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A Review Article on Mineral Nutrition and Fertilizer Management of Cereal Crops

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Abstract

This article was conceptualized to provide the readers other options and easy access to review the basics aspects of plant nutrition and fertilizer management of cereal crops. This article provided a brief overview of the plant mineral nutrition and fertilizer management in cereal crops. The concept behind the 17 essential elements the macronutrients and the micronutrients needed by the cereal crops. The nutrient elements are absorbed by plants primarily in ionic form from the soil. Nutrients can be taken up and distributed equally in straw and grain of the cereal crops. Thus, soils must therefore be replenished with those nutrient elements in the form of fertilizers. To have a basis for fertilizer application, the fertility status of the soil must be determined. Once the soil test results indicate the need for supplemental fertilizer, one must know how to calculate the amount of fertilizer needed and select the right one to avoid wastage and minimize costs. It needs to familiarize the fertilizer recommendation rate that will fit specific cereal crops and their ecosystems. Its cropping season, the effectiveness of the crop to use specific kind and availability of fertilizers in the market and financial resources of the farmer.

Keywords: Mineral nutrition, cereal crops, crop development, and nutrient essentiality

Research article
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INTRODUCTION

Worldwide, cereal crops are mostly grasses grown for their edible seeds and cultivated in more significant quantities than any other type of crops. It can provide more food energy to the human population and feeds to the animals. Examples of cereal crops are rice (*Oryza sativa* L.), wheat (*Triticum* L.), barley (*Hordeum vulgare*), oats (*Avena sativa*), rye (*Secale cereale*), corn (*Zea mays*), grain sorghum (*Sorghum bicolor*), and millet (*Pennisetum glaucum*). These cereal plants need essential nutrients to live and grow healthy, just as the human body needs vitamins and minerals. There are 17 mineral nutrients supplied solely by the soil.

They are divided intotwo groups according to the amounts required, namely, the macronutrients, which are Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), P hosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and Sulfur (S), and the micronutrients which are Boron (B), Copper (Cu), Iron (Fe), C hlorine (Cl), Manganese (Mn), Molybdenum (Mo), Nickel (Ni) and Zinc (Zn) (Roy et al., 2006).

Under natural conditions, these mineral nutrients are dissolved in water and absorbed through the plant's roots, and recycled to the soil through plants` herbage. However, crops demand more nutrients under crop production than natural vegetation (Biller et al., 2017). Supplemental nutrients are needed to satisfy the plant's needs, which canbe achieved by applying fertilizers.

Fertilizers, which can be organic or inorganic, provide plants with nutrients needed to grow healthy and strong. However, they contain different ingredients, and the number of nutrients present is in different ways. To have a basis for fertilizer application, the fertility status of the soil must be determined. Once the soil test results indicate the need for supplemental fertilizer, one must know how to calculate the amount of fertilizer needed and select the right one to avoid wastage and minimize costs. This paper was conceptualized to provide the reader's options and easy access to review plant nutrition in cereal crops.

THE CONCEPT OF CROP`S MINERAL NUTRITION

In plants, nutrition is defined as a synthesis of food, its breakdown, and utilization for various functions in the body. The chemical substances in food are called nutrients, *e.g.,* carbon dioxide, water, protein, fats, carbohydrates, and minerals. The elements present in the food chemical substances can be subdivided into macro and microelements. Macro-elements are required in relatively large quantities for the normal physiological processes of the plant, while microelements are required in relatively small quantities or trace amounts. Macro-elements include carbon, hydrogen, nitrogen, potassium, sodium, calcium, chloride, magnesium, phosphorus, and sulfur, while microelements include boron, chlorine, copper, iron, manganese, molybdenum, and zinc.

Table 1. presents the chemical elements that can be further divided into two main groups: non-mineral elements (C, H, O) absorbed from air and water or in the atmosphere as a component of compounds. The remaining elements are under the mineral elements, whichare absorbed by plants primarily in ionic form from the soil. Therefore, mineral nutrition can be defined as the collective processes involved in plant assimilation and metabolism of all chemical elements, except for carbon, hydrogen, and oxygen (Mattson, 2018).

Table 1. Essential elements and their functions (Adapted from NIOS, 2012)

Elements	Form in which the element is taken in	Region of the plant that requires the element	Function
The basic Nutrients are derived from air and water			
Carbon	$C0_2$	Stem and young leaves of the plant	Forms the backbone of most plant biomolecules, including proteins, starches and cellulose. Carbon is fixed through photosynthesis; this converts carbon dioxide from the air into carbohydrates which are used to store and transport energy within the plant.
Hydrogen	H_20	All tissues	Necessary for building sugars and building the plant. It is obtained almost entirely from water. Hydrogen ions are imperative for a proton gradient to help drive the electron transport chain in photosynthesis and for respiration.
Oxygen	H_20, 0_2	Leaves and root tips of the plant	A component of many organic and inorganic molecules within the plant, and is acquired in many forms. These include: O_2 and CO_2 (mainly from the air via leaves) and H_2O, NO^{-3}, H_2PO^{-4} and SO_2^{-4} (mainly from the soil water via roots). Plants produce oxygen gas (O_2) along with glucose during photosynthesis but then require O2 to undergo aerobic cellular respiration and break down this glucose to produce ATP.
The macronutrients which are needed by the plants in a larger amount			
Nitrogen, N	$NO2^-$, $NO3^-$ or $NH4^+$ ions	All tissues, particularly in meristematic tissues	Required for the synthesis of amino acids, proteins, nucleic acids, vitamins, hormones, coenzymes, ATP and chlorophyll.
Phosphorus, P	$H_2PO_4^-$ or HPO_4^{2-}	Young tissues from the older metabolically less active cells	Required for the synthesis of nucleic acids phospholipids, ATP, NAD, and NADP. Constituent of cell membrane and some proteins.

Potassium, K	K^{+}	Meristematic tissues, buds, leaves, and root tips.	Activates enzymes associated withK^+/Na^+ pump in active transport, anion-cation balance in the cells. Brings about the opening and closing of stomata. Common in cell sap in the plantcell vacuole and helps in turgidity of cells.
Calcium, Ca	Ca^{2+}	Meristematic and differentiating	Present as calcium pectate in the middle lamella of cell walls that join the adjacent cells together. Activates
Magnesium, Mg	Mg^{2+}	Leaves of the plant	Forms part of the chlorophyll molecule. Activates enzymes of phosphate metabolism. Necessary for the synthesis of DNA and RNA. Essential for binding of ribosome subunits.
Sulfur, S	SO_4^{2-}	Stem and root tips, young leaves of the plant	As a constituent of amino acids, cysteine and methionine, and someproteins. Present in coenzyme A, vitamin thiamine, biotin, and ferredoxin. Increases root development. Increases the nodule formation in legumes.
The micronutrients which are needed by the plants in a lesser amount			
Iron, Fe	Fe^{3+}	Leaves and seeds	Needed for the synthesis of chlorophyll. As a constituent of ferredoxin and cytochromes. Activates the enzyme catalase.
Manganese, Mn	Mn^{2+}	All tissues. Collects along the leaf veins.	Activates many enzymes of photosynthesis, respiration, and N2 metabolism. Acts as an electron donor forchlorophyll b. Involved in decarboxylation reactions during respiration.
Molybdenum, Mo	MoO_2^{2+}	All tissues, particularly in roots	Required for nitrogen fixation. Activates the enzyme nitrate reductase.

Boron, B	BO_3^{3-} or $B_4O_7^{2-}$	Leaves and seeds	Increases the uptake of water and calcium. Essential for meristem activity and growth of pollen tube.
Silicon (Si)			They are involved in the translocation ofcarbohydrates.
Copper, Cu	Cu^{2+}	All tissues	Component of oxidase enzymes and plastocyanin. Involved in electrontransport in photosynthesis.
Zinc, Zn	Zn^{2+}	All tissues	Component of indoleacetic acid – aplant hormone. Activates dehydrogenases and carboxylases. Present in enzyme carbonic anhydrase.
Chlorine, Cl	Cl^-	All tissues	Essential for oxygen evolution in photosynthesis. Anion-cation balance in cells.

NUTRITIONAL DISORDERS IN PLANTS

Nutritional disorders are physiological disorders in plants that affect the productivity and quality of the grain or fruit. If the minerals are not available at the right amount to plants, specific symptoms (some disease-like) appear due to the deficiency of a particular element or the presence of nutrients at levels toxic to the plant (Figure 1).

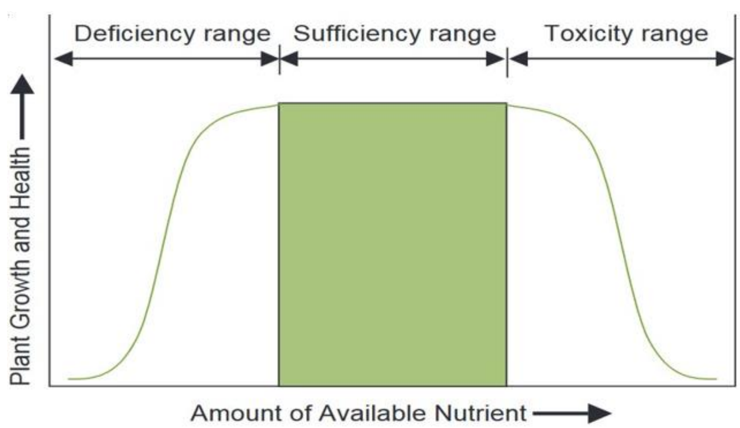

Figure 1. Relationship between plant growth and health and amount of nutrients available (Brady and Weil, 1999).

Hence, identifying between nutrient and disease disorder and preventi n g plant nutrient deficiencies and toxicities is an integral part of crop production. Symptoms are first seen in older leaves for some deficiencies and in young leaves and tissues for others (Table 2). This depends on the mobility of the nutrient. For mobile nutrients (N, P, K and Mg), deficiencies are first seen in older leaves; for immobile nutrients (Ca, B, Cu, Zn and Fe), deficiencies are first seen in the youngest leaves and growing tissue.

Table 2. Typical nutrient deficiency symptoms and general information for corrective orpreventive actions (AUSVEG, n.d.)

Nutrient Deficiency	Symptoms	Action
Nitrogen (N)	Poor plant growth; older leaves are pale green to yellow, and they eventually dry anddrop; fruit and tubers are small.	Add N fertilizer, for exampleas a side dressing before irrigation; regular foliar sprays; improve irrigation management.
Phosphorous (P)	Poor germination, seedling establishment, and plant growth; leaves may be dull bluish/greyish-green or have red pigment in leaf bases and dying leaves; oldest leaves may turn yellow and drop.	Application of phosphorus fertilizers and manure, particularly from grain-fed animals.
Potassium (K)	Older leaves have yellowing and scorching ofedges and interveinal region; lettuce heads are loose; leaves may cup; fruit maybe unevenly colored or distorted.	Increase K fertilizer rate; improve irrigation management
Calcium (Ca)	Retarded growth; roots usually affected first, becoming brown; young leaves become yellow and distorted; blossom end rot in cucurbits and tomatoes; can be confused with the physiological disorder tip burn.	Side dress with a Ca fertilizer; foliar spray susceptible crops at critical growth stages; apply lime or gypsum; existing damage is permanent.
Magnesium (Mg)	Growth retarded; chlorotic patches between the veins of older leaves; a triangle of green remains at the leaf base; leaf margins may burn.	Application of fertilizer or weekly foliar sprays; primary sources of Mg are dolomite and Epsom salts.
Sulfur (S)	Yellowing of young leaves while older leaves remain dark green; growth stunted.	Application of sulfate compounds.
Boron (B)	Bushy stunted growth and dying growing tips; corky markings on plant parts; cankered patches on roots; internal brown rot; planttissue can become brittle and split easily; hollow areas in stems.	Application of boron-amended fertilizers or boron foliar fertilizer; existing damage is permanent.

Iron (Fe)	Leaves turn yellow/bleached between veinmargins; stunting and abnormal growth; fruit may not mature.	A weekly foliar spray of iron sulfate or chelate; reduce soil pH below 7.5.
Manganese (Mn)	Yellow patches between veins; reduced flowerformation.	Root drench or weekly foliar sprays with manganese sulfate;do not over-lime.
Molybdenum (Mo)	Stunting and pale green or yellowish-green color between the veins and along the edges ofleaves; leaf tissue of margins dies; older leaves more severely affected.	Lime the soil to increase soil pH (to about 6.5, measured in water); soil or foliar applications of sodium or ammonium molybdate.
Zinc (Zn)	Plants appear stunted and pale with the creamy yellow interveinal area, death of leaf margins, deformed young leaves.	Application of a basal fertilizer Containing Zn at sowing; application of a Zn foliar spray.
Copper (Cu)	Chlorosis in young leaves; tips of leaves distorted; stunted growth.	Apply a copper fertilizer

On the other hand, an excess amount of an element may also cause nutritional plant disorders. But toxicity in plants may not always be the direct effect of the element in excess, but the effect of the excess element on one or more other essential elements. For example, an excessive level of K in the plant can lead to either an Mg and Ca deficiency, excess P can result in Zn deficiency, and excess Zn to Fe deficiency (Table 3).

Table 3. Generalized symptoms of nutrient toxicity in crops (Jeyakumar and Balamohan, n.d.)

Element	Visual Symptoms
Nitrogen (N)	Plants will be dark green, and new growth will be succulent; susceptible, if subjected to disease and insect infestation and subjected to drought stress, plants will easily lodge. Blossom abortion and lack of fruit set will occur.
Phosphorus (P)	Phosphorus excess will not directly affect the plant but may showvisual deficiencies of Zn, Fe, and Mn. High P may also interfere with normal Ca nutrition, with typical Ca deficiency symptoms occurring.
Potassium (K)	Plants will exhibit typical Mg and possibly Ca deficiency symptoms due to cation imbalance.

Calcium (Ca)	Plants may exhibit typical Mg deficiency symptoms, and when in high excess, K deficiency may also occur.
Magnesium (Mg)	Results in cation imbalance showing signs of either a Ca or K deficiency.
Sulfur (S)	Premature senescence of leaves may occur.
Boron (B)	Leaf tips and margins will turn brown and die.
Chlorine (Cl)	Premature yellowing of the lower leaves with the burning of the leaf margins and tips. Leaf abscission will occur, and plants will quickly wilt.
Copper (Cu)	Fe deficiency may be induced with prolonged growth. Roots maybe stunted.
Iron (Fe)	Bronzing and tiny brown spots on the leaves.
Manganese (Mn)	Older leaves will show brown spots surrounded by a chlorotic zone and circle.
Molybdenum (Mo)	Not of common occurrence.
Zinc (Zn)	Fe deficiency will develop.

Fertilizer Management in Cereal Crops

Soil fertility and light, moisture, weeds, pests, and diseases are also an essential part of cereal production as they can affect crop yield. The fertilizer application rate must be carefully considered in fertilizer management as applications overcrop needs may pose harmful effects from environmental and economic viewpoints. The number of nutrients to be applied to suffice the recommended rate can be derived from soil testing and determining nutrient removal by grains and straw. For example, in rice production, a sufficient amount of nutrients must give the maximum economic return.

According to Roy et al. (2006), to produce 1 ton of paddy rice (rough rice), it needs to absorb an average of 20 kg N, 11 kg P_2O_5, 52 kg Si. Out of the total uptake, about 50% N, 55% K, and 65% P are absorbed by the early panicle-initiation stage, while about 80% N, 60% K and 95% P uptake are completedheading stage. Higher N and P are taken by grain than in straw (3:1), whereas K, Ca, Mg, Si, Fe, Mn, and B remains in more significant proportions in the straw.

On the other hand, nutrients taken up and distributed equally in straw and grain were S, Zn, and Cu (Yoshida, 1981). The soils must therefore be replenished with those nutrient elements in the form of fertilizers. However, there is no single fertilizer recommendation rate that will fit all cereal crops and their ecosystems. It depends on the cropping season, the effectiveness of the crop to use a specific kind of fertilizer, and availability of fertilizers in the market, and the financial resources of the farmer. For example, the dry season requires more nitrogen input in terms of the cropping season because nitrate ions carry negative charges that cause them not to bind to soil particles. Thus, they easily volatilize, particularly at soils with moist and warm temperatures. Thus, the application of urea fertilizers when soil and air temperatures are cool and incorporating the fertilizer into the soil will reduce volatilization (Schwenke, 2014).

Nitrogen-use efficiency by crops can also be improved by splitting the application of N fertilizer. For instance, part of the crop N requirement can be applied as starter fertilizer that can be top-dressed beside the crop rows. This helps the first stages of crop growth without applying significant N that could only volatilize before the crop requires it. The rest of the crop N requirement can be applied to other stages of the crop. It requires more during early tillering, mid-tillering, panicle initiation, and heading to 1st flowering (Maguire et al. 2009).

Its kind also influences the efficient use of fertilizer by the plant. Hamissa et al. (1997) found that, as regards nitrogen, field experiments carried on cotton, wheat, maize, and rice indicate that calcium nitrate and urea are near equal effectiveness. Furthermore, on rice, sulfur-coated urea and super urea granules were superior to urea and ammonium sulfate, while iso-butidylin di-urea was the least effective. Moreover, high cost and unavailability of fertilizers and other farm inputs like seeds, pesticides, etc. most especially when the season starts, cause delays in implementing agricultural activities, which in turn reduce the number of crops planted in a specific area per year and, ultimately, reduce the potential net income of the farmer (Herrera, 2014). Therefore, the ability of the farmer to identify the right kind of fertilizer to use and to follow the appropriate way of fertilizer application and the application schedules must also be considered in fertilizer management. The farmer must choose the fertilizer materials available locally and the least expensive per unit of needed plant nutrients by computing possible combinations of a single, compound, or complete type of fertilizers. For example, a recommended rate of 90 - 60-60 can be made up of complete fertilizer and urea, urea, solophos, and muriate of potash. The option to choose will depend on which combination costs less. The chosen fertilizer must also be well-suited to the farm soil conditions because some slightly acidic soil requires fertilizer with less residual effects (Xuan and Ross, 1972).

Proper timing of the fertilizer application also increases yields, reduces nutrient losses, increases nutrient use efficiency, and prevents environmental damage. But applying fertilizers at the wrong timing might result in nutrient losses, waste of fertilizer, and even damage to the crop. The mechanisms by which losses occur depend on the properties of the nutrient and its reactions with the surroundings (Sela, n.d.). Also, a nutrient loss can be reduced through basal application wherein fertilizer will be buried and incorporated in the soil than broadcasting where fertilizers were only applied over the field uniformly (Manna and Singh, 1991).

Fertilizer Calculation

The International Rice Research Institute and partners across Asia begun and led the development of site-specific nutrient management (SSNM) for rice which eventually provides scientific principles on field-specific management of N, P, and K for other cereals (Doberman et al., 2004; Buresh et al., n.d.). The fertilizer N required by a cereal crop (FN, expressed in kg N ha^{-1}) to achieve an attainable target yield is determined from the anticipated yield gain to the application of fertilizer N and a targeted efficiency of fertilizer N use to attain the targeted yield;

$FN = (GY - GY_{0N})/(AE_N/1000)$

$GY - GY_{0N}$ is the increase in grain yield due to fertilizer N, which is the difference between the attainable target yield (GY) expressed in t ha^{-1} and yield without fertilizer N (GY_{0N}) expressed in t ha^{-1}. The GY_{0N} is the N-limited grain yield, which reflects the yield attainable from only non-fertilizer sources of N referred to as the indigenous N supply. AE_N is the targeted agronomic efficiency of fertilizer N expressed as kg grain yield increase per kg of fertilizer N applied. The targeted AE_N is adjusted for crop and crop response to N based on the field trials conducted across Asia in the development and verification of SSNM principles.

The total supply of P or K from sources other than fertilizer is estimated through a nutrient balance. The requirement of a crop for fertilizer P (FP, expressed in kg ha^{-1}) or fertilizer K (FK, expressed in kg ha^{-1}) to achieve a targeted yield (GY, expressed in t ha^{-1}) is estimated from the deficit in the nutrient balance with each input expressed in kg ha $^{-1}$ (Buresh et al., 2010): where RIE_P is reciprocal internal efficiency for P expressed in kg plant P at maturity per ton of grain produced, RIE_K is reciprocal internal efficiency of K expressed in kg plantK per ton of grain, P_{CR} and K_{CR} are P and K inputs with retained crop residues, P_{OM} and K_{OM} are P and K inputs from organic materials, K_W is K input with irrigation water, K_L isK loss by percolation or leaching in kg ha^{-1}. P_S and K_S are threshold limits for the drawdown of soil P and K reserves expressed in kg ha^{-1}. The input of P in irrigation water, loss of P by percolation and leaching, and inputs of P and K with rainfall are treated as negligible. Loss of K by percolation or leaching (K_L) is treated as negligible except on sandy soils. For simple and general computation of fertilizer recommended rate, the following formulamay be utilized, and Table 5 shows a list of fertilizer materials with respective percent nutrient analyses.

$$\text{Weight of Fertilizer Material (kg)} = \frac{\text{Recommended Rate (kg N, } P_2O_5\text{, } K_2O\text{/ha}}{\text{Percent nutrient in fertilizer material}}$$

Table 5. Common basic fertilizer materials used for blending and their nutrient contents

Material	**Analysis**	**N (%)**	**P_2O_5 (%)**	**K_2O (%)**
Complete	14-14-14	14	14	14
Urea [$CO(NH_2)_2$]	46-0-0	46	0	0
Solophos	0-18-0	0	18	0
Ammonium phosphate [$(NH_4)_3PO_4$]	16-20-0	16	20	0
Ammonium sulfate	21-0-0-24S	21	0	0
Muriate of potash [KCl]	0-0-60	0	0	60

RECOMMENDATION

Some good agricultural practices for fertilizer management, for example in corn, which could also be imposed on other cereal crop production, are enumerated by the Bureau of Product Standards (2008) under the Department of Trade and Industry as follows:

1. Use only fully decomposed organic materials. Raw and slightly decomposed animal manure should be confined in a designated area for treatment.
2. Use only registered commercial fertilizers. Observe the appropriate method and time of application of the recommended combination and amount of fertilizers based on soil analysis.
3. Seed inoculant may be used to supplement part of the corn plant nutrient requirement.
4. Fertilizers should be stored separately from pesticides in a clean and dry area (preferably slightly elevated above the ground on pallets).
5. The storage area of fertilizers should be isolated from corn drying and storage areas to prevent contamination due to leaching, runoff, or wind drift.
6. A complete set of records of fertilizers and fertilizer preparation should be kept. Information includes the source of fertilizer materials, details of the composting procedures, dates, amounts, and methods of applying the fertilizer, as well as the person responsible for the application.

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Determination of Some Biotechnical Characteristics of Ornamental Plum *(Prunus cerasifera* var. *atropurpurea)* Fruit

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Abstract

Ornamental plum (*Prunus cerasifera* var. *atropurpurea* (Rosaceae)) is a species of ornamental tree. The fruits turn red when ripening and are edible. Ornamental plum fruit has bioactive substance potential. In this study, some biotechnical characteristics of the ornamental plum fruits such as size dimensions, sphericity, surface area, geometric mean diameter, colour properties, frictional properties and mechanical behaviors were determined in this study. The puncture and compression tests were carried out for the behavior of fruits against mechanical forces. Three different loading speeds (30, 60, and 90 mm min^{-1}) were used in mechanical tests. The sizes such as length, width, and thickness values of ornamental plum were determined as 2.785 cm, 2.638 cm, 2.568 cm and fruit weight of 10.34 g, respectively. The sphericity, surface area, and geometric mean diameter, values of fruits were determined as 95.28% and 22.13 cm^2, and 6.53 mm, respectively. Among the volumetric properties of ornamental plum, the porosity value was determined as 57.16%. L^*, a^*, b^* colour characteristics were determined as 35.59, 6.83 and 8.82, respectively. The coefficient of static friction values of the ornamental plum on different friction surfaces were higher on the rubber surface than the other surfaces. The highest compression force value was measured as 82.14 N in the Y- axis at a loading speed of 90 mm min^{-1}. The results of the bio-technical characteristics must be taken into account for the quality of ornamental plum fruit during processing, sorting, cleaning, storage, packaging, and presentation to the consumer after harvesting.

Keywords: Plum, Surface area, Friction, Chroma, Puncture, Compression

Research article
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INTRODUCTION

Ornamental plum (*Prunus cerasifera* var. *Atropurpurea*) (Pruno) is a tree from the Prunus Pissardii Rosaceae family (peach, cherry, plum, almond). It has an average height of 6-7 meters, with a solid and deep root system. Pruno is is known as the 'purple-leaf plum'. Its leaves have year-round purple or red (Zhang et al., 2013). Its origin is Turkey, the Balkans and Iran. It grows in the Black Sea, Marmara and Central Anatolia in Turkey. They are generally sensitive to frost (-20°C). It grows in sunny places and in temperate climates. Although it grows in all kinds of soils, it prefers moist, fertile, less clay soils. It can be used as an ornamental plant in parks and gardens, as an ornamental plant, and in fruit gardens, and there are also different cultural forms (Anonymous 2022a, 2022b).

The edible fruits are about 1 inch diameter and dark purple during maturity. The ripe fruit can be used for jams, jellies and juices (Anonymous 2022c).

Knowing of the biotechnical (physical, colur, mechanical) characteristics such as size and shape, sphericity, surface area, geometric mean diameter, porosity fruit and bulk densities, mechanical behaviors under dynamic or static forces during the compression and puncture tests, friction coefficients, colour characteristics of agricultural materials will increase the value of the product for the preservation of the commercial and economic quality of agricultural products (Şahin et al., 2020).

The puncture and compression force of agricultural products are the basic parameters that show the behavior of the products under the post-harvest load. They constitute the basic parameter for the design of machine and equipments to be developed in the storage, transportation and packaging stages (Coşkun et al., 2005, Işık and Ünal, 2007, Kabas et al., 2007, Alnıak, 2012).

Many studies have been carried out to determine the physical and mechanical properties of biological materials such as fruits, vegetables, grains and seeds. It is revealed in the literature review that there is a limited number of studies on the biotechnical properties of plum fruits.

Altuntas et al. (2020) determined the effects of different harvest times and MeJA (Methyl Jasmonate) sprayed at 1120 mg L^{-1} and 2240 mg L^{-1} concentrations on pre-harvest plum (*Prunus domestica*) fruits on the mechanical, physical and chemical characteristics of fruits. Alnıak (2012) studied the determination of some mechanical and physical characteristics of plum (*Prunus cerasifera* Ehrh.) fruits in different harvest times.

A study examining the mechanical, physical, and colour characteristics of the ornamental plum fruit with biotechnological properties could not be reached. Therefore, in this study, biotechnological properties such as physical, colour, coefficient of static friction and mechanical behaviors under compression and puncture tests of ornamental plum fruits were investigated.

MATERIALS and METHODS

In this study, ornamental plum fruits used were obtained from the garden of the Faculty of Agriculture at Tokat Gaziosmanpaşa University during the semi-maturity period in June 2022. Experiments were carried out in the Department of Biosystem Engineering, Biological Materials Laboratory, Faculty of Agriculture at Tokat Gaziosmanpaşa University. For the initial moisture content, the samples were dried by oven at 70±1°C for 24 hours and taking the wet basis (Suthar and Das, 1996). Fruits' moisture content were determined as 85.53% on a wet basis and the fruit samples was given in Figure 1.

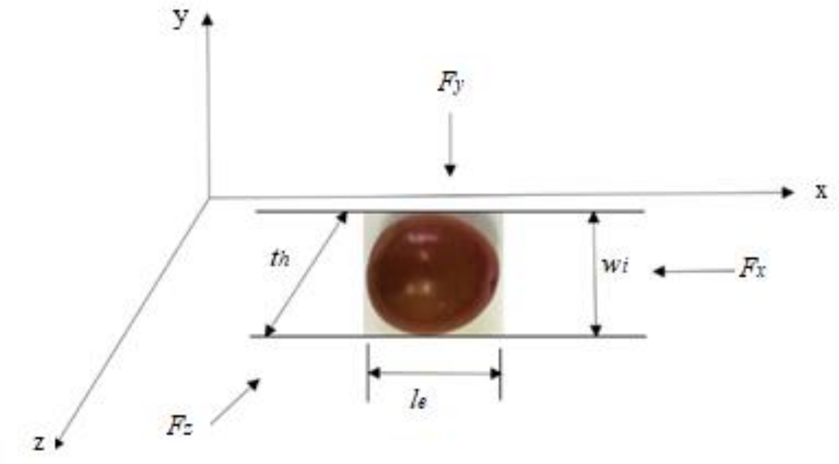

Figure 1. Representation of the axial dimensions (F_x, F_y, F_z) forces of a sample ornamental plum fruit and the ornamental plum fruit samples.

