their place in many fields today.

This study, it is aimed to reuse PET wastes by increasing their hydrophobic properties. For this, talc powder and silica powder were added to the waste material, which was ground into powder, at different rates. The powder solution homogeneously dispersed in the solvent was coated on the glass substrate surface by the spray method. The samples subjected to heat treatment at 360°C were allowed to adhere to the glass surface. The contact angle measurements were carried out by performing the drop test. As a result of the measurements, it was observed that while the contact angle on the untreated PET material surface was 53°, the droplet contact angle increased to 113° with the contribution of 20% talc and 10% silica of the material that gave the best results.

Keywords: Hydrophobic Surfaces, Polyethylene Terephalate Waste, Powder, Coating

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1. INTRODUCTION

Polyethylene terephthalate, which accounts for 18% of the world's plastic production, ranks third after polyethylene and polypropylene. Polyethylene terephthalate, one of the plastics we encounter most in our daily lives and that we use the name the most, is commonly referred to by the abbreviation PET. However, PETE, PETP or PET-P are also used for polyethylene terephthalate. PET from the polyester group is a linear thermoplastic polymer. PET materials, shaped mainly by thermoforming method, can be composed of pure PET polymer. In some applications, they can be reinforced with glass fiber and used as a structural material in engineering applications. PET, the most important commercial polyester, was first introduced in 1944.

PET has a hard and rigid chain backbone with a very high melting point of 270°C. For this reason, it has high strength, high toughness and high resistance to fatigue up to 150°C. PET with a low specific gravity can be semi-rigid or full-rigid, depending on the thickness from which it is produced. PET, which is durable plastic, is also resistant to impact. Besides having good mechanical properties, it is an excellent barrier to gases, solvent chemicals and alcohols. Although its moisture barrier property is not that good, it still remains sufficient next to other plastics. Thanks to its strong barrier properties, PET, which is frequently used in plastic bottles, can be used to create a better barrier by forming a composite with polyvinyl alcohol in cases where oxygen permeability is critical.

45% of synthesized PET plastics are used in fiber applications. PET fibers are very resistant to wrinkles and abrasion. In addition, it is processed by cross-linking and has permanent anti-wrinkle properties. Better resistance to moisture and a natural feeling is created in the textile product used by mixing with cotton or cellulose-based fiber. PET produced as a fiber is used in curtains, clothing, upholstery fabrics, rubber strips and industrial filtration processes. Thanks to the successful gas barrier feature of PET, 10% of the produced PET polymer is used in the food and beverage packaging industry, especially in bottling. PET polymer used in film applications is mainly used in photographic films, magnetic and X-ray tapes and electrical insulation applications. In addition to these areas of use, PET is also widely used in electronic devices, office equipment and automotive parts, replacing metals such as steel and aluminum in some engineering applications. PET used in such engineering applications is generally doped with glass fiber, silicon, graphite, or Teflon further to increase its strength and hardness [1].

PET, which has such a wide area of use and has a very high annual production amount, can be recycled 100% and repeatedly. Many organizations in the world continue to work for the recycling of PET materials. The Organization for Economic Cooperation and Development (OECD) stated that only 9 percent of existing plastic waste worldwide is successfully recycled. It is stated in the report that worldwide plastic production, which was 234 million tons in 2000, reached 460 million tons in 2019. The report noted that only 9 percent of plastic waste is successfully recycled after accounting for losses during recycling. While 19 percent of global plastic waste is incinerated, about 50 percent goes to landfills, and the remaining 22 percent is dumped in uncontrolled landfills or the environment; the report states that plastics accounted for 3.4 percent of global greenhouse gas emissions in 2019. It has been stated that it is responsible [2].

Recycled PET (rPET) is used for numerous applications. From reusable carry bags to roof insulation, there are recycled plastics all around us. Carpet companies use recycled fibre to make polyester carpets. PET is spun into fibre filling for pillows and quilts. Fibre is also used to make clothing, jackets and even polar fleeces. PET bottles may even reappear in the form of non-woven automotive carpets. Retailers use rPET in pillows, duvets and reusable shopping bags; automotive manufacturers use rPET in boot linings and carpets; architects and designers use rPET in the form of roof insulation; clothing designers use rPET in the manufacture of clothing – like jeans, fleece jackets, and sophisticated sportswear; engineers use rPET in industrial applications, such as strapping, geotextiles for buildings, dams, power stations and tunnels; brand owners use rPET as a blend in new bottles [3].

One of the European Green Deal priorities includes improving waste management. Accordingly, longer-lasting products that can be repaired, recycled and reused have been identified as one of the beneficial outcomes of this priority [4].

The 'Global Goals for Sustainable Development' movement, which includes the goals aimed to be achieved by the member states of the United Nations by the end of 2030, has also included the issue of waste management among its priorities. Within the scope of the 12th target, responsible production and consumption, it is aimed to significantly reduce solid waste generation by 2030 through prevention, reduction, recycling and reuse [5].

