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# Determination of Water Quality Characteristics of Süphan and Hıdırmenteş Lakes (Van-Eastern Türkiye)

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## ABSTRACT

This study investigated the physical and chemical properties of the waters of Süphan and Hıdırmenteş Lakes in Van province, Eastern Turkey. Water samples were collected between November 2022 and August 2023 covering three seasons: autumn, spring, and summer. A total of 38 parameters from each lake were analyzed. The average parameter values were evaluated according to water quality classes. For Hıdırmenteş Lake, the average water temperature was 12.74°C, salinity was 0.40 mg L<sup>-1</sup>, electrical conductivity (EC) was 785.12 µS/cm, suspended solids (SS) was 181.01 mg L<sup>-1</sup>, turbidity was 152.33 NTU, pH was 8.17, dissolved oxygen (DO) was 8.14 mg L<sup>-1</sup>, nitrite (NO<sub>2</sub><sup>-</sup>) was 0.01 mg L<sup>-1</sup>, nitrate (NO<sub>3</sub><sup>-</sup>) was 6.23 mg L<sup>-1</sup>, ammonia (NH<sub>3</sub>) was 0.57 mg L<sup>-1</sup>, ammonium (NH<sub>4</sub>) was 0.60 mg L<sup>-1</sup>, phosphate (PO<sub>4</sub><sup>-3</sup>) was 1.22 mg L<sup>-1</sup>, phosphorus (P) was 0.41 mg L<sup>-1</sup>, and iron (Fe<sup>+2</sup>) was 2.877 mg L<sup>-1</sup>. For Süphan Lake, the average water temperature was 14.57°C, salinity was 0.23 mg L<sup>-1</sup>, EC was 453.13 µS/cm, SS was 156.00 mg L<sup>-1</sup>, turbidity was 125.33 NTU, pH was 8.35, DO was 8.19 mg L<sup>-1</sup>, NO<sub>2</sub><sup>-</sup> was 0.12 mg L<sup>-1</sup>, NO<sub>3</sub><sup>-</sup> was 8.03 mg L<sup>-1</sup>, NH<sub>3</sub> was 0.96 mg L<sup>-1</sup>, NH<sub>4</sub> was 1.01 mg L<sup>-1</sup>, PO<sub>4</sub><sup>-3</sup> was 0.03 mg L<sup>-1</sup>, P was 0.01 mg L<sup>-1</sup>, and Fe<sup>+2</sup> was 0.377 mg L<sup>-1</sup>. The water parameters, except for suspended solids, were suitable for agricultural use. According to the Regulation on the Protection and Improvement of waters where trout and carp fish species live, the phosphate, ammonia, and SS in Hıdırmenteş Lake, and the ammonia, SS, and nitrite in Süphan Lake, were not suitable for trout and carp production. To prevent water waste, modern irrigation systems should be used instead of traditional flood irrigation methods. Additionally, farmers should be educated about this issue and encouraged to adopt modern irrigation techniques.

**Keywords:** lakes, ponds, Van province, water quality parameters, water pollution.

## INTRODUCTION

Water has played a crucial role in the rise and progress of societies, effectively determining where civilizations have been established. With the increase in population, environmental problems have emerged, making water an even more critical resource due to the

growing demand and excessive consumption, as well as limitations caused by the current population trends (Şen 2016; Yılmaz and Peker 2013).

In the 1960s, Turkey had a population of 28 million, with an average water use right of 4,000 m<sup>3</sup> per person. By the 2000s, with the population reaching 70 million, this figure had decreased to 2,000 m<sup>3</sup> per



person. Today, with a population exceeding 85 million, the per capita water use right has further decreased to around 1,500 m<sup>3</sup>. It is projected that by 2030, when the population is estimated to be approximately 100 million, water use per person will drop to 1,400 m<sup>3</sup> (Şen 2016). These calculations do not account for potential drought and typical rainfall scenarios. Currently, there is a decline in water resources due to global warming and other negative factors. If these limited water resources are not managed scientifically and rationally, water scarcity and drought are imminent (Ceylan et al. 2009; Şen 2016).

