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Content

CHAPTER I

The Effects of Acid Rains on Plants

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1. Introduction

Pollution, one of the biggest problems in the world, negatively affects living life in many ways. Due to factors such as rapid population growth, increased industrial activities, and urbanization there has been a significant increase in environmental pollution. The factors contributing to environmental pollution effect living organisms in various ways, causing disruptions in the matter and energy cycles, a decline in individual and species populations, and consequently adversely affecting biological diversity.

Perhaps one of the most significant factors causing environmental pollution is acid rain. Due to various sources and their different emissions, acid rain reaches the Earth's surface and negatively impacts living organisms (Bricker and Rice, 1993). Harmful chemicals, which reach the Earth in the form of snow, fog, dew, rain, and dry particles, cause damage to life of organisms in the

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areas they meet and can even lead to the extinction of certain species (Krug and Frink, 1983).

Generally, substances that exist in pure solid, liquid, or gas form release hydrogen ions when dissolved in water and exhibit acidic properties due to their pH values being below 7. Acid rain is formed in regions where industrialization is prevalent, residential heating is widespread, there are high levels of gas emissions from vehicles, and fossil fuels are used for energy consumption (Likens et al., 1979; Bricker and Rice 1993). It consists of acidic chemicals released into the atmosphere because of combustion, which then fall to the Earth's surface in the form of rain, snow, fog, dew, or dry particles, and are integrated into the natural water cycle (URL-1).

Especially in areas where industrial activities are widespread, nitrogen and sulfur gases released because of combustion combine with water vapor in the air to form sulfuric acid and nitric acid. Under normal conditions, the pH value of clean rainwater is around 5.7-7, but when it combines with these harmful acids, the pH can drop below 5. This demonstrates how harmful acid rain can be (Singh and Agrawal, 2007).

Since the early 1850s, with the onset of the Industrial Revolution, there has been an increase in the amounts of sulfur and nitrogen gases in the atmosphere. Large factories began using coal rich in sulfur to power their machines. When coal is burned, large amounts of sulfur and nitrogen gases are released into the atmosphere. These gases typically rise to the upper levels of the atmosphere and are carried toward areas where rain clouds form, eventually reaching the Earth's surface in the form of acid rain (Likens et al., 1979; URL-2).

Acid rain was first noticed in Manchester, England. Robert Angus Smith, by observing the connection between air pollution and acid rain, conducted studies on the phenomenon. In the early 1970s, public demonstrations led to significant changes in pollution and emission standards. Smith was the first to use the term "acid rain" in his book Air and Rain: The Beginnings of a Chemical Climatology (URL-3).

The "Adirondack Council" is one of the leading organizations advocating for the reduction of central emissions. In their report titled Acid Rain: A Continuing National Tragedy, they provided important information regarding this phenomenon (URL-4).

1.1. Factors Causing Acid Rain

1.1.1. Natural Sources

The most significant factor in the natural formation of gases like sulfur dioxide (SO_2) and carbon dioxide (CO_2) that cause acid rain is volcanic activity (Bhargava and Bhargava 2013). The molten rock layers beneath the Earth's crust, subjected to high temperatures in the Earth's core, melt and form magma. The magma contains gases such as SO_2, CO_2, and water vapor (Bricker and Rice 1993). Because magma is less dense than the solid rock on top of it, it begins to rise. During this process, water vapor escapes in the form of bubbles, increasing the relative density of carbon dioxide and sulfur dioxide (Likens et al., 1979).

In addition, some organisms also contribute to the formation of these gases. CO_2 is converted into simple carbohydrates by photosynthesis performed by phytoplankton in the oceans. The organic carbon produced by phytoplankton is fully incorporated into the food chain, where it is consumed, oxidized, or broken down into CO_2. CO_2 can also be produced as a result of microbial decomposition of organic matter under aerobic and anaerobic conditions. Under aerobic conditions, CO_2 and water are the final products, and all the carbon is released into the atmosphere as CO_2 (Dioxide, 1985; Jansson et al., 2000).

In nature, CO_2 is consumed through processes such as photosynthesis by land and marine plants, the formation of shells by marine animals, the death of marine animals, and the deposition of carbonates in lakes and seas (Jansson et al., 2000). The CO_2 that is consumed is released back into nature through processes like respiration by living organisms, the burning or decay of organic matter, the use of hydrocarbon fuels like coal and wood, and the application of artificial fertilizers derived from carbon-rich formations. Some carbon also enters the atmosphere as CO_2 through animal respiration, and when animals and plants die, CO_2 is released into the atmosphere as well (Dioxide, 1985; Singh and Agrawal 2007).

Some of the carbon is stored in decomposed organic matter, where it transforms into fossil fuels such as coal, oil, and natural gas. CO_2 also enters the carbon cycle through the oceans, as phytoplankton convert CO_2 into organic compounds via photosynthesis, and other organisms consume these plankton. A significant portion of carbon is deposited in the form of carbonate rocks (typically $CaCO_3$). These rocks are formed from the shells of mollusks in ancient seas (Amthor, 1995; Aresta et al., 2021)

1.1.2. Human-Related Factors

Human activities such as transportation, industry, mining operations, thermal power plants, heating, and self-care contribute to the formation of harmful gases that cause acid rain. Along with the growing global population, the production of these gases has also accelerated.

1.1.3. Factors Caused by Heating

Materials primarily used for heating are mostly fossil fuels in the world. The combustion of fossil fuels releases gases such as CO_2, SO_2, and NO_2 (Karmakar et al., 2024). These gases react with water vapor or other substances in the clouds, or ionize, forming acids such as sulfuric acid (H_2SO_4), nitric acid (HNO_3), and carbonic acid (H_2CO_3) (Newbery et al., 1990). These acids mix with rainwater and fall to the ground as acid rain. Natural gas, being free of sulfur and nitrogen, is considered a clean fuel and does not contribute to acid rain. However, coal with low calorific value and high sulfur content, especially when burned with improper techniques, increases the formation of acid rain (Likens et al., 1979; Singh and Agrawal, 2007).

1.1.4. Factors from Motor Vehicles

The rapid increase in population, urbanization, and transport has led to a widespread use of motor vehicles. The toxic chemicals emitted from the exhaust of motor vehicles contribute significantly to the formation of acid rain by mixing with the air (Aresta et al., 2021).

1.1.5. Factors from Industry

In parallel with technological advancements, industrial activities have increased, leading to a rise in the number of industrial establishments. Incorrect locations chosen for industrial facilities, inadequate measures to protect the environment from pollution, the use of unsuitable technologies, and the high sulfur content of fuels used in energy production are significant factors contributing to acid rain (Singh and Agrawal, 2007). Specifically, gases such as CO_2, SO_2, NO_2 are the primary industrial sources of acid rain-causing pollutants (Manisalidis et al., 2020; Aresta et al., 2021).

1.1.6. Personal Care Activities

The chemicals used as propellants in cosmetics such as deodorants, hair sprays, and shaving foams contribute to the accumulation of harmful gases that cause acid rain. Chlorofluorocarbons (CFCs) are organic compounds made up of chlorine, fluorine, carbon, and often hydrogen. CFC gases are primarily released into the atmosphere from deodorants (Solomon, 2024). These gases react with ozone in the ozone layer, causing the breakdown of ozone and leading to a reduction in the concentration of ozone in the ozone layer.

1.2. Emissions Causing Acid Rain and Leading to Acidification in the Atmosphere

1.2.1. Sulfur Oxides (SO_x)

Sulfur oxides, primarily SO_2, are one of the main contributors to acid rain (Poonia, 2012). They are released into the atmosphere through natural sources such as volcanic eruptions and the decay of organic matter, as well as from human activities like the burning of fossil fuels (coal, oil, and natural gas) and industrial processes (Manisalidis et al., 2020; Aresta et al., 2021). Once SO_2 is released into the atmosphere, it reacts with oxygen to form sulfur trioxide (SO_3). The sulfur trioxide then combines with water vapor in the atmosphere to produce sulfuric acid (H_2SO_4), which is a key component of acid rain (Singh and Agrawal 2007). These emissions significantly contribute to the acidification of rain, which can have harmful effects on ecosystems, soils, water bodies, and human-built structures (Vermeulen, 1980).

One of the most important emissions that cause air pollution and, consequently, acid rain, is SO_2. Every year, large amounts of SO_2 are released from various sources into the atmosphere. Typically, industries and thermal power plants use solid and liquid fuels that contain high levels of sulfur to generate electricity (Manisalidis et al., 2020; Aresta et al., 2021). When fossil fuels are burned, the sulfur and carbon are converted into CO_2 and SO_2. Volcanic eruptions, swamps, and seas also release sulfur gas components into the air. These gas components combine with substances like water vapor and turn into sulfuric acid and sulfate. The reaction of O_2 in the air with SO_2 forms SO_3. Then, SO_3 reacts with water in the clouds to produce sulfuric acid (H_2SO_4).

Globally, sulfur emissions are responsible for 60-70% of the acid deposition. More than 90% of the sulfur in the atmosphere is of human origin (Kellogg et al., 2012). The main sources of sulfur are:

Coal Burning: Coal typically contains 2-3% sulfur, so when it is burned, SO_2 is released into the atmosphere (Manisalidis et al., 2020; Aresta et al., 2021).

Smelting of Metal Sulfide Ores for the Extraction of Pure Metals: Metals such as zinc, nickel, and copper are obtained through this process, which releases sulfur compounds.

Volcanic Eruptions: While not a common issue, a volcanic eruption can release large amounts of sulfur into the atmosphere in a given region.

Organic Decay: The decomposition of organic matter also releases sulfur compounds into the atmosphere.

Ocean Spray: The oceans release sulfur compounds, which can contribute to the sulfur content in the atmosphere (Singh and Agrawal, 2007; Chou, 2012; Kellogg et al., 2012;).

1.2.2. Nitrogen Oxides (NOx)

Nitrogen oxides (NO_X) are another significant emission contributing to acid rain formation. There are two major factors contributing to the high levels of NO_X in the atmosphere (Chen et al., 2007). The first is the exhaust from motor vehicles, and the second is emissions from stationary combustion facilities. These gases enter the natural nitrogen cycle in the atmosphere and result in the formation of nitric acid (Mehta, 2010; Likens et al., 1979).

The most important nitrogen oxides include nitrous oxide (N_2O), nitric oxide (NO), and nitrogen dioxide (NO_2).

Most of the nitrogen oxide in the atmosphere results from human activities, with the remaining 5% coming from natural processes. The main sources of nitrogen dioxide include:

1. The combustion of oil, coal, and gas

2. Bacterial activity in soils

3. Forest fires

4. Volcanic activity

5. Lightning (Robinson and Robbins, 1970; Singh and Agrawal, 2007)

In urban areas, higher concentrations of NO and NO_2 gases are observed. The use of fossil fuels for electricity production and the gases emitted from motor vehicles are sources of nitrogen oxides (Khalil and Rasmussen, 1992). Compared to sulfur oxides, nitrogen oxides are more widespread on Earth. Vehicles, the respiration of living organisms, and various combustion activities all contribute to the formation of CO_2. CO_2 then reacts with water vapor in the atmosphere to form carbonic acid (H_2CO_3), which subsequently leads to the formation of acid rain (Likens, 1979).

