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Research And Evaluations In Agriculture, Forestry **AND AQUACULTURE**

EDITORS
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CONTENTS

CHAPTER 1

HALYOMORPHA HALYS IN ALL DETAILS

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1. Introduction

In addition to increasing trade and transportation in the world, pest species have spread across continents and countries due to global climate change. Invasive species cause heavy economic losses worldwide by negatively affecting biodiversity, natural and agricultural ecosystems in a new ecosystem (Panizzi and Grazia, 2015). They can also act as disease vectors that negatively affect ecosystem function and human health (Crowl et al., 2008). Invasive alien species can establish high populations in a short period of time due to the absence of natural enemies in their countries of origin, finding new hosts and their high adaptability (Pimentel et al., 2000).

Brown marmorated stink bug [*Halyomorpha halys* (Stål, 1855) (Hemiptera: Pentatomidae)] is one of the best known invasive pests. Since its detection, it has spread rapidly to many countries of the world and continues to cause damage to hundreds of plant species.

Scientific name: *Halyomorpha halys* (Stål), 1855 (Hemiptera: Pentatomidae)

Other relevant scientific names: *Halyomorpha mista, H. brevis, H. remota*

Common name: Brown Marmorated Stink Bug (BMSB)

Synonyms: * *Pentatoma halys* Stål, * *Poecilometis mistus* Uhler, * *Cappaea halys* Stål, * *Dalpada brevis* Walker, * *Dalpada remota* Walker, * *Halyomorpha picus* Fabricius,* *Halyomorpha timorensis* Signoret, * *Halyomorpha brevis,* Hasegawa, * *Halyomorpha mista* Uhler

2. Origins and Distribution

Halyomorpha halys is native to China, Japan, Korea and Taiwan (Rider, 2006). This invasive species was first recorded in Pennsylvania (USA) in the mid-1990s (Hoebeke and Carter, 2003). It was determined that *H. halys* entered the country with products from China. In a very short time, it spread to 44 states of the USA and 4 regions of Canada (Hamilton, 2009; Nielsen et al., 2013). It attracted attention by damaging agricultural crops with an epidemic in the summer of 2010 in most of the Mid-Atlantic (Leskey et al., 2012a).

In Europe, it was first detected in Switzerland in 2004 (Haye et al., 2014). It was subsequently detected in many European and Asian countries, in Liechtenstein (Arnold, 2009), Germany (Heckmann, 2012) in 2011; Greece (Milonas and Partsinevelos, 2014), Italy and France (Callot and Brua, 2013) in 2012; Hungary (Vetek et al., 2014), Romania (Macavei et al., 2015), Serbia (Seat, 2015), Austria (Rabitsch and Friebe, 2015), Spain (Dioli et al., 2016), Russia (Mityushev, 2016), Bulgaria (Simov, 2016), Georgia and Russia (Gapon, 2016) in 2013; Croatia (Sapina and Jelaska, 2018), Turkey (Çerçi and Koçak, 2017) and Slovenia (Rot et al., 2018) in 2017 and Malta in 2018 (Tassini and Mifsud, 2019) (Figure 1).

As of 2023, *H. halys* was found in Albania, Austria, Belgium, Bulgaria, Canada, Chile, China, Corsica Island, Croatia, Czech Republic, France, Georgia, Germany, Greece, Guam, Hungary, Iceland, India, Italy, Liechtenstein, Japan, Kazakhstan, Korea North, Korea South, Macedonia, Malta, Myanmar, Nigeria, Norway, Poland, Romania, Russian Federation, Serbia, Spain, Slovakia, Slovenia, Sweden, Switzerland, Taiwan, Türkiye, Ukraine, United Kingdom, United States of America and Vietnam (Wermelinger et al., 2008; Arnold, 2009; Heckmann, 2012; Callot and Brua, 2013; Milonas and Partsinevelos, 2014; Vetek et al., 2014; Macavei et al., 2015; Rabitsch and Friebe, 2015; Seat, 2015; Dioli et al., 2016; Gapon, 2016; Mityushev, 2016; Simov, 2016; Çerçi and Koçak, 2017; Göktürk 2020).

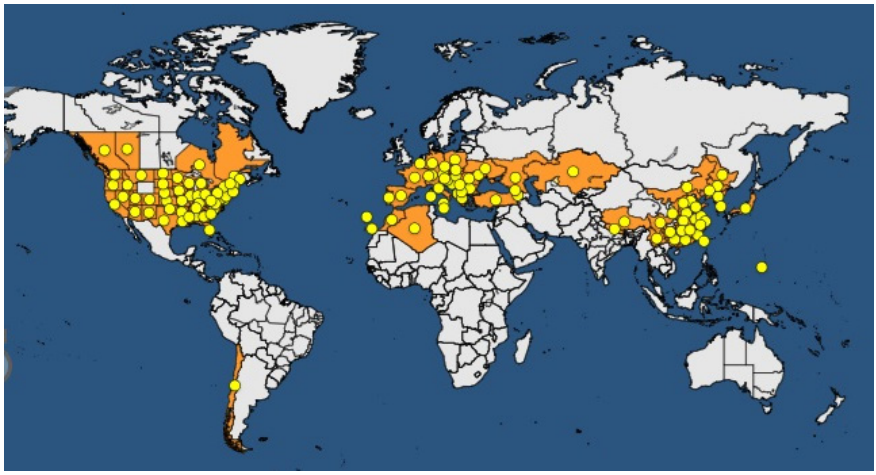

Figure 1. *World distribution map of Halyomorpha halys (URL 1).*

Halyomorpha halys was recorded for the first time in Türkiye in Istanbul (Çerçi and Koçak, 2017) and Artvin in the Eastern Black Sea Region near the border with Georgia in 2017 (Göktürk and Tozlu, 2019). During the last 6 years, *H.halys* has spread to Giresun, Ordu, Rize, Trabzon and Samsun provinces in the Eastern Black Sea Region. It is also reported to have spread to İstanbul, Yalova and Kocaeli provinces in the Marmara Region (Göktürk and Tozlu, 2019; Göktürk, 2020) (Figure 2).

Figure 2. *Türkiye distribution map of Halyomorpha halys*

3. Morphological Descriptions

3.1. Egg stage

The eggs of the brown skunk are smooth and dull in color. Eggs are found in groups of 20-30. Eggs are usually laid under the leaves of host plants. As the embryos develop, the eggs become prominent and eyes appear as two red dots. Egg laying peaks in July and ends at the end of August. Eggs are about 1.6 mm long and 1.3 mm in diameter, elliptical in shape and light green (Figure 3).

3.2. Nymph stage

Halyomorpha halys has 5 nymphal stages. In the later stages of the nymphs, spines are present on the pronotum and dark red eyes are the most prominent features. Hatching nymphs are shiny, black and reddish-orange in color and 1 mm in diameter. They spend the first nymphal period on or around the eggs. First stage nymphs are about 2.4 mm long. The head and thorax are black, while the abdomen is orange and red. Towards the second nymphal stage, it loses its orange red color. Second instar nymphs appear darker and have a superficial sting towards the side of the thorax. Wing scars and molting become prominent. In the last nymphal stage, white bands are seen on the leg and antennal margins (Figure 3).

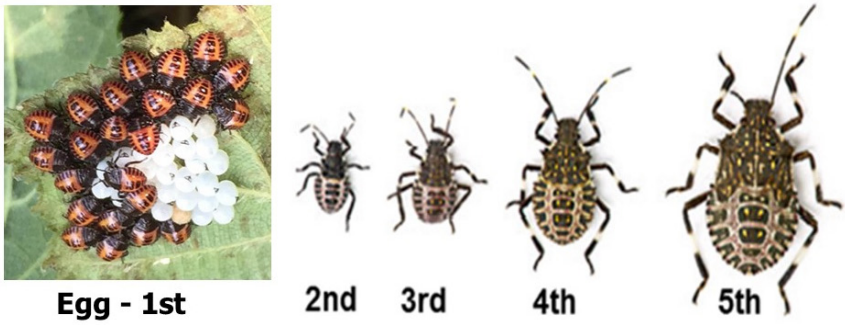

Figure 3. *Eggs and Nymph stages of Halyomorpha halys (URL 2)*

3.3. Adult stage

The adult of *Halyomorpha halys* is dark brown and 12-17 mm long, the antennae are partly pale white except for the 4th and 5th segments, which are black, and the legs are reddish yellow. The color is shades of brown, red and black on the dorsal surface (Figure 4).

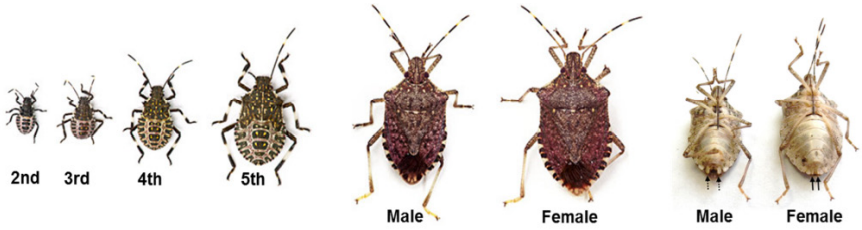

Figure 4. *Adult stage of Halyomorpha halys (URL 2)*

4. Biology

It is reported that BMSB has 1-2 generation per year (Leskey et al., 2012a; Rice et al., 2014), with up to 5 generations per year in tropical regions and 1 generation per year in most parts of the USA (Nielsen et al., 2016). In Türkiye, *Halyomorpha halys* gives 1 offspring (Göktürk, 2020).

Adults mate about two weeks after emerging from diapause or resting stage in spring. Shortly afterwards, females begin laying eggs on the underside of the leaves of host plants. The emergence of adults from their wintering grounds can start in April, but peaks between mid-May and early June. Females usually lay a total of 360-400 eggs in clusters of 20-30. Egg laying takes place at weekly intervals and can last up to 2 months. The insect's egg-laying season starts in June, with the highest number of eggs laid in July and ends at the end of August. Throughout the season, as females persistently lay new egg masses, one can observe various nymphal stages on the same host plant (Göktürk, 2020).

Halyomorpha halys has five nymphal stages and each stage lasts about a week, depending on temperature. The first nymphs appear four to five days after egg laying. Hatching nymphs spend the first nymphal stage together in clusters around or on the eggs. Approximately 538 days/degree is required for the insect to develop from egg to adult. After September, the pests move to places where they can safely spend the winter (buildings, barns, building roofs, tree hollows, window openings, curtain cornice parts, natural cracks, etc.). It is also known that adults overwinter among fallen plant debris, under the bark of trees and in holes. The gradual increase in the spread of adult *H. halys* from host plants to overwintering sites occurs during September, with the most significant rise observed be-

tween September 21 and mid-October. Subsequently, there is a notable decrease in this spread, as stated by Göktürk in 2020.

5. Biotic and abiotic factors affecting dispersal and flight ability

Temperature, light and wind speed are the main abiotic factors affecting flight. It has been reported that adults of BMSB can fly an average of 2.7-5 km per day (Lee and Leskey, 2015). The flight distances are different for males and females, with males flying longer distances. Studies have shown that BMSB can fly up to 75 km or 117 km in one season (Wiman et al., 2015; Lee and Leskey, 2015). In areas where *H.halys* has two generations, the flight distance is shorter. The proportion of flying individuals is positively influenced by rising temperatures, with an increase observed up to 30°C. On the other hand, a decrease in wind speed enhances the chances of BMSB flying. In stable conditions, approximately 83% of individuals are expected to take flight. However, when wind speeds reach or exceed 0.75 m/s, less than 10% of individuals will engage in flight. Typically, flight activity takes place in the direction opposite to the sun, particularly in the morning hours (Lee and Leskey, 2015). Temperature is one of the main factors affecting the biological development and spread of *H.halys*. In a study on the effect of temperature on biological development, it was observed that the development period of *H.halys* was completed in 81.2 days at 20°C, 44.9 days at 25°C and 33.4 days at 30°C (Haye et al., 2014).

6. Similar species confused with *Halyomorpha halys*

There are many species similar to *H.halys*. These are Rhaphigaster nebulosi (Poda), Holcostethus vernalis (Wolff), Arma custos (Fabricius), *Carpocoris purpureipennis* (DeGeer), *Dolycoris baccarum* L., *Troilus luridus* F., (Hemiptera: Pentatomidae), *Elasmucha grisea* L. (Hemiptera: Acanthosomatidae) (Figure 5).

7. Damage and economic importance

Halyomorpha halys, both adults and nymphs, pose a threat as they inject digestive enzymes directly into the fruit and extract plant juices through their stinging-sucking mouthparts. Various enzymes secreted during feeding also cause bitterness in fruits (Peiffer and Felton, 2014; Rice et al., 2014). After the first nymphs feed on egg chorion, they prefer softer textured plants in the 2nd, 3rd and 4th nymph stages. Late-stage nymphs and adults move to woody ornamental plants from the soft and stone fruits they suck. Moreover, this host switching continues throughout the growing season and the most nutritious host is sought (Funayama, 2002). The damage caused by adults on fruits is higher than nymphs. The manifestation of feeding damage on tree fruits includes surface discolor-

ation, depressions or deformations, as well as areas of internal necrosis (Joseph et al., 2015). As a result, these products cannot be marketed (Rice et al., 2014; Bariselli et al., 2016) (Figure 6).

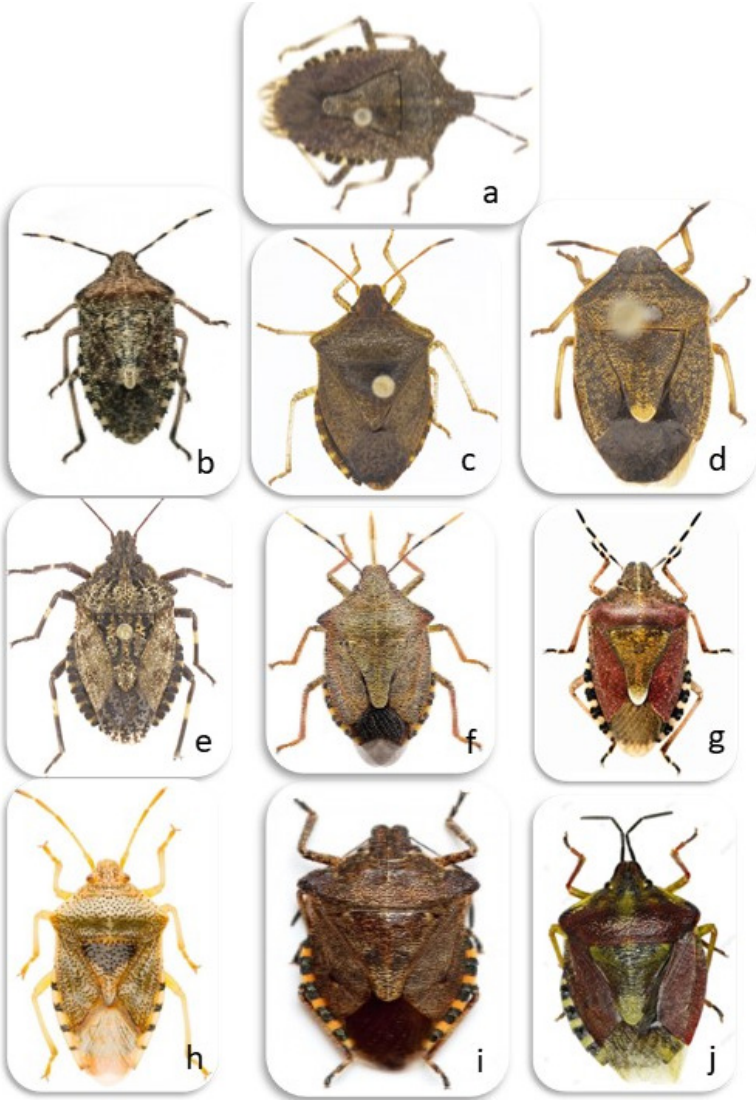

Figure 5. *Species similar to Halyomorpha halys (a-Halyamoprha halys, b-Rhaphigaster nebulosa, c- Euschistus sp., d-Holcostethus vernalis, e-Brochymena sp., f-Arma custos, g-Dolycoris baccarum, h-Elasmucha grisea, i-Troilus luridus, j-Carpocoris purpureipennis)*

Figure 6. *Damage of Halyomorpha halys*

When injury occurs early in the development of peach fruits, fruit drop may occur (Nielsen and Hamilton, 2009). Injury scars, pits, deformities and discoloration occur as a result of feeding on the fruit, and another harm of *H.halys* is that it is an important urban problem due to the entry of the pest into houses during overwintering, the gathering of huge groups in such structures and the negative effects of the foul odors it emits on human health (Inkley, 2012; Lee et al., 2013; Rice et al., 2014; Scheihing et al., 2016).

Halyomorpha halys can overwinter in houses from November to May. *Halyomorpha halys* does not bite or sting humans but releases a foul odor when squeezed. It has been recorded that more than 25,000 beetles infest some houses, and that beetles heading towards the light hit people and contaminate them with their unpleasant odor and feces, and that proteins associated with the beetles can also cause allergies (Inkley, 2012; Mertz et al., 2012). In addition, *H.halys* carries some plant diseases (Paulownia tomentosa) (Jones and Lambdin, 2009).

Halyomorpha halys is a difficult pest to control because of its mobility, spreading over large areas in a short time and having a wide host range (Bergmann et al., 2016). The significant economic risks posed by *H.halys* to numerous crops can be attributed to several key factors. Firstly, its highly polyphagous nature allows it to feed on a wide range of plants, making it a versatile pest. Secondly, *H.halys* has the ability to pose a threat for extended periods of time, leading to prolonged damage to crops. Additionally, its strong capacity to spread between different hosts and habitats further exacerbates the economic risks. Lastly, unlike native pentatomids, both nymphs and adults of *H.halys* are capable of feeding on and damaging crops, intensifying the potential harm caused.

In North America, it has been reported that BMSB can be responsible for losses of up to 70% of crop value in fruits and vegetables. In New Jersey and the surrounding region, it caused a loss of approximately USD 37 million in apples and peaches in 2010 (Seetin, 2011). It is also reported to have caused serious losses in corn, peppers, tomatoes, soybeans, grapes and ornamental plants grown in nurseries in 2010 (Leskey et al., 2012b; Rice et al., 2014).

Halyomorpha halys, which has become a major pest of many crops since its first detection in Italy, has also been found to be harmful to hazelnut orchards (Bosco et al., 2020). In Italy, economic damages were observed in peach and pear orchards as well as apricot, plum, apple, persimmon and tomato (Bariselli et al., 2016). The estimated loss caused by the pest in hazelnuts in Georgia in 2016 is reported to be approximately 52.7-68.6 million dollars (Murvanidze et al., 2018). In 2018, hazelnuts in all hazelnut fields in Anaklia, Georgia were not purchased as hazelnuts in all hazelnut fields became bitter as a result of the damage caused by the pest in hazelnut fields.

When evaluated in terms of this invasive pest in Türkiye, hazelnut is the crop under the greatest risk in the short term, especially in the Black Sea region. As a result of the epidemic in hazelnut areas in Türkiye as in Italy and Georgia, it is very likely that the pest will become the most im-

portant problem threatening yield and internal quality in terms of hazelnut production in Türkiye.

In addition, apples, pears, peaches, kiwis, corn, tomatoes, peppers and cereals are widely cultivated crops in Türkiye where *H. halys* causes significant losses. Moreover, the fact that the pest is now generally observed in the Black Sea region does not mean that its spread will be limited to this region. As a matter of fact, when the spread of brown skunk in other countries is examined, it is seen that it has spread to the whole country in a short time.

8. Host plants of *Halyomorpha halys*

Halyomorpha halys possesses a considerable capacity to cause harm to approximately 300 plant species globally, encompassing agricultural crops, nuts, vegetables, and ornamentals, owing to its extensive range of hosts (Table 1).

The main host species of *H. halys* include hazelnuts, almonds, pistachios, apples, kiwis, olives, peaches, citrus fruits, pears, plums, nectarines, apricots, cherries, maples, lilacs, persimmons, maize, soybeans, tomatoes, okra, peppers, eggplants and tomatoes, grapes and rice, with varying preferences among different hosts (Nielsen and Hamilton, 2009; Inkley, 2012; Leskey et al, 2012b; Morrison et al., 2016; Zobel et al., 2016; Bosco et al., 2017; Maistrello et al., 2017; Ak et al., 2019).

Considering the wide host range of agricultural crops grown in Türkiye, especially in the Eastern Black Sea Region, such as citrus beans, corn, kiwifruit, persimmon, and tomatoes, which are important hosts for the pest, this pest is considered a great potential threat to many of the agricultural products in our country.

Tablo 1. Host plants of Halyomorpha halys

Family name	**Scientific name**	**Family name**	**Scientific name**
Adoxaceae	*Sambucus cerulean*	Rosaceae	*Amelanchier grandiflora*
	Viburnum opulus		*Crataegus crusgalli*
Altingiaceae	*Liquidambar styraciflua*		*Crataegus laevigata*
Amaryllidaceae	*Allium aflatunense*		*Crataegus mollis*
Anacardiaceae	*Cotinus coggygria*		*Crataegus monogyna*
Apocynaceae	*Vinca major*		*Fragaria vesca*
	Asclepias syriaca		*Malus domestica*
Araliaceae	*Hedera helix*		*Malus floribunda*
	Rhus typhina		*Malus ioensis*
	Rhus typhina		*Malus sylvestris*
Asteraceae	*Artemisia tridentata*		*Physocarpus opulifolius*
	Helianthus annuus		*Physocarpus opulifolius*
Berberidaceae	*Berberis thunbergii*		*Prunus armeniaca*
	Berberis vulgaris		*Prunus avium*
	Mahonia repens		*Prunus cerasifera*
Betulacea	*Corylus sp.*		*Prunus cisterna*
Bignoniaceae	*Campsis radicans*		*Pyrus communis*
	Catalpa speciosa		*Prunus domestica*
Boraginaceae	*Borago officinalis*		*Prunus dulcis*
Caprifoliaceae	*Lonicera maackii*		*Prunus persica*
Cornaceae	*Cornus alba*		*Prunus virginiana*
	Cornus kousa		*Prunus mahaleb*
	Cornus sericea		*Prunus virginiana*
Cucurbitaceae	*Cucurbita pepo*		*Pyrus calleryana*
	Cucumis sativus		*Pyrus pyrifolia*
Cupressaceae	*Thuja plicata*†		*Rosa acicularis*
Cannabaceae	*Celtis occidentalis*		*Rosa* spp.
Caprifoliaceae	*Lonicera heckrottii*		*Sorbus alnifolia*
	Symphoricarpos albus		*Spiraea japonica*
Cupressaceae	*Juniperus chinensis*	Rutaceae	*Evodia daniellii*
	Metasequoia glyptostroboides		*Evodia hupehensis*
Elaeagnaceae	*Elaeagnus angustifolia*		*Tetradium daniellii*

Fabaceae	*Cladrastis kentukea*	Salicaceae	*Populus angustifolia*
	Cladrastis lutea		*Populus deltoides*
	Maackia amurensis		*Populus fremontii*
	Phaseolus vulgaris		*Populus tremuloides*
Fagaceae	*Quercus gambelii*		*Salix lasiolepis*
	Quercus rubra		*Salix purpurea*
Ginkgoaceae	*Ginkgo biloba*	Sapindaceae	*Acer campestre*
Grossulariaceae	*Ribes alpinum*		*Acer freemanii*
Hydrangeaceae	*Philadelphia virginalis*		*Acer ginnala*
Juglandaceae	*Juglans regia*		*Acer griseum*
Lamiaceae	*Ocimum basilicum*		*Acer grandidentatum*
	Nepeta cataria		*Acer negundo*
Lauraceae	*Lindera benzoin*		*Acer nigrum*†
Leguminosae	*Cercis canadensis*		*Acer palmatum*
	Cladrastis kentukea		*Acer pensylvanicum*
	Sophora japonica		*Acer platanoides*
Magnoliaceae	*Liriodendron tulipifera*		*Acer rubrum*
	Magnolia denudata		*Acer saccharinum*
Malvaceae	*Alcea rugose*		*Aesculus hippocastanum*
	Hibiscus syriacus		*Aesculus carnea*
	Tilia cordata		*Koelreuteria paniculata*
	Tilia platyphyllos	Saxifragaceae	*Astilbe arendsii*
	Tilia tomentosa	Scrophulariaceae	*Buddleia davidii*
Moraceae	*Ficus carica*	Simaroubaceae	*Ailanthus altissma*
	Morus alba	Solanaceae	*Capsicum annuum*
Oleaceae	*Forsythia intermedia*		*Lycium barbarum*
	Fraxinus pennsylvanica		*Solanum melongena*
	Ligustrum vulgare	Ulmaceae	*Ulmus americana*
	Syringa hyacintriflora		*Ulmus parvifolia*
	Syringa pekinensis		*Ulmus propinqua*
	Syringa reticulata		*Ulmus pumila*
	Syringa vulgaris	Vitaceae	*Vitis Vinifera*
Plantaginaceae	*Penstemon strictus*		*Parthenocissus quinquefolia*
Poaceae	*Zea mays*		

9. Control methods

9.1. Chemical control

IPM programs for *H.halys* are under development (Leskey et al., 2012b). Insecticides can be ineffective because *H.halys* adults have strong flight capabilities and are resistant to insecticides. As a result of the extensive crop damage inflicted by *H.halys*, numerous cultivators have primarily addressed the issue of this invasive species by resorting to the application of artificial insecticides (Leksey et al., 2012b). The use of insecticides was especially high in 2010 when *H.halys* populations exploded. Synthetic insecticides are the most commonly used against *H.halys*. Chemical management of *H.halys* has primarily focused on the use of broad-spectrum insecticides administered at higher recommended dosages. The most effective insecticides against *H.halys* have been found to be carbamates, organophosphates, pyrethroids, and neonicotinoids. According to various studies, dimethoate, malathion, bifenthrin, mehydathion, endosulfan, methomyl, chlorpyrifos, acephate, fenpropathrin, and permethrin have demonstrated efficacy against *H.halys* (Leskey et al., 2012d). While pyrethroid and neonicotinoid insecticides are known to be effective against this species, they have been observed to have adverse effects on beneficial arthropods and pollinators (Leskey et al., 2012b).

The effectiveness of these insecticides is short-lived, and there is evidence suggesting that *H.halys* has developed resistance to them. Additionally, the insect has shown increased resistance to organophosphates, carbamates, and neonicotinoids (Lee et al., 2013). In laboratory trials, organic insecticides that are approved for use, such as azadirachtin, potassium salts of fatty acids, spinosad, pyrethrins, and pyrethrins + kaolin, were predominantly utilized and yielded successful results (Lee et al., 2014c). The mortality rate of *H.halys* adults and nymphs increased when treated with carbaryl, permethrin, insecticidal soap, petroleum oil, acetamiprid, and permethrin and acetamiprid. It is worth noting that *H.halys* nymphs are generally more susceptible to insecticides compared to adults (Bergmann and Raupp, 2014).

A study conducted by Leskey et al. in 2014 found that apples treated with dinotefuran and fenpropathrin had fewer injuries. Various commercial products such as methomyl (Lannate), chlorpyrifos (Lorsban),

beta-cyfluthrin (Baythroid), bifenthrin (Brigade), cyfluthrin (Renounce), deltamethrin (Delta Gold), esfenvalerate (Asana), fenpropathrin (Danitol), gamma-cyhalothrin (Declare), lambda-cyhalothrin (Warrior), zeta-cypermethrin (Mustang Max), acetamiprid (Assail), clotianidin (Belay), dinotefuran (Scorpion), imidacloprid (Admire Pro), thiacloprid (Calypso), and thiamethoxam (Actara) showed effectiveness against *H.halys*. Additionally, bifenthrin (Ortho Bug B Gon), gamma-cyhalothrin (Spectracide Triazicide Insecticide), acetamiprid (Ortho Flower, Fruit and Vegetable Insecticide), pyrethrins (Pyganic), azadirachtin/neem (Aza-Direct), and kaolin clay (Surround) are certified organic insecticide options. For indoor/outdoor applications, chlorpyrifos (Vulcan) and bifenthrin (Menace) can be used. Insecticides such as bifenthrin, gamma-cyhalothrin, cyfluthrin (Bayer Vegetable and Garden Insect Spray), cypermethrin (Ortho Ant and Cockroach Killer), deltamethrin (Spectracide Scented Insect Killer), permethrin (Monterey Scented Insect Spray), imidacloprid (Ortho Dual Action Bedbug Killer), and azadirachtin (organic) are suitable for treating buildings. It is worth noting that studies indicate that overwintering *H.halys* are more susceptible to insecticides compared to the new generation (Leskey et al., 2014). In Türkiye, Decis 2.5 EC has been recommended for the Eastern Black Sea Region. It should be kept in mind that frequent use of chemicals and disruption of IPM will cause secondary pests to cause more damage or develop increasing levels of chemical resistance.