Drought can lead to fish kills, reduced yields in animal and agricultural production, problems in food supply, decreased water availability, oxygen shortages in water, and high aquaculture stock density (Kabay 2019). For instance, in regions experiencing severe drought, large-scale fish kills have been reported, significantly impacting local ecosystems and economies. Similarly, drought conditions have led to substantial decreased in milk and meat production in livestock, and crop yields have suffered, causing food prices to rise and threatening food security. To mitigate drought impacts on agriculture, advanced planning and good management practices are essential (Kaplunan 2013).

As a result of climate changes, the earth's crust temperature increased by approximately 0.7-0.8°C between the 20th and 21st centuries due to global warming. Without necessary precautions, these temperature values will continue to rise, leading to the melting of glaciers, rising sea levels, and the occurrence of natural disasters (Şen 2016). Consequently, agricultural production will be significantly affected, and many plant and animal species may face extinction due to deteriorating living conditions (Karaman and Gökalp 2010; Şen 2016).

Lakes and ponds are generally formed naturally or through human-made dam constructions. They are named differently based on their formation structures, such as tectonic, volcanic, glacial, karst, landslide set, and coastal delta lakes. Human-made ponds are created for various purposes, including drinking, irrigation, and electricity generation (Duran 2016).

The Van Lake Basin, one of Turkey's basins, contains numerous lakes, ponds, dams, and streams. Key water bodies include Lake Van (607 km<sup>3</sup>), Lake Erçek (31 km<sup>3</sup>), Morgedik Dam (102 hm<sup>3</sup>), Sarımemet Dam (134 hm<sup>3</sup>), Koçköprü Dam (86 hm<sup>3</sup>), and Zerneke Dam (104 hm<sup>3</sup>). The water potential of the Van Lake Basin sub-basins is as follows: Ahlat-West (452.96 hm<sup>3</sup> year<sup>-1</sup>), Bendimahi-East (457.16 hm<sup>3</sup> year<sup>-1</sup>), Deliçay-East (275.63 hm<sup>3</sup>/year), Engil (309.78 hm<sup>3</sup> year<sup>-1</sup>), South (418.36 hm<sup>3</sup> year<sup>-1</sup>), Karasu-East (551.11 hm<sup>3</sup> year<sup>-1</sup>), and Zilan-North (869.83 hm<sup>3</sup>/year) (TOB 2018). Additionally, there are numerous smaller lakes and ponds such as Arin (1,260 ha), Nazik (4,625

ha), Nemrut (1,280 ha), and many others (Demir 2023a).

In the Van Lake Basin, several fish species both endemic and introduced are found in lakes, ponds, streams, and dams. These include *Alburnus tarichi* Güldenstädt, 1814, *Alburnus timarensis* Kuru, 1980, *Barbus ercisianus* Karaman, 1971, *Capoeta kosswigi* Karaman, 1969, *Oxynoemacheilus ercisianus* Erk'akan & Kuru, 1986, *Cyprinus carpio* Linnaeus, 1758, *Oncorhynchus mykiss* Walbaum, 1792, and *Gambusia holbrooki* Girard, 1859 (Elp et al. 2016; Şen et al. 2018). Pollution, including industrial waste, solid waste from streams and sewers, oils, synthetic detergents, pesticides, artificial organic chemicals, and bilge waste from ships, is a major threat to the life of the pearl mullet (*Alburnus tarichi*) in Lake Van. Furthermore, hydroelectric power plants (HEPPs) and sand quarries on streams flowing into Lake Van negatively impact the ecosystem, particularly affecting the pearl mullet. Climate change also significantly affects water resources in Van province, leading to reduced water flow in streams, drying up small water sources, and disrupting the migration of pearl mullet. Severe droughts have resulted in the complete drying of some ponds and significant water loss in others, leading to widespread fish deaths (Elaçmaz, Altınboğa, Çubuklu, Define Ponds; Değirmigöl and Dolutaş Ponds) (Demir and Şen 2021).

The Van Lake Basin, covering a total area of 17,964 km<sup>2</sup>, receives an average annual rainfall of 474 mm and has an average annual flow of 95.32 m<sup>3</sup> s<sup>-1</sup>. The basin's annual average yield is 6.25 L s<sup>-1</sup> km<sup>3-1</sup>, with a flow-to-precipitation ratio of 0.42 and a participation rate of 1.64%. The provinces of Van, Bitlis, and Ağrı are located within the Van Lake Basin (Batur et al. 2009).