When it comes to smart surface, the first thing that comes to mind in the world of science and technology; features such as self-cleaning, water retention or non-water retention. These features, which are structurally found in some living things in nature, provide them with opportunities such as survival and facilitating their lives. For example; Large marine animals such as sharks expend more energy while swimming due to small fish and algae sticking to their skin. However, this situation disappears due to the water and dirt repellent properties of their skins. As another example, some insect species living in deserts that receive very little precipitation per year continue their lives due to their water-holding properties, and can always remain clean and dry despite living in polluted lakes and waters due to the water-repellent feature of a lotus flower tissue. Inspired by the structural features of these living things in nature, scientists try to impart these features to some organic and inorganic substances. At the beginning of these works that will make people's daily lives easier; hydrophobic (water-repellent) and photocatalytic (self-cleaning) surface applications are coming.

Surfaces that love water are described as hydrophilic. These types of surfaces are generally charged and attract water molecules thanks to the polar group in their structure. Surfaces that do not like water are called hydrophobic surfaces. The magnitude of the water-to-surface contact angle is a measure of whether the surface is hydrophobic or hydrophilic. In this context, as the contact angle increases, the water dislike feature of the surface also increases and it leads to being superhydrophobic. If the water droplet tends to stay spherically on a surface, that surface is a hydrophobic surface. The geometric shape of the water drop is measured by the contact angle. If the contact angle is less than 90°, the surface may get wet and such surfaces are called hydrophilic. If the contact angle is greater than 90°, the surface is hydrophobic and not wetted by the liquid. The water droplet stays on the surface in a slightly spherical structure. If the contact angle is between 150-180°, the surface is superhydrophobic. Here, the water droplet stops without spreading to the surface like a ball in a spherical shape or leaves the surface by rolling. Most of the time, when leaving the surface, it drags dust and small particle structures on the surface with it. This gives hydrophobic surfaces the ability to self-clean. The slip angle determines whether a surface is self-cleaning in addition to its hydrophobic feature. For the water drop to roll, the angle given to the surface must be less than 5°.

The hydrophobic feature is used in many areas and studies are being carried out on new application areas. In the textile field, clothes that do not repel dirt, do not get wet and can clean themselves are produced. Hydrophobic liquids provide waterproofing and protection against scratches in electronics. Thin films are produced and offered for use in order to prevent fogging of glass surfaces and to ensure self-cleaning. Stone, wooden and ceramic surfaces, thanks to their hydrophobic feature, bead up the liquids spilled on them and prevent the surface from absorbing the liquid. Moisture, mold and stain formation are prevented. The dust accumulated on the surfaces is cleaned by falling rain or water. In the automotive sector, it is ensured that the scratches on the surfaces of the vehicles are removed and the paint is protected. In addition to these, it is applied in many other areas [6].

Various studies are carried out to create a hydrophobic surface or to increase the characteristic of the existing hydrophobic surface feature. These studies are laser surface treatment and coating processes with different techniques. Coating processes, on the other hand, are divided into many different branches in terms of method. These methods are; electrospray, spray pyrolysis, chemical vapor precipitation, thermal evaporation, homogeneous precipitation, hydrothermal and sol-gel methods.

In a study by Wu et al., the improvement of the hydrophobic property with the sol-gel coating method, as well as the effect of some chemical and morphological modifications on the sol on the hydrophobicity, were investigated. The addition of silica filler at 47% increased the contact angle from 89° to 123° and improved the hydrophobic property [7].

B.S. Yılbaş and his colleagues conducted experiments on increasing the hydrophobic property by laser processing on the alumina (Al2O3) surface. As a result, laser gas texturing increased the hydrophobicity [8].

Kulinich et al., in this study, presented a comparative analysis of the hydrophobic behaviour on smooth and rough surfaces coated with fluoroalkyl siloxane (FAS-17 and FAS-13) and octadecyl siloxane (ODS) monolayers. Accordingly, CF3 has increased the contact angle to a high value, 120°, compared to the others. The lowest contact angle value is seen in CH2 [9].

Lefebvre et al., In their study (Dry coating of talc particles with fumed silica: Influence of the silica concentration on the wettability and dispersibility of the composite particles), provided an increase in the hydrophobic properties of the surfaces by physically coating the silica particles and talc particles with the dry coating method. Depending on the concentration of silica particles, the contact angle increased from 53.3° to 133.4° [10].

The electrospray method is also encountered in the literature as electrostatic atomization and electrohydrodynamic atomization. The electrospray method is a coating technique used to produce micro- and nano-level drops of ceramic suspensions and to obtain thin films by spraying them on the substrate. The purpose of using this technique is to obtain a homogeneous thin film layer to be applied on the substrate and to spray the prepared ceramic suspension in very small sizes. Today, the use and research of nanostructured materials in materials science are increasing. Thanks to this technique, materials with porous nano-sized different surface properties are produced from very dense materials depending on the storage conditions. The surface properties of the materials obtained in film coating depend on the prepared starting sol, coating temperature, size and size distribution. High temperature coating and metal alkoxide, metal acetate sols are preferred to produce high porosity nanostructured thin films.

Compared to other methods, chemical vapour deposition (CVD), physical vapour deposition (PVD), and plasma spray, this method has advantages such as easy experimental setup, fast film production, working under atmospheric conditions, and being economical.