9.3. Biotechnical (Semiochemical) control

Semiochemicals are frequently used in monitoring and control efforts against *H.halys.* These pheromones attract and capture both nymphs and adults. The utilization of the aggregation pheromone of *Plautia stali* (Hemiptera: Pentatomidae) is employed to attract *H.halys* during the late season. This pheromone is composed of methyl (E, E, Z) and 2,4,6 decatrienoate (MDT) (Weber et al., 2014). The most commonly used PHEROCON Brown Marmorated Stink Bug brand sticky traps and PHEROCON® CSB' type pheromone capsules. Recently, the male-produced aggregation pheromone of *H.halys* (3S,6S,7R,10S)-10,11-epoxy-1-bisabolen-3-ol and (3R,6S,7R,10S)-10,11-epoxy-1-bisabolen-3-ol) has also been used. The pheromone is also reported to attract other pentatomids and, acting as a kairomone, the insect's natural enemies, tachinids and wasps (Cottrell et al., 2014; Aldrich et al., 2009). Black pyramid traps placed on the ground, green traps hung from trees and sticky sheet traps are used against *H.halys* (Aldrich et al., 2007) (Figure 7).

Figure 7. *Pheromone types of a-Sticky trap, b- Black pyramid trap, c- Green trap*

9.4. Biological control

Natural enemies known for most pentatomid species are typical for *H.halys*. There have been many studies investigating the natural enemies of *H.halys* and their development of biological control programs (Gouli et al. 2012; Abram et al. 2014a,b; Gariepy et al. 2014b; Jones et al. 2014). Studies have shown that insects, spiders and entomopathogens have a sup-

pressive effect on insects (Talamas et al. 2013; Haye et al., 2015; Balusu et al. 2019; Fusu and Andreadis, 2023; Göktürk et al., 2023) (Table 2).

Tablo 2. *Natural enemies of H.halys*

Order	Family	Scientific name	Biological Period of Natural Enemy Influence on *H.halys*
Aranea	Arachnida	----	Egg, nymphs and adult
Coleoptera	Coccinellidae	*Harmonia axyridis*	Egg
Dermaptera	Forficulidae	----	Egg
Diptera	Tachinidae	*Trichopoda pennipes*	Nymphs and adult
		Cylindromyia bicolor	Adult
Hemiptera	Anthocoridae	*Orius* sp.	Egg and nymphs
	Geocoridae	*Geocori*s sp.	Egg and nymphs
	Reduviidae	*Arilus cristatus*	Egg, nymphs and adult
Hymenoptera	Crabrionidae	*Astata* unicolor	Egg and nymphs
		Astata bicolor	Nymphs
		Bicyrtes quadrafaciata	Nymphs
	Encyrtidae	*Ooencyrtus mirus*	Egg
	Eupelmidae	*Anastatus mirabilis*	Egg
		Anastatus pearsalli	Egg
		Anastatus bifasciatus	Egg
		Anastatus reduvii	Egg
	Platygastridae	*Gryon obesum*	Egg
	Scelionidae	*Telenomus utahensis*	Egg
		Telenomus podisi	Egg
		Trissolcus basalis	Egg
		Trissolcus brochymenae	Egg
		Trissolcus cultratus	Egg
		Trissolcus edessae	Egg
		Trissolcus euschisti	Egg
		Trissolcus japonicus	Egg
		Trissolcus halymorphae	Egg
		Trissolcus mitsukurii	Egg
		Trissolcus thyantae	Egg
		Trissolcus utahensis	Egg
Mantodea	Mantidae	*Tenodera sinensis*	Nymphs and adult
Neuroptera	Chrysopidae	*Chrysoperla carnea*	Adult

Figure 8. *Trissolcus japonicus parasitizing eggs and Cylindromyia bicolor parasitizing adult*

Beauveria bassiana, Bacillus cereus and *Metarhizium anispoliae* isolates were found to be effective as entomopathogens against *H.halys* in the laboratory (Gouli et al., 2012; Tozlu et al., 2019).

9.5. Others

In studies on the capture of *H.halys* adults with light traps, successful results were obtained when used together with pheromone (Cambridge et al., 2017; Rice et al., 2017; Göktürk, 2020).

10. Conclusion and Recommendations

Halyomorpha halys is a very important invasive species that attracts attention with its high spreading capacity, reproductive power, easy adaptation to many different ecosystems of the world and high competitive power with the native species of the areas where it is newly introduced. It has been spreading rapidly especially in the Eastern Black Sea Region since 2017. It is not possible to say that sufficient results have been obtained in the control of *H.halys* with mechanical, biotechnical and chemical control methods in the world. Most of the studies have been laboratory experiments and it has been late to apply these studies to the field. Due to the high plant diversity in the Eastern Black Sea Region, the damage of the insect is not fully seen. In the following years, it is likely to threaten many agricultural products in Türkiye, especially hazelnuts. As in many countries of the world, an action plan against *H.halys* should be prepared in our country as well as in many other countries of the world and control efforts should be started as soon as possible. As in many countries of the world, egg parasitoid *Trissolcus japonicus should be* produced in laboratories and biological control should be started in our country. Some measures should be taken to prevent the spread of *H.halys*. Within the scope of biotechnological control, mass use of pheromone traps should be ensured and mass catches should be realized. Broad spectrum organic insecticides should be used against *H.halys* nymphs in suitable areas. In order to combat invasive alien species in Türkiye, an IPM commission consisting of academicians and ministry employees should be established and coordinated studies should be started.

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CHAPTER 2

AN OVERVIEW OF WATER SECURITY

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Introduction

Although water covers 75% of the earth's surface, only a small portion of freshwater (Fig. 1) can be used directly by living organisms. The reasons for this are listed below.

- Although oceans cover 97% of the world's water, these waters are too salty for living things to use.
- Frozen water in the north and south poles, glaciers and snowy mountain ranges constitutes 2% of the total amount of water in the world (https://www.australianenvironmentaleducation.com.au/education-resources/what-is-water/).

One of the most critical components of the global environment is aquatic ecosystems (LeRoy Poff et al., 2002). In addition to being essential contributors to biodiversity, ecological productivity and stabilizing the global climate they also provide a variety of services for human populations (water for drinking and irrigation, recreational opportunities, transportation and habitat for economically important fisheries etc), (LeRoy Poff et al., 2002; Hader et al., 2020).

For a healthy life, sustainable access of a population to water in sufficient quantities and of acceptable quality is of great importance. People always want to have access to "water in sufficient quantity and quality for health, livelihood and production activities" for the continuity of life.

Global water problems, one of the factors that negatively affect people, welfare and national security, continue to grow worldwide (Wouters, 2010). Throughout history, humanity has frequently faced water crises. Before the Industrial Revolution, agriculture-based economies frequently went into crisis due to loss of productivity caused by drought or excessive rainfall. These have led to conflict, war and mass migration. Historians have identified more than 900 water-related conflicts and wars recorded to date (Worldwater, "Water Conflict Chronology", http://www.worldwater.org/conflict/map/).

We are experiencing a dangerous human-caused decline in natüre (Fig. 2). Some information about these is given below;

- We use the equivalent of 1.6 Earths to sustain our lives. Therefore, ecosystems are inadequate to meet our demands. (Becoming Generation Restoration, UNEP), (https://www.unep.org/facts-about-nature-crisis),
- There are approximately 8 million plant and animal species in the world. 1 million of these organisms are threatened with extinction (Intergovernmental Science-Policy Platform on Biodiversity

and Ecosystem Services-IPBES), (https://www.ipbes.net/; https://www.unep.org/facts-about-nature-crisis),

- 75 percent of terrestrial ecosystems and 85 percent of aquatic ecosystems have been significantly altered due to human activities (IPBES, 2019),
- 66 percent of oceans and seas are impacted by human activities, including fishing and pollution (IPBES, 2019),
- The number of people living in water-stressed areas is estimated to be more than five billion by 2050 (Burek et al., 2016),
- It is estimated that 700 million people will be displaced by extreme water scarcity by 2030 (Global Water Institute, 2013),
- 72% of the water withdrawn from freshwater ecosystems is used by agriculture, 16% by municipalities and households, and 12% by industry. (UN-Water, 2021),
- It is estimated that more than 85% of wetlands have been lost since the pre-industrial era, and the rate of loss continues to increase (IPBES, 2019),
- The regions most experiencing water scarcity are the world's largest cities (World Economic Forum, 2017),
- The number of people worldwide who have inadequate access to clean drinking water is more than 1.1 billion. Additionally, the number of people without basic sanitation facilities is approximately 2.6 billion (AWDO, 2018),
- The number of people living in regions where water supply is not sufficient to meet demand and where there is physical water scarcity is approximately 1.2 billion (Majumder, 2015),
- As of now, the number of people facing human economic water scarcity is approximately 1.6 billion. These people do not have sufficient financial means to access existing water resources (Hanjra and Qureshi, 2010),
- Global freshwater demand is expected to exceed supply by 40% by 2030. As a result, the number of people who will be without safely managed drinking water is estimated to be more than 1.6 billion (https://blogs.worldbank.org/water/why-water-security-our-most-urgent-challenge-today).

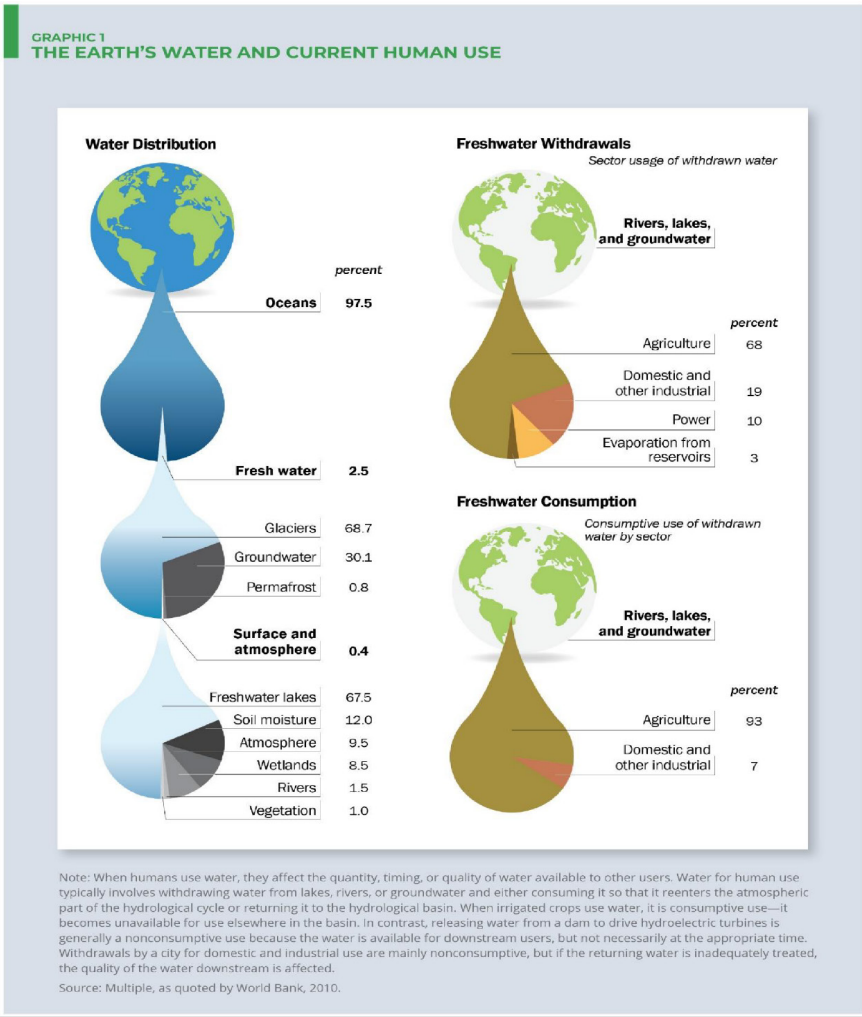

Figure 1. *The earth's water and freshwater use (ICA, 2012)*

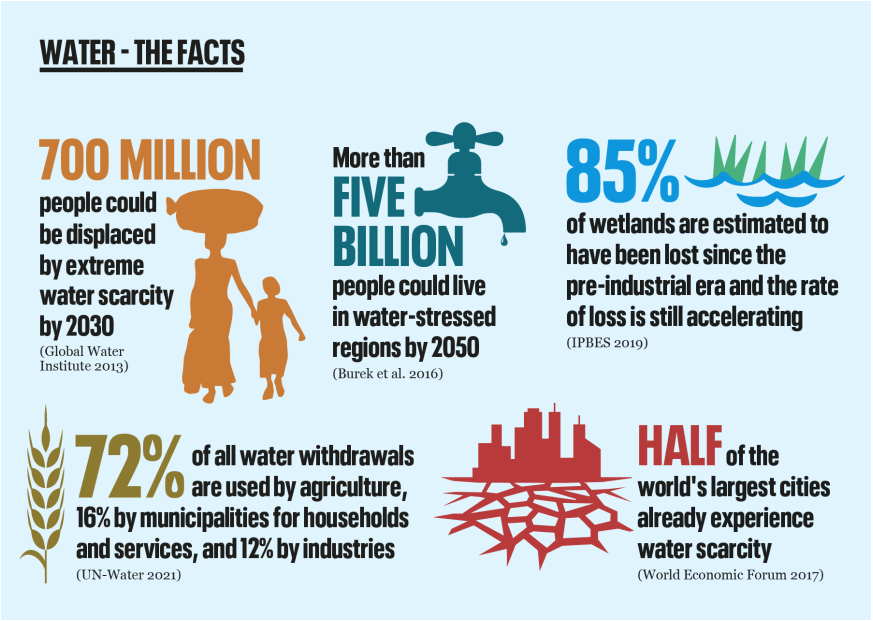

Figure 2. *Water- the facts (https://populationmatters.org/food-water/)*

An Overview of Water Security (WS)

Promoting environmental protection and social justice, water security (WS) also deals with the consequences of poor water management (Mishra et al., 2021). The conceptualization of WS differs from discipline to discipline, from area to area, from theme to theme (Gain et al., 2016).

Various definitions have been proposed for WS in general. One definition of WS is "the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies" (Grey and Sadoff, 2007).

WS is a multidimensional concept that includes water availability (whether water is in the physical environment), accessibility (whether water can be acquired through socially acceptable means), use (whether there is enough safe and acceptable water for all needs), and stability across time (Fig. 3), (Miller et al., 2021).

WS is defined by the United Nations as "the capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a clima-

te of peace and political stability". The definition was developed by the UN and experts from around the World (https://sdg.iisd.org/news/un-water-brief-defines-water-security/).

In parallel with the increase in knowledge about WS, it has become clear that WS can be applied to different sectors and each of these sectors has different points of interest in terms of WS (Table 1), (Babel, 2019).

Making the most of the benefits of water for people and ecosystems is one of the most important goals of WS. Another important goal of WS is to limit the risks of destructive effects of water to an acceptable level (Sadoff et al., 2020). WS emerged as a concept for the first time in the 21st century (Cook and Bakker 2012; Sadoff et al., 2020). WS has its roots in 1940s postwar diplomacy to redraw political boundaries of former colonial empires (Garrick and Hall, 2014).

The concepts of food security and energy security include reliable access to food or energy. For this reason, the concept of WS differs from these two concepts, WS covers not only the problem of lack of water, but also the problems that occur when there is too much water (Grey and Sadoff, 2007).

Table 1. *WS definitions by disciplines/sectors (Cook and Bakker, 2012)*

Discipline/Sector	**WS focus or definition**
Agriculture	• Food security and input to agricultural production
Engineering	• Protection against water-related hazards such as floods, drought, pollution and terrorism • Supply security (percentage of demand satisfied)
Environmental science, environmental studies	• Access to water functions and services for humans and the environment • Water availability in terms of quality and quantity • Minimizing impacts of hydrological variability
Fisheries, geology/geosciences, hydrology	• Groundwater (hydrological) variability • Security of the entire hydrological cycle

Public health	• Supply security and access to safe water • Prevention and assessment of contamination of water in distribution systems
Anthropology, economics, geography, history, law, management, political science	• Drinking water infrastructure security • Input to food production and human health/ wellbeing • Armed/violent conflict • Minimising (household) vulnerability to hydrological variability
Policy	• Interdisciplinary linkages (food, climate, energy, economy and human security) • Sustainable development Protection against water-related hazards • Protection of water systems and against floods and droughts; sustainable development of water resources to ensure access to water functions and services
Water resources	• Water scarcity • Supply security (demand management) • "Green" (versus "blue") WS - the return flow of vapour

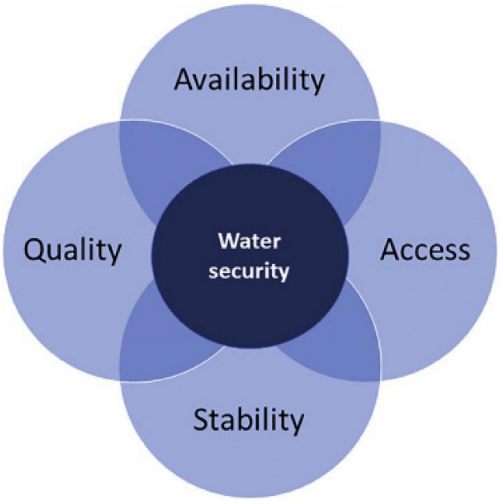

Figure 3. *Multidimensional concepts of WS (Miller et al., 2021)*

There are many challenges with contemporary water management. WS is therefore increasingly used to conceptualize these challenges. As shown in Fig. 4, the UN water security is based of broad framework of different dimensions and cross sectors to achieve sustainable water management.

Three main factors are considered to determine how difficult or easy it is for a community to maintain WS. These factors are given below;

- Hydrological environment,
- Socio-economic environment,
- Future changes in the environment due to climate change (Sadoff and Grey, 2007).

WS risks can be assessed by decision makers at various levels. These range from the household to community, city, basin, country and region (Murgatroyd et al., 2021). In order for societies to benefit from water, water resources and services must be managed successfully and comprehensively. In this way, it will be possible to meet the needs in every dimension of WS (Fig. 5), (https://waterfundstoolbox.org/getting-started/what-is-water-security). These are given below;

1. **Domestic WS:** Providing all human with reliable, quality water and sanitation services.
2. **Economic WS:** Efficient use of water to sustain economic growth in all areas of the economy (such as food production, industry and the energy sector).
3. **Urban WS:** Supporting vibrant and livable water-sensitive cities through the creation of better water management and services.
4. **Environmental water management:** Monitoring progress in restoring rivers, groundwater resources and ecosystems at national and regional scales.
5. **Resilience to water related natural disasters:** Building resilient and informed communities that can reduce risks from water-related natural disasters, minimize the impact of future disasters, and adapt to change.

Improving WS has been recognized as a major issue worldwide because of its vital importance. This development has paved the way for improving WS to be considered as an action item within the scope of the 2030 Development Agenda (Babel, 2019).

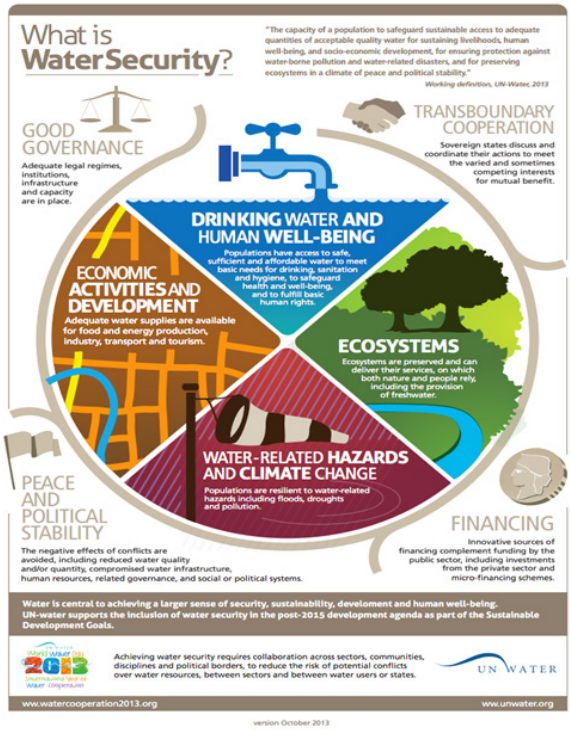

Figure 4. *United Nations framework of WS (*UN-Water, 2013; https://www.unwater.org/publications/what-water-security-infographic*)*

Figure 5. *The five dimensions of WS (https://waterfundstoolbox.org/getting-started/what-is-water-security)*

The 'web' of WS

The 'web' in Fig. 6 centres on the interdependencies and a combined reading of how social and physical processes combine to create or deny WS (WEF, 2009; Zeitoun, 2011). Analytical application of the web is necessarily interdisciplinary; the development and implementation of policy deriving from the web is unavoidably cross-sectoral (Zeitoun, 2011).

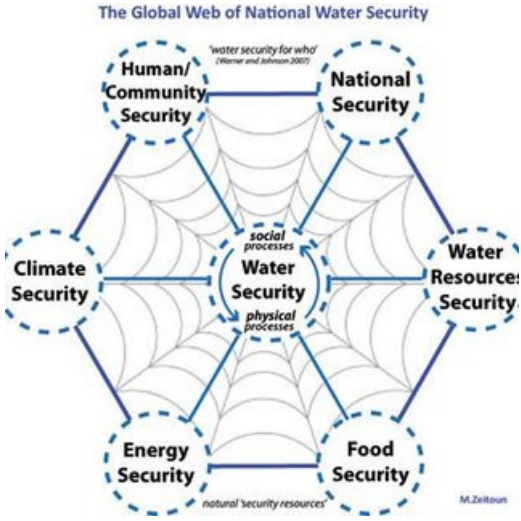

Figure 6. *The global 'web' of national WS (Zeitoun, 2011)*

General Information About Research on WS

WS is a concept that emerged in the 1990s (Marcal et al., 2021). WS has been the subject of many reviews focusing on its definition (Grey and Sadoff, 2007; Cook and Bakker, 2012; Hoekstra et al., 2012; Jensen and Wu, 2018; Cook and Bakker, 2018; Allan et al., 2018; Cook and Bakker, 2018; Krueger et al., 2019; Li et al., 2019; Su et al., 2019;) use and focus on different disciplines, application to scales and geographical regions (Gerlak et., 2018), and assessment tools (Octavianti et al., 2021). Most of these studies were conceptual and the main focus was on determining the scope of WS (Babel et al., 2020). Some examples of research conducted on this subject are listed in Table 2.

Table 2. *Some existing frameworks for WS assessment*

Authors	**Elements of WS**
Grey and Sadoff (2007)	WS: Human and ecosystem health security against water-related risks.
Falkenmark and Molden (2008)	Quantified WS: water stress and water shortage.
Zeitoun (2011)	Human/Community security; National security; Water resources security; Food security; Energy security; Climate security.
Cook and Baker (2012)	Reviewed the literature around WS from 1990–2010: They explored definitions, analytical approaches and scales, offering major insights into the importance of an integrative approach in water security studies.
Lankford et al. (2013)	Volumetric sufficiency; Water quality; Flood protection; Water allocation/equity; Dynamic apportionment; Productivity/efficiency
UN-Water (2013)	Drinking water, sanitation and hygiene; Water resources; Water governance; Water-related disasters; Wastewater pollution and water quality.
Fischer et al. (2015)	Total renewable water resources per capita; Ratio of annual water withdrawal to total renewable water resources; Runoff variability; Ratio of external to total renewable water resources.
Sadoff et al. (2015)	Droughts and water scarcity; Floods; Water supply and sanitation; Ecosystem degradation and pollution.

Garrick and Hall (2014)	Proposed a risk perspective overview of WS: Analysis of definitions, indicators, indices and how they vary at different scales.
Octavianti and Staddon (2021)	They reviewed assessment tools that included themes and scale analysis, comparing approaches and arguments used to define measures.

Conclusion

WS has come to the fore as one of the key concepts for sustainable development and the continuation of life in the last twenty years, WS relates to the increasing importance of sustainable management of water resources, drinking water and human well-being, as well as the protection of life and property from water-related disasters, the health of ecosystems and economic development (Marcal et al., 2021).

As a result we can say that;

- Today, nearly 80% of the world's population faces a high-level WS and water-related risk (biodiversity loss). WS has a very important role in ensuring sustainable and inclusive growth (Vörösmarty et al., 2010).
- WS indicators reveal the disparity in hazards and vulnerability between geographical and political-economic conditions (Garrick and Hall, 2014).
- WS is an important challenge for science and society (Garrick and Hall, 2014).
- WS refers to the capacity of a population to secure sustainable access to water in sufficient quantities and of acceptable quality. However, water safety is at risk for many people. This situation will worsen over the next few decades (Boretti and Rosa, 2019).
- While there have been significant advances made in the knowledge of WS, its translation on the ground has been a challenge (Babel, 2019).

Researchers working with WS assessment (case studies, experiences, observations, consultations, etc.) have collected data that allows the identification of solutions, recommendations and/or interventions that can help improve WS. Specific actions that have the potential to help achieve WS goals are provided in Fig. 7 (Marcal et al., 2021).

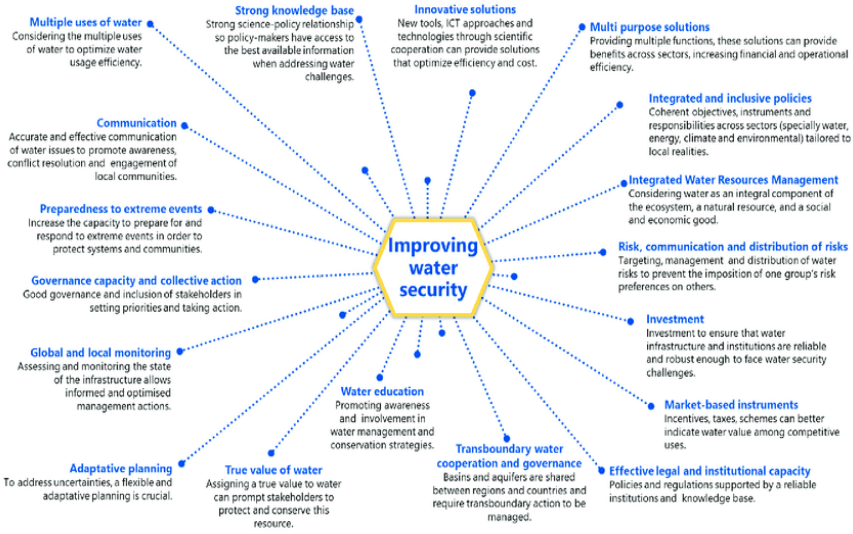

Figure 7. *Summary of actions with potential to improve WS (Marcal et al., 2021)*

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CHAPTER 3

THE EFFECT OF ADDING *SCENEDESMUS OBLIQUUS* TO FEED IN DIFFERENT WAYS ON THE GROWTH AND POPULATION DENSITY OF *DAPHNIA MAGNA*

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Introductıon

Daphnia magna is a planktonic crustacean that lives in freshwater ecosystems and feeds on bacteria, algae and cyanobacteria suspended in the water (Tkaczyk, Bownik, Dudka, Kowal, & Ślaska, 2021). The body length of the adults varies between 1 mm and 5 mm, and green algae are their best food (Ebert, 2005). *D. magna*, also known as the water flea, is an invertebrate that is small, has a lifespan of about 8 weeks at 20 ˚C and can reach sexual maturity in 6 to 8 days (Ten Berge, 1978). This invertebrate is an important model organism for toxicological research and studies on environmental conditions and nutrition (Gust, et al., 2019).

Algae is commonly known as seaweed. Approximately 160 species of algae can be consumed as food by humans. They are seen as alternative food especially in China, Korea, Japan and Far Eastern Countries. Microalgae contain carbohydrates, proteins, essential amino acids, lipids, vitamins and mineral substances necessary for nutrition (De Carvalho vd., 2020). They are also the most sustainable natural source of production of a wide variety of carotenoids, including astaxanthin, β-carotene, lutein, lycopene, canthaxanthin and zeaxanthin (Rammuni vd., 2019*). Scenedesmus obliquus* is a well-known fresh water microalgae and is of primary importance in the study of organisms called microalgae. It is a rapidly growing organism. It has been found that it can tolerate a wide range of environmental conditions such as light intensity, photoperiod, pH and temperature (Husin and Basri, 2022). *Scenedesmus obliquus* has been the center of attention in recent years due to its growth rate, easy cultivation and bioactive component content, which attracts the attention of both scientists and industry, and has been studied for many years. However, most of these studies are on biodiesel production, growing conditions, increasing the amount of oil, growing in wastewater, and fatty acid synthesis (Martinez et al., 2000; Mandal et al., 2009; Ho et al., 2010; Tang et al., 2011). There are many studies on biodiesel since its oil content varies between 11-55% depending on the growing conditions and it can also be grown in wastewater (Mata et al., 2010*). S. obliquus* has numerous potential uses in food and nutrition. However, there are few academic studies evaluating this potential. This study was conducted to investigate the toxicological effects of *Scenedesmus obliquus* and to provide the basis for usability studies in the field of food.