This study aimed to determine the water quality characteristics of Hidirmenteş (Çaldıran) and Süphan (Çaldıran) Lakes, located in the Van Lake Basin and used by local communities for agricultural activities. Water analysis was conducted to evaluate the usability of these lakes for fishing, fish transfer, aquaculture, and irrigation activities. The data obtained were interpreted according to the values specified in relevant regulations to provide a comprehensive evaluation of the lakes' water quality.

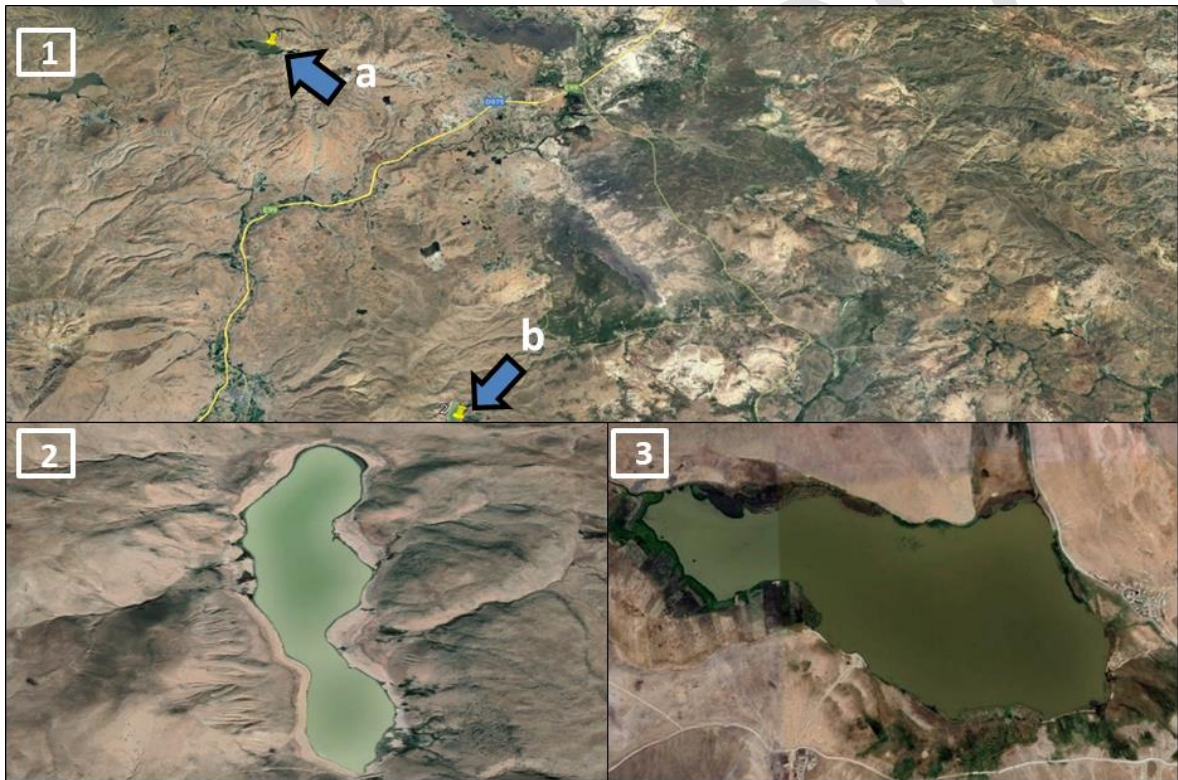
## METHODS

### Study Area

Information about the locations of Hidirmenteş and Süphan Lakes (Figures 1 and 2) is provided in Table 1. These lakes host mirror carp and scaled carp (*Cyprinus carpio*, L., 1758) fish species. Commercial fishing is prohibited year-round, while amateur fishing is permitted outside the breeding periods.



**Figure 1.** Sampling from the lakes Süphan (1) and Hıdırmenteş (2) in Van Lake Basin (Türkiye).



**Figure 2.** The locations of the Lakes Hıdırmenteş (1a, 3) and Süphan (1b, 2) in Van Lake Basin (Türkiye).

**Table 1.** Coastal length, surface area, and location information of Lakes.

Lakes	District	Coast length (km <sup>2</sup> )	Surface area (km <sup>2</sup> )	Coordinates	
				Latitude	Longitude
Hıdırmenteş	Çaldıran	2.00	0.96	39°10'50.30"K	43°46'17.43"D
Süphan	Çaldıran	2.95	1.80	38°57'45.79"K	43°52'06.08"D

### Sampling and Data Analysis

This study evaluated various physical and chemical parameters of lakes used for agricultural irrigation purposes before, during, and after the irrigation period (May, July, and November). Water sampling methods adhered to Ayyıldız (1983).