This study aims to create more functional products from waste materials. In this context, powdered waste PET bottles were given hydrophobic properties and coated on glass surfaces by electrospray method and surface characterization was carried out.

2. MATERIAL AND METHODS

2.1. Materials

The matrix element of the surface coating material consists of PET powder. Additives have been added to the PET material to give it hydrophobic properties. These substances are given below along with their chemical and physical properties.

Talc ($Mg_3Si_4O10(OH)_2$): It is a mineral composed of hydrated magnesium silica. It is a chemically inert substance with a lamellar structure, showing hydrophobic properties [11].

Silicon dioxide (SiO_2): Also known as silica, it is a chemical compound containing oxygen and silicon.

2-Propanol: Isopropyl alcohol (IUPAC name propan-2-ol and also called isopropanol or 2-propanol) is a colorless, flammable organic compound (chemical formula $CH_3CHOHCH_3$) with a strong alcoholic odor [12].

2.2. Methods

In the experiment, first of all, PET wastes should be made suitable for use as coating material. For this, pet wastes are divided into small pieces for convenience in the melting process. It was heated in an oven heated to 320°C in a heat-resistant container (aluminum foil, which was given a hollow form in the experiment) until it ultimately transitioned to the liquid phase (approximately 5 minutes). The melted PET material is taken from the furnace and cooled to room temperature. The cooled material can be easily removed from the aluminum foil.

It is then ground in a ring mill to be pulverized. For this process, PET particles are thrown in a size that can fit into the metal container. The metal roller container placed in the ring mill is securely clamped. Grinding is carried out in the mill for 10 seconds. When the grinding process is completed, the powdered PET is taken out of the container. A fine powder is obtained by passing through a sieve below 200 µm in a vibrating sieving device. Talc powder and SiO_2 powder were mixed in various proportions into the PET powder, which was brought to the desired particle size. These ratios are given in Table 1 by weight. Accordingly, in the first mixture, 10% of the amount of talc and 5% of SiO_2 were added, while in the second mixture, talc that corresponds to 20% of the amount of PET material and SiO_2 that corresponds to 10% was added.

Table 1. Ratios of powder materials.

Material	PET	Talc	SiO2
Amount (g)	10	1	0,5
			1
		2	0,5
			1

For the powder mixture to be sprayed onto glass samples with a spray gun, it must be dispersed in a liquid. The liquid used should have high volatility and not form chemical compounds with these materials. For this, the 2-Propanol liquid is preferred. A ball mill was used to mix powder materials and solvent liquid as homogeneously as possible. 20 ml of 2-Propanol liquid was put into the glass bottle where the mixing would occur. Then, the balls that will provide the mixing process were added to the bottle. Powder materials were also added and taken to the shaking process for 10 minutes in the ball mill. For the electrospray coating process, the suspension filled in the gun chamber was sprayed on the glass samples. Glass samples coated by spraying were left to dry. The coating process was applied in two layers. When the applied mixture dried, it formed a thin layer on the glass sample. However, it is not permanent as it can be easily wiped off the glass in this state. In order to ensure that the coating adhered to the glass sample, it was melted on a heating plate at a temperature of 360°C and closed to the atmosphere. The glass sample is covered with a heat-resistant material, such as a glass beaker. The temperature was gradually reduced on the heating plate for the melted layer to pass into the solid phase and become a coating layer. This process was carried out again close to the atmosphere. In this way, it is prevented that the glass and coating material from interacting with the outside air, cooling very quickly and causing cracks. The cooling coating forms a layer on the glass sample. The experimental design stages are briefly given in the diagram shown in Figure 1.

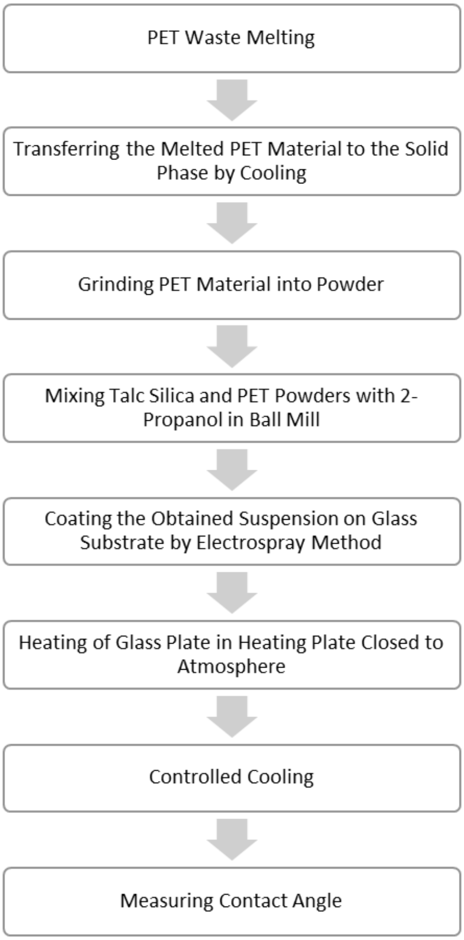

Figure 1. Experimental design

3. RESULT AND DISCUSSION

The hydrophobic property of the obtained material is measured by the drip method. With the help of a syringe, water drops of equal size are dropped on the sample each time. The contact angles of the water droplets, from which a vertical photographic image is obtained, can be easily measured. Measurements of contact angles were made in the Autocad program. Figure 2 shows the water droplets dripping onto the surfaces coated with uncoated and doped PET at different rates.