Materials and Methods

Daphnia magna culture

Daphnia magna kept in aquaria for the production of live food in the Aquatic Vertebrate Experimental Unit of Tekirdağ Namık Kemal University, Faculty of Arts and Science, Department of Biology, is produced in an

automatic lighting period of 8 hours of darkness, 14 hours of light and an average water temperature of 24 ˚C (Figure 1). They are fed various ready-made feed powders, baker's yeast and some microalgae cultures (*Chlorella sorokiniana*, *Scenedesmus obliquus* and *Scenedesmus quadricauda*) (Yağcılar, Pehlivanoğlu, Başel, & Erdoğan,2022).

Figure 1. Tekirdağ Namık Kemal University, Faculty of Arts and Sciences, Department of Biology, Aquatic Vertebrate Experimental Unit

Experimental design

The *D. magna* to be used for the study were selected from different production aquaria using a scoop with a mesh size of 1 mm. A total of 378 animals were randomly placed in 3 replicates in transparent plastic aquaria measuring 30 × 30 × 30 cm (Figure 2). 42 animals were kept in each experimental aquarium. Three different feeding methods were used in the study: The first feeding used ready-made commercial feed (Inve O. RANGE start 200-300 microns), the second feeding used commercial feed + solid microalgae (*Scenedesmus obliquus*) and the third feeding used commercial feed + liquid microalgae culture (*Scenedesmus obliquus*) (Figure 3). Our feeding work continued for 24 days and the water in the aquaria with *D. magna* was changed daily. Newborn fry were collected and recorded during the daily water changes. The length and width measurements as well as the number of eggs of *D. magna* were carried out at intervals of three days. Length and width were measured using an ophthalmoscope under a SOIF microscope. The creature's heart measurements were recorded with a SONY brand camera for 6 seconds, while length and width measurements were taken under a microscope. After the measurements, the heart rate was measured using the "Windows Media Player" program. When measuring the heart rate, the video was slowed down and the number of measurements was calculated.

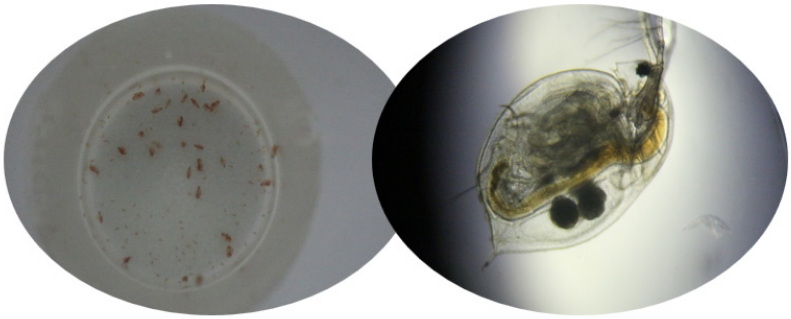


Figure 2. Daphnia magna microscope image

Figure 3. Scenedesmus obliquus microscope image, liquid microalgae and solid microalgae

Feed Preparation

For feeding, 0.1 gram of powdered feed was dissolved in 10 ml of water in the first group, 0.1 gram of commercial feed and 0.1 gram of dried powdered microalgae in the second group and 0.1 gram of powdered feed in 10 ml of live microalgae culture fluid in the third group. Feeding took place once a day.

***Scenedesmus obliquus* cultures**

In our study, a *Scenedesmus obliquus* culture grown in the Department of Microalgae Production of Tekirdağ Namık Kemal University Faculty of Arts and Science Aquatic Vertebrate Experiment Unit was used. The production conditions of the culture were carried out in F/2 environment and average water temperature of 28 ˚C (Table 1).

Table 1. F/2 medium

Component	Stock solution (g/L)	Culture medium (mL)
$NaNO_3$	75	1.0
$NaH_2PO_4H_2O$	5.0	1.0
$Na_2O(SiO_2)2$	12.0	1.0
$CuSO_4$	9.8	
$ZnSO_4$	22.0	
$MgCl_2$	10.0	
$Na_2MoO_4.2H_2O$	6.3	
$FeCl_2$	3.0	1.0
$Na_2EDTA2H_2O$	4.6	0.5
Thiamine hydrochloride	2.0	
Pyridoxine hydrochloride	2.0	
Cyanocobalamin	0.1	
Distilled water		1000

Harvesting and drying

After the cultured *Scenedesmus obliquus* was filtered with a fine mesh of 10 μm, it was washed with clean water and dried with an infrared lamp at an average temperature of 40 ˚C. After drying, it was ground into powder in a mortar and stored in clean containers in a cool place.

Statistical analysis

Using the IBM SPSS Statistics 22.0 software package, data were analyzed using one-way ANOVA and Tukey post hoc test, with different letters indicating significant differences between groups.

Results

Length, width and hearth rate

Height and width were measured and recorded every three days. The data obtained from the study are listed in Table 2.

As can be seen from the table, the result of the one-way analysis of variance (ANOVA) performed to determine whether the arithmetic mean values of height, width and heart rate of *Daphnia magna* showed a significant difference depending on the variable of different feeding style is due to the fact that the p-value is less than 0.05. Therefore, it was conc-

luded that they are statistically different from each other (p=0.00, p=0.01, p=0.00). Following this process, the Tukey test, one of the complementary post hoc analysis techniques, was used to determine which groups caused the significant difference found after ANOVA.

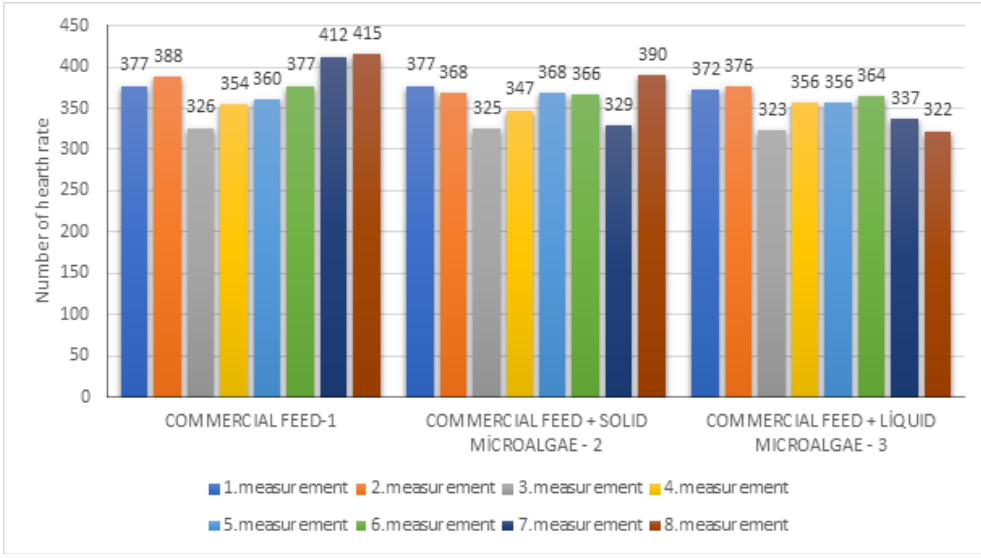
Table 2. Descriptive statistical data according to different feeding methods

	COMMERCIAL FEED -1 (Mean±SD)		COMMERCIAL FEED + SOLID MICROALGAE – 2 (Mean±SD)		COMMERCIAL FEED + LIQUID MICROALGAE – 3 (Mean±SD)	
	Initial	Final	Initial	Final	Initial	Final
Length (mm)	2.55±0.26	2.63±0.21^{a}	2.55±0.25	2.92±0.19^{b}	2.55±0.21	3.03±0.37^{b}
Width (mm)	1.77±0.13	1.86±0.14^{a}	1.77±0.18	1.91±0.14^{ab}	1.77±0.19	1.98±0.23^{b}
Heart rate (dk)	377.38±45.15	415.00±110.52^{a}	377.61±49.17	390.47±70.81^{b}	372±42.48	322.14±35.51^{b}

*Same superscript lettres show values with statistically insignificant differences per property ($p<0.05$)

In this context, it was found that there was a significant difference ($p<0.05$) between feeding commercial feed by mixing solid and liquid microalgae and feeding only commercial feed ($p<0.05$) and that the height value of these groups was higher than that of commercial feed. Depending on the feeding method, a statistically significant difference was found at the longest ($p<0.05$) level when the commercial feed with a liquid microalgae mixture was administered compared to the other groups, and it was observed that the creatures fed in this group achieved a higher value compared to the other groups.

Depending on the feeding method, a significant difference ($p<0.05$) was found between feeding commercial feed by mixing solid and liquid microalgae and feeding commercial feed alone, and these groups had a lower heart rate compared to the commercial feed (Figure 4).



Figüre 4. Number of hearth rate by measurement

Eggs

The average egg counts of *D. magna* fed according to different feeding methods are shown in Table 3. In this context, when the data obtained at the end of the experiment were analysed, the highest egg productivity was observed in the group fed with liquid microalgae culture, with a rate of 3.64±1.98 (Figure 5).

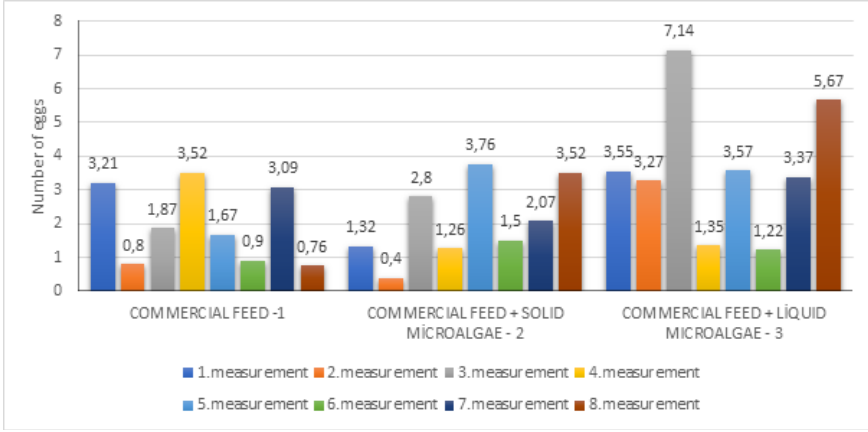


Figure 5. Number of eggs by measurement

Table 3. Average values for the number of eggs obtained

	1.measurement X±SS	2.measurement X±SS	3.measurement X±SS	4.measurement X±SS	5.measurement X±SS	6.measurement X±SS	7.measurement X±SS	8.measurement X±SS	X±SS
COMMERCIAL FEED-1	3.21±0.72	0.80±2.45	1.87±1.19	3.52±2.11	1.67±3.85	0.90±1.48	3.09±1.89	0.76±2.27	1.97±1.15
COMMERİİAL FEED+ SOLID MICROALGAE - 2	1.32±0.85	0.40±2.96	2.80±0.92	1.26±1.60	3.76±2.74	1.50±1.49	2.07±2.17	3.52±1.96	2.07±1.18
COMMERCIAL FEED+ LIQUID MICROALGAE - 3	3.55±0.95	3.27±4.34	7.14±2.77	1.35±3.26	3.57±4.45	1.22±3.23	3.37±1.96	5.67±2.14	3.64±1.98

Offspirings

When the data in Table 4 were analysed, it was found that the number of offspring in the group fed with liquid microalgae culture was higher than in the other two groups, with a ratio of 455.12±296.08 (Table 4). At the end of the experiment, when the total population density was examined, it was found that there were 1733 in the group fed with commercial feed, 1690 in the group fed with commercial feed + solid microalgae, and 3683 in the group fed with commercial feed + liquid microalgae (Figure 6).

Table 4. Average values for the number of offsprings obtained

	1.measurement	2.measurement	3.measurement	4.measurement	5.measurement	6.measurement	7.measurement	8.measurement	X±SS
COM-MERCIAL FEED-1	61	254	165	216	139	346	455	55	211.37±138.23
COMMER-CIAL FEED + SOLID MICROAL-GAE - 2	113	414	185	283	354	81	154	64	206±130.20
COMMER-CIAL FEED + LIQUID MICROAL-GAE - 3	135	349	205	592	788	696	791	85	455.12±296.08

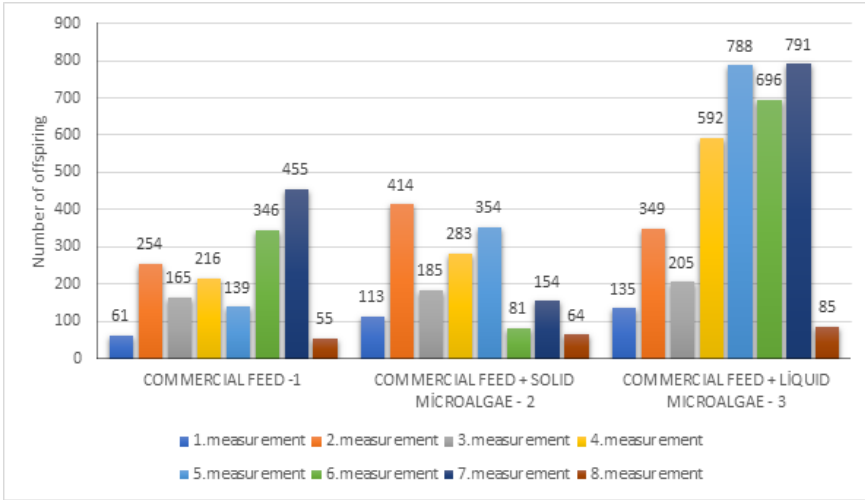


Figure 6. Number of offsprings by measurement

When the images obtained at the beginning and end of the experiment were analysed, it was found that the group fed with liquid microalgae produced more growth, more eggs and more offspring than the other feeding groups (Figure 6).

Discussion

No mortality was observed in *D. magna* with any of the diets used in this study. A feed was prepared by combining the commercial feed of *Daphnia magna* cultures produced under laboratory conditions with the solid and liquid forms of microalgae cultures (Figure 7-8).

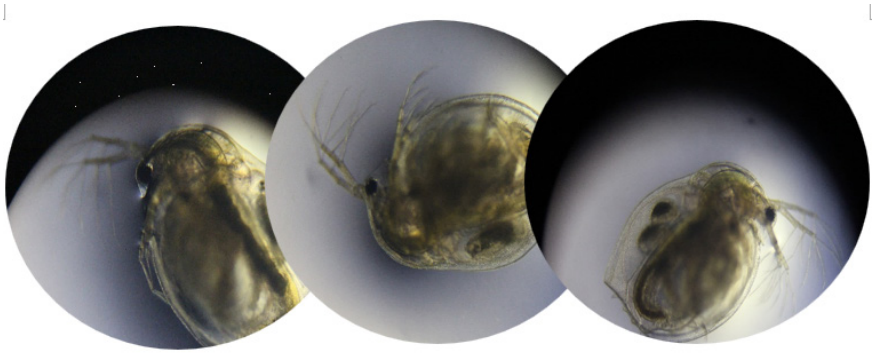


Figure 7. First measurement; commercial feed, commercial feed + solid microalgae, commercial feed + liquid microalgae

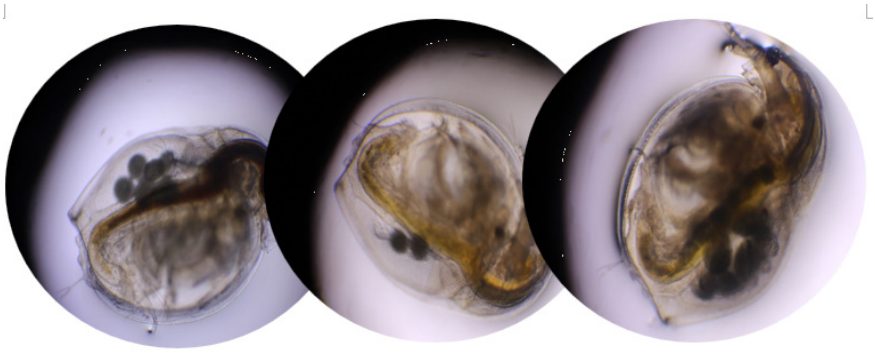


Figure 8. Last measurement; commercial feed, commercial feed + solid microalgae, commercial feed + liquid microalgae

In this study, it was found that the growth and development of *D. magna* fed with *Scenedesmus obliquus* dry and live culture was better than the control group. The biochemical composition of S. obliquus is known to have a very high protein content, ranging between 50-56% depending on the growth environment (Becker, 2007). Thus, the culture of *S. obliquus* microalgae, which has a high protein content, can be a good alternative for aquatic organisms. In our study, it was found that the use of commercial feed together with the microalgae culture showed no negative effects with different feeding methods of the *D. magna* culture. However, it was found

that the use of microalgae liquid cultures with commercial feed resulted in a positive increase in growth, egg and fry numbers of *D. magna* cultures. It was emphasized that the use of microalgae cultures and commercial feed mixtures in live feed production has positive effects. Its positive effect will have a positive impact in terms of stability, cost efficiency and sustainability in the feeding of fish, especially in aquaculture (Polat & Yağcılar, 2021).

Conclusion

The evaluation of the microalgae culture, which was added to the feed in different ways for the growth and reproduction of *D. magna*, showed that the best result was achieved in the group that received the live culture. It has been observed that the enrichment of commercial feed with live cultures has a significant positive effect on the growth and reproduction of *D. magna*. To this end, it has been observed that *S. obliquus* microalgae can be a good source of protein and promote the growth of fish larvae, especially in aquaculture.

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CHAPTER 4

RHODE ISLAND RED-II KAHVERENGİ YUMURTACI HATTIN 43 HAFTALIK PERFORMANS DEĞERLERİNİN TESPİTİ

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Bu çalışmada, Ankara Tavukçuluk Araştırma Enstitüsü'nde yetiştirilen Rhode Island Red-II kahverengi yumurtacı hattın 43 haftalık performans değerlendirilmesi yapılmıştır. Yumurta ağırlığı, yumurta verimi, cinsel olgunluk yaşı, canlı ağırlık gibi özellikler üzerinde durulmuş, 1715 tavuk için değerler sırasıyla, yumurta ağırlık ortalaması 57 g, yumurta verimi 128 adet, cinsel olgunluk yaşı 157 gün ve cinsel olgunluk ağırlığı 1842 g bulunmuştur. Çalışmada yumurta ağırlık ortalamaları karşılaştırılmış, elde edilen veriler değerlendirildiğinde 28. hafta 55,284 g, 32. Hafta 58,523 g, 36. haftada ise 58,887 g olarak tespit edilmiştir. Yapılan varyans analizi sonucu, her geçen hafta yumurta ağırlık ortalamalarının arttığı belirlenmiş, ancak önemli bir fark bulunmamıştır.

GİRİŞ

Bütün ülkeleri hayvansal üretimlerini artırmaya zorlayan ana etken ise, hayvansal proteinin yüksek biyolojik değere sahip olması ve dengeli bir beslenmenin sağlanabilmesi açısından büyük bir önem taşımasıdır (Türkoğlu, 1979).

Hiçbir çiftlik hayvanı bu kadar az yemle , çok sınırlı bir alanla, çok kısa bir sürede, bol ve çeşitli besin maddeleri üretmede tavukla rekabet etme yeteneğinde değildir (Türkoğlu ve Akpınar, 1979). Dar bir alanı en ekonomik şekilde değerlendirebilen, üreme ve verim performansı çok yüksek olan tavuk, ülkemizde uğraşı alanı olan diğer hayvansal üretim kolları arasında, hayvansal proteini en kolay ve en ucuz olarak sağlayabilecek niteliktedir (Akbay, 1985).

Dünya nüfusunun her geçen gün hızla artması ve büyük kentlerde yaşam tarzının buna bağlı olarak da beslenme alışkanlığının değişmesi, hayvansal protein gereksiniminin artmasına neden olmuştur. Gelişmiş ülkeler hayvansal üretimde sahip oldukları modern teknikleri geliştirerek üretimlerini yükseltmeyi başarmış ancak gelişmemiş ve az gelişmiş ülkelerdeki açlık ve yetersiz beslenme sorunu halen çözüme kavuşmamıştır. Dünya nüfusu yılda 80 milyon kişi artışla 50 yıl içerisinde büyük bir beslenme sorunuyla karşı karşıya kalacaktır. Ülkelerin ekonomik politikaları toplumun sosyal yaşamını etkilemektedir (Anonim, 1998).

Türkiye'de tavukçuluğun gelişmesine ilişkin ilk resmi çalışmalar Ankara'da Merkez Tavukçuluk Enstitüsü'nün 1930 yılında kurulmasıyla başlamış ancak teknik bilgi ve eleman yetersizliğinden 1950 yılına kadar önemli bir ilerleme sağlayamamıştır. Oysaki tarihi belgelerde Türk toplumunun tavuk yetiştiriciliğini çok eski devirlerden itibaren yürüttüğünü görmekteyiz. Osmanlı devleti döneminde yumurta ihraç eden ülkeler arasında olmamıza rağmen ilerleyen yıllarda gelişmelerin yeterince izlenmemesi gelişmiş ülkelerle aramızdaki uçurumu hızla açmıştır. Türkiye'de modern

tavukçuluğun temeli cumhuriyetin kuruluşundan sonra atılmış özellikle 1960'lı yıllardan sonra hızlı bir gelişme sağlanmıştır (Şenköylü, 2001).

Türkiye 543,000 ton yumurta üretimi ile Orta Doğu'nun başta gelen yumurta üreticisi ülkelerinden biridir ancak dünyanın önde gelen yumurta üreten ülkelerinden birisi olmasına rağmen yumurta tüketiminde aynı sıraya sahip değildir (FAO, 2004) (Çizelge 1).

Çizelge 1. Yumurta üretiminde başta gelen ülkelerde üretim (ton)

Sıra	Ülke	2001	2002	2003
1	Çin	20.229.700	21.287.900	22.332.500
2	ABD	5.084.600	5.131.500	5.123.000
3	Japonya	2.514.218	2.513.652	2.500.000
4	Hindistan	1.870.000	2.000.000	2.200.000
17	Türkiye	528.750	543.000	543.000

(FAO, 2004)

Türkiye 2000 yılında kişi başına 106 adet yumurta tüketimi ile 47. sırada yer almaktadır. Kişi başına yılda ortalama yumurta tüketimi Afrika kıtasında 2,1 kg, Avrupa kıtasında 12,0 kg, ve Kuzey ve Orta Amerika'da 13,2 kg olduğu ifade edilmektedir (FAO, 2004) (Çizelge 2).

Çizelge 2. Yumurta tüketiminde başta gelen ülkeler (kg, kişi, yıl)

Sıra	Ülke	2001	2002	2003
1	Japonya	19,31	19,1	19,1
2	Çin	16,2	16,7	16,4
3	Macaristan	16,0	16,8	17
4	Danimarka	13,8	16,3	16,4

(FAO, 2004)

MATERYAL VE YÖNTEM

Materyal

Bu araştırmada hayvan materyali olarak ATAE'de yetiştirilen RIR-II kahverengi yumurtacı hattı kullanılmıştır. Bu hattan 1700-1800 arası tavuk teste tabi tutulmuş 43 haftalık periyot içinde, hattın yumurta verimi, yumurta ağırlığı, cinsel olgunluk yaşı ve canlı ağırlığı gibi özellikler üzerinde durulmuş, performans değerlendirilmesi yapılmıştır.

Bu değerlendirme sonucunda yumurtacı saf hattın çeşitli özelliklerinin belirlenmesi, bunların aynı koşullarda yetiştirilen dış kaynaklı genotipler

ile karşılaştırılması ve bir sonraki generasyonun performans değerlerinin yükseltilmesi amaçlanmıştır.

Civcivler tüp yemlikler ve otomatik suluklarla donatılmış kümes bölmesine rasgele dağıtılmıştır. Piliçler büyütme dönemi sonunda (18-19. haftada), ATAE'de bireysel kafeslerin bulunduğu kümese alınmış, deneme materyali yumurtlama döneminde bireysel kafes gözlerinde verim kontrolüne tabi tutulmuştur. Piliçlerin bulunduğu kafesler numaralı olup, nipel tipi suluklar bulunmaktadır. Verim kontrolünde cinsel olgunluk yaşı, cinsel olgunluk ağırlığı, yumurta verimi ve yumurta ağırlığı bireysel olarak tek tek kaydedilmiştir.

Kümeslerdeki ısıtma, aydınlatma, havalandırma ve diğer çevre şartlarından hayvanların mümkün olduğunca eşit şekilde yararlanmalarına çalışılmıştır. Ortam sıcaklığı sabit olmayıp, çevre kontrollü kümes değildir. Max. Sıcaklık 30 C, min. Sıcaklık 10 C dir. Kümesler pencereli olup, havalandırma fanlarla yapılmıştır. Yumurtlama döneminde 16,5 saat ışıklandırma yapılmış, aydınlatma ampullerle sağlanmıştır. Hayvanlara 0-3 haftalar arası civciv, 4-8 haftalar arası piliç büyütme, 13-21 haftalar arasında piliç geliştirme ve 22. haftadan sonra tavuk yemi verilmiştir.

Yöntem

Araştırmada üzerinde durulan özellikler ve bunların tespit edilme yöntemleri aşağıda verilmiştir.

Yumurta Ağırlığı

Yumurta ağırlığının tespit edilmesi iki yolla yapılmaktadır. Bu yollardan birincisi, başlangıçtaki hayvan sayısına göre her hayvandan elde edilen (Hen-housed) haftalık yumurta ağırlığıdır. Bunda, haftalık toplam yumurta ağırlığı, başlangıçta kümese konulan hayvan sayısına bölünerek her hayvandan bir haftada elde edilen ortalama yumurta ağırlığı kg. olarak belirlenir. İkinci yolda ise, bir hafta içinde elde edilen yumurtaların toplam ağırlığı yumurta adedine bölünerek yumurtaların ortalama ağırlıkları belirlenmektedir (Şenköylü,2001).

Bu araştırmada, yumurtalar haftanın belirli bir gününde düzenli olarak tartılmaları suretiyle tavukları bireysel olarak ortalama yumurta ağırlıkları belirlenmiştir.

Yumurta Verimi

Yumurta verimi genellikle iki yöntemle tespit edilmektedir. Bunlardan ilki yumurtlama noktasında kümese konan tavuk sayısına göre (Hen- housed) yumurta verimidir. Bu yönteme göre yumurta veriminin hesaplanabilmesi için, ilk önce kümesin yumurta verimi bulunur. Bu değer başlangıçta

kümese konulan hayvan sayısına bölünerek tavuk başına yumurta verimi bulunur. İkinci yöntem, o günkü hayvan sayısına göre (Hen – day) yumurta veriminin hesaplanmasıdır. Bu yöntem genellikle tavuk – gün yumurta verimi olarak bilinir ve belirli bir günde kümeste bulunan hayvanların yumurta verimini belirtir. Üretilen yumurta sayısının kümesteki o günkü hayvan sayısına bölünmesi ile tavuk – gün yumurta verimi hesaplanır (Şenköylü,2001).

Bu araştırmada, bireysel kafeslerde yetiştirilen tavukların yumurtaları her gün düzenli olarak sayılarak belirlenmiştir.

Cinsel Olgunluk Yaşı ve Ağırlığı

Çok erken cinsel olgunluk yaşı ve çok düşük cinsel olgunluk ağırlığı yeni yumurtaya gelen piliçlerin uzun süre küçük yumurta vermesine prolapsus'un (gerinin çıkması) artmasına neden olmaktadır. Bundan dolayı ,ebeveyn hatlarının bu özellikler bakımından,arzu edilen seviyelerde olması çok fazla heterosisin istenmeyeceği de dikkate alınmalıdır.

Bu araştırmada, her tavuğun ilk yumurtasını verdiği gün ile kuluçkadan çıkış tarihi arasında geçen sürenin gün olarak hesaplanması suretiyle cinsel olgunluk yaşı belirlenmiştir.

Yumurta büyüklüğünü kontrol etmenin en kolay yolu cinsel olgunluktaki vücut ağırlığının ayarlanmasıyla mümkün olabilir. İdeal bir vücut büyüklüğü ve kondisyonuna sahip piliçlerin nispeten erken yaşta cinsel olgunluğa erişmelerinin bir sakıncası yoktur.

Bu araştırmada, ilk yumurtasını veren hayvanın o gün tartılması suretiyle bireysel olarak cinsel olgunluk ağırlıkları belirlenmiştir.

Yemden Yararlanma

Yumurta tavuklarının yemleme programlarının günlük yem tüketimlerine göre ayarlanması önem taşımaktadır. Günlük yem tüketimini belirleyen en önemli faktörler ise yemin enerji içeriği ile çevre sıcaklığıdır eğer yemin enerji değeri bilinirse yaşama payı ve verim payı için harcanan yem gereksinimi hesaplanabilir.

Bu araştırmada, yem tüketimi ve yumurta ağırlığının tespit edildiği günlerde bir kg yumurta veya bir adet yumurta için tüketilen yem miktarları da tespit edilmiştir.