Water samples from Hidirmenteş and Süphan Lakes were collected between November 2022 and July 2023, covering autumn, spring, and summer seasons, as winter access to the lakes was not feasible (Figures 1 and 2). Temperature, dissolved oxygen (DO), total dissolved solids (TDS), salinity (‰), electrical conductivity (EC), and pH measurements from water samples were obtained using an HQ2200 Portable Multimeter device. Turbidity was analyzed with a turbidimeter device (HACH 2100 Q, Germany), and sodium and potassium concentrations were measured using a BWB flame photometer. Analyses of carbonate, bicarbonate, calcium, chloride, magnesium, total hardness, and organic matter (permanganate value) were performed using the titrimetric method (APHA 1995). Zinc, copper, nickel, cobalt, nitrite, nitrate, ammonium, ammonia, and phosphate were analyzed using an ICP-MS device (Agilent Technologies 7700 Series ICP-MS). Sulfate and boron were analyzed using a Shimano 2V spectrophotometer at the Soil, Fertilizer, and Water Resources Central Research Institute Laboratory. Phosphorus and suspended solids (SS) were measured with a spectrophotometer (HACH Lange DR 5000, Germany) at the Van Yüzüncü Yıl University Fisheries Faculty Laboratory (HACH 2005).

Water samples were collected using 1-liter plastic (polyethylene) containers from 40-50 cm below the water surface in areas where the lakes were at least 1-2 meters deep. The sample containers were rinsed 4-5 times with the lake water before being filled to the brim and sealed tightly. Each container was labeled with the sample taker's name, the sample location and date, and the sample number. The samples were then placed in thermoses and stored in a sample cabinet at the Provincial Directorate at +4°C for no more than 24 hours before being sent to the laboratory by courier for analysis. A letter requesting analysis accompanied the samples to the laboratory.

The quality of the obtained water parameters was classified based on the following standards: Regulation on the Protection and Improvement of Waters Where Trout and Carp Type Fish Live (ASSKY 2014), Surface Water Quality Management Regulation (YSKY 2015), Quality Criteria of Intra-Continental Surface Water Resources According to Classes in Terms of General Chemical and Physicochemical Parameters, Waters for Human Consumption (TSE 2005), Regulation on the Quality and Purification of Water Supply (İSY 2019), (WKY 2008), and World Health Organization (WHO 1993).

### RESULTS

The seasonal water quality parameter values (excluding winter) for Hidirmenteş and Süphan Lakes in Van province are presented in Table 2.

In Hidirmenteş Lake, the average values for water temperature, salinity, EC, suspended solids, turbidity, and TDS were higher than those in Süphan Lake. However, the average pH value in Hidirmenteş Lake was lower. Both lakes exhibited similar average readings for DO (Table 2).

Regarding mineral content, Hidirmenteş Lake had higher average values of calcium and bicarbonate, and lower average values of chloride, magnesium, calcium + magnesium, and total hardness compared to Süphan Lake. The carbonate levels were similar in both lakes (Table 2).

Except for phosphorus, the concentrations of the following compounds were lower in Hidirmenteş Lake than in Süphan Lake: nitrite, nitrite nitrogen, nitrate, nitrate nitrogen, ammonium, and ammonia, phosphate (Table 2).

Sulfate and potassium elements had higher concentrations in Hidirmenteş Lake compared to Süphan Lake. The sodium concentration was lower in Hidirmenteş Lake, while both lakes had the same concentration of boron. Hidirmenteş Lake exhibited higher levels of organic matter and sodium absorption rate (Table 2).

Both lakes contained the same levels of chromium and zinc. However, Hidirmenteş Lake had higher concentrations of iron, manganese, and copper (Table 2).

The classification of water quality parameter values measured seasonally (except winter) in Hidirmenteş and Süphan Lakes in Van province is given in Table 3.

### DISCUSSION

This study was conducted in Süphan and Hidirmenteş lakes in the Çaldıran district, within the borders of Van province.