The geometric and volumetric properties of the fruits, the size dimensions were measured with a digital caliper (Precision: 0.01 mm). Fruit masses were determined with KERN brand EW620-3NM model (Precision: 0.001 g). The following equations were used to calculate the geometric mean diameter (D_{ge}) (cm), sphericity (S_{ph}) (%), surface area (Sar) (cm^2) and volume (V_{fr}) (cm^3) of fruits (Mohsenin, 1980).

$$D_{ge}= (l_e.w_i.t_h)^{1/3} \tag{1}$$

$$S_{ar}= \pi (D_{ge})^2 \tag{2}$$

$$S_{ph}=(D_{ge}/l_e)100 \tag{3}$$

$$V_{fr}=\pi /6\ (l_e.w_i.t_h) \tag{4}$$

Where; l_e: Length (cm), w_i: Width (cm), t_h: Thickness (cm), D_{ge}: Geometric mean diameter (cm), S_{ar}: Surface area (cm^2), S_{sh}: Sphericity (%).

The liquid displacement as method was used to determine the fruit density ($\rho_{fr,}$ kg m^{-3}) of the samples, pure water was used as the fluid (Saçılık et al., 2003). Hectoliter method was applied for bulk denstiy ($\rho_{bl,}$ (kg m^{-3}). Porosity (P_{or}) was calculated according to fruit density and bulk density values (Mohsenin, 1980).

In order to determine the colour (L^*, a^*, b^*) properties of fruits on the fruit peel surface, a colorimeter (Minolta, CR-400 (Tokyo, Japan) was used (McGuire, 1992). Hue angle ($h°$) and Chroma were calculated according to Equations 5 and 6. The chroma value (C_h) indicates the vivid or pastel tone of the fruit, values close to 0 are defined as pastel tones, and values close to 100 are defined as vivid tones (Günaydın, 2020).

$$h° = tan^{-1}[b^*/a^*] \tag{5}$$

$$C_h = \sqrt{a*2 + b*2} \tag{6}$$

As the mechanical properties of fruits, a friction measurement device was used to measure the coefficient of the static friction on different friction surfaces (rubber, galvanized metal, PVC, plywood, and laminate). The coefficient of the friction was calculated from the equation $\mu = tan\alpha$ depending on the angle of inclination (α) in the device where the movement of the fruit sample from the surface that can be tilted with a lever is allowed (Yılmaz and Altuntas, 2020).

As Biological Materials testing device (Sundoo HP-500) was used fort he mechanical tests. Test device has drawbar pressure dynamometer, measuring stand, a motorized motion unit and a computer connection. In the compression and puncture tests, both the force and deformation ranges of the fruits were determined, and the force and time curves can also be taken graphically. The deformation was determined in millimeters from the measuring stand attached to the test device. Three different loading rates (30, 60, and 90 mm min^{-1}) were used for drilling tests. In the study, the energy absorbed (E_{ab}), hardness (H_r) and power required for drilling (P_w) were determined with the help of the following equations (Mohsenin, 1980).

$$E_{ab} = (F_r.\ D_{ef})/2 \tag{7}$$

$$H_r = F_r/D_{ef} \tag{8}$$

$$P_w = \left[\frac{E_{ab}\,H_r}{60000\,D_{ef}}\right] \tag{9}$$

Where; E_{ab}: Absorbed energy (N mm), F_r: Puncture force (N), D_{ef}: Deformation (mm), H_r: Hardness (N mm^{-1}), and P_w: Puncture power (W).

For the statistical analysis, SPSS 17 (Statistical Package for Social Sciences) program was used. The analysis of variance was performed for mechanical test results and the multiple comparison (Duncan) test was also applied to determine the differences related to the parameters examined for mechanical test results.

RESULTS and DISCUSSION

Physical Properties

Within the scope of biotechnological characteristics of ornamental plum samples, size-dimensional properties, sphericity, surface area, geometric mean diameter, fruit volume and mass, porosity, fruit and bulk densities were determined. The geometric and volumetric properties of fruits are given in Table 1.

Table 1. Some geometric and volumetric characteristics of ornamental plum fruits.

Physical properties	Parameter	Mean (*)	Maximum	Minimum	Variation coefficient	Standard error
Geometric	l_e (cm)	2.785±0.081	2.990	2.625	2.910	0.0256
	w_i (cm)	2.638±0.083	2.836	2.427	3.160	0.0264
	t_h (cm)	2.568±0.082	2.749	2.300	3.190	0.0260
	D_{ge} (cm)	2.653±0.074	2.827	2.464	2.780	0.0233
	S_{ph} (%)	95.28±1.057	98.47	91.04	1.650	0.0497
	S_{ar} (cm^2)	22.130±1.233	25.100	19.079	5.570	3.9024
Mass and Volumetric	M_s (g)	10.34±0.870	12.580	8.600	8.380	0.0270
	V_{fr} (cm^3)	9.898±0.830	11.943	7.912	8.390	0.2630
	ρ_{bl} (kg m^{-3})	423.60±88.17	476.15	174.49	20.810	27.900
	ρ_{fr} (kg m^{-3})	989.79±21.74	1016.39	943.95	2.200	6.880
	P_{or} (%)	57.16±9.01	82.510	52.490	15.750	2.850

l_e: Length, w_i: Width, t_h: Thickness, S_{ph}: Sphericity, S_{ar}: Surface area, D_{ge}: Geometric mean diameter, M_s: Fruit mass, V_{fr} Fruit volume, P_{or}: Porosity (%) ρ_{fr}: Fruit density, ρ_{bl}: Bulk density, (*): ± values indicate standard deviation.

The width, length and thickness of the ornamental plum fruits were determined as 2.638 cm, 2.785 cm and 2.568 cm, respectively. The sphericity, geometric mean diameter and surface area of fruits were determined as 95.28%, 2.653 cm and 22.130 cm^2, respectively. The fruit mass was 10.34 g, and the porosity value was 57.16%. Alnıak and Çetin (2021) reported that length values fruits ranged from 2.292 to 3.001 cm, width values ranged from 2.084 cm to 2.888 cm, thickness changed from 2.028 cm to 2.754 cm, and fruit mass between 5.49 g and 20.03 g for Papaz plum varieties in three harvest (15 April, 1 May and 15 May) periods respectively. Esehaghbeygi et al. (2013) reported that the physical properties of varied from 2.805 to 3.652 cm, from 2.678 to 3.546 cm and from 2.585 to 3.401 cm for the length, width and thickness for Ghandi, Gatretala and Black plum cultivars. Calisir et al. (2005) reported that the mass, diameter, length, sphericity and geometric mean diameter values of plum (wild) fruits were as 15.330 g, 3.016 cm, 2.814 cm, 1.04, and 2.947 cm, respectively. In the studies different plum varieties were studied and it was seen that the geometric properties were similar and close to the values found in the ornamental plum fruit.

Colour characteristics

The values of the colour characteristics of the ornamental plum are given in Table 2.

Table 2. Colour characteristics of ornamental plum fruit.

Colour characteristics	Mean (*)	Maximum	Minimum	Variation coefficient	Standard error
L^*	32.59±0.93	33.98	31.07	2.85	0.29
a^*	6.83±0.59	7.84	6.21	8.71	0.19
b^*	8.82±0.70	9.81	7.82	7.96	0.22
C_h	11.17±0.63	11.89	9.99	5.63	0.20
$h°$	52.22±3.44	56.55	44.93	6.58	1.09

(*): ± values indicate standard deviaiton.

*a** and *b** and *L** colour characteristics of the ornamental plum fruits were determined as 6.83, 8.82 and 32.59, respectively. Ertekin et al. (2006) examined some nutritional, pomological and physical properties of Stanley and Frenze 90 plum (*Prunus domestica* L.) cultivars. The mean values for the *a** value were 2.40 and 9.51, respectively, and the mean values for the *b** value were -7.11 and -0.66, respectively. *L** (brightness) value showed similar results with literature, but there was a difference in the *a** and *b** values.

Frictional properties

Coefficient of static friction values of ornamental plum fruits aere given in Table 3. The coefficient of the static friction for ornamental plum fruits was found with the highest value of 0.363 on the rubber surface and the lowest on the galvanized sheet surface with the value of 0.207 (Table 3). Calisir et al. (2005) observed the coefficients of static friction of wild plums at 20% moisture content on rubber, galvanized metal and plywood surfaces and determined that the highest value was on the rubber surface. According to the literature, the friction coefficient values were found similar.

Table 3. Static friction coefficients of ornamental plum fruits.

	Coefficient of static friction				
Friction surfaces	**Mean (*)**	**Maximum**	**Minimum**	**Variation coefficient**	**Standard error**
PVC	0.209±0.022	0.249	0.176	10.735	0.0071
Galvanized metal	0.207±0.029	0.249	0.176	13.794	0.0090
Laminate	0.213±0.023	0.249	0.176	10.703	0.0072
Plywood	0.266±0.021	0.306	0.249	7.756	0.0065
Rubber	0.363±0.049	0.424	0.287	13.638	0.0157

PVC: Polivinil Klorür, (*): ± values indicate standard deviation.

Puncture and compression tests

The results of the puncture test and compression test results for the mechanical behaviors of ornamental plum fruits are given in Tables 4 and 5. As a result of the puncture test of ornamental plum fruits, the changes in force, deformation, absorbed energy, hardness and power values required along loading speeds and loading axes.

The highest puncture force was obtained as 8.02 N in the Y- axis and at 90 mm min^{-1} loading speed (Table 4). The highest hardness was found with 0.424 N mm^{-1} in the X- axis at 30 mm min^{-1} loading speed. The significant statistically differences were observed in the puncture force, deformation, absorbed energy, hardness and puncture power of ornamental plum fruits at 90 mm min^{-1} loading speed.

Table 4. The mechanical behaviors related to the puncture tests of ornamental plum fruit according to different loading axes and loading speeds.

Loading speeds (mm min^{-1})	Loading axes	Puncture force (N)	Deformation (mm)	Puncture energy (N mm)	Hardness (N mm^{-1})	Puncture power (W)
30	***X-***	6.13 ± 1.26^{ns}	16.55 ± 4.32^{ns}	48.76 ± 10.25^{ns}	0.424 ± 0.20^{ns}	$0.0015\pm0.0003b^{**}$
	Y-	5.20 ± 1.10^{ns}	17.08 ± 1.86^{ns}	44.89 ± 11.12^{ns}	0.304 ± 0.06^{ns}	$0.0026\pm0.0006a^{**}$
	Z-	5.00 ± 0.86^{ns}	17.52 ± 2.19^{ns}	42.83 ± 4.60^{ns}	0.299 ± 0.09^{ns}	$0.0013\pm0.0002b^{**}$
	F value	3.04	0.26	1.10	2.98	33.68
60	***X-***	$6.89\pm1.00a^{*}$	21.10 ± 4.00^{ns}	71.66 ± 11.34^{ns}	0.344 ± 0.11^{ns}	$0.0034\pm0.0005a^{*}$
	Y-	$7.15\pm0.66a^{*}$	20.65 ± 2.19^{ns}	74.11 ± 12.14^{ns}	0.348 ± 0.03^{ns}	$0.0036\pm0.0003a^{*}$
	Z-	$6.01\pm0.82b^{*}$	21.44 ± 1.91^{ns}	63.99 ± 7.38^{ns}	0.285 ± 0.06^{ns}	$0.0030\pm0.0004b^{*}$
	F value	5.03	0.20	2.53	2.27	5.03
90	***X-***	$6.98\pm0.92b^{**}$	$25.11\pm2.29a^{**}$	$87.40\pm12.52a^{**}$	$0.281\pm0.05b^{**}$	$0.0052\pm0.0007b^{**}$
	Y-	$8.02\pm0.85a^{**}$	$22.77\pm1.16b^{**}$	$91.26\pm10.16a^{**}$	$0.353\pm0.04a^{**}$	$0.0060\pm0.0006a^{**}$
	Z-	$6.49\pm0.63b^{**}$	$21.55\pm1.81b^{**}$	$70.08\pm10.34b^{**}$	$0.303\pm0.03b^{**}$	$0.0049\pm0.0005b^{**}$
	F value	6.14	4.42	7.14	2.53	6.14

***:p<0.01, *: 0.01<p<0.05 ns: non significant, ± values indicate standard deviation.*

The changes in compression force, deformation, absorbed energy, hardness and compression power of ornamental plum fruits according to different loading speeds and loading axes as a result of the compression tests are given in Table 5.

Table 5. The mechanical behaviors related to the compression tests of ornamental plum fruit according to different loading axes and loading speeds.

Loading speeds (mm min^{-1})	Loading axes	Compression force (N)	Deformation (mm)	Compression energy (N mm)	Hardness (N mm^{-1})	Compression power (W)
30	***X-***	$40.22\pm7.83c^{**}$	$4.09\pm1.01a^{**}$	$82.09\pm24.39b^{**}$	$10.28\pm3.14c^{**}$	$0.0101\pm0.0020c^{**}$
	Y-	$59.86\pm3.26b^{**}$	$3.61\pm0.16ab^{**}$	$107.73\pm4.43a^{**}$	$16.67\pm1.55b^{**}$	$0.015\pm0.00068b^{**}$
	Z-	$68.25\pm2.85a^{**}$	$3.07\pm0.18b^{**}$	$104.96\pm9.59a^{**}$	$22.31\pm1.04a^{**}$	$0.0171\pm0.0007a^{**}$
	F value	77.55	7.29	8.41	81.55	77.53
60	***X-***	72.02 ± 7.51^{ns}	$3.67\pm0.38b^{**}$	$131.62\pm16.43b^{**}$	$19.91\pm3.61a^{**}$	0.0360 ± 0.0038^{ns}
	Y-	73.60 ± 1.16^{ns}	$4.33\pm0.14a^{**}$	$159.25\pm5.38a^{**}$	$17.04\pm0.62b^{**}$	0.0368 ± 0.0006^{ns}
	Z-	69.68 ± 1.56^{ns}	$3.52\pm0.07b^{**}$	$122.65\pm5.02b^{**}$	$19.81\pm0.21a^{**}$	0.0348 ± 0.0008^{ns}
	F value	1.94	32.71	33.67	5.93	1.94
90	***X-***	81.45 ± 10.26^{ns}	$3.94\pm0.38a^{**}$	$161.21\pm28.54a^{**}$	20.78 ± 2.44^{ns}	0.0611 ± 0.0077^{ns}
	Y-	82.14 ± 1.18^{ns}	$4.17\pm0.28a^{**}$	$171.39\pm12.65a^{**}$	19.83 ± 1.11^{ns}	0.0616 ± 0.0009^{ns}
	Z-	77.18 ± 1.63^{ns}	$3.58\pm0.12b^{**}$	$138.15\pm2.79b^{**}$	21.61 ± 1.17^{ns}	0.0579 ± 0.0012^{ns}
	F value	1.98	11.24	8.85	2.78	1.98

***:p<0.01, *: 0.01<p<0.05 ns: non significant, ± values indicate standard deviation.*

The highest compression force of the ornamental plum fruits was found with 82.14 N on the width (Y-) axis) of 90 mm min^{-1} loading speed (Table 5). The highest hardness value was found as 22.31 N mm^{-1} in the Z- axis at 30 mm min^{-1} loading speed. The significant statistically differences were observed in the compression force, deformation, absorbed energy, hardness and compression power values of the ornamental plum fruits in three loading axes at 30 mm min^{-1} loading speed.

Altuntas et al. (2013) reported the compression force, absorbed energy, and compression power of the President plum variety are effective for different harvest times and compression axes for 1.120 mg L^{-1} and 2.240 mg L^{-1} MeJA applications at a constant 1.06 mm s^{-1} loading speed. They also reported the specific deformation and absorbed energy values observed for plum fruits compressed along the X- and Z-axes were lower than Y-axis.

CONCLUSION

In this study, the geometric, volumetric, colour, coefficients of static friction on different surfaces and mechanical resistance properties within the scope of the bio-technical characteristics of the ornamental plum fruit were investigated. The length, width and thickness values were determined as 2.785 cm, 2.638 cm, 2.568 cm and fruit mass was 10.34 g, respectively. The porosity, fruit density, and bulk density were determined as 57.16%, 989.79 kg m^{-3}, 423.60 kg m^{-3}, respectively. In terms of colour characteristics, the highest *a**, *b**, and *L*, values were determined as 7.84, 9.81 and 33.98, respectively. For the coefficient of static friction values of ornamental plum on different friction surfaces, the highest value was found on the rubber surface. In the mechanical test results, the highest puncture force value was 8.02 N on the width (Y-) axis along the 90 mm min^{-1} compression speed, and the highest hardness value was 0.38 N mm^{-1} in the length (X-) axis at 60 mm min^{-1} loading speed. The highest force value was found to be 82.14 N in the width (Y-) axis of 90 mm min^{-1} and the highest hardness value was found with 22.31 N mm^{-1} in the thickness (Z-) axis at 30 mm min^{-1} loading speed according the compression test. Depending on the increase in ornamental plum production areas, the results of the biotechnological properties of the equipment of the systems and facilities to be used for the sorting, classification and packaging of fruits in fresh and industrial applications can be used as engineering data. It is thought that these data may contribute to the increase of the commercial value of ornamental plums, as well as the quality of the harvest and post-harvest product.

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Impacts of Climate Change on Water Resources in Sudan

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Abstract

The water sources in Sudan vary, as they represent river water, rain water, surface water and groundwater, where the lands of Sudan divide rivers, valleys, and creeks. However, Sudan suffers a variety of issues with regard to water, from a lack of safe drinking water and inadequate sanitation to water pollution and scarcity. Rapid population increase, urbanization, shifting consumption patterns, and competing demands from agriculture, industry, and energy are the main risks to the nation's water supplies. Additionally, with current and projected environmental changes on the horizon there is an urgent need to measure and analyze the impact of these changes. With global warming that has become a reality and the increase in greenhouse gas emissions will have a profound climatic, environmental, and social impact globally. Especially in the field of water sources, where droughts have begun in some areas, so it is necessary to reduce greenhouse gas emissions and switch to clean energy. Urgent and long-term efforts should also be made to conserve water and reduce risks related to climate change. All of these things may threaten life in large areas in Sudan, so through this review we have highlighted some of the problems related to climate change and its impact on water resources in Sudan, Where we focused in some detail on the expected effects on the rate of rainfall on agriculture, as it encapsulates the most significant water supply indirect effects of climate change.

Keywords: Climate Change, Water Resources, Sudan.

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INTRODUCTION

Sudan is a vast country rich in natural resources. The main dependence of Sudan is agriculture, it is 80% of the population's activity, and it also depends on industry, especially agricultural industries. There are two main farming systems used in the Sudan for agriculture. More than 90% of the land used for cultivation (total cultivated land in 2018 was 21.2 million hectares) is covered by the main system, which is rainfed (both mechanically and traditionally), while the secondary system is irrigated (CBoS, 2018; Ministry of Agriculture and Forestry, 2017).

There are numerous agro-ecological zones with a range of climatic conditions, rainfall, soils, and vegetation due to its vastness and extend from south to north. The Nile system's water resources, along with groundwater resources, provide Sudan the possibility of a 30-year growth in the irrigated sub-sector. Additionally, there are chances to improve hydropower production (Abdeen, 2010).

Around 75 per cent of Sudan’s land area lies within the Nile River Basin, which represents 44 per cent of the Nile Basin’s total area (FAO, 2017). Sudan shares several transboundary aquifers with its neighbors, such as the Nubian Sandstone Aquifer, used by Sudan, Egypt, Libya and Chad, and the Um Ruwaba Aquifer, shared with South Sudan. Seasonal flows, erratic rainfall, siltation, floods, riverbank erosion, and pollution all have an impact on Sudan's inland rivers. The nation's marine and coastal resources are under threat from pollution, unchecked economic development, and climate change, despite the fact that they are becoming more and more essential to the economy and draw a sizable number of tourists (UNEP, 2020).

Sudan's share of the Nile water is about 18.5 billion cubic meters, and yearly rainfall ranges from nearly nothing in the North’s hot, dry climate to more than 1600 mm in the South’s tropical region (Abdeen, 2010; UNEP, 2020). In accordance with the promotion of basin-wide integrated development of the shared water resources, the national strategy of Sudan aims at the multipurpose use of water resources to achieve water security for achieving food security, drinking-water security, and hydro-energy security, at the regional levels (Abdeen, 2010).

Despite all of this, Sudan is considered a country with a water shortage. Water competition has historically been a source of hostility, but it may also be a chance for cooperation and peace. The careful management of Sudan's water resources is viewed as a means of fostering stability and long-term growth. Water resources could significantly contribute to enhancing the economy, society, and environment with effective institutions and suitable legislation (UNEP, 2020). Numerous research have examined the various aspects of climate change in Sudan. The majority of both the study that was done and the future forecasting work was concentrated on changes in temperature and precipitation, the two most significant climate parameters and extreme occurrences.

CLIMATE CHANGE and WATER RESOURCES in SUDAN

Global climate change, the industrial revolution of the then mankind atmosphere to release the carbon dioxide, methane, ozone and nitrogen oxides as gases are very quickly heat the earth by the greenhouse effect that occurred as a result of the increase is a result of an increase above normal (Bağdatlı and Bellitürk, 2016a). Increasing or decreasing changes in climatic values affect living things negatively and cause a decrease in productivity, especially in agricultural production (İstanbulluoğlu et al., 2013).

Greenhouse gas emissions are the primary source of both global warming and climate change. There are varied contributions and intensities to the emissions of these gases from all economic activities, which implies diverse policy implications for how to cut emissions and deal with the effects of climate change at the national level (Mohammed, 2022). Climate change, as opposed to short-term weather variations, refers to large and ongoing changes in the average weather conditions over an extended period of time (IPCC, 2014). Increasing world population, changing climate conditions and economic activities are growing with each passing day makes it more important than water (Bağdatlı and Bellitürk, 2016b).

The second most important element for human survival is water. We face numerous problems with water supply, sustainability, and quality on a global scale (Ahuja, 2015). Therefore finding strategies to increase water sustainability is essential (Ahuja, et al., 2014).Most importantly, we need to reuse contaminated water and utilize water sparingly. The water cycle is an integrated and dynamic component of the earth's geophysical system and both affects and is affected by climate conditions. Changes in the earth's radiation balance affect winds, temperatures, atmospheric energy and water transport, cloud dynamics and more. Changes in temperature affect evaporation and transpiration rates, cloud characteristics and extent, soil moisture, and snowfall and snowmelt regimes. Changes in precipitation affect the timing and magnitude of floods and droughts, and shift runoff regimes. Synergistic effects will alter cloud formation, soil and water conditions, vegetation patterns and growth rates (Abdeen, 2010).

Water resources are one of the most important natural wealth of the country. Increasing parallel to the increase of the population’s food needs is revealed as the role of water more efficiently. Water in agricultural production as well as significant human life is one of the indispensable inputs (Bağdatlı and Bellitürk, 2015).

Water scarcity is a result of both natural and human-caused factors. Freshwater is plentiful enough to supply the needs of 7 billion people, but it is dispersed unevenly and too much of it is squandered, polluted, and handled in an unsustainable manner. Every continent is impacted by the water crisis. Although there isn't a worldwide water scarcity per se, more and more regions are experiencing chronic water shortages due to the fact that water demand has been increasing at a rate more than twice as fast as population growth over the past century (Mejía, et al., 2012). In addition, sea level rise affects the water cycle under the surface of the coastal areas, which leads to a decrease in the flow of fresh water and a decrease in the proportion of fresh water areas. On the other hand, the rise in sea levels increases the water level in groundwater aquifers, which may increase the percentage of surface runoff, but at the expense of recharging the groundwater aquifers.

World has been threatened by climate change under the effect of increased carbon emission and greenhouse gas. Carbon is one of the basic elements of life and shows search without being fixed. The amount of CO_2 reduces the protective use of the bard layer. With this effect, it causes irregular precipitation and excessive temperature increases (Bağdatlı and Arıkan, 2020). Population growth rate along with the climate change phenomenon will cause lots of problems for worldwide food supply and we will face numerous nutritional problems in the near future. By gradually reaching to the 8 billion population on the earth, the mankind is really in challenge to provide the growing population food needs (Bağdatlı et al., 2015)

Sudan experiences mean annual temperatures between 26°C and 32°C, with summer temperatures in the north often exceeding 43°C. Rainfall in Sudan is unreliable and erratic, with great variation experienced between northern and southern regions. Northern regions typically experience virtually no rainfall (less than 50 mm annually), central regions receive between 200 mm and 700 mm per year, and some southern regions experience more than 1,500 mm annually. Most rainfall occurs during the rainy season from March to October, with greatest concentration between June and September (Ali, 2017). The Sudan is vulnerable to climate change because of its hot climate, with mean annual temperatures that range from 26 °C to 32 °C nationwide. From North to South, the nation is ecologically divided into five vegetation zones by rainfall patterns3: (1) desert with 0 to 75 millimetres of precipitation yearly; (2) semi-desert with 75 to 300 mm; (3) low rainfall savannah on clay and sand with 300 to 800 mm; (4) high rainfall savannah with 800 to 1500 mm; and (5) mountain vegetation with 300 to 1000 mm of precipitation (Ministry of Environment, Natural Resources and Physical Development, 2015).

With the escalation of climate change, The Sudan as a whole will be affected by a rise in local temperatures. The sectors most vulnerable to rises in temperature are rainfed agriculture, aquaculture, natural ecology systems and biodiversity and water resources (Siddig et al., 2020; Elsheikh, 2021).

Sudan may reportedly consume 26 km^3 of surface water annually. This includes the water that Sudan is allowed to take from the Nile, which is specified in the 1959 Nile Water Agreement and amounts to 18.5 km3 annually as measured at Aswan in southern Egypt (equivalent to 20.5 km^3 in the center of Sudan before the transportation loss due to evaporation and seepage). Flow from streams not connected to the Nile is also included (5.5 km3) (Adam and Abdo, 2017). Sudan depends heavily on the Nile for drinking water, irrigation, hydropower generation, river transport and recreation. Other major sources of drinking water include groundwater reserves and wadis or khors, which are exploited for both people and livestock (UNEP, 2020).

Sudan suffers a variety of issues with regard to water, from a lack of safe drinking water and inadequate sanitation to water pollution and scarcity. Rapid population increase, urbanization, shifting consumption patterns, and competing demands from agriculture, industry, and energy are the main risks to the nation's water supplies. Additionally, there are unforeseen hazards associated with environmental degradation and climate change, as well as rising conflict over the limited water resources that span administrative lines (UNEP, 2020).

The International Fund for Agricultural Development carried out an evaluation study of Sudan's environment and climate change in 2011. Data for various starting years (1900-1937) up to 2011 were obtained from nine meteorological stations (Abdelaty and Babiker 2013). According to the study, Sudan's average temperatures have been rising overall, from 0.6 °C in El Obeid to 2.1 °C in Khartoum (Abdelaty and Babiker 2013).

By 2050, it is anticipated that the average annual temperature will have risen by 1.5°C to 2.5°C. Rainfall decreased by between 10% and 20% over the western and southern states from 1970 to 2011. According to predictions, rainfall will fluctuate from 9 percent less to 9 percent more between now and 2050. (Abdelaty and Babiker 2013). Extreme climatic events are anticipated to occur more frequently (Abdelaty and Babiker 2013). The entire Nile basin is predicted to experience increases in precipitation early in the century (period 2010-2039) (Beyene et al. 2010). Some native flora, insects, and small animals may vanish forever in the northern states if temperatures increase more. Plants from the subtropics that need moisture may go further south (Abdelaty and Babiker 2013). With a considerable decline in the long-term average, crop yields are expected to fluctuate significantly. According to the World Bank, a 1°C rise in temperature might result in a 10% decline in agricultural output (Abdelaty and Babiker 2013). By 2050, this might result in an output decline of up to 25% in the northern states. Currently, the southern, southeastern, and mountainous northeast of the country are all affected by floods, flash floods, and possibly landslides, whilst the northern regions and those in the centre and middle west of the country are more affected by droughts. Pastoralists, impoverished farmers, and usually poor households with elderly members, children, and women make up the groups that are most vulnerable to droughts and floods (Sayed and Abdala, 2013).