İstatistik Analizler

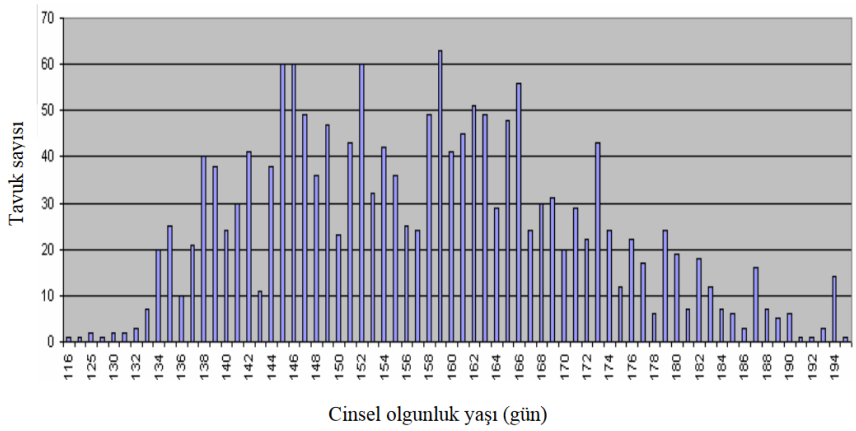
Araştırmada, bireysel olarak bulunan cinsel olgunluk yaşı, cinsel olgunluk ağırlığı, yumurta verimi ve yumurta ağırlığı gibi özelliklerden elde

edilen verilere uygun istatistik yöntemler olan, Jump ve MINITAB for Windows istatistik paket programları kullanılmıştır(Soysal,2000).

Jump paket programı ile hesaplamalarda her bir özellik için ortalama, standart hata, minimum ve maximum değerlerden oluşan tanımlayıcı istatistikler elde edilmiştir. Yumurta ağırlığı ortalama değerleri üzerinden 28. hafta, 32. hafta ve 36. Hafta yumurta ağırlık ortalamaları 3 tekrarlı olarak karşılaştırılmış, MINITAB for Wındows-Anova-one-way istatistik paket programı kullanılmış ve varyans analizi ile F testi yapılmıştır.

ARAŞTIRMA SONUÇLARI VE TARTIŞMA

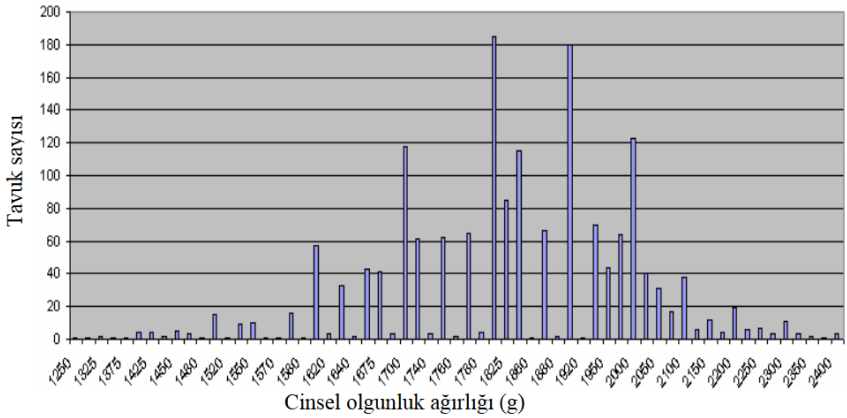
Cinsel Olgunluk Yaşı



Şekil 1. Cinsel olgunluk yaşı

Şekil incelendiğinde cinsel olgunluk yaşı bakımından en erken cinsel olgunluğa ulaşma yaşı 116 gün, en geç ise 195 gün olduğu görülmektedir. Ortalama cinsel olgunluk yaşı 1715 hayvanda 157 gün olup s. 0,337'dir.

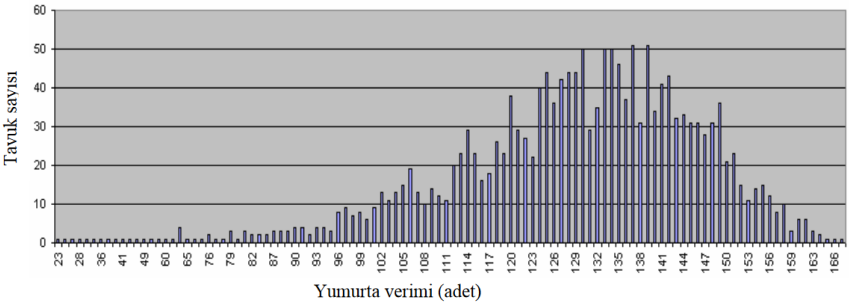
Cinsel Olgunluk Ağırlığı



Şekil 2. Cinsel olgunluk ağırlığı

Şekil incelendiğinde cinsel olgunluğa maksimum 2400g ağırlıkta, minimum 1250g ağırlıkta ulaştığı görülmektedir.1715 hayvan arasında ortalama cinsel olgunluk ağırlığı 1842g olup s. 3,955 tir.

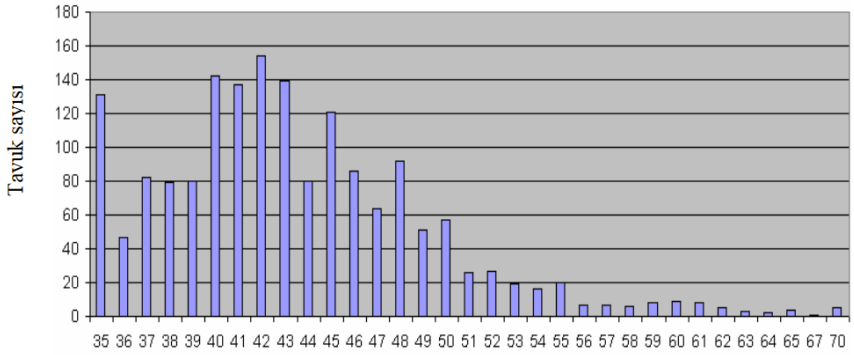
Yumurta Verimi



Şekil 3. Yumurta verimi

Şekil incelendiğinde 43 haftalık maksimum yumurta veriminin 168 adet, minimum yumurta veriminin ise 23 adet olduğu görülmektedir. 1715 hayvan arasında ortalama yumurta verimi 128 adet olup s. 0,452'dir.

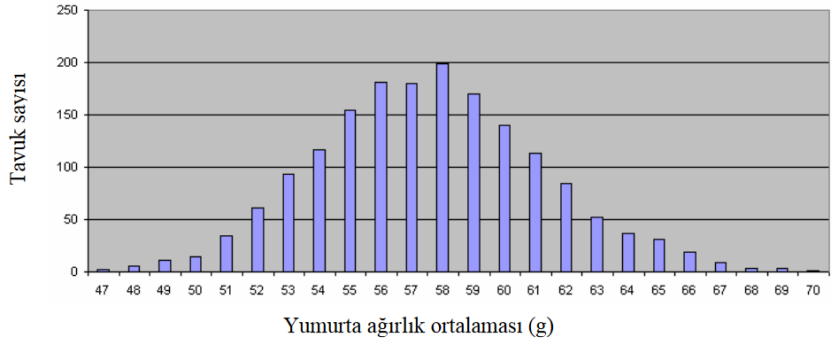
İlk Yumurta Ağırlığı



Şekil 4. İlk yumurta ağırlığı

Şekil incelendiğinde maximum ilk yumurta ağırlığının 70 g , minimum ilk yumurta ağırlığının ise 35g olduğu görülmektedir.1715 hayvan arasında ortalama ilk yumurta ağırlığı 43g olup s.0,142'dir.

Yumurta Ağırlık Ortalaması



Şekil 5. Yumurta ağırlık ortalaması

Şekil incelendiğinde yumurta ağırlık ortalamasının maksimum 70g, minimum ise 47 g olduğu görülmektedir.1715 hayvan arasında ortalama yumurta ağırlık ortalaması 57 g olup s.0,0881'dir.

Yumurta ağırlık ortalamasının değerlendirmesi yapılırken ;

1. ayın ilk 3 yumurtasının ağırlık ortalaması (28. hafta)

2. ayın ilk 3 yumurtasının ağırlık ortalaması (32. hafta)

3. ayın ilk 3 yumurtasının ağırlık ortalaması (36. hafta)

Çizelge 3. 28., 32. ve 36. haftalardaki yumurta ağırlık ortalamaları

	28. hafta	32. hafta
32. hafta	- 3,564 * - 2,913	
36. hafta	- 3,928 * - 3,276	- 0,689 * - 0,038

Yukarıdaki değerlerde 28., 32. ve 36. haftalardaki yumurta ağırlık ortalamaları arasında farklılık olduğu görülmektedir. Yem tüketiminin artmasıyla ilerleyen haftalarda canlı ağırlığının arttığı buna bağlı olarak da yumurta ağırlığında artışa neden olduğu söylenebilir.

TARTIŞMA

Yapılan hesaplamalar sonucunda üzerinde durulan toplam yumurta verimi, yumurta ağırlığı, cinsel olgunluk yaşı, cinsel olgunluk ağırlığı ve ortalama yumurta ağırlığı gibi özelliklerin değerleri incelendiğinde aşağıdaki bulgular elde edilmiştir. RIR-II'nin yumurta kalite özellikleri iyi olup saflaştıkça RIR-I yakın özellikler gösterse de yem değerlendirme ve yumurta verim özellikleri bakımından geridedir. RIR-I'in 72. hafta sonu yumurta verimi 278 adet, RIR-II'nin 72. hafta sonu yumurta verimi 276 adet olup ,43. hafta sonu verimi ortalama 128 adettir.

ATAE'de ebeveyn hatlar ve hibritleriyle yaptığı bir araştırmada 72. hafta sonu yumurta verimleri çeşitli hatlarda sırasıyla; 213,3, 219,8, 212,5, 222,3 ve 184 adet olarak tespit etmiştir (Yüceer,1985). Almanya'da 1985-1986 yılları arasında 5 ayrı deneme istasyonunda beyaz Leghornlarla yapılan bir araştırmada, 500 günlük yaşta yumurta verimi (tavuk-kümes) 301 adet olarak bildirilmiştir (Flock, 1987).

Avrupa'da yapılan rasgele örnekleme yumurta verim testinin, 1985 yılı sonuçlarına göre, beyaz ve kahverengi yumurtacı hibritlerin, 500 günlük yaşta (tavuk-kümes) yumurta verimi sırasıyla 269-294 adet ve 262-286 adet arasında, 1986 yılı sonuçlarına göre ise, 277-303 adet ve 268-292 adet olduğu bildirilmiştir (Anonim, 1989).

ATAE'de OxTx yerli beyaz ve GxSx yerli kahverengi yumurtacı hibritlerin 72 haftalık yaşta yumurta verimi sırasıyla 262,70 ve 250,49 adet olarak saptanmıştır (Uysal ve Boğa, 1994).

Yumurtacı tavuklarda 1956-1960 döneminde 340 günlük bir yumurtlama sürecinde ortalama (tavuk-kümes) 225 adet yumurta alınırken, 1971-

1976 yılları arasında bu rakamın 386 günlük yumurtlama döneminde 273 adete, 1988-1993 yılları arasında 360 günlük yumurtlama döneminde 306 adete yükseldiğini ve 1995-1996 yılları arasında 360 günlük yumurtlama döneminde beyaz yumurtacılardan 305,9 adet ve kahverengi yumurtacılardan 308,6 adet yumurta elde edilir duruma gelindiği bidirilmiştir (Hunton,1997). Almanya'da 1985-1995 yılları arasında beyaz ve kahverengi yumurtacı tavuklarda yapılan rasgele örnekleme testi sonuçlarına göre, 72 haftalık bir dönemde (tavuk-kümes) yumurta veriminin sırasıyla 297 ve 293 adet olduğu, her iki grubun da %50 verime aynı yaşta (22 hafta) girdiği bildirilmiştir (Flock, 1998).

ATAE'de yapılan bir araştırmada büyük ebeveyn hatlarda 43. hafta yumurta verimi sırasıyla 132,47, 124,72, 114,09, 117,57 adet olarak tespit edilmiştir (Anonim,2000). İki yerli (biri beyaz ve biri kahverengi) ve iki dış kaynaklı (ISA Babcok B-300 beyaz ve ISA Babcock B-380 kahverengi) hibritin , 66 haftalık yaşta (tavuk-gün) yumurta verimleri sırasıyla 235,53, 259,52, 221,73 ve 258,68 adet (tavuk-kümes) yumurta verimleri ise sırasıyla 224,21, 228,23, 212,74 ve 240,78 adet olarak belirlenmiştir (Karaçay, 2000). ATAE'de ki diğer kahverengi yumurtacı saf hatlar Bareed Rock-I, Bareed Rock- II,Columbian Rock, Lıne-54 sırasıyla 72. hafta sonu yumurta verimleri; 266,0, 268,0, 260,0, 258,0 adettir (ATAE el broşürü,2003).

Yapılan istatistiksel analizler sonucunda 28., 32. ve 36. hafta yumurta ağırlık ortalamaları karşılaştırılmış, 28. haftada 55,284 g olan yumurta ağırlık ortalaması 32. haftada 58,523 g olarak hesaplanmış 36. haftada ise 58,887 g olarak tespit edilmiştir.70. hafta yumurta ağırlığı 63,3 g 'dır.

Yaptıkları araştırmada ATE-K(1), ATE-K(2), ATE-B(1), ATA-B(2), YB-K(1), YB-K(2) ve YB-B(1) ortalama yumurta ağırlıkları sırasıyla 62,2 g, 59,1 g, 61,6 g, 58,0 g, 63,8 g, 62,8 g ve 59,0 g olarak bulunmuştur (Düzgüneş vd,1985).

ATAE'de elde edilen iki kahverengi ve iki beyaz yumurtacı hattın 72. haftalık yaşa kadar ki toplam yumurta verimi ve yumurta ağırlığı ortalaması sırasıyla; kahverengi yumurtacı hat I 235 adet ve 62,2 g, kahverengi yumurtacı hat II 248 adet ve 59,1 g, beyaz yumurtacı hat III 241 adet ve 61,6 g, beyaz yumurtacı hat IV 254 adet ve 58,6g olarak bildirilmiştir (Düzgüneş,1985).

Avrupa'da yapılan bir teste göre ISA Bobcock B-300 beyaz ve ISA Bobcock B-380 kahverengi yumurtacı hibritlerin ortalama yumurta ağırlıkları 59,3 ve 63,4 g olarak saptanmıştır (Anonim,1986). Yumurta verimi ve yaşama gücünden sonra yumurta üretiminde karlılığı etkileyen en önemli etmen yumurta ağırlığıdır. Kahverengi yumurtacılarda 20-74 hafta ortalama yumurta ağırlığı 62-65 g, beyaz yumurtacıların ortalama yumurta ağırlığı ise 60,7-64,8 g olarak bildirilmektedir (Eratek,1991). Avrupa'da

yumurta verim özellikleri ile ilgili olarak yapılan bir çalışmada beyaz ve kahverengi yumurtacı hibritlerde 500 günlük yaşa kadar ortalama yumurta ağırlıkları belirlenmiş ve bu değerler 1991 yılı için sırasıyla 60,9-67,9 g ve 62,4-72,7 g 1992 yılı için ise 61,2-68,2 ve 64,2-73,3 g olarak bildirilmiştir (Anonim, 1994).

1992-1995 yılları arasında yapılan karşılaştırmalı yumurta performans testlerinden elde edilen sonuçlara göre, 44 haftalık bir verim döneminde ortalama yumurta ağırlığının beyaz yumurtacılarda 61g olduğu bildirilmiştir (Bell, 1998).

ATAE'de yapılan çalışmalarda Bareed Rock-I, Bareed Rock-II, Columbian Rock, Line- 54 gibi kahverengi yumurtacı saf hatların yumurta ağırlık değerleri sırasıyla; 61,9, 62,4, 60,5, 59,3 g'dır (ATAE el broşürü,2003).

RIR-II'nin en erken cinsel olgunluğa ulaşma yaşı 116 gün, en geç ise 195 gün olup ortalama 157 gün olarak hesaplanmıştır. ATAE'nin bildirdiği ekonomik değerlerde ise 125 gündür.

1 beyaz dış kaynaklı ve 2 beyaz yerli yumurtacı genotipin, cinsel olgunluk yaşının sırasıyla 120 gün ve 141 gün olarak bildirmişlerdir (Yüceer vd, 1990).

ATAE' de Kanada'dan ithal edilerek getirilen saf hatların 1996 ve 1999'da cinsel olgunluk yaşı verim değerleri sırasıyla 1996'da Barred Rock-I 162 gün, Barred Rock-II 159,01 gün, Columbian Rock 168,71 gün, Line-54 159,53 gün, 1999'da ise sırasıyla 152,40, 141,24, 154,16, 154,70 gündür (Anonim, 2000).

ATAE'de yapılan 1999-2000 yılı Grand-Parent (Büyük Ebeveyn) hatlara ait cinsel olgunluk yaşı verim değerleri şöyledir; Sh(Ana hattı) 150,5 gün, Gh(Baba hattı) 157,2 gün, Sy (Ana hattı) 157,8 gün Gy (Baba hattı) ise 160,2 gündür (Anonim,2000).

ATAE'de ki kahverengi saf hatların cinsel olgunluk yaşları sırasıyla; Barred Rock-I 132 gün, Barred Rock-II 130 gün, Columbian Rock 133 gün, Line-54 121 gündür (ATAE el broşürü,2003).

RIR-II'nin yapılan araştırmada cinsel olgunluk ağırlığına max. 2400 g, min. 1250 g ağırlıkta ulaştığı tespit edilmiş, ortalama cinsel olgunluk ağırlığı 1842 g olup, ATAE'nin belirlediği ekonomik değerlerde 72. hafta sonu canlı ağırlığı 2223 g' dır. Canlı ağırlık bakımından ATAE'de ki diğer kahverengi yumurtacı saf hatlardan düşük olup Line-54 ile aynı değere sahiptir.

Avrupa'da yapılan rasgele örnekleme testi sonuçlarına göre ISA Bobcock B-300 beyaz ve ISA Bobcock B-380 kahverengi yumurtacı hibritlerin

cinsel olgunluk ağırlığı sırasıyla 1280 g ve 1790 g verim dönemi sonu ağırlığı ise sırasıyla 1760 g ve 2210 g'dır (Anonim,1986).

Avrupa'da 1985 yılında beyaz ve kahverengi yumurtacı hibritlerde yapılan araştırmalar sonucunda cinsel olgunluk ağırlığının sırasıyla 1280-1390 g ve 1550-1700 g arasında olduğu, verim dönemi sonu (500 gün) canlı ağırlığının ise sırasıyla 1790-1970 g arasında olduğu bildirilmiştir. 1986 yılında ise, cinsel olgunluk ağırlığı beyaz ve kahverengi yumurtacı hibritlerde sırasıyla 1340-1440 g ve 1650-1770 g arasında verim dönemi sonu canlı ağırlığı ise sırasıyla 1780-1930g ve 2240-2300 g arasında saptanmıştır (Anonim,1989).

ATAE'de Kanada'dan ithal edilerek getirilen saf hatların 1996-1999 yılı cinsel olgunluk ağırlığı değerleri 1996 yılı Barred Rock-I 2000 g, Barred Rock-II 2024.3 g, Columbian Rock 1891,69 g, Line-54 1738,1 g olup ,1999 yılında ise sırasıyla 1976,5 g, 1942,9 g, 1931,09 g, 1729,9 g' dır (ATAE el broşürü, 2003).

SONUÇ

ATAE' de yapılan çalışmalarda 1960-1970'li yıllarda başlangıç materyalinin saf hat olmaması ve bu hatlara zaman zaman farklı kan katarak yeni kombinasyonların elde edilmesi sonucu sürekli bir ilerleme sağlanamamıştır. Bu çalışmada hayvan materyali olarak RIR-II kahverengi yumurtacı hattı kullanılmış olup bu hat 1964 yılından bu yana Amerikan ve İngiliz hatlarının melezlenip, kapalı yetiştirilmeleri sonucu elde edilmiştir. Bu hat saflaştıkça RIR-I'e yakın özellikler göstermiştir.

Bu çalışmada ATAE'de yetiştirilen yumurtacı saf hattın çeşitli özelliklerinin belirlenmesi ve bunların aynı koşullarda yetiştirilen dış kaynaklı genotipler ile karşılaştırılması ,Türkiye'de yürütülen çalışmalara katkı sağlaması amaçlanmıştır. Araştırmada RIR-II kahverengi yumurtacı hattın yumurta verimi,yumurta ağırlığı, cinsel olgunluk yaşı ve cinsel olgunluk ağırlığı gibi özellikler üzerinde durulmuştur. Yapılan 43 haftalık performans değerlendirmesinin sonuçları aşağıda belirtilmiştir. Bütün verim süresi boyunca yumurta verim değerleri Barred Rock-I, Barred Rock- II, Columbian Rock, Line -54'e göre yüksek olup RIR-I 'e yakın değerler gösterse de yumurta verimi ve yem değerlendirme daha düşük bulunmuştur. Ancak yumurta kalite özellikleri iyi olduğu söylenebilmektedir. Yapılan analizler sonucunda 28. , 32. ve 36. hafta yumurta ağırlık ortalamaları karşılaştırılmış, her geçen hafta yumurta ağırlık ortalamalarında artış gözlenmiş ancak önemli bir fark bulunamamıştır ($p<0,05$). Bu durumda yem tüketiminin artmasıyla ileriki haftalarda artan canlı ağırlığın yumurta ağırlığını artırdığı söylenebilir. Cinsel olgunluk yaşı bakımından RIR-I 'e yakın değerlere sahip olsada, Line-54'ün cinsel olgunluk yaşı daha düşüktür. Ancak ATAE'de yapılan birçok araştırmanın bulgularına göre cisel olgunluğa erişme yaşı diğer hat ve melezlere göre düşük olduğu söylenebilir. Canlı ağırlık değerleri ve yem tüketimi RIR-I'e yakın olmakla beraber daha düşük olup, diğer saf hatlarla karşılaştırıldığında sadece Line-54'ün değerlerinin daha düşük olduğu söylenebilir.

Sonuç olarak ATAE'de yetiştirilen RIR-II kahverengi yumurtacı saf hattın diğer saf hatlara göre genel verim özellikleri göz önüne alındığında yem değerlendirme ve yumurta verimi yüksek düzeyde olup, yapılan melezlemede iyi kalitede bir baba hattı oluşturulmuştur.

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CHAPTER 5

EVALUATION OF FOREST CADASTRE STUDIES (ARTVİN REGİONAL DİRECTORATE OF FORESTRY EXAMPLE)

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Forests need to be legally recorded in order to maintain their existence, protect them and maintain them in a planned manner. This is possible by determining the boundaries of forests. OGM can legally work in forest areas within its own borders. The finalization of the qualification of the working areas as forests is done by forest cadastre.

Cadastre was initially organized to collect taxes in a fair and regular manner from agricultural lands, which were the most important means of production at the time, in order to meet the common expenses of societies. Over time, it has been determined that it is a reliable tool that can be used in the resolution of ownership and boundary disputes regarding immovable property, and this feature has started to be utilized. Gradually, the area of use, power and benefit of cadastre has increased and today, it has become an indispensable tool in the transfer and implementation of all kinds of research, planning and projecting studies for the land and the transfer of the prepared plans and projects to the land (Erkan, 2010).

In the world and in Turkey, the determination of the boundaries and ownership of forests and all other immovable properties is ensured by cadastre, and the cadastralized immovable properties are secured by being registered in the land registry. However, in our country, not all forests and other immovable properties have yet been cadastralized and registered in the land registry. Forest cadastre, which has been seen as an important problem for many years, has been solved many times with legal regulations, but each solution law has led to the emergence of a new set of problems. Today, forest cadastre is waiting to be solved in a ball of problems from the past (Gençay, 2012).

In Turkey, cadastre of immovable properties is carried out according to three different institutions and laws. These are general cadastre according to the cadastral law numbered 3402, forest cadastre according to the forest law numbered 6831 and pasture cadastre according to the Pasture Law numbered 4342 (Ayanoğlu, 1992).

According to Law No. 6831, the authority to carry out forest cadastre belongs to forest cadastral commissions. Commissions consist of 5 people under the chairmanship of a forest engineer or a forest engineer. The maps created by the commissions as a result of their work must be registered. The maps issued are subject to registration. Although the responsibility for maps and plans should be with the map and cadastral engineer in accordance with the legislation, there is no map engineer in the cadastral commissions. This situation results in maps and plans not having the desired technical qualities. Therefore, it causes the forest cadastral works to drag on.

On the other hand, Article 4 of Law No. 3402 also authorized cadastral teams to determine forest boundaries. However, this time there were no forest and agricultural engineers in the cadastral teams. As a matter of

fact, the objections of the forest administration to the works carried out by the cadastral teams were high, and the immovables deeded in this way remained within the forest map in the forest cadastre made later (URL-1, 2021).

This two-headedness caused problems in practice, and the view was gaining weight that the problems in practice could be overcome if both cadastres were carried out by a single institution from a single source. In order to realize this view, Law No. 3402 was amended by Law No. 5304. With this amendment; in case there is a forest in the unit where the facility cadastre is carried out, the participation of one forest engineer and one agricultural engineer in the cadastral team is obligatory (URL-1, 2021).

Thus, in areas where forest cadastre has not yet been started or has not yet been finalized even if it has been started, it would be ensured that the establishment cadastre and forest cadastre would be carried out through cadastral directorates from a single source. However, forest cadastre was still being carried out by forest cadastral commissions in places where forest cadastre had not yet been carried out, although the first facility cadastre had already been carried out. This meant the continuation of the two-headedness in forest cadastre (URL-1, 2021).

Finally, in accordance with Annex Artıcle 5 added to the Cadastral Law No. 3402 with the Law No. 6495; if the forest cadastre has not yet been carried out in the previously cadastralized working areas, the cadastre of these forests will also be carried out by cadastral teams in accordance with the Cadastral Law No. 3402. Thus, the cadastre of all forests during or after the establishment cadastre will be carried out by cadastral teams in accordance with the Cadastral Law No. 3402. This is a positive arrangement brought by Law No. 6495, as the two-headedness is now completely eliminated.

In order to achieve the desired efficiency, the obligations set out in the protocols between the Directorate of Land Registry and Cadastre and the General Directorate of Forestry must be fulfilled in full. It should be ensured that the forest engineer requested by the Cadastral Directorate to participate in the cadastral team on time (URL-1, 2021).

In this study, the process of forest cadastre in Artvin forests was examined and evaluated. The cadastral studies carried out in Artvin Regional Directorate of Forestry, which was selected as the study area, and the data on the legal basis of these studies were obtained and the cases of objection to the cadastral studies carried out in the region were examined.

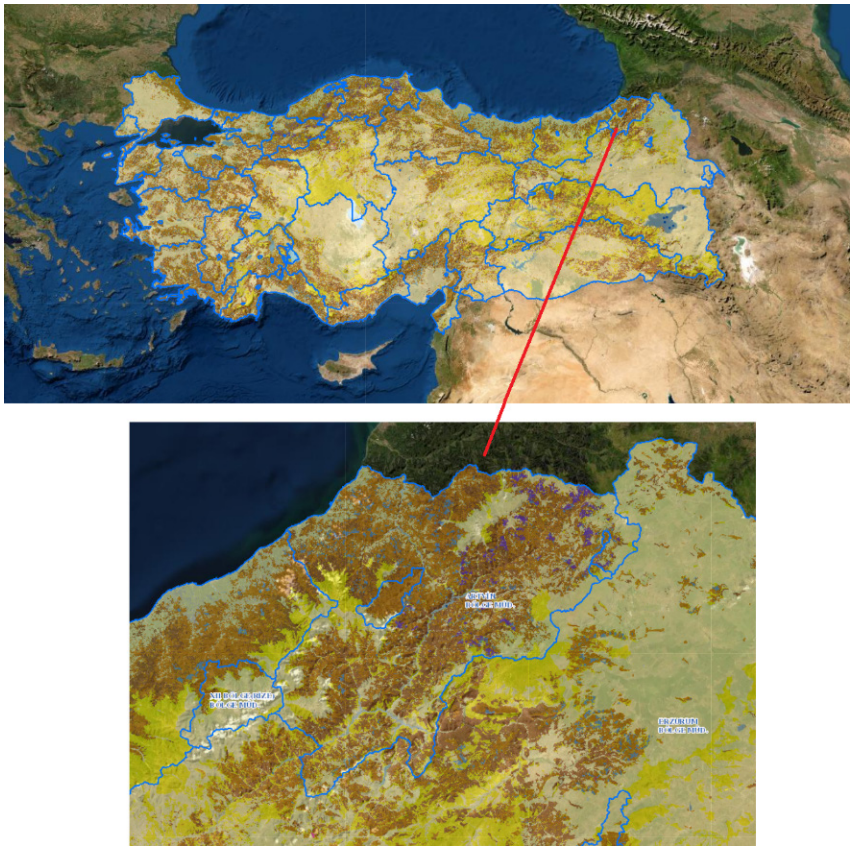
1. MATERIALS AND METHODS

1.1. Material

Artvin Regional Directorate of Forestry was selected as the research area. The records of forest cadastral works of Artvin Regional Directorate of Forestry Cadastre and Property Branch Directorate, documents showing the legal basis of forest cadastral works were used as material in the research. The situation after 2007 was considered in the study.