1.2.4. Hydrogen Chloride (HCl)

Hydrogen chloride (HCl) emissions contribute to the formation of hydrochloric acid (HCl). When released into the atmosphere, hydrogen chloride can react with water vapor or other substances, forming hydrochloric acid, which can contribute to acid rain (Evans et al., 2011).

1.3. Mechanisms of Acid Rain Formation

Acid deposition can result from two processes: dry and wet deposition (Georgii et al, 1986; Rodhe, 2002; Wondyfraw, 2014). In some cases, hydrochloric acid may be directly released into the atmosphere. More commonly, acid rain originates from secondary pollutants formed by the oxidation of nitrogen oxides (NO_X) or sulfur dioxide (SO_2) gases released into the atmosphere (Irwin and Williams, 1988; Khemani et al., 1994; Rafie-Rad et al., 2024). Reactions in the Earth's surface or within the atmosphere can transform these pollutants into nitric acid or sulfuric acid. The process of converting these gases into acid forms can take several days, during which time these pollutants can be transported hundreds of kilometers away from their original sources (Cheng et al., 2024). Acid rain formation can also occur when nitrogen oxides and sulfur dioxide settle on the land and interact with dew or frost on the surface (Parungo et al., 1987; Singh and Agrawal, 2007; Sedyaaw et al., 2024).

1.3.1. Dry Deposition

Acidic particles and gases can accumulate in areas where there is no moisture, remaining in the atmosphere as dry deposition. These acidic particles and gases can quickly settle on surfaces (such as water bodies, vegetation, and buildings), remain suspended in the air, or react during atmospheric transport to form larger particles that may be harmful to human health (Georgii et al, 1986; Rodhe, 2002; Wondyfraw, 2014). When these accumulated acids are washed away by the next rainfall, the acidic water can mix with groundwater and surface water, as well as with the soil, causing damage to nature and living organisms. This type of deposition can account for 20-60% of total acid deposition (URL-5).

1.3.2. Wet Deposition

The most common form of acid rain is wet deposition. This occurs when gases such as nitrogen oxides, sulfur oxides, and carbon dioxide in the atmosphere combine with water vapor to form acids like nitric acid, sulfuric acid, and carbonic acid. (Georgii et al, 1986; Rodhe, 2002; Wondyfraw, 2014) These acids then fall to the Earth's surface as snow, rain, or dew, which is defined as wet deposition.

In addition to dry and wet deposition, acidic compounds can also reach plants, soil, and water through contact with acidic clouds. Although cloud deposition affects only a limited number of locations, it can provide a relatively steady source of acid, especially at high altitudes, when compared to wet deposition. As a result, trees like the red spruce have been notably impacted in areas with significant cloud deposition (URL-6).

1.5. General Effects of Acid Rain

Acid rain falls on lakes, rivers, oceans, forests, urban areas, and agricultural land. These rains pollute both surface and groundwater, damage organisms, destroy agricultural fields, natural vegetation, urban settlements, and even historical monuments (Veziroğlu, 1998; Anonim b, 2003 et al., Kant and Kızıloğlu, 2002).

1.5.1. Effect of Acid Rain on Soil Properties

Acid rain affects the chemical and biological properties of soil. The sulfur and nitrogen compounds that accumulate in the atmosphere are deposited onto the soil through precipitation, leading to a decrease in soil pH. As soil pH decreases, elements like Ca, Mg, and K are leached away from the soil. When the soil pH falls below 5, the solubility of heavy metals (such as Fe, Mn, Zn, Cu, Al, etc.) increases, causing the concentration of Al, Fe, and Mn in the soil solution to rise rapidly. Acid rain leads to soil acidification, disrupting the balance of nutrient elements in the soil. This results in a reduction in soil fertility, which in turn causes a decline in agricultural productivity (Aydın and Sezen, 1990; Nuhoğlu et al., 1995; Kant and Kızıloğlu, 2002).

1.5.2. Effect of Acid Rain on Aquatic Environments

Lakes and rivers typically have a pH between 6 and 8. Acid rain lowers the pH of these water sources, increasing their acidity. Aquatic plants thrive best in waters with a pH between 7.0 and 9.2. At a pH of 6.0, shrimp cannot survive. At pH 5.5, bacterial decomposers die, and nearly all fish perish at pH levels below 4.5. Even small changes within these pH ranges can have detrimental effects on aquatic life, potentially leading to their death. Additionally, lakes can have acid layers in the form of snow or ice. With sudden weather changes in the spring, this snow melts, and the acids in the snow can cause a rapid pH shift in the lake. Spring is a crucial reproductive period for many organisms, and they are unable to adapt to such sudden pH changes (URL-7).

The decrease in pH in wetlands caused by acid rain disrupts the balance of the aquatic ecosystem, leading to a reduction in the number of fish, aquatic plants, and other organisms living in these areas. Acid rain makes these waters more acidic, which results in increased absorption of aluminum from the soil that is carried from lakes and rivers. This combination makes the water toxic to species such as crayfish, oysters, fish, and other aquatic animals (URL-8).

1.5.3. Effects of Acid Rain on Soil Microorganisms

Soil microorganisms are abundant in the rhizosphere, the region around plant roots. These microorganisms play essential roles in the nutrient cycling of carbon (C), nitrogen (N), sulfur (S), and other essential elements, transforming them into forms that can be readily absorbed by plants (Çengel, 1993; Kızıloğlu, 1995). Acid rain that falls on the soil disrupts the pH balance, negatively affecting soil microorganisms. As a result, their activities and, consequently, their ability to survive are impaired (Kızıloğlu, 1995). The number and activity of bacteria in the soil are significantly influenced by the soil pH level. In general, acidic conditions are not suitable for bacteria.

1.5.4. Effects of Acid Rain on Humans

SOx emissions, which can lead to respiratory infections and heart problems in humans, combine with rain in the atmosphere and return to the Earth as acid rain. NOx emissions, resulting from the burning of fossil fuels, convert into acids upon inhalation, causing damage to lung tissue in humans (Anonim, 2003; Kant and Kızıloğlu, 2002). Acidic particles, such as SO_2 and NOx, convert into nitric acid and sulfuric acid in the atmosphere. These acids then attach to particles like soot, dust, and smoke. When these particles are inhaled, they can directly irritate the upper respiratory tract, pass through the moist and warm alveoli of the lungs, chemically enter the bloodstream, and potentially cause lung hemorrhages (Müezzinoğlu, 1987; Turan and Gökalp, 1993; Anonim, 2000).

1.5.5. Effects of Acid Rain on Animals

Acid rain negatively affects animals through respiration and the food chain. The most affected by these rains are frogs and fish eggs. Chronic poisoning in animals often occurs due to the adsorption of atmospheric pollutants onto feed plants or the toxic effects of acid rain. In areas where animals graze on such pastures, an increase in mortality rates has been observed (Müezzinoğlu, 1987; Karpuzcu, 1991; Şişli, 1999).

The increasing degradation of forests due to acid rain also negatively affects both wild and domestic animal populations. The shrinking of wildlife habitats, the rapid spread of diseases, behavioral changes in animals, and issues related to reproduction are among the problems caused. Changes in their environment can reduce hunting abilities in animals and also lead to increased harm from predators on certain species (Traş and Elmas, 1998).

1.5.6. Effects of Acid Rain on Historical Places

Acid rain causes significant damage to historical places made of materials such as marble, sandstone, and limestone, which contain calcium carbonate. Additionally, exposed metal surfaces, paint coatings, and certain plastics deteriorate due to the sulfur dioxide and acid diluted by rain (URL-9). Especially natural stones are damaged by the conversion of calcium carbonate ($CaCO_3$) into calcium sulfate ($CaSO_4$) because of acid rain. Over time, metal accumulations form on the stone surfaces, leading to surface degradation and color changes (Kocaeli Provincial Environmental Status Report, 2006; Demirarslan, 2008).

1.5.7. Effects of Acid Rain on Plants

Acid rain generally has negative effects on plants. The impacts of acid rain on seed germination, development, growth, and metabolic activities of plants are significant. Plants exposed to acid rain often exhibit visible damages and deformations, and acid rain can cause harm to their roots, branches, and leaves. Examples of harmful effects of acid rains on plants include a reduction in the number of organelles and the inability of organelles to perform their functions (Zhang et al., 2023).

Young roots, leaves, and shoots are typically more sensitive to low pH conditions, but plants can be damaged in various ways. Additionally, since acid rain affects soil water, nutrient composition, and structure, it can lead to disruptions in plant development (Wood and Borman, 1975).

Effect on Seed Germination

Acid rain affects seed germination. For seeds with thick seed coats, this effect can facilitate germination, while in some species, it inhibits the germination process (Zhang et al., 2023).

Effect on Plant Growth

Studies have shown that acid rain generally has a negative impact on plant growth (Zhang et al., 2023). Fan and Wang (2000) reported that, due to the increase in acidity, the seedling height decreased in all five species. This reduction was particularly significant in *Ligustrum lucidum*, *Castanopsis fissa*, *Melia azedarach*, and *Koelreuteria bipinnata*. On the other hand, when the effect of acidity on root diameter was examined, it was determined that the root diameter decreased in *Ligustrum lucidum* and *Castanopsis fissa*. The effect of acid rain on the head diameter of sunflower plants has been studied, and it has been determined that as the acidity increases, both the plant height and the head diameter decrease (Nandlal and Sachan, 2017). Additionally, acid rain has caused necrosis, curling, and deformities in both the young and mature leaves of sunflower plants.

Effect on Morphological Structures

Acid rain causes necrosis on plant surfaces and disrupts structural integrity. It also reduces the plant resistance to external factors. By affecting the light absorption of photosynthetic pigments, it influences photosynthesis. In leaves exposed to acid rain, collapse of epidermal and palisade parenchyma cells, hypertrophy of spongy parenchyma cells, and accumulation of phenolic compounds and starch granules have been observed (Zhang et al., 2023). Additionally, degradation of the cuticle layer and plasmolysis in guard cells have been detected (Sant'Anna-Santos et al., 2006). In *G. americana*, a reduction in turgor pressure of the auxiliary cells observed may lead to changes in guard cell permeability (Kozlowski, 1980), affecting gas exchange rates (Evans, 1984). Damage to stomata disrupts plant growth and productivity by decreasing photosynthesis rates (Sant'Anna-Santos et al., 2006).

Effect on Chlorophyll Content

Research has shown that acid rain also affects the chlorophyll content in plants. Morrison (1984) noted that acid rain can reduce chlorophyll formation due to the leaching of nutrients, particularly magnesium, which is one of the main components of chlorophyll, from the leaves. However, some studies have found no change in chlorophyll content (Neufeld et al., 1985; Fan and Wang, 2000). In a study conducted by Du et al. (2017), it was determined that acid rain decreased the chlorophyll content by 6.71% for each unit decrease in pH. It was determined that among grass, tree, and shrub species, the group most affected by the decrease in chlorophyll content due to pH changes was the grasses. Among evergreen and deciduous plants, the reduction in chlorophyll content was more significant in deciduous plants. It has been found that the decrease in chlorophyll content due to acidity is more significant in angiosperms and dicots.