Sudan is a poor country with 58% of rural households living below the national poverty line of USD 1.25 per day in 2012 (Ministry of Human Resources Development and Labor, 2013). The economy is mainly dependent on agriculture, which also provides 65% of inhabitants' livelihoods and one-third of foreign exchange profits (CBoS, 2016). Since more than 90% of the land is used for agriculture, the Sudanese population is subject to variations in rainfall as well as more general climate change and variability. Therefore, it is crucial to comprehend the many impact routes as the effects of climate change on agriculture are anticipated to have an impact on the entire economy, either directly or indirectly.

Despite its significance, the effects of climate change in the Sudan have not received significant scientific attention. According to the research that are now available, climate change will increase rainfall, which will increase agricultural productivity.

For instance, Basheer et al. (2016) used a hydrological model, two statistical downscaling methodologies, and five GCMs to assess how climate change may affect the streamflow in the Dinder River Basin and, ultimately, Dinder National Park. According to their findings, most scenarios' increased rainfall will cause the climate in the Dinder River Basin to become wetter and the river's streamflow to increase (Siddig et al., 2020).

In 2016, Sudan published its climate change National Adaptation Plan (NAP), which was produced by a large number of institutions headed by the Higher Council for Environment and Natural Resources (Ministry of Environment, Natural Resources and Physical Development, 2015). The NAP's main proposals center on enhancing human resource, institutional, methodological, technological, and informational capabilities. The importance of reducing sensitivity, enhancing resilience to variability and extremes, and enhancing heat tolerance and water efficiency in agricultural production are underlined in a recent review of climate change adaptation strategies for the Sudan (World Food Program, 2017).

This suggests that in addition to expected mean climate changes, changes in climate variability and an increase in the frequency of extreme weather events also require preparation. The suggested interventions include creating programs and initiatives for reducing and adapting to the effects of climate change, addressing water shortages by promoting water harvesting and making full use of seasonal streams and rainfall outside the Nile Basin, using groundwater, and creating drought-resistant crop varieties; and treating water as a scarce resource and improving its efficient use, especially in irrigated agriculture, to best utilize the available water resources (Siddig et al., 2020). The increase in the impact of global climate change will cause global water crises between countries. Necessary measures and measures should be taken in advance to reduce the impact of global climate change (Bağdatlı and Arslan, 2019).

Despite the fact that the Sudan is particularly susceptible to the effects of climate change on water resources, however, the political authorities are not focusing on strengthening adaptive governance measures to deal with the this increasing risks, which may exacerbate the situation.

CONCLUSION

There are changes in the water surface in the world due to global warming. This is the effect of evaporation in water resources and irregularity in the current precipitation regime due to climate change (Albut et al., 2018). Climate change and global warming are reducing the available water resources almost everywhere in the world (Uçak and Bağdatlı, 2017). Excessive increase and decrease of temperatures negatively affect the life of living things. It will be difficult to find clean water in the future as the increase of temperatures will increase the evaporation level. Increasing or falling temperatures will cause climate change (Bağdatlı and Can, 2020). As a result of the effect of global climate change, an increasing trend is observed in temperatures. Rainfall, on the other hand, is gradually decreasing and endangering habitats. In order to minimize the effects of global warming, it is necessary to take measures to prevent the greenhouse effect and global warming. Reducing carbon dioxide in the air may be a solution (Bağdatlı and Can, 2019).

Sudan is characterized by a diversity of water sources. Numerous elements, such as the seasonality of rainfall, siltation, floods, riverbank erosion, and pollution, have an impact on Sudan's inland waters. Despite that, Sudan is considered to be a water-stressed nation, and pollution, unchecked economic growth, and climate change are all posing an increasing threat to the country's water supplies. A serious challenge to global and Sudanese economic progress is the lack of fresh water.

In addition, Sudan suffers from a critical situation with regard to low rainfall and severe variation in its rainfall. Increasing shortage of water resources will lead governments to resort to severe economic projects such as desalination plants, pipelines and dams. For all that, urgent and long-term plans must be made to conserve water by reducing requirements and consumption, by improving water infrastructure to reduce leakage, and by improving water technologies and management. In addition, Sudan should implement an ecosystem-based strategy to manage its inland and marine water resources and integrate the principles of sustainable development into all its institutional practices.

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Evaluation of Climate Change on Agricultural Production in Afghanistan

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Abstract

This review article focuses on evaluation of climate change on Agricultural production in Afghanistan. Because a large portion of the population in Afghanistan relies on farming as a source of income, sustainable agricultural techniques are essential. In addition, one of the south Asian nations affected by climate change is Afghanistan. Crop yields are also very low due to negative effects of climate change. The yields of crops like wheat, rice, and corn have recently continued to decline because of the recent drought related to agriculture; livestock, connected dynamics of desertification, land degradation, water, economic sectors, urban, and energy are the most likely negative effects of climate change in Afghanistan. Climate models predict that Afghanistan will be subject to a variety of new and increasing climatic dangers. Climate change has already begun and will not stop, that it is expected to affect different biological processes differently.

Keywords: Agricultural Production, Climate Change, Global Warming, Afghanistan

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INTRODUCTION

Increasing world population, changing climate conditions and economic activities are growing with each passing day makes it more important than water (Bağdatlı and Bellitürk, 2016a). Increasing or decreasing changes in climatic values affect living things negatively and cause a decrease in productivity, especially in agricultural production (İstanbulluoğlu et al., 2013). Agriculture is highly dependent on the weather pattern, because Agriculture is likely to get affected positively and negatively by the climate change, and change in weather pattern (climate) is expected to have an adverse effect on food security, agricultural production, and rural livelihoods (EPA, 2017; Omerkhil et al., 2020). Research has been conducted to assess the potential effects of climate change on agriculture globally (Rosenzweig and Parry, 1994; Kane et al., 1992; Darwin et al., 1995). But, notable doubts remain and concern has shifted to farm-level impacts or regional effects (Adams et al., 1998; Adams et al., 1990; Mendelsohn et al., 1994) on US agriculture (Kaiser et al., 1993; Easterling et al., 1993; Adams et al., 1998). That is why Climate change is a global issue that is not only related to a land, country or a specific region; rather, it is an all-embracing thing that has affected the whole world over time. The effects of climate change on agriculture may result in less product harvests, increased temperature during growing season can decrease harvests, since crops producing less grain and nutritional quality through their physiological development (Shukla et al., 2019; Sutton et al., 2007).

The unstable effects of global climate change are distributed throughout the universe and are caused by precipitation, temperature changes, and atmospheric carbon dioxide (CO_2) levels (Solomon et al., 2009; Esa and Sapawe, 2020; Cline, 2008).

Climate change and global warming are reducing the available water resources almost everywhere in the world (Uçak and Bağdatlı, 2017). Atmospheric warming is probably increase rainfall, the pure impact of higher temperature on water availability is a race between higher precipitation and higher evapotranspiration. As the precipitation is not regular, the race will be won by higher evapotranspiration (Cline, 2008). The increment of greenhouse gasses emissions in atmosphere along with the global warming and the changes of temperature and precipitation regimes have lots of negative effects on agricultural crop production (Bağdatlı et al., 2015). CO_2 and greenhouse gases accumulated in the atmosphere descend to the earth with precipitation. This event is called acid rain. Acid rains change the pH of the water and affect the life of the living creatures in the water. It causes the natural structure of plants to deteriorate (Bağdatlı and Can, 2019). Excessive increase and decrease of temperatures negatively affect the life of living things. It will be difficult to find clean water in the future as the increase of temperatures will increase the evaporation level (Bağdatlı and Can, 2020).

Agriculture also effect by these events, specially South Asia is among the hardest hit regions by climate change Bhutan, Bangladesh, Pakistan, India, Sri Lanka Nepal, and Afghanistan (Mirza, 2011; Weiss, 2009; Safdar et al., 2022; Wijenayake, 2018). According to World Bank South Asians 750 million people were impacted by one or more climate-related disasters in the last 20 years. The reason the South Asian countries are amongst the most affected countries by global warming mainly owing to complex socio economic-demographic challenges and impoverishment. That is why change in atmospheric conditions is expected to have a bad impact on agricultural production, food security and rural livelihoods especially in Southern Asia countries (Omerkhil et al., 2020). Increasing the necessary studies and measures to minimize the emissions of carbon emissions should be taken all over the world and measures that will minimize the greenhouse gas effect will play an important role in reducing the effects of global warming (Bağdatlı and Arıkan, 2020).

The increase in factory activities, the rapid increase in the utilization of automobiles and dozens of other elements bring about the planet earth to become warmer, cause the rise of greenhouse gases. In particular, economically poor countries are affected by some factors one of this country is Afghanistan. The atmospheric concentrations of the greenhouse gases carbon dioxide (CO_2), methane (CH4), and nitrous oxide (N_2O) have climbed to unprecedented levels in the last years, according to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Afghanistan's total greenhouse gas emission is lower than the global average of 4.4 metric tons of carbon dioxide. This country produces about 5 percent of the world's total greenhouse gas emissions. The climate models suggest that Afghanistan will be confronted by a range of new and increased climatic hazards (Rosvold et al., 2021; Pachauri and Meyer, 2014).

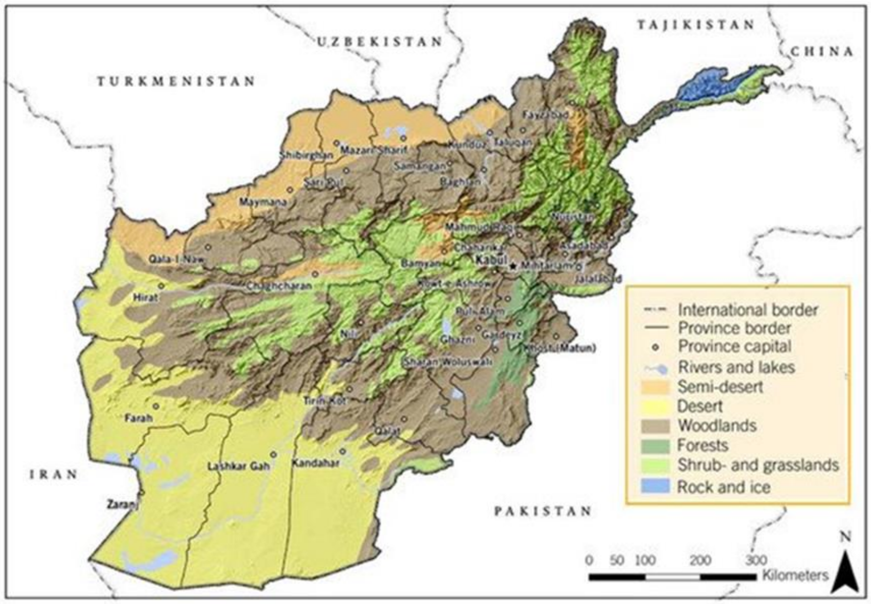

Figure 1. Physical geography of Afghanistan, including major vegetation zones (Olson et al., 2001; Aich et al., 2017).

According to World Bank Group and Afghanistan - Climate Change Knowledge, 2021 Afghanistan has a dry weather conditions with significant temperature and precipitation variation between seasons. By these characteristics, the most likely adverse impacts of climate change in Afghanistan are drought associated with agriculture, livestock, associated dynamics of desertification, land degradation, water, economic sectors, urban and energy (Savage et al., 2009). This review focused on climate change and its effects on agricultural production in Afghanistan.

THE IMPACTS OF CLIMATE CHANGE ON AFGHANISTAN'S AGRICULTURAL SECTOR

Afghanistan is largely dependent on agricultural production. Approximately % 67–85 of Afghans work in agriculture. (Pervez et al., 2014; Fox, 1967; Qutbudin et al., 2019; Formoli,1995; Qureshi, 2002; Tavva et al., 2013; Palka, 2001). Agricultural crops require particular climate conditions, and changes to the climate can have significant negative effects on crops. Summer and winter are the two seasons when crops are grown. The most significant food crops for the people are corn, wheat, and rice. Rice and corn are the primary summer crops while Wheat and barley are the winter crops. Seventy nine percent of Afghanistan's total cultivable land (2.575.000 ha), is used for wheat production. 200.000 ha are used for rice production, while 140.000 ha are used for corn production (Qutbudin et al., 2019). Afghanistan is a country where more than 2/3 of its people live in rural areas and eighty percent of their fed on agricultural production (World Bank, 2021; Byrd, 2008). This is despite the fact that only (%12.1) of Afghanistan's soil is agricultural land, (%5) of which is cultivated (irrigated) and (%7) is rainfed (Goodhand and Sedra, 2010). The aggravating climatic situations in Afghanistan will continue to effect socioeconomic development of Afghanistan (Osmani, 2015).

Water and agriculture resources management are likely to be severely impacted by changes in climate. The vulnerability of the agricultural section getting increase the temperatures and changes the patterns of rainfall and snow melting is high. Therefore, reduced river flow from earlier snowmelt, and Increased soil evaporation less frequent rain during peak cultivation seasons will affect upon agricultural fertility, yield and crop choice availability (Azimi, 2002). The decrease over time of the changes in the surface of the water reservoir is discernible. This also shows itself as the effect of disorder in the vaporization and current precipitation regime in the water sources dependent on global climate change (Albut at al., 2018).

Precipitation is significantly less in the southwest and northwest and significantly more at some grid sites in the northeast and southeast (Aich and Khoshbeen, 2016; Qutbudin et al., 2019). Nearly all grid sites in the northwest and southwest of the nation experienced a significant increase in temperature. Qutbudin et al., (2019) reported the geographical distributions of the changes in precipitation, Rainfall reduced dramatically at a few sites in the southwest and northwest (Kim and Jehanzaib. 2020; Qutbudin et al 2019). Influence of the global climate will have an effect on the change of seasons, especially in the observation of significant changes in temperature and precipitation (Bağdatlı and Arslan, 2020).

These changes negative effect on corn, rice and wheat products. According to forecasts and reports, some areas of Afghanistan will suffer 8.5 percent decrease in average mean rainfall. Similar to this, increases in mean minimum and mean maximum temperatures of up to 4.5 and 5 ^{o}C respectively are anticipated (Sharma et al., 2015). As the same way to another studies and researches, the susceptibility of Afghanistan to climate change can be discussed in a number of ways, water supplies, pastures, forests, biodiversity, and agricultural operations are all impacted by climate change (Commons, 2006). According the (World Bank Group, 2021) was reported Afghanistan might warm by 1.4 to 5.4 °C by the 2080s and 2090s, relative to the baseline of 1986-2005, which is greater than the global average. (Jawadi et al., 2019; Shroder and Ahmadzai, 2016).

CROP YIELD

In this part, our main focus is on the effects of climate change on crop yields. Rice and corn are grown in the summer, whereas wheat is grown in the winter (Qutbudin et al., 2019; Thomas and Ramzi 2011; Hashimi et al., 2020; Tiwari, et al., 2020). The sowing of irrigated wheat typically starts in late October and ends in early December. When sufficient soil moisture content has been accumulated by rainfall, the rain-fed cropping season begins in the winter (Rycroft and Wegerich, 2009).

Crop harvesting for the winter season begins in late May and lasts until early July because of the frigid winters. Beginning in April, the summer season lasts until the end of the winter season in early July. In contrast to rice and corn, which are only grown in the northern part of the nation, wheat is grown throughout Afghanistan. The north of Afghanistan is used as the primary source of irrigation for summer crops because there is sufficient surface water (Rycroft and Wegerich, 2009).

More than % 70 of total crop production depends on irrigation. Therefore, Crop fail owing to water shortage and the amount of potentially productive land or field left uncultivated will likely both getting increase (Parenti, 2015).

According to some studies by 2060, large parts of the agricultural economy are likely to have become edgy without remarkable investment in irrigation and water management. By these problems, more water intensive staple crops will become less noteworthy to agronomist and farmers, with a likely increase in the attractiveness of those that are more drought hardy, including opium poppy (Savage et al., 2009).

Crop yields are very low because of the low water use, and lack of organization, improved seed, and chemical fertilizer. Recently, drought has caused further decrease in the crop yields, e.g., wheat, rice and corn. Potential impact of climate change on wheat, rice and corn are one main challenge in hydro-climatological studies around the world is inadequate or lacking long-term records and reliable climatic data (Ahmed et al., 2018). In the central highlands, winter wheat planting can begin in October, although spring wheat planting can be harvested there starting in August (Sharma et al., 2015).

Wheat crops in Afghanistan are impacted by temperature patterns and precipitation from October to June. Wheat is as a cool-season crop, wheat can be successfully grown in Afghanistan thanks to the country's climate. Fluctuations in rainfall distribution can affect the nation's wheat harvest by millions of tons (Sharma and Habibi, 2012). Similar to this, fluctuations in rainfall distribution can affect the nation's wheat harvest by millions of tons (Sharma and Habibi, 2012).

Global climate change, the industrial revolution of the then mankind atmosphere to release the carbon dioxide, methane, ozone and nitrogen oxides as gases are very quickly heat the earth by the greenhouse effect that occurred as a result of the increase is a result of an increase above normal (Bağdatlı and Bellitürk, 2016b).

Qutbudin et al., (2019) reported that almost the entire country had temperature increases, with the exception of the southeast. For the wheat cropping season, the counts of the grid sites where precipitation, temperature, and standardized precipitation evapotranspiration index (SPEI) changed considerably across a 50 year sliding window and a 10-year period of 1901 to 2010. SPEI was found to be sensitive to rainfall and temperature. Decreases in SPEI were observed at up to 45 grid points (%16 area) during the period temperatures were increasing at about 40 grid points (%14 area) and when rainfall was decreasing at 70 grid points (%25 area) until 1931. In addition, the geographical distributions of the changes in precipitation, temperature, and the standardized precipitation evapotranspiration index (SPEI) during the rice-growing season was provided. Precipitation was significantly less in the southwest and northwest and significantly more at some grid sites in the northeast and southeast, according (Aich,and Khoshbeen, 2016; Qutbudin et al., 2019).

Nearly all grid sites in the northwest and southwest of the nation experienced a significant increase in temperature. The other crop is corn, according some studies; it has been investigated effect of climate change on corn products. (Qutbudin et al., 2019) was reported the geographical distributions of the changes in precipitation, which depicts temperature and SPEI during the corn-growing season, Rainfall reduced dramatically at a few sites in the southwest and northwest. Nearly all grid sites in the northwest and southwest of the country saw a considerable increase in temperature. As a result the number of grids for the corn cropping season during a 50-year sliding window and a 10 year period of 1901 to 2010 that reported substantial changes in rainfall, temperature, and SPEI (Kim and Jehanzaib, 2020; Qutbudin et al., 2019). Therefore these changes negative effect on corn , rice and wheat products.

CONCLUSION

In this review, we assessed the changes in meteorological during crop growing seasons in Afghanistan, because Afghanistan is primarily dependent on agriculture and has a diverse climatic profile. According to certain research, the country has been significantly impacted by climatic changes during the wheat, rice, and corn cropping seasons due to a study of the changing characteristics of droughts for various crop producing seasons. The country was increasingly afflicted by droughts as a result of changes in temperature and rainfall.

Afghanistan, like many other semi-arid and arid countries, is vulnerable to the effects of a changing climate since water is scarce in these areas due to the low annual rainfall and high rates of evaporation. Climate models predict that Afghanistan will be subject to a variety of new and increasing climatic dangers as a result. Climate change has already begun and will not stop. Different biological processes are anticipated to be affected differently by it. The threat of climate change must be seriously considered in Afghanistan. We must consider the issue of climate change while creating the nation's development initiatives and managing its water resources, which is one of the important, factors that has a direct impact on agriculture.

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A Review on the Impact of Organic, Conventional and Nano Fertilizer Application in Crop Production

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Abstract

Both organic, conventional, and nano fertilizers have advantages and disadvantages. This paper aimed to find out the three kinds of fertilizers and their efficiency in crop production and management. However, it will also depend on some factors to consider. An example is the area of farm for crop production and the capacity of a farmer to acquire such fertilizers. Organic fertilizers are bulky to carry on the farm. These require high transportation costs when compared with synthetic fertilizers. These also lower costs and can be made locally. The slow-release of nutrients into the plants is the vital action of these fertilizers. This will increase the nutrient use efficiency of a plant. The nutrients are slowly distributed into the plants making them sustainable and continually. Conventional fertilizers are not bulky to carry as compared to organic fertilizers. Since these fertilizers contain a high amount of macronutrients and have fast release. Meaning the nutrients are rapidly distributed into the plants. This will lead to elemental loss through leaching, evaporation, or volatilization, and other losses which decrease the availability of these fertilizers into the plants. Similarly, this also pollutes the environment such as water, air, and soil. On the other hand, nano fertilizers are cost-effective. Only 25% is used from the recommended rate as compared with conventional fertilizers. This is also slow-release like with the organic fertilizers. This slow-release action of nano fertilizers results in higher nutrient use efficiency. When large crop plantation, nano fertilizers is suitable while smaller farms are suitable by using organic and conventional fertilizers. This strategy resulted to crop production efficiency.

Keywords: Fertilizers application, yield impact, conventional and nanotechnology

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INTRODUCTION

Many factors can affect crop production, one of these is fertilizer. Fertilizers are the driving force to have a better crop yield, quality, and efficiency of production and most importantly the enhancement of food for human consumption. Recent advances in high-yielding varieties need a plentiful amount of fertilization. And most of these varieties need intensive use of chemicals. On the other hand, natural farming is introduced for healthier human food consumption from the farm. But it needs time for its effectivity, on which the mouth to feed is increasing. However, the soil`s fertility is decreasing as it was intensively cultivated previously. It needs an increasing amount of fertility from what the plant needs. But the challenge is the price of fertilizers as of today also increases.

The increasing human population is the big challenge on how the production system works efficiently to supply human needs. As to the current observation, food production systems are all instant. In contrast, the production made shorten the inputs to have an extreme output. The question is, is it safe to consume?

This paper would be the answer to how these conventional, organic, and nano fertilizers could contribute significantly and effectively the crop production. Additionally, this also helps farmers find and choose the best inputs to use on the farm.

According to Hassani et al., (2015), the use of chemical fertilizers is essential to bridge the gap between supply and demand in food and also in soil fertility. It was also the need to have the highest yield per area of a crop planted. These chemical fertilizers may be conventional or nano fertilizers.

In connection, Ullah et al., (2008) reported that the application of both organic and inorganic fertilizers alone or combined had a significant effect on the vegetative growth of the crop. So, therefore, both these kinds of fertilizer can enhance the production of a crop. Kakar et al., (2020) also presented that the combined application of manure (organic) and inorganic fertilizer significantly improved the physiological and morphological status of crops. This paper aimed to find out the advantages and disadvantages of synthetic and organic fertilizers. Specifically, to determine the advantages of using conventional fertilizers, organic fertilizers, and nano fertilizers in crop production; evaluate the bad effects of these three types of fertilizers, and discuss its comparison related to crop production efficiency.

RESULTS AND DISCUSSION

Advantages in Conventional Fertilizers

Conventional fertilizers are synthetic fertilizers that are locally available in the market. These kinds of fertilizers are mainly composed of nitrogen, phosphorus, potassium, and other trace elements. Some of the fertilizers are compounds, which means that a bag of fertilizers contains more than one element. On the other hand, some are single elements like urea. According to Ullah et al., (2008) that conventional fertilizer's application significantly affects the fast flowering and fruiting of an eggplant crop. They also reported that soil pH gradually increased when applied with conventional fertilizers.

The above findings are also supported by Nizamuddin et al., (2003) that during the vegetative stage of potatoes, it is gradually increased as the rate of conventional fertilizers increases. Especially, the increased rate of nitrogen fertilizer. Additionally, a higher yield is obtained when the dose of conventional fertilizer is above the recommended rate, particularly in potatoes. And also increases marketable yield.

Table 1 and Table 2 below show the significant results of using conventional fertilizers on the yield and its components of potato (Nizamuddin et al., 2003). The results showed that treatment 6 which is the highest fertilizer dose had yielded the maximum as compared to other treatments. The number of tubers, including the medium and big sizes, their weight, and most importantly the marketable tubers was significantly affected by 120kg N, 150kg P_2O_5, and 75kg K_2O of conventional fertilizers, as they concluded and suggested rate.

Table 1. The Treatments Presented by Nizamuddin et al., (2003) in their study on the potato crop

Treatments	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
T1	0	0	0
T2	100	0	0
T3	100	50	0
T4	100	50	50
T5	150	100	50
T6	200	150	75

Table 2. The effect of conventional fertilizers on the yield of potatoes (Nizamuddin et al., 2003).

Treatments	No. of tubers m^2	% Small Tubers <35mm	% medium tubers 35-55mm	% of big tubers >55mm	Ave. Tuber wt. (g)	Yield (t/ha)	% Marketable Yield
T1	42.00d	33.67a	58.67b	7.66d	67.23e	21.00e	66.33d
T2	41.00d	26.67b	59.00b	14.33c	96.50d	27.40d	73.23c
T3	45.00c	20.00c	66.00a	14.00c	103.51c	33.00c	80.00b
T4	46.33bc	14.00d	67.34a	18.33b	110.92b	35.76c	86.43a
T5	48.00b	13.67d	66.00a	20.00ab	116.28a	38.50b	86.09a
T6	51.67a	12.67d	65.33a	22.00a	118.00a	44.10a	87.23a

The study of Janmohammadi et al., (2016) also supported the results of Nizamuddin et al., (2003). Janmohammadi et al., (2016) reported that conventional fertilizers as one of the treatments applied in fertilizing potatoes increase the height of a crop and its stems. The quickest row closure or increased ground cover of potatoes is also influenced by the application of conventional fertilizers as compared to bio-fertilizers. Application of complete conventional fertilizer increases the number of tubers and 16% increased in potato tuber yield. Moreover, also increased in harvest index and significantly increased the nitrate content. Due to nitrate content in potatoes, this also increased and improved the vegetative and tuber yield as significantly affected by complete conventional fertilizer.

Disadvantages of Conventional Fertilizers

Even though conventional or synthetic fertilizer promotes plant growth, the world's food security is met, and the plants cultivated in this manner do not acquire good plant characteristics. The consumer of this chemically produced food will accumulate in the human body, which is bad for the health.

The negative effects of chemical fertilizers will begin with the manufacturing of these chemicals, whose products and byproducts include hazardous substances or gases such as NH_4, CO_2, CH_4, and others that pollute the air. Additionally, these chemical fertilizers are high costly (Chandini et al., 2019).

Table 3. The average use of chemical fertilizers by selected countries (Savci, 2012).

Country	Amount of Chemical Fertilizer Used (kg/ha) $N+P_2O_5+K_2O$
Turkey	100.4
Netherlands	665.5
Egypt	624.8
Japan	373.2
China	301.5
Britain	287.5
Germany	205.4
France	180.1
USA	160.8
Italy	126.4
India	121.4
Greece	115.4
Indonesia	106.9

Table 3 shows the average use of chemical fertilizers kilogram per hectare from the selected countries. Netherlands and Egypt used a huge amount of fertilizers kilogram per hectare as compared to Indonesia and Turkey which are the lowest average chemical fertilizer used. Additionally, Savci, (2012) reported that most of the farms cultivated with water like aquaculture or in a greenhouse will utilize a huge amount of chemical fertilizer resulting in severely polluted water.

According to Savci, (2012) that nitrogen fertilizers reach water in three ways, these are drainage, leaching, and surface flow. Figure 1 shows the distribution of chemical fertilizers in the soil. Plants only use 50% of nitrogenous fertilizers applied to soil, 20% lost through evaporation, 20% react organic compounds in the clay soil and the remaining 10% interfere with surface and groundwater.

According to Chandini et al., (2019) that one of the serious pollutants in water from applied nitrogen fertilizers is nitrates. This could mix in groundwater which contributes to bad effects to human health as drinking water when it exceeds the intolerable amount. Bad effects such as baby blue syndrome in infants and gastric cancer in ruminants.