This study deals with the forest cadastral works carried out in the areas of Artvin Regional Directorate of Forestry, which is one of the thirty regional directorates of the General Directorate of Forestry.

Graph 1, where the map of the study area is given, shows the location of the study area in Turkey..



Graph 1. Map of the research area

In this study, the forest cadastral activities carried out in the areas of seven Forestry Directorates in total, namely Ardanuç, Arhavi, Artvin, Borçka, Murgul, Şavşat and Yusufeli Forestry Directorates within the borders of Artvin Regional Directorate of Forestry were examined.

The research area is the province of Artvin located in the Eastern Black Sea Region of the Black Sea Region. Artvin, a border province in the north-east of Turkey, has a surface area of 7359 km2 and 23 people per square kilometer. The population density of Artvin is 23/km2" (URL-3, 2022).

According to the estimated data, the population of Artvin in 2022 is 170108. This population data is estimated according to the population growth rates in previous years. The official population data for Artvin 2022 will be announced at the beginning of 2023 (URL-3, 2022).

1.2. Method

In this study, data sources such as institutions, published sources, unpublished documents, documents and archive documents were utilized.

In the study, all cadastral studies carried out after 2007 on the lands within the borders of Artvin Regional Directorate of Forestry were accessed. First of all, "Artvin province forest existence table" was created. Then, in the light of the data obtained from Artvin Regional Directorate of Forestry, Cadastral and Property Branch Directorate, the "cadastral studies table" and the "forest areas as a result of cadastral studies" table made after 2007 were created.

2. FINDINGS AND DISCUSSION

2.1. Forest Assets of Artvin Regional Directorate of Forestry

The forest area of Artvin province is 398,089.9 ha. Within the administrative boundaries of Artvin province, there are Ardanuç, Arhavi, Artvin, Borçka, Murgul, Şavşat, Yusufeli Forest Management Directorates under the Artvin Regional Directorate of Forestry (URL-5, 2022).

The forest areas of Artvin province are shown in Table 1 on the basis of forest management directorates.

Table 1. Forest assets of Artvin forest regional directorate (URL-2, 2022)

Forest Management Directorate	Normal Forest (ha)	Degraded Forest (ha)	Total Forest Area (ha)	General Area (ha)
Ardanuç	18.803,7	19.300,0	38.103,7	76.817,0
Arhavi	20.573,5	8.314,1	28.887,6	48.953,5
Artvin	45.531,3	35.538,6	81.069,9	109.299,3
Borçka	56.032,1	26.397,2	82.429,3	118.785,0
Şavşat	31.222,3	34.200,7	65.423,0	134.042,2
Yusufeli	35.903,4	68.273,0	104.176,4	224.179,4
TOTAL	**208.066,3**	**192.023,6**	**400.089,9**	**712.076,4**

As seen in the data in Table 1, Artvin Regional Directorate of Forestry was established on an area of 712,076.4 ha. There are 208,066.3 ha of normal forest and 192,023.6 ha of degraded forest, totaling 400,089.9 ha of forest area. In addition, 311,986.5 ha of the area is unforested. In summary, 29.22% of the Artvin Regional Directorate of Forestry area is normal forest area, 26.97% is degraded forest area and 43.81% is unforested area. In this case, 56.19% of the area is forest and 43.81% is non-forest area.

2.2. Forest Cadastral Studies in Artvin Regional Directorate of Forestry

In the forest cadastral works in Artvin province, the practices carried out by the forest regional directorate were carried out according to the laws numbered 3302, 6831, 1744, 4999, 6292 4th article, 7269; the practices carried out by the cadastral directorate were carried out according to the laws numbered 3402, 2613, 6495, 766, 5304.

The forest cadastral works carried out in Artvin between 2010-2021 are given in Table-2**.**

Table 2. Forest cadastral surveys conducted between 2010-2021 in Artvin province (URL-8, 2022)

Years	Forest Area as a Result of Cadastre (ha)	Registered Forest Area (ha)	Annual Forest Cadastral Work Amount (ha)
2010	222.262,00	204.962,00	-
2011	230.988,00	213.784,00	8.726,00
2012	302.871,00	302.871,00	71.883,00
2013	241.269,00	337.889,00	-61.602,00
2014	396.379,00	337.889,00	155.110,00
2015	396.379,00	381.615,00	00.000,00
2016	415.636,00	382.131,00	19.257,00
2017	430.184,00	390.549,00	14.548,00

2018	431.461,00	410.898,00	1.277,00
2019	445.511,00	413.339,00	14.050,00
2020	445.511,00	422.773,00	00.000,00
2021	466.170,85	424.567,52	20.659,85
TOTAL	-	-	243.908,85

From 2010 to 2021, the cadastral forest areas and registered forest areas as a result of the cadastral cadastral studies carried out in Artvin OBM by year are given in Table 2. When the data are analyzed, it is seen that the most work was done in 2014. In 2013, there was a decrease in the forest area as a result of cadastral survey. This situation refers to the forest area that decreased as a result of the conclusion that it was not forest as a result of the examinations made during the objection lawsuits filed against the determination made as a result of cadastral work.

As of 2021, the data of the forest cadastral studies carried out within the borders of Artvin Regional Directorate of Forestry according to the Forest Management Directorates are shown in Table 3.

As of 2021, the data of forest cadastral surveys carried out within the borders of Artvin Regional Directorate of Forestry according to Forest Management Directorates are shown in Table 3.

Tablo 3. Forest cadastral works carried out in Artvin province as of 2021 (Records of Artvin OBM Cadastral Departmant Directorate, December 2021)

Forest Management Directorate	Cadastral Forest Area (ha)	Registered Forest Area (ha)	%
Ardanuç	40.761,63	38.352,38	93,84
Arhavi	32.742,22	32.757,11	100,05
Artvin	95.362,73	95.197,94	99,83
Borçka	85.497,62	69.949,32	81,81
Şavşat	65.354,31	54.288,34	83,07
Yusufeli	146.452,34	134.122,43	91,58
TOTAL	**466.170,85**	**424.567,52**	91,08

As can be seen in Table 3, as of 2021, the cadastre of 466,170.85 ha of the study area has been completed and 424,567.52 ha of these areas have been registered. This shows that 91.08% of the area that needs forest cadastre has been completed.

In her study, Ozdemir stated that "by the end of 2007, a total of 114,754.3 hectares of forest area had been cadastred in the province. The ratio of the cadastred forest area to the total forest area is 29%" (Ozdemir, 2008). Looking at the current situation, there has been an increase of 62.08% since 2007. According to the data in Table 3, 8.74% of the cadas-

tre work was conducted in Ardanuc, 7.02% in Arhavi, 20.46% in Artvin, 18.34% in Borcka, 14.02% in Savsat, and 31.42% in Yusufeli Forest Management Directorate boundaries.

When we look at the forest areas of the Artvin Forest Regional Directorate given in Table 1, we see that it is 400,086.9 hectares, while in Table 3, the forest cadastre study data shows that the cadastre completed forest area is 466,170.85 hectares. In this case, it is possible to say that there is an increase in the total area of forest areas during cadastre studies. During the cadastre studies, while negative changes are made in areas where the forest quality has been lost, that is, when the cadastre study results in a qualification other than forest, it is also revealed that areas previously not seen as forest but now should be considered as forest due to their forest nature. For example, the result of a cadastre study on a field that was previously a meadow but now has forest cover, revealing that the field is currently in a forest quality and should be registered as a forest in the cadastre, is defined as in favor of the forest. On the other hand, the situation that arises when a field known as forest and recorded as forest in previous plans loses its forest quality over time due to clearings or unauthorized uses and then takes on a different qualification through forest cadastre studies is referred to as against the forest. The reason for the difference between the Forest Regional Directorate and the cadastre study results is this situation. The results that are finalized with the registration process in the land registry after the cadastre studies are also entered into the forest area table through occasional updates made in the resources of the Forest Regional Directorate.

The practices carried out by the Forest Regional Directorate and the Cadastre Directorate in forest cadastre studies, as well as the areas where these practices are valid on a management directorate basis, are listed in Table 4. In addition, the forest management directorate to which the cadastre study area is affiliated, its district, location, cadastre directorate, the legal practices carried out by the Forest Regional Directorate, and the forest and 2b areas determined as a result of the forest cadastre studies are also provided in the table.

3. RESULTS AND RECOMMENDATIONS

The historical development of forest cadastre, the implementation of forest cadastre studies, and the problems encountered in forest cadastre studies from the past to the present were examined in the evaluation of the cadastre studies of the Artvin Forest Regional Directorate. The reason for following such a path is the understanding that today's problems are rooted in past issues. The determination of the boundaries of state forests and the registration of these forests in the land registry first occurred in 1937. Since then, the goals set for the completion of forest cadastre in Turkey have not

been achieved due to various reasons. In order to expedite cadastre studies by reducing the problems encountered during forest cadastre works, several legal changes have been made. However, while these changes have resolved certain issues, they have also caused other problems. The aim of this study is to evaluate the forest cadastre studies carried out at the Artvin Forest Regional Directorate within the current framework and to provide solutions to the problems encountered.

The regulations on forest cadastre have been made with the laws numbered 3116, 6831, 1744, 2896, 3302, 3402, 5304, 6495, and 7139. When looking at the past to the present, some of the forest cadastre problems, which have decreased compared to the past, continue to persist. The frequency of legal regulations made to solve forest cadastre problems and the necessity for the personnel responsible for the implementation of these regulations to visit the same field repeatedly undermine the public's trust in the administrative units. As seen, while legal regulations are made to solve problems on one hand, new problems arise due to situations that undermine trust on the other hand.

Another issue is the lack of skilled personnel and insufficient equipment, which slows down the work and hinders the achievement of goals related to forest cadastre activities. To address this, the institution should prioritize the training of personnel. Internal training programs should be increased, and the necessary equipment and tools for the personnel should be provided by the institution. In order to minimize the margin of error in the work, the technological quality of the equipment and tools should be ensured.

One of the longstanding issues in the implementation of forest cadastre activities is the lack of coordination between institutions. However, in the current situation, with the legal regulations made in this regard, the lack of coordination between institutions has been minimized.

The attitude of the public towards forest cadastre activities has a significant impact on the course of the work. Sometimes, the resistance of the public to the implementation of the work causes delays. Examples of these delays include objections and lawsuits against the results of forest cadastre activities, which can take a long time to resolve. When these issues are resolved, it is expected that the relationship between the forest and the public will develop positively.

Another issue is the lengthy process for the finalization of forest cadastre. Since this is a legal process, the acceleration of this process can only be achieved through legal regulations. Recent legal regulations have not shortened this period, so the problem persists. These periods can be shortened with new regulations.

In this study evaluating the forest cadastre works between 2007 and 2021, a 62.08% progress has been recorded in forest cadastre over 15 years. In recent years, forest cadastre works at the Artvin Forest Regional Directorate have gained momentum, with 91.08% completion.

The forest cadastre works in Artvin province were carried out in accordance with the laws numbered 3402, 5304, 2613, 6495, 766, 3302, 6292, 1744, 6831, 4999, and 7269. As of 2021, the forest cadastre works identified a forest area of 466,170.85 hectares, and 424,567.52 hectares of this area have been registered. The ratio of the registered area to the total area is 91.08%. This represents a 62.08% increase from the ratio of 29% before 2007.

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CHAPTER 6

CLOUD COMPUTING IN AGRICULTURE

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1.Introduction

As in every sector in the world, the use of information and technologies has become widespread in agriculture. With such high-dimensional information technology, a problem arose as to how large volumes of data can be evaluated and used. It is now a vital element that these data can be stored, protected and accessed at any time and place. At this point, cloud computing, which has entered our lives, has contributed to the management of large amounts of data by adapting it to agriculture. It has undeniable benefits, mainly for ensuring high efficiency and sustainability. It is not only about efficiency, but also provides less input and high marketing ability. In this section, it is aimed to examine what cloud computing is, the opportunities and negativities it brings to agriculture, and present the results obtained by analyzing it.

The rapid increase in factors such as population, hunger and lack of resources in the world has become a common problem of countries and has enabled the formation of unity of power in solving these problems globally. Many methods have been put forward and continue to be put forward to eliminate the problematic elements. It was not only the increasing population, but also the change that has been going on for years since the industrial revolution, from hand-held tools to animal-drawn equipment, tractors and self-propelled machines, and finally to computerized autonomous structures. It is planned to integrate technology into agriculture to increase productivity, facilitate heavy operations and reduce inputs with the use of Information Communication Technologies (ICT), also known as Agriculture 4.0, which is currently used today.

In recent years, new ICT technologies have been applied in every sector of developing countries whose main source of income is agriculture. That is, ICT development is mainly focused on the agricultural sector. However, the significant investment cost and maintenance for ICT infrastructure is one of the primary disadvantages. Consequently, the main concern for information is to find ICT tool that makes farmers' operations faster, reliable, efficient, user-friendly but also cheap. Therefore, our article will deal with the concept of implementing cloud computing, one such ICT tools. Cloud Computing is the way to provide a large but well-customized, updated and secure database with instant connection feature at a reasonable investment cost. In this way, it can meet the need to know the physical location and configuration of the system, which provides services such as real-time calculation, data access and storage to end users. Therefore, if we need to improve the economic situation of these developing countries, the only way to do this is through the successful implementation of the new ICT tool, cloud computing (Erbay, H. and Yıldırım, N. (2019).

Cloud computing in agriculture, as a scalable and flexible service, maximizes the level of service between the service provider and consumers by providing a shared pool of configurable IT resources with minimal management workload (e.g. processing, network, software, information and storage).

2. Internet of things (IoT)

The Internet of Things is a network of digital objects with sensors and software to exchange and store data over the Internet. IOT (Internet of Things) has important roles in the digitization of agricultural data. IoT offers an infrastructure where devices (such as RPID-Radio Frequency identification, sensors, mobile phones) that communicate with each other through radio frequency or the internet can receive and transmit information thanks to the service providers they are connected to.

There are many benefits of using the Internet of Things, but the two most prominent aspects in agriculture are;

1. Can be used for real-time monitoring of fields.
2. Data from sensors are transferred to the cloud, processed and visualized in applications on mobile phones or computers.

3. Big Data

Big data; It refers to the transformation of all data collected from various sources such as field data, climate data, satellite and drone photographs, video and log files into a meaningful and processable format. When deciphered with right investigation techniques, enormous information can empower organizations to pursue right essential choices, better deal with their dangers and improve.

The greater part of the specialist organizations in farming keep on pursuing choices in view of the information they acquire through ordinary data warehouse and information mining methods. However, being able to predict consumer trends dynamically requires being able to analyze big data and act according to these analyses. Large information is a term that incorporates many issues, for example, the creation, stockpiling, streaming and investigation of this enormous information, which is challenging to process with conventional data set devices and calculations. The information is huge enough that old-style data sets can't deal with it, and the development pace of the information surpasses a PC or an information stockpiling unit. As per 2012 figures, 2.5 quintillion bytes of information are delivered every day on the planet. The term "Big Data" refers to any activities on this scale, including big data processing and transfer.

Big data was initially characterized by three components (Laney, 2001). However, it was later characterized as five-component and denoted 5V. These; variety, velocity, volume, verification and value. These are given below;

a. **Variety**: Unstructured data accounts for 80% of all data produced, and each new technology can produce data in a variety of formats. One has to deal with a variety of "Data Types" coming from phones, tablets, integrated circuits. Assuming you likewise consider that this information can be non-Unicode in various dialects, they should be coordinated and changed into one another.

b. **Velocity**: The speed at which Big Data is delivered is extremely high and is expanding. Data that produces quicker expects that the number and assortment of exchanges that need that information increment at a similar speed.

c. **Volume**: According to IDC statistics, the amount of data will increase from 4.4 trillion gigabytes to 44 trillion from 2013 to 2020. Again, according to IDC statistics, 20 % of digital data was processed in the cloud in 2013, while 40% in 2020. It has been stated that it will be reached (Erbay, 2016). According to IDC (International Data Corporation) statistics: Data is produced from 44 different tools, from sensors to supercomputers, from personal computers to servers (Kör, 2016). It is important to contemplate the limits and "large systems" utilized today, which we call "large", and ponder how they will adapt to information that is multiple times bigger. Organizations need to plan how information chronicling, handling, mix, capacity, and so forth. Innovations will adapt to this huge information volume. During the 2010s, absolute IT uses on the planet expanded by 5 % each year, however how much information delivered expanded quicker, that is to say, by 40 %.

d. **Verification**: One more part of this data thickness is that the information is "secure" during its stream. During the flow, it needs to be monitored at the required security level, visible to the right people, or kept secret, without adding it correctly.

e. **Value**: The creation of value is the most crucial aspect. Big Data, depicted with every one of the above endeavors, ought to make an added incentive for the association after your information creation and handling layers. It requires to in a flash affect your dynamic cycles and be readily available to assist you with pursuing the ideal choice. A government agency that makes strategic decisions about health, for instance, should be able to instantly see how diseases, medications, and doctors are distributed by region,

province, district, etc. (2022. URL: https://en.wikipedia.org/wiki/Unstructured_data (visited on).

3.1 Strategic Importance of Big Data and Usage in Türkiye

The most important criterion that reveals how valuable data is is the value it adds to the critical decision process. Big data is used in many areas such as crime prevention, defense, security, revenue management, transportation, etc.

Big data usage in our country is at 1V level, Ministry of Development 2014-2018 Information Society Strategy and Action Plan Draft 50th Action "Implementation of Big Data Pilot Application in the Public Sector" is planned to be completed in 2014-2016. With this action, it is aimed to transform big data into economic value and to develop big data applications in the public sector, especially in areas such as social security, health, tax and security. (Erbay, H. & Kör, H. (2016; Erdoğan E and Bejaranobig J S. (2020).

4. Cloud computing

Cloud Technology is characterized as programming applications, information capacity administration and handling limits over the web. It permits admittance to a wide range of data and individual information from any place, whenever, even with the least limit gadget. It uses a digital network to connect multiple servers for these operations. The three building blocks of cloud technology are SaaS (Software as a Service); offering software as a service, PaaS (Platform as a Service); platform service and IaaS (Infrastructure as a Service); server infrastructure service. (Figure 1).

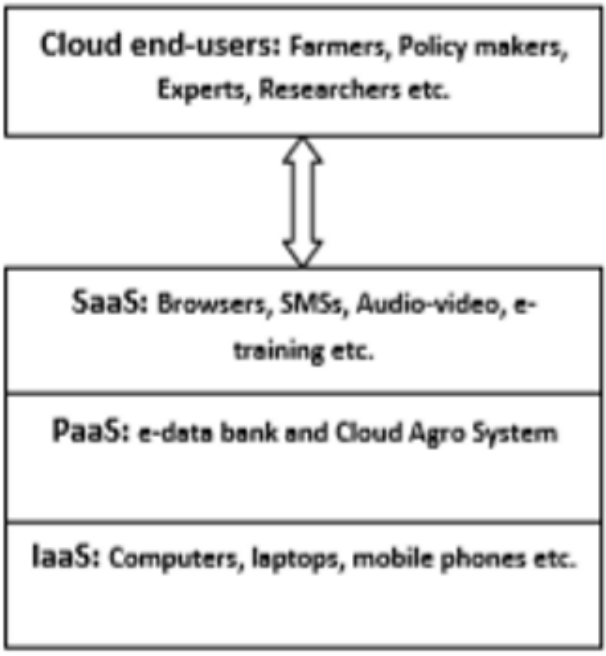

Figure 1. A Simple Cloud Structure (Chaudhuri, 2012)

Cloud technology is laid out and shared by huge associations. The cloud server supports a wide range of applications and reduces the load on personal computers through the use of this technology. Ordinarily, clients would rather not download and introduce applications on their PCs. All handling and stockpiling are given by the cloud framework. By putting away every one of the applications, projects and information we have on the web on a virtual machine, most ordinarily known as the cloud, this data, projects and information can be handily gotten to in any area with a gadget associated with the web.

Advantages of Cloud Technology

- Cloud computing systems provide fast ease of use with APIs.
- It gives various open doors, for example, more extra room, quick information move and cost reserve funds on this reinforcement.
- The infrastructure complexity created by issues such as archiving of ever-increasing data and authorization and tracking of users is eliminated.

- Cloud technology software is platform-independent and can be used on computers, tablets, smartphones, and Smart TVs because it runs through web browsers.
- The servers where the data of companies providing cloud software services are kept are safer than the main computer because they take software and hardware security measures 24/7.

Briefly; Cloud computing is a service that is much cheaper, does not require installation, and supports working from anywhere.

Disadvantages of Cloud Technology

- Putting away information utilizing cloud innovation administration seriously jeopardizes the client's information and can't guarantee data security and client protection. There are numerous security weaknesses.
- Because of the monetary circumstances of nations, it will expand the advanced gap, which will cause global, political and financial issues.
- The main issue is that there should be a web association with access to the put away information. To put it another way, without access to the internet, it is impossible to access our information. On the off chance that you have low-speed web association, your information trade speed will be slower too.
- The fact that the costs of software and hardware maintenance and repair will go down as a result of the growth of services is one of the last drawbacks. As a result, there will be fewer IT professionals working in these fields.

4.1 Features of Cloud Computing

- Being optional: The user will be able to access the information he wants unilaterally without requiring human or human interaction.
- It has a wide network system: It can be easily reached from any client that can access the network (tablet, phone, computer, etc.).
- Measured service: Payment per parameter used.
- Fast flexibility: Cloud computing is sometimes required to be fast and flexible.

- Resource pooling: service providers are gathered in one area to help many consumers. The customer has a sense of location independence. There is typically no data, for example, the area of the assets given, yet to indicate the area at a more elevated level of virtuality (for instance, nation, state, or server farm), instances of assets incorporate capacity, handling, memory, network transfer speed, and virtual machines.

4.2 Cloud Model

The three building blocks of cloud technology are SaaS (Software as a Service); offering software as a service, PaaS (Platform as a Service); platform service and IaaS (Infrastructure as a Service); server infrastructure service.

4.2.1 Software as a Service (SaaS) Application services, optionally directly over the network. Cloud consultants and administrators are required for such services. Examples are email addresses and some Google applications (Figure 2).

4.2.2. Platform as a Service (PaaS) Developing custom applications for customers with computer design and minimal redundancy. It also takes care of these hosts. Applications that are not related to hardware and data storage requirements. It also guarantees. Availability and security of the latest platforms (Figure 3).

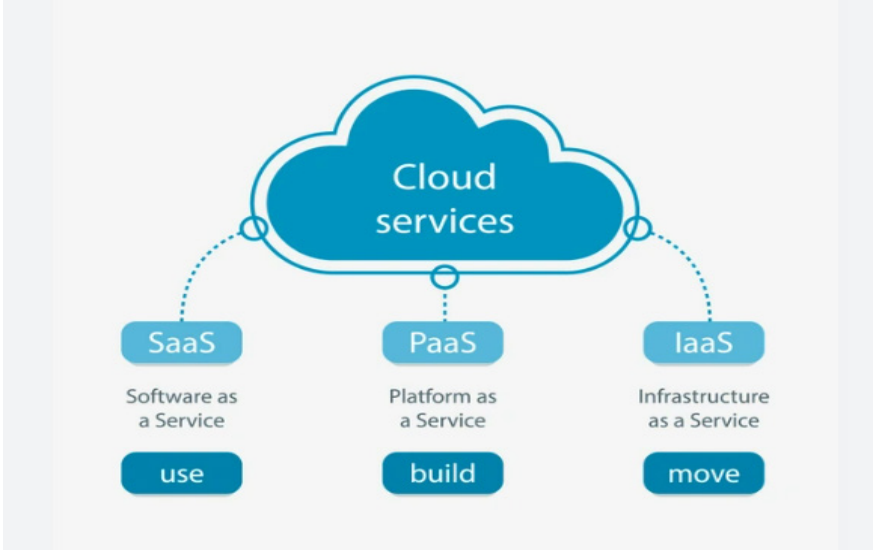

Figure 2. Cloud model services structure (https//www.endustri40.com/Cloud computing)

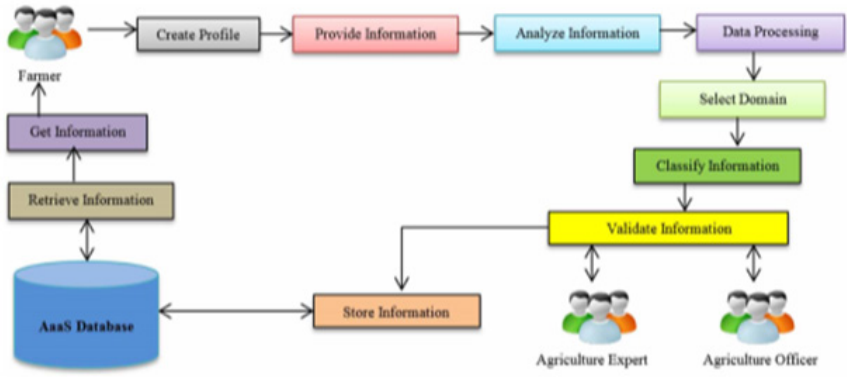

Figure 3. Interaction Structure of PaaS in Agriculture (Gill S S et all, 2017)

4.3. Deployment Module of Cloud Computing

Cloud infrastructure is run either on-premises or off-premises for a single organization only. It might likewise be possessed, overseen and worked by the association or an outsider. This technology, which comes in 4 different types, allows it to be used in different areas and in different ways (Figure 4).

4.3.1 General Cloud It is a type of cloud that some companies and organizations offer to consumers either publicly or for a fee. Organizations such as Amazon and Google can be given as examples.

4.3.2 Community Cloud It is the type of infrastructure used by communities that have the same jurisdiction (security compliance jurisdiction, etc.).

4.3.3 PrivateCloud It is a type of cloud that is used and managed only by a single company or organization.

4.3.4 HybridCloud It consists of the combination of at least two or more (public, community, or private) clouds.

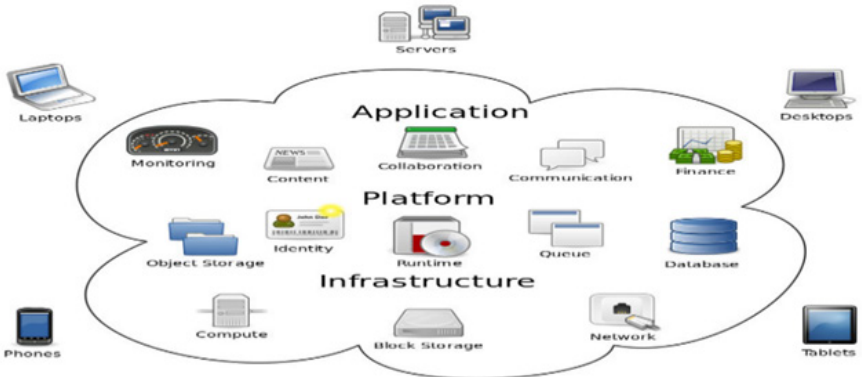

Figure 4. Cloud Computing and Distribution Modules (Choudhary S K et all, 2016)

5. Cloud computing use in agriculture

The agricultural sector is a science that has a very complex structure and in case of a minor disruption and conditions are not met or precautions are not taken, production and efficiency can be greatly affected. It is affected by many factors temporally or spatially, and collecting, analyzing and applying this information requires serious investment and technology (Figure 4).

When we look at developed countries, agriculture appears to be the main source of income and ICT development is directed towards this sector. However, agricultural systems cannot meet the needs of today's generation due to large amounts of processing. Data, processing speed, data storage space, reliability, availability, scalability, etc. The lack of important requirements such as and even the resources used in computer-based agricultural systems are not used efficiently.

Cloud computing networks are configurable networks that provide access to a shared pool of servers, storage, services, applications, and other critical computing resources. In the modern era of cloud computing technology, all agriculture-related data banks (soil-related parameters, satellite images, weather, information, product development, communication between farmers, E-commerce and agricultural marketing, fertilizers and pesticide information, etc.) are centralized in the cloud to achieve the desired results. In time, it becomes possible to access these data (Figure 5).