Effect on Photosynthesis

In some *Liriodendron* species, a decrease in biomass has been recorded due to the reduction in photosynthesis capacity caused by acid rain (Neufeld et al., 1985; Sant'Anna-Santos et al., 2006). The direct non-linear effect of acid rain on photosynthesis rate in leaves was found to be neutral or positive when the pH was above

5.0, but negative below this value. Additionally, it was determined that below pH 5.0, the sensitivity of photosynthesis to acid rain did not vary significantly between herbaceous and woody species; however, above this pH value, significant differences were observed. While woody species showed a significant increase in photosynthesis rate, the increase in herbaceous species was negligible (Dong et al., 2017).

Effect on Biomass

Fan and Wang (2000) observed a significant reduction in the average dry weight of seedlings in five species when exposed to acid rain simulation at pH 2.0. A significant decrease in leaf dry weight has been observed in *Lugistrum lucidum*, *Castanopsis fissa*, and *Melia azedarach* plants due to acidity. In *Lugistrum lucidum* and *Castanopsis fissa* species, root and shoot dry weight have also significantly decreased. Milton and Abigael (2015) reported that the pH value with the highest root biomass in okra plants was 5, while the lowest root biomass occurred at a pH of 1. It was determined that the pH value with the highest shoot biomass was 5, while the lowest shoot biomass occurred at a pH of 4.

Effect on Nutrient Uptake

Acid rain increases soil acidity, acidifies soil water, and enhances the solubility of certain elements, leading to the dissolution and leaching of some elements from the soil. This process alters plant metabolism and affects the uptake of nutrients. Wood and Bormann (1977) examined the effects of acid rain application on the concentration of certain nutrient elements in *Pinus strobus* L.. Between pH 2 and 3, the concentrations of Mg^{2+}, Ca^{2+}, and K^{+} elements increased, while the concentration of nitrogen (N) decreased. Between pH 4 and 6, the concentrations of N, Ca^{2+}, and K^{+} decreased, while the concentration of Mg^{2+} increased. This indicates that the solubility of certain elements varies in response to acidity.

In a study conducted by Zang et al. (2020) with tea seedlings, it was found that compared to the control, the pH 4.5 treatment reduced the nitrogen content in the roots by 18.3%, while it had no significant effect on the shoots. The pH 3.5 and pH 2.5 treatments did not significantly affect the nitrogen content in the roots, but these pH treatments increased the total nitrogen content in the leaves by 23.8% and 35.8%, respectively, and in the stems by 35.4% and 65.1%, respectively.

Effect on Budding and Flowering

Acid rain has an impact on the processes of budding and flowering in plants. For example, in *Helianthus annuus*, the first flowering time gradually increased between pH 7 and 3, while the budding process gradually decreased within this pH range (Lal et al., 2017). Between pH 7 and 3, the first flowering time gradually increased, which led to an extension in the flowering period due to the increased acidity. The duration of flowering and flower size gradually decreased within this range. The increase in acidity negatively affected the flowering process.

Effect on Leaf Abscission

Eguagie (2015) reported that in plants exposed to acid rain simulation, there was a parallel decrease in leaf number corresponding to a decrease in pH. Additionally, the highest leaf drop rate was observed at a pH of 3. It was noted that older leaves were prepared to shed and dropped one week after the application. At pH 3, a significant decrease in the number of plant leaves was observed. In the study of Lal et al., (2017), it was recorded that there was a gradual reduction in leaf abscission in *Helianthus annuus* due to the increase in acidity. Low pH levels can also lead to early succession.

Effect on Pollen Germination and Pollen Tube Formation

Studies have shown that acid rain also affects pollen germination and pollen tube formation. Yao et al. (1996) found that acid rain applications at pH 4.0 and 3.0 reduced the germination of pollen grains in rice. Munzuroğlu et al. (2003) applied acid rain to apple (*Malus sylvestris*) pollen and found that as the amount of acid rain increased, pollen germination significantly decreased, and it also affected pollen tube length. Lal et al. (2017) reported that acid rain had significant effects on pollen germination. Between pH 7 and 3, the pollen tube length gradually decreased, with the shortest pollen tube length recorded at pH 3.

1.6. Prevention of Acid Rain

To mitigate the effects of acid rain, which negatively impacts the lives of organisms on Earth, several measures and solutions can be implemented:

Transition to Cleaner Energy Sources: Widespread use of alternative energy sources such as natural gas (which contains less sulfur and nitrogen), and sustainable energy sources like solar and wind power, instead of fossil fuels used in industrial and residential sectors, can help reduce the effects of acid rain.

Installation of Filters in Industrial Chimneys: Filters should be installed in the chimneys of industrial facilities to reduce the emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx), which are the primary contributors to acid rain.

Minimizing the Use of Motor Vehicles and Promoting Public Transportation: The use of motor vehicles should be minimized, and the use of public transportation should be encouraged to reduce emissions of nitrogen oxides (NOx) and other pollutants that contribute to acid rain formation.

Forest Fires Should Be Prevented, Green Areas Should Be Protected and Expanded: Efforts should be made to prevent forest fires, and green spaces should be preserved and expanded to maintain environmental balance and reduce the pollutants that contribute to acid rain.

Renewable Energy Sources Should Be Preferred Over Thermal Power Plants in Energy Production: The use of renewable energy sources such as solar energy, wind energy, and geothermal energy should be prioritized over thermal power plants to reduce the emissions of sulfur and nitrogen compounds that contribute to acid rain.

Conclusions

This chapter examined the effects of acid rain on plants. As a result of acid rain, a decrease in pH levels led to morphological, anatomical and physiological negative effects in plants. It is known that acid rain affects many processes in plants, and new research continues to contribute new insights to the literature. As one of today's biggest environmental issues, studying the effects of acid rain is crucial for the continuity and sustainability of the ecosystems and life on Earth. Identifying the impacts of acid rains on plants, which form the first step of the food chain, will be beneficial in terms of various topics such as healty food supply for organisms, biodiversity, nutrient cycles, and environmental pollution.

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URL-2: http://www.bilgiinegi.com/asit-yagmuru-nedir.htm

URL-3: https://prezi.com/i3qvic7ai9ah/asit-yagmurlarinin-etkileri/

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CHAPTER II

A Look at the Liverworts (Marchantiophyta) of Denizli Province From Past to Present

Hanife TARIM[1]
Kamil Mert YUCEL[2]
Isa GOKLER[3]

1.Introduction

Denizli is located in the Eastern Aegean region and serves as a bridge between the Mediterranean and Central Anatolian regions. The diversity of climate types in the area is widespread due to this geographical positioning. The most common climate type is Mediterranean (Semiz, 2003). The first steps of botanical research in Turkey were carried out by Boiss. and P.H. Davis in this region. As a result of their studies, they noted that the area possesses a very rich biodiversity and decided to conduct further research for the entire country. The average temperature of the region is 16.18°C and the average precipitation value is 567,8 mm (Akbaş, 2019). Significant

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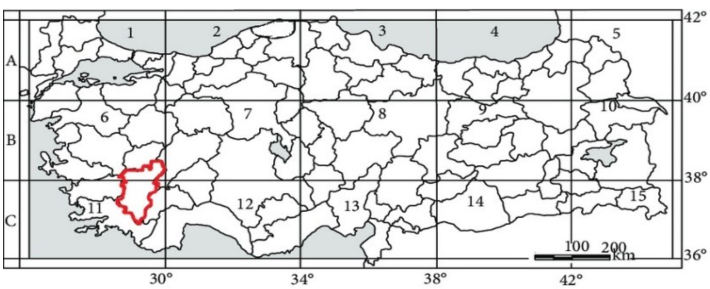
mountain formations in Denizli are as follows: Honaz (2571 m), Akdağ (2449 m), Bozdağ (2421 m), Karcı (2308 m), Eşeler (2254 m), Bulkaz (1990 m), Elmadağ (1805 m), Büyük Çökelez (1340 m) and Beşparmak (1307 m) meters in height (Akarsu, 1969). The most common plant communities in the area are certain maquis groups, along with black pine and red pine forests (Cirit, 2019).

The study area is located at the intersection of the B6 and C11 quadrature system according to Henderson's (1961) classification. Currently, bryophytes are classified into three separate taxa: Hornworts, Liverworts, and Mosses. The global species count for liverworts is approximately 5.000 (Glime, 2009; Goffinet & Shaw, 2009). Due to the presence of waterfalls, streams, brooks and shaded areas created by forests, Denizli provides suitable habitats for liverworts. The first studies on the Hepaticae Division were conducted by foreign researchers up until the 1960s, after which many local researchers have contributed to this field. Currently, 215 liverwort species have been recorded in Turkey (Kürschner & Erdağ, 2020). Previous research in the region, spanning from the past to the present, includes the identification of 35 species by K. Walther (1964), Crundwell and Nyholm (1979), İ. Gökler (1986), M. Kırmacı (2007). The aim of our study is to investigate the liverworts of Denizli under the Marchantiophyta Division rather than the Bryophyta Division, and to contribute to the cryptogamic flora of Turkey.

Figure 1. Location of Denizli province according to Henderson (1961) quadrature system



2.Material and Method

The samples collected in this study were gathered during fieldwork conducted between 2022 and 2024 in the B6 and C11 quadrature system (Henderson, 1961). Liverworts were collected during the most suitable period for their growth between November and April. Since the natural colors of the specimens are important for identification, multiple photographs were taken from different angles during fieldwork and each specimen was assigned a unique code. Additionally, photos representing the geological and sociological characteristics of the area were also included. To preserve the structure of the samples they were collected in sealed bags with ice packs. To facilitate the separation of thalloid specimens from their surfaces, large-surfaced digging tools were used while fine-tipped forceps were employed to detach leafy specimens from their epiphytic surfaces (Yücel & et al., 2024). The GPS coordinates, collection date and elevation of each sample were recorded in the field notebook. In the laboratory phase, priority was given to identifying thalloid forms to prevent structural damage. Leafy specimens were dried using a drying oven and then transferred to temporary envelopes. For determining the distribution patterns in the world and in Turkey according to the Henderson Turkey Grid System (Henderson, 1961) as well as for acquiring identification characteristics, the key flora books of European countries and various floristic publications were consulted, including Watson (1981), Smith (1996), Paton (1999), Atherton et al. (2010), Kürschner & Erdağ (2020) and Glime (2009). The plant list was organized according to the system developed by Hodgetts et al. (2020). All specimens are preserved at the Fauna and Flora Research and Application Center of Dokuz Eylül University, where the identification work was carried out.