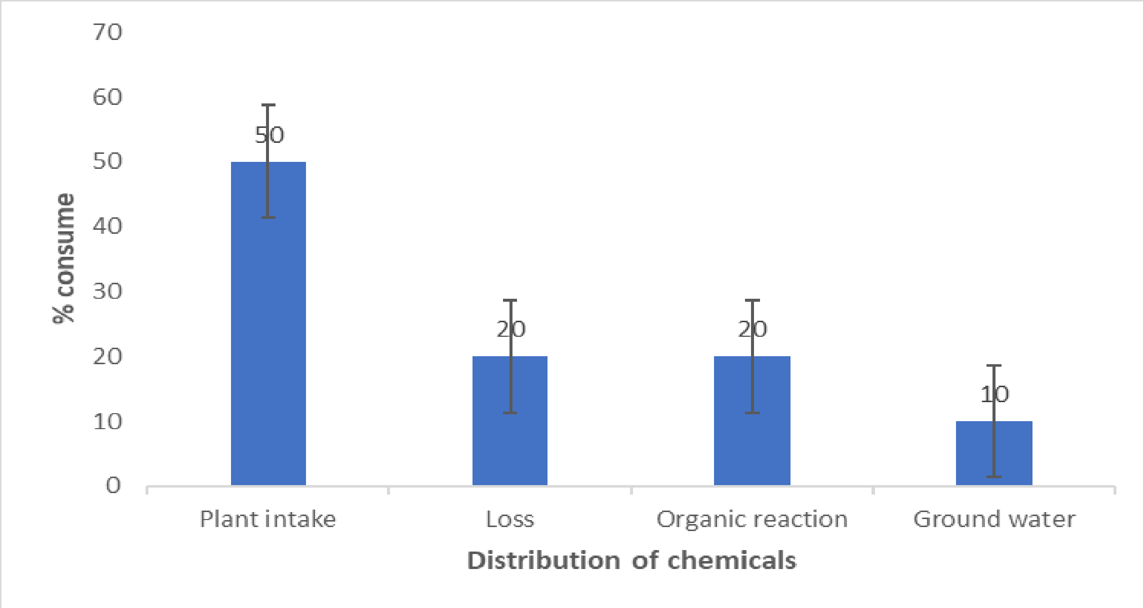

Figure 1. The Distribution of chemical fertilizers applied in the farm (Savci, 2012).

Additionally, Chandini et al., (2019) also reported that chemical fertilizer could pollute not only in water but also in soil and air. The high amount of nitrogen chemical fertilizers may contribute to harmful greenhouse gases that could decrease the protective ozone layer which results in harmful direct effects on humans. For soil pollution, a huge amount of application of chemical fertilizer may result in soil acidity and degrade soil physical and chemical properties caused by imbalance used of the essential nutrients needed by plants. This results in inefficient crop production. This is also supported by Assefa & Tadesse, (2019) that the use of conventional caused the destruction of soil texture and structure that lead to soil erosion and acidity resulting from the leaching of soils.

Advantages of Organic Fertilizers

Organic manure such as from poultry and cow have multiple benefits due to the balanced supply of nutrients, including complete micronutrients, increased soil nutrient availability due to increased soil microbial activity, the decomposition of harmful elements, soil structure improvements, root development, and increased soil water availability (Han et al., 2016).

Moreover, Ullah et al., (2008) also reported that the availability of major plant nutrients mostly macro elements is also affected by organic farming. This results in an increase of nitrogen, phosphorus, and sulfur from the applied poultry manure. And increase the availability of potassium when cow dung is applied. These was shown below in table 4. From the finding, chemical fertilizers had the lowest value of microelements than poultry manure and cow dung. In addition, Lin et al., (2019) also reported that the use of organic fertilizers can enhance crop yield and soil properties and will prevent pest and disease infestations.

Table 4. The effect of organic manure on the soil's chemical properties (Ullah et al., 2008).

Treatments	Soil pH	%OM	Total N (%)	Available P (ppm)	Exchangeable K (me/100g)	Available S (ppm)
T1	6.01c	2.05cd	0.16bc	13.12b	0.17a	12.75ab
T2	6.27ab	2.67bc	0.16bc	13.59b	0.16b	12.09ab
T3	6.13bc	3.06ab	0.17ab	14.91a	0.17a	13.50a
T4	6.38a	1.82d	0.16bc	13.10b	0.15c	12.19b
T5	6.19abc	3.57a	0.16bc	13.55b	0.16bc	12.80ab
CV (%)	2.04	4.06	3.09	5.08	3.47	5.28
Initial Value	6.36	1.98	0.12	12.59	0.14	12.02

Legend: T1-Cowdung; T2-Mustard oil cake; T3-Poultry manure; T4-Chemical fertilizer; T5-Organic 50% + inorganic chemical 50%

Moreover, Lin et al., (2019) reported that the soil pH level was significantly higher in the organic fertilizer application than chemical fertilizers. They also found out that these organic fertilizers are decreasing the number of heavy metals in the soils of tea farms. According to Assefa & Tadesse, (2019) organic fertilizers are the by-products of plant, animals, and mineral decomposition. The nutrients from it will be released slowly. This will allow the plant to process it the natural way that results in undamaged the plant. Additionally, soil drainage and air circulation improved. It also reduces soil acidity and does not cause leaching.

Disadvantages of Organic Fertilizers

Organic manure has several disadvantages, including little nutrient content of each manure, slow decomposition, and unlike nutrient compositions depending on its organic materials (Han et al., 2016).

According to Assefa & Tadesse, (2019), the increased demand for organically grown crops or food for consumption leads to expensive produce. In connection, Ullah et al., (2008) reported from the result of their study that organic manures did not increase the vegetative growth of plants, this is due to the slow release function of this kind of fertilizers.

Moreover, Ukoje & Yusuf, (2013) reported that with the growing population, the demand for food sustainability is critical. Adapting organic farming alone without the application of fast-release fertilizers will not sufficiently support the demand for food in the people of Africa.

Combination of Organic and Inorganic fertilizers

The productive results of cultivating solanaceous crops are due to the combined application of organic and inorganic fertilizers. This result is due to organic fertilizers functioning as slow-release while inorganic fertilizers are fast-release. So, the nutrients needed by plants are supplied continuously and rapidly. In addition, these results in more productive, continuous soil fertility and productivity of crops (Ullah et al., 2008).

Fertilizer Cost Efficiency

Fertilization costs accounted for 20% to 30% of the total production costs in biomass production. However, the effects of the mixed-use of chemical fertilizer and organic manure on the growth of trees and soil fertility vary significantly according to the fertilizer amounts and the organic manure characteristics. The amount of organic manure required is mainly determined by the nitrogen content. However, special attention needs to be paid because the ratios of nutrients other than nitrogen can differ from the trees' requirements (Adegbidi et al., 2003). Nano fertilizers only require 25% of the recommended rate, then the production is optimum. So, therefore, nano fertilizer is cost-effective.

Advantages of Nano fertilizer

Nano fertilizer application promoted the growth, development, and antioxidant activity in rice which have the potential to improve crop production and plant nutrition (Benzon et al., 2015). According to Astaneh et al., (2021) nano fertilizer can increase crop yield, improve soil fertility, reduce pollution and make a favorable environment for microorganisms in the soil. It also prevents nutrient loss in the soil such as leaching, evaporation or volatilization, and other ways that the nutrients needed are essential to plants.

In connection, Burhan & AL-Hassan, (2019) revealed that productivity of wheat grain yield applied with nano fertilizers increases, about 48.99%, the protein percentage has 27.24%, gluten ratio in flour has 58.45% and flag leaf area 38.69%, nitrogen has 19.37%, phosphorus has 44.11% and potassium has 12.03% as shown below in table 5.

Table 5. The effect of Nano fertilizer on the physiological traits of wheat (Astaneh et al., 2021).

Application of N fertilizer (kg/ha)	**% Protein**		**Phosphorus (mg)**		**Potassium (mg)**	
	Conventional N fertilizer	Nano N fertilizer	Conventional N fertilizer	Nano N fertilizer	Conventional N fertilizer	Nano N fertilizer
80	4	33	17	26	11	11
160	10	54	35	58	18	25
240	17	69	54	80	27	38

Moreover, Astaneh et al., (2021) concluded that the problem of a growing population that increases the demand for food and the problem of environmental pollution, nano fertilizers can help provide a solution on this issue. Accordingly, they also recommended that conventional fertilizers are good to be replaced by nano fertilizers especially in some soil types that are prone to leaching.

The study of Abdel-Aziz et al., (2021) revealed that the 25% concentration NPK nano fertilizers promote the growth of crops and showed better results with fruit yield and quality. So, it is more effective with low concentration application of NPK nano fertilizers into the crops than synthetic or conventional chemical fertilizers.

Khalid et al., (2021) also presented the result of their study that nano fertilizers help increase morphological parameters of the crop by 50–93% while 28–50% only when applied with conventional fertilizers and the increase in chlorophyll content of about 30-80% is observed when nano fertilizers are applied.

Disadvantages of Nano fertilizers

According to Abdel-Aziz et al., (2021) that their results from the study suggested that it needs future research about toxicological studies about nano fertilizers. In which they believe and observed that this nano fertilizer may have a toxic substance that might affect the health of humans and animals.

Conclusion and Recommendation

This paper finally found out that these three kinds of fertilizers have also provide an efficient nutrients needed by the crop. However, it will also depend on some other factors to consider in crop production and management. An example is the type of the soil in the farm for crop production and the capacity of a farmer to acquire such fertilizers. Organic fertilizers are bulky to carry on the farm. These require high transportation costs when compared with synthetic fertilizers. These also lower costs and can be made locally. The slow-release of nutrients into the plants is the vital action of these fertilizers. This will increase the nutrient use efficiency of a plant. The nutrients are slowly distributed into the plants making them sustainable and continually. Conventional fertilizers are not bulky to carry as compared to organic fertilizers. Since these fertilizers contain a high amount of macro-nutrients. On which function as fast release. Meaning that the nutrients are rapidly distributed into the plants. This will lead to elemental loss through leaching, evaporation, or volatilization, and other losses which decrease the availability of these fertilizers into the plants. Similarly, this also pollutes the environment such as water, air, and soil. Nano fertilizers are cost-effective. Only 25% is used from the recommended rate as compared with conventional fertilizers. This is also slow-release like with the organic fertilizers. This slow-release action of nano fertilizers results in higher nutrient use efficiency or NUE. When large crop plantation, nano fertilizers is suitable while smaller farms are suitable by using organic and conventional fertilizers. This results to crop production efficiency. Nutrient use efficiency (NUE) is a critically important concept in the evaluation of crop production systems. The objective of nutrient use is to increase the overall performance of cropping systems by providing economically optimum nourishment to the crop while minimizing nutrient losses from the field.

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The Assessment of Global Warming on Fish Production in Red Sea Region of Sudan

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Abstract

The Red Sea is one of the warmest and saltiest seas in the world. Generally Marine communities are facing increasing pressures especially with climate change. Climate change means changes in weather for years that either occur naturally or by human activities. Temperature, winds, vertical mixing, salinity, oxygen, pH and other physical and chemical elements, among others, have a range of direct and indirect effects that have an impact on fisheries. The direct effects act on the physiology, development rates, reproduction, behavior and survival of individuals and can in some cases be studied experimentally and in controlled conditions. Indirect effects act via ecosystem processes and changes in the production of food or abundance of competitors, predators and pathogens. Besides all that, Policymakers continue to pay insufficient attention to the fishing industry. Fisheries should be prioritized throughout the adaptation phase of policy development, and enough funding should be allocated to increase regional fish output that is sustainable. The aim of this study was to determine the effects of climate change on fish production in the Red Sea region of Sudan. It has been observed that the average maximum temperature for many years in the region is 33.8 ^{0}C. The total precipitation average was recorded as 165 mm. To reduce the potential effects of climate change on fisheries and food security for many impoverished fishing communities in Sudan, it is advised that expanded and sustained investments in market development, fisheries governance, and the provision of economic incentive mechanisms be made.

Keywords: Global Warming, Fish Production, Red Sea, Sudan

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INTRODUCTION

Millions of people reside in communities that are reliant on the fruitful, nourishing abundance of fisheries around the shores of the world's seas and oceans, as well as along the shores of rivers and lakes. With this nutritional commodity, fish and other marine creatures play a clear role in supporting household food security in many nations.

The sale of seafood is a significant source of revenue for coastal towns (Matthews et al., 2014). More than 200 million Africans frequently consume fish, according to estimates (Heck et al., 2007).

Global climate change, the industrial revolution of the then mankind atmosphere to release the carbon dioxide, methane, ozone and nitrogen oxides as gases are very quickly heat the earth by the greenhouse effect that occurred as a result of the increase is a result of an increase above normal (Bağdatlı and Bellitürk, 2016a).

Increasing or decreasing changes in climatic values affect living things negatively and cause a decrease in productivity, especially in agricultural production (İstanbulluoğlu et al., 2013). The majority of African nations lack crucial data on the present situation and prospective contribution of fisheries resources to livelihoods and food security despite the fact that they are of utmost importance (Béné and Neiland, 2003). In many countries, family food security is clearly supported by aquatic products.

Increasing world population, changing climate conditions and economic activities are growing with each passing day makes it more important than water (Bağdatlı and Bellitürk, 2016b). There are changes in the water surface in the world due to global warming. This is the effect of evaporation in water resources and irregularity in the current precipitation regime due to climate change (Albut et al., 2018).

Sudan's freshwater fisheries are concentrated on the Nile River, its tributaries, and sizable reservoirs, As well as fisheries in the Red Sea. The Nile River System and the geography of Sudan are both ideal for aquaculture and catch fisheries. Sudan has an abundance of water resources. In Sudan, man-made lakes cover around 3,075 km^2. In 2017, Sudan's capture fisheries produced close to 38400 tons, 3300 tons from maritime captures and 35100 tons from catches in interior waters (FAO, 2019). Sudan has a total coastline of 853 km, and Its territorial rights in the Red Sea cover an Exclusive Economic Zone (EEZ) of 91 600 km^2 and a continental shelf area of 22 300 km^2. These waters are bountiful in fishing resources and also possess abundant coral populations. Although the coast is long, the marine fisheries sector in Sudan is small with official annual catches at 5000 tons in 2012 and 4000 tons in 2013 A catch reconstruction for 2010 of 2000 tons was low compared to the official catches statistics of 5700 tons, likely attributable to poor quality of available fisheries statistics in terms of degree of coverage and representatively (Tesfamichael and Elawad, 2016).

Sudan depends on fresh water fisheries where the Maximum Sustainable Yield (MSY) is about 110,000 tons. In comparison marine fisheries MSY stands at around 10,000 metric tons/annum (Ministry of Livestock and Fisheries, Sudan 2018**)**.

The world's per capita intake of fish is 34 kg per year, compared to Sudan's estimated 6.5 kg per year, which is deemed low when compared to other regional African nations (average: 13 kg per person/year), The fact that many tribes and tribal sub-sectors in red sea state dislike eating fish or shellfish of any kind or engaging in any type of fish-related activities (UNIDO, 2017).

Although utilization methods remain largely traditional, The Sudanese private sector and international businesses have lately made some limited efforts in the direction of commercial usage of fish deposits in the Red Sea.

Due to significant evaporation rates and a lack of riverine inputs, the Red Sea is one of the youngest seas on Earth, as well as one of the hottest and saltiest (Rasul et al., 2015). The Red Sea has a relatively short rejuvenation period, similar to other marginal seas, and is anticipated to react quickly to climate change given the current and impending environmental changes (Belkin, 2009).

Sea surface temperature (SST) in the Red Sea suddenly increased, according to Raitsos et al., (2011), with geographic patterns indicating greater increases in the north. According to Chaidez et al., 2017; there has been an increase of 0.25°C each decade, which is greater in its northern part.

Important issues about the Red Sea ecosystem's functioning and prospects in a changing environment are raised by the stated developments. Therefore, this study was carried out to assess the effects of Global Warming on Fish Production in red sea Region, Sudan. Stakeholders and decision-makers in Sudan would benefit from the findings of this study because they will enable them to more accurately estimate the effects of climate change and evaluate the viability of intervention alternatives.

MATERIAL AND METHOD

The study area includes the Nile River States and the Northern State (Figure 1), Red Sea is one of Sudan's 18 states. It has a 212,800 km^2 area and 1,482,053 people living there. The state's capital is Port Sudan. In this study, linear regression method was calculated for the analysis of climate data the standard deviation of the climatic data was also calculated. The Linear Regression Model is the most commonly used kind of regression in applications and is one of the oldest and most researched subjects in statistics. Regression analysis is a method for describing quantitative connections between one or more explanatory factors and a response variable (Rezaeianzadeh et al., 2014; Salihi and Üçler, 2021).

Figure 1. The location of research area

RESEARCH FINDINGS

Analysis of Climate Data

Figures 2, 3 and 4 shows the climatic change data including average Temperature (°C), Minimum temperature (°C), and Max. Temperature (°C). When we see on standard deviation average temperature, minimum temperature and maximum temperatures have almost same value of standard deviation. The highest max. temperature was 40.8 °C recorded in August, while the lowest min. temperature was 19.1 °C recorded in January.

While Figure 5 and 6 shows Precipitation and Rainy days, where it rains in all months of the year except May and June, while the highest rate of rain and the number of rainy days were in November and October. Figure 7 shows Humidity, the highest humidity recorded in October, November, December and January, while the lowest was in June and July. As for Figure 8, it shows the Sunny days, where the daylight hours were higher in June and July.

By performing a linear regression analysis between months and climatic change factors separately, the values of all climatic variables data may be explained. Where R^2 values indicate whether these climatic variables are closer to the regression line's expected values or not.

We find that the real values of all of these variables are not closer to the projected values after analyzing regression. Precipitation has higher R^2 value followed by Min. temperature, rainy days, Average temperature, humidity, Max temperature, and sunny days. Which means Precipitation actual values are closer to predicted values to some extent. It was found that real values of climatic variables are rapidly changing as a result of climate change.

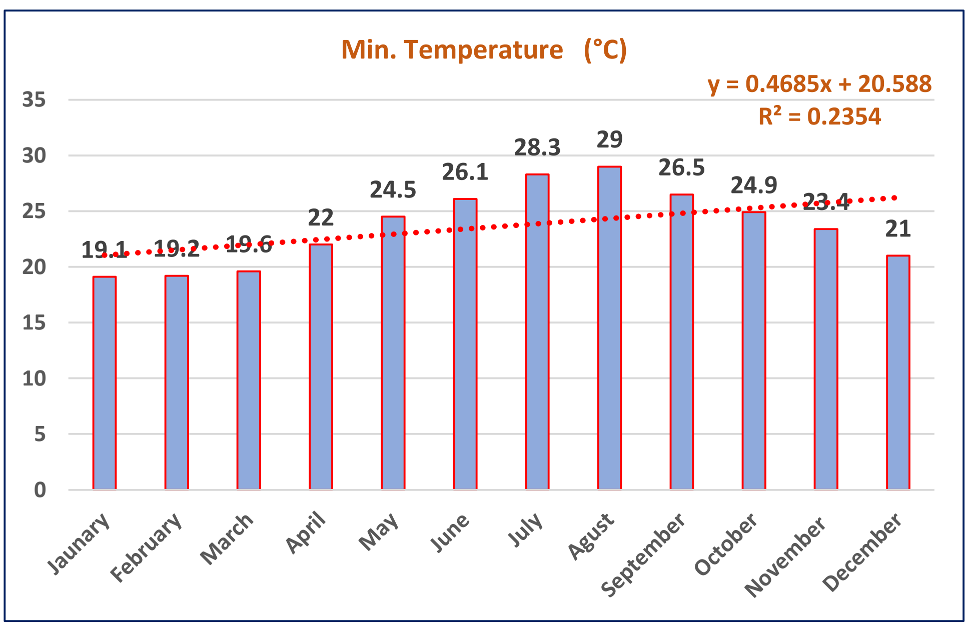

Figure 2. The distributions of Min. Temperature according to months

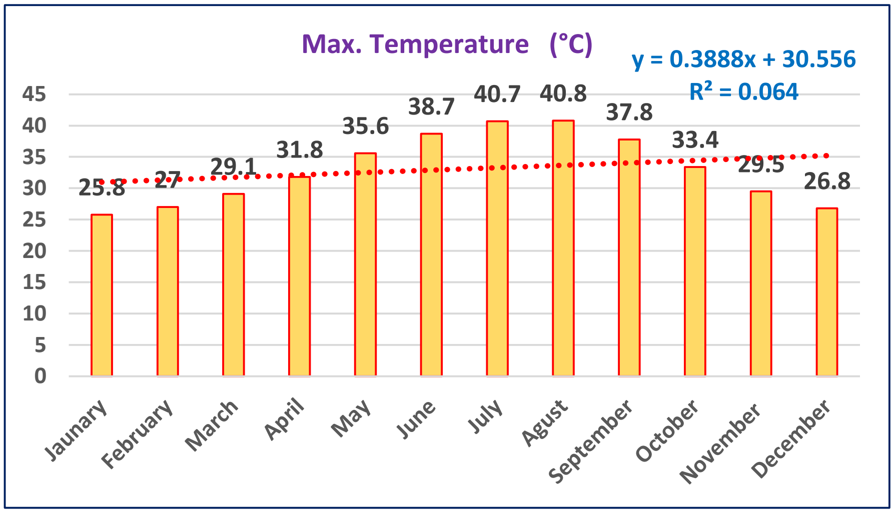

Figure 3. The distributions of Max. Temperature according to months

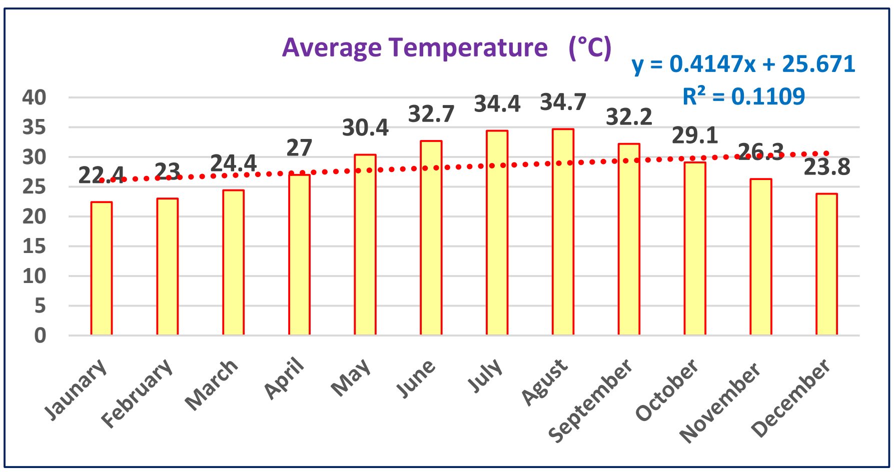

Figure 4. The distributions of Average Temperature according to months

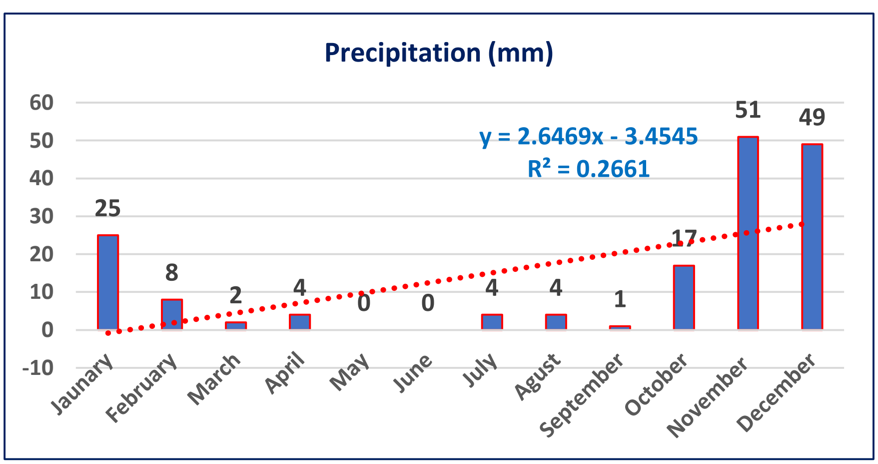

Figure 5. The distributions of Precipitation according to months

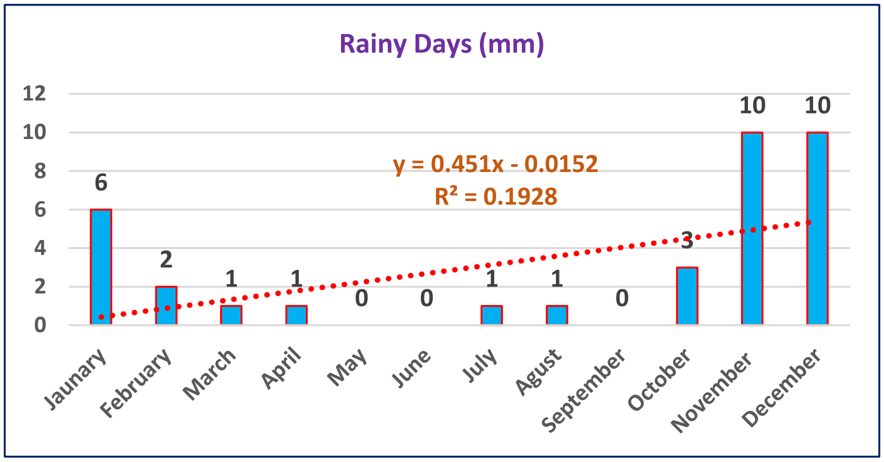

Figure 6. The distributions of Rainy Days according to months

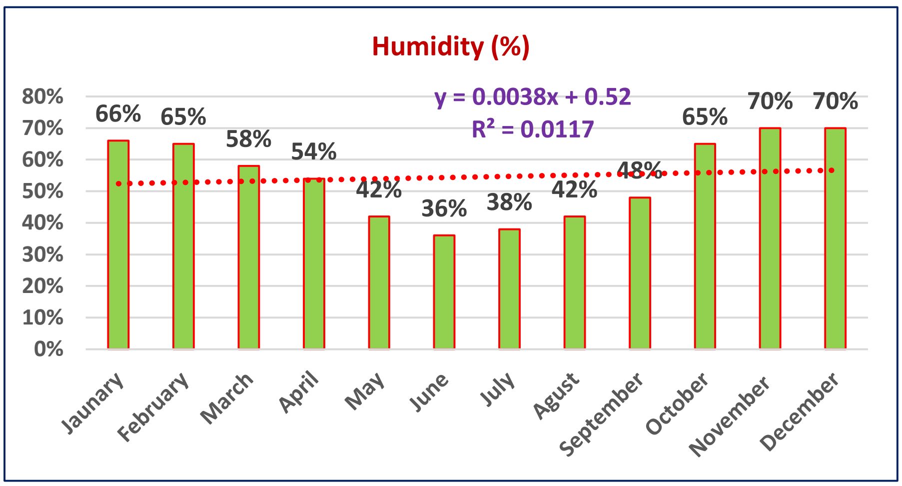

Figure 7. The distributions of Humidity according to months

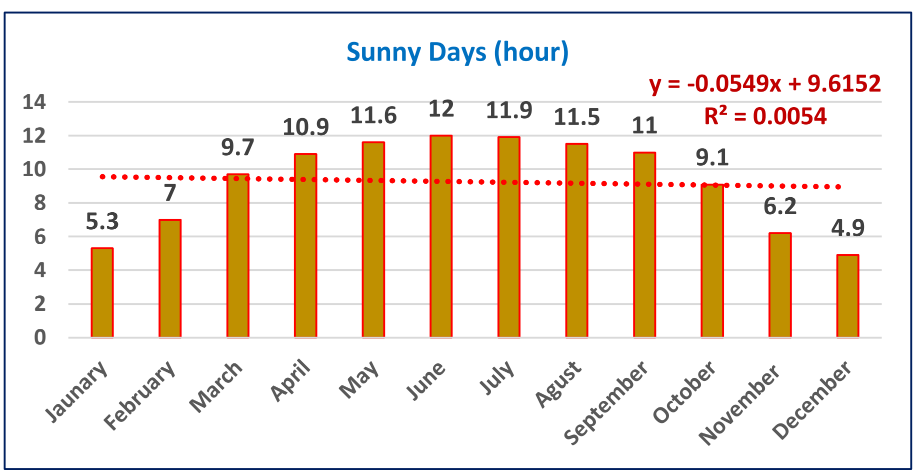

Figure 8. The distributions of Sunny Days according to months

Khartoum is one of the warmest region in Sudan with an average daily high temperature of 38 degrees centigrade. It is yearlong warm or hot. While Red Sea is one of the coldest regions in Sudan with an average daily high temperature of only 35 ºC. It is warm to hot all year round, at average water temperatures of 28 degrees (Table 1).

