



WATER REGIME CHALLENGES AND ECOHYDROLOGICAL RISKS IN THE LAKES REGION (TÜRKİYE): PROBLEMS AND STRATEGIC RECOMMENDATIONS

Belkıs MUCA YİĞİT^{1*}, Hasan ÖZÇELİK²

¹Iğdır University, Vocational School of Technical Sciences, Department of Forestry, 76000, Iğdır, Türkiye

²Süleyman Demirel University, Faculty of Engineering and Natural Sciences, Department of Biology, 32260, Isparta, Türkiye

Abstract: In the Göller Region, multiple factors such as drinking water quality, mineralogical features, and regional vegetation influence how suitable water resources are for irrigation purposes. Rock structure of the region is generally volcanic and limestone, and partly conglomerate. This structure is very effective in composition of the water. Karacaören Baraj Lake is very rich in arsenic (As); water of Gölçük Lake is very rich in fluoride (F). Burdur and Salda lakes cannot be used for irrigation purposes. Salda Lake is extremely soda; low in salt and high in alkaline. Fauna and flora are poor in such lakes. The main reason why its water is not drinkable is serpentine rocks and sulphure beds around it. Akşehir Lake, Beyşehir Lake and Eğirdir Lake have been experiencing water scarcity in recent years. Eber Lake and Çorakgöl have largely dried up. Waters of Burdur and Eğirdir lakes are gradually decreasing and the composition of the water is deteriorating due to pollutant inputs and evaporation. The decrease in water input and narrowing of the lake bed are the most important factors. The dams built on the streams feeding the lakes, decrease in precipitation and increase in evaporation and also tectonic movements, have brought the lake to its current state. Water resources must be well protected from various pollution sources. Due to water scarcity in the region, ways are being sought to benefit from water resources that are of poor quality and unsuitable for use. It is recommended to grow some plants in purification of water contaminated with heavy metals and polluted water. This purified water can be used in agricultural production, industry and cleaning works. In residences and workplaces, 2-line water installations should be installed, one for cleaning works and the other for drinking water, and the price of drinking water should be more expensive than water for cleaning purposes. The purpose of this article is to draw attention to water regime and faulty practices in the Göller Yöresi; to make some suggestions to implementing persons and institutions in order to protect the ecosystem. This study is based on long-term ecological and floristic field observations conducted since 1994 in the Lakes Region. Approximately 2000 vascular plant specimens were collected, identified, and preserved in the GUL Herbarium, and additional technical reports and floristic inventories were utilized. Detailed assessments were made through on-site inspections of Burdur, Salda, and Eğirdir lakes with a focus on hydrogeochemical and ecological properties.

Keywords: Lakes region, Aquatic Ecosystems, Water management, Water pollution, Purification method

*Corresponding author: Iğdır University, Vocational School of Technical Sciences, Department of Forestry, 76000, Iğdır, Türkiye

E mail: belkismuca@gmail.com (B. MUCA YİĞİT)

Belkıs MUCA YİĞİT



<https://orcid.org/0000-0002-3966-4774>

Hasan ÖZÇELİK



<https://orcid.org/0000-0002-0207-0921>

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1. Introduction

At present, nations where the annual per capita water availability is below 1,000 m³ are defined as water-scarce, while those exceeding 10,000 m³ per person per year are regarded as water-abundant (FAO, 2020). Approximately 75% of the world's total water consumption is used in agricultural irrigation (UNESCO, 2021). Türkiye encompasses 25 distinct hydrological basins, collectively yielding an average annual water flow of 186 billion cubic meters (DSİ, 2023). Lakes Eğirdir and Kovada are located in the 09-numbered 'Antalya Basin'. The Lake Region lies within a transitional climatic zone, where Mediterranean influences gradually give way to continental climate characteristics. Humid air masses coming from the Mediterranean have created a

microclimate around lakes Kovada, Beyşehir, and Burdur. Humanity's destructive efforts were first directed at forests, then at rivers and lakes. Until recently, 14% of the world was covered with forests, but today the total amount of forested areas has decreased to 6%. Türkiye's forest area is 22,933,000 ha, which is close to 30% of its surface area. With studies conducted in recent years, Türkiye has risen from 46th to 27th place in terms of forest assets among world countries. For this reason, Türkiye is one of the few countries in the world that has increased its forest areas. It is accepted that deforestation poses an environmental threat both in terms of climate change and biodiversity; forests are a 'Life Support System' for humans and all other living things (Karacabey et al., 2021). The first civilizations



were established around water resources throughout history. They met their needs for fuel and construction from the surrounding forests, and turned the forests into agricultural land and turned to food production. Drought has increased with the decrease in forests, the deterioration of rivers and lakes or inland water ecosystems. The decrease in inland waters all over the world has caused swelling in large water masses (seas and oceans); and has led to major disasters in countries bordering the sea and ocean. In these disasters; global warming has encouraged evaporation on water surfaces, evaporation has melted solid water masses (glaciers), and disasters have become a kind of trigger for each other. In other words, as glaciers melt, warming has increased; as warming increases, glaciers melt and drought has increased. The world's ecosystems are rapidly progressing towards a situation that is becoming increasingly inefficient, deteriorating and shrinking biosphere. It is unthinkable that the Göller Yöresi will not be affected by this situation. However, the region is a more suitable living space compared to other regions, 2 of the 8 gene centers in the world are in Türkiye. One of these is in the Mediterranean region (Vavilov, 1951). The reason for this is that there are many unique microclimates in the Mediterranean region. Importance of aquatic areas is the most important factor in the formation of these microclimates. Therefore, aquatic areas, lakes and ponds should not be seen as just a water source. For example, Isparta and Burdur are heart of rose oil cultivation. When we look at the areas where rose cultivation is most done, area around Burdur Lake comes out. Of the 20 or so rose plants in Isparta, 10-12 of them were established around Burdur Lake. The important water sources of the region are listed below:

In Isparta; Eğirdir, Kovada and Gölcük lakes and Karagöl. There are also about 20 lakes/ponds for irrigation purposes in the province.

In Burdur; Burdur Lake, Akgöl, Yarışlı Lake, Salda Lake, Karataş Lake, Kestel Lake, Gölhisar Lake, Çorakgöl and about 20 dam lakes/ponds;

In Konya; Akşehir Lake and Akşehir Yaylabeleden Dam;

In Afyonkarahisar; natural lakes such as Acıgöl, Karamık, Eber, and Akşehir are accompanied by approximately 40 irrigation ponds, including Emre, Karakuyu, Kırka, Bayat, Taşoluk, Selevir, Örenler, and Pınarbaşı, which are primarily used for agricultural irrigation (Anonymous, 2024a).

Except for Van and Tuz lakes, other lakes are in this region. Beyşehir Lake is the 3rd largest lake in Türkiye, Eğirdir Lake is the 4th, Burdur Lake is the 7th largest lake in the country. The dam lakes/ponds of Burdur and Isparta provinces are listed in Table 1 and Table 2 below according to the date of entry into service.

The majority of the regions encompassing natural lakes are designated as protected areas due to their ecological significance (Fakir et al., 2005; Fakir, 2007): Burdur Lake Ramsar Area, Beyşehir Lake National Park, Kovada Lake National Park, Eğirdir Lake Natural Protected Area.