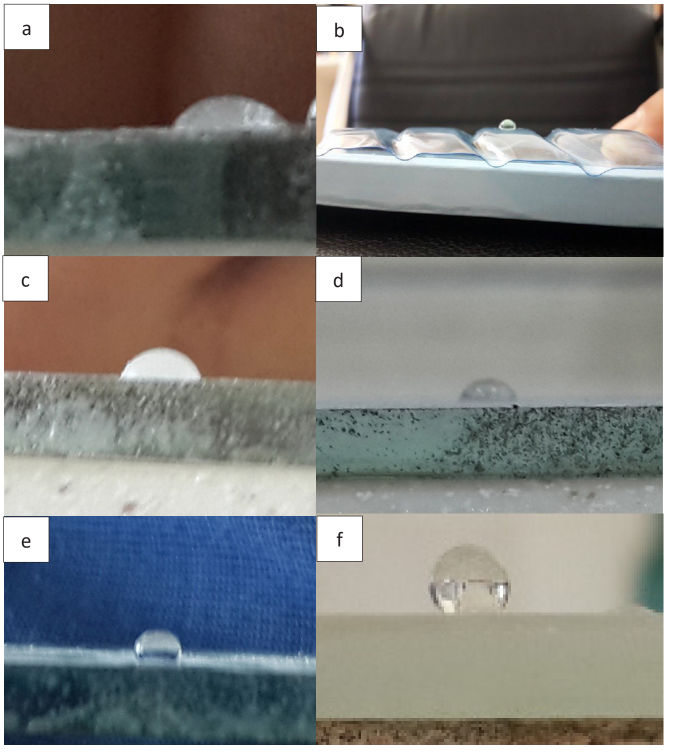

Figure 2. (a) PET coated on glass sample, (b) untreated PET bottle surface, (c) 10% Talc and 5% Silica added PET surface, (d) 10% Talc and 10% Silica added PET surface, (e) % 20 Talc and 5% Silica added PET surface, (f) 20% Talc and 10% Silica added PET surface.

The surface of the glass sample seen in Figure 2a is covered with molten PET material. When the contact angle was measured, it was 49°. Figure 2b shows the untreated PET packaging surface. The contact angle of this surface was measured as 53°. If the two surfaces have to be evaluated, the hydrophobic property of the molten PET structure has decreased compared to the initial situation. The contact angle difference between them is 4°. Figure 2c shows the contact angle of the water droplet dropped on the PET surface doped with 10% Talc and 5% Silica. This contact angle was measured as 65°. Figure 2d shows a water droplet dripping onto the PET surface with 10% Talc, and 10% Silica added. The measured contact angle is 73°. Figure 2e shows the PET surface doped with 20% Talc and 5% Silica. The contact angle of the water droplet measured on this surface is 109°. Finally, 20% Talc and 10% Silica doped PET surface is shown in Figure 2f. The contact angle on this surface is 113°. These contact angle values are given in Table 2.

Table 2. Contact angle values between surface and liquid drop

Material	PET	Processed PET	%10 Talc %5 Silica (TS1005)	%10Talc %10 Silica (TS1010)	%20 Talc %5 Silica (TS2005)	%20 Talc %10 Silica (TS2010)
Contact Angle (°)	53	49	65	73	109	113

4. CONCLUSION

In this study, waste PET bottles were collected to form solid particles, doped with SiO2 and talc powders, and recycled coating material with hydrophobic properties was produced. Optimum additive ratios were determined by applying contact angle measurements to the produced coating material. The greatest contact angle value occurred in the material with 20% talc and 10% silica additives. While the contact angle measured on the surface of the PET material before processing was 53°, the best contact angle value reached 113°.

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COMPOSITE PRODUCTION WITH HEMP AND BANANA FIBERS MODIFIED WITH BORIC ACID

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ABSTRACT

Many problems such as the increase in the world population and therefore the increase in global drought and greenhouse gases have caused the materials used in industries to be reconsidered. Thus, the concept of green composite emerged. Environmental friendly materials play an important role in the building materials market. To obtain such materials, various additives such as natural fibers are used to strengthen composite material typologies. In this project, gypsum was determined as the main material. The main reason for its use is that it is cheap and suitable for use in many applications such as non-flammability and decoration for the internal structure system. Organic fibers are preferred as additive material. It is aimed to use natural organic fiber additives. It is aimed to produce green biocomposite by adding such natural fibers to gypsum composite. It is aimed to perform thermal conductivity and microstructure analyzes of the composites to be obtained in this study. Since organic fibers of natural origin are used, it has both sustainable and recyclable features at its advantages. The positive results and comments that can be obtained in line with the study results will be a guide for natural fibers to replace synthetic fibers.