Table 1. The average or total values and Standard deviation of Some Climate Data in Red Sea Region of Sudan

Climate Parameters	Average	Standard deviation
Min. Temperature (°C)	23.63	3.4820
Max. Temperature (°C)	33.08	5.5406
Average Temperature (°C)	28.37	4.4903
Precipitation (mm) (Total)	165.00	18.4988
Humidity (%)	0.55	0.1285
Rainy Days (Total)	35	3.7040
Sunny Hours (hour)	9.26	2.6980

Analysis of Fish Production Data in red sea

The Red Sea's yearly marine capture is less than 1500 tons. Red bass, jack, mullet, and sardinella make up the majority of the catch. Port Sudan is the principal landing location. The major tools utilized are headlines, beach seines, and gillnets. The Red Sea is also used for mother-of-pearl and trochus shell fishing. There is also small-scale commercial shrimp fishing. However, statistics on fisheries and biomass are lacking, thus efforts should be made to increase output in order to satisfy domestic demand and enhance exports. Figure 9 shows fish production in the study area. The figure shows the fluctuation in the volume of production, which is due to many factors, perhaps the most prominent of which is climate change, which has become a major issue threatening fisheries all over the world, in addition to the fact that the Red Sea is one of the warmest and saltiest seas in the world. Water exchange occurs only in the south, and there is moderate variability in nutrients at macro-environmental levels.

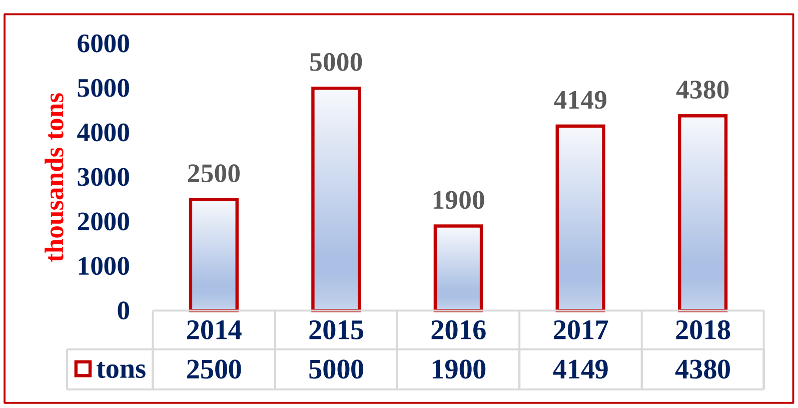

Figure 9. Fish Production in the study area. (Ministry of Livestock and Fisheries, Sudan 2018)

Fisheries are a major source of food for the majority of poor and vulnerable communities in Sub-Saharan African countries. The sector also provides jobs to many men and women and is one of the most traded food commodities in the region. However, the region's fisheries are seriously threatened by climate change. Physical and biological changes are the two categories used to classify possible effects of climate change on fisheries;

Physical changes include increases in sea level, water salinity, and water temperature; biological changes include shifts in primary production and the distribution of fish stocks (Mohammed & Uraguchi, 2013). According to the greenhouse gas emission scenario and the model forecasts for marine regions, the world's exclusive economic zones' maximum catch potential would both decline by 2050 by between 2.8 and 5.3 percent and between 7.0 and 12.1 percent, respectively (Barange et al., 2018).

CONCLUSION AND RECOMMENDATIONS

World has been threatened by climate change under the effect of increased carbon emission and greenhouse gas. Carbon is one of the basic elements of life and shows search without being fixed. The amount of CO_2 reduces the protective use of the bard layer. With this effect, it causes irregular precipitation and excessive temperature increases (Bağdatlı and Arıkan, 2020).

Population growth rate along with the climate change phenomenon will cause lots of problems for worldwide food supply and we will face numerous nutritional problems in the near future. By gradually reaching to the 8 billion population on the earth, the mankind is really in challenge to provide the growing population food needs (Bağdatlı et al., 2015)

There is always the critical importance of aquaculture and fisheries to the millions of people who rely on them to maintain a fair quality of living. However, climate change poses a significant threat to fisheries in the region. If the industry is to continue helping the world achieve its objectives of reducing poverty and ensuring food security, it must pay special attention to those who are most vulnerable to the effects of climate change when implementing adaptation strategies. The highest temperature may be a more pertinent feature in respect to some particular concerns, but most assessments concentrate on the mean seawater temperature. For instance, when temperatures rise over an organism's thermal threshold, thermal collapse occurs. It consequently depends on the highest temperature the organisms encounter rather than the mean temperature. In the Red Sea, where maximum seawater temperatures are already very high, this could be especially crucial. Future monitoring and research must be intimately connected to responsive, adaptive, and reflexive management systems in order to adapt to the changing environment.

Climate change and global warming are reducing the available water resources almost everywhere in the world (Uçak and Bağdatlı, 2017). Excessive increase and decrease of temperatures negatively affect the life of living things. It will be difficult to find clean water in the future as the increase of temperatures will increase the evaporation level. Increasing or falling temperatures will cause climate change (Bağdatlı and Can, 2020).

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The Evaluation of Solid Waste Management Via Urbanization for Kirklareli Province (Turkey)

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Abstract

Due to industrialization and urbanization, resources are consumed disproportionately and as a result, a significant amount of waste is left to receiving environments. The increasing volume of waste affects nations, communities, agricultural lands, families, and individuals. Kırklareli province is the city of Turkey in Western Thrace, which is part of the Marmara Region, which houses a significant part of the national industry and agricultural industry and population. This study aimed to determine the solid waste types and the volume of each type of waste generated in Kırklareli province and to analyze the recycling possibilities of these wastes. Thus, the study aimed to determine the current state of solid waste production in Kırklareli during the urbanization process. The findings of the study showed that the waste collection and disposal procedures implemented in Turkey were also adopted in Kırklareli.

Keywords: Waste management, Recycling, Solid waste, Urbanization, Kirklareli

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INTRODUCTION

Our border province, located on the Yıldız (Istranca) Mountains and Ergene Plain sections of the Marmara Region, is surrounded by Bulgaria in the north, the Black Sea in the northeast, Tekirdağ in the south and southeast, and Edirne in the west. Our province, which has a surface area of 6,550 square kilometers, has 180 kilometers of land border with Bulgaria and 60 kilometers of seacoast to the Black Sea. The north and east of our province, which is 203 meters above sea level, is mountainous and forested, while the other parts are generally flat. The region has a continental climate, with harsh and rainy winters and hot and dry summers. Its main streams are Ergene River and Mutlu Creek. It shows forest and steppe characteristics as vegetation. “Ergene River were directly affected by problems originating from pollutants in the river bed. It has been thought that the yearly observation of the differences in the land use and in the changes occurring in the range of products in the agricultural fields adjacent to the Ergene River in the region and the pooling together of these differences has formed a base in other studies” (Albut et al., 2018).

With the development of society, the amount of solid waste produced every year is increasing. Solid wastes cause various environmental problems if they are not handled and used properly due to their complex structure (Cai et al., 2016). The amount of solid waste produced globally is approximately 1.7 billion tons per year, and this amount is estimated to be 2.7 billion tons in 2024 (Laurent et al., 2014).

However, solid wastes containing precious metals (mining tailings, ore processing wastes, fuel slag, slag from smelting and chemical processes, organs from hospital waste, agricultural waste, etc.) still have reuse value (Mazumder and Rano, 2015). Most of the solid wastes are misused even though they can be recycled after separation and purification.

Solid waste management is important for controlling environmental pollution, reducing greenhouse gas emissions, persistent organic compounds, and conserving resources. With the increase in global waste generation, solid waste management has placed an increasing burden on the planet and needs to be well organised (Hoornweg et al., 2013). The accumulation of carbon dioxide and other greenhouse gas levels in the atmosphere have reached has increased rapidly since the industrial revolution (Bagdatli and Belliturk, 2016a).

Most of the municipal solid wastes are from domestic, commercial, and institutional activities. Food, paper, plastic, glass, textile scrap, wood and other materials are examples of these types of waste. Since materials from such wastes do not decompose naturally and their degradation may take longer, an alternative method must be found to reduce such a problem (Ashani et al., 2020). With the extensive use of pesticides, many waste pesticide packages were produced, which refer to the waste packaging that is directly contacted with pesticides or contains pesticide residues after use, including bottles, tanks, barrels, bags, and other types of containers (Li and Huang, 2018). With the widespread use of pesticides, the supply of pesticides from the market has intensified with plastic bottles, tanks, barrels, plastic bags, and other containers. Waste packages that come into direct contact with pesticides or contain pesticide residues after pesticide use cannot be abandoned to nature (Li and Huang, 2018). Adequate management of such wastes is important to minimize environmental impacts, reduce economic costs and eliminate any social impact on citizens (Stone et al., 2019). One of the main sources of agricultural and non-point pollution is the combined pollution of pesticides and heavy metals (Akter et al., 2022). When dry agricultural lands and irrigated agricultural lands are compared, it has been observed that pesticides and heavy metals are easily released into the receiving environments by the paddy soil and the flowing overload enters these environments and creates serious agricultural non-point source pollution (Schaffner et al., 2010).

MATERIAL and METHOD

Kırklareli province of Turkey is choosen for study area. This city is an important city with its fertile agricultural lands covering a significant part of the fertile plains of Thrace, on the one hand, and a large part of the Yıldız Mountains, which have a rich forest existence, on the other hand. It is an exceptional settlement with tourism potential. With these features, Kırklareli, which is both Thracian and Black Sea, is ranked 11th among 81 provinces in terms of socio-economic development with its fertile lands, industry, historical and natural beauties, artistic and cultural texture, 7th in the education sector development ranking and 15th in the health sector development ranking. is one of the important border provinces of our country, neighboring Istanbul, and Europe.

In the city center, there are small industrial estates and carpenters' estates in different regions. Some of the heavy industry establishments are located at the exits of the city, on the side of the intercity highway. Pollutant elements originating from this region affect the air quality of the city center due to the proximity of this region to the city center.

Despite this, it is necessary to prevent the construction that may create local environmental pollution in different regions and pose problems within the scope of the solution of infrastructure problems. Zoning arrangements should be made to leave a certain distance between industrial facilities and residential areas, and infrastructure works should be carried out to move industrial facilities and workshops outside the city settlement.

The methodology of the study followed to achieve a case study analysis of selected waste types in Kirklareli province as munipical, package, hazardous, excavation, construction and demolition, mineral oil, batery of wehicles, tires, electrical and electronic wastes, medical, vegetable oil, mining, sludges, composts, and hazardous wastes. Additionally, the R^2 values of the logaritmic correlation from datas given in graphics were added with each formula. These values were calculated with microsoft word excel program. The quantity and properties of domestic solid waste are associated with urban characteristics, the social and economic conditions of the population, the climate, the type of fuel consumption, and similar factors.

RESULTS AND DISCUSSION

Based on the Kirklareli Provincial Directorate of Environment and Urbanization 2020 data, the composition of Kirklareli Province solid waste is presented in Figure 1.

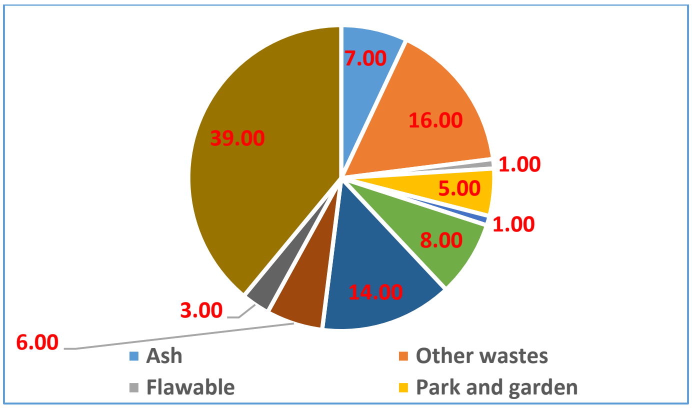

Figure 1. Kirklareli Province Solid Waste Composition

As seen in Figure 1, the ratio of the recycled material to the production is % 14 for plastic, % 1 for metal, % 39 for kitchen waste materials, % 9 for paper and cardboard, and % 7 for ash in Kirklareli province, where % 8 for the recovery of glass packaging.

Municipal Waste

The Sanitary Waste Landfill Area has been transferred to the Kırklareli Local Governments Solid Waste Facilities Construction and Operation Association (KIRK-KAB) by the Municipality of Kırklareli. Due to the electricity transmission line passing over the second lot, which is about to be filled, this lot is planned to be canceled as a second lot by combining lots three and four. Within the scope of the Provisional Article 1 of the "Regulation on Landfilling of Wastes", which was published in the Official Gazette dated 26.03.2010 and numbered 27533, it is planned to build a pre-treatment facility for the reduction of biodegradable wastes.

Packaging Waste

According to the European Union Packaging and Packaging Waste Directive, packaging includes all recyclable and non-recyclable products manufactured with any material and used for transportation, protection, storage, and sale of a product, including raw materials and processed products, during the delivery of a product from the manufacturer to the user or consumer (Packaging Information System, 2019). Packaging waste was defined as sales, secondary, shipping, and packaging waste that are disposed to the environment, including those used for the presentation of the product during delivery or produced after the consumption of the product, including packaging the economic life of which is over or reusable material excluding the manufacturing waste (Sayar, 2012). For the area owned by Kırklareli Municipality with a surface area of 150.000 m^2 on 589 blocks, 78 parcels in Kırklareli Merkez Karaca İbrahim Mahallesi Kirmizi Yar Locality, on Kirklareli-Pınarhisar road route, with the decision of "Environmental Impacts are Negligible" taken by the Local Environmental Board on 06.07.2000, the site selection of the regular waste storage area The project contract was signed on 01.08.2005, and the design of an area of 80,000 m^2 over 4 lots was carried out. The packaging waste recovery facilities that operate in Kirklareli province in 2020 for zero waste activities are presented in Table 1 and the total number of facilities in province was 886 while the number of facilities in the system was 558**.**

Hazardous waste

In recent years, with the increase in industrial activities, a large amount of toxic and hazardous waste is produced and discharged. If we make the definition of hazardous waste, the expression of waste with chemical composition that harms people, plants, animals, and ecosystems such as disease and death when pollutants are released into the environment is appropriate (EPA, 2021). There are 3 licensed hazardous waste recovery facilities in Kirklareli province, and the recovered waste was 20.059.122 tons in these facilities in 2019 (Kirklareli Province Environmental Status Report, 2020). Since the waste statistics for 2020 in the Waste Management Application contain raw data, the evaluation and examination process of which is still ongoing, the charts and graphs include 2019 as the final data. The equations and R^2 values correlated with recycling, disposure, and export datas between 2016-2019 were given in Table 2. Hazardous waste management in our province according to waste management application data were given in Figure 2.

Table 1. Number of institutions/organizations implementing the zero-waste system as of 2020 (zerowasteinformationsystem.csb.gov.tr, 2021)

Institution Type	**Total Number of Institutions**	**Number of Institutions in the System**
Sites with 300 or more residences	3	-
Fuel stations and resting facility	89	84
The mall	6	one
Council	21	23
Industrial facility in Annex-1 of the EIA regulation	66	40
Industrial facility in Annex-2 of the EIA regulation	178	29
Provincial directorate of environment and urbanism	1	5

Educational institution and dormitories	263	105
airport	-	-
City administrations	1	1
Business center and commercial plaza	10	-
Public institution and organization	-	136
Accommodation establishments	6	2
Port	3	-
Organized industrial zone	4	5
Healthcare organizations	76	14
Train and bus terminals	7	-
Chain markets	152	113

Table 2. The equations related with recycling, disposure, and export activities

Data	**Equations**	**R^2**
Recyling	y=YE+0,6ln(x)+8E+0,6	0,6009
Disposure	y=208698ln(x)+3E+0,6	0,0061
Stock	y=1952ln(x)+30935	0,0027
Export	y=-23094ln(x)+40972	0,5611

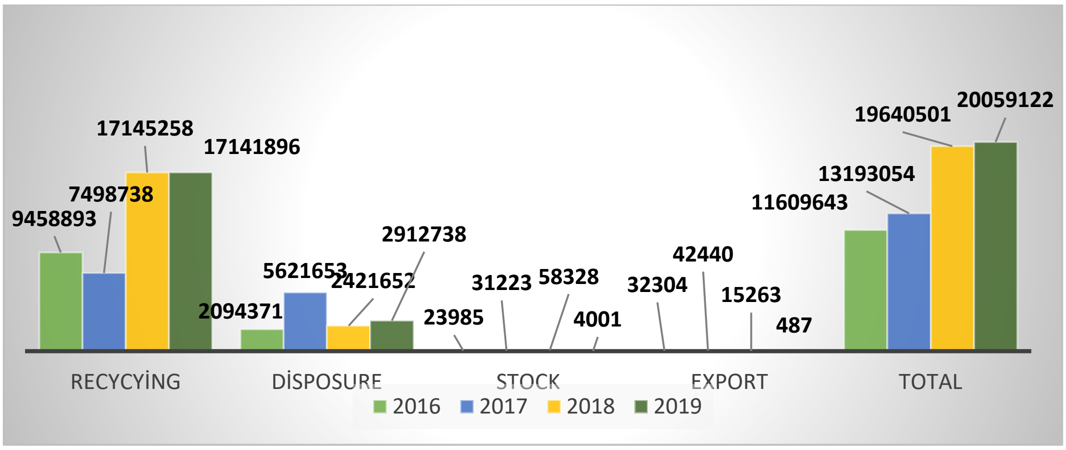

Figure 2. Hazardous waste management in our province according to waste management application data*(Waste Management Application, 2021)

Waste mineral oils

Oil waste is partially or completely composed of mineral, synthetic, or biogenic oil waste. Mineral oils are employed in lubrication of mechanical tools and equipment, and after a certain period, the chemical and physical properties of the mineral oil deteriorate due to friction and development of solid residue and should be replaced. Oil waste could be recyled by reclaiming the oil waste as raw material or by adding to energy fuels.

Efforts have been spent to ensure the disposal of oil waste in accordance with the "Oil Waste Control Regulation" in Kirklareli, and to raise awareness in public and private organizations that produce oil waste. The storage of oil waste is not allowed in the facilities in the province. However, the facilities that desire to store oil waste in the facility are provided with a temporary waste storage permit if they meet the required physical conditions. In 2019, 203870 tons of oil waste was produced in the province (Kirklareli Province Environmental Status Report, 2020). It was informed that the facilities should collect and send the waste mineral oils in accordance with the “Regulation on the Control of Waste Oils”. Waste Mineral Oil Collection Amounts in Kırklareli Province by Years is given in Figure 3.

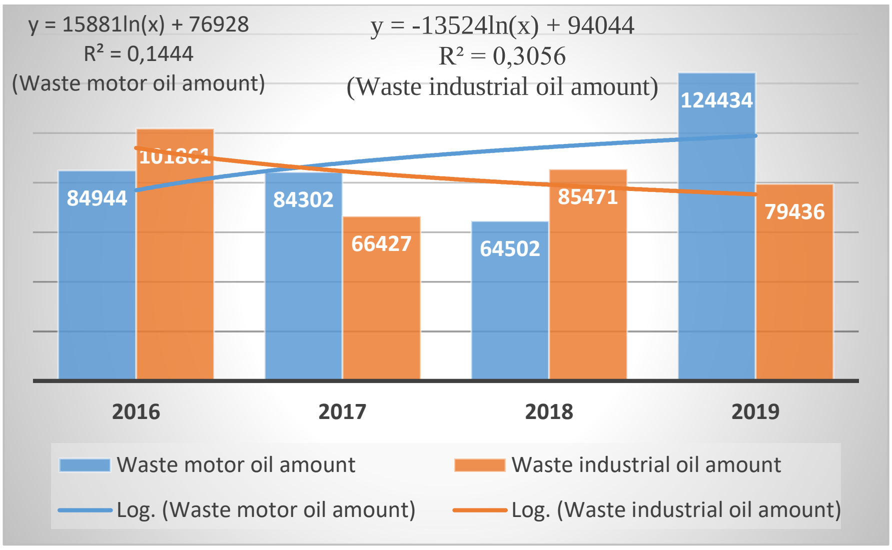

Figure 3. Waste Mineral Oil Collection Amounts in Kırklareli Province by Years (Waste management application, 2021)

Most excavation, demolition and construction waste are employed for municipal landfill cover material and rehabilitation in Kirklareli. Furthermore, excavation and vegetative soil are employed in landscaping and reclamation of private land. Thus, inhabitable private real estate is reclaimed for agriculture.

Waste batteries and accumulators

With the new technologies they use, battery manufacturers not only create more benefits, but also produce more environmentally friendly products. However, we should not throw exhausted batteries into the environment or in the trash. Because various chemicals in waste batteries can cause pollution by mixing with groundwater and soil in landfills. “Increasing world population, changing climate conditions and economic activities are growing with each passing day makes it more important than water” (Bağdatli and Bellitürk, 2016b). For this reason, as well as to increase the efficient use of natural resources through the recycling of waste batteries, waste batteries should be collected in plastic bags, cardboard boxes or jars, thrown into waste battery boxes in supermarkets, schools, headman offices, collection centers determined by municipalities, or returned to the point of sale where they were purchased. Heavy metal content in batteries and vehicle batteries could lead to damages in the central nervous system, cancer, kidney, liver, brain tissue damages, and birth defects. In addition to heavy metals, electrolytes (KOH, H_2SO_4, etc.) found in batteries have adverse effects on all living organisms in the ecosystem and lead to pollution in the receiving environment and soil. For example, an exhausted mercury oxide battery could pollute 800,000 liters of drinking water (Skeete et al., 2020).

Battery and vehicle battery waste are collected by licensed institutions in Kirklareli province based on the Regulation on Control of Battery and Accumulator Waste. The amount of waste batteries and batteries (kg) collected in Kırklareli province by years is presented in Figure 4.

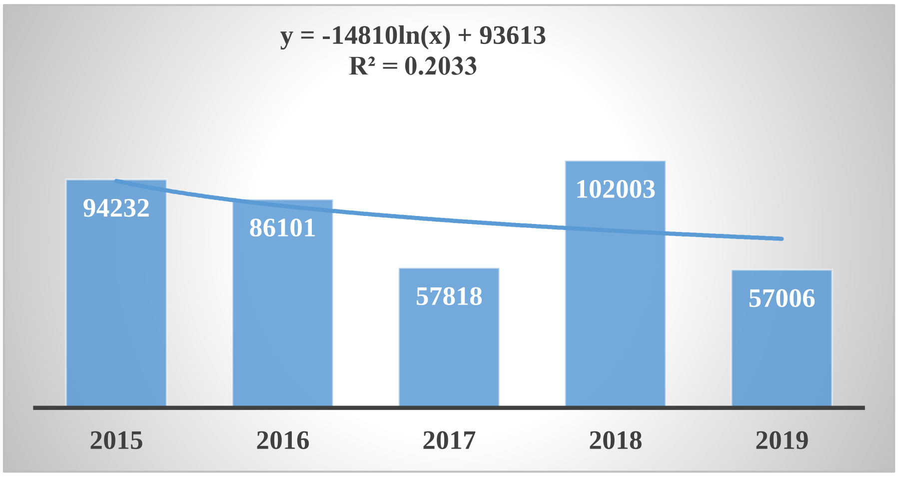

Figure 4. Amount of waste batteries (kg) collected by years in Kırklareli province (Waste management application, 2021)

As seen in Figure 4, the annual battery and vehicle battery waste collection has increased due to public awareness and realization of the fact that recycling plays a key role in environmental health.

End of life tires

End-of-life tire stock in Kirklareli are processed based on "Regulation on the Control of End-Of-Life Tires" provisions. Tires include hazardous and non-biodegradable substances in their chemical composition. The increase of these pollutants due to the increasing population and number of vehicles, their accumulation in the ecosystem for extended periods and transmission to the food chain pose a danger for the living organisms. The end-of-life tires collected annually in Kirklareli are presented in Figure 5 Collected tires are processed with two methods in the province in recycling and waste incineration facilities.

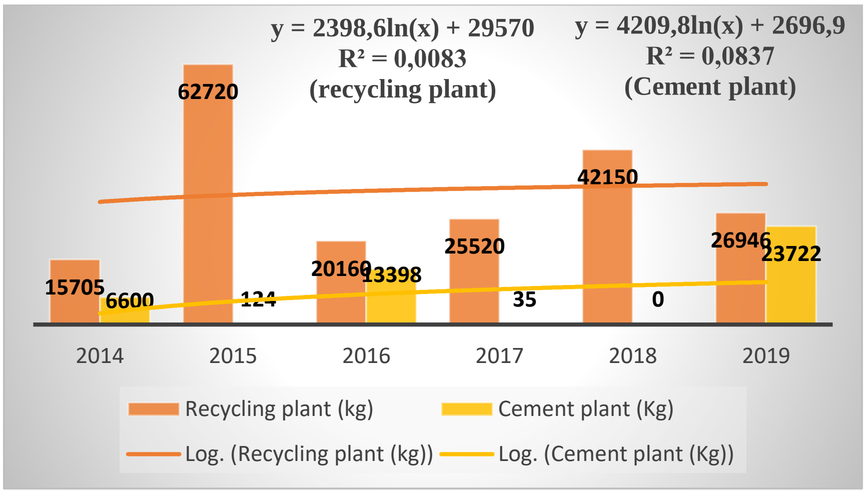

Figure 5. The total amount of tires sent to recycling facilities and waste incineration facilities in Kırklareli province by years (kg/year)

Electrical and electronic waste

Although the increase in electrical and electronic equipment waste are 3 times higher than urban waste, the collection, processing and recycling of electrical and electronic equipment waste are still quite low. However, valuable material content in electronic devices and equipment that completed their economic life are a significant source of secondary raw material due to their reuse and recycling capacity. However, when e-wastes are not properly separated and disposed of, they could turn into toxic substances and cause major problems for human and environmental health due to their hazardous content (Senturk, 2019).

Although electrical and electronic waste is not collected regularly in Kirklareli province, a collection system that was established by the municipalities and licensed contractors is available. Electronic waste collected by the municipal authorities based on the citizens' application are delivered to these licensed facilities. There is one Electrical and Electronic Equipment Waste Processing facility in the province. Efforts are underway to collect the Electrical and Electronic Equipment Waste based on a waste management plan (Waste Management application, 2020).

Within the scope of the harmonization of the European Union's Waste Electrical and Electronic Equipment Directive No. 2002/96/EC and the Directives No. 2002/95/EC on the restriction of the use of certain harmful substances in electrical and electronic equipment, which prohibits the use of dangerous substances used in the production of electrical and electronic equipment, “Waste Electrical and Electronic Equipment Control (AEEE) Regulation” was prepared and entered into force by being published in the Official Gazette dated 22.05.2012 and numbered 28300.

The regulation includes large household goods, small household appliances, information and telecommunications equipment, consumer equipment, lighting equipment, electrical and electronic equipment (excluding large and fixed industrial appliances), toys, recreational and sports equipment, medical devices (implantation products and disease-communicable devices). It includes electrical and electronic goods included in the categories of monitoring and control instruments and vending machines, electric light bulbs and household lighting equipment. In the province of Kırklareli, there is no collection facility for Waste Electrical and Electronic (WEEE) Goods in 2020.

Medical waste

One of the most important waste materials in the hazardous waste category is wastes generated during medical activities. The health institutions, which are the source of this type of waste, are subject to strict rules that determine the classification, separation at source, temporary storage, transportation, processing, and final disposal of this waste to minimize the possible damages to human health and environment both onsite and outside based on the regulation on control of waste (Awodele et al., 2016) In addition to infectious content, medical waste may also contain substances such as drugs, radioactive materials, cutting-piercing materials, toxins, and hazardous chemicals (Omeleke et al., 2021).

The collection, transportation and sterilization processes of medical wastes generated in Kırklareli province are carried out by 1 licensed company. Medical wastes collected in Kırklareli are sterilized in the Sterilization Facility of the company contracted with Lüleburgaz Municipality.