Figure 2. Map representation of the samples collected during the field study (© earth.google.com)

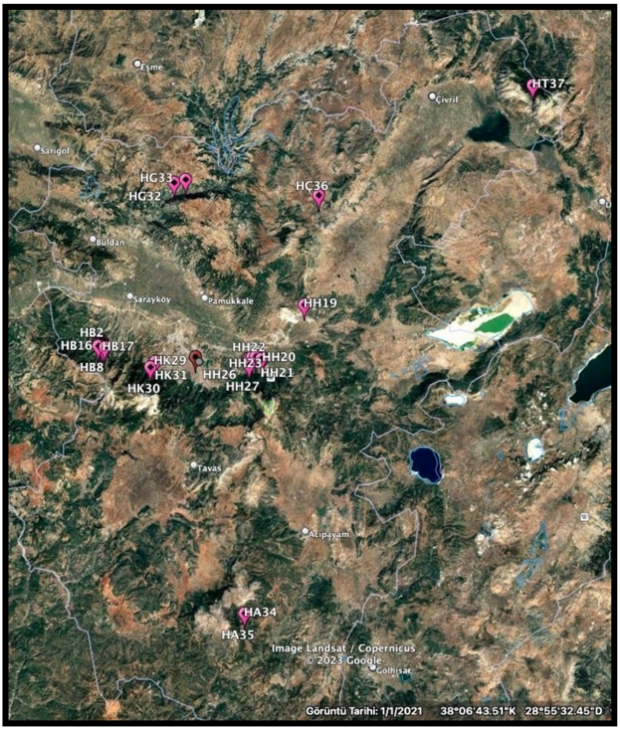


Table 1 - Stations where fieldwork was carried out

NO	PROVINCE	GPS	DATE	ALTITUDE (m)
HB1	DENİZLİ	37°47'52.16"K 28°50'38.93"D	29.01.2023	796
HB2	DENİZLİ	37°47'57.64"K 28°50'41.67"D	29.01.2023	755
HB3	DENİZLİ	37°48'6.95"K 28°50'39.44"D	29.01.2023	740
HB4	DENİZLİ	37°48'2.03"K 28°50'34.01"D	29.01.2023	707
HB5	DENİZLİ	37°47'47.80"K 28°50'44.58"D	29.01.2023	787
HB6	DENİZLİ	37°48'19.00"K 28°50'43.75"D	25.02.2023	706
HB7	DENİZLİ	37°47'38.70"K 28°50'39.66"D	25.02.2023	830
HB8	DENİZLİ	37°47'28.31"K 28°50'41.99"D	25.02.2023	842
HB9	DENİZLİ	37°47'12.86"K 28°50'34.79"D	12.03.2023	913
HB10	DENİZLİ	37°47'27.03"K 28°51'2.27"D	12.03.2023	907
HB11	DENİZLİ	37°47'29.07"K 28°51'9.34"D	28.11.2023	856
HB12	DENİZLİ	37°47'31.78"K 28°51'16.52"D	28.11.2023	813
HB13	DENİZLİ	37°47'26.32"K 28°51'17.61"D	28.01.2024	822
HB14	DENİZLİ	37°47'38.01"K 28°51'14.71"D	28.01.2024	795
HB15	DENİZLİ	37°47'45.70"K 28°51'17.45"D	09.02.2024	770
HB16	DENİZLİ	37°47'17.27"K 28°51'44.54"D	14.02.2024	976
HB17	DENİZLİ	37°47'12.55"K 28°51'24.03"D	14.02.2024	878
HB18	DENİZLİ	37°47'59.29"K 28°51'23.58"D	14.02.2024	740
HH19	DENİZLİ	37°51'20.09"K 29°23'6.97"D	31.12.2023	559
HH20	DENİZLİ	37°44'57.57"K 29°16'13.81"D	31.12.2023	688
HH21	DENİZLİ	37°44'56.27"K 29°15'59.25"D	04.12.2023	690
HH22	DENİZLİ	37°45'17.01"K 29°15'7.93"D	04.12.2023	522

HH23	DENİZLİ	37°45'13.24"K 29°14'33.93"D	04.12.2023	522
HH24	DENİZLİ	37°45'1.72"K 29°13'54.41"D	15.09.2023	551
HH25	DENİZLİ	37°44'50.92"K 29°14'15.76"D	15.09.2023	712
HH26	DENİZLİ	37°44'46.53"K 29°14'3.20"D	03.12.2022	780
HH27	DENİZLİ	37°44'17.37"K 29°14'4.88"D	03.12.2022	1056
HH28	DENİZLİ	37°44'29.39"K 29°13'59.47"D	19.12.2022	946
HK29	DENİZLİ	37°45'11.18"K 28°59'21.05"D	14.04.2023	795
HK30	DENİZLİ	37°44'35.29"K 28°58'41.60"D	14.04.2023	896
HK31	DENİZLİ	37°45'15.84"K 28°59'29.52"D	14.04.2023	770
HG32	DENİZLİ	38° 7'9.39"K 29° 3'38.11"D	14.04.2023	261
HG33	DENİZLİ	38° 7'28.17"K 29° 5'27.15"D	16.06.2023	273
HA34	DENİZLİ	37°13'48.75"K 29°11'31.53"D	16.06.2023	1231
HA35	DENİZLİ	37°13'52.32"K 29°11'30.87"D	16.06.2023	1240
HÇ36	DENİZLİ	38° 4'40.54"K 29°26'13.85"D	05.10.2024	787
HT37	DENİZLİ	38°16'40.62"K 30° 0'37.28"D	05.10.2024	1679

3.Results

MARCHANTIOPHYTA

JUNGERMANNIOPSIDA

Jungermanniales H.Klinggr.

Cephaloziellaceae Douin

- *Cephaloziella baumgartneri* Schiffn.
- *Cephaloziella divaricata* (Sm.) Schiffn.
- *Cephaloziella hampeana* (Nees) Schiffn. ex Loeske

Jungermanniaceae Rchb.

- *Jungermannia atrovirens* Dumort.

Solenostomataceae Stotler & Crand.-Stotl.

- *Solenostoma gracillimum* (Sm.) R.M.Schust.

Southbyaceae Váňa, Crand.-Stotl., Stotler & D.G.Long

- *Southbya nigrella* (De Not.) Henriq.
- *Southbya tophacea* (Spruce) Spruce

Lophocoleaceae Vanden Berghen

- *Chiloscyphus polyanthos* (L.) Corda
- *Plagiochila porelloides* (Torr. ex Nees) Lindenb.

Porellales Schljakov

Frullaniaceae Lorch

- *Frullania dilatata* (L.) Dumort.

Porellaceae Cavers

- *Porella arboris-vitae* (With.) Grolle
- *Porella baueri* (Schiffn.) C.E.O.Jensen
- *Porella cordaeana* (Huebener) Moore
- *Porella obtusata* (Taylor) Trevis.
- *Porella pinnata* L.
- *Porella platyphylla* (L.) Pfeiff.

Radulaceae Müll.Frib.

- *Radula complanata* (L.) Dumort.

Metzgeriales Chalaud

Aneuraceae H.Klinggr.

- *Aneura pinguis* (L.) Dumort.
- *Riccardia chamedryfolia* (With.) Grolle

Metzgeriaceae H.Klinggr.

- *Metzgeria conjugata* Lindb.
- *Metzgeria furcata* (L.) Corda

Fossombroniaceae Hazsl.

- *Fossombronia angulosa* (Dicks.) Raddi
- *Fossombronia caespitiformis* (Raddi) De Not. ex Rabenh.
- *Fossombronia pusilla* (L.) Nees

Petalophyllaceae Stotler & Crand.-Stotl.

- *Petalophyllum ralfsii* (Wilson) Nees & Gottsche

Pelliales He-Nygrén

Pelliaceae H.Klinggr.

- *Apopellia endiviifolia* (Dicks.) Nebel & D.Quandt
- *Pellia epiphylla* (L.) Corda

MARCHANTIOPSIDA

Lunulariales H.Klinggr.

Lunulariaceae H.Klinggr.

- *Lunularia cruciata* (L.) Dumort. ex Lindb.

Marchantiales Limpr.

Aytoniaceae Cavers

- *Mannia androgyna* (L.) A. Evans
- *Plagiochasma rupestre* (J.R. Forst. & G. Forst.) Steph.
- *Reboulia hemisphaerica* (L.) Raddi

Conocephalaceae Müll.Frib. ex Grolle

- *Conocephalum conicum* (L.) Dumort.

Corsiniaceae Engl.

- *Corsinia coriandrina* (Spreng.) Lindb.

Marchantiaceae Lindl.

- *Marchantia polymorpha* L. subsp. *polymorpha*
- *Marchantia polymorpha* L. subsp. *montivagans* Bischl. & Boisselier
- *Marchantia quadrata* Scop.

Oxymitraceae Müll.Frib. ex Grolle

- *Oxymitra incrassata* (Brot.) Sérgio & Sim-Sim

Ricciaceae Rchb.

- *Riccia ciliata* Hoffm.
- *Riccia glauca* L.
- *Riccia rhenana* Lorb. ex Müll.Frib.
- *Riccia sorocarpa* Bisch.

Sphaerocarpaceae Heeg

- *Sphaerocarpos texanus* Austin

Targioniaceae Dumort.

- *Targionia hypophylla* L.
- *Targionia lorbeeriana* Müll.Frib.

4.Discussion and Conclusion

As a result of the fieldwork conducted, 28 liverwort species belonging to 16 different families within the Marchantiophyta division were identified from the 250 collected samples. Twelve of these species are new records for Denizli Province. The families with the highest number of species are Porellaceae with four species, Ricciaceae and Fossombroniaceae, each with three species. Based on studies conducted from the 1960s to the 2010s. the number of liverwort species recorded for Denizli Province, which was previously 35 has been updated to 48 with the addition of new data. Of the identified species, 24 are in thalloid form, 4 are in transitional forms and 16 are in leafy form. When evaluated on a national scale, the number of recorded species represents nearly a quarter of the total, indicating not only the richness of the study area in terms of flowering plants but also its considerable diversity in non-flowering plants. The results were compared with previously published floras of nearby provinces and regions as shown in Table 2 (Gökler & et al., 2022; Gökler, 2017; Özenoğlu, 2001).

Table 2. Comparison Ratios of Other Flora Studies Conducted in the Regions Close to the Study Area and the Number of Species in the Families.