Keywords: Hemp Fiber, Thermal Properties, Microstructure, Gypsum Plaster

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1. INTRODUCTION

Gypsum is widely used as a coating material in the construction and building industry due to its excellent performance, ease of application, fire resistance and environmental friendliness. The reasons for choosing plaster as the main material in the study; due to its low cost, availability. Many applications in buildings are the reasons such as light weight, good heat and sound insulation behavior, fire resistance and low energy consumption.

Gypsum plaster is more sensitive to impacts, although it can be subjected to loads, it can damage other building components. In addition, at the fire resistance point properties need to be developed [1-2]. To overcome such limitations, plaster and all binders are often reinforced. Fibers of synthetic origin (glass, polyamide, etc.) are used as such reinforcement materials. The aim of this project is to use natural fibers. The reason for this is global drought and many kinds problems, such as the increase in greenhouse gases, have caused the materials used in industries to be reconsidered. The concept of green composite emerged in this way, especially in the last recent years, products and processes of this type of composites have been investigated in all sectors. One of the most important of these sectors is the building sector and building materials. Environmentally friendly materials play an important role in the building materials market. To obtain such materials, natural fibers are used to strengthen composite material typologies. Among the natural fibers that can be used are hemp, palm, straw fibers, and varieties such as short cellulose. Especially when used as a green additive material in hemp fiber studies, it showed good performance in mechanical and physical properties [3-4].

Hemp fibers, from the hemp plant under the genus hemp. The resulting pot is considered one of the strongest member of the natural fibers family. Today, these fibers are biodegradable compared to artificial fibres, and due to their low density or etc. It has gained wide acceptance as a supplement in materials. In addition, these materials have natural mechanical, thermal and acoustic properties. Surface functionalization of hemp fibers, essential for expanding its applications. Banana fiber is also one of the strongest natural fibers in the world. Biodegradable, natural fiber of the banana tree. It is made from the trunk and is incredibly durable. Banana fiber is similar to natural bamboo fiber, but its spin ability, fineness and tensile strength are better. Banana fiber is also used in textiles in different weights and thicknesses, depending on where the fiber is extracted from different parts of the banana stem [5].

The advantages such as low cost, low density and recyclability of materials such as hemp and banana fiber, which are intended to be used in this study, show that they can replace synthetic fibers used in building materials. The use of hemp fibers grown in the Black Sea Region and supplied from the Hemp Research Institute of OMU and additives in the composite material investigation of its effect on material properties is one of the original values of this study.

2. MATERIAL AND METHODS

Before applying chemical modification to the surfaces of the fibers, the same dimensions were cut to certain sizes. The purpose of surface modification of fibers is to perform chemical modifications on the surface to increase the bond strength between the fiber and the matrix without affecting the basic properties of the fibers. In this study, the fibers were modified with boric acid solution. Then the drying process was carried out.

In this study, gypsum-fiber mixture was prepared in accordance with TS EN 13279-1 standards. Gypsum water ratio is 0.6 and fiber additive ratios were selected 1, 3, 5 wt. %. Thermal conductivity and microstructure analyzes were performed on the produced composites. Produced different sizes of samples are shown in Fig.1.

Figure. 1. Different size of gypsum composite samples

3. RESULTS AND DISCUSSION

3.1. Thermal Conductivity and Microstructure Analyzes of Gypsum-Fiber Composites

The thermal conductivity of the composites was measured according to the TS EN 13279-2 standard. In addition, the dimensions of the thermal conductivity test samples are 40 x 40 x 160 mm, and this analysis was made using the KD2 PRO thermal conductivity device. Thermal properties give important information about soil, lime, cementitious, gypsum or other porous materials.

The thermal conductivity results of hemp and banana fiber reinforced composites are shown in the Fig. 2. According to the results, it was observed that the thermal conductivity of the fiber-doped samples decreased compared to the pure sample. The main reason for this is that hemp and banana fibers have low thermal conductivity compared to pure gypsum. This guides the use of natural fiber reinforced gypsum boards as thermal insulation materials in buildings.

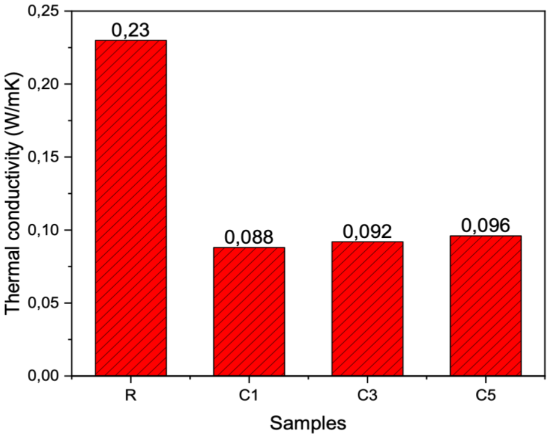

Figure 2. Thermal conductivity result of reference and composite samples

SEM images of composites are shown in the Fig.3. It can be seen from the figure, as the fiber fiber ratio increases, the porous structure increases, the heat is trapped in these spaces and the thermal conductivity value decreases. It is also seen that the fibers added to the composite after chemical modification to the fibers establish a better interface interaction with the matrix due to the surface roughness.