All health institution waste in the province is collected by the above-mentioned facility. Regular inspections are conducted to prevent improper disposal and collection of medical waste. Health institutions and other medical waste producers temporarily store the waste in temporary storage areas or containers in the facility. The annual medical waste production in Kirklareli province is presented in In Figure 6 (Kirklareli Province Environmental Status Report, 2020).

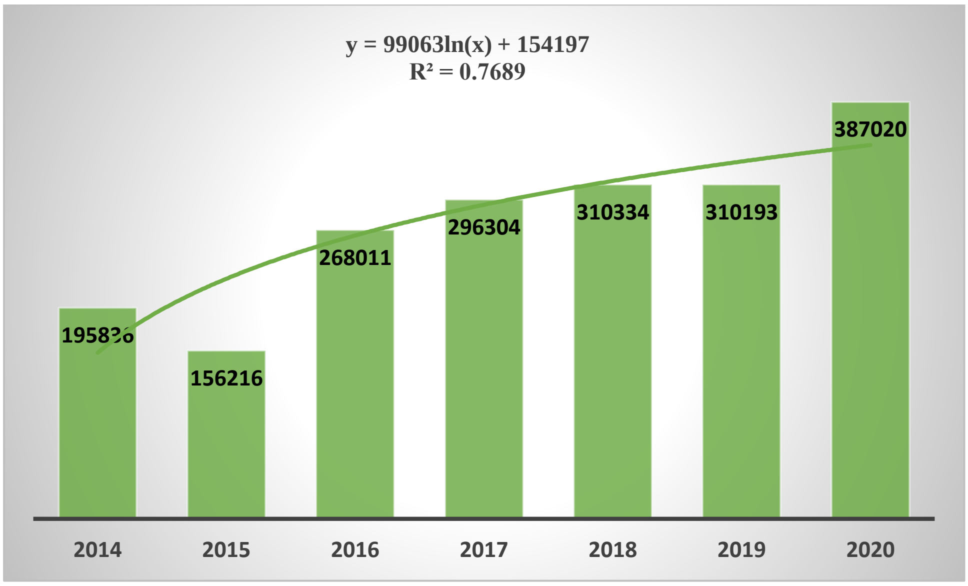

Figure 6. Medical Waste in Kirklareli Province

As seen in Figure 6, the collected medical waste has increased every year in the province. Hazardous medical waste is sterilized in the medical waste sterilization facility that operates in the city, and then transferred to the regular landfill, demonstrating that medical waste is properly managed.

Wastewater treatment facility sludge

In Kirklareli, the treatment facility sludge (16324 tons/year) produced in municipal domestic/urban wastewater treatment plants and industrial enterprises are collected by licensed businesses and recycled by drying to obtain fuel alternative or incinerated (Kırklareli Water and Sewerage Administration, 2021)

Compost

There is no compost facility in Kirklareli province where organic waste is recycled (Kirklareli Province Environmental Status Report, 2020). Considering the population growth and the fact that the domestic waste constitutes 34% of the total waste, recycling organic waste as compost would significantly reduce the waste volume disposed to regular landfills, extend the regular storage life, and allow the utilization of the compost in the agricultural cultivation, which is very important to meet the demands of the population growth.

Zero-waste management

It is a waste management method that includes the prevention of waste, effective employment of available resources, the prevention of waste production by analyzing the reasons for waste production, and the collection and recovery of waste at the source.

Zero-waste management aims

- The improvement of performance and productivity in a clean environment,
- Cost reduction by preventing waste of resources,
- The reduction of environmental risks,
- Savings and economic profits (Awasthi et al., 2021).

To improve and expand the Zero-Waste Project, which was introduced in the Presidential Complex and the Ministry of Environment and Urbanization, information meetings were organized for all the supervisors in all public institutions in Kirklareli and the focus personnel in the institutions responsible with the project, District Governorships, Mayorships, soldiers, and students, and the project was initiated in February 2018. With the enforcement of the "Zero-Waste Regulation" in 2019, Waste collection Centers were established in 178 district municipalities in Kirklareli to establish an effective zero-waste management system based on the Waste Collection Center Directive and these centers were licensed by the Kirklareli Provincial Directorate of Environment (Kirklareli Zero Waste Management Plan, 2020). Information on the types of institutions that have received the Basic Level Zero Waste Certificate as of 2020 is given in Table 3.

Table 3. Information on the types of institutions that have received the Basic Level Zero Waste Certificate as of 2020 (zerowastemanagementsystem.csb.gov.tr, 2021)

Institution type	Number of facilities reporting activities in zero waste system	Number of facilities with zero waste certificate
Sites with 300 or more residences	-	-
Fuel stations and resting facility	14	22
The mall	-	-
Council	9	2
Industrial facility in Annex-1 of the EIA regulation	25	12
Industrial facility in Annex-2 of the EIA regulation	3	-
Provincial directorate of environment and urbanism	2	-
Educational institution and dormitories	2	-
airport	-	-
City administrations	-	-
Business center and commercial plaza	-	-
Public institution and organization	53	46
Accommodation establishments	-	-
Port	-	-
Organized industrial zone	4	3
Healthcare organizations	4	1
Train and bus terminals	-	-
Chain markets	62	1

Waste is studied based on the economic and environmental approaches. The transportation, collection, disposal, and management of the waste of various types such as solid waste, packaging waste, hazardous waste, medical waste, special waste generated by the consumption of products in daily life are quite important. Attention should be paid to the management of solid waste. Several types of solid waste significantly affect humans, nature, health, environment, and economy. Costs incurred during storage, collection, and transportation of waste could adversely affect national economies. Thus, the solid waste is recycled to minimize these costs. Although recycling is a broad topic, it should be prioritized by every segment in the society. The recycling of products such as paper, plastic and batteries, the negative effects of waste on the environment could be reduced and recycling could contribute to the economy. In addition, the negative effects of wastes on agricultural lands should not be ignored. Many agricultural residues in our country are either burned or thrown away because they cannot be used under appropriate conditions. One of the best ways to evaluate agricultural residues is to use these residues in the production of vermicompost (Belliturk et al., 2018) The main cause of the eliminate the negative effects are related with unconscious use of pesticides since they are in the class of hazardous wastes

A strict inspection program has been implemented to ensure that industrial establishments create hazardous waste storage areas in accordance with the legislation and to send the hazardous wastes generated in the enterprises to licensed institutions with licensed vehicles, thus preventing the dumping of such wastes into the soil with domestic wastes. It is essential to improve more inclusive aquaculture extension lead and training program (Afreen et al., 2022). It has been ensured that industrial establishments collect packaging waste at its source and give it to licensed establishments.

Necessary correspondences were made with municipalities regarding the collection of recyclable wastes, and presentations were made to provincial and district schools. In our province, studies are continuing the selection of a location for the storage of excavation soil, construction, and demolition wastes.

As a result of the contract signed with a private company, in the 'Solid Waste Landfill Facility' of Kırklareli Municipality, the power of 1,232MWm/1,200MWe (with an increase in capacity of 2,464MWm/2,400 MWe) and the annual electrical energy production amount of 8,294,400 kWh "Electricity Production from Garbage Biogas" Under the name of “KIRKAB-1 Garbage Biogas Power Plant Project”, an electrical power generation facility was established in Kırklareli in order to utilize the methane gas generated in the solid waste landfill site and to contribute to the economy.

In Kırklareli, studies are continuing the selection of a location for the storage of excavation soil, construction, and demolition wastes. The solution of the chronic waste management problems, which have been neglected for several years, requires large-scale and high-cost investments. However, it seems difficult to conduct these activities successfully with the existing structure and resources. Municipalities, which are organized as the main implementation units, do not have the resources for these investments, and they lack instruments such tax revenues that would finance waste management costs or these costs could not be entirely funded by waste producers based on the principle of “polluter pays”. Although the separation of waste at source and the recycling of the separated recyclable waste are the basis of waste management policies, decomposition at source and recycling are quite primitive in Turkey. In fact, the current legislation imposes the responsibility of separation on all manufacturing, distribution, and sales units, including households and end consumers, and misconduct is penalized. It even prohibits the disposal of waste other than organic waste in landfills and mandates recycling.

On the other hand, recycling is mostly conducted by street collectors under insanitary conditions, manufacturing and distribution business that are required to recycle meet their quotas mostly by financing the street collectors rather than undertaking this activity.

CONCLUSION

It could be suggested that the waste collection and disposal processes are conducted like the rest of the country in Kirklareli province. Thus, the development of a modern and effective waste management system would not be possible only through the efforts of public institutions and organizations or industrial and commercial corporations. All social segments have important responsibilities in this issue. Thus, participatory policies should be developed to maximize the support and contribution of institutions and organizations such as non-governmental and professional organizations, educational and academic institutions, media, etc. To solve the waste management problems, institutional capacity should be improved. The institutional capacity of the Ministry should be improved to introduce an effective monitoring, auditing, and reporting infrastructure, to increase cooperation and coordination between relevant institutions and organizations, and to concentrate on research, training and orientation activities. The administrative and technical capacity of the provincial organizations in the Ministry should be strengthened and they should operate effectively as monitoring and deterrence systems. The number of pilot projects implemented to encourage waste recycling and seperation at the source should be increased and the implementation should be disseminated in all cities as soon as possible. For this purpose, the Ministry should assist the establishment of the necessary technical and sociocultural infrastructure. Dissemination of the deposit method instead of quota approach in the recycling of packaging waste would lead to a much higher recycling rate. Despite the significance of the issue, social, cultural, and economic concepts would be a major factor in the planned implementation of ideas and sanctions to favor the society in Turkey. Thus, local governments should be more sensitive to public health and protection of natural balance.

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Evaluation and Spatial Analysis of Agricultural Soils by GIS based Mapping in Nevsehir Province (Türkiye)

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Abstract

In this study, soil depths, degrees of erosion and other soil properties in Nevşehir province of Türkiye were evaluated spatially. For this purpose, 1/25.000 scale digital soil maps were used. Digital soil maps were analyzed spatially using Arc GIS 10.3.1 program from Geography Information Systems (GIS) software. As a result of the research, 7.50% of Nevşehir province is Deep soils (>150 cm), 8.88% is medium deep (90-150 cm) soils, 53.65% is shallow (50-90 cm) soils, 26.28% of it is very shallow (20-50 cm) soils. 57.01% of the surveyed lands consist of soils that may be exposed to moderate erosion. Soils exposed to severe erosion cover 26.32% of the total area. 23.25% of the research area consists of stony soils. Areas with insufficient drainage correspond to 1.49% of the total area. It is thought that the results obtained in the research will make significant contributions to the farmers and local governments operating in the region.

Keywords: Soil Depth, Land Properties, Erosion, Spatial Analysis, GIS, Nevsehir, Türkiye

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INTRODUCTION

The characteristics of the soils vary according to their location. In order to identify and solve the problems, the determination of all the characteristics of the existing soils, the management techniques applied from the beginning to the end of production should serve the sustainable and efficient use of the land. For the sustainable use of production areas, at this stage, it is necessary to determine all the characteristics of the existing soils and to review the management and techniques applied from the beginning to the end of production in order to identify and solve the problems (Tunçay and Bayramin, 2010).

Soil is an important factor in obtaining most of the nutrients necessary for life. Land owners and managers concerned with the conservation of land uses stated that rational and sustainable land use is important for the benefit of current and future populations (Dengiz et al., 2009).

Today, the rapid development of technology provides many conveniences. This comprehensiveness of GIS plays an active role in accessing many data as well as analyzing and storing numerical data. Revealing the geographical distribution of important soil features is a necessary prerequisite for the sustainable use and management of soils and guides which applications can be made in which areas (Doğan and Aslan, 2013).

In this study, soil depth classes, erosion degrees and other soil properties of the lands were spatially evaluated with the help of geographic information systems using 1/25.000 scaled digital soil maps of Nevşehir province. It is thought that the results obtained will make significant contributions to public institutions and organizations operating in the region and to the private sector investments.

MATERIALS and METHODS

This study was carried out within the borders of Nevşehir province. The location of Nevşehir province, which is the subject of the research, is shown in Figure 1.

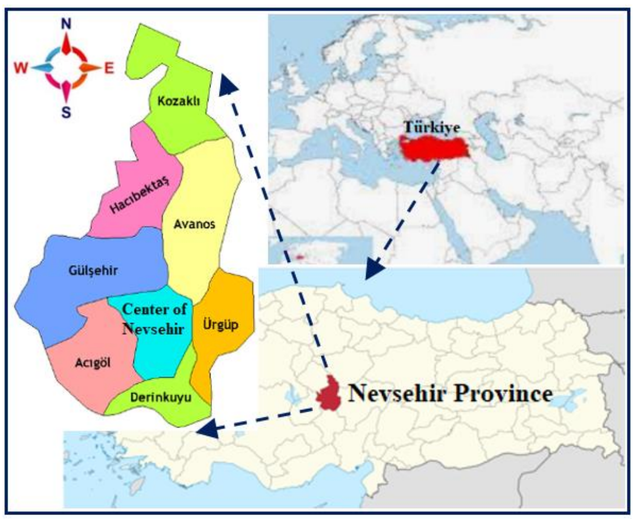

Figure 1. The location of research area

Nevşehir is located in the Central Anatolia Region and is surrounded by Kayseri in the east, Aksaray in the west, Niğde in the south, and Yozgat and Kırşehir in the north. The surface area of Nevşehir province is 5,386 km^2. The altitude of Nevşehir city center, which was established on the southern slope of the Kızılırmak valley, is 1150 m (Anonymous, 2016).

The longest river of Nevşehir province, Kızılırmak, passes through this region. The center of Nevşehir province was established on the western slopes of the wide and high plains known as the Kızılırmak plateau. Nevşehir province has a surface area of 5.485 km² and consists of a total of 23 municipalities and 153 villages, 8 of which are districts (including the central district), 15 of which are town municipalities (Anonymous, 2021).

Agricultural land in Nevşehir has % 65.4 of the total land. 538,630 hectares (% 2.5) of Nevşehir Province is forest, 65.4% is arable land, 18.8% is unsuitable for agriculture and % 13.3 is meadow-pasture. In Nevşehir, % 56.1 of the agricultural production area use is made up of grain cultivation areas (Anonymous, 2022).

Nevşehir has a warm and temperate climate. In winter, there is much more rainfall than in other months. Nevşehir's annual average temperature is 10.73 °C and average precipitation is 362.9 mm. Considering the climatic characteristics of the study area, the continental climate is dominant in Nevşehir. Summers are hot and dry, winters are cold. In a study conducted with temperature data for many years between 1970 and 2017, the average minimum temperature for many years in Nevşehir center was calculated as -1.99 ^{0}C, the maximum temperature was 26.85 ^{0}C and the average of all temperature values was 10.73 ^{0}C. The long annual averages of maximum temperature values are 27.1 ^{0}C in spring, 15.17 ^{0}C in winter, 28.36 ^{0}C in autumn, 36.76 ^{0}C in summer, and the general temperature average is 26.85 ^{0}C (Bağdatlı and Arıkan, 2020).

In order to spatially evaluate some soil features related to the study area, 1/25.000 scale digital soil maps were used (Anonymous, 2000). With the help of Arc GIS 10.3.1 program, which is a GIS software, soil depth classes, erosion degrees and other soil properties of the research area were analyzed spatially (Anonymous, 2010).

Spatial analyzes were interpreted in accordance with the criteria specified in the soil and land classification tandards Ttechnical instruction of the Ministry of Agriculture and Forestry (Türkiye) and spatial distribution maps of soil properties were created (Anonymous, 2005). In the spatial evaluation of digital soil maps, soil depth classes, erosion degrees and layers related to other soil properties of the investigated areas are presented in Tables 1, 2 and 3.

Table 1. Soil deep classes (Anonymous, 2005).

Symbol	Class	Soil Depth Classes (cm)
A	Deep	150+
B	Medium Deep	90-150
C	Shallow	50-90
D	Too Shallow	20-50
E	Lithosolic	0-20

Table 2. Erosion classes (Anonymous, 2005).

Erosion Classes	Explanation
1	None or Very little (1) Light (less than 25% of topsoil eroded)
2	Medium (2) Hydrangea (25-75% of topsoil eroded)
3	Severe (3) (more than 75% of the topsoil and less than 25% of the subsoil is eroded)
4	Very Severe (4) (all topsoil, 35-75% of subsoil eroded)

Table 3. Other soil properties (Anonymous, 2005).

Other Soil Properties	Symbol
Poorly Drainage	(f)
Lightly salted	(h)
Slightly saline with poor drainage	(hf)
Slightly salty Insufficient Drainage	(hy)
Slightly salty-Alkaline poorly Drained	(kf)
Slightly salty-Alkaline Insufficient Drainage	(ky)
Kayali	(r)
Salty Insufficient Drainage	(sy)
Stony	(t)
Salty Alkali Poor Drained	(vf)
Salty Alkali Insufficient Drainage	(vy)
Insufficient Drainage	(y)

RESEARCH FINDINGS

Spatial Analysis of Soil Depth Classes

Soil depth classes of Nevşehir province lands were spatially evaluated using 1/25.000 scaled digital soil maps. As a result of the analyses, the spatial distributions of soil depth classes are presented in Figure 2.

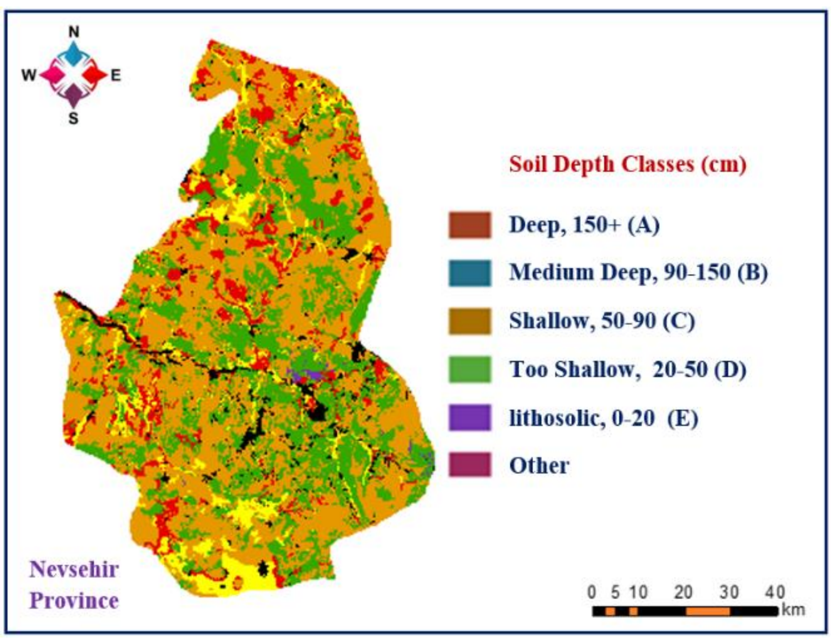

Figure 2. Spatial distributions of soil depth classes

Considering the soil depth distribution in Nevşehir province, it is seen that the soils in the depth class of 50-90 cm are generally dominant. It has been observed that the soils with a depth of 20-50 cm are predominant in the southeast, middle and north parts of Nevşehir province.

The soil group between 90-150 cm, defined as medium deep, is located in the northwest and center of the region. The soil group, known as deep, with a depth of 150 cm, is mostly seen in the southern part of the field. The areal amounts of the depth classes of Nevşehir province are calculated and given in Table 4.

Table 4. Areal quantities of soil depth classes

Soil Depth Classes (cm)	Area (ha)	Ratio to General Area (%)
Deep , 150+ (A)	45052,04	7,50
Medium Deep ,90-150 (B)	53317,77	8,88
Shallow , 50-90 (C)	322101,01	53,65
Too Shallow , 20-50 (D)	157769,49	26,28
lithosolic , 0-20 (E)	1802,89	0,30
Other	20286,20	3,38

It is seen that 53.65% of Nevşehir province has soils with a depth of 50-90 cm. Very shallow soils (20-50 cm) cover an area of 157.769,49 hectares. Areas that fall under the medium deep soil class (90-150 cm) correspond to % 8.88 of the total area. Deep soils (>150 cm) spread in 45052.04 hectares of the studied area.

Soil depth, in general, refers to the depth at which the roots of cultivated plants can process and benefit from water and nutrients. Soil depth and nutrient and water holding capacity often determine crop yield, especially in summer crops. In summary, it has been observed that shallow soils with a soil depth of 50-90 cm are dominant throughout the province of Nevşehir.

Spatial analysis of erosion degrees

Erosion degrees of Nevşehir province lands were evaluated spatially. The results obtained and the distribution of erosion degrees are presented in Figure 3 and the calculated areal amounts are summarized in Table 5.

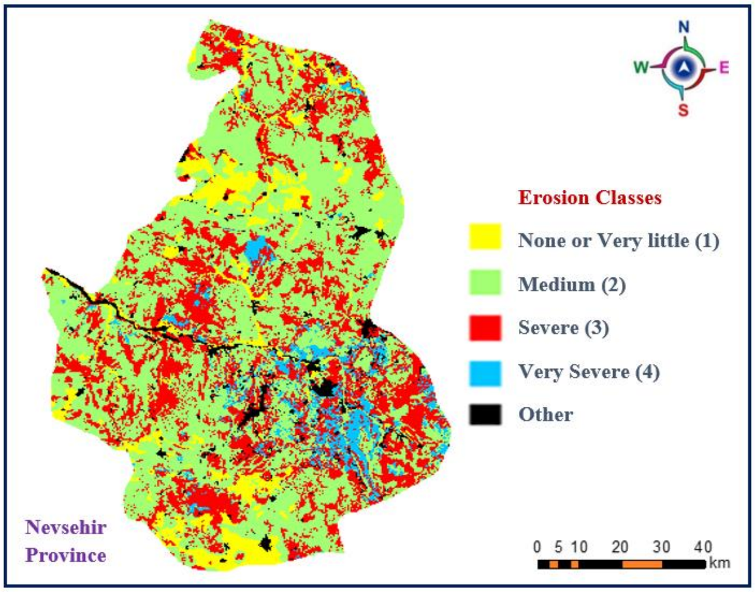

Figure 3. Spatial distribution of erosion classes

Table 5. Areal quantities of erosion degrees

Erosion Classes	Area (ha)	Ratio to General Area (%)
None or Very little (1)	50794,70	8,46
Medium (2)	342227,47	57,01
Severe (3)	158023,88	26,32
Very Severe (4)	28997,15	4,83
Other	20286,20	3,38

Erosion is a concept that expresses the transportation and removal of soil by being exposed to all kinds of effects. As a result of the spatial analysis, it has been seen that the areas that can be exposed to moderate erosion in Nevşehir province are dominant. In the southeastern part of the study area, it was determined that areas that could be exposed to very severe erosion dominate. It has been observed that there are no or very few areas that can be exposed to erosion in the lands towards the north and the areas in the southern part of Nevşehir province.

When the area is examined generally, it is determined that the soils with the 2nd degree medium erosion class are formed and this area covers an area of 342.227,47 hectares. Areas with 3rd degree erosion group correspond to 26.32 % of the total area. It has been calculated that soils with 1st degree erosion cover an area of 50.794,77 hectares. Areas that may be exposed to severe erosion correspond to 4.83 % of the total area.

Spatial Analysis of Other Soil Properties

It is seen that there are mostly stony areas in the southeast of Nevşehir province. Salty and poorly drained soils are observed in the center and north of the province. There are poorly drained soils in the northwest of the study area. It has been observed that there are slightly salty, alkaline and poorly drained and salty alkali poorly drained soils in the research area. The stony areas cover 23.25% of the study area. It has been determined that there are insufficiently drained soils in an area of 8916.61 hectares in Nevşehir province. The rocky areas cover an area of 5292.76 hectares. Spatial distribution analyzes and areal amounts of other soil properties of Nevşehir province are given in Figure 4 and Table 6

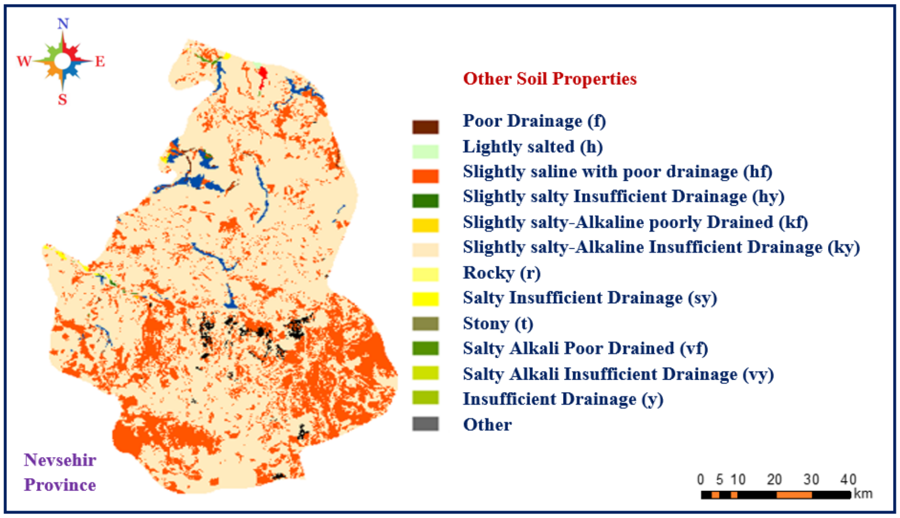

Figure 4. Spatial distributions of other soil properties

Table 6. Areal quantities of other soil properties

Other Soil Properties	Area (ha)	Ratio to General Area (%)
Poorly Drainage (f)	967,00	0,16
Lightly salted (h)	226,29	0,04
Slightly saline with poor drainage (hf)	157,71	0,03
Slightly salty Insufficient Drainage (hy)	370,21	0,06
Slightly salty-Alkaline poorly Drained (kf)	178,73	0,03
Slightly salty- Alkaline Insufficient Drainage (ky)	1133,32	0,19
Kayali (r)	5292,76	0,88
Salty Insufficient Drainage (sy)	563,61	0,09
Stony (t)	139553,11	23,25
Salty Alkali Poor Drained (vf)	368,12	0,06
Salty Alkali Insufficient Drainage (vy)	28,96	0,00
Insufficient Drainage (y)	8916,61	1,49
Other	442572,96	73,72

CONCLUSION and RECOMMENDATIONS

Spatial distribution maps of soil classes are important for appropriate land use and management decisions. Numerical soil mapping can predict the spatial distribution of soil classes as GIS analysis. Many studies have been found in the literature on the determination of some soil and land properties in the GIS environment using digital soil maps.

In a study carried out within the scope of spatial evaluation of some land features of the Çiftlik district of Niğde province in the Geography Information Systems (GIS) environment, the majority of the lands were located in the VI. and VII. It has been seen that it is in the class of agricultural land (Bağdatlı and Arslan, 2021a)

In a research conducted in the Çankırı Ilgaz Gökdere basin, different land types were determined in the GIS environment and the effect of land aspect on soil properties was analyzed. As a result of the study, 55 soil samples were taken and some soil properties were evaluated and distribution maps for these properties were created (Yılmaz, 2010).

In a study carried out in an area where industrial establishments are concentrated in Kocaeli province; Soil moisture, organic matter and elemental contents were determined by taking soil samples from seven villages determined in the area (Uytun, 2012).

In a study around Çorlu and Çerkezköy in Tekirdağ, 20 soil and wheat plant samples were taken from agricultural areas at a depth of 0-20 cm. The results of heavy metal analysis in the soil were spatially evaluated with the help of Arc GIS 10.3.1 software and distribution maps showing the heavy metal pollution levels were produced in this context (Kocaman, 2016).

In a research to determine the soil potential of Kırşehir province using GIS, current land use, large soil groups, other soil properties, soil depth, slope and erosion were classified using Arc GIS 10.3.1 software, which is a GIS program, and the results were revealed in detail as map outputs. they have put. In the light of the data obtained, they concluded that this study will provide infrastructure support to the investor organizations in the region, and that the study will be transferred to users in the digital environment, creating a database and thus setting a precedent, and will guide similar studies (Bağdatlı and Arslan, 2020). Considering other similar studies in the literature; For example, in Nevşehir, Kayseri, Niğde and Ankara provinces, land and soil properties were spatially analyzed and distribution maps were produced using 1/25.000 scaled digital soil maps (Bağdatlı and Can, 2021a; Bağdatlı and Can; 2021b; Bağdatlı and Ballı, 2021; Bağdatlı and Arıkan, 2021; Bağdatlı and Öztekin, 2021; Pekacar and Bağdatlı, 2020; Bağdatlı and Can 2020; Bağdatlı and Arslan, 2021a; Bağdatlı and Arslan 2021b; Bağdatlı and Arslan, 2021c

In this study, spatial evaluation of soil depths, degrees of erosion and other soil properties was carried out by using 1/25.000 scaled digital soil maps of Nevşehir province. For this purpose, Arc GIS 10.3.1 software, which is one of the GIS software, was used and it was seen that shallow soils constitute % 53.65 of the total area, according to the depth class analysis in Nevşehir province. Very shallow soils cover an area of 157.769,49 hectares. Areas classified as medium deep correspond to %8.88 of the total area.