The average temperature values measured in Hidirmenteş and Süphan lakes were classified as 1st class water values according to YSKYY (2015) and WKY (2008), and deemed appropriate according to ASSKY (2014). In other studies, the average water temperature was reported as 13.6±2.5°C in Aygır Lake (Çavuş 2018) and 17.4°C in Koçköprü (Demir 2023b). This variation is likely due to differences in measurement times, climate, and geopolitical conditions.

The average dissolved oxygen (DO) value of Hidirmenteş and Süphan Lakes was classified as class 1 according to YSKYY (2015) and deemed appropriate according to ASSKY (2014). In other



studies, conducted in the Van Lake basin, the average DO value was reported as 8.15 mg L<sup>-1</sup> in Yumrukluk Pond (Atıcı 2020) and 8.10±0.4 mg L<sup>-1</sup> in Arin Lake (Çavuş 2018). When water samples are taken, arid climate conditions and decreasing water levels negatively affect the amount of dissolved oxygen (Gümüş and Akgöz, 2020). The resulting values are similar to those reported in declarations.

In some scientific studies, the salinity value was reported as 0.29 mg L<sup>-1</sup> in Kabaklı Pond (Kaya

and Şen, 2022) and 0.21±0.003 mg L<sup>-1</sup> in Aygır Lake (Çavuş 2018). The average salinity value obtained is similar to the values reported for Süphan Lake, while Hidirmenteş has the highest value. The salinity of water varies depending on precipitation, evaporation, and soil characteristics. As evaporation increases, so does the salinity, particularly in the summer months (Dorak et al., 2018).

**Table 2.** Seasonal, average and standard deviation values of water quality parameters of lakes (mg L<sup>-1</sup>). EC: Electrical Conductivity, TDS: Total Dissolved Solids, SS: Suspended Solid, SAR: Sodium Adsorption Rate. T2-A1: These are moderately saline and low-sodium waters. T1-A1: are common salt and low sodium waters. DLA: Below Detection Limit, SD: Standard Deviation