ARTICLE / THESIS TITLE	**A Look at Denizli Province Liverworts (Marchantiophyta) from Past to Present**		**Liverwort (Marchantiophyta) Flora of the Sultan Mountains**		**Contributions to the flora of liverworts in Uşak**		**Investigation of Liverwort (Hepaticae) Flora of Southwestern Anatolia Region (C11)**	
Total Number of Taxa	44		22		19		29	
Families	Tk. S.	%	Tk. S.	%	Tk. S.	%	Tk. S.	%
Sphaerocarpaceae	1	2,2	-	-	-	-	2	6,88
Targioniaceae	2	4,4	1	4,54	1	5,26	-	-
Aytoniaceae	3	6,6	2	9,09	2	10,52	2	6,88
Conocephalaceae	1	2,2	1	4,54	1	5,26	1	3,44
Lunulariaceae	1	2,2	1	4,54	1	5,26	1	3,44
Corsiniaceae	1	2,2	-	-	-	-	1	3,44
Oxymitraceae	1	2,2	-	-	-	-	1	3,44
Ricciaceae	4	4,4	-	-	-	-	7	24,08
Marchantiaceae	3	6,6	1	4,54	-	-	-	-
Metzgeriaceae	2	4,4	2	9,09	2	10,52	-	-
Pelliaceae	2	4,4	1	4,54	2	10,52	1	3,44
Lophoziaceae	-	-	3	13,63	-	-	2	6,88
Jungermanniaceae	1	4,4	-	-	-	-	2	6,88
Arnelliaceae	-	-	-	-	-	-	1	3,44
Cepholoziellaceae	3	6,6	-	-	-	-	1	3,44
Fossombroniaceae	3	8,8	-	-	1	5,26	3	10,32
Lophocoleaceae	2	4,4	-	-	2	10,52	-	-
Anastrophyllaceae	-	-	-	-	-	-	-	-
Scapaniaceae	-	-	2	9,09	1	5,26	-	-
Radulaceae	1	2,2	2	9,09	1	5,26	1	3,44
Porellaceae	6	6,6	2	9,09	3	15,78	1	3,44
Frullaniaceae	1	2,2	1	4,54	1	5,26	1	3,44
Lejeuneaceae	-	-	1	4,54	1	5,26	1	3,44
Solenostomataceae	1	4,4	-	-	-	-	-	-
Southbyaceae	2	4,4	-	-	-	-	-	-
Aneuraceae	2	4,4	-	-	-	-	-	-
Petalophyllaceae	1	2,2	-	-	-	-	-	-
Geocalycaceae	-	-	1	4,54	-	-	-	-
Gymnomitriaceae	-	-	1	4,54	-	-	-	-

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CHAPTER III

The Physiological Effects of Pesticides and Their Residues on Edible Plants

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1. Introduction

Pesticides are natural or synthetic chemicals that save cultivated plants from pests, diseases or weeds. Herbicides, insecticides and fungicides are the most important elements of pesticides (Sharma et al.,2019). In fruit production %78 yield loss was declared, %54 vegetable production and %32 cereal production without using pesticides in agricultural activities. On the other hand, pesticides negatively affect non-target organisms in the ecosystem (Tudi et al.,2021). In the 20th century, using pesticides in agricultural activities to feed the rising human population has brought about many environmental problems, mainly soil pollution (Altıkat et al., 2009).

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According to the FAO (2022), the average pesticide usage was 2.69 kg/ha worldwide. China, the USA, and Brazil were in the top three, and Turkey took 13th place. The Agriculture and Forestry Ministry declared 53672 tonnes of pesticide consumption in Turkey in 2020. Antalya was the first city that used pesticides mostly, and Manisa, Adana, Mersin and Bursa followed this. At the regional level, the most pesticide usage was detected in the Mediterranean Region, which is the centre of agricultural activities. In the World, herbicides, fungicides-bactericides, and insecticides are the first three used pesticides, respectively, while in Turkey %38 fungicides, %25 herbicides and %23 insecticides were used (Özercan & Taşçı, 2022).

Pesticides decrease the yield losses induced by diseases and pests in agricultural activities; conversely, they have many negative effects. It is estimated that every year, at least 5000 humans die and 500000 get poisoned because of pesticides, and the people affected by pesticides are mainly agricultural labourers. Pesticides sprayed on fruits and vegetables filter and pollute the soil and underground waters and also contaminate the air. They may kill target pests with their natural enemies and other pollinator organisms (Yadav & Devi, 2017).

Pesticides were classified by WHO (2009) for their toxic effects on human health. These are: Class 1a- Extremely hazardous (Parathion, Dieldrin); Class 1b- Highly hazardous (Eldrin, Dichlorvos); Class 2- Moderately hazardous (DDT and Chlordane); Class 3- Slightly hazardous (Malathion) and Class 4-Unlikely to present acute hazard in regular use (Carbetamide and Cycloprothrin), (Yadav & Devi, 2017).

The pesticides applied on fruit or leaf surfaces may be washed by rain, evaporated, decayed by microorganisms, photolysed, or carried to the plant inside. The most effective way of pesticide loss was declared as evaporation (Keikotlhaile& Spanoghe, 2011). Pesticide degradation occurs through two primary pathways: biotic and abiotic. The biotic way involves the activity of microorganisms, such as bacteria, fungi, and other microbes, which degrade pesticides through mineralisation. Additionally, plants contribute to the degradation process through cometabolism, leading to the formation of metabolites that are generally more water-soluble and less toxic than the original pesticide. On the other hand, the abiotic way includes chemical and physical degradation mechanisms. Chemical degradation involves oxidation, reduction, and hydrolysis processes, while physical degradation occurs through volatilisation and photolysis. These processes collectively help reduce pesticide residues in the environment (Yiğit & Velioğlu, 2020)

Some pesticides are applied to plants at the vegetative stage, some at the fruit stage, and some after harvest. Pesticide experts think the residues on fruits and vegetables are higher than guide values. The pesticide contents of fruits and vegetables depend on their applied value and the characteristics of the soil and drainage water (Donkor et al.,2016).

This study aimed to present the physiological effects of pesticides and their residues on edible plants at different stages.

2. The Effects of the Pesticides on Plants at Different Stages

2.1. The Effects of the Pesticides on Germination Stage

Although pesticides applied at low concentrations do not ultimately affect germination, they can cause delays. This situation makes us think the effects of pesticides on crop plants were more at the early stages (Shakir et al.,2016). In the germination stage, the macromolecules in the seed are digested and break into their monomers. Acetamiprid application on pea seeds decreased amino acid content, and the negative effect of the pesticide was associated with this decrease at germination (Lin et al.,2023). In addition to these, it was stated that pesticide usage pressed amylase activity in monocotyledons and affected seed respiration in dicotyledons (Calvelo Pereira et al., 2010; Somtrakoon & Pratumma, 2012). Metconazole stereoisomers and their mixture reduced the germination rate in wheat seedlings (Deng et al.,2021). This reduction was explained because of the degradation of gene expression of gibberellin and abscisic acid signal transduction pathway by pesticides. The germination was restrained in cucumber and maize plants that applied paraquat, glyphosate, glufosinate ammonium herbicides (Wibawa et al.,2009); in mung bean seedlings applied Bayleton and Topsin-M fungicides (Siddiqui & Ahmed,1996); in pearl millet applied fungicide and insecticide (Siddiqui et al.,1999; Parween et al.,2015).

2.2. The Effects of the Pesticides on Vegetative Stage

Pesticide usage has many adverse effects on non-target crop plants at the growth stage after germination, too. Growth inhibition is one of the fundamental effects of these. Excessive accumulation of pesticides destroys the roots, humpers water transfer, causes deficiency of nutrient elements and reduces growth (Liu et al.,2021). This was explained as the functional groups of pesticides damage the plant-soil-water relation (Siddiqui & Ahmed, 2006; Misra & Mani, 1994; Shakir et al.,2016).

Different paraquat herbicide concentrations were applied on wild and cultivated forms of wheat seedlings and decreased chlorophyll a+b and carotenoid content (Ekmekçi & Terzioğlu, 2005). In parallel, these results of photosystem-2 quantum efficiency and electron transfer rate were reduced by pesticide. Interruption of photosynthesis, the first step of the important mechanisms that ensure plant growth and development, can be shown as a reason for growth retardation.

Pesticide applications cause reactive oxygen species formation and oxidative stress. Oxidative stress destroys chlorophyll and protein structure and decreases photosynthesis. Later chlorosis, necrosis, growth inhibition, curling and burns occur in the leaves (Sharma et al., 2019). The Emamectin benzoate, Alpha-cypermethrin, and Imidacloprid pesticides produced reactive oxygen species, caused membrane damage, and affected cell viability in tomato seedlings. Also, soluble sugar and protein contents decreased while antioxidants increased by pesticides (Shakir et al.,2018). The enzymatic of these antioxidants are superoxide dismutase, catalase, ascorbate peroxidase, and glutathione reductase, while the non-enzymatic ones are phenylpropanoids, carotenoids, glutathione, and proline. These compounds remove the reactive oxygen species by inactivating or detoxifying (Mahapatra et al.,2019).

Pesticides have hazardous effects on cell genomes, too. Abamectin had genotoxicity on onion plants. This genotoxicity caused abnormalities of chromosomes, such as micronucleus, fragment, and sticky chromosomes, unequal distribution of chromatin, vacuole and nucleus damage, and multipolar anaphase stage (Kalefetoğlu Macar, 2021). Pesticides also affect the xenobiotic mechanisms that play a role in deactivating toxic materials at the cellular level (Ahammed et al.,2012; Shahzad et al.,2018).

Stomata, which have an essential role in plant water metabolism, are affected by pesticides; Polychlorinated Biphenyl and Imidacloprid suppressed stoma conductivity, according to Ahammed et al.,2012. It was also declared that Terbutryn decreases carbon dioxide assimilation (Piñol & Simon, 2009; Shahzad et al.,2018).

2.3. The Effects of the Pesticides on Flowering Stage

Pesticides delay flowering and reduce production even in low concentrations (Carpenter et al.,2020). Londo et al. (2014) indicate that glyphosate postponed flowering and affected the plant reproduction of *Brassica* sp. Also, Dicamba and diflufenzopyr decreased soybean yield (Standberg et al., 2020).

Pesticides negatively affect pollens that carry male reproduction cells (Larrival et al.,1996). Pesticides inhibit pollen germination and pollen tube formation. (Sawidish et al.,1997). Topdemir and Gür (2012) applied different concentrations of Chorus ve Dodine to cherry and apricot pollens and found that the pesticides significantly inhibited pollen germination and tube formation.

Pesticide application at the flowering stage also harms bees' lives (Yıldız et al.,2005). Zioga et al. (2023) applied different pesticide mixtures to canola plants and determined that remnants in pollens and nectars belong to these pesticides. The researchers indicated that Azoxystrobin, Boscalid, and Clothianidin from fungicides and Clothianidin from insecticides had the highest remnant contents and were dangerous for pollinator insects among these pesticides.

The flowering stage is crucial for species maintainability. For this reason, plants develop adaptations against biotic and abiotic stress factors during the flowering stage. They induce histone and DNA methylation, change gene expression, and regulate RNA methylation, mRNA stability, and antioxidant mechanisms to increase stress tolerance (Shi et al.,2022).

2.4.The Effects of the Pesticides on Fruit and Seed Formation

Pesticides negatively affect fruit formation in cultivated plants; the first of these effects is the low number of fruits. Hatamleh et al. (2022) recorded that flower and fruit quality decreased; fruit numbers, size, fresh weight, and biomass were reduced in pesticide-applied tomato plants. It has been suggested that these declines in plant qualitative and quantitative properties may be due to the disruption of metabolic pathways at the cellular level due to the uptake of pesticides into the plant body, the decrease in turgor that provides cell elongation, and the change in the content of components such as proteins, enzymes, and nucleic acids caused by reactive oxygen species.

In another study done with pesticide-applied tomatoes, Metalaxyl was declared to reduce mesocarp and fruit thickness (Özturk et al., 2006). Cuticula, endocarp, and exocarp were broken into pieces in the fruit transverse section. This deterioration in mesocarp, which has a role in starch storage, was declared to cause a reduction in fruit quality.

Seed formation is also the last generative stage suppressed by pesticides. Methamidophos (an insecticide) decreased seed number in legumes, seed weight, and yield of mung beans (Khan et al., 2006).