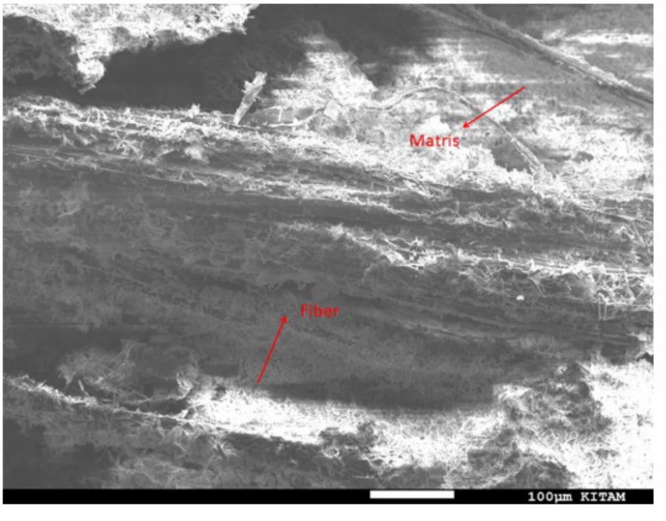

Figure 3. SEM images of gypsum-fiber composite

4. CONCLUSION

The aim of this study is to produce a natural green biocomposite insulation material by using recyclable hemp and banana fibers, which are recovered from nature and have many contributions, in different proportions, instead of synthetic fibers that are harmful to nature and cannot be recycled. The thermal conductivity of fiber-doped samples decreases and it is observed that a hollow structure is formed. 1% fiber reinforced gypsum composite gave the best result with 0.088 W/mK compared to pure gypsum (0.23 W/mK).

It is important for sound insulation that the fibrous structure creates a void. It is thought that the sound insulation of the composite may also be low. In terms of being sustainable, we think that the use of fibers obtained from nature and the use of these fibers will be an economic and environmentalist approach to our country. This study can be a project that will guide people towards guiding and exemplary thoughts about the use of natural fibers.

ACKNOWLEDGEMENT

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INVESTIGATION OF LUBRICATION PERFORMANCE OF NANO-PARTICLE ADDED WASTE OILS

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ABSTRACT

Friction at the interface of the die and the workpiece is an important parameter. For this reason, it is important to investigate and control the friction at the interface. This study investigated the effect of different lubricants on the friction coefficient with the ring compression test. The aim is to find the oil with a better friction coefficient than the others. It is planned to compress the aluminium rings in a hydraulic press machine under dry conditions with vegetable oil, motor oil, and nanoparticle-reinforced waste oil (nano-oil), respectively. For the preparation of nano-oil, silicon oxide was added to waste vegetable oil at additive ratios of 1%, 3% and 5% by weight. The mixture was mixed first mechanically and then in an ultrasonic mixer. Then, the compression process was applied to the rings under 320 bar pressure. The lubrication performance of the lubricants was determined in the Male and Cockroft friction calibration curves according to the size changes of the compressed rings. The highest friction coefficient was detected in the dry ring, and the lowest friction coefficient was detected in the 5% nano oily ring. The friction coefficient of the ring lubricated with 5% nano oil is 93.7% lower than in dry conditions. As a result, the friction coefficient values are as dry conditions, vegetable oil, 1% nano oil, motor oil, 3% nano oil and 5% nano oil, from largest to smallest.

Keywords: Friction, Lubricant, Ring Compression Test, Waste Oil

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1. INTRODUCTION

During metal forming, contact occurs between the die and the workpiece. As a result of these contact events, friction forces occur. Friction significantly affects the quality of the product, production speed, and wear [1-2]. For this reason, it is necessary to determine the friction conditions at certain limits. However, it is complicated to determine the friction conditions between the die and the workpiece. Because the friction magnitude changes depending on the location and time in the contact area [3].

Many methods (ring compression, double cup extrusion, barrel compression test, etc.) have been developed to simulate friction during forming [4]. The ring compression test is the most commonly used of these methods. With this test, the lubrication properties of different lubricants can be determined under friction conditions. The method is based on the size variation of the compressed rings. Because these changes create sensitivity to friction in the contact area [5]. If the material flows inward when the ring is compressed, the inner diameter becomes smaller, and the friction increases. If the material flows outward, the inner diameter becomes larger and the friction decreases. Using these size changes, the friction coefficient is determined by the friction coefficient calibration curve developed by Male and Cockroft, shown in Figure 1 [6].