When the study area is examined in general, it has been determined that the soils with the 2nd degree erosion class are mainly formed and this area covers an area of 342227.47 hectares. The rate of areas with 3 degrees of erosion is % 26.32. Class 1 erosion areas, which are classified as no or very little erosion, cover an area of 50794.70 ha. In the study area, it is seen that the 2nd and 3rd degree eroded land areas dominate. In the research area, stony areas cover % 23.25 of the study area. 8916.61 hectares of the area consists of poorly drained soils. It has been determined that 5292.76 hectares of the field are rocky soils. The data obtained at the end of the research will provide significant background information to public institutions and organizations operating in the region, local governments and investor organizations.

ACKNOWLEDGMENT

This study is based on some of the Master's Thesis titled "Evaluation of Soil and Water Resources Potential of Nevşehir Province in Geographic Information Systems (GIS) Environment" by Mohammad Aalim NAZARI, Graduate Student of Nevşehir Hacı Bektaş Veli University, Institute of Science and Technology, Department of Environmental Engineering prepared using the results.

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The Physicochemical Properties of Soil in Yenagoa and Amassoma Communities Under Selected Land-Use Types

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Abstract

Inappropriate land-use is a worldwide problem that negatively affects sustainable agriculture; hence this study, to recommend the preferred farming method. The study was carried out to determine the effect of different land-use system on selected soil physicochemical properties inYenagoa and Amassoma communities, in Yenagoa and Southern Ijaw Local Government Area of Bayelsa state. The study took into account four land-use regimes, including virgin land (VVL), plantain plantations (PPT), fallow land (FFL), and oil palm plantations (OPT). The result showed that the different land-use type had significant effect ($P< 0.05$) on some physiochemical properties. The virgin land showed higher mean values of the soil properties compared to fallow land, oil palm and plantain plantation; the trend is as follows: Base saturation (VVL-42.35% > OPT-31.73% > FFL-29.12 > PPT-23.67%), organic carbon/organic matter (VVL-21.67/43.33gcm^{-3}>OPT-17.33/34.67gcm^{-3}> FFL-11.67/23.33gcm^{-3}> PPT-7.33/14.67g/cm^{-3}), CEC (VVL–1.83 cMolkg^{-1}> OPP-1.10 cMolkg^{-1}> FFL – 0.87 cMolkg^{-1}> 0.66 cMolkg^{-1}), and exchangeable acidity.Land-use had a significant effect on bulk density and Porosity. The fallow land (FFL) showed less compaction with the lowest bulk density of 1.25gcm^{-3}< OPT (1.34gcm^{-3})<(VVL) (1.30gcm^{-3})< PPT (1.34gcm^{-3}). It is therefore recommended that conservative measures such as land fallowing be practiced to regenerate lost and depleted nutrients in the soil; and also,a call for reduced conversion of forested lands to cultivated land.

(Abbreviations: VVL-Virgin land, PPT- Plantain Plantation, OPT – Oil palm plantation, FFL – Fallow land, CEC, Cation Exchange Capacity, BD – Bulk Density, POR – Porosity, BS – Base saturation, Av.P – Available Phosphorus, ECEC- Effective Cation Exchange Capacity, EA – Exchangeable acidity, Org.C – organic carbon, Org.M – Organic matter, T_N – Total Nitrogen, EC – Electrical conductivity)

Keywords: Land-use, Bayelsa State, properties, correlation

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INTRODUCTION

Sustainable agricultural production has focused on the global issue of environmental degradation brought on by inappropriate land-use. As people's arrangements, actions, and input in a particular piece of land are meant to produce, alter, or retain its worth (Ufot et al, 2016). In order for soil to be productive and sustainable, there must be a good ratio between its physical, chemical, and even biological qualities.

Land-uses continuously affect these qualities. Since soil can quickly lose its quality and quantity due to factors including heavy farming, leaching, and soil erosion, successful agriculture needs the sustainable use of soil resources (Kiflu and Beyene 2013).

Where there is a very high population density and a significant reliance on land resources, the ever-increasing human population poses the greatest challenges. This is a nasty threat because it compromises soil qualities, which causes land degradation and hinders the sustainability of soil resources (Yimer and Abdulkadir, 2011).

The primary causes of land degradation, the depletion of natural resources, and environmental deterioration include overgrazing and deforestation, farming on steep terrain, and irregular and torrential rainfall patterns (Aytenewand Kibret, 2016). Due to a rise in both human and animal populations, the growth of agricultural and pastoral areas has begun to have an impact on the soil's quality (Mustapha, 2007). This resulted in the spread of land-use change because the existing forestland was turned into cultivated land and grazing pastures (Chemada et al., 2017).

In Bayelsa State, there is an increasing rate of deforestation and farming in native forests leading to exposure of lands to erosion and decrease in fertility status. The emphasis is to investigate how different land-use practices affects the soil properties under different management operating within the same soil-forming factors, which will help farmers and land-usersrealize the extent of land degradation caused by human activities. Hence the aim of this study, to determine the effect of land-use system on some physical and chemical properties of soils in Yenagoa and Amassoma Communities, Bayelsa state, Nigeria.

MATERIALS AND METHODS

Description of the study area

For this research, the towns of Yenagoa and Amassoma in Bayelsa State were chosen. Bayelsa is located in the southern portion of the Nigerian Niger Delta Region, about in latitudes 4°55' 36.30"N and longitudes 6°16' 3.50"E, and at an elevation of around 206m above sea level. In Bayelsa, the year-round harsh conditions include hot, gloomy weather in both the wet and dry seasons. The predominant environment is characterized by a humid tropical climate with annual rainfalls of about 4900 mm and relative humidity of 85%. Maximum rainfall is acquired from June to September, while minimum rainfall is achieved from November to March, during the dry season. The annual minimum and maximum temperatures are 25°C and 31°C, respectively. The soils were created from kaolinitic parent materials (Agbai et al., 2022).

Shrubs found in the area include elephant grass *(Pennisetum purpureum L.)*, *Jatropha tanjorensis Ellis &Saroja*, *Costus afer Ker Gawl*, Goat weed (*Ageratum conyzoides L.*). Other trees found in the area include plantain (*Musa paradisiaca L.*), oil palm (*Elaeis guineensis Jacq.*) etc.Virgin land and fallow land are situated in Amassoma, while plantain plantation and oil palm plantation are in Yenagoa. The virgin area is located deep within Amassoma in the Southern Ijaw Local Government Area of Bayelsa State and has had only minimal and regulated human influence for more than 30 years. As the name suggests, the fallow land at the Niger Delta University, Amassoma has been left for more than 10 years to recover and reestablish its fertility. The plantain plantation has seen frequent weeding, fertilization, and harvesting whereas the oil palm plantation has endured for more than 20 years with regular pruning, fertilization, and weeding using herbicides (Agbai and Kosuowei, 2022).

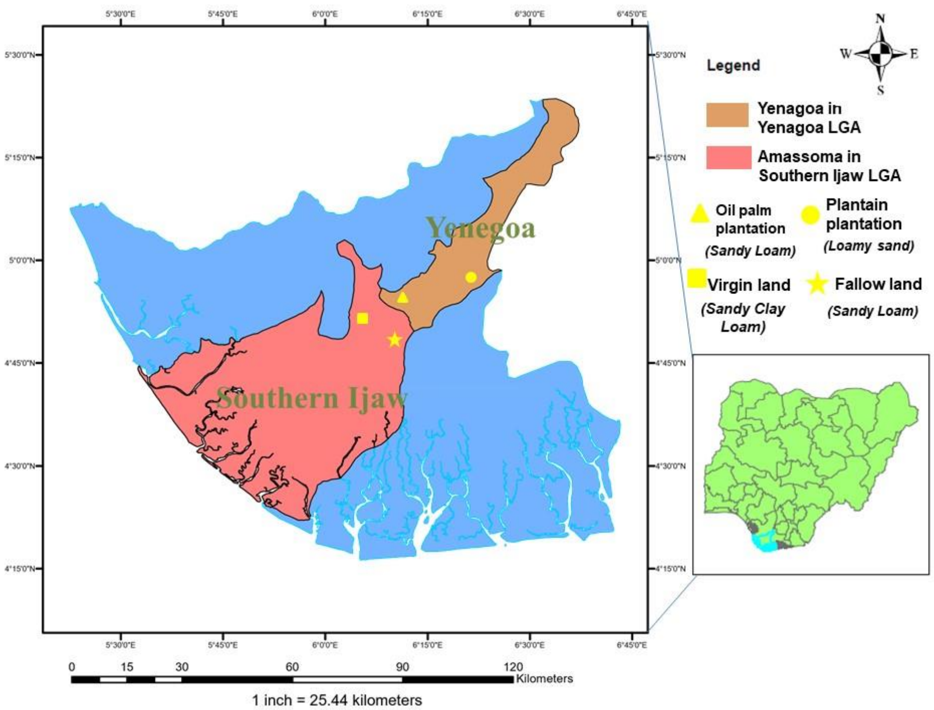

Figure 1. Map of Bayelsa State showing the two Local Government Areas housing the land-use types and the sampling points.

Sample collection

The sampling sites (virgin land, plantain plantation, fallow land, and oil palm plantation, respectively) each generated three replicate samples. Each land-use type had nine (9) samples collected from three depths (0-15 cm, 15-30 cm, and 30-45 cm). The nine replicated samples were further bulked to provide three composite samples per depth for each land-use type. Twelve composite samples in total were collected. Plantain plantations (4°59'45" N, 6°22'20" E) and oil palm plantations (4°58'50" N, 6°06'15" E) are located in Yenagoa, while virgin land (4°59'35" N, 6°07'21" E) and fallow land (4°53'06" N, 6°09'26" E) are located in Amassoma.

Three different sites at each land-use location were sampled using a single, 5-cm-diameter Edelman Eijkelkamp soil auger. The samples from the three locations were properly mashed and bulked with the hand to reflect the location. After being marked with a permanent marker, each soil sample was put into a clean polythene bag. The physical and chemical characteristics of the soil samples were then determined after they had been air-dried, crushed, and sieved through a 2mm sieve in the Niger Delta University's Soil Science Laboratory. At the depths of 0–15 cm, 15–30 cm, and 30–45 cm, respectively, samples for bulk density and porosity were taken using steel cores that were 5.8 cm in diameter and 6 cm high.

Dead plants, furrows, old manure, wet patches, regions close to trees, and compost pits were avoided during sample collection to minimize variations brought on by the addition of organic matter to the soil and to minimize possible errors during evaluation.

Soil Analysis and Evaluation

Soil texture was analyzed by Bouyoucous hydrometer method (1962) while the USDA soil textural triangle categorization method was used to identify the soil's textural class (USDA 2008). Bulk density was determined using ISO (2017), and total porosity (TP) was computed from bulk density values with an assumed particle density of 2.65 gcm^{-3} (Aikins and Afuakwa, 2012).

The soil organic carbon was determined using Walkley- Black wet oxidation methods (Walkley-Black 1934).The organic matters values were computed by multiplying the value of the organic carbon by a value of 1.725 Douglas (2010).The soil pH and Electrical Conductivity were determined with the use of pH meter and EC meter in a soil-water suspension using a 1:2.5 soil water ratio. Total Nitrogen was determined using the regular micro Kjeldahl method as reported by Bremmer and Mulvaney (1982).

Exchangeable cations, Ca, Mg, K and Na were extracted with 1N ammonium acetate solution (1N NH_4OAc) buffered at pH 7.0 the Ca and Mg were determined from the extract using 0.01m EDTA (ethylenediaminetra-acetic acid) titration method as described by Black (1965), while K and Na were determined using flame photometer (Jackson, 1962).Percent Base Saturation (BS) was calculated as the ratio of the sum of the base forming cations (Ca, Mg, K and Na) to the cation exchange capacity (CEC) to the sum of the soil and multiplied by 100.

Statistical Analysis

Randomized Complete Block Design was used to arrange the data gotten from the field. The data was kept in a Microsoft Excel file where it was used to analyze the overall significance of land-uses using Duncan Multiple Range Test on a grand mean data at the 5% level of probability ($p \leq 0.05$), and correlation analysis was carried out amongst selected soil properties using GenStat Statistical Package, 12thEdition.

RESULTS AND DISCUSSION

Table I shows some soil physicochemical properties under the different land-use types.

Plantain plantation

In the Plantain plantation, pH increased as depth increased, with a range of 4.4 - 4.7, with an average of 4.6. There was no significant difference at 15-30 and 30-45 cm depth. The pH was strongly acidic (4.4) at the surface soil (0-15 cm) and also in the subsurface (15-45 cm). The acidic state of the soils can cause stunted shoot and root growth in crops and also as such, some beneficial elements such as K, P, Ca, and Mg may become poorly available (Sanjay, 2022).

Electrical conductivity ranged from 30.4 1µScm^{-1}(0.0304 dSm^{-1}) – 53.1µScm $^{-1}$(0.053 dSm^{-1}). This value according to Ganjegunte*et al*. (2018) places the soil less than four (<4), which is non-saline. This indicates that there is no obstruction to the soil structure and is poses no threat to seedlings and salt-sensitive crops. EC value was highest at the depth of 30 – 45cm and lowest at 15-30cm.

Organic carbon and organic matter were low (11 & 22 gkg^{-1}) at the surface soils, and decreased as the depth increased. The low organic carbon and organic matter indicate reduced organic substrates and energy sources in the soils. There was a consistent significant reduction in their values from the surface soils (0-15 cm) downwards. The Total Nitrogen at the surface was also low and continuously reduced drastically at increasing depth. The low organic carbon and organic matter could be attributed to the continuous utilization of the land for agricultural purposes, therefore depletion of nutrients. The low organic matter content caused a lighter and loose texture for the soils, which gets heavier as the organic matter increases down the profile.

Oil palm plantation

In the Oil palm plantation, pH ranged from 4.3 – 4.5 with a mean of 4.43, which is strongly acidic. The soils from the depth of 0-15 cm and 15-30 cm recorded the highest values while the depth of 30-45 cm recorded to lowest value. The result showed that there was no significant difference in pH between the depth of 0-15 and 15-30cm. Electrical conductivity (EC) ranged from 36.3 µScm^{-1} (0.0363 dSm^{-1}) - 78.1 µScm^{-1} (0.0781 dSm^{-1}) with a mean of 54.17 µScm^{-1} (0.0542 dSm^{-1}). The surface soils (0-15 cm) recorded the highest EC value of 78.1 µScm^{-1} (0.0781 dSm^{-1}) which reduced downwards. The average organic carbon, organic matter, and total nitrogen were 17.33, 34.67, and 1.60 gkg^{-1}respectively. The organic carbon, organic matter, and total nitrogen were highest at the topsoil (36, 72, and 1 gkg^{-1}), which decreased constantly as depth increased. The organic matter content was high (72 gkg^{-1}) at the surface soil but drastically reduced downwards. This could be as a result of decomposing palm fronds and fertilizer application at the surface. Total nitrogen was moderately low (3.3 gkg^{-1}) at the surface soil but reduced drastically as the soil depth increased.

Virgin Land

In the virgin land, pH was 4.7 (acidic) with no significant change amongst the depths. The EC value showed that there was not salinity stress in the three depths: (74.3 µScm^{-1} (0.0743 dSm^{-1}) at 0-15 cm, 58 µScm^{-1} (0.0058 dSm^{-1}) at 15-30 cm and 68.2 µScm^{-1} (0.0682 dSm^{-1}) at 30-45 cm; with a mean of 66.83 µScm^{-1} (0.0668 dSm^{-1}).

The average organic carbon, organic matter, and total nitrogen value were 21.67, 43.33 and 1.97 gkg^{-1}respectively, with the surface soils having the higher values Organic matter was moderate at the surface soil (58 gkg^{-1}) and decreased downwards. Similar to the oil palm plantation, total nitrogen was low (2.6 gkg^{-1}) at the surface soil and was lowest (1.3 gkg^{-1}) at the subsurface (30-45cm).

Fallow land

Under the fallow land, pH of 4.5 showed no significant difference between the first and second depth but increased at the 30-45 cm depth. The average pH was 4.5 which is acidic. The lowest EC value (39.6 μScm^{-1} (0.0396 dSm^{-1}) was recorded in the subsurface soils at 30-45 cm, while the highest value (64.5 μScm^{-1} (0.0645 dSm^{-1}) was at the intermediate depth of 15 – 30 cm. EC recorded a mean of 50.10 μScm^{-1} (0.05010 dSm^{-1}) indicating no salinity threat. There was also a downward reduction in organic carbon, organic matter, and total nitrogen; the surface soils (0-15 cm) recorded the highest values (17, 34, and 1.5 gkg^{-1}) while the subsurface soils (30-45 cm) recorded the lowest values (7, 14, and 0.6 gkg^{-1}). The average organic carbon, organic matter, and total nitrogen value were 11.67, 23.33, and 1.03 gkg^{-1} respectively. The organic carbon and organic matter were moderately low through the three depths, while the total nitrogen was low.

Table 1. Physicochemical properties of the different land-use types

Land-use systems	Depth	pH	EC	Org.C	Org. M	T. N
			μScm^{-1}	gkg^{-1}		
$4^0 59'45"N\ 6^0 22'20"$ E						
PPT1	0-15	4.4^a	41^b	11^c	22^c	1^c
PPT2	15-30	4.7^b	30.4^a	7^b	14^b	0.6^b
PPT3	30-45	4.7^b	53.1^c	4^a	8^a	0.4^a
	Mean	4.6	41.5	7.33	14.67	0.67
$4^0 58'50"N\ 6^0 06'15"$ E						
OPP1	0-15	4.5^b	78.1^c	36^c	72^c	3.3^c
OPP2	15-30	4.5^b	36.3^a	11^b	22^b	1^b
OPP3	30-45	4.3^a	48.1^b	5^a	10^a	0.5^a
	Mean	4.43	54.17	17.33	34.67	1.60
$4^0 59'35"N\ 6^0 07'21"$E						
VVL1	0-15	4.7^a	74.3^c	29^c	58^c	2.6^c
VVL2	15-30	4.7^a	58^a	22^b	44^b	2^b
VVL3	30-45	4.7^a	68.2^b	14^a	28^a	1.3^a
	Mean	4.7	66.83	21.67	43.33	1.97
$4^0 53'06"N\ 6^0 19'26"$E						
FFL 1	0-15	4.5^a	46.2^b	17^c	34^c	1.5^c
FFL 2	15-30	4.5^a	64.5^c	11^b	22^b	1^b
FFL 3	30-45	4.6^b	39.6^a	7^a	14^a	0.6^a
	Mean	4.53	50.10	11.67	23.33	1.03

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land., EC – Electrical conductivity, Org. C – Organic Carbon, Org. M – Organic Matter, T.N – Total Nitrogen.Mean values with the same letters are not significantly different from one another at 5% level of probability

Table 2 shows that plantain plantation (PPT) had mean exchangeable acidity, sodium, Calcium, Magnesium, Available Phosphorus, Cation exchange capacity, and effective cation exchange capacity of 2.07, 0.14, 0.02, 0.28, 0.2, 1.68, 0.66 and 2.73 $cMolkg^{-1}$ respectively. These characteristics were highest at the surface soils (0-15 cm) and constantly decreased downwards, with the lowest values recorded at the subsurface (30-45 cm). Oil palm plantation, Virgin land, and fallow land displayed a similar trend with each depth significantly different from the other.

These elements were found to be very low which correlated with the low CEC and ECEC as classified by Adepetu *et al*. (2014).This can be attributed to the kaolinitic nature of the soils of this area and the low organic carbon and organic matter content as stated by (Kiflu and Beyene, 2013). Factors such as leaching, low content of basic cations in the parent material, and proportion of clay (Muche *et al*.,2015) might have contributed to the low CEC in the respective land-use system

Table 2. Some soil chemical properties under the different land-use system

	Depth	EA	Na	K	Ca	Mg	Av. P	CEC	ECEC
		cMol/kg							
PPT1	0-15	2.2^b	0.17^c	0.07^c	0.41^c	0.3^c	2.32^c	0.95^c	3.15^c
PPT 2	15-30	2^a	0.15^b	0.04^b	0.27^b	0.19^b	1.701^b	0.65^b	2.65^b
PPT 3	30-45	2^a	0.09^a	0.02^a	0.17^a	0.11^a	1.03^a	0.39^a	2.39^a
	Mean	2.07	0.14	0.043	0.28	0.2	1.68	0.66	2.73
OPP1	0-15	2.3^c	0.32^c	0.18^c	0.89^c	0.51^c	5.82^c	1.9^c	4.2^c
OPP2	15-30	2.1^b	0.19^b	0.07^b	0.41^b	0.27^b	2.24^b	0.94^b	3.04^b
OPP3	30-45	2^a	0.1^a	0.03^a	0.2^a	0.14^a	1.21^a	0.47^a	2.47^a
	Mean	2.13	0.20	0.09	0.50	0.31	3.09	1.10	3.24
VVL1	0-15	1.9^b	0.26^b	0.15^c	0.7^c	0.47^c	3.516^c	1.58^c	3.48^c
VVL2	15-30	1.9^b	0.25^b	0.11^b	0.64^b	0.45^b	3.37^b	1.45^b	3.35^b
VVL3	30-45	1.8^a	0.17^a	0.09^a	0.53^a	0.33^a	2.411^a	1.12^a	2.92^a
	Mean	1.87	0.23	0.12	0.62	0.42	3.10	1.38	3.25
FFL 1	0-15	2.1^b	0.18^b	0.05^a	0.32^b	0.24^b	1.722^b	0.79^b	2.89^b
FFL 2	15-30	2^a	0.11^a	0.04^a	0.22^a	0.15^a	1.642^a	0.52^a	2.52^a
FFL 3	30-45	2^a	0.2^c	0.1^b	0.61^c	0.39^c	3.143^c	1.3^c	3.3^c
	Mean	2.03	0.16	0.06	0.38	0.26	2.17	0.87	2.90

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land; Ca –Calcium; EA-Exchangeable acidity; Na-Sodium; K-Potassium; Mg –Magnessium; Av.P –Available Phosphorus; CEC, Cation Exchange Capacity; ECEC – Effective Cation Exchange Capacity. Mean values with the same letters are not significantly different from one another at 5% level of probability

The base saturation (BS) of the plantain plantation as indicated in Table 3 was highest at the surface depth of 0-15 cm (30.16%) and decreased with increasing depth, having the lowest (16.32%) at the subsoils (30-45 cm). The plantain plantation was dominated by the sand fraction with a mean of 820.08 g/kg, clay (1114.4 gkg^{-1}), and silt (68.53 gkg^{-1}).

The sand proportion decreased with an increase in depth, while clay increased with increasing depth depicting the process of illuviation. The first two depths were characterized to be loamy sand while the last depth was sandy loam indicating thickness in the soil structure. The bulk density value was lowest (1.22 gcm^{-3}) at the surface soils and was below the critical value of 1.63 gcm^{-3}(Weil et al., 2016), but increased with increasing depth; having an average of 1.34 gcm^{-3}. Porosity showed an inversely proportional relationship with the bulk density, an increase in the bulk density caused a reduction in the porosity values.

In the oil palm plantation, sandy loam dominated the three depths with an average of 736.73 gkg^{-1} of sand, 141.4 gkg^{-1} of clay, and 121.87 gkg^{-1} of silt. There was a significant decrease in sand and an increase in clay and silt indicating illuviation. Base saturation was also highest at the surface (45.24%) and decreased with increasing depth, having the lowest (19.03%) at the subsoils (30-45 cm). Similar to the plantain plantation, the bulk density value was lowest (1.24 g/cm^{-3}) at the surface soils and was below the critical value of 1.63 gcm^{-3}.Itincreased with increasing depth, having an average of 1.30 gcm^{-3}. Porosity showed an inversely proportional relationship with the bulk density, an increase in the bulk density caused a reduction in the porosity values

In the virgin land, the surface soils (0-15 cm) recorded the highest base saturation value of 45.4% and decreased consistently with increase in depth, therefore having the lowest value (38.4%) at 30-45 cm. The texture in the virgin land changed from sandy loam to sandy clay loam as the depth increases, indicating an increase in the clay content and a decrease in sand particles. The bulk density of the surface soils (0-15 cm) recorded the lowest values and the porosity recorded the highest value (53%). The highest bulk density value was found in the 15-30cm depth having the lowest porosity of 49%.

In the fallow land, base saturation was highest (39.4%) at the subsurface (30-45 cm) and was lowest (20.6%) at the 15-30 cm depth. Bulk density was found to be higher (1.30 g/cm^3) in the subsurface soil (30-45 cm) and lowest (1.26 gcm^{-3}) at the 15-30 cm depth. Porosity followed the inversely proportional trend, recording the highest porosity of 55% at the 15-30 cm depth and the lowest porosity of 51% at the 30-45 cm subsoil depth. The entire soil depth was dominated by sandy loam with evidence of illuviation.

Table 3. Some soil physicochemical properties of the different land-use types

	Depth (cm)	BS (%)	Sand	Clay	Silt	soil texture	BD (g/cm^{-3})	POR (%)
			gkg^{-1}					
PPT1	0-15	30.16^{c}	853.4^{c}	91.4^{a}	55.2^{a}	loamy sand	1.22a	54c
PPT2	15-30	24.53^{b}	813.4^{b}	111.4^{b}	75.2^{b}	loamy sand	1.38b	48b
PPT3	30-45	16.32^{a}	793.4^{a}	131.4^{c}	75.2^{b}	sandy loam	1.41c	47a
	Mean	23.67	820.08	111.4	68.53		1.34	49.7
OPP1	0-15	45.24^{c}	773.4^{c}	111.4^{a}	115.2^{a}	sandy loam	1.22a	54c
OPP2	15-30	30.92^{b}	723.4^{b}	151.4^{b}	125.2^{b}	sandy loam	1.30b	51b
OPP3	30-45	19.03^{a}	713.4^{a}	161.4^{c}	125.2^{b}	sandy loam	1.33c	50a
	Mean	31.73	736.73	141.4	121.87		1.28	51.7
VVL1	0-15	45.40^{c}	693.4^{c}	191.4^{a}	115.2^{b}	sandy loam	1.24a	53c
VVL2	15-30	43.28^{b}	683.4^{b}	211.4^{b}	105.2^{a}	sandy clay loam	1.36c	49a
VVL3	30-45	38.36^{a}	653.4^{a}	221.4^{c}	125.2^{c}	sandy clay loam	1.30b	51b
	Mean	42.35	676.73	208.07	115.20		1.30	51
FFL 1	0-15	27.34^{b}	733.4^{c}	141.4^{a}	125.2^{a}	sandy loam	1.26b	52a
FFL 2	15-30	20.63^{a}	723.4^{b}	151.4^{b}	125.2^{a}	sandy loam	1.20a	55b
FFL 3	30-45	39.39^{c}	703.4^{a}	161.4^{c}	135.2^{b}	sandy loam	1.30b	51a
	Mean	29.12	720.07	151.40	128.53		1.25	52.7

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land, BD – Bulk Density, POR – Porosity.Mean values with the same letters are not significantly different from one another at 5% level of probability

Effect of different land-use types on pH and Exchangeable acidity

Table 4 shows that pH had significant differences ($p \leq 0.05$) amongst the different land-use systems, acidity was lowest (4.7) in Virgin land and was highest (4.4) in the oil palm plantation. The land-use systems therefore had a significant effect on the pH. The high acidity could be attributed to the long period the oil palm plantation has been cultivated causing high removal of the basic cations (Selassie *et al.*, 2015), and is indirectly proportional to the fallow land and virgin land with pH of 4.5 and 4.7 which has been left unutilized for some time. The result agrees with (Habitamu, 2014) who stated that H^{+} released by nitrification of NH^{4+} from chemical fertilizer lowers the pH value of cultivated land as compared with non-cultivated land.