Table 1. Dams constructed in Burdur province (Anonymous, 2024b)

Locality and Dam name	Date of construction
Karamanlı Dam	1970-1974
Çavdır: Kozağacı Dam	1981-1985
Bucak: Karacaören-1 Dam	1977-1989
Gölhisar: Yapraklı Dam	1985-1991
Karamanlı: Bademli Barajı	1993-1996
Çavdır Dam	1997-2003
Yeşilova: Değirmendere Dam	1998-2006
Bucak: Onaç 2 Dam	1996-2006
Tefenni: Belkaya Dam	1993-2007
Merkez: Karaçal Dam	1992-2012
Tefenni: Çaylı Dam	2012-2014
Yeşilova: Güney Dam	2012-2015
Merkez: Bügdüz Dam	2012-2014
Bucak: Çamlık Dam	2012-2014
Gölhisar: İbecik Dam	2012-2014
Kemer: Kayı Dam	2013-2014
Tefenni: Beyköy Dam	2014-2016
Merkez: Aziziye Kocapınar Dam	2014-2016
Çeltikçi: Bağsaray Dam	2015-2017
Çavdır: Küçükalan Dam	2016-2017

Table 2. Dams constructed in Isparta province (Anonymous, 2024b)

Locality and Dam name	Date of construction
Yalvaç: Sücüllü Dam	1969-1973
Uluborlu Dam	1977-1984
Aksu: Sorgun Dam	1993-2001
Şarkıkaraağaç: Çarıkсарайlar (Şehitler) Dam	1993-2003
Yalvaç: Çetince Dam	1993-2005
Merkez: Darıderesi 1 Dam	1995-2009
Şarkıkaraağaç: Köprüköy Dam	1995-2010
Yalvaç: Kozluca Dam	2005-2012
Eğirdir: Y. Gökdere Dam	2013-2016
Aksu: Terziler Dam	2014-2016
Yalvaç: Aşağıkaşıkara Dam	2013-2016
Gönen: Güneykent Dam	2014-2016
Sütçüler: Ayvalıpınar Dam	2013-2017
Gönen: Gölbaşı Dam	2013-2017
Sütçüler: Kesme Dam	2013-2017
Aksu: Sofular Dam	2013-2017
Yalvaç: Çakırçal Dam	2016-2017
Yalvaç: Kırkbaş Dam	2016-2017
Yalvaç: Özbayat Dam	2013-2019

Rapid population growth, waste, urbanization and industrialization are very effective in the formation of water scarcity. The suitability or drinkability of water resources for irrigation is closely related to the mineralogical structure of the water, the flora and

vegetation of the area and the land area to be irrigated recent years, deliberate forest fires have increased greatly in both the number and damage in the Mediterranean and Aegean regions. Forests have been severely damaged by these fires (Özçelik, 2023).

Water resources are greatly affected by geogenic and anthropogenic activities. The hydrogeochemical properties of groundwater are formed by groundwater quality and rock/mineral-water interactions in groundwater layers and sometimes by the mixing of two different water layers (Eyankware et al., 2018). There are basically 3 factors that deteriorate the quality of water:

- 1) Anthropogenic factors: Among these are mining operations, unauthorized waste dumping, seepage from septic tanks (currently a minor issue in the Lakes Region), and the intensive use and improper disposal of pesticides in agricultural zones.
- 2) Geological factors: These include rock erosion, volcanism and rock-water interaction in this group (Eyankware et al., 2020).
- 3) Environment (climatic and edafic)-living relationships: Agricultural and animal productions are weakening day by day. In 2022, the Ministry of Agriculture and Forestry paid direct crop loss support to registered farmers across the country. In 2023, grape production in the Lakes Region decreased significantly. In recent years, since tomatoes could not be grown in the field, greenhouse production was made up for even in the summer months. Water prices increased approximately 10-fold in the city center of Isparta from 2023 to 2024. Those who raise animals such as cattle suffered from water and feed costs and reduced production. In 2024, field mice and moles dug up the thirsty agricultural lands, especially in Keçiborlu, and ate the products. For this reason, those who planted chickpeas in particular could not produce even as much as the seeds they threw into the soil.

Watering the plant did not work either due to the dryness of the air. Because the dry air absorbed the water from the plants, and the plants turned yellow and dried out. Of course, climate changes such as a decrease in humidity in the air, drought and sudden warming of the weather led to food shortages and increased prices.

In recent years, internal and external migration movements have accelerated in the country. The country has received more than 10 million external migrations in the last 15 years. When we look at internal migration, there is a strong migration flow to the Mediterranean, Aegean and Marmara regions. The settlement areas in these regions have begun to be insufficient for the population, and the existing water resources have begun to be insufficient for the needs of the increasing population. The regions that have emigrated are the Eastern, Southeastern, Black Sea and partly the Central Anatolian regions. In every region, there is migration from rural areas to cities and this migration is accelerating.

This skewed population distribution has reduced the rural population to 7%, while increasing the urban population to 93 %. 68 % of the country's population resides in large cities, which are classified as densely populated. 58 million people (68% of the total population) live in densely populated cities (large cities), which constitute only 1.6% of the country's total surface area. 17.3 % of the total population resides in rural areas, which constitute 93.5 % of Türkiye's surface area; 14.8 % of the population resides in medium-density urban settlements, which constitute 4.9 % of the country's surface area (Anonymous, 2024c). In the 1970s, 10 % of the Turkish population lived in cities and 90 % in rural areas (villages, towns and hamlets).

The urban population in the provinces of Isparta and Burdur, located in the center of the region, is also increasing. Water consumption and water fees in 2023 and 2024 are important indicators of water scarcity. For this reason, Isparta Municipality stopped watering the grass in city parks in 2024. Burdur Municipality, having previously perceived the problem, tried to use natural aromatic plants and drought-resistant plants in urban landscaping (Özçelik and Pesen, 2016). Drought-resistant ground cover plants were determined and their adaptation to arid areas was tested (Gül et al., 2012; Gül and Özçelik 2016). The effects of land degradation on water resources and ecosystems were studied (Kesici et al., 2011).

With the rapid increase in urbanization and industrialization, the metallurgical industry and parts production have begun to grow rapidly. Discharging wastewater from the metallurgical industry into the receiving environment without proper treatment leads to deterioration of water quality and rendering the receiving environment unusable for drinking and utility water. Our water resources are depleting day by day and our renewable energy resources are decreasing. The importance of wastewater treatment emerges at this point (Erşen and İçsen, 2024). Management of urban biowaste poses serious social and economic challenges for all countries. Approximately 70 % of biowaste is taken to landfills without any treatment. The most effective way to reduce biowaste is to prevent food waste.

The purpose of this article is to draw attention to the water regime and faulty practices in the Göller Yöresi which includes the provinces of Burdur and Isparta, and partly Afyonkarahisar, Konya, Denizli and Antalya, and to make recommendations to implementing persons and institutions.

2. Materials and Methods

Plant materials of the study are identified which the vascular plant specimens found in the GUL Herbarium. In total, approximately 2000 vascular plant specimens were collected from the region, most of them in 2014, dried, identified and preserved in the GUL Herbarium. Many photographs were taken from each locality during field

trips. The Göller Yöresi constitutes an important part of the Mediterranean Region. Flora, vegetation and ecological studies have been carried out in the region since 1994 (Özçelik and Çetinkaya, 2002; Özçelik and Tanriverdi, 2005; Anonymous, 2012; Özçelik, 2018a). This article is based on observations made in the field during these studies. In addition, the plant inventory of Burdur and Isparta provinces were written by us for the Ministry of Forestry of the Republic of Türkiye. There are technical reports written by us on Burdur Lake and Salda Lake and marble quarries, and meadow/pasture management in provinces of Isparta and Burdur. These reports were also used in the preparation of the article. Burdur Lake, Beyşehir Lake and Eber Lake were studied in more detail by us. In these studies, the floristic features of the lakes, its physical structure and coordinates, altitude, and surrounding settlements were examined. This information is explained below in the light of our observations and literature. All photographs in the paper were taken from the habitat by us and originals.

2.1. General Characteristics of Water Resources in Lakes Region (Göller Yöresi) and Its Environs

2.1.1. Burdur Lake Ramsar site

General status: It is one of the 14 'Ramsar Sites' of Türkiye (area code: 3TR002). It has a tectonic origin. It is one of the deep lakes of Türkiye. In 1998, it was designated as a first-degree Natural Conservation Site, and later in 2006, it received the status of a Wildlife Improvement Area. It is a very important factor in the formation of microclimate in the geography where it is located. The heart of rose farming is the Burdur Lake area. The situation is generally the same for other agricultural products.

Burdur Lake is located in a small and closed basin between the villages of Çendik, Yazıköy, Yarımköy, Soğanlı, Karakent, İlyas, Ardıçlı, Tepecik, Senir, Gölbaşı and Kışla. It is fed by Bozçay, which enters the lake from the southwest, and a few small streams (Kravgaz, Kurna, Çerçin, Lengüme streams and Adalar stream). It is fed by precipitation falling on the lake area, seasonal and permanent streams reaching the lake and groundwater flow (Anonymous, 2012). Its surroundings are limestone and conglomerate rocks. Its average depth is 40 (-100) m. It is at an altitude of 848 m. The flora of the area was studied by Çetin et al. (2013).

Problems: It is believed that the extreme decrease in the lake water level in recent years is due to the dams built on the streams that feed the lake and the extreme drought experienced in the region in recent years. According to research conducted on the lake; it is stated that its water is not very rich in nutrients (Anonymous, 2012). However, its water is rich in dissolved organic and inorganic substances. It is known that the reason is due to the geological structure of the region and organic waste. The lake water is salty. The amount of arsenic, sodium sulfate and chloride in the lake water is high.

As its water decreases due to evaporation, the minerals

(salt, soda, phosphate etc.) in it become denser; its water becomes even more unusable. The flora and fauna in the lake are not very rich. The water level and bed area of the lake vary depending on the rainfall; according to the years and seasons.

Water input to Burdur Lake is provided from 3 sources:

- Domestic wastewater of Burdur city center,
- Industrial wastewater is discharged without any precautions or collected in accumulation pits and removed by leakage and evaporation,
- There is intensive agriculture in entire vicinity of the lake. The pesticide residue water returning from these lands also contains high levels of nitrate and phosphate and pollutes the lake. These waters are both the input source and the most important polluting elements of the lake. There are no natural water resources.

In agriculture, water-loving plants such as corn, spinach, beet, alfalfa, and sesame are produced. Commercial fishing is not possible in the lake. There are large poplar groves in many places. Since the lake does not have an external discharge, its ability to clean the pollution is weak. Although treatment facilities have been established for the dirty water (domestic and industrial wastewater) flowing into the lake, it is stated by the villagers that these facilities do not work efficiently. Our observations are in this direction.

A large number of dam lakes/ponds have been built on the streams feeding Burdur Lake for irrigation purposes. Aim of these dams was to 'evaluate fresh water before it enters the lake'. As a result of uncontrolled agricultural, domestic and industrial discharges into the lake, its pollution has reached significant levels. Urban, domestic wastewater discharges and solid waste storage leachate etc. are the most important polluting factors. As a result of the decrease in water input and the increase in pollutants, organic pollution in the lake has increased and the lake has become eutrophic. The Ministry of Forestry and Water Affairs, the Local Wetland Commission and other authorized institutions and organizations are responsible for the management of the area.

Flora in the water: Due to the reasons explained above, in-water flora is poor. In the areas where the streams between Yazıkent and Karakent villages mix with the lake and where salinity is relatively low, flora and vegetation are relatively strong (Figure 1).

2.1.2. Kocapınar Swamp

It is located within the borders of Eldere and Çapalı villages (Dinar, Afyonkarahisar) and İncesu village and Aydoğmuş town (Keçiborlu). Majority of the area remains within border of Afyonkarahisar province. It is a shallow lake or swamp formed by a strong water source that emerges 10-13 km after Keçiborlu (Isparta) on Afyonkarahisar highway and in its bed. Local people call the area 'Pınarbaşı' and the mountain behind it 'Sultan Dağı'. It is an important freshwater source.

The flow rate of the water is high. However, it is

gradually decreasing. Since it is discharged, it does not accumulate. Therefore, it is not a lake, but a swamp. It is the head of the main source of the Büyük Menderes River. This source is born by being fed by the snow waters coming from Karlıkkaya (1708 m) mountain rising behind the area. The slopes of the mountain are in the status of degraded black pine forest.

According to our field observations; it is the coldest aquatic area of the region. Therefore, organic matter decomposition and vegetation are weak. Peat production is high under water and near the shore. Due to the high organic matter rate, natural fires can occur on the shores in the hot months. Over time, many activities that destroyed the land were carried out. The ecological importance of the area for water birds is very high. It is a

very important area for pollen research. Unfortunately, anthropogenic destruction continues. Material collection from the area is especially carried out for peat production. Birds are forced to migrate. This area is a very important and unique area that can provide findings on the geological history and vegetation of the region. Unfortunately, it cannot be protected. In order not to dry up Burdur Lake, the following proposal was made to the board by local administrators and businessmen in scientific meetings and despite the response given by the scientific circles, the proposal was insisted on: Let's drain the wasted water of Kocapınar to Burdur Lake through a canal! This danger has not passed yet, Kocapınar marsh and water are considered unimportant by the relevant circles (Figure 2).



Figure 1. Burdur Lake has been gradually drying up for not incoming water and becoming polluted in recent years.



Figure 2. A view from Kocapınar marsh/lake (Keçiborlu-Dinar).



Figure 3. A view from Salda Lake (Yeşilova-Burdur) and interactions of water with main rocks.

2.1.3. Salda Lake Nature Park

General situation: It is in the Yeşilova district of Burdur. It is 4 km away from the town center; It is on the Yeşilova-Denizli highway. It attracts attention with its karst feature. It is a tectonic lake with light water. It is among the deepest lakes in Türkiye with a depth of 184 m (Karaca, 2002).

Problems: There has been rapid construction and tourism around the lake since 2010. Anthropogenic pressures on the lake are increasing due to these activities (Figure 3).

2.1.4. Yarıklı Lake

It is a small lake located within the borders of Yeşilova (Burdur) district. It is a tectonic lake located in

depression basin between Salda and Burdur lakes. Its main rock is marble and limestone. For this reason, there are many marble quarries around it. When viewed from a distance, the lake bed looks like a lake. There is a small hill around it. Some summers it dries up and turns into a salt marsh. It is a karstic lake between Harmanlı, Yarıklı, Sazak, Kocapınar and Düğer villages. It is at an altitude of 905 m. It is a shallow lake, it can deepen up to 4 m. It is rich in sodium phosphate, sodium chloride and sodium sulfate, its waters are bitter. It is fed by Kümbet, Yarıklı, Kirse, Kadınca water, Başkuyu stream and rainfall. Its living life is weak. Flora and vegetation are strong in areas where the streams meet the lake (Özçelik et al., 2015) (Figure 4).



Figure 4. A view from Yarıklı Lake (Burdur).

2.1.5. Karacaören Dams

General situation: It is located 30 km from Bucak district; 75 km from Burdur; and approximately 60 km from Isparta. It is 65 km from Antalya. It was established on Aksu stream. It is located on a part of the land of Çandır (Sütçüler/Isparta) village and mostly on the land of Bucak (Burdur). Its surroundings are conglomerate rocks. Karacaören Dam Lake, built between 1977 and 1990; it has two parts as Karacaören-1 and Karacaören-2. The common feature of both lakes is that their nature is wonderful, the protected sweet gum (*Liquidambar orientalis*) trees and fish production farms are their most important features. It is known that the fish in cages are also a significant source of pollution to the lake due to their feeding with artificial feed, and cage fishing has been reduced in recent years. The arsenic rate in water of the lake is much higher than acceptable values. This is because the arsenic content may be high in the volcanic sulfur deposits around the lake. It is planned to clean the water by carrying out various improvement works until 2035. Rocks of the area are volcanic at bottom and limestone at the top. The Karacaören dam lakes are fed by precipitation, as well as surface flow from Isparta stream, Aksu stream, Değirmen stream, Eğirdir and Kovada lakes, and partly from groundwater discharges (Özçelik et al., 2015). One source in particular is very important and most of the water comes from here.

Problems: The wastewater of Isparta Organized Leather Industry is purified and released into the stream, used as irrigation water in the lower parts, and carries a lot of detergent residue. It has been observed that the levels and volumes of Karacaören-1 dam lake have decreased in recent years (Varol and Ulusoy, 2023). Antalya wants the

water of this lake as drinking water due to water insufficiency. A water transmission line has been laid from these dams to Antalya. However, its use is not considered appropriate due to its high arsenic content. A method needs to be developed to convert it into drinking water (Kalyoncu et al., 2012; Milošković and Simić, 2015; Köksal et al., 2024).

2.1.6. Gölcük Lake Nature Park

General situation: It is located 5 km southwest of Isparta and at an altitude of 1380 m. It was formed by the filling of the crater pit with water. It is surrounded by hills formed from volcanic ash and rising up to 150-300 m. Its depth reaches to 32 m in places. The lake is generally fed by rainwater and springs boiling from the bottom. Its water is sweet and its surroundings are wooded. There are many sand dunes. There are Chara meadows at the bottom of the lake.

Problems: Its water is rich in terms of fluoride. There is fluoride above normal limits. Tourist facilities and tourism are at an important level. Since it was declared a Nature Park, protection activities in the area have accelerated. Since recreational areas and areas that need protection are limited, the protection-use balance is at an acceptable level. Its water is used as drinking water in neighborhoods close to Pilav Hill such as Hızırbey, Mavikent, Işıkkent, Yeni Mahalle, and Dere in Isparta. Water is supplied to these neighborhoods from the Andık Creek. The water of Lake Gölcük is mixed with the water of Lake Eğirdir and used as drinking water. The water of Gölcük Lake decreases with the decrease in precipitation. Its flora was studied by Fakir and Dutkuner (1999) (Figure 5).



Figure 5. A view from Gölcük Lake Nature Park.



Figure 6. Eğirdir Lake, the drinking water source of the region, is drying up day by day and turning into a swamp.

2.1.7. Eğirdir Lake Natural protected area

General situation: It is the most important lake of Isparta and Göller Yöresi. It is located between the Sultan and Karakuş mountains and in the middle of the provincial area. It is the 4th largest lake in Türkiye in terms of area covered. The lake is at an altitude of 918 m. Its depth is 13.6 (-16.5) m. In addition to spring water, the lake is fed by nearby springs (Kanlı Palamut Spring, Karaot Avlığı Spring, Koca Spring and Havutlu Spring). The lake and its surroundings were declared a natural protected area in 1996. There are marshes on the shores of the lake on the Gelendost and Hoyran sides. Its rocks are mainly limestone and marble. Its surroundings are forested. It is an important plant area in terms of biological diversity. Aquatic flora is rich in marsh areas and in the water (Özçelik et al., 2015; Karaca, 2002). Eğirdir Lake is the second largest natural lake in Turkey whose waters are

used after Beyşehir Lake. The lake actually reached its maximum water level of 919.31 m in 1969 and fell to its lowest level of 915.42 m in 1975 (Özçağdaş, 2020; Anonymous, 2025).

Problems: In recent years, its water has been decreasing, and as a result, swamps have been seen here and there, and the lake bed is shrinking. Most of its water is used for agricultural irrigation. It irrigates a basin of approximately 3,309 km². Excessive chemical pesticides are used in agricultural production areas around the lake. Apple production consumes the most water and uses chemical pesticides. 33.6% of Türkiye's total apple production is carried out in Isparta, namely the agricultural areas around Eğirdir Lake (Bayav and Karlı, 2020). These pesticides poison the soil, percolate through the soil and spoil the groundwater, and a significant portion of them leaks from the soil and

returns to the lake. Lake indices applied in Europe were tested at this station, but could not be applied to these lakes because the parameters forming the substructure of the indices were missing. According to all biotic indices, the lake was determined to be polluted. It can be stated that pollution was high and weak in April compared to other periods.

There are tunnels in some parts of the lake. A significant amount of water is discharged from these areas to the Antalya side. This situation is perceived as a threat by some groups. There are marble quarries on the Aksu road in the vicinity of the lake. Although the lake area is one of the important areas of Isparta that needs to be protected, its protection is very weak. Both the water reserves are decreasing and the quality of the water is deteriorating.

Eğirdir Lake is the 4th largest lake and 2nd freshwater lake in Türkiye. It has a surface area of 487.76 km² at maximum water level and a storage capacity of 4,005.10 hm³. Its annual average flow is 871.85 hm³. The lake has a drainage area of 3,309 km² and constitutes the upper basin of the Antalya Aksu stream (Esendal, 2007).

In 1955 year, an improvement study was carried out by the DSI. Thanks to this, the floods of Lake Eğirdir were brought under control and Boğazova, which was a completely swampy area, was dried. Before 1955, the elevation was 918.96 m. The waters rising above this altitude with rainfall were overflowing and flowing into some sinkholes in Boğazova, and the remaining was reaching the Aksu basin from the valley where Kovada Hydro Electric Central is located today. Work to prevent sinkhole leaks in lakes of Eğirdir and Kovada was started in 1977. The sinkholes and karstic cracks that emerged due to the decrease in water levels in both lakes were closed with various methods (such as concrete coating, dam creation). Thanks to the closing of the sinkhole in Eğirdir Lake, 30 hm³/year of water was saved (Işıldar and Ercoşkun, 2021).

Agricultural irrigation from Eğirdir Lake started in 1971 and has increased continuously every year. Water was continuously supplied to Kovada 1 and 2 power plants under the name of water supplied to energy from Eğirdir Lake and also to irrigate Antalya-Aksu plain until 1991 year. The annual average water that can be drawn by the more than 200 pumps of different capacities located on the lakeside and drinking water for settlements and villages such as Uluborlu, Senirkent, Yalvaç, Hoyran, Barla, Gelendost and Eğirdir within the precipitation basin of Eğirdir Lake is estimated to be 12 hm³. More than 10 ponds have been built on the streams feeding the lake within the Eğirdir Lake catchment: Yalvaç-Hisarardı, Uluborlu-İleydağı and Yalvaç-Dedeçam ponds, Gelendost-Balcı, Barla, Yalvaç-Körküler and Yalvaç-Çetinçe, Yalvaç-Sücüllü dam are some of them. Waters of Eğirdir Lake are in the C2S1 class. In other words, it can be used both for agricultural irrigation and as drinking water. The drinking and utility water of Isparta city center is mostly provided from this lake (Figure 6).

2.1.8. Kovada Lake National Park

General situation: Kovada Lake which is the fresh water source of the region and a national park, is located on the shores of Lake Eğirdir. Its altitude 905 m, water level is 8.78 km² and its volume is 29.92 hm³. Its precipitation basin is 208 km². It was formed as a result of karst pits filling with water. If the water coming out of the regulator of Eğirdir Lake is excessive, it is transferred to Kovada Lake through a channel. The most important streams of the Yukarı Gökdere, Aksuçayı and Kovadaçayı. Karakavaklı stream, Taşlı stream, Gâvurboğazı stream and Kuruçay streams are also important. Except for the western region, the surroundings of the lake are generally reeds and reeds. Its water is sweet and does not become cloudy. There are significant changes in the lake level between seasons. The lake level increases especially in winter season, decreases in the summer season due to reasons such as increased evaporation and lack of rainfall, and the streams flowing into the lake being used for irrigation in agriculture (Plenty of fish live in the lake). Its bedrock is limestone and marble. The lake is surrounded by forests. Its view is very beautiful. It has been included in the national park due to the very rich flora and fauna in its surroundings. The tallest and most lush forest trees in Isparta are around this lake. Red pine forests can reach 40 m in this area. There are giant forest trees. Educational activities are carried out in Kovada Lake National Park. It is considered as an extension of Eğirdir Lake from the bottom. Its flora was studied by Fakir (2007).

Problems: Organic pollution is high. The problems mentioned for Eğirdir Lake are also valid for this lake.

2.1.9. Karagöl

Karagöl is a small lake in Yenişarbademli district. It is a glacial lake between the 2375 m peaks of Dedegül (Anamas) mountain, the highest mountain in the region. Its surroundings are peat bogs. It is fed by rainfall and snow water. There is at least one tunnel at its base (Özçelik et al., 2015) (Figure 7).

2.1.10. Beyşehir Lake National Park

The lake originated from a tectonic depression located to the east of the Anamas Mountains that gradually filled with water. In terms of surface area, it ranks as the third largest lake in Türkiye. Its waters partially flow into Suğla Lake through a channel. It is important for the irrigation of agricultural areas. Fishing is done. Its water is salty. Its flora was studied by Karaca (2002).

2.1.11. Rivers and fishing

Waste from fishing in rivers in Aksu, Çandır, A. Gökdere and dam lakes such as Karacaören are also important sources of pollution. These wastes must be processed and disposed of or destroyed (Figures 8-13).



Figure 7. A view from Karagöl (Yenişarbademli/ Isparta).



Figure 8. A view from Aksu Zindan cave (Isparta) and its environs.



Figure 9. A view from Çayır plateau (Aksu/Isparta).



Figure 10. A view from Pınargözü cave (Yenişarbademli/Isparta).



Figure 11. A view from Çandır Nature Park (Sütçüler/Isparta).



Figure 12. The historical water cisterns on the Çubukbeli highway of the Burdur-Antalya border have dried up in recent years.



Figure 13. A view from Acıgöl and soda factory (Çardak/Denizli).

3. Results and Discussion

In the study we conducted, the pressures on the water regime in the Lakes Region and the resulting ecohydrological risks were examined in a multifaceted manner. Although the primary aim of our study was not to conduct a species inventory, our assessments regarding endemism and the region's floristic potential reveal that water-related degradation may cause irreversible impacts on ecosystem components in the long term.

Numerous studies have been conducted to reveal the plant diversity in various locations of the Lakes Region. One of the earliest accessible studies on the subject is the work conducted by Meral Avcı in 1996, titled "Plant Communities and Their Distribution in the Western Part of the Lakes Region." According to Avcı (1996), although the region is defined as a transitional zone between the

Mediterranean and continental climates, the vegetation exhibits a genuine mosaic structure due to the complexity of environmental conditions. The study clearly demonstrates the decisive role of water availability in enhancing plant diversity both in terms of species composition and density. Avcı (1996) examined in detail the areas surrounding Eğirdir Lake, Kovada Lake, Burdur Lake, Acıgöl, and Salda Lake, including the mountainous and lowland zones adjacent to these lakes. She highlighted that the humid microclimate created by Eğirdir and Kovada Lakes supports the presence of semi-humid forests and contributes to higher species richness. In contrast, the saline and alkaline nature of Burdur Lake and Acıgöl results in a more monotonous vegetation structure, with dry forests being predominant. The surroundings of Salda Lake are characterized by dry forests dominated by species such as black pine (*Pinus*

nigra) and Turkish red pine (*Pinus brutia*). Avcı assessed the vegetation structure around these lakes and evaluated the indirect influence of water presence on plant distribution.

Another early study in this field is "A General Overview of the Flora of Isparta" by Özçelik and Serdaroglu (1998). This was followed by many other important contributions, including "A General Overview of the Flora of the Lakes Region" (Özçelik et al., 2001), "Some Interesting Plants of the Lakes Region" (Özçelik et al., 2002), "Contributions to the Flora of Sütçüler-Isparta (Türkiye)" (Özçelik and Korkmaz, 2002), "Flora of Kovada Lake National Park and Its Environs" (Karaca, 2002; Fakir et al., 2005; Fakir, 2007), "Floristic Analysis of Çandır Nature Park and Its Surroundings (Isparta-Antalya)" (Özçelik and Tanrıverdi, 2005), "Flora of the Surroundings of Lake Burdur" (Çetin et al., 2013), "Conservation and Monitoring Studies on Terrestrial and Freshwater Ecosystem Diversity in Isparta Province" (Özçelik et al., 2015), "Conservation and Monitoring Studies on Terrestrial and Freshwater Ecosystem Diversity in Burdur Province" (Özçelik et al., 2015), "Determination of Some Naturally Growing Ground Cover Plants in the Lakes Region" (Gül and Özçelik, 2016), "Biodiversity and Its Economic Importance in the Lakes Region (Türkiye)" (Özçelik, 2017), "Flora Inventory of Köprülü Kanyon National Park (Antalya-Isparta)" (Özçelik, 2018b), and "Biodiversity in the Lakes Region (Türkiye) and Its Agricultural Importance" (Özçelik, 2019). Among these, the most comprehensive studies are those focusing on biodiversity. All plant specimens collected during these research efforts are preserved in the GUL Herbarium. According to the findings of these studies, the Lakes Region exhibits a remarkably high rate of endemism. In particular, due to plant transitions between neighboring provinces, the provinces of Isparta and Burdur are recognized as botanically rich areas within the Lakes Region.

This richness is particularly vulnerable to ecohydrological threats, especially in the case of endemic and locally distributed species sensitive to changes in water regime. Species inhabiting microhabitats around lakes, which require high humidity or have narrow ecological amplitudes, are likely to be severely affected by fluctuations in water levels. Therefore, the sustainable management of water resources is crucial not only for the preservation of hydrological systems but also for maintaining floristic diversity in the region. In this regard, the strategic measures proposed in our study are considered to offer an integrated approach that supports both environmental stability and biological integrity.

In recent years, climate in the Göller Yöresi has changed; precipitation has decreased, water consumption has increased, warm periods have lasted longer, and cold periods have shortened, and it is easily noticed and expressed by older people.

The region is an important area of Türkiye in terms of water resources. It has about 15 natural lakes and about

50 ponds for agricultural irrigation. The water reserves in the region, which are utilized for household consumption, farming activities, and industrial operations, are more abundant compared to other parts of the country. However, in recent years, a water scarcity problem has emerged throughout the country. Water resources tend to be polluted and diseases are increasing. We do not have enough information to take protective measures against the proper management of water resources and pollution. Waste from fishing on rivers (Aksu, Çandır, Aşağı Gökdere etc.) and dam lakes are also important sources of pollution. More information is needed on agricultural irrigation and industrial use. Limited attention has been given in the literature to the role of natural and human-related factors in shaping the condition of water resources used for irrigation in the region. Detailed information is needed for correct interpretation.

Although numerous studies have been conducted on the floristic structure of the Lakes Region, research specifically focusing on the biodiversity surrounding the lakes is rather limited. In particular, studies examining the relationship between plant diversity and water presence are scarce. For instance, the macrophytic flora of Lakes Eber, Salda, and Beyşehir has been investigated by Özçelik and Korkmaz (2002) and (Karaca, 2002). As a result of the identification of approximately 1300 vascular plant samples collected, a total of 276 taxa belonging to 47 families and 163 genera were identified. The richest flora of these was found in Beyşehir Lake. This situation was accepted as an indicator of the shallowness of the lake and the sweetness of its water. The results are as follows:

Eber Lake:

Families: Alismataceae 2 (4%), Apiaceae 5 (10%), Asteraceae 5 (10%), Brassicaceae 3 (6%), Caryophyllaceae 1 (2%), Convolvulaceae 1 (2%), Equisetaceae 1 (2%), Fabaceae 4 (8%), Poaceae 6 (12%) and Ranunculaceae 2 (4%).

Genera: *Alisma* 2 (3%), *Apium* 1 (1.6%), *Berula* 1 (1.6%), *Calamagrostis* 2 (3%), *Equisetum* 2 (3%), *Juncus* 2 (3%), *Myriophyllum* 2 (3%), *Potamogeton* 5 (8%), *Ranunculus* 6 (10%), *Senecio* 2 (3%).

Salda Lake Nature Park:

Families: Asteraceae 7 (14%), Boraginaceae 2 (4%), Brassicaceae 4 (8%), Caryophyllaceae 5 (10%), Chenopodiaceae 3 (6%), Cyperaceae 2 (4%), Fabaceae 2 (4%), Papaveraceae 2 (4%), Poaceae 10 (20%), Scrophulariaceae 3 (6%).

Genera: *Alyssum* 3 (5%), *Centaurea* 4 (6.6%), *Cichorium* 1 (1.6%), *Echinops* 1 (1.6%), *Inula* 1 (1.6%), *Salsola* 2 (3.3%), *Taraxacum* 1 (1.6%), *Teucrium* 3 (5%), *Verbascum* 3 (5%), *Xeranthemum* 1 (1.6%).

Beyşehir Lake National Park:

Families: Apiaceae 6 (4.5%), Asteraceae 14 (10.6%), Boraginaceae 6 (4.5%), Brassicaceae 13 (10%), Caryophyllaceae 7 (5.3%), Fabaceae 9 (7%), Lamiaceae 6 (4.5%), Lythraceae 6 (4.5%), Poaceae 21 (16%),

Ranunculaceae 5 (4%).

Genera: *Alopecurus* 4 (0.2%), *Anthemis* 3 (0.15%), *Equisetum* 3 (0.15%), *Juncus* 10 (0.5%), *Potamogeton* 7 (0.35%), *Ranunculus* 8 (0.4%), *Silene* 5 (0.25%), *Trifolium* 5 (0.25%), *Vicia* 5 (0.25%), *Veronica* 4 (0.2%).

About 800 vascular plants samples had been collected from the Kovada Arboretum area. In the end of the samples identification 350 taxa belonging to 71 families and 222 genera are determined (Özçelik and Çetinkaya, 2002).

The distribution rations of the taxa according to phytogeographic regions are as follows:

The floristic composition of the area comprises 28.8% Mediterranean, 11.4% Irano-Turanian, and 6.8% Euro-Siberian elements. The number of endemic taxa is 43, accounting for 12.3% of the total flora identified in the region.

The ten families and genera which including the most taxa are as follows:

Families: *Apiaceae* 14 (4.0%), *Asteraceae* 31 (8.8%), *Brassicaceae* 19 (5.4%), *Caryophyllaceae* 15 (4.2%), *Fabaceae* 26 (7.4%), *Lamiaceae* 26 (7.4%), *Poaceae* 24 (6.8%), *Rosaceae* 12 (3.4%), *Rubiaceae* 13 (3.7%) and *Scrophulariaceae* 13 (3.7%).

Genera: *Galium* 9 (2.5%), *Hypericum* 5 (1.4%), *Medicago* 6 (1.7%), *Populus* 5 (1.4%), *Prunus* 4 (1.1%), *Ranunculus* 5 (1.4%), *Silene* 6 (1.7%), *Verbascum* 4 (1.1%), *Veronica* 4 (1.1%), *Vicia* 4 (1.1%).

Following Özçelik (2019), the most recent studies on the subject are those conducted by Gülle et al. (2022) and Özdal and Çetinkaya (2024). In their study titled "Biological and Ecological Characteristics of Lake Eğirdir," Gülle et al. (2022) evaluated the macrophytes present in the lake in terms of floral composition. However, they did not address the relationship between changes in the water regime and macrophyte populations. On the other hand, Özdal and Çetinkaya (2024) conducted a comprehensive review examining the habitat characteristics, diversity of macrophytes, their potential uses, and the various threats facing the Lakes Region, which is recognized as a significant aquatic hotspot. The study documented a total of 144 aquatic plant species representing 43 botanical families found within the surface water bodies of the region and its surrounding areas.. Furthermore, the study emphasized that seasonal changes in the water regime and the drying of water sources pose significant threats to plant life. However, despite covering a broader area compared to the study conducted by Özçelik and Korkmaz (2002) and (Karaca, 2002), fewer plant species were identified, which may suggest the effects of habitat degradation or methodological differences between the studies. It was noted that the population growth of certain species depending on water availability, as well as the development of invasive species in the area, create problems for the aquatic ecosystems in the region. However, no quantitative data or index regarding the aquatic ecosystems in the area was provided; instead, the

region was described as a "Hotspot" in terms of its plant diversity. In the study conducted by Gülle et al. (2022), it was emphasized that the increasing effects of drought and climate change in recent years have led to significant decreases in lake water levels in the Lakes Region, resulting in a substantial reduction in the habitats of water-dependent plant species. The authors particularly noted that endemic and narrowly distributed species are among the most affected. The study also examined the impacts of agricultural activities on the water regime, highlighting that intensive irrigation practices, especially around major lakes such as Eğirdir, Beyşehir, and Burdur, have disrupted wetland ecosystems. Traditional flood irrigation methods have been shown to cause both a decline in groundwater levels and the drying of coastal ecosystems. Furthermore, agricultural pollution has emerged as a critical threat, as increased nitrogen and phosphorus loads from fertilizers and pesticides negatively affect macrophyte communities—leading to the overdominance of certain species and the disappearance of others due to habitat degradation. With the shrinkage of lake areas, significant losses have occurred in temporary wetlands, marshes, and riparian vegetation zones, particularly affecting populations of reeds and bulrushes. Lastly, the study drew attention to hydrological interventions such as stream and lakebed modifications, which disrupt the natural water balance and contribute to the transformation of vegetation types. It is a well-known fact that global water resources are under significant threat. Climate change and the ongoing global warming process are among the primary factors contributing to this threat. Human-induced environmental degradation has not only led to the depletion of water resources but has also rendered many clean water sources increasingly unusable. Industrial facilities established near freshwater sources often fail to implement adequate environmental safeguards and discharge wastewater into these sources, thereby reducing the availability of potable water. As a result, the public's trust in municipal water supplies has declined, leading to a growing reliance on packaged drinking water (Kızılaslan et al. 2014) to meet daily consumption needs. In the past 20 years, the sale of ready water has become increasingly widespread in the country. Until 20 years ago, water from taps, wells and networks was used for all kinds of purposes. The proverb 'cheaper than water' was frequently used in trade to indicate the abundance of water. Today, bottled ready water for drinking purposes is sold in every market of the country. On the other hand, consumers, see water prices as very expensive. The public's growing distrust in drinking water sources and the commercialization of water clearly reveal the quantitative and qualitative threats to water resources. This situation further underscores the urgent need for the conservation and sustainable use of wetlands.

Determining the problems of wetlands is first step towards protecting and sustainable use of the relevant area. The final point is to achieve sustainable use of the

area in long term. In the last 50 years, more than 1 million 300 thousand ha of wetlands in Türkiye have lost their ecological function due to reasons such as drying and pollution. When the effects of global climate change are added, it can be said that the future of more than 1.2 million ha of wetlands is not safe. This situation also means that the economic importance of the same wetlands has weakened (Tapan, 2018).

The reason why the problems mentioned above cannot be prevented is due to poor management. These problems are as follows:

- Insufficient understanding of the importance of wetlands by practitioners and local people,
- Insufficient consideration of ecological principles when making water and land use plans,
- Reaction of producers to errors and wrong practices observed in land consolidation practices,
- Insufficient communication, cooperation and solidarity between relevant institutions and organizations. Some areas being managed by more than one institution, causing chaos,
- Weakness of necessary administrative mechanisms that will continuously monitor changes that will ensure the decentralization of areas,
- Covering soil surfaces (asphalt etc.) with a waterproof layer due to unplanned urbanization and reducing the use of rainfall. Instead of rainfall being absorbed from the soil and feeding the groundwater, it turns into a disaster by creating floods,
- People obtaining agricultural land from drying aquatic areas and illegal promises from some authorities regarding this: Such promises have been made for Beyşehir Lake and these promises were fulfilled. Currently, due to the shrinkage of Burdur Lake and the narrowing of its bed, field openings are rapidly increasing in the Senir, Karakent and İnar villages. It is desired that the lake be dried up since opening a short road from Senir to Burdur would be beneficial for the people.

In Türkiye, 72% of the water consumed is used in agriculture, 18% for domestic needs and 10 % in industry. The sector where fresh water is used the most is agriculture. The biggest factor in the loss of wetlands is wrong agricultural irrigation methods and wild (flood) irrigation or unnecessary irrigation. These practices should be minimized (Altınbilek and Hatipoğlu, 2020).

The dangers of water pollution are as follows:

Uncontrolled withdrawal of groundwater, changing the direction of water flow and polluting it.

With industrialization, rapid and unplanned urbanization, wetlands have become waste storage pools where sewage waste from both industry and residential areas is discharged.

In addition, when the widespread use of chemical fertilizers and pesticides in agriculture is added to the careless use of these substances, pollution has become the most important problem threatening wetlands.

Due to excessive pollution, the natural balance has been

disrupted in many wetlands and fish deaths have begun to occur from time to time. In 2024, the mains water in the city center of Isparta began to flow turbidly and emit an unpleasant odor.

The water regime and characteristics of the region are explained below:

- 1) The Göller Yöresi in the mediterranean region were formed as a result of volcanic movements. For this reason, there is mineral water around the villages of Kadılar, Direkli, Darıören (Isparta). The waters in the region are generally rich in minerals. Drinking water of the Sav town and the water in Sidre Hill are the favorite drinking waters of the people of Isparta.
- 2) Interaction of bedrock and drinking water: Bedrock of the region is volcanic and limestone. Volcanic movements have great importance in the formation of its topography. Mountain range in the region, called 'the Aksu Bindirmesi/Aksu Thrust' in geology, is generally volcanic in structure. In other words, the 'Aksu Thrust' is limestone in nature and is located on volcanic bedrock. There is a great risk of death due to the vortex while working in the water in glacial lakes. It turns into drinking water springs on the Antalya by licking the volcanic rocks under the Aksu Thrust.
- 3) Other results obtained from the findings show that the dominant chemical in groundwater is chlorine (Cl⁻). The rocks richest in chlorine are abundant around Keçiborlu district and Burdur Lake. The most important factor that makes salty water of the lake is these rock salts. It showed that the rock-water interaction that comes with precipitation is the main process affecting groundwater chemistry.
- 4) Purposes of use of lakes: Large lakes (Burdur, Salda, Eğirdir, Beyşehir lakes and Karacaören dam) create a microclimate around them. Endemic plants are abundant here and agriculture and animal husbandry are strong.
- 5) Karacaören Dam Lake, Burdur and Salda lakes cannot be used as drinking water. Lakes used as drinking water are Eğirdir, Gölcük and Beyşehir Lake. As a drinking water source, Beyşehir Lake is the largest and Eğirdir Lake is the second largest lake in Türkiye. Gölcük Lake has long been the drinking water source for Isparta city center. However, with the population growth of the city, Gölcük Lake began to be insufficient; water was also taken from Eğirdir Lake. The water of Eğirdir Lake is generally used for aquaculture and irrigation purposes.
- 6) In recent years, the water input of all lakes and dams in the region has been decreasing. With the decrease in water input to drinking water sources, the chemical composition of the water is negatively affected, and pollution and heavy metal accumulation are increasing. The best example of this is Lake Eğirdir.
- 7) Karacaören Dam Lake Arsenic (Kalyoncu et al, 2012; Milošković and Simić, 2015; Köksal et al, 2024); water of Gölcük Lake is very rich in fluoride (F)

(Oruç, 2008). Although fluoride is a necessary element for bone and tooth health, it damages bones and teeth when it is in excess in drinking water. For this reason, due to the excessive fluoride content water of Gölcük Lake, which is the drinking water source of the province, yellowing of teeth was frequently seen in Isparta people. Arsenic (As) is a very dangerous element known to have been used in the past for suicide or to kill someone.

- 8) Underground waters of the region can be generally accepted as suitable for irrigation. Waters of Burdur and Salda lakes cannot be used for irrigation purposes. Salda Lake is extremely soda; low in salt and high in alkaline. Therefore, the fauna and flora in the lake are poor. The surrounding serpentine rocks have a great effect on composition of its water, its non-drinkability and the formation of its turquoise color. Waters that interact with serpentine main rocks are known to be poisonous and are blue in color.
- 9) Groundwater is used for irrigation purposes more than surface water. The values derived from irrigation indices—such as soluble sodium percentage, magnesium hazard, permeability index, and residual sodium bicarbonate—serve as indicators of intensified anthropogenic influences on water quality. This substance is produced abundantly in Acıgöl in Çardak district of Denizli. Acıgöl is the only and the second largest, clean and natural sodium potential closed basin in Türkiye. The country provides 90% of its sodium sulfate from Acıgöl (Anonymous, 2024d).
- 10) Some of the water is also used in industry. However, the amount and rate are unknown. Industrial sectors that use water in the region are rose oil production facilities and marble production.
- 11) Fresh water in the region is used in domestic, industrial, agricultural and animal husbandry sectors without distinguishing between sectors.

4. Problems and Solutions

4.1. Problems

- 1) Türkiye, due to its geographical and climatic conditions, is important wetlands in the Middle East and Europe. However, considering that the total wetlands in the country are 2.5 million ha, it is saddening that it has lost half of its wetlands in last 40 years. (Karadeniz et al., 2009; Altınbilek and Hatipoğlu, 2020) Clean, high quality air, water and food affect all livings. This order is also the order of importance of values. They are environmental factors that trigger each other. Every passing day, we are reducing reserves by polluting the air, water and soil. Food, water and air are getting polluted, diseases are increasing. It is estimated that we are mistaken in the idea that the solution is to expand hospitals, increase the number of hospitals and healthcare professionals.
- 2) According to several studies, various human-induced

pressures—including unregulated urban expansion, extractive industries, industrial discharges, waste disposal, pesticide runoff, leachates, accumulation of heavy metals, microbial contaminants, nutrient imbalances, and both radioactive and chemical pollutants—threaten the long-term viability of groundwater systems (Ahada and Suthar, 2018; Chidambaram et al., 2018; Kumar et al., 2018). In parallel, naturally occurring (geogenic) factors can also contribute to groundwater deterioration by elevating chloride levels (Panno et al., 2006) or increasing sulphate concentrations (Champidi et al., 2011; Grützmacher et al., 2013). Eyankware et al. (2020) define geogenic contamination as the presence of pollutant levels exceeding established drinking water standards without any direct anthropogenic input. Such contamination typically arises from the prolonged interaction between groundwater and its host geological matrix under favorable mineralogical and hydrological conditions. Contributing processes may include dissolution of evaporitic minerals (Irfan et al., 2019), vertical or lateral intrusion of saline groundwater, saline water encroachment, and aquifer mixing facilitated by inadequately constructed wells (Aunay et al., 2006). Keçiborlu (Isparta) and Dazkırı (Afyonkarahisar) sides are equipped with saline rocks.

- 3) According to the general opinion; groundwater is used for irrigation purposes more than surface water. Although groundwater is less susceptible to contamination than surface water due to its natural filtration processes, the remediation of pollutants, once contamination occurs, is significantly more challenging and time-consuming. The most important factor that pollutes groundwater is chemical pesticides used in the region (Jiang et al., 2019; Eyankware et al. 2020). For this reason, we have to reduce the use of pesticides in agricultural areas.
- 4) The potential salinity sources of groundwater are salt rocks. These rocks are broken down by effects of heat and cold or melted by rain and mixed with water; and thus the chemical structure of the water and therefore the soil is damaged.
- 5) 4. Wastes from fishing on rivers (Aksu, Çandır A. Gökdere rivers etc.) and in dam lakes are also important sources of pollution.
- 6) The wastewater generated after rose processing has a high flow rate and is loaded with pollution. The fact that this type of wastewater is spread to different regions makes treatment difficult in treatment plants. For this reason, alternative treatment methods are needed other than the existing treatment methods.
- 7) It is extremely important to protect the environment and natural resources from pollution. Cleaning polluted areas is equally important. Since there is an increasing water shortage in the region, it is inevitable to purify water resources that contain salt, arsenic or heavy metal pollution.

8) Drainage in meadow areas: Drainage was made in meadow areas in Düğür and Bucak districts of Burdur province, approximately 20 years ago. It was a very wrong application. As a result of this application, the meadows were turned into pastures for a few years and the grass yield increased. Shepherds and those who were engaged in animal husbandry were satisfied with the application. In the following years, these meadow areas were converted into steppes and then into drylands. The waters of the surrounding agricultural areas and the moisture under the soil were affected by these activities.

Groundwater quality in urban environments is reported to be predominantly influenced by the region's geogenic characteristics and geochemical composition, the pace of urbanization, leakage from waste disposal sites, industrial activities, mining operations, bacteriological contamination, heavy metal accumulation, and seasonal variations (Eyankware et al., 2020). Since the cities in the Göller Yöresi are also growing rapidly, groundwater will be more polluted by surface water and diseases will increase more. It is thought that surface water is more prone to pollution compared to groundwater due to being exposed to all kinds of pollutants (landfill, domestic waste, dumps, septic tanks and oil spills, etc.); however, it is easier to clean.

It has been stated that ornamental plants *Calendula officinalis* and *Althaea rosea* can be used in phytoremediation due to their tolerance to cadmium. The use of plants (*Tagetes patula*, *Syngonia* sp., *Pteris cretica* and *Pteris vittata*) in the removal of As (Arsenic/ NaAsO_2) pollution in soil has given positive results (Imamul Huq et al., 2005; Wei and Chen, 2006).

Hyperaccumulator plants are plants that accumulate more metal levels in their aboveground parts than in the soil, and are therefore used in the cleaning of heavy metal pollution (phytoremediation). These plants can accumulate heavy metals 100 to 1000 times more than other plants without showing any toxicity symptoms. Approximately 450 plant species (only 0.2% of angiosperms) have been described as hyperaccumulators (Özay and Mammadov, 2013).

4.2. Suggestions

1) In order to prevent decrease in surface water quality, waste should be not disposed of in places close to surface water bodies. A rainwater project was carried out in the city center of Isparta. It cannot be said that we were able to evaluate rainwater with this project. Rainwater is not polluted since it also includes rainwater coming to closed areas. It should have been kept separate from polluted water falling on roads and collection areas should have been different and this water could have been collected in a pond without any processing and used in agriculture. However, when this project was carried out, there was no water scarcity problem in the country. Therefore, rainwater was seen as a problem for the city at the date of implementation of the

relevant project and it was requested to be disposed of. In order to prevent the complete deterioration of the irrigation regime of water resources, the relevant institutions should monitor it from time to time.

- 2) As the settlement area of cities grows, applications such as houses with gardens and farm houses become more difficult. Buildings are becoming almost stuck to each other. The construction area should have been around 10% in an environmentally friendly approach. In cities, the ground that will absorb water is covered with waterproof material, and even if there is rain, cities suffer more from the rain than benefit. We need to find an alternative permeable material to waterproof ground covering. At least the neighborhood and street spaces should be covered with interlocking stones and should be able to let water through.
- 3) Water consumption should be charged according to purpose. The price should be increased in the order of housing, animal husbandry, agriculture and industry. Higher fees should be imposed on sectors that pollute water a lot, such as car washing, marble production and carpet washing. Drinking water and cleaning water lines should be separated and charged differently.
- 4) Establishment of green areas and grass fields in cities: While grass fields beautify city on the one hand, they also cause serious damage to water reserves on the other. Grasses are plants originating from Europe-Siberian region. They require excessive moisture. In our region, they require watering every day and mowing once a week. Taking Europe as an example and creating grass fields is a significant technical mistake for Türkiye, which is a water-poor country. In most European countries, there is no need to water grass. Türkiye is a water-poor country. The Mediterranean region is characterized by a climate typified by hot, dry summers and mild, wet winters. It is drier than other regions. Its ecology is not suitable for the growth of plants that require high humidity. Instead of grass, a hybrid plant of grass (*Agropyron repens*) can be planted. Since this plant has rhizomes, it is resistant to drought and does not require mowing for short periods as it does not grow excessively. Instead of grass, evergreen, herbaceous and rhizomes, bulbous, corm-like plants with underground stems should be planted. In order to reduce water consumption, dry and oily plants should be preferred and encouraged in agriculture and landscaping.
- 5) Filtration of polluted water and disposal of treatment sludge: In terms of physical characteristics, metals with a density exceeding 5 g/cm^3 are classified as 'heavy metals'. Among the more than 60 known heavy metals, the most prominent ones include iron (Fe), lead (Pb), copper (Cu), cadmium (Cd), mercury (Hg), nickel (Ni), chromium (Cr), zinc (Zn), and cobalt (Co). These elements are typically found in nature in

the form of silicates, carbonates, oxides, and sulfides. Salty, gypsum rocks and limestone can be used to purify polluted waters in the region. These rocks can be turned into gravel and wood ash can be sprinkled between them to prepare purification sludge. Polluted waters can be filtered with this sludge. Sludges that have completed their economic life should be collected in a certain area and capped mushrooms, *Thlaspi* spp., *Helianthus annuus*, *Nicotiana tabacum*, *Brassica* spp., *Zea mays*, *Pteris vittata*, *Gypsohila* spp., *Euphorbia* spp., *Tagetes* spp., *Typha* spp., *Carex* spp., *Cyperus* spp. group plants should be produced in this sludge and then the plants should be destroyed. Some plants such as *Chenopodium*, *Polygonum*, *Urtica sachalase* and *Alyssum* species possess the ability to accumulate heavy metals such as cadmium, copper, lead, nickel, and zinc within their tissues. *Salvinia natans*, *Lemna minor*, mosses can be grown wherever there are water bodies or excessive humidity.

- 6) The following plants are recommended for the purification of water from heavy metals. Mushrooms, *Helianthus annuus*, *Nicotiana tabacum*, *Brassica* spp., *Zea mays*, *Pteris vittata*, *Arundo donax*, *Juncus*, *Cyperus*, *Typha*, *Thlaspi* spp. are recommended as a method of production and destruction. In addition, by creating peatlands and filtering polluted water; by making panels with a mixture of gypsum, limestone and wood ash and filtering the water, microbiological purification and adjustment of acid-base balance can be done.
- 7) For surface waters; water collection basins should be created and pollution should be prevented. The eyes of springs and their immediate surroundings as well as wetlands should be protected and controlled.
- 8) Animal producers, especially those around Burdur Lake, should be encouraged to establish manure digestion areas and to purify and dispose of wastewater at the production site.
- 9) Relevant authorities are encouraged to acknowledge this recommendation and to establish water quality standards that can serve as a reference for determining suitable irrigation management strategies.
- 10) Water resources, especially Salda Lake, need to be protected on a basin basis. Protecting the lake cannot be done by putting up tarpaulins to prevent water evaporation in the lake (as explained for Burdur Lake). It cannot be done by blocking the entrance to the lake with barbed wire. Protecting up to 50 m as in Beyşehir Lake cannot be enough. Ecological, Aquatic Area Protection Agreements and coastal protection laws must be followed seriously. Protection must be done on a basin basis, resources that feed aquatic areas must not be dried up. The application must not be changed according to the administrations and must not be sacrificed to fruitless conflicts. It is recommended that the responsible institutions

seriously inspect the area and not allow construction and activities that do not comply with the legal regulation.

- 11) In recent years, efforts to open fields by cutting or burning reeds and draining the marsh have accelerated. Peat soil, or peat, intake from the surrounding area has increased and the peat bogs that filter the water have been damaged. The idea that we can prevent the drying of Lake Burdur with this lake is a mistaken view. Managers should be sensitive to destruction, water intake, as well as the migration of birds from the area. The area is an important freshwater source that needs to be protected.

It is of great necessity to implement the following suggestions regarding these results.

- New irrigation areas should not be opened by allocating water from Lake Eğirdir and new dams should definitely not be allowed in the precipitation basin;
- Economic water use should be ensured by carrying out a planned, programmed and conscious operation.
- Due to the decrease in water coming to the lake due to the extreme drought and global warming experienced in recent years, lake operation studies should be carried out for at least 20 years and implemented meticulously.
- The increase in the dead volume in the lake has caused the active volume to decrease. There is a very large sediment transport especially from Gelendost Stream, Pupa Stream and Hoyran Stream. Rivers, streams and precipitation basins need to be afforested urgently.
- Economic water use should be ensured by carrying out a planned, programmed and conscious operation.

Author Contributions

The percentages of the authors' contributions are presented below. All authors reviewed and approved the final version of the manuscript.

	B.M.Y.	H.Ö.
C	50	50
D	50	50
S	50	50
DCP	50	50
DAI	50	50
L	50	50
W	50	50
CR	50	50
SR	50	50
PM	50	50
FA	50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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- 1) Ürkütlü (Bucak), Düger, Gölhisar towns (Burdur) rangeland improvement and management project, TR. Ministry of Agriculture, Burdur Provincial Directorate, 2004-2008.
- 2) Göksöğüt-Çiçekpınar towns (Şarkikaraağaç-Isparta) rangeland improvement and management project. TR. Ministry of Agriculture, Isparta Provincial Directorate, 2004-2008.

- 3) Burdur Lake Wetland Revised Management Plan project, TR. Ministry of Agriculture and Forestry, Nature Conservation and National Parks, 6th Regional Directorate, Burdur, 2018.
- 4) Burdur/Isparta Isparta province terrestrial and inland water ecosystem diversity, protection and monitoring studies project, TR. Ministry of Agriculture and Forestry, Nature Conservation and National Parks 6th Regional Directorate, Burdur. 2014-2015.
- 5) Macrophytic flora of Eber, Salda and Beyşehir lakes project, Süleyman Demirel Univ., BAP project, Isparta.

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References