3. Pesticide Residues in Fruits and Vegetables

Although pesticides are degraded in various ways after being taken into the plant, as mentioned in previous sections, they can cause different physiological and morphological damages in all plant life stages. Moreover, they can accumulate as residues in fruits and leaves consumed as food. The intake of these residues through the food chain creates a food safety problem that threatens human health. Bakırcı et al. (2014) researched the pesticide residues of 1423 fruits and vegetables harvested from the Aegean region. According to the results, pomegranate, cauliflower, and kale samples did not contain pesticide residues; 745 samples contained MRL (maximum residue limit) value or lower than it; %8.4 of fruit samples and %9.8 of the vegetables contained higher than MRL value. In the same research, rocket, cucumber, lemon, and grapes samples' residue values were found to be higher than MRL, while apricot, carrot, kiwifruit, and leek samples contained lower than MRL. Acetamiprid, Chlorpyrifos and Carbendazim pesticides were reported to be the most detected pesticides among others.

Similarly to the upper study, Kaya and Tuna (2019) analysed the pesticide residue content of the fruit and vegetables they bought from the bazaar. They found Boscalid and Dimethomorph fungicide contents of grape leaves at very high levels and Myclobutanil and Penconazole contents close to MRL. The high quantity of these levels was correlated with the harvest time before the pesticide half-life. Fenvalarate ve Esfenvalarate insecticides in orange, Chlorpyrifos, Cypermethrin, and Pyriproxyfen in lemon were found to be high levels. Also, fenvalerate and fenvalerate values were close to MRL in lemons. The 35 of the analysed 42 samples have no residue higher than MRL.

Hepsağ (2019) analysed the pesticide residue content of tomato samples collected from 30 different farmers. As a result, no residue was determined in 74% of the samples, and 26% of the samples that contained residue had a significantly lower value than MRL.

3.1. The Analysis of Pesticide Residues in Food

Four main procedures are necessary for determining the pesticides on fruits and vegetables: The preparation of the samples, separation, detection and data analysis. For preparing and separating the samples, Liquid-liquid extraction (LLE), Solid phase extraction (SPE), Solid phase microextraction (SPME), Matrix solid-phase dispersion (MSPD), and Quick, easy, cheap, effective, rugged, and safe method (QuEChERS) methods are used. For the detection of pesticides and data analysis, GC (gas chromatography), LC (Liquid chromatography), enzyme-linked immunosorbent assay (ELISA) and capillary electrophoresis (CE) methods are used basically (Narenderan et al.,2020).

4. Conclusion

Although pesticides (especially fungicides, herbicides, and insecticides) used for plant protection aim to fight pests and diseases, they cause many problems. In addition to their environmental damage, they can reduce and delay all life stages of non-target crop plants. Pesticide residues remaining intact on cultivated plants threaten food safety and human health throughout the food chain.

The suggestions below could be presented to minimise pesticide harm:

- Promote the use of non-pesticide control methods, such as cultural practices, physical controls, biological controls, and biotechnical methods.

- Increase awareness among agricultural workers, who are the most exposed to pesticides, about safe use practices.
- Ensure that pesticide commerce is strictly regulated and monitored by authorised institutions.
- Allow sufficient time for pesticides to degrade and complete their half-life between application and harvest.
- Educate consumers on the importance of Maximum Residue Limits (MRLs) to ensure safe consumption of agricultural products.

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CHAPTER IV

Contributions to the Liverwort (Marchantiophyta) Flora of Eskisehir Province

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1.Introduction

Eskişehir is located in the northwest of the Central Anatolian Region. The general climate of the province is continental, and it is under the influence of the Iran-Turan floristic region. One of the most important factors affecting the region's species diversity is its unique cli[8]matology, resulting from the convergence of the Western Black Sea, Mediterranean, and Central Anatolian climates. According to the region's thermal regime diagram, the annual average temperature is 10.8°C and the average annual precipitation is 373.8 mm (Aktaş & Erkuş, 2009). The significant mountains in Eskişehir province are in order: Türkmendağı (1833 m), Eryiğit Dağı

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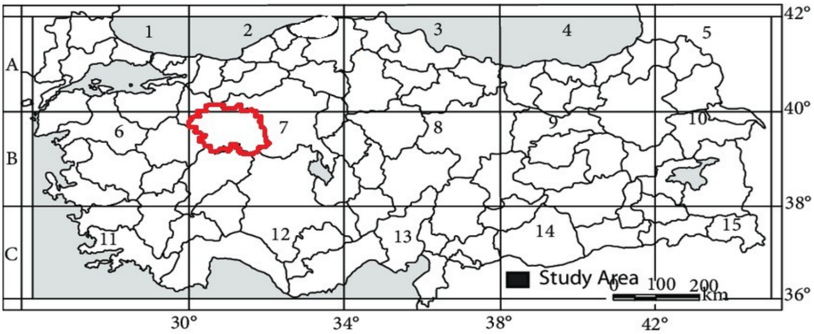
(1822 m), Uzanyatak Tepesi (1790 m), Göktepe (1778 m), Sivrihisar Dağı (1766 m), Sündiken Tepesi (1764 m), Gök Tepe (1749 m) and Düzçam Tepesi (1719 m) (Gözler et al., 2017). The forest composition in terms of high-altitude plants is as follows: 78% black pine, 9% yellow pine and 6% red pine. The remaining areas represent swamp and include examples of oak species (Ocak & et al., 2008)

The study area is located in grid B7 according to the Henderson (1961) Grid System. Recent studies have classified terrestrial non-flowering plants into four groups: Anthocerotophyta, Marchantiophyta, Bryophyta and Pteridophyta. The number of identified species in the liverwort taxon is approximately 5.000 worldwide. In Turkey, this number was recorded as 215 species by foreign researchers up until the 1960s. and later by local researchers (Kürschner & Erdağ, 2020).

In bryophyte studies conducted in Eskişehir province after foreign researchers, liverwort specimens were also included in the publications by İsa Gökler (1990), Ersin Yücel & Tülay Ezer (2018). The forested areas of the region, along with the shaded areas and the edges of water bodies scattered throughout the area, provide suitable habitats for liverworts.

The aim of this study is to assess the liverwort biodiversity of the region which has not been thoroughly studied and supported by fieldwork due to the lack of detailed investigations on liverworts in grid B7 and Eskişehir province.

Figure 1. Location of Eskişehir province according to Henderson (1961) quadrature system



2.Material and Method

Fieldwork was conducted between 2021 and 2024 in grid B7 (Henderson, 1961). The samples were collected during the most active reproductive months, November and April. Additionally, multiple photographs were taken in the field to ensure better visibility of the basic structures of the specimens for identification. During fieldwork, digging tools were used to collect thalloid samples from the soil while forceps were used for collecting epiphytic leafy specimens. Each collected specimen was labeled with the GPS coordinates of the site and sociological tags relevant to the area to distinguish them from other samples. The samples were transported to the laboratory in sealed bags under cold conditions. Special care was taken to prevent structural damage to thalloid samples. Leafy specimens were placed on newspapers and dried through air circulation before identification (Yücel & et al., 2024). To determine the distribution patterns in the world and in Turkey according to the Henderson Turkey Grid System (Henderson, 1961) as well as to obtain identification characteristics, the key flora books of European countries and various floristic publications were consulted, including Watson (1981), Smith (1996), Paton (1999), Atherton et al. (2010), Kürschner & Erdağ (2020) and Glime (2009). The plant list was organized according to the system developed by Hodgetts et al. (2020). All specimens are preserved at the Fauna and Flora Research and Application Center of Dokuz Eylül University where the identification work was carried out. The collected data were compared with previous studies conducted in nearby provinces and regions and are presented in Table 2.

Figure 2. Map representation of the samples collected during the field study (© earth.google.com)

Table 1 - Stations where fieldwork was carried out

NO	PROVINCE	GPS	DATE	ALTITUDE (m)
KME1	ESKİŞEHİR	39°38'14.77"K 30°16'44.14"D	16.10.2022	914
KME2	ESKİŞEHİR	39°37'15.32"K 30°16'39.52"D	23.10.2022	916
KME3	ESKİŞEHİR	39°38'58.66"K 30°18'21.89"D	18.10.2022	895
KME4	ESKİŞEHİR	39°38'18.80"K 30°15'32.02"D	21.10.2022	891
KME5	ESKİŞEHİR	39°30'41.50"K 30°25'45.14"D	18.03.2023	1016

KME6	ESKİŞEHİR	39°34'22.02"K 30°26'44.92"D	18.03.2023	905
KME7	ESKİŞEHİR	39°18'52.90"K 30°24'53.11"D	10.11.2021	1385
KME8	ESKİŞEHİR	39° 6'35.95"K 30°38'10.77"D	10.11.2021	1366
KME9	ESKİŞEHİR	39°16'51.98"K 31°11'39.30"D	08.04.2024	865
KME10	ESKİŞEHİR	39°10'51.24"K 31°40'15.19"D	08.04.2024	826
KME11	ESKİŞEHİR	39° 7'27.10"K 31°34'47.24"D	10.04.2024	885
KME12	ESKİŞEHİR	39° 8'21.82"K 31°46'35.28"D	09.04.2024	821
KME13	ESKİŞEHİR	40° 2'39.04"K 31° 6'57.57"D	01.05.2023	514
KME14	ESKİŞEHİR	40° 0'56.13"K 30°57'21.96"D	02.05.2023	305
KME15	ESKİŞEHİR	40° 0'33.50"K 31°29'49.08"D	01.05.2023	536
KME16	ESKİŞEHİR	39°44'7.77"K 30°30'46.48"D	18.03.2023	848

Table 2. Comparison Ratios of Other Flora Studies Conducted in the Regions Close to the Study Area and the Number of Species in the Families.

ARTICLE / THESIS TITLE	Contributions to the Liverwort (Marchantiophyta) Flora of Eskisehir Province		Liverwort (Marchantiophyta) Flora of the Sultan Mountains		Contributions to the flora of liverworts in Kütahya Province (2017)	
Total Number of Taxa	32		22		24	
Families	Tk. S.	%	Tk. S.	%	Tk. S.	%
Sphaerocarpaceae	-	-	-	-	-	-
Targioniaceae	1	3,125	1	4,54	1	4,16
Aytoniaceae	2	6,25	2	9,09	2	8,32
Conocephalaceae	1	3,125	1	4,54	1	4,16
Lunulariaceae	1	3,125	1	4,54	1	4,16
Corsiniaceae	-	-	-	-	-	-
Oxymitraceae	-	-	-	-	-	-
Ricciaceae	-	-	-	-	-	-
Marchantiaceae	1	3,125	1	4,54	1	4,16
Metzgeriaceae	2	6,25	2	9,09	2	8,32
Pelliaceae	2	6,25	1	4,54	1	4,16
Lophoziaceae	-	-	3	13,63	1	4,16
Jungermanniaceae	2	6,25	-	-	-	-
Arnelliaceae	-	-	-	-	-	-
Cepholoziellaceae	5	15,625	-	-	-	-
Fossombroniaceae	2	6,25	-	-	1	4,16
Lophocoleaceae	4	12,5	-	-	-	-
Anastrophyllaceae	-	-	-	-	-	-
Scapaniaceae	1	3,125	2	9,09	2	8,32
Radulaceae	1	3,125	2	9,09	2	8,32
Porellaceae	2	6,25	2	9,09	3	12,48
Frullaniaceae	2	6,25	1	4,54	1	4,16
Lejeuneaceae	2	6,25	1	4,54	1	4,16
Solenostomataceae	-	-	-	-	-	-
Southbyaceae	-	-	-	-	-	-
Aneuraceae	-	-	-	-	-	-
Petalophyllaceae	-	-	-	-	-	-
Geocalycaceae	-	-	1	4,54	3	12,48
Gymnomitriaceae	-	-	1	4,54	1	4,16
Calypogeiaceae	1	3,125	-	-	-	-

3.Results

MARCHANTIOPHYTA

JUNGERMANNIOPSIDA

Jungermanniales H.Klinggr.

Cephaloziellaceae Douin

- *Cephaloziella baumgartneri* Schiffn.
- *Cephaloziella divaricata* (Sm.) Schiffn.
- *Cephaloziella hampeana* (Nees) Schiffn. ex Loeske
- *Cephaloziella rubella* (Nees) Warnst.
- *Cephaloziella stellulifera* (Taylor ex Spruce) Schiffn.

Scapaniaceae Mig.

- *Scapania undulata* (L.) Dumort.

Calypogeiaceae Arnell

- *Calypogeia fissa* (L.) Raddi

Jungermanniaceae Rchb.

- *Jungermannia atrovirens* Dumort.
- *Mesoptychia turbinata* (Raddi) L.Söderstr. & Váňa

Lophocoleaceae Vanden Berghen

- *Chiloscyphus polyanthos* (L.) Corda
- *Lophocolea bidentata* (L.) Dumort.
- *Lophocolea heterophylla* (Schrad.) Dumort.
- *Plagiochila porelloides* (Torr. ex Nees) Lindenb.

Porellales Schljakov

Frullaniaceae Lorch

- *Frullania dilatata* (L.) Dumort.
- *Frullania tamarisci* (L.) Dumort.

Lejeuneaceae Cavers

- *Lejeunea cavifolia* (Ehrh.) Lindb.
- *Lejeunea lamacerina* (Steph.) Schiffn.

Porellaceae Cavers

- *Porella baueri* (Schiffn.) C.E.O.Jensen
- *Porella cordaeana* (Huebener) Moore

Radulaceae Müll.Frib.

- *Radula complanata* (L.) Dumort.

Metzgeriales Chalaud

Metzgeriaceae H.Klinggr.

- *Metzgeria conjugata* Lindb.
- *Metzgeria furcata* (L.) Corda

Fossombroniaceae Hazsl.

- *Fossombronia angulosa (Dicks.) Raddi*
- *Fossombronia pusilla* (L.) Nees

Pelliales He-Nygrén

Pelliaceae H.Klinggr.

- *Apopellia endiviifolia* (Dicks.) Nebel & D.Quandt
- *Pellia epiphylla* (L.) Corda

MARCHANTIOPSIDA

Lunulariales H.Klinggr.

Lunulariaceae H.Klinggr.

- *Lunularia cruciata* (L.) Dumort. ex Lindb.

Marchantiales Limpr.

Aytoniaceae Cavers

- *Plagiochasma rupestre* (J.R. Forst. & G. Forst.) Steph.
- *Reboulia hemisphaerica* (L.) Raddi

Conocephalaceae Müll.Frib. ex Grolle

- *Conocephalum conicum* (L.) Dumort.

Marchantiaceae Lindl.

- *Marchantia polymorpha* L.

Targioniaceae Dumort.

Targionia hypophylla L.

4.Discussion and Conclusion

As a result of the fieldwork, 198 plant samples were collected and identified, leading to the identification of 26 liverwort species belonging to 14 different families within the Marchantiophyta division. Of these, 9 species were recorded in thalloid form, 2 in transitional form and 15 in leafy form. Ten species are new records for grid B7 and 26 species are new records for Eskişehir. The families with the highest number of species are Cepholoziellaceae with 5 species and Lophocoleaceae with 4 species. Prior to the fieldwork, such a high diversity of liverworts was not anticipated for Eskişehir, a region dominated by a continental climate. However the unique climatology resulting from the coexistence of Western Black Sea, Mediterranean and Central Anatolian climates has proven to be a significant factor in the observed diversity. Additionally the relatively low number of previous studies in this region has positively influenced the diversity of species records. Given that the biodiversity richness of the area is highlighted in this study, it is clear that project-supported research should be conducted on the oak communities formed by the swamp in the inner parts of Eskişehir as well as on Riccia species and certain epiphytic liverworts.

Calypogeia fissa (L.) Raddi, Cephaloziella hampeana (Nees) Schiffn. ex Loeske, Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort, Conocephalum conicum (L.) Dumort, Fossombronia pusilla (L.) Nees, Fossombronia angulosa (Dicks.) Raddi, Frullania dilatata (L.) Dumort, Frullania tamarisci (L.) Dumort, Jungermannia atrovirens Dumort., Lejeunea lamacerina (Steph.) Schiffn. species are new records for square B7.

Mesoptychia turbinata (Raddi) L.Söderstr. & Váňa, Lejeunea cavifolia (Ehrh.) Lindb., Lophocolea bidentata (L.) Dumort., Lophocolea heterophylla (Schrad.) Dumort., Lunularia cruciata (L.) Dumort. ex Lindb,Marchantia polymorpha L., Metzgeria conjugata Lindb., Metzgeria furcata (L.) Corda, Apopellia endiviifolia (Dicks.) Nebel & D.Quandt, Plagiochasma rupestre (J.R. Forst. & G. Forst.) Steph, Plagiochila porelloides (Torr. ex Nees) Lindenb., Porella baueri (Schiffn.) C.E.O.Jensen, Porella cordaeana (Huebener) Moore, Reboulia hemisphaerica (L.) Raddi, Scapania undulata (L.) Dumort., Targionia hypophylla L. are new records for Eskişehir province.

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CHAPTER V

Evaluation of Plant Diversity and Floristic Composition in a *Q. cerris* var. *cerris* Forest Depending on Disturbance

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Hamdi G. KUTBAY[2]

1. Introduction

Biodiversity may be decribed as the total of different genes, species and ecosystems in a region. The most common definition of the biodiversity refers to number of different species in a given area, in a word species diversity (Khera et al., 2001; Jones and Laughlin 2009).

Human disturbance cause obvious changes in canopy structure, light intensity, temperature, humidity, and soil properties (Collings and Pickett, 1987) and these changes finally determine plant diversity of an area (Roberts et al.,1998). The human effects on biodiversity and ecosystem functioning are in form of changes in resource use, increased frequency and proliferation of biotic invasions, decrease in number of species, creation of stresses and may be a potential for changes in the climate system (Singh et al., 2011). Many species are eliminated from areas dominated by human activities and species stand up to disturbance constitute the vegetation (Chapin et al., 2000; Kumar and Ram 2005). The effect of disturbance on plant diversity may be positive or negative. The direction of effect is absolutely depends on the intensity of disturbance.

Only a few decades ago, disturbance was explained as extraordinary events, unnatural differences from the normal successional development of equilibrium communities. While low or intermediate disturbance may enable other plants to grow by decreasing the number of indivuduals of dominant species, intensive disturbance may leads to destruction of some species in ecosystems. Additionally, Chase (2005) explained that anthropogenic disturbance usually leads to the extinction of sensitive species, thus making disturbed regions more susceptible to the colonisation of opportunistic species.

The human-caused disturbances substantially affect the species diversity and structural characteristics of a community. According to Mishra et al., (2004) floristic composition is one of the major distinguishing characters of a community, and therefore, any depletion of biodiversity is bound to alter the community attributes.

The objective of the study was to determine the effects of human-based disturbance on plant diversity and composition in a Quercus cerris var. cerris forest.

Oak (*Quercus* L.), a genus under the family Fagaceae, is a large group of hardwood trees with about 600 species. *Quercus* species are wide spread trees in the worldwide and densely distributed in the northern temperate zone, subtropical and tropical Asia, and the Andes of South America (Shrestha, 2003).

Oaks are also one of the most important deciduous tree species in Northern Turkey (Kutbay et al., 1999). Mediterranean woodlands occupy wide extensions in Mediterranean basin and harboring critical biodiversity components, contributing to basic ecological functions and supporting profitable goods and services (Zavala and Zea, 2004).

Determining the effects of human-based disturbance is also important for estimating threat status and planning the conservation strategies of ecosystems.

2. Materials and Methods

The study area was in a Turkey oak (*Quercus cerris* L. var. *cerris*) forest in Samsun, Northern Turkey. In this region, *Q. cerris* var. *cerris* forests are very common and cover a large area. Two permanent plots were chosen to examine the effects of disturbance. Disturbance factor was management of forest by lumbering and harvesting in the study area.

Plot 1 (20 ha) was selected from the site (highly-disturbed) disturbed by lumbering some of the trees and harvesting all plants of herb and shrub levels of the woodland two years ago. Plot 2 (20 ha) was selected from an undisturbed site.

The canopy cover was 65% and 45% in undisturbed and disturbed sites, respectively. Field studies were carried out between March and August with respect to plants growing season. Plots were visited weekly and plant species were collected and their abundances were recorded as percentage cover.

Taxonomic nomenclature was determined according to Davis (1965-1985) and Davis et al. (1988). Brummitt and Powell (2003) was used to upload latin names of plant species. In order to define the effects of disturbance on tree, shrub and herb layers several diversity indices were calculated for these strata.

Shannon's diversity index was calculated as;

$$H' = -\sum_{i=1}^{R} p_i \ln p_i$$

where R is the number of species, Pi, (i = 1,…,s) is the proportional abundance of the ith species (abundance of i / total abundance).

We also estimated Berger-Parker Indice, where nmax number of individuals of the most abundant species within a plot and N number of total individuals.

$$d = nmax / N$$

Shannon's biological diversity and evenness, and Berger-Parker dominance were calculated by using a software programme (Mcaleece et al., 1997). Similarity of quadrats estimated according to Sørensen's similarity indices where w: total lowest scores of collective species that occur in both quadrats, a: total scores of species in one of the quadrats and b: total scores of species in the other quadrats.

$$\% \; Si = \quad (2w/a + b) \times 100$$

Family importance value (FIV) was calculated by summing the relative diversity (number of species in the family/total number of species × 100) and relative density of the individuals (Rasingam and Parthasarathy, 2009).

3. Results

At the end of the field study, 64 plant species were collected from the disturbed area and 52 plant species were collected from the undisturbed area (Table 1). SI% of plots was estimated as 76% and dissimilarity was estimated as 24%. Figure 1 indicates the number of species and cover (%) in comporison with tree, shrub and herb layer.

Tablo 1: Number of families, genera and species in disturbed area and undisturbed area

	Undisturbed Plot	Disturbed Plot
Families	26	29
Genera	44	57
Species	52	64

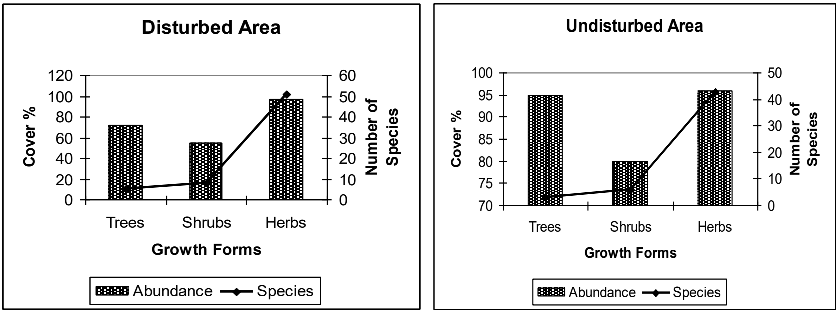

Figure 1. Number of species and cover (%) values according to growth forms in disturbed and undisturbed areas

Diversity indices were given in Table 2. Shannon's diversity indices of herb layer in both disturbed and undisturbed area were the highest compared to that of the other layers and they were calculated as 1.55 and 1.36 in disturbed and undisturbed area, respectively.

Shannon's diversity indices of shrub and herb layers in disturbed area were higher than that in undisturbed area. However, undisturbed area had a higher index value in tree layer. Evenness values generally followed the same trend, whereas undisturbed area had a higher evenness value in tree layer.

The dominance indice of Berger-Parker was higher in disturbed area in tree layer. However, the opposite trend was found in shrub and herb layers. In both plot, herbs were the most species-rich life-forms, trees and shrubs ranked next with 5 and 10 species, respectively. In other words, low diversity and low evenness were generally found in undisturbed area in shrub and herb layers (Tab. 2).

Tablo 2: Diversity indices in disturbed and undisturbed area

TREE LAYER	Disturbed area	Undisturbed area
Shannon H' Log Base 10,	0.34	0.35
Shannon Hmax Log Base 10,	0.69	0.48
Shannon J'	0.49	0.73
Berger-Parker Dominance (d)	0.77	0.63
Berger-Parker Dominance (d%)	76.39	63.16
SHRUB LAYER		
Shannon H' Log Base 10,	0.71	0.60
Shannon Hmax Log Base 10,	0.90	0.78
Shannon J'	0.79	0.76
Berger-Parker Dominance (d)	0.37	0.50
Berger-Parker Dominance (d%)	36.37	50.01
HERB LAYER		
Shannon H' Log Base 10,	1.55	1.37
Shannon Hmax Log Base 10,	1.71	1.63
Shannon J'	0.91	0.84
Berger-Parker Dominance (1/d)	9.75	5.65
Berger-Parker Dominance (d%)	10.26	17.71

The density and family importance values were the greatest for Poaceae in undisturbed area while Leguminosae has the highest density and family importance values in disturbed area (Table 3 and 4).

The most common Raunkiaer's life-form category was hemicryptophtes and the distribution of life forms were generally similar in both areas although some differences were exist for example, the number of chamaephytes in undisturbed area were higher than that of disturbed area (Figure 2).

Tablo 3: Family importance values (FIV) in undisturbed area

Family	Species	No of genus	No of species	FIV
Araliaceae	*Hedera helix*	1	1	1.93
Betulaceae	*Carpinus orientalis*	1	1	1.93
Boraginaceae	*Myosotis sicula* *Myosotis sparsiflora*	1	2	3.84
Campanulaceae	*Campanula glomerata*	1	1	1.93
Caryophyllaceae	*Holosteum umbellatum* *Stellaria holostea*	2	2	3.84
Compositae	*Carduus pycnocephalus* *Lapsana communis subsp. communis* *Sonchus oleraceus*	3	3	5.77
Crassulaceae	*Sedum pallidum var. bithynicum*	1	1	1.93
Euphorbiacea	*Euphorbia stricta*	1	1	1.93
Fagaceae	*Quercus cerris var. cerris* *Quercus petrea subsp. iberica*	1	2	3.84
Geraniaceae	*Geranium asphodeloides* *Geranium sanguineum*	1	2	3.84
Poaceae	*Brachypodium sylvaticum* *Cynosurus cristatus* *Dactylis glomerata* *Festuca heterophylla* *Phleum exaratum subsp. exaratum*	5	5	9.61
Guttiferae	*Hypericum perforatum*	1	1	1.93
Labiatae	*Ajuga reptans* *Prunella vulgaris*	2	2	3.84
Leguminosae	*Lathyrus inconspicuous*	3	4	7.69

	Lathyrus laxiflorus subsp. laxiflorus			
	Trifolium fragiferum			
	Vicia hirsute			
Liliaceae	*Ornihogalum sigmoideum*	2	2	3.84
	Ruscus acuelatus			
Oleaceae,	*Phillyrea latifolia*	1	1	1.93
Onagraceae	*Epilobium hirsutum*	1	1	1.93
Plantaginaceae	*Plantago lanceolata*	1	1	1.93
Primulaceae	*Cyclamen coum*	2	2	3.84
	Primula vulgaris			
Ranunculaceae	*Helleborus orientalis*	2	4	7.69
	Ranunculus constantinopolitanus			
	Ranunculus ficaria subsp. ficariiformis			
	Ranunculus sceleratus			
Rosaceae	*Crataegus monogyna subsp. monogyna*	4	4	7.69
	Geum urbanum			
	Rosa canina			
	Rubus discolour			
Rubiaceae	*Asperula arvensis*	2	3	5.77
	Galium aparine			
	Galium odoratum			
Scrophulariaceae	*Verbascum blattaria*	2	2	3.84
	Veronica pectinata var. pectinata			
Smilacaceae	*Smilax excels*	1	1	1.93
Umbelliferae	*Oeanthe pimpinelloides*	1	1	1.93
Violaceae	*Viola odorata*	1	2	3.84
	Viola siehana			

Table 4: Family importance values (FIV) in disturbed area

Familya	Tür	No of genus	No of species	FIV
Aceraceae	*Acer campestre*	1	1	1.56
Araliaceae	*Hedera helix*	1	1	1.56
Betulaceae	*Carpinus orientalis*	1	1	1.56
Boraginaceae	*Lithospermum purpurocaeruleum*	2	3	4.69
	Myosotis ramosissima			
	Myosotis sicula			
Campanulaceae	*Campanula glomerata*	1	1	1.56
Caryophyllaceae	*Silene dichotoma*	1	1	1.56
Compositae	*Anthemis cretica subsp. cretica*	4	4	6.25
	Circium pseudopersonata subsp. Pseudopersonata			
	Lapsana communis subsp. Communis			
	Tragopogon aureus			
Cornaceae	*Cornus sanguine*	1	1	1.56
Cyperaceae	*Carex divulsa subsp. divulsa*	1	1	1.56
Euphorbiacea	*Euphorbia stricta*	1	1	1.56
Fagaceae	*Quercus cerris var. cerris*	1	2	3.13
	Quercus petrea subsp. iberica			
Geraniaceae	*Geranium asphodeloides*	1	2	3.13

	Geranium sanguineum			
Poaceae	*Brachypodium sylvaticum*	5	5	7.81
	Dactylis glomerata			
	Festuca heterophylla			
	Holcus lanatus			
	Setaria glauca			
Guttiferae	*Hypericum perforatum*	1	1	1.56
Labiatae	*Ajuga reptans*	5	5	7.81
	Oryganum vulgare			
	Prunella vulgaris			
	Salvia forskahlei			
	Stachys annua subsp. Annua			
Leguminosae	*Coronilla varia*	6	9	14.06
	Hymenocarpus circinnatus			
	Lathyrus laxiflorus subsp. Laxiflorus			
	Medicago xvaria			
	Trifolium arvense			
	Trifolium physodes			
	Trifolium subterraneum			
	Vicia cracca			
	Vicia lutea			
Liliaceae	*Ornihogalum sigmoideum*	2	2	3.13
	Ruscus acuelatus			
Oleaceae,	*Fraxinus oxycarpa*	2	2	3.13
	Ligustrum vulgare			
Onagraceae	*Epilobium hirsutum*	1	1	1.56

Plantaginaceae	*Plantago lanceolata*	1	1	1.56
Primulaceae	*Cyclamen coum* *Primula vulgaris*	2	2	3.13
Ranunculaceae	*Clematis vitalba* *Helleborus orientalis* *Ranunculus constantinopolitanus*	3	3	4.69
Rosaceae	*Crataegus monogyna subsp. Monogyna* *Filipendula vulgaris* *Rosa canina*	3	3	4.69
Rubiaceae	*Asperula arvensis* *Asperula orientalis* *Galium aparine*	2	3	4.69
Scrophulariaceae	*Parentucellia latifolia subsp. Latifolia* *Scrophularia scopolii var. scopolii*	2	2	3.13
Smilacaceae	*Smilax excels*	1	1	1.56
Ulmaceae	*Ulmus glabra*	1	1	1.56
Umbelliferae	*Astrodaucus orientalis* *Chaerophylum byzantinum*	2	2	3.13
Violaceae	*Viola odorata* *Viola siehana*	2	2	3.13

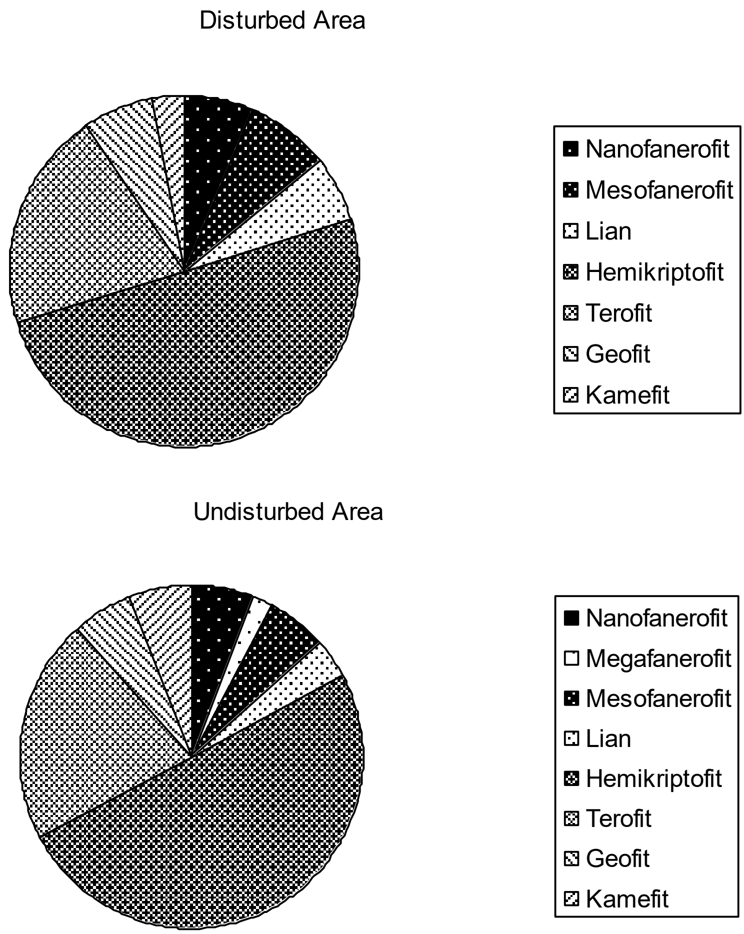

Figure 2. The distribution of Raunkiaer’s life-form categories in disturbed and undisturbed area (disturbed area).

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