On the other hand, exchangeable acidity was lowest (1.87 cMolkg^{-1}) on the Virgin land and was highest (2.13 cMolkg^{-1}) at the oil palm plantation. This indicates that exchangeable H^{+} was readily available in the oil palm plantation and was reduced in virgin land. This could be because the oil palm plantation has experienced consistent cultivation and utilization over a long period.

Effect of different land-use types on Electrical Conductivity

Electrical conductivity amongst the four land-use types was significantly different from each other, salinity was at its non-hazardous state in all the land-use systems. EC followed this order from highest to lowest: VVL>OPT>FFL>PPT.

Effect of different land-use types on Organic carbon, organic matter, and total nitrogen

The average organic carbon, organic matter, and total nitrogen were significantly different ($p \leq 0.05$) amongst the four land-use systems. The virgin land (VVL) recorded the highest organic carbon, organic matter, and total nitrogen values of 21.7, 43.3, and 1.97 g/kg, while the plantain plantation recorded the lowest values of 7.3, 14.7, and 0.67 gkg^{-1} respectively. The Oil palm plantation recorded average organic carbon, organic matter, and total nitrogen of 17.3, 34.7 & 1.60 gkg^{-1} while fallow land follows at 11.7, 23.3, and 1.03 gkg^{-1}. The higher organic carbon, organic matter, and total nitrogen in the Virgin land could be attributed to the mineral release from the decomposition of leaves consistently falling from trees in the area. Amusan *et al.* (2006) observed a similar trend in their study, they reported the lowest organic carbon and organic matter content in the cultivated plot. Jamala and Oke (2013) reported higher soil organic carbon under natural forest compared with cropped land and fallow land respectively. The result of this study agrees with other studies that land-use type can markedly affect organic carbon and organic matter content (Houghton, 2003; Li *et al*., 2014; Alcantara *et al*., 2016).

The relatively low total nitrogen content recorded in the soils of the cultivated land could be attributed to the rapid mineralization of soil organic matter. Brady and Weil (2005) reported that the distribution of soil nitrogen paralleled that of soil organic mattersince nitrogen along with other nutrients, is present in organic combination and is slowly released by the process of mineralization; which was also supported by Matsumoto (2004).

Effect of different land-use types on basic cation, Effective Cation Exchange Capacity, and Base Saturation

Table 4 shows that the basic cation state of the four land-use types was generally low. Nevertheless, the highest value of Na, K, Ca, and Mg were found in the virgin land with 0.23, 0.12, 0.62, and 0.42 $cMolkg^{-1}$ while Plantain plantation recorded the lowest values of 0.14, 0.04, 0.28 and 0.2 $cMolkg^{-1}$. Virgin land was followed by oil palm plantation and then the fallow land. The low basic cation effect also affected the effective cation exchange capacity (ECEC), as the ECEC was also found to be lowest in the Plantain plantation with 2.73 $cMolkg^{-1}$ and highest at the Virgin land (3.25 $cMolkg^{-1}$).

These low values ultimately affected the base saturation of the different land-use in the following order: Virgin land (42.35%) > oil palm plantation (31.72%) > fallow land (29.12%) > plantain plantation (23.67%). The low basic cations and ECEC can be attributed to the kaolinitic nature of the soils of this area. Cation exchange capacity has been established to increase and decrease with soil organic carbon content (Kiflu and Beyene, 2013) and the result confirms it: as organic matter decreases, so does the basic cations and cation exchange capacity.

Furthermore, the continuous cultivation and the use of acidic inorganic fertilizers have been reported to deplete the cation exchange capacityof continuously cropped land-use, as indicated in the cation exchange capacity, and organic matter result of the plantain plantation and oil palm plantation (Wakene and Heluf, 2003). The study shows that land-use type influences the cation exchange capacity, effective cation exchange capacity, basic cation, and base saturation amongst the soils of the area. (Awdenegest et al., 2013).

Effect of different land-use types on bulk density and porosity

The result showed that the land-use types had significant effect on bulk density and porosity (Table 5). The fallow land showed less compaction with the lowest bulk density of 1.25 gcm^{-3}< oil palm plantation (1.28 gcm^{-3}) < virgin land (1.30 gcm^{-3}) < plantain plantation (1.34 gcm^{-3}). Porosity showed its inverse proportion correlation with the bulk density, the lowest bulk density of 1.25 gcm^{-3} in the fallow land was followed by the highest porosity of 52.7%, while the others followed suit: Oil palm plantation (1.28 gcm^{-3}: 54.7%), virgin land (1.30 gcm^{-3}: 51%) and plantain plantation (1.34 gcm^{-3}: 49.7%). None of the soil bulk density values were above the critical value of 1.63 gcm^{-3}(Weil et al., 2016) at which hindrance to root penetration and seed emergency are likely to occur. The result of this study corroborates the findings of Amusan *et al*. (2006) and, Tellen and Yerima (2018) who both reported that the highest bulk density was found in continuously cultivated plots.

The decrease in bulk density was due to the higher organic matter content, better soil aggregate, and increased root growth (Bandyopadhyay *et al*., 2010). A well-aggregated soil, loose and porous has high organic matter and lower bulk density while poorly aggregated soil has low organic matter content and high bulk density that make total pore spaces greater (USDA, 2017).

Table 4. Influence of the different Land-use systems on some soil chemical properties

	pH	EC	Org.C	Org. M	T. N	EA	Na	K	Ca	Mg	Av. P	CEC	ECEC	BS
Land use		μScm^{-1}	gkg^{-1}			$cMolkg^{-1}$								(%)
PPT	4.6c	41.5a	7.3a	14.7a	0.67a	2.07c	0.14^a	0.04a	0.28a	0.2a	1.68a	0.66a	2.73a	23.67a
OPT	4.43a	54.17c	17.3c	34.7c	1.60c	2.13d	0.20c	0.09c	0.50c	0.31c	3.09c	1.10c	3.24c	31.73c
VVL	4.7d	66.83d	21.7d	43.3d	1.97d	1.87a	0.23^d	0.12d	0.62d	0.42d	3.10c	1.38d	3.25c	42.35d
FFL	4.53b	50.10b	11.7b	23.3b	1.03b	2.03b	0.16^b	0.06b	0.38b	0.26b	2.17b	0.87b	2.90b	29.12b

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land. Mean values with the same letters are not significantly different from one another at 5% level of probability

Table 5. Influence of the different Land-use systems on some soil physical properties

	Sand	Clay	Silt	BD	POR
Land use		gkg^{-1}		gcm^{-3}	%
PPT	820.08d	111.4a	68.53a	1.34d	49.7a
OPT	736.73c	141.4b	121.9c	1.28b	51.7c
VVL	676.73a	208.1d	115.2b	1.30c	51b
FFL	720.07b	151.4c	128.5d	1.25a	52.7d

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land. Mean values with the same letters are not significantly different from one another at 5% level of probability

Correlation Studies

The correlation matrix in Table 6 showed that Base saturation had a strongly positive correlation (r=0.85) with Available Phosphorus.

Cation Exchange Capacity (CEC) had a strongly positive relationship with Available phosphorus and base saturation. Calcium positively correlated with Available Phosphorus (r=0.95), base saturation (r=0.97), and Cation Exchange Capacity. Effective Cation Exchange Capacity (ECEC) also showed a positive and strong correlation coefficient with available phosphorus, base saturation, CEC, Calcium, Clay, and Electric conductivity at r = 0.99, 0.84, 0.93,0.95, 0.72 and 0.87 (Agbai and Kosuowei, 2022).

Clay correlated with available phosphorus at r=0.71, base saturation at 0.97, CEC (0.90) and calcium at 0.89. Exchangeable acidity showed a negative correlation with Base saturation, CEC, Calcium, and Clay at r = -0.77, -0.62, -0.59, and -0.86. An increase in exchangeable acidity will cause a decline in base saturation, CEC, and calcium.

Electrical conductivity (EC) showed strongly positive correlations with Available Phosphorus, Base saturation, CEC, Calcium, and clay at r = 0.87, 0.99, 0.99, 0.98, 0.96; while it showed a negative relationship with Exchangeable acidity. An increase in exchangeable acidity will foster a negative change in the electrical conductivity of the soil (Musa et al., 2021)

Potassium showed a strong positive correlation with available phosphorus, base saturation, CEC, Clay, Calcium, electrical conductivity, and ECEC but showed a negative correlation with Exchangeable acidity. An increase in the exchangeable acidity will cause a decrease in the cation exchange and retention of basic cations in the soil(Musa et al., 2021).

Magnesium, sodium, organic carbon, and organic matter showed a positive correlation with Available phosphorus, base saturation, CEC, Calcium, Clay, and Electrical conductivity but a negative correlation with exchangeable acidity (r = -0.71, -0.55, -0.75, and -0.75).

Magnesium positively correlated with ECEC, sodium with ECEC & Potassium; Sodium with potassium and magnesium, organic carbon with potassium, Mg, and Na; organic matter with K, Mg, Na, and Organic Carbon.

Porosity showed a strong negative correlation with bulk density at r = -0.99

Sand indicated a negative correlation with available phosphorus, base saturation, CEC, Calcium, clay, ECEC, K, Mg, Na, organic carbon, organic matter, and porosity but responded with a positive correlation with only bulk density and exchangeable acidity. Silt correlated positively with Available phosphorus, base saturation, CEC, Calcium, EC, ECEC, K, Mg, Na, organic carbon and matter, and porosity; while it negatively correlated with bulk density, and Sand at r=-0.92 and -0.83.

Total nitrogen correlated positively with all the variables except exchangeable acidity and sand (r = -0.53 and -0.85).

pH correlated positively with clay and EC at r=0.55 and 0.79 while it showed a negative correlation at r= -0.56 base saturation and Exchangeable acidity at r =-0.88.

Table 6. Correlation matrix of some soil physicochemical properties

	Av_P	BD	BS	CEC	Ca	Clay	EA	EC	ECEC	K	Mg	Na	Org_C	Org_M	POR	Sand	Silt	T_N	pH
Av_P	1.00																		
BD	-0.34	1.00																	
BS	0.84*	-0.21	1.00																
CEC	0.93*	-0.25	0.98*	1.00															
Ca	0.95*	-0.26	0.97*	0.99*	1.00														
Clay	0.71*	-0.29	0.97*	0.90*	0.89*	1.00													
EA	-0.30	-0.04	-0.77*	-0.62*	-0.59*	-0.86*	1.00												
EC	0.87*	-0.28	0.99*	0.99*	0.98*	0.96*	-0.73*	1.00											
ECEC	0.99*	-0.33	0.84*	0.93*	0.95*	0.72*	-0.30	0.87*	1.00										
K	0.93*	-0.19	0.96*	0.99*	0.99*	0.88*	-0.59*	0.97*	0.93*	1.00									
Mg	0.88*	-0.20	0.99*	0.99*	0.99*	0.95*	-0.71*	0.89*	0.88*	0.98*	1.00								
Na	0.94*	-0.18	0.95*	0.99*	0.99*	0.86*	-0.55*	0.96*	0.95*	1.00*	0.98*	1.00							
Org_C	0.96*	-0.28	0.95*	1.00*	1.00*	0.87*	-0.75*	0.97*	0.96*	0.98*	0.97*	0.99*	1.00						
Org_M	0.96*	-0.28	0.95*	1.00*	1.00*	0.87*	-0.75*	0.97*	0.96*	0.98*	0.97*	0.99*	1.00	1.00					
POR	0.34	-0.99*	0.20	0.25	0.26	0.28	0.06	0.27	0.32	0.21	0.20	0.19	0.27	0.27	1.00				
Sand	-0.78*	0.61*	-0.90*	-0.88*	-0.87*	-0.93*	0.65*	-0.92*	-0.78*	-0.84*	-0.88*	-0.82*	-0.87*	-0.86*	-0.61*	1.00			
Silt	0.66*	-0.92*	0.53*	0.59*	0.60*	0.56*	-0.15	0.59*	0.65*	0.55*	0.54*	0.54*	0.61*	0.61*	0.93*	-0.83*	1.00		
T_N	0.97*	-0.26	0.95*	0.99*	1.00*	0.85*	-0.53*	0.96*	0.97*	0.99*	0.97*	0.99*	1.00*	1.00*	0.25	-0.85*	0.60*	1.00	
pH	-0.07	0.46	-0.56	0.29	0.25	0.55*	-0.88*	0.79*	-0.05	0.28	0.40	0.25	0.20	0.20	-0.46	-0.22	-0.32	0.19	1.00

CONCLUSION

The research showed that the different land-usehad significant effects on the soils. pH was generally strongly acidic at the surface soils but reduced (acidic) downwards. The Electrical Conductivity of the soils showed no salinity threat to prospective crops to be planted. Organic matter was generally low to moderate at the surface soils but reduced drastically through the subsoils.The virgin land and fallow land showed higher values of basic cations, organic matter, cation exchange capacity, base saturation; and lower exchangeable acidity as compared to oil palm and plantain plantations. The bulk density of the soils under the different land-use systems was within the normal range, indicating that heavy-duty machines have not been used or consistently utilized over the years, also activities such as overgrazing have been curtailed.This indicates that the conversion of the natural ecosystem into cultivated land will result in the deterioration of the fertility status, structure, and quality of the soil. Also, sustainable and conservative management practices such as land fallow systems will help regenerate depleted nutrients in the soil.

In general, the information generated from the study will be helpful for the proper management of land in the area. It is therefore recommended that soil conservative measures such as land fallowing be practiced to regenerate lost and depleted nutrients in the soils,and heavy machinery and overgrazing be controlled to the minimum to increase soil pore space distribution for free root penetration and growth.

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Antimicrobial Efficiency of Chitosan Coatings Containing Garlic Essential Oil on The Preservation of Rainbow Trout Fillets

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Abstract

This study objected to evaluate the antimicrobial effects of chitosan coatings enriched with garlic essential oil (GEO) in the rainbow trout fillets during cold storage. Rainbow trout fillets were treated with chitosan coating solutions with (GEO) and without (CF) garlic essential oil emulsion. One group left as control (C) without chitosan coating. All samples were stored at refrigeration for 15 days and during the storage period total psychrophilic bacteria, total mesophilic bacteria and total Enterobacteriaceae counts were determined. During the storage period the highest bacteria growth was reported in the control group and the group coated with chitosan solution. At the end of the storage, total psychrophilic bacteria count was found as 5.34, 4.71 and 4.16 log CFU/g in C, CF and GEO groups, respectively. Control group showed the highest total mesophilic bacteria count at 15th day (5.91 log CFU/g), while this value was 5.24 log CFU/g and 4.83 log CFU/g in the CF and GEO, respectively. The group coated with chitosan solutions containing garlic essential oil emulsion showed the lowest Total Enterobacteriaceae count during the storage and remained as 3.82 log CFU/g at the end of the storage. The results showed that the addition of garlic essential oil emulsion in the chitosan solutions as coating material is showed antimicrobial effect in the rainbow trout fillets during refrigerated storage.

Keywords: Chitosan, Rainbow trout, Garlic essential oil, Antimicrobial effect

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INTRODUCTION

Fish has a very important place in human nutrition because it contains antioxidants such as proteins, vitamins, carotenoids and tocopherols, beneficial effects on human health, and long-chain omega-3 polyunsaturated fatty acids (PUFA), which are essential nutrients for growth and development. Especially eicosapentaenoic (EPA, C20:5n-3) and docosahexaenoic acid (DHA, C22:6n-3) are responsible for many beneficial effects on human health. Fish meat is also known as a high quality protein source. However, fish meat spoils very quickly due to its high moisture content, near-neutral pH value, weak connective tissue structure, and high content of unsaturated fatty acids. Especially lipid oxidation and microbial spoilage are the most important causes of spoilage during the storage of fish.

However, today, where reliability comes to the fore in the production of foodstuffs, the demands for plastic packaging materials made of synthetic materials are gradually decreasing and the use of natural additives is gaining importance both in daily life and industrially.

Recently, essential oils have been used as natural antioxidant and antimicrobial agents in edible coatings to increase the shelf life of perishable foods such as fish. However, the hydrophobic and volatile properties of essential oils and their sensitivity to oxygen and light reduce their stability during processing and storage. In addition, since essential oils can cause organoleptic deterioration in foods, effective application doses are limited in direct applications. Therefore, the use of essential oils with edible films or coatings is an alternative way. Forming emulsions with essential oils and adding them to edible coatings increase their stability and effectiveness. There are some studies on the effects of edible films and coatings on the maintenance of quality of fish and fish products (Ucak and Afreen, 2022; Renur et al., 2016; Ebadi et al., 2019; Ucak et al., 2021; Ucak, 2020; Hosseini et al., 2016; Alsaggaf et al., 2017; Ucak, 2019; Ucak et al., 2019; Shahbazi et al., 2018), however, about the chitosan coating combined with garlic essential oil on the rainbow trout fillets there is not enough study. Therefore, the main objective of this study is to prepare emulsions with garlic essential oil and to apply the chitosan coating prepared with this emulsion to fish fillets. It is objected to inhibit microbial growth in fish fillets during cold storage.

MATERIALS AND METHODS

Materials

Rainbow trout (*Oncorhynchus mykiss*) fillets were provided freshly from a fish market in Niğde region. Garlic essential oil was supplied commercially from a local market in Niğde.

Method

Chitosan coatings preparation application to fish fillets

Chitosan coating solution was prepared according to the method of Ojagh et al. (2010). Emulsions were formed by adding the 1% concentration of garlic essential oil and the same amount of Tween 80. One of the chitosan coating solution was prepared without adding the essential oil emulsion. One group left as control without chitosan coating. Fish fillets were immersed in the prepared chitosan solutions for 30 seconds and left for 2 minutes, and then the fish fillets were immersed in the solution for a second time for 30 seconds and allowed to dry for 2 minutes (Ojagh et al., 2010). Then the samples were taken into styrofoam plates and covered with stretch film. All samples were stored at 4ºC±1 for 15 days and microbiological analyzes were carried out at 0, 3, 5, 8, 12, and 15th days of storage period.

Analyzes

For the determination of total mesophilic and total psychrophilic bacteria counts Plate Count Agar (PCA) was used by the spread plate method (ICMSF, 1982). The plates were incubated at 8ºC for 7 days for total psychrophilic bacteria counts and at 37ºC for 24-48 h for total mesophilic bacteria counts, respectively. Total Enterobacteriaceae were enumerated according to the method of FDA (1998) by the use of Violet Red Bile Agar (VRBA). Pour plating method was performed incubating at 37ºC for 36-48 h.

Statistical analysis

Statistical analyzes were performed with SPSS software (Statistical Analysis System, Cary, NC, USA) and Duncan multiple comparison test (One-way Anova at P<0.05 significance level) were applied to compare the data obtained.

RESULTS AND DISCUSSION

Bacterial growth is one of the main causes of spoilage of fish and fish products. The effect of chitosan coating enriched with garlic essential oil emulsion on the total psychrophilic bacteria growth in the rainbow trout fillets is presented in Fig. 1. The initial total psychrophilic bacteria count was determined as 2.67 log CFU/g in the trout fillets. During the storage period, this value showed increase in all samples while reached the highest value in the control group at the end of the storage (5.34 log CFU/g). The group coated with chitosan solutions incorporated with garlic essential oil emulsion showed the lowest values along the storage and found as 4.16 log CFU/g at the end of the storage.

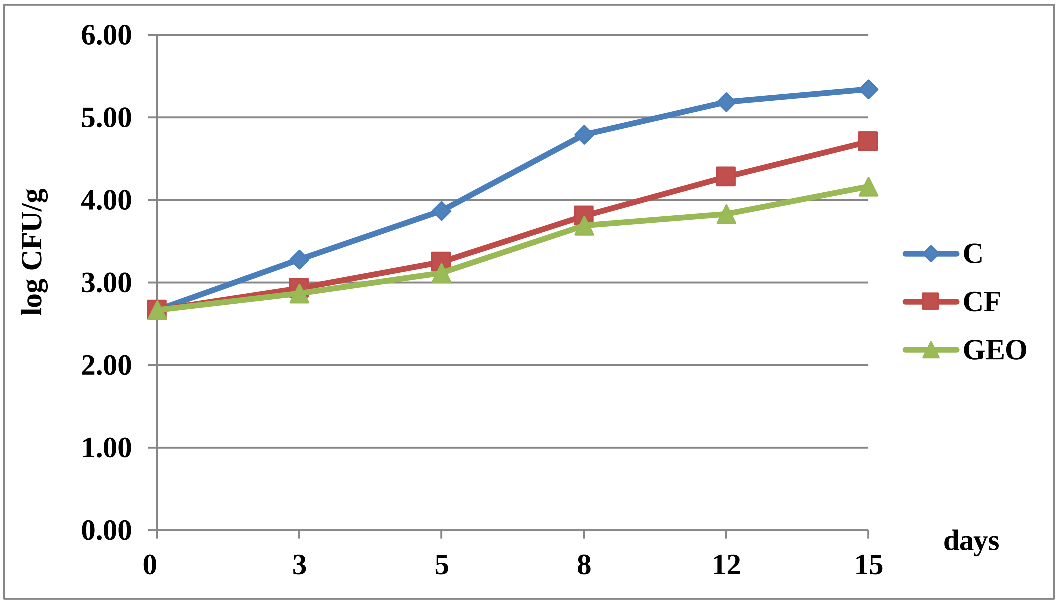

Figure 1. Changes in total psychrophilic bacteria count of rainbow trout fillets during storage. C: Control without chitosan coating, CF: Control coated with chitosan coating, GEO: fillets coated with chitosan coating enriched with garlic essential oil emulsion.

Total mesophilic bacteria count was 2.18 log CFU/g in the rainbow trout fillets at the beginning. This value increased in all groups until at the end of the storage. The highest total mesophilic bacteria count was found in the control group at 15th day as 5.91 log CFU/g, while this value was observed as 5.24 log CFU/g and 4.83 log CFU/g in the group coated with only chitosan and the group coated with chitosan containing garlic essential oil, respectively.

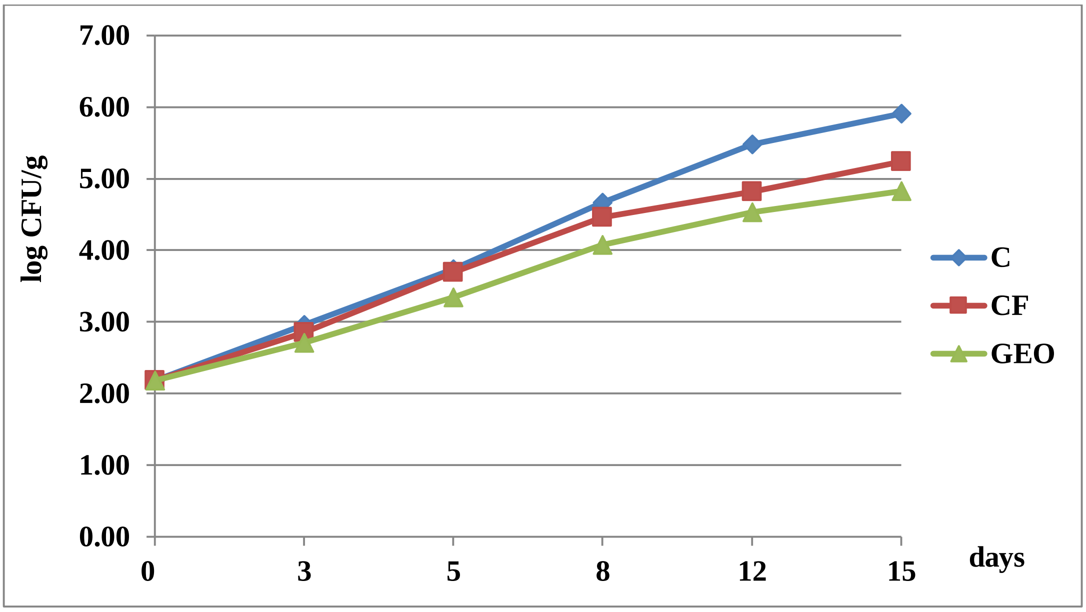

Figure 2. Changes in total mesophilic bacteria count of rainbow trout fillets during storage. C: Control without chitosan coating, CF: Control coated with chitosan coating, GEO: fillets coated with chitosan coating enriched with garlic essential oil emulsion.

The total number of coliform bacteria is accepted as an indicator of hygiene in fish. Total Enterobacteriaceae count of the rainbow trout fillets was found as 1.78 log CFU/g at the beginning of the storage (Fig. 3). In the control group this value reached at 4.91 log CFU/g, while it was determined as lower (4.41 log CFU/g) in the group coated only with chitosan coating. The group coated with chitosan solutions containing garlic essential oil emulsion showed the lowest total Enterobacteriaceae count during the storage and remained as 3.82 log CFU/g at the end of the storage.

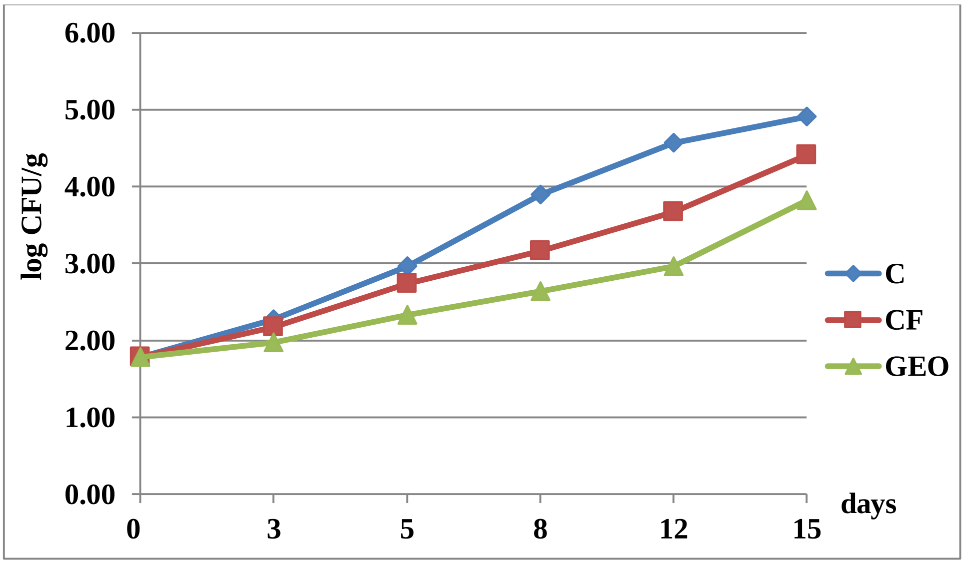

Figure 3. Changes in total Enterobacteriaceae count of rainbow trout fillets during storage. C: Control without chitosan coating, CF: Control coated with chitosan coating, GEO: fillets coated with chitosan coating enriched with garlic essential oil emulsion.

Natural extracts are effective on total coliform bacteria growth in fish and fish products (Uçak et al., 2018; Frangos et al., 2010; Mexis et al., 2009). According to the study by Ucak et al. (2018), the initial total viable count of trout fillets were found to be 1.48 log CFU/g, similarly, Öz (2018) found the total viable count of trout fillets as 2.80 log CFU/g. In another study the total bacteria count of the trout meatballs prepared with laurel and rosemary essential oils was found higher (5.24 log CFU/g) than the present study (Keser and İzci, 2020). They also reported that essential oils of laurel and rosemary inhibited the bacteria growth. Keser and Izci (2020) found the initial psychrophilic bacteria count of trout meat as 4.22 log CFU/g.

Ucak (2019) found the total viable count as 2.27 log CFU/g in trout fillets coated with gelatin films prepared with garlic peel extract and reported that bacterial growth was slower in the fillets coated with films containing garlic peel extract. Similarly, Jouki et al. (2014) reported that the microbial growth was lower in trout fillets coated with chitosan films prepared with thyme essential oil compared to the control group.

CONCLUSION

Based on these findings of this study, it can be concluded that the addition of garlic essential oil emulsion in the chitosan coating can inhibit the microbial growth in the rainbow trout fillets during refrigerated storage for 15 days. Therefore, garlic essential oil can be recommended as natural antimicrobial additives with chitosan coating to enhance the microbiological quality of rainbow trout fillets.

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