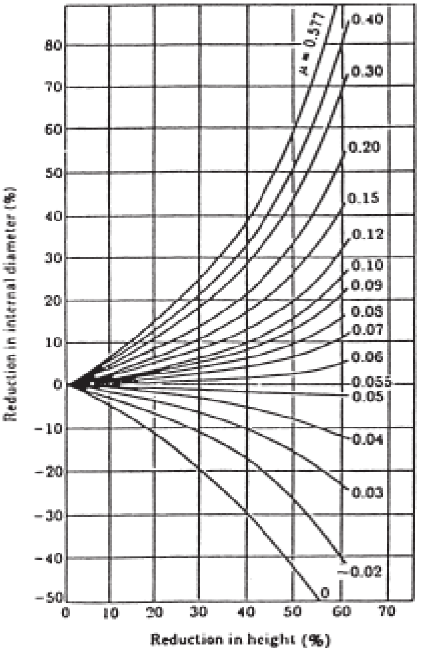

Figure 1. Friction calibration curves [6]

There are many studies in the literature on the determination of lubricant properties and the comparison of friction coefficients of different oils. Sofuoglu and Rasty investigated whether the coefficient of friction curves used with ring compression tests are valid for all materials and test conditions [6]. As a result of the tests, it has been determined that it is not correct to use the general friction coefficient calibration curve for each material. For this reason, it is recommended to use calibration curves created according to test conditions and material to determine the friction coefficient. Valero et al. determined the differences in the calibration curves under different load and lubricant conditions applied during the ring compression test [7]. They used two methods: lubrication at the beginning of compression (continuous) and at the end of each compression (incremental). As a result, they suggested using the incremental method if the lubricant layer will remain constant, and the continuous method if the lubricant layer will not remain constant. Ma et al. developed a new method for determining the friction coefficient of magnesium (Mg) alloy sheet [8]. The bulging test is applied to the sheet metal processing with a hole in the center. It has been determined that the friction coefficient between the punch/piece can be calculated by increasing the hole diameter. Pang and Ngaile developed a new method to disperse SiO_2 nanoparticles into the oil [9]. The distribution and tribological properties of the oil were investigated by dynamic laser scattering and ring compression tests. The dispersion process based on hydrodynamic cavitation is quite effective. As a result, it has been determined that the lubricating properties of nano-oils are increased by decreasing the particle size and increasing the dispersion time. Rajesh and Sivaprakash applied the ring compression test to aluminum rings in dry, graphite, zinc stearate, and MoS_2 conditions [10]. The friction coefficients of the lubricants were determined according to the size change of the rings. The lowest coefficient of friction was determined in MoS_2, Zinc stearate, and the highest coefficient of friction was determined in dry conditions.

In this study, ring compression tests applied to dry, motor oil, vegetable oil, and nano oil (1, 3, and 5%) rings. Size changes were calculated as a result of the tests. The coefficient of friction of these six conditions was determined according to the size changes.

2. MATERIAL AND METHODS

2.1. Material

In this study, motor oil, vegetable oil and silicon oxide (SiO_2) nanoparticles and oleic acid added vegetable oil were used. The general properties of the materials used are given in Table 1.

Table 1. General properties of materials

Material name	General properties	Purpose of usage
Vegetable oil	• It is a type of oil obtained from plants. • The most important plants used in their production are soy, canola, olives and peanuts.	• They are used in food and for cooking purposes.
Motor oil	• It is a fluid used to reduce heat and wear caused by friction.	• It is used to lubricate, clean and protect the parts inside the engine.
Silicon oxide	• It is a transparent or translucent, hard and brittle inorganic substance. • It is a fine white powder consisting of silicon oxide particles with a diameter of 10-30 nm. • It is divided into two structural types, porous P-type silica and spherical S-type silica.	• It is generally used for thickening and strengthening.
Oleic acid	• It is a fatty acid naturally found in various animal and vegetable oils. • It is odorless and colorless. • Oleic acid is the most common monounsaturated fatty acid in nature.	• It is used as an ingredient in soaps and foods. • It is also used as a solvent.

Aluminum alloy rings were preferred to perform the tests. Aluminum and its alloys are frequently preferred in engineering applications due to their low density (2.7 g/cm_3), good modulus of elasticity (68.3 GPa), and advanced tribological properties [11]. The aluminum alloy rings have an outer diameter of 15.30 mm, an inner diameter of 7.60 mm, and a height of 5.12 mm (Figure 2).

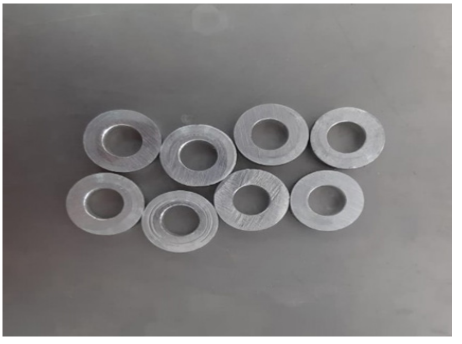

Figure 2. Aluminum alloy rings

2.2. Methods

Nano oil preperation method and the ring compression test are illustrated in Figure 3. Firstly, 100 ml of waste oil and different weight ratios (1, 3 and 5%) of silicon oxide were mixed mechanically for 5 minutes. In order to obtain a homogeneous distribution, oleic acid (0.5% by weight) used as a surfactant was added to the mixture. Afterward, the dry and immersed rings in different oils (vegetable oil, motor oil, and nano oil) were compressed in a press machine under 320 bar pressure. Percent changes of the inner diameter and height of the compressed rings were calculated. Finally, the friction coefficients of the oils were determined from the Male and Cockroft friction calibration curves.