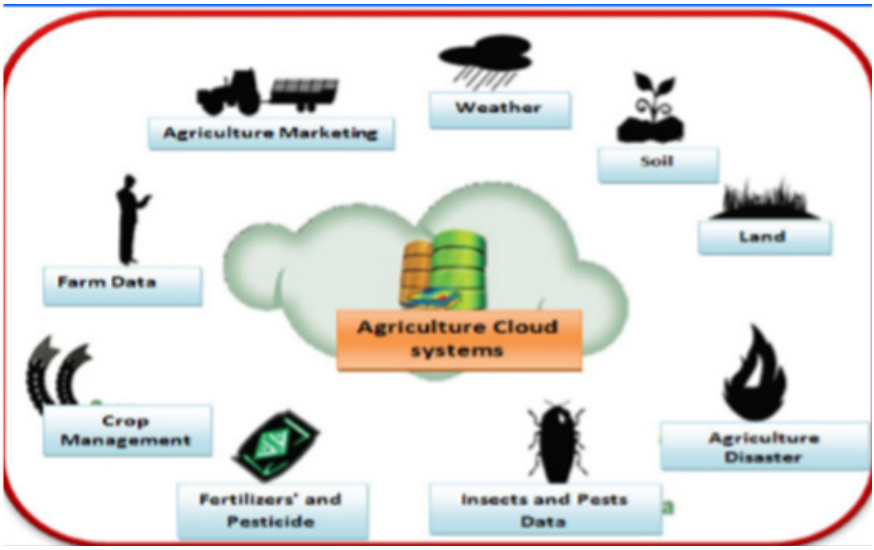

Figure 5. Agriculture Cloud System (Choudhary S K et all, 2016)

As an example of cloud computing application in agriculture, we see that it is also used as a plant tracking system in agricultural areas such as orchards or fields. Information received with the help of different sensors and nodes is sent wirelessly to the cloud-sensor network. Instant data is monitored and stored. Cloud network unmanned aerial vehicles enable operations such as spraying and fertilizing at appropriate times and conditions. The applied inputs are used with the lowest usage amount and therefore low cost. Tracking of plants grown in agricultural production areas includes information about their health and development status, mainly visual information (diseases and pests, fruit growth status, leaf area, etc.) and phytobiota information (chlorophyll content, product nitrogen, photosynthetic rate, etc.). A typical cloud-based plant monitoring system is shown in Figure 6.

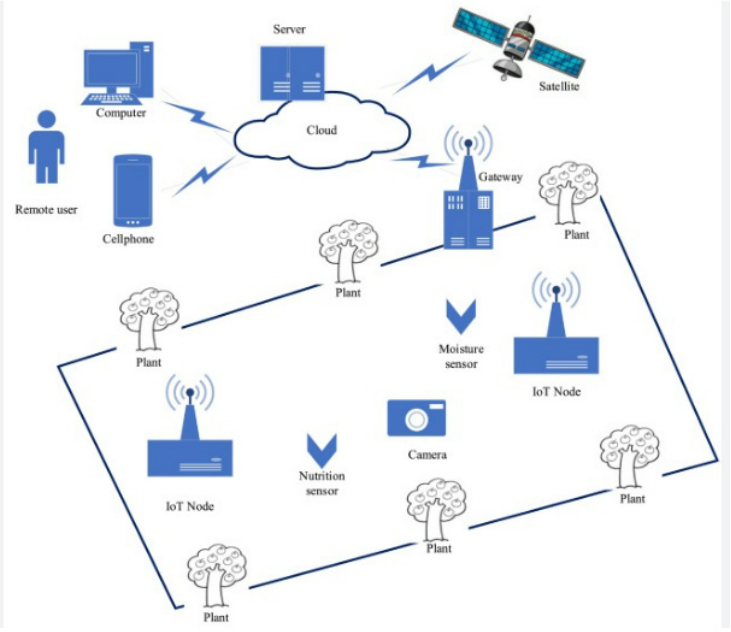

Figure 6. Typical cloud-based plant growth information monitoring system (Xu J et all,2022).

Cloud System Role in Agriculture;

- Agriculture information database (crop, weather, soil, growth status, farmer data and expert consultation)
- Store all agriculture-related information in a central cloud; users anytime, anywhere
- The board of all information connected with land, area and location; Central decision support systems thanks to soil and soil properties
- High integration and agricultural information sharing. Providing agricultural technology service and science that it can eliminate farmers' technical knowledge and resource constraints
- Improving marketing of agricultural products
- Proficient utilization of agricultural resources
- Advance the dissemination of agricultural items and administrations all the more broadly.

IoT for smart applications in agricultural machinery Integrated and monitored with cloud systems requires internal, cluster and remote com-

munication and data sharing. The communication and control between agricultural machinery's sensors, actuators, and central processing unit is referred to as internal IoT. Cluster IoT alludes to correspondence and control between agrarian apparatus. Remote IoT alludes to correspondence and control between the functional site and distant terminals and servers. The structure of smart agricultural machinery IoT is shown in Figure 7.

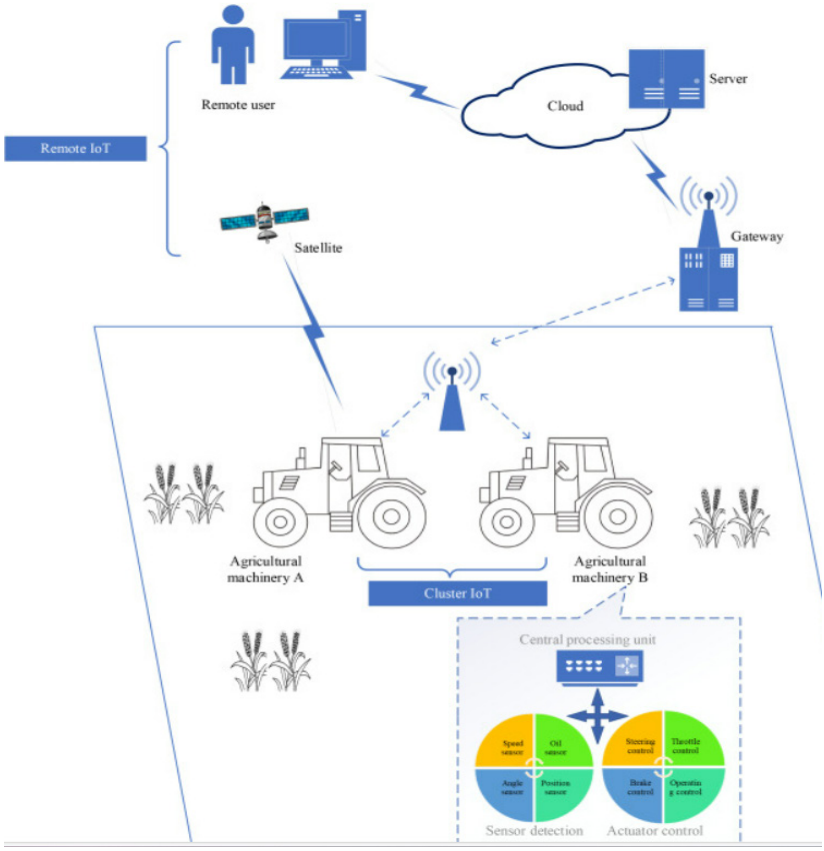

Figure 7. Cloud-integrated smart agricultural machines IoT structure (Xu J et all,2022).

6.Conclusion

Cloud computing in agriculture is considered among the new Technologies that will provide significant benefits in Turkey when applied appropriately. The model can make a positive contribution to the overall economic development by closing the knowledge gap within and outside the country. In the agricultural sector, effective implementation of cloud computing will encourage other clouds. This prominent technique can deliver agriculture-based knowledge, as well as natural resources management and knowledge, directly to consumers, but also across a wider region. This will change the entire supply chain, which is currently mostly in the hands of large companies, but could evolve into a more direct, shorter chain between producers and consumers. Therefore, it needs mass awareness and promotion among key stakeholders to achieve its full potential for the nation.

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CHAPTER 7

EVALUATION OF PEST CONTROL IN FORESTS OF TURKEY

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Turkey's rich biodiversity and vast forest areas constitute an important economic and ecological resource of the country. Technological advancements, increasing human population, emission of greenhouse gases into the atmosphere, climate change, and many other harmful factors have created a significant problem for forests in terms of the pressure and damage caused by insects. These damages threaten the health, productivity and long-term sustainability of forests. Therefore, pest control is recognized as an important component of Turkey's forest management strategy.

Sustainable management of forests is becoming extremely important for humanity, considering issues such as environmental problems, climate events, lack of usable and healthy water resources, food security and social expectations. forests preserve water, prevent erosion, preserve biodiversity. Forestry balances the needs of society. It should be managed with an approach that is compatible with changing technology, evolving desires, and a shifting human profile.

The world's forest areas consist of approximately 4 billion hectares. Between 1990 and 2015, one third of the world's forest areas, i.e. one hundred and twenty-nine million hectares, were lost for various reasons. After 1990, forest loss began to occur worldwide. The forest area, which was 7.6 million hectares, decreased to 3.3 million hectares in 2015. 34.1% of the forest assets are used for production, 9.3% for soil and water conservation, and 11.7% for biodiversity purposes.(Eroğlu, 2017). The highest annual forest growth rates (more than 0.5%) are observed in China and the surrounding East Asian countries, as well as in Southern Europe, the Adriatic and Balkan countries. Sustainable Forest Management envisages the protection of forests and forest areas against all threats and hazards in the future, ensuring biodiversity, productivity, self-renewal, ecological, economic and social functions at local, national and global levels. Our forests, which constitute approximately 30% of the total area of our country, need to be protected from all kinds of damage (İnanç, 2021).

According to recent scientific studies, millions of hectares of forests have been lost due to pests in addition to human interventions. With their wide adaptability based on their biological characteristics and very high reproductive rate in a very short time, the insects, which spread almost worldwide, threaten an entire forest and often cause five times more damage than forest fires. Some of these harmful bark beetles are known as Dendroctonus micans (Kug), Ips typographus (L), Ips sexdentatus (Boern). Turkey's forestry policy fulfills its duties to protect, develop and expand forests in harmony with nature within the framework of sustainable forest management approach, and to operate them in a way to provide multifaceted benefits to society. Projects and action plans prepared for the protection, development and improvement of forests in terms of quantity and

quality, ensuring social and economic development and making more use of forests with rich resource values have been put into practice.

Important plans and programs regarding the management of forests are shown below. (Anonymous, (2019), (Anonymous, (2004), (Anonymous, (2010), Anonymous, (2011).

-Eleventh Development Plan (2019-2023)-

-Turkey National Forestry Program (2004-2023)-

-Turkey Climate Change Strategy (2010-2023)-

-Republic of Turkey Climate Change Action Plan (2011-2023)-

- Forest Inventory and Monitoring System

This study aims to evaluate the effectiveness of pest control programs in different forest regions of Turkey. For this purpose, the success rates and effects of control measures on forest pests and diseases in different regions were examined. The use and effectiveness of chemical and biological control methods were also investigated.

MATERIALS AND METHODS

Material

Study Area

Turkey's forest assets were determined by the evaluation of Forest Management Plans, which were arranged to cover all forests throughout the country for the first time between 1963-1972 and were published in 1980. Our forest assets reached 20.2 million ha in the 1963-1972 period, 21.1 million ha in 2004, 21.7 million ha in 2012 and 22.3 million ha according to 2015 data. In the same period, the ratio of forest areas to country area increased from 26.1% to 28.6%. Accordingly, there has been an increase of approximately 2.1 million ha and an annual average of 0.25% in forest areas in the last 40 years. While the rate of productive forest areas was 43% in the first plan period, it became 52% in the last period. 50% of our forests are planned according to economic, 42% ecological and 8% socio-cultural functions (OGM, 2021).

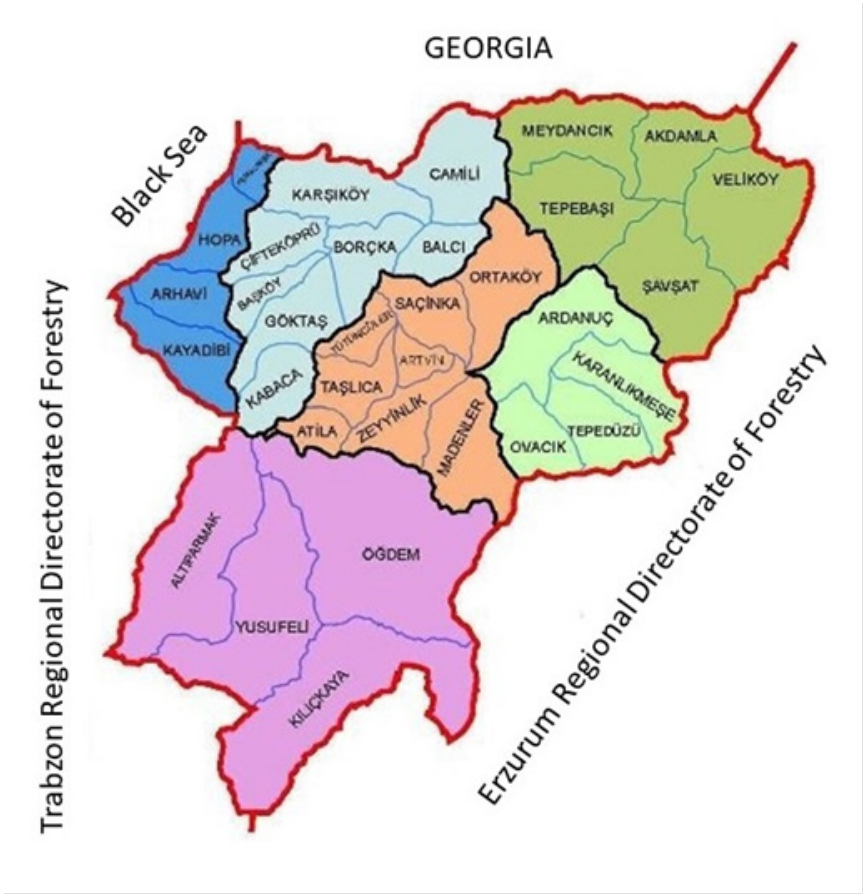

Figure 1. *Artvin Forest Regional Directorate's map*

There are forest pests caused by insects and other factors throughout the world. A good control method must be used to prevent and reduce these damages.

Methods

Artvin Regional Directorate of Forestry was selected as the study area. The fact that Artvin has shown a pioneering approach in the fight against forest pests in Turkey has caused Artvin to take a step forward in this regard. official records of the organization showing a successful management were used for the study.

The data obtained through face-to-face interviews with 100 local people were analyzed using frequency analysis.

FINDINGS

After the 1960s, Dendroctonus micans began to pose a significant problem for our forests in Turkey. This insect, which came to the Black Sea coast via Georgia, caused significant economic damage to our country's forests. Up until 1970, it had caused damage to approximately 500,000 trees. Despite effective mechanical combat with the insect during this period, complete success was not achieved.

Between 1972 and 1980, approximately 32,000 fir trees were sprayed with pesticides to continue the fight against the insect (İnanç and Ayaz, 2019). Due to the high cost of pesticides, the environmental damage they caused, and their harmful effects on natural resources, the spraying process could not be fully completed, and the insect population continued to increase rapidly

After the 1985s, a transition was made from chemical pesticides to biological pesticides. Rhizophagus grandis predatory beetles were cultivated in the Şavşat and Ardanuç forest enterprises of the regional directorate and released into the affected areas. For this purpose, 14 laboratories were established. The rich biological diversity of the region and the large number of protected areas necessitated further measures for this region. A joint effort was initiated, and pheromone traps were also introduced in the area (URL-2b, 2020, (İnanç, 2021).

Chemical pesticides have negative effects on human health as well as on natural resources and other living beings. Therefore, the decision was made to use biological pesticides. Success has been achieved with the production of predatory insects in the laboratory, and effective combat has been carried out after 1985 (URL-3, 2021).

The forestry organization, which carried out an effective struggle between 2008 and 2017, failed in 2012. Reasons such as the change in the structure of the institution and the displacement of experienced personnel played an active role in this failure (URL-2, 2020).

The most effective tool in combating insect damage in Artvin has been the production of predatory insects (Aksu, 2002; Özkazanç, 1985). Predatory insects have been bred in 5 laboratories established and used in other damaged surrounding forests. The data for the last 10 years are shown in Table 1 (Anonymous, 2018).

Table 1. Insect damage in Artvin forest regional directorate for years

Years	Biotic Damage DKGH (m3)	%	Other Damage DKGH (m3	%	Total Damage (m3)
2008	21.948	38	36.474	62	58.422
2009	8.681	34	16.991	66	25.672
2010	5.988	18	27.846	82	33.834
2011	3.109	9	30.828	91	33.937
2012	1.746	3	66.295	97	68.041
2013	2.162	3	65.920	97	68.082
2014	6.001	12	42.284	88	48.285
2015	5.283	6	80.661	94	85.944
2016	6.823	2	268.087	98	274.910
2017	12.466	6	188.340	94	200.806
Total	74.207		823.726		897.933

The table shows not only insect damage but also damage caused by other factors. such as floods, avalanches and mushroom damage. In addition, structures such as hydroelectric power plants and sand quarries built on forests cause a lot of damage to forests. Legal changes have been shown to be effective in protection.

Many natural events negatively affect forests in our country, as well as all over the world. It is possible to list a wide variety of factors such as drought, melting of glaciers, climatic events, increase in temperatures, and epidemic diseases. Forests are the most effective tool in combating climate change. For this reason, ensuring the continuity of forests is a very important issue.

The most important duty of laws is to protect forests. Both the ministry and the law work hard to ensure this. Article 169 of the constitution orders the protection of forests. It commands protection from wrong interventions of people, insect damage and fires. Ensuring the continuity of forests is the primary duty of the forest organization and the citizen.

The first forest law was enacted in 1937. Since then, forest pests have been fought and this issue has been given importance. Pests were combated in an area of approximately 8 million hectares. Between 2003 and 2015, forest pests and diseases were taken under control with mechanical control on an average of 156,966 hectares. (URL-1, 2016).

A smokeless fire analogy is used for insect damage. Insects cause much more damage to forests than fire. 5 million lira is spent on an area of approximately 450 thousand hectares. If there is extensive damage, this price increases even more.

Insects have the ability to reproduce even in adverse climatic conditions. Technological developments in recent years play a very effective role in combating insect pests. Effective methods should be tried to combat insects without harming biodiversity.

With the rapid change in technology in recent years, new and effective methods have emerged in the fight against forest pests. Additionally, importance is given to the preservation of biodiversity, and in the biological control of harmful insects, parasitoid insects bred under hunter and laboratory conditions are used, taking into account the continuity of biological diversity.

The use of chemical pesticides was banned after 2007 due to their harmful effects. Due to their negative effects on nature, new and nature-friendly methods have been used. Nature-friendly methods that do not harm nature have gained importance. 1985 yılı sonrası biyolojik mücadele yöntemi kullanılmaya başlanmıştır. 53 labaratuarda yaklaşık 11 milyon avcı böcek üretilerek zarar g*örmüş ormanlarda kullanılmıştır* (URL-3, 2021).

Artificial bird nests have important roles in increasing the population of insectivorous birds. 30-50% of the nests are used by birds and constitute an important factor in population increase. Parus major, Phoenicurus phoenicurus, Sitta krueperi, Parus ater, Otus scopus, Certhia brachydactyla are known nest species.

The forest management started to hang artificial bird nests and support the growth of some bird species in 1941 and 1,644,172 nests have been placed so far. In recent years, approximately 60,000 nests have been hung annually (URL-3, 2021.

In order to support insectivorous birds, especially woodpeckers, many dry, old trees are planted or felled in forests to provide natural nesting, and fruit trees, shrubs and leafy trees with high branches are given the opportunity to grow.

Biotechnical control method, which does not harm nature, has been another preferred method. pheromones compatible with nature are used in this method. Pheromones are checked once a week and used as bait for predatory insects. the strongest of the predatory insects are used as mother insects in the laboratory. 45 thousand pheromones are used in the forests of turkey every year, while 45 million insects that damage the forests are caught. these numbers may vary depending on the number of harmful insects.

In order to remove pests from the forest, control methods and techniques are very important. monitoring studies are of great importance in order to access healthy information about the population of pests. a good monitoring study will be a very appropriate tactic in order to make the struggle more effective and efficient.

Therefore, forestry policy should be in line with the changing and developing conditions of the country. protection of forests and prevention of misuse of forests are essential for successful management. human-induced damages should be prevented by making the necessary legal arrangements for sustainable forest management. correct methods and techniques should be used for insect damages and forests should be protected.

For the study, a survey was conducted with 100 forest villagers. (Table 2). As can be seen from the tables below, 40% of the participants were female and the rest were male. Considering the age of the participants, it is seen that the majority are over 51 years of age.

Table 2. Socio-demographic characteristics

Socio-demographic characteristics			
Gender	%	Job	%
Female	40	Employee	39
Male	60	Public servant	26
Age	%	Retired	20
17-20	5	Housewife	12
21-30	15	Student	3
31-40	12		
41-50	17		
51+	51		
Educational Level	%	Level of income ($)	%
Primary school	32	1000-2500	50
Secondary school	23	2501-4000	35
University	45	4001 and +	15

Half of the participants were asked about the combat activities carried out by the forest organization and half of the participants stated that they were aware of the issue. In such studies, it is desirable that the awareness of the participants is high. because awareness can be used as an important weapon in the fight against forest pests (Table 3).

Table 3. Opinions of local people about the work of the Forest Organization on destruction

Is there a fight for the insect?	Person	%
Yes	50	50
No	50	50
Total	100	100

Conclusions

forest pests can cause a lot of damage to forests and cause deforestation. After the 1970s, bark beetles that came to our country caused a lot of damage to the forests. However, Artvin forests, which exhibited a good struggle, managed to save the forests from this insect. Until 1985, chemical struggle was carried out. the insect population was damaged but could not be completely finished. After 1985, biological control started and natural balance started to be restored in forests.

The aim of biological control is both to remove the pest from the environment and not to harm the natural balance of natural life. there is a balance in nature. and it is not desirable to disrupt this natural balance. therefore, any action that will harm nature is not allowed. the survival of the host species in the food chain of the bark beetle is also important for balance. for this reason, nature-friendly and nature-friendly methods should be adopted.

It is important to adopt sound and decisive policies for the sustainable conservation, development and management of forests and forest vegetation. One of the most important policies to be implemented is to monitor changes in the health of forests and forest vegetation to keep damages at low levels.

The findings of the study show that pest control in different forest regions of Turkey is generally effective, but in some cases inadequate. In particular, overuse of chemical control methods can lead to environmental impacts and resistance development. Therefore, it is recommended to encourage greater use of biological control methods.

In conclusion, to improve the effectiveness of pest control in Turkey's forests, integrated pest management strategies need to be developed and implemented. These strategies should ensure a balanced use of chemical and biological control methods and minimize environmental impacts. It is also important to involve local communities and forest managers more in the control of forest pests and diseases. This study could be an important step to protect the long-term health of Turkey's forests.

The increase in temperatures with global climate change causes an uncontrolled increase in insect populations. for this reason, it would be a good decision to carry out afforestation works with resistant species. having species that will show resistance to insect damage will be an important development in terms of sustainable management of forests.

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CHAPTER 8

THE GLOBAL PROBLEM: WATER POLLUTION AND HEAVY METALS-A REVIEW

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Introduction

More than two thirds of our world is made up of aquatic ecosystems, which are essential to maintaining a stable global temperature and provide a wide range of benefits to a rapidly expanding human population (Hader et al., 2020). Water and water resources is very important for the all living organisms because of the many nutrients and mineral substances it contains (Vasistha and Ganguly, 2020). Therefore, water, which is vital for all living things, is an invaluable natural resource. In addition, surface water resources are used to drinking, irrigating, producing electricity, transporting merchandise and producing food. It also feeds on a wide variety of ecologically important species (Akhtar et al., 2021).

According to the UNESCO-published World Water Development Report 2021, freshwater use worldwide has grown at a rate of roughly 1% annually since the 1980s and has increased six-fold in the last 100 years. Approximately 80% of wastewater from cities and industries worldwide is released into the environment untreated. Both ecosystems and human health are negatively impacted by this. Because there are significantly less facilities for wastewater treatment and sanitation in the least developed nations, the rate is greater there (https://www.frontiersin.org/articles/10.3389/fenvs.2022.880246/full).

The most unique advantage of aquatic ecosystem is the existence of life, and the most special feature of life is its biodiversity (Bassem, 2020). In an environment where resources are limited, this valuable resource must be managed sustainably to ensure the sustainable development of the human population and the continuation of life.

In this review study, general information about water pollution and heavy metals will be given.

What is Pollutant?

One of the main environmental causes of illness and mortality, environmental pollution is not a recent occurrence and is one of the major issues facing humanity (Ukaogo et al., 2020). Holdgate (1979) defined environmental pollution as the introduction by man, into the environment, of substances or energy liable to cause interference with legitimate uses of environment. Singh (1991) has defined pollution in a very simple manner, i.e., “Disequilibrium condition from equilibrium condition in any system.” His definition may be applied to all types of pollution. The substances that cause pollution are known as pollutants. In other words substances that cause undesirable effects or adversely affect resources when released into the environment are called pollutants (Chaudhry and Malik, 2017). Pol-

lutants that cause environmental pollution are divided into two: point and non-point pollutants (Fig. 1).

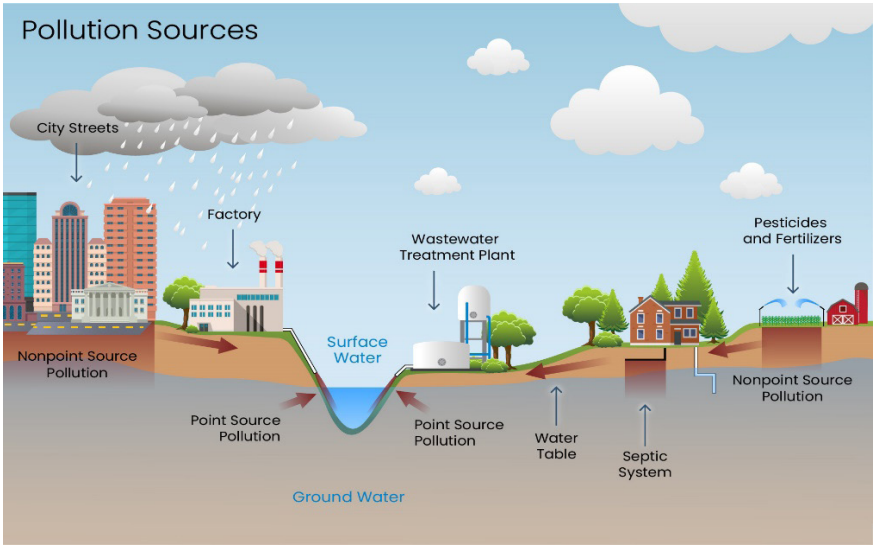

Figure 1. *Pollutants that cause environmental pollution (https://www.bcwater.org/threats/)*

Point Source Pollution

The U.S. Environmental Protection Agency (EPA) defines point source pollution as "any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack." (Fig. 2, 3). Two common types of point sources are factories and wastewater treatment plants. Factories including oil refineries, pulp and paper mills, and chemical, electronics, and automobile manufacturers often discharge wastewater containing one or more contaminants into the environment. Some factories discharge their waste directly into aquatic ecosystems without any processing. Some treat their waste in treatment facilities before releasing it to the environment, while others send their waste to sewage treatment facilities for treatment (https://oceanservice.noaa.gov/education/tutorial_pollution/03pointsource.html). The pollutant may cause long or short term damage. Pollutants that cause short term damage are biodegradable pollutants.

Figure 2. *This image shows a point source of industrial pollution along the Calumet River. Photo: U.S. Environmental Protection Agency (https://oceanservice.noaa.gov/education/tutorial_pollution/03pointsource.html),*

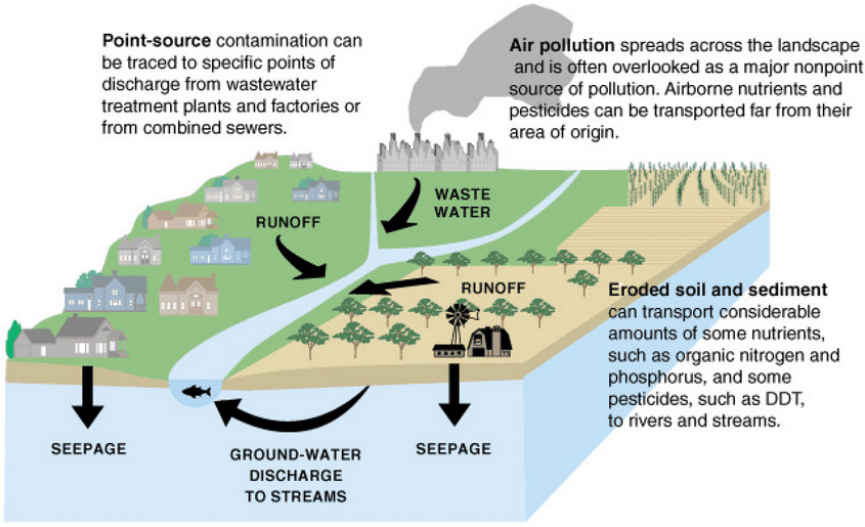

Figure 3. *Point source pollution (source: U.S Geological Survey, Fact Sheet 2009–3093; https://pubs.usgs.gov/circ/circ1225/html/sources.html)*

Non-point Source Pollution

Non-point source pollution is a type of pollution that occurs when the source of water pollution is unknown or the pollution does not come from a single source (Brian, 2008; Chaudhry and Malik, 2017). Non-point source pollution may come from different sources like pesticides, fertilizers

industrial wastes etc. (Chaudhry and Malik, 2017), (Fig. 4). This type of pollution is often very difficult to control because it involves the cumulative effect of small amounts of pollutants collected from a large area.

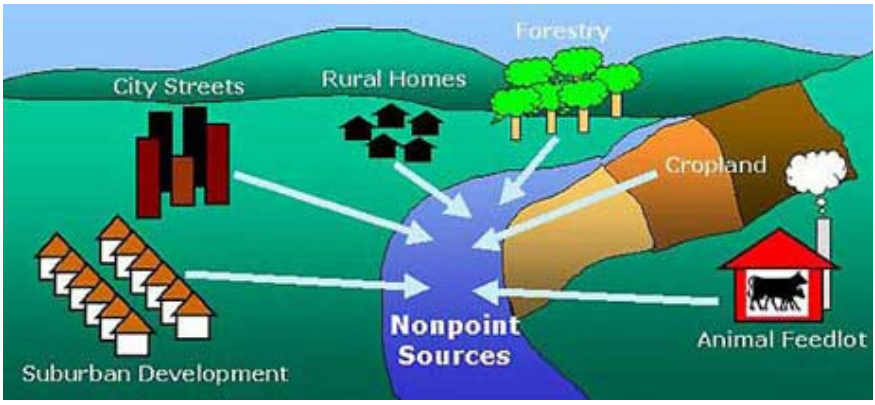

Figure 4. *Non-point source pollution*
(https://oceanservice.noaa.gov/education/tutorial_pollution/04nonpointsource.html)

Worldwide, compared to point source discharges, nonpoint or diffuse source pollutants cause more widespread degradation of surface and groundwater quality (Duda and Nawar, 1996). Table 1 lists the attributes of point and non-point sources that contribute chemical input to receiving waters.

Table 1. *Characteristics of point and non-point sources of chemical inputs to receiving waters (Carpenter et al., 1998)*

Point Sources	**Non-point Sources**
Wastewater effluent (municipal and industrial)	Runoff from agriculture (including return flow from irrigated agriculture)
Runoff and leachate from waste disposal sites	Runoff from pasture and range
Runoff and infiltration from animal feedlots	Urban runoff unsewered and sewered areas with a population
Runoff from mines, oil fields, unsewered industrial sites	Septic tank leachate and runoff from failed septic systems
Storm sewer outfalls from cities with a population >100,000	Runoff from construction sites

Overflows of combined storm and sanitary sewers	Runoff from abandoned mines
Runoff from construction sites >2 ha	Atmospheric deposition over a water surface
	Activities on land that generate contaminants, such as logging, wetland conversion, construction, and development of land or waterways

Water Pollution

Water pollution (WP) is a major problem in both developed and developing countries. (Chaudhry and Malik, 2017). In the twenty-first century, environmental problems and the diseases and deaths they cause are one of the world's biggest problems. WP is one of them. WP negatively affects all living things all over the world, especially in developing countries. In many developing countries, efficient and effective management of water resources is a problem due to the lack of integration and holistic approach, often with little involvement of the public and other stakeholders outside the government (Medema et al., 2008, Afroz et al., 2014). For this reason, WP has become one of the most important problems in the global environment.

WP can be defined as a factor that changes the quality of water by adversely affecting the physical, chemical or biological properties of water, restricts the intended use of water and/or harms those who consume water and adversely affects the ecosystem. Water quality varies depending on many factors such as climate, precipitation, soil structure, vegetation, geological structure, flow conditions, groundwater and human activities (Florescu, 2010).

WP happens when some unwanted constituents enter into the water bodies and change the water quality (Fig. 5). The discharge of various pollutants into the aquatic eecosystems is the outcome of various human activities (such as urbanization, industrialization, and agricultural activities), threatening the health of the organisms and damaging the quality of the environment by rendering water bodies unsuitable (Ekubo and Abowel, 2011, Bashir et al., 2020). Aquatic ecosystems are pickers for industrial applications (solid/liquid wastes, chemical compounds, mining activities, spills, and leaks), urban development (municipal wastes, land use practices, and others), and agricultural practices (pesticides and fertilizers), (Fig. 6,7), (Akhtar et al., 2021).

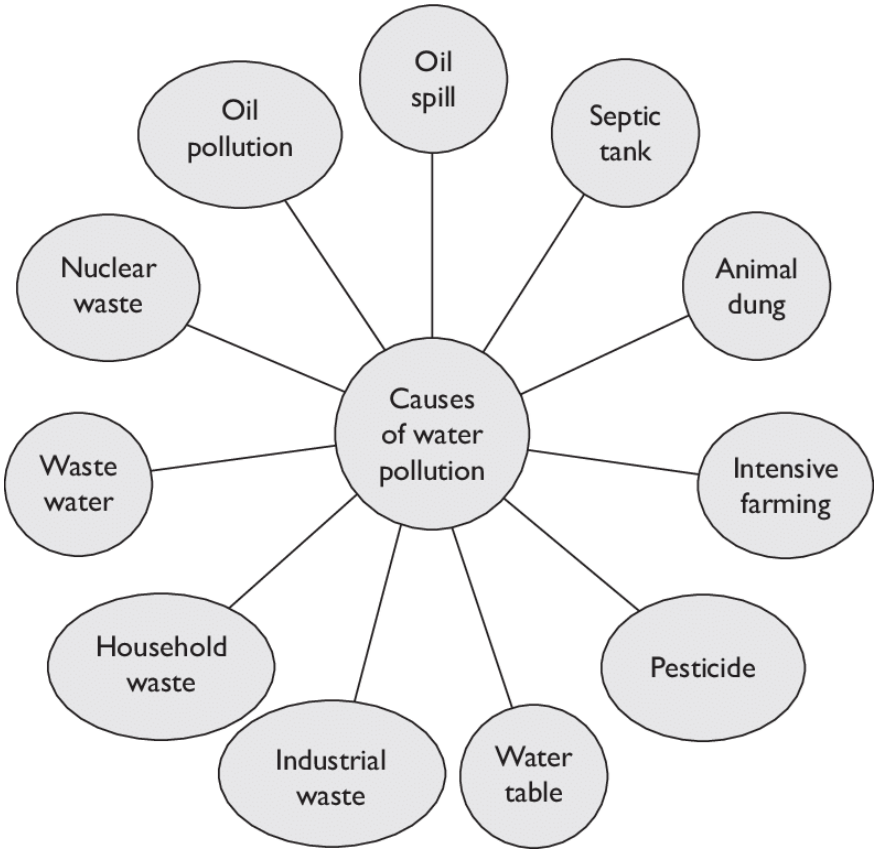

Figure 5. *Major causes of water pollution (Afroz et al., 2014)*

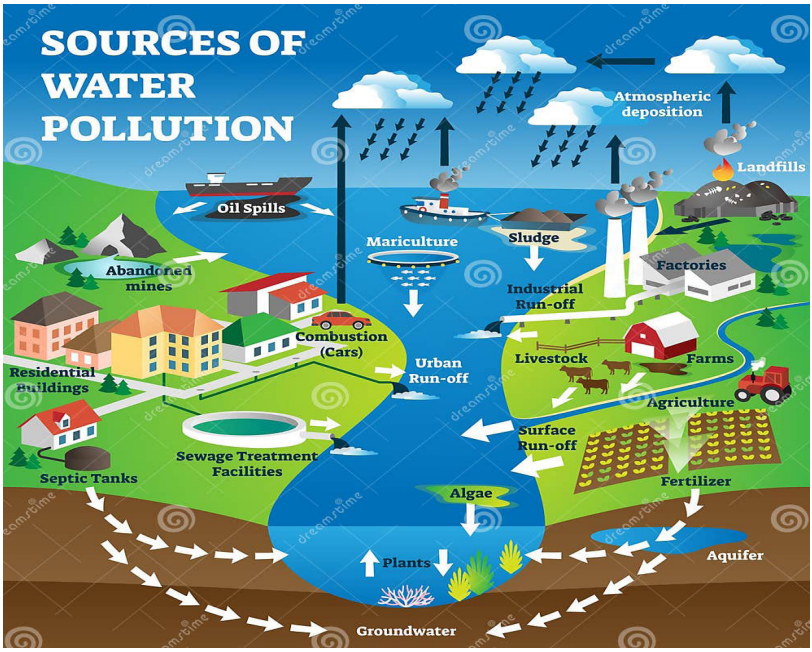

Figure 6. *The discharge of various pollutants into the aquatic eecosystems (https://www.dreamstime.com/sources-water-pollution-as-freshwater-contamination-causes-explanation-sources-water-pollution-as-freshwater-contamination-image198558385)*

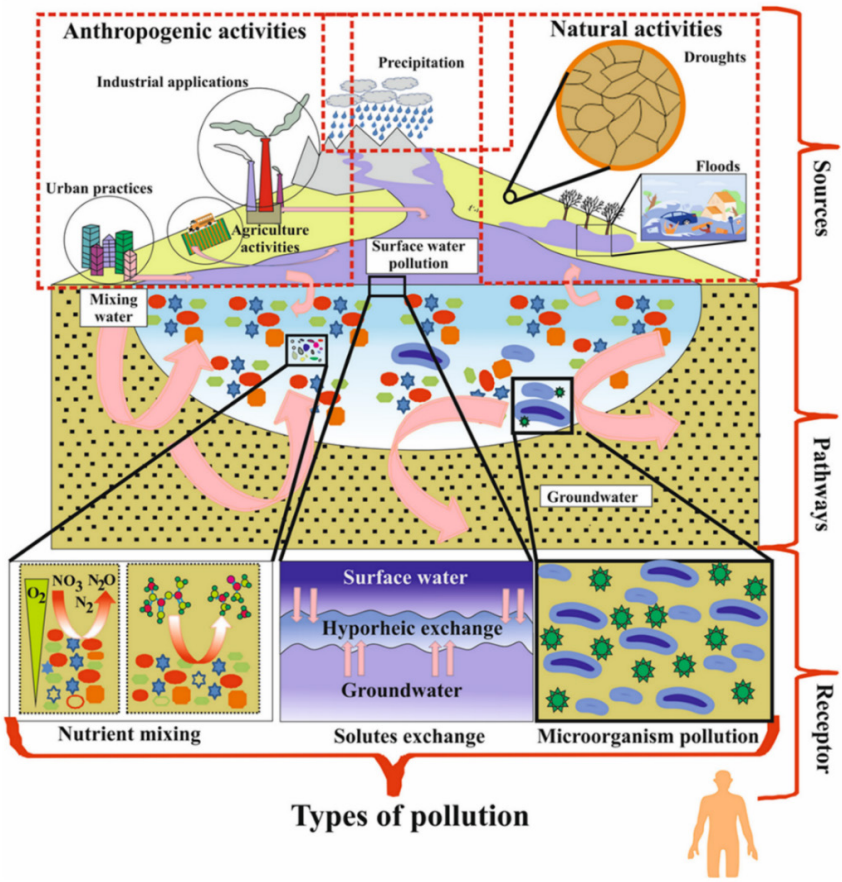

Figure 7. Schematic diagram illustrates water contamination (Akhtar et al., 2021)

The number of diseases and deaths is also increasing due to increasing water pollution worldwide. Approximately 14000 people die every day due to water pollution (Letchinger, 2000; Pink, 2006; Chaudhry and Malik, 2017).

What is Heavy Metal?

Three distinct criteria are used to characterize heavy metals (HMs): density, atomic number, and chemical characteristics (Tarekegn et al., 2020). The name "HMs" refers to a broad category of metals and metalloids that have an atomic density higher than 4 g cm^{-3}, or at least five times, that of water (Fig. 8), (Ferguson, 1990; Tchounwou et al., 2012, Riaz et al., 2021; Alsafran et al., 2023). HMs also include metalloids that might cause toxicity at low exposure levels, like arsenic (As), assuming that toxicity

and heaviness are related (Duffus, 2002). Various HMs, such as chromium (Cr), cadmium (Cd), nickel (Ni), copper (Cu), zinc (Zn), lead (Pb), mercury (Hg), and As, are recognized as biologically dispensable and detrimental to the aquatic ecosystem (Jacob et al., 2018; Abd Elnabi et al., 2023).

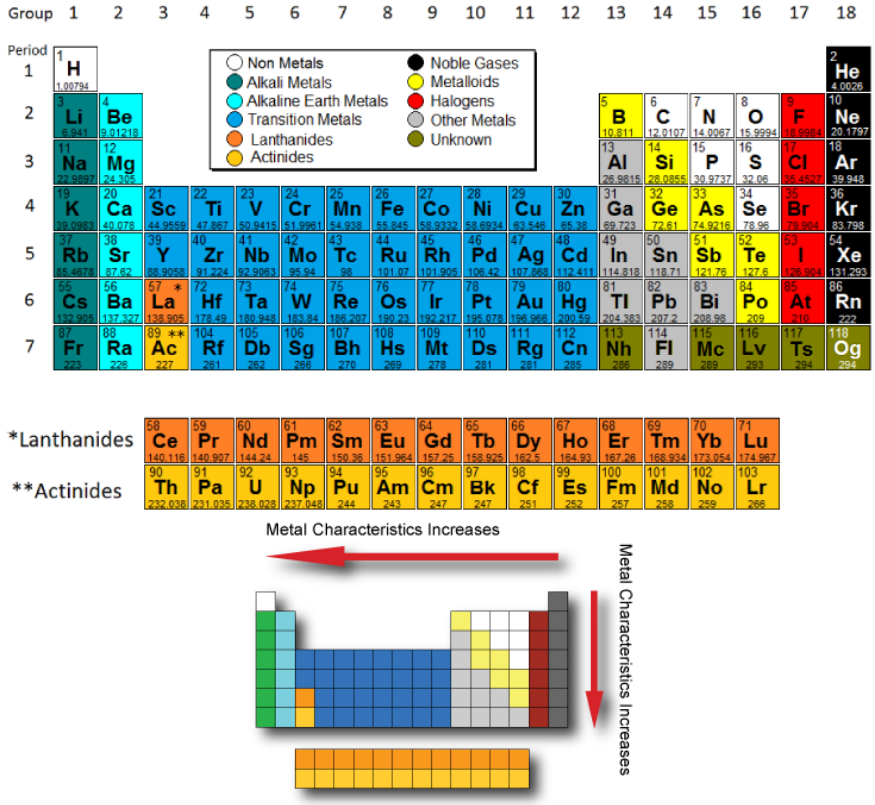

Figure 8. *Position of HMs in periodic table (https://www.modelscience.com/PeriodicTable.html)*

A partial list of HM definitions is given below (SG=specific gravity), (Duffus, 2002);

- Metals fall naturally into 2 groups: light metals (densit ies < 4) and HMs (densities >7) (Bjerrum, 1936)
- Metal having a SG.4 (Van Nostrand, 1964)
- Metal of high SG, especially a metal having a SG of 5.0 or greater (Merriam, 1976)
- Metal with a density >5 (Brewer, 1983)
- Metal with a density >6 g/cm^3 (Davies, 1987)

- Metal of SG>4 (Grant, 1987)
- Metal with a density of 5.0 or greater (Flexner, 1987)
- Metal with a density >4.5 g/cm^3 (Streit, 1994)
- Metal with a density >3.5-5 g/cm^3 (Falbe, 1996)
- Element with a density >6 g/cm^3 (Thornton, 1995)

Earth Crust Abundance of HMs

Ninety-five percent of the earth's crust is composed of igneous rocks, with the remaining five percent being sedimentary rocks, of which eighty percent are shales, fifteen percent are sandstones, and five percent are limestone (Thornton, 1981; He et al., 2005). But since they usually cover the igneous rocks they are generated from, sediments are more common at the surface (He et al., 2005). The concentration range of some metals and metalloids in igneous and sedimentary rocks is given in Table 2.

Table 2. *Concentration range of some metals and metalloids in igneous and sedimentary rocks (mg kg^{-1}), (He et al., 2005)*

Elements	Basaltic igneous	Granitic igneous	Shales and clays	Limestone	Sandstone
As	0.2-10	0.2-13.8	1-17	0.1-8.1	0.6
Cd	0.006-0.6	0.003-0.18	0-11	0.05	0.05
Cr	40-600	2-90	30-590	10	35
Co	24-90	1-15	5-25	0.1	0.3
Cu	30-160	4-30	18-120	4	2
Hg	0.002-0.5	0.005-0.4	0.005-0.51	0.01-0.22	0.001-0.3
Pb	2-18	6-30	16-50	9	<1-31
Mo	0.9-7	1-6	2.5	0.4	0.2
Ni	45-410	2-20	20-250	20	2
Se	0.05-0.11	0.05-0.06	-	0.08	0.05
Zn	48-240	5-140	18-180	20	2-41

In Figure 9, the share of each element in both the earth's crust and the entire world is given as a percentage.

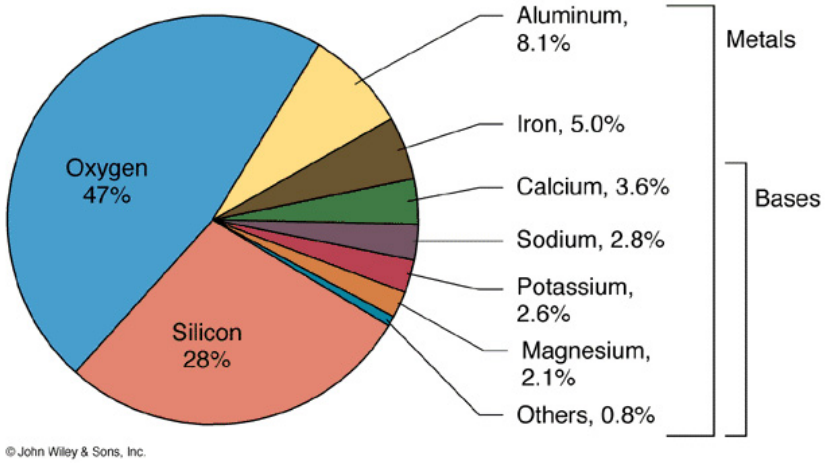

Figure 9. *The percentage wise share of each element in both the earth's crust and the whole earth (https://upscstudysharing.wordpress.com/2016/09/21/earths-crust-elements-minerals-and-rocks/)*

Sources of HM Pollution

HMs are present in all environments, but in varying degrees. Trace elements including zinc, copper, nickel, iron, and magnesium are among the many compounds with a variety of characteristics (Poli et al., 2009; Tarekegn et al., 2020). Trace elements have two sides: beneficial and toxic. Trace elements although present in trace quantities can play an essential role in living organisms; for instance, the ions are frequently bound to the active sites of enzymes. Depending on dose or concentration, trace elements also include microelements and toxic elements (Mikulewicz et al., 2017).

Most of the HMs naturally found in the earth's crust originate from environmental pollution and anthropogenic activities (see Fig. 10 for details on anthropogenic and natural sources as well as the distribution of HMs in aquatic environments), (He et al., 2005). Man's disruption of the naturally occurring geochemical cycle of metals causes one or more HMs to accumulate in the soil and waterways. When this buildup reaches certain thresholds, it poses a threat to all living species (Tarekegn et al., 2020). Human exposure to HMs has increased significantly due to industrial activities and anthropogenic activities of the 20th century (Canpolat et al., 2022;Abd Elnabi et al., 2023).

The FAO listed the following as the sources of HMs: batteries, paints, pigments, paints, glass, fertilizers, textiles, pharmaceutical, dental,

and cosmetic industries; urban stormwater; mining effluents; industrial effluents; leaching of metals from garbage and solid waste dumps; metal inputs from rural areas; domestic effluents; atmospheric sources; and petroleum industrial activities (Fig. 11), (Brad, 2002; Zeitoun and Mehana, 2014). HMs are also released into the environment by natural processes such wildfires, biogenic processes, and the weathering of rocks (Zaynab et al., 2022; Kosar et al., 2023). Fig. 11 depicts the origins and impacts of HMs on humans through the food chain.

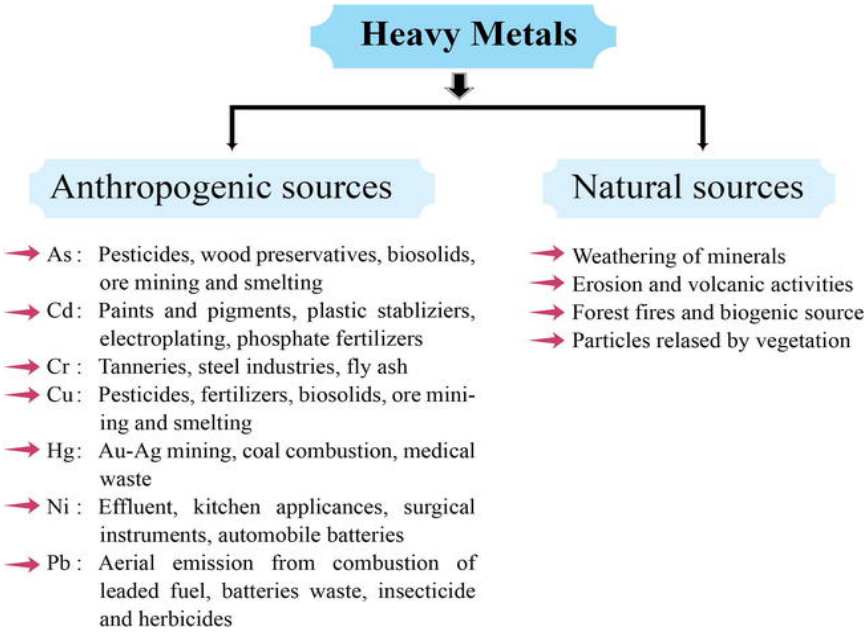

Figure 10. *Sources of HMs in the environment (Mir et al., 2020)*

WHO compiled a list of the 10 chemicals of major public health concern including HMs (www.who.int/ipcs/features/10chemicals_en.pdf – accessed 22 September 2011);

- Air pollution
- Arsenic
- Asbestos
- Benzene
- Cadmium
- Dioxin and dioxin-like substances
- Inadequate or excess fluoride
- Lead

- Mercury
- Highly hazardous pesticides

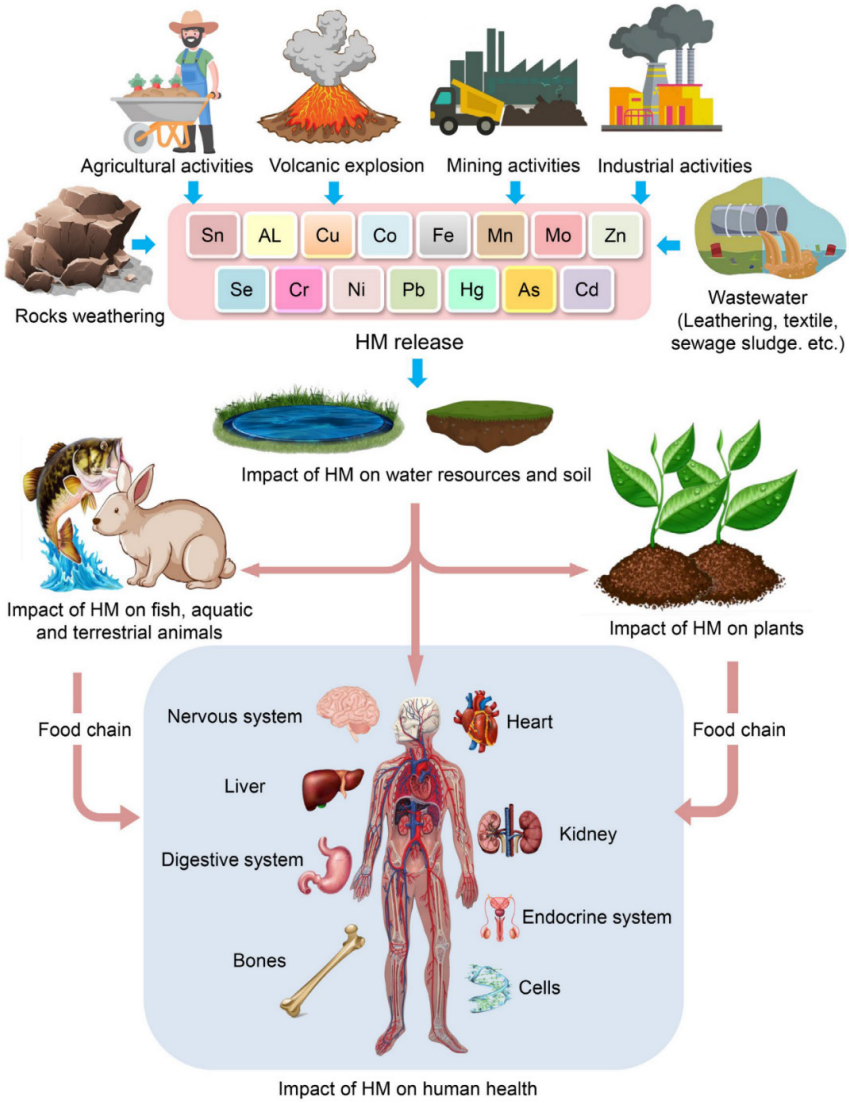

Figure 11. *Origins and impacts of HMs on humans through the food chain (Abd Elnabi et al., 2023)*

The Emergence of HM Pollution As a Global Problem

Pollution of terrestrial and aquatic ecosystems with toxic HMs is an important environmental problem affecting habitats and living things (Mir et al., 2020; Mitra et al., 2022). The local aquatic environment has become

contaminated with HMs as a result of industrial expansion in developing and underdeveloped nations. Among the many different toxic compounds found in aquatic ecosystems, HMs are considered one of the most dangerous pollutants (Zeitoun and Mehana, 2014).

HMs, which cause air, water and soil pollution and are one of the most important pollutants, cannot be biodegraded and have the ability to accumulate in living things (Kakade et al., 2023). Therefore, HMs constitute one of the most significant pollutant problems in all ecosystems. Many disorders worldwide, including arsenic acid poisoning, asthma linked to air pollution, minamata sickness (organic mercury poisoning), and itai-itai disease (cadmium poisoning), are known to be caused by HM pollution (Matsuo, 2003; Baby et al., 2010). HM pollution has caused serious problems on a local, regional and global scale. It was reported that 2252 people were affected and 1043 people died due to the discharge of mercury oxide into the bay waters from a chemical plant near Minamata Bay in Japan in 1968 (Kudo and Miyahara, 1991; Nomura and Futatsuka, 2006). İtai-itai disease first emerged in Japan in the 1960s and was caused by exposure to cadmium (Cd) produced as a result of human activities related to industrialization (Nishijo et al., 2017). The presence of As in the environment was first reported from West Bengal in 1982. Many cases of poisoning due to As have occurred in Bangladesh and West Bengal and India (Varelis, 2024). Recently, countries such as Bangladesh and Italy have faced the problem of groundwater contamination with arsenic (As), (Alam et al., 2003). HM pollution (such as Cd, Pb, Cu and Zn) has been reported in drinking water sources in countries such as Bolivia, Hong Kong and Berlin (Ho et al., 2002; Miller et al., 2004; Zietz et al., 2003).

HMs in Aquatic Ecosystems

HM pollution in aquatic ecosystems is a very comprehensive subject, and very brief information will be given in this section.

Since the beginning of time, advances in mining and metal processing techniques have produced a strong relationship between metals, metal pollution, and human history (Nriagu, 1996). HM pollution in the biosphere has increased significantly from the beginning of the industrial revolution to the present day (Rai, 2008). Therefore HM pollution is a major global environmental problem and threatens both aquatic ecosystems and human health (Canpolat et al., 2020). The distribution of HMs in aquatic ecosystems has been extensively reported since the mid-1950s, when Hg and Cd pollution disasters occurred in Japan resulting from the contamination of coastal, river and irrigation systems with production and mining process wastes (McCormac, 1991; Rai, 2008).

Pollutants entering water can be divided into two classes: emerging (frequently degraded, including household waste such as pesticides, insecticides, PAH, DDT and detergents) and traditional pollutants (nitrates, fluorides, and HMs such as As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn), (Connell et al., 2006; Gioia et al., 2011; Schell et al., 2012; Ahamad et al., 2020; Kadim and Risjani, 2022).

HMs introduced into aquatic ecosystems through natural weathering (weathering of rocks, wind-blown soil particles) and intensive anthropogenic activities (activities related to agricultural cultivation, industrial waste, mining and smelting, transportation, transportation, sewage runoff, and energy production) contribute to both water and accumulates in sediment (Fig. 12), (Vasiliu et al., 2020). In recent years, anthropogenic inputs of HMs have exceeded natural inputs (Pendias and Pendias, 1989; Rai, 2008).

Under certain environmental conditions in aquatic ecosystems, HMs can accumulate and reach toxic concentrations. As a result, serious ecological damage may occur in that ecosystem (El-Serehy et al., 2012). Due to the desorption and remobilization processes of HMs, sediments constitute a long-term source of contamination for the food chain (Gheorghe et al., 2017).

HMs in aquatic ecosystems can be found in dissolved, particulate or chelated/combined forms in water, sediment or aquatic organisms (Al Naggar et al., 2018; Amankwaa et al., 2021; Kakade et al., 2023).

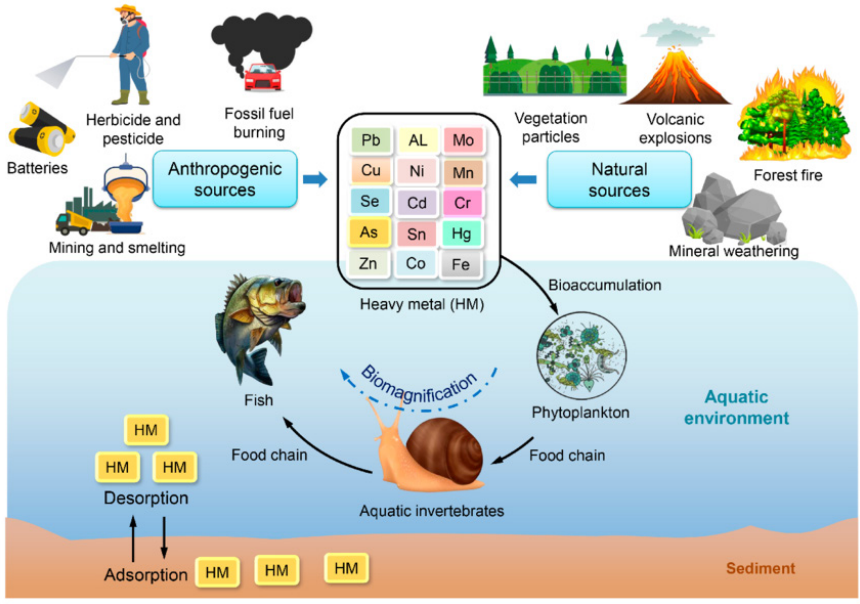

Figure 12. *Distribution of HMs in aquatic environments (Abd Elnabi et al., 2023)*

Conclusion

One of the most important problems faced by people all over the world is environmental pollution. One of the most important pollutants that cause environmental pollution is HMs. HMs can enter aquatic environments from various sources. Some sources that cause HM pollution in aquatic environments are given in Fig. 13.

HM pollution is a major problem for aquatic environments as it causes a wide spectrum of toxicity with significant consequences for aquatic organisms. HMs in aquatic ecosystems are not removed from the water as a result of self-cleaning and accumulate in their environment and enter the food chain. As HM concentrations increase at each trophic level in the food chain in aquatic environments (biomagnification), they can reach high toxicity levels. Therefore, HMs have great ecological importance in aquatic environments.

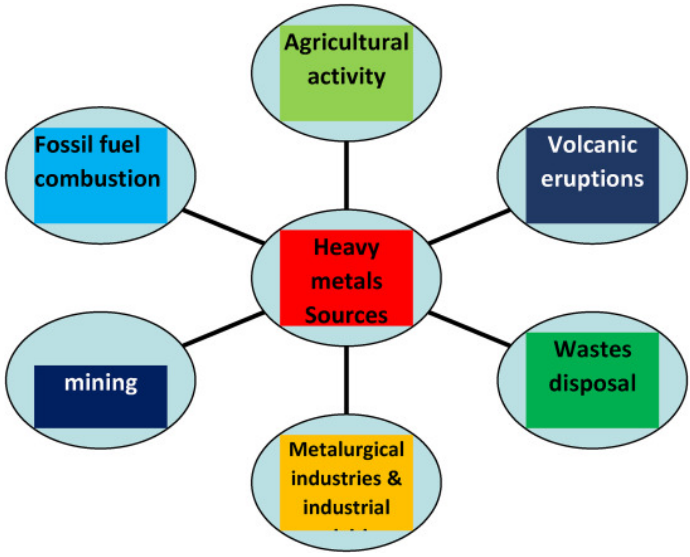

Figure 13. *Various HMs sources from the aquatic environment (Kadim and Risjani, 2022)*

In summary, because of their high toxicity, environmental durability, biological accumulations, and detrimental impacts on human health through the food chain, HMs are regarded as significant pollutants in aquatic settings.

In recent years, water pollution has become a global problem due to developing industry, overpopulation and rapid urbanization. In order to tackle this problem, it is urgently necessary to evaluate water resources policy and determine a roadmap for the sustainable use of water resources.

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CHAPTER 9

FISHES USED AS BIOINDICATOR FOR HEAVY METAL POLLUTION IN AQUATIC ECOSYSTEMS

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INTRODUCTION

Environmental pollution, which is the main environmental cause of disease and death in today's world and is not a new phenomenon, is one of the major global problems facing humanity. Environmetal pollution is a negative change in one of the environmental components that results, in whole or in part, from vital and industrial human activities. Environmental pollution is also known as the quantitative and qualitative change that occurs in one or more elements of the environment in a way that harms the life of the organism and weakens the ability of the ecosystem to continue its production (Al-Taai 2021).

Environmental pollution occurs as a result of the discharge of pollutants of natural origin (e.g. erosion, volcanism) or anthropogenic origin (e.g. burning of fossil fuels, leachate from landfills, runoff from agricultural lands, mine residues) into the environment (Chiarelli and Roccheri, 2014).

In the 20th century, rapid socio-economic development based on population, increased urbanization, industrial development and agricultural activities led to an increase in the demand for clean water resources (Jurdi et al., 2002; Mokhtar et al., 2011; Yozukmaz and Yabanlı, 2023). Pollution or risk of contamination of water resources (inland waters, seas and oceans) necessary for life negatively affects ecosystem health and sustainable social development (Al-Taai 2021).

Heavy metals HMs) are one of the most important pollutants that cause pollution in all ecosystems. Pollution of ecosystems by HMs is a result of the global industrial revolution, and this pollution has caused and continues to cause very serious ecological problems.

The biological approach for the determination of water quality has been developed as a complementary method to chemical analysis. The use of bioindicators in studies on the water quality of surface waters began about a century ago (De Pauw, 1983). Used to describe the characteristics of a particular biosphere, biotas are biological indicators frequently used to study the severity of changes occurring in the ecosystem (Gaston, 2000; Marques, 2001; Joanna, 2006; Zaghloul et al., 2020).

In this review study, it is aimed to provide information about fish, which are bioindicators of heavy metal pollution in aquatic ecosystems.

AN OVERVIEW OF HEAVY METALS AND BIOINDICATOR ORGANISMS

Heavy Metals

Some of these HMs have basic functions and only produce toxic effects in overdose. Some are xenobiotic and highly toxic. In addition, some metals that are essential in some organisms are not found in others and have toxic effects (borderline). Accordingly, metals and metalloids for living organisms are generally divided into three classes: essential, non-essential and borderline. Some of these are shown in Table 1 (Chiarelli and Roccheri, 2014).

Table 1. *Classes of metals and metalloids relatively to living organisms (Chiarelli and Roccheri, 2014)*

Types of HM	HMs
Essentials	Calcium (Ca), Magnesium (Mg), Manganese (Mn), Potassium (K), Sodium (Na), Strontium (Sr), Zinc (Zn), Iron (Fe), Copper (Cu)
Non-essentials	Cadmium (Cd), Mercury (Hg), Silver (Ag) Tallium (Ti), Lead (Pb)
Borderline	Chromium (Cr), Cobalt (Co) Nickel (Ni), Arsenic (As), Vanadium (V), Tin (Sn)

HMs are classified into essential metals (e.g., Fe, Ni, Cu, and Zn), which are essential for living organism, and non-essential metals (e.g., Pb, Hg, and Cd), which are toxic even in trace amounts (Wakawa et al., 2008). All living things, including fish, need trace amounts of some HMs (such as Cu, Fe) to maintain their metabolic activities. While excessive amounts of some metals can harm the organism, metals such as mercury, lead, and cadmium have no metabolic significance in organisms and can cause illness or death upon prolonged exposure in the body (Azaman et al., 2015; Luczynsk et al., 2018).

Bioindicator Species

Bioindicators are used and promoted by various organizations such as the World Conservation Union and the International Union for Conservation of Nature as tools for biomonitoring and assessing human impacts (Fig. 1). Bioindicator species are used to estimate the natural state or pollution level/degree of a particular area (Parmar et al., 2016).

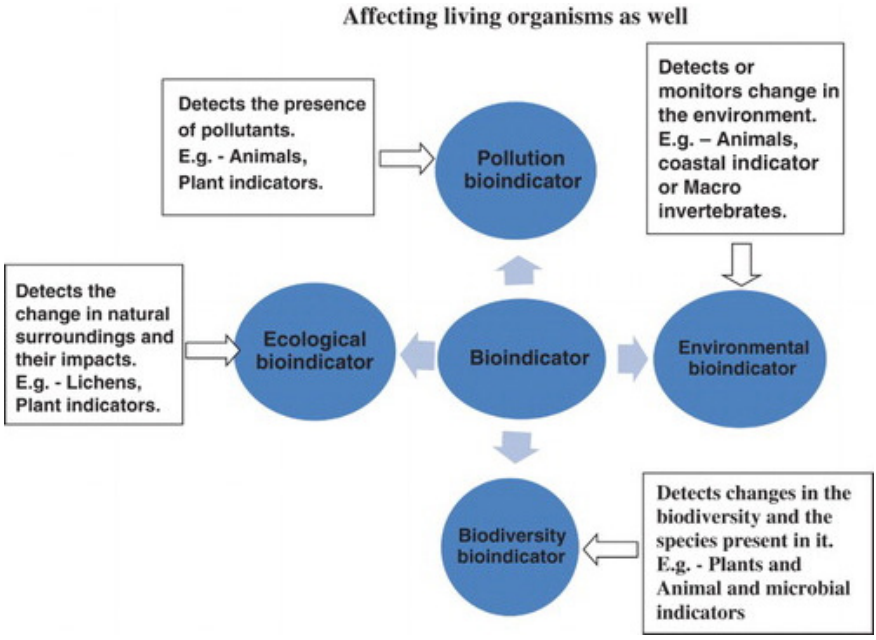


Figure 1. Sub-types of bioindicators (Parmar et al., 2016)

It is a new approach to visualize ecosystem health by using some living organisms as bioindicators. For this purpose, phytoplankton, macrophytes, invertebrates and fish are widely used as bioindicators of HM pollution (Vardanyan et al., 2008; Burger, 2006).

Bioindicators are widely used because they provide information about the biological effects of pollutants rather than precise information about their concentrations. As they provide an understanding of the mechanisms of action of pollutants; monitoring multiple bioindicators provides crucial information about the contaminants and stress to which the organism is exposed. Pollution stress leads to many biological responses that, in theory, all these biological responses can be used as bioindicators. Above a certain level, the biomarker response to the pollutant (either in terms of the concentration of the pollutant or in time of exposure) becomes apparent, differing from normal levels in the unstressed state (Van Der et al., 2003).

Living organisms in polluted environments respond to the disruption of the ecosystem in various ways. Bioindicators respond to environmental pollution by changing life functions or accumulating toxins in the body (Ellenberg et al., 1991). In other words, they are species that make it easier to recognize the characteristics

of that environment with their presence in an ecosystem. The most obvious responses are species diversity, species richness, abundance and similarity values, which are called distribution characteristics. Although pollution may cause a group of organisms to leave the environment or become extinct, some other organisms can resist and continue their existence in the environment. In this situation, it is inevitable that they will be affected by pollution to some extent. While this impact is generally negative, it may be positive for some species. Resistant and opportunistic species with broad ecological tolerance are harbingers of pollution types that give them an advantage (https://www.aquast.org/uploads/pdf_232.pdf). Bioindicators are responses to environmental impacts that can be measured at the individual, community and ecosystem levels, such as reproductive success, mortality, size distribution, population such as reduction in abundance and biomass, primary production, and disruption of nutrient cycling (Lam and Gray, 2003; Tejeda-Vera et al., 2007).

Bioindicator organisms are of two types. These are explained below;

1. **Accumulating bioindicators:** When living things in this group are exposed to pollutants, they accumulate pollutants in their bodies without any change in their metabolism.
2. **Bioindicators that react to pollutants:** Organisms in this group are organisms that experience changes in their cells or show symptoms when they are exposed to or absorb even small concentrations of pollutants. The following changes occur in these organisms.

   a) Ecological Changes: Change in population density (key species and species diversity).
   b) Behavioral Changes: Change in feeding activity.
   c) Physiological Changes: Ability to accumulate HMs and increase in CO_2 production (Jain et al., 2010).

The majority of organisms used as bioindicators are benthic organisms that live attached to the bottom or can move very slowly. However, indicator species are also found among other groups. Among these, some algae and aquatic flowering plants are known to be indicators of pollution. Some pollution indicator species are also found among nektonic and planktonic organisms, although not as much as benthic animal and plant organisms. Aquatic plants, invertebrates, fish, fish parasites and some species of microorganisms are widely used as bioindicators of HM pollution in aquatic ecosystems.

There are some basic criteria for a species to be used as a bioindicator to determine HM pollution. These criteria are listed below (Aksoy et al.,1999; Jain et al., 2010);

- Representation in large numbers in the collection area,
- Availability throughout the year,
- Having a wide geographical area,
- Easy to sample
- No diagnostic problems.

The advantages of using bioindicator species are listed below (Parmar et al., 2016);

- Biological effects can be determined.
- The synergistic and antagonistic effects of various pollutants on a living thing can be monitored.
- It can be diagnosed at an early stage and its harmful effects on both plants and humans can be monitored.
- More economically viable compared to other special measuring systems.

Some Fish Species As HM Bioindicators In Aquatic Ecosystems

Fish are organisms widely used to assess the quality of aquatic ecosystems as bioindicator species for environmental pollutants including HMs (Kock et al., 1996). The use of fish as bioindicators is due to their highly sensitive response to changes in the aquatic environment and their important role in monitoring water pollution. While the sudden death of fish indicates a high degree of pollution, their reactions when exposed to sub-lethal pollutants can be measured through biochemical, physiological or histological changes observed in the fish (Mondon et al., 2000). Although changes in the age of the fish population and the distribution of species living in the area thought to be polluted are a general indicator of water pollution, there are also more specific responses to a single pollutant or groups of pollutant (Guyonnet et al., 2003). Biochemical changes induced in the presence of a specific group of chemical substances with the same mechanism of toxic activity are called biochemical indicators. This method is frequently used to monitor pollution in the aquatic environment (Siroka et al., 2004).

Fish provide similar toxicological and adaptive responses to oxidative stress as mammals in water pollution studies (Kelly et al., 1998). In addition, they are considered bioindicator creatures because they can be

consumed as food and cause pollutants to reach humans (Begum and Vijayaraghavan, 1999; Fabacher and Little, 2000).

Since fish are at the top of the food chain in aquatic environments, they accumulate high concentrations of metals in their tissues and organs.

Some fish species used as bioindicators are given below (Fig.2);

- *Liza saliens*,
- *Hypophthalmichthys molitrix*,
- *Pseudobagrus fulvidraco*,
- *Hemiculter nigromarginis*,
- *Ctenopharyngodon idellus*,
- *Xenocypris argentead*,
- *Silurus soldatovi meridionalis*,
- *Varicorhinus simus*,
- *Cyprinus carpio*,
- *Carassius auratus*,
- *Coreius heterodon*,
- *Coreius guichenoti*,
- *Leiocassis longirostris*,
- *Leiocassis crassilabris*,
- *Leptobotia elongata*,
- *Rhinogobio typus*,
- *Saurogobio dabryi*,
- *Hemimyzon abbreviata*,
- *Rhinogobio cylimdricus*,
- *Hemiculter leucisclus*,
- *Oreochromis niloticus,*
- *Clarias gariepinus*,
- *Abramis brama,*
- *Astyanax fasciatus*
- *Tilapia nilotica* is used as an indicator of Fe, Mn, Ni, Cd and Zn (Zhou et al., 2008)

Bioindicators used to evaluate fish health in their habitat generally include biometric parameters such as standard length, weight, condition factor (CF), hepatosomatic index (HSI) and gonadosomatic index (GSI), (Corsi et al., 2003; Tejeda-Vera et al., 2007).

Biochemical biomarkers are widely used. The most important features of these biomarkers are that they can be applied to a wide range of organisms, that they are early warning tests, and that they are sensitive and specific. Metallothioneins (MT) are low molecular weight, cysteine-rich cytosolic proteins. They bind metals such as copper, silver, zinc, cadmium and mercury. It has various functions such as detoxification of essential metals such as copper and zinc and protection of cells against oxidative stress caused by free radicals. MT induction is a bioindicator used in the assessment of metal pollution in aquatic ecosystems, which has been included in programs monitoring marine pollution all over the world. However, MT levels vary depending on body weight, gender, reproductive status, season and water temperature (Berthet et al., 2005).

Evaluation of blood parameters in fish is very useful in routine and clinical applications. Evaluation of these parameters provides important information about the physiological state of fish (Chen et al., 2003). Most environmental factors in fish; For example, environmental factors (such as temperature, light, density, salinity), physiological factors (breeding period, age, food) (Chen et al., 2003) and HMs (Lauren and Mc Donald, 1985; Munoz et al., 1991) affects blood parameters. Researchers attribute the ability of hematological parameters to provide useful information on the physiological responses of fish to environmental pollutants to the following important reasons;

- The circulatory system is in close relationship with the external environment,
- Being sensitive to changes in the environment,
- Fish blood is easy to obtain (Houston, 1997; Lohner et al., 2001; Gabriel et al., 2004).

Studying metabolic and enzymatic activities in aquatic organisms is important as it allows understanding the ecological effects of pollutants entering the freshwater and marine environment. Enzymes, which are physiological and biochemical markers, are used to detect possible environmen-

tal pollution before the health of aquatic organisms is seriously affected by pollutants (Jiminez and Stegeman, 1990).

Most enzyme responses are secondary stress responses, occurring with cellular damage and allowing early diagnosis of stress before pollutants cause irreversible damage to higher biological mechanisms (Barnhoorn and Van Vuren, 2004). Measuring serum enzyme activities is important in determining the effect of pollutants in water on fish (Bucher and Hofer, 1990). For this reason, researchers consider serum enzymes (such as cholinesterase, alanine aminotransferase, aspartate aminotransferase, lactate dehydrogenase and alkaline phosphatase) as both biochemical markers of pollutants and sensitive parameters for the presence of pollutants in aquatic ecosystems (Cajaraville et al., 2000; Hamed et al., 2003). The negative effects of environmental pollutants have been demonstrated by measuring ALT and AST enzyme activities (Nemcsok et al., 1987). It is stated that increases in ALT and AST activities in plasma occur as a result of damage to other organs (kidneys and/or gills), especially the liver (Nemcsok and Hughes, 1988). Biochemical analysis of blood plasma or serum reveals information about internal organs (such as liver and kidney), proteins (albumins, globulins), nutritional and metabolic parameters (such as cholesterol, triglyceride, glucose) and electrolytes (Na, Cl, K, Ca, P) provides information (Jain, 1986; Allen, 1988; Duncan et al., 1994). For this reason, plasma/serum parameters are used as indicators of the toxic effects of HMs (Bergdahl et al., 1997). Ions (such as Na, Cl, K and Ca) are necessary for the growth of fish and to maintain ion balance, and most of them are taken from the water through the gills (Eddy, 1982). In interaction with HMs in water, ion uptake is damaged and ion balance is disrupted (McDonald and Wood, 1993). Cortisol, glucose, total protein, cholesterol and triglyceride are other important components of serum and provide information about the physiological state and tissue damage in fish under the influence of pollutants. Cortisol plays an important role, directly and/or indirectly, in internal metabolism, ionic and osmotic regulation, growth, stress and immune function of fish (McCormick, 1995; Wendelaar Bonga, 1997; Mommsen et al., 1999). The energy requirement is very important for the organism to combat the negative effects caused by HMs in fish. Glucose provides the energy needed by tissues against stress metabolites. It is known that cortisol, which is also a stress hormone, increases glucose production in fish through gluconeogenesis and glycogenolysis and thus causes increases in plasma glucose levels (Iwama et al., 1999). Studies (O'Neill, 1981; Cyriac et al., 1989; Munoz et al., 1991) have reported that some metals either increase or decrease hemoglobin, hematocrit, plasma protein, ion level, cortisol, glucose and blood enzymes. It has been observed that plasma glucose levels increase in trout under the influence of Cu, depending on

concentration (Lauren and Mc Donald, 1985). Ellsaesser and Clem (1987) observed that changes occurred in serum enzymes, serum components and serum electrolytes in blood serum chemistry measurements in *Ictalurus nebulosus* under normal and acute stress.

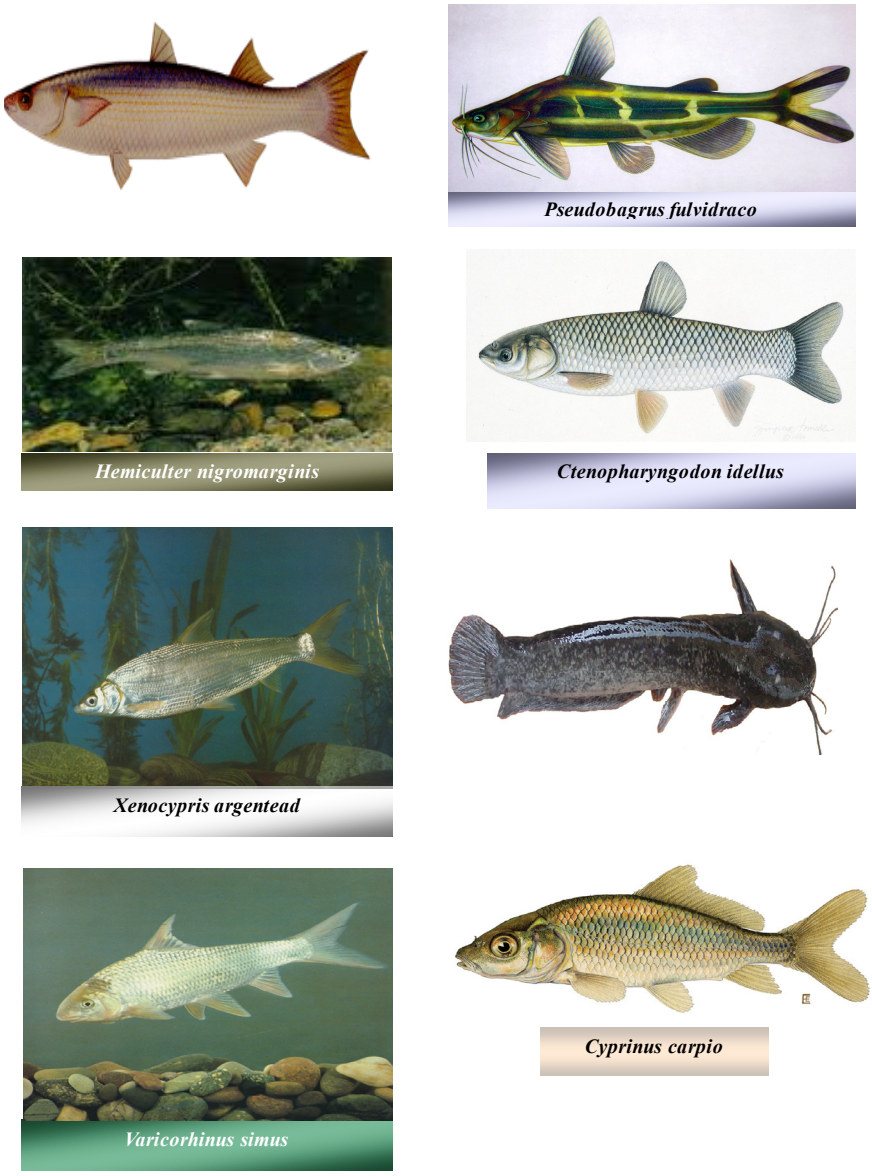
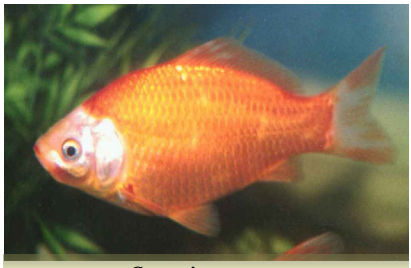
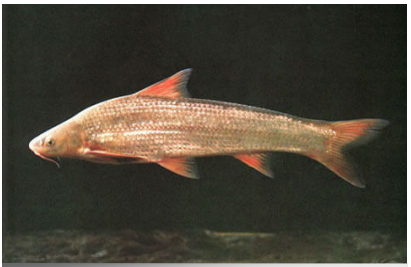


Figure 2. *Some fish species as HM bioindicators in aquatic ecosystems*

Figure 2. *(Continue)*



Carassius auratus



Coreius heterodon

Coreius guichenoti

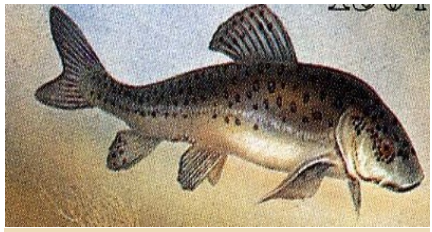
Leiocassis longirostris

Leptobotia elongata

Saurogobio dabryi

Figure 2. *(Continue)*

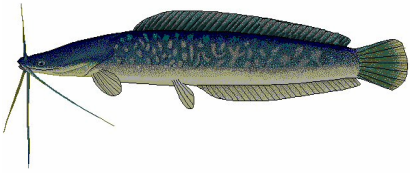
Hemimyzon abbreviata



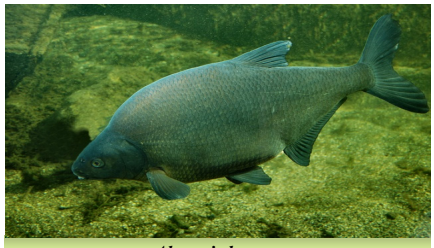
Rhinogobio cylimdricus

Hemiculter leucisclus

Oreochromis niloticus



Clarias gariepinus



Abramis brama

Astyanax fasciatus

Tilapia nilotica

Conclusion

While technological developments offer many new and alternative products for the benefit of humanity, they cause the generation of wastes that are not to be underestimated and that are quite different in qualitative and quantitative terms. The treatment of such solid and liquid wastes cannot be carried out adequately with existing conventional treatment processes. In addition, effective treatment costs

a lot of money for the relevant industrial organizations. One of the industrial establishments that increase environmental pollution and play an important role in deteriorating the ecological balance are the establishments whose wastewater contains HMs. Relevant industrial organizations use various HMs due to their processes and their wastes contain metal ions such as mercury, zinc, cobalt, copper, iron, lead, chromium, arsenic and silver. If effective treatment is not carried out, discharging such wastes into receiving environments such as lakes, rivers, seas and oceans becomes highly toxic to the living systems and environment that live in water and use this water. It is important for living systems and environmental health due to its permanent effects on aquatic ecosystems, and when it exceeds a certain limit, it has an extremely toxic effect (Sağlam and Cihangir, 1995).

While the European Economic Council classifies chemicals as green and black lists according to hazard priority, the United States Environmental Protection Agency (USEPA) has listed 129 pollutants that are considered to be the most dangerous for living things and ecosystems. This list includes both organic chemicals and metals (such as mercury, cadmium, silver, lead, copper and zinc). Due to their physicochemical properties, most organic chemicals are abundant and constantly present in the ecosystem. Metals cause problems in the environment due to industrial and domestic use (Sofyan, 2004).

Some aquatic organisms are sensitive indicators of environmental changes and are widely used in the development of environmental regulations and evaluation of dangerous developments in freshwater and marine ecosystems (Yan and Pan, 2002). Therefore, indicator organisms can also be used to monitor the uptake, excretion and bioavailability of HMs and to determine toxic effects. Since they are in direct contact with the aquatic environment they are in, they can absorb and accumulate pollutants in the aquatic environment and thus provide information about the pollution level of the environment (Kurt, 2000).

If water pollution continues to increase in water resources damaged by various types of pollution, water resources will face the risk of depletion in a short time. The increase in water pollution caused by HMs in recent years also increases the need to develop effective screening methods for HMs. For this purpose, methods that are

affordable, reliable, simple to use and sensitive are the most ideal methods (Khishamuddin et al., 2018; Wong et al., 2018; Jusoh et al., 2020). Although bioindicators have some limitations, the most important features of bioindicators are that they have versatile advantages such as being useful, objective, understandable and reproducible. For this reason Bioindicators, which can be used at various scales from the cellular to the environmental level, are widely used to evaluate changes occurring in a particular biological community.

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