Parameters		Lake Hidirmenteş					Lake Süphan				
		Autumn	Spring	Summer	Ave	SD	Autumn	Spring	Summer	Ave	SD
Physical Parameters	Temperature (°C)	4.90	14.30	19.03	12.74	±7.19	5.50	17.10	21.10	14.57	±8.10
	Salinity (mg L <sup>-1</sup> )	0.40	0.40	0.40	0.40	±0.00	0.20	0.20	0.30	0.23	±0.07
	EC (µS/cm)	784.00	781.30	790.07	785.12	±4.49	435.40	449.40	474.60	453.13	±19.86
	TDS (mg L <sup>-1</sup> )	339.50	338.50	342.70	340.23	±2.19	216.53	223.91	235.10	225.18	±9.35
	SS (mg L <sup>-1</sup> )	151.92	78.10	313.00	181.01	±120.12	161.30	59.70	247.00	156.00	±93.76
	Turbidity (NTU)	110.00	60.00	287.00	152.33	±119.27	130.00	50.00	196.00	125.33	±73.11
Chemical Parameters	PH	8.87	7.57	8.08	8.17	±0.66	8.42	7.94	8.68	8.35	±0.38
	DO (mg L <sup>-1</sup> )	10.18	7.39	6.86	8.14	±1.78	9.70	7.52	7.36	8.19	±1.31
	Alkalinity (mg L <sup>-1</sup> )	T1-A1	T1-A1	T1-A1	T1-A1	-	T1-A1	T2-A1	T1-A1	T1-A1	-
	Cl <sub>2</sub> (mg L <sup>-1</sup> )	19.53	28.75	24.14	24.14	±4.61	41.18	31.95	30.53	34.55	±5.78
	Ca <sup>2+</sup> (mg L <sup>-1</sup> )	16.80	10.60	13.20	13.53	±3.11	14.60	12.00	8.40	11.67	±3.11
	Mg <sup>2+</sup> (mg L <sup>-1</sup> )	5.76	6.72	1.68	4.72	±2.68	7.80	14.48	3.84	8.71	±5.38
	Ca <sup>2+</sup> +Mg <sup>2+</sup> (mg L <sup>-1</sup> )	42.24	34.88	25.60	34.24	±8.34	44.16	48.48	23.68	38.77	±13.25
	CO <sub>3</sub> <sup>2-</sup> (mg L <sup>-1</sup> )	0.00	0.00	0.00	0.00	±0.00	0.00	0.00	0.00	0.00	±0.00
	HCO <sub>3</sub> <sup>-</sup> (mg L <sup>-1</sup> )	31.11	35.38	38.43	34.97	±3.68	18.30	26.27	50.2	31.59	±10.44
	Total Hardness (mg L <sup>-1</sup> )	6.59	5.46	4.02	5.36	±1.29	6.90	23.18	3.71	11.26	±10.44
	NO <sub>2</sub> <sup>-</sup> (mg L <sup>-1</sup> )	0.01	0.01	0.01	0.01	±0.00	0.13	0.10	0.14	0.12	±0.02
	NO <sub>2</sub> -N (mg L <sup>-1</sup> )	0.01	0.01	0.01	0.01	±0.00	0.03	0.03	0.04	0.03	±0.01
	NO <sub>3</sub> <sup>-</sup> (mg L <sup>-1</sup> )	5.40	6.20	7.10	6.23	±0.85	6.10	8.00	10.00	8.03	±1.95
	NO <sub>3</sub> -N (mg L <sup>-1</sup> )	1.35	1.30	1.60	1.42	±0.16	1.90	2.05	2.30	2.08	±0.20
	NH <sub>3</sub> (mg L <sup>-1</sup> )	0.56	0.55	0.60	0.57	±0.03	0.96	0.98	0.93	0.96	±0.03
	NH <sub>3</sub> -N (mg L <sup>-1</sup> )	0.50	0.50	0.55	0.52	±0.03	0.80	0.81	0.79	0.80	±0.01
	NH <sub>4</sub> <sup>+</sup> (mg L <sup>-1</sup> )	0.58	0.58	0.64	0.60	±0.03	1.00	1.01	1.02	1.01	±0.01
	PO <sub>4</sub> <sup>-3</sup> (mg L <sup>-1</sup> )	0.98	1.11	1.68	1.22	±0.40	0.03	0.02	0.05	0.03	±0.02
	P (mg L <sup>-1</sup> )	0.37	0.31	0.55	0.41	±0.12	0.01	0.00	0.02	0.01	±0.01
	SO <sub>4</sub> <sup>-2</sup> (mg L <sup>-1</sup> )	29.28	11.92	10.00	17.07	±10.62	12.40	11.28	5.00	9.56	±3.99
	K (mg L <sup>-1</sup> )	3.51	5.07	4.29	4.29	±0.78	0.39	1.95	2.34	1.56	±1.03
	Na (mg L <sup>-1</sup> )	5.98	4.60	6.21	5.60	±0.87	2.79	9.20	5.52	5.84	±3.22
Organic matter (mg L <sup>-1</sup> )	7.32	3.56	0.66	3.85	±3.34	1.54	0.82	0.90	1.09	±0.39	
SAR	0.32	0.27	0.43	0.34	±0.08	0.15	0.26	0.40	0.27	±0.13	
B (mg L <sup>-1</sup> )	0.75	0.05	0.04	0.28	±0.41	0.75	0.10	0.02	0.29	±0.40	
Co (mg L <sup>-1</sup> )	DLA	DLA	DLA	DLA	-	DLA	DLA	DLA	DLA	-	
Cr <sup>+6</sup> (mg L <sup>-1</sup> )	0.003	0.001	0.002	0.002	0±.001	0.002	0.002	0.002	0.002	±0.000	
Fe <sup>+2</sup> (mg L <sup>-1</sup> )	3.760	2.800	2.070	2.877	±0.848	0.530	0.270	0.330	0.377	±0.136	
Mn <sup>+2</sup> (mg L <sup>-1</sup> )	0.039	0.030	0.010	0.026	±0.015	0.001	0.005	0.020	0.009	±0.010	
Cu (mg L <sup>-1</sup> )	0.003	0.001	0.003	0.002	0±.001	0.001	0.001	0.001	0.001	0±.000	
Ni (mg L <sup>-1</sup> )	DLA	DLA	DLA	DLA	-	DLA	DLA	DLA	DLA	-	
Zn (mg L <sup>-1</sup> )	0.017	0.008	0.003	0.009	0±.007	DLA	DLA	DLA	DLA	-	

**Table 3.** Classification of lakes according to average parameter values. A1: Water becomes drinkable after simple physical purification and disinfection. A2: Water becomes drinkable after physical treatment, chemical treatment and disinfection. A3: Water becomes drinkable after physical treatment, chemical treatment, advanced treatment and disinfection. DLA: Below Detection Limit

Parameters	Average Values	Lake Hidirmenteş						Parameters	Lake Süphan					
		YSKYY	WKY	ASSKY	İSY	TSE	WHO		Ave	YSKYY	WKY	ASSKY	İSY	TSE
Temperature (°C)	12.74	1	1	Suitable	-	-	-	14.57	1	1	Suitable	-	-	-
EC (µS/cm)	785.12	2	-	-	A1	Low	-	453.13	2	-	-	A1	Low	-
SS (mg L <sup>-1</sup> )	181.01	-	-	High	-	-	-	156.00	-	-	High	-	-	-
Turbidity (NTU)	152.33	-	-	-	A3	-	-	125.33	-	-	-	A3	-	-
PH	8.17	1	1	Suitable	A1	Suitable	-	8.35	1	1	Suitable	A1	-	-
DO (mg L <sup>-1</sup> )	8.14	1	1	Suitable	-	-	-	8.19	1	1	Suitable	-	-	-
Cl <sub>2</sub> (mg L <sup>-1</sup> )	24.14	-	1	-	A1	Low	-	34.55	-	1	-	A1	Low	-
NO <sub>2</sub> <sup>-</sup> (mg L <sup>-1</sup> )	0.01	-	-	Low	A1	-	Low	0.12	-	-	High	A1	-	Low
NO <sub>2</sub> -N (mg L <sup>-1</sup> )	0.01	-	2	-	-	-	-	0.03	-	3	-	-	-	-
NO <sub>3</sub> <sup>-</sup> (mg L <sup>-1</sup> )	6.23	-	-	-	A1	Low	Low	8.03	-	-	-	A1	Low	Low
NO <sub>3</sub> -N (mg L <sup>-1</sup> )	1.42	1	1	-	-	-	-	2.08	1	1	-	-	-	-
NH <sub>3</sub> (mg L <sup>-1</sup> )	0.57	-	-	High	-	-	-	0.96	-	-	High	-	-	-
NH <sub>4</sub> (mg L <sup>-1</sup> )	0.60	-	-	Suitable	A2	High	-	1.01	-	-	Suitable	A2	High	-
PO <sub>4</sub> <sup>-3</sup> (mg L <sup>-1</sup> )	1.22	-	-	High	-	-	-	0.03	-	-	Suitable	-	-	-
P (mg L <sup>-1</sup> )	0.41	3	3	-	-	-	-	0.01	1	1	-	-	-	-
SO <sub>4</sub> <sup>-2</sup> (mg L <sup>-1</sup> )	17.07	-	1	-	A1	Low	Low	9.56	-	1	-	A1	Low	-
Na (mg L <sup>-1</sup> )	5.60	-	1	-	A1	Low	Low	5.84	-	1	-	A1	Low	-
B (mg L <sup>-1</sup> )	0.28	1	1	-	A1	Low	Low	0.29	1	1	-	A1	Low	Low
Co (mg L <sup>-1</sup> )	DLA	1	1	-	A1	-	-	DLA	1	1	-	A1	-	-
Cr <sup>6+</sup> (mg L <sup>-1</sup> )	0.002	2	1	-	A1	Low	Low	0.002	2	1	-	A1	Low	Low
Fe <sup>2+</sup> (mg L <sup>-1</sup> )	2.877	3	3	-	A3	High	-	0.377	2	2	-	A1	High	-
Mn <sup>2+</sup> (mg L <sup>-1</sup> )	0.026	1	1	-	A1	-	-	0.009	1	1	-	A1	-	-
Cu (mg L <sup>-1</sup> )	0.002	1	1	Low	A1	Low	Low	0.001	1	1	Low	A1	Low	Low
Ni (mg L <sup>-1</sup> )	DLA	1	1	-	A1	Low	Low	DLA	1	1	-	A1	Low	Low
Zn (mg L <sup>-1</sup> )	0.009	1	1	Low	A1	-	Low	DLA	1	1	Low	A1	-	Low

The average EC values of Süphan and Hidirmenteş