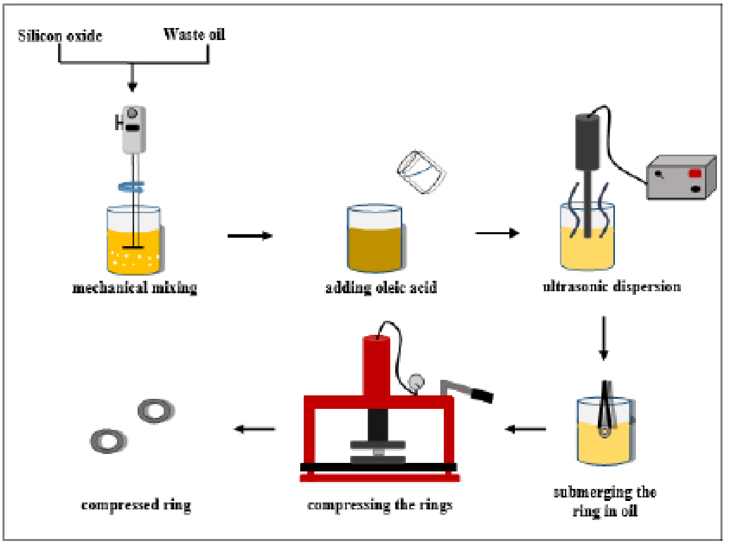

Figure 3. Nano oil preperation method and the ring compression test

3. RESULT AND DISCUSSION

The lubricant directly affects the friction between the die and the workpiece interface. The ring compression test is the most common and reliable test method for contact friction. According to the geometric variation in the test results, the friction coefficients of different oils can be determined with the Male and Cockroft friction calibration curves. The inner diameter and height changes of the compressed rings are given in Table 2. The greatest change in inner diameter and height was determined in the ring compressed under dry conditions.

Table 2. Size variation of the rings

Test Condition	Change in Inner Diameter (%)	Change in Height (%)
Dry	23,92	34,27
Vegetable oil	18,59	33,80
Motor oil	-3,27	26,02
%1 nano oil	-3,27	26,03
%3 nano oil	-4,21	23,43
%5 nano oil	-6,87	26,98

The friction coefficient values obtained according to these changes are shown in Figure 4. The friction coefficients of the dry (0,35) and vegetable oiled (0,25) rings are close to each other. However, the friction coefficients of the motor oiled (0,03) and nano oiled rings (%1=0.035, %3=0.0028, %5=0.022) are lower than the others. This depends on the way the aluminum rings are lubricated. If the oil fills the inside of the ring, the inner diameter expands with the compression of the ring. These results indicate that the friction between the die and the workpiece can be reduced with the proper lubrication.

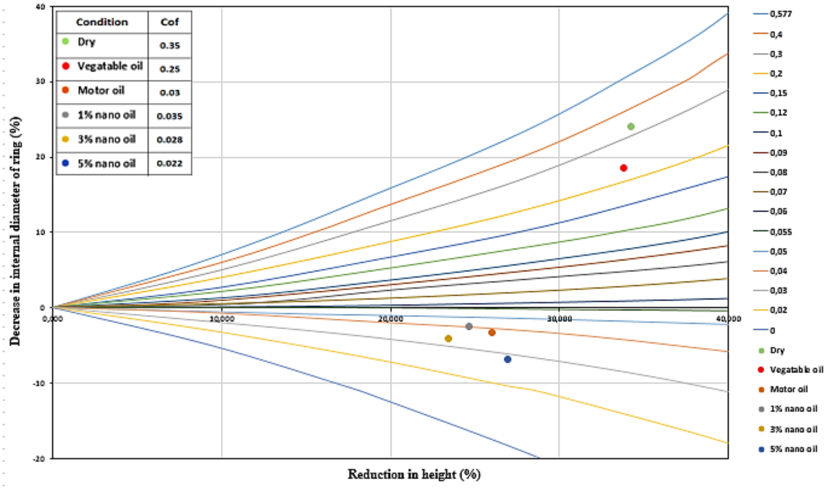

Figure 4. Coefficients of friction under different conditions

4. CONCLUSION

In this study, the lubricating properties of dry conditions, vegetable oil, motor oil, and nano oil were determined by ring compression test. Aluminum alloy rings were used during the experiment. According to the test results, the ring compression test greatly contributed to determining the effect of different oils on the friction coefficient. The results of the study are presented below:

- The highest (μ= 0.35) and lowest (μ= 0.022) friction coefficient values were determined in the dry ring and 5% nano oil, respectively.
- The friction coefficient of the rings lubricated with vegetable oil and motor oil is 25.8% and 91.2% lower than the dry ring.
- In addition, the friction coefficient of the rings lubricated with 1%, 3%, and 5% nano oil is 90%, 92%, and 93.7% lower than the dry ring.
- As a result, the coefficient of friction values is as dry conditions (0.35),*000 vegetable oil (0.25), 1% nano oil (0.035), motor oil (0.03), 3% nano oil (0.028) and 5% nano oil (0.022), from largest to smallest.
- The best lubricating properties have been obtained in nano oils.

As a result, lubricant properties can be determined by the ring compression test and comparisons can be made between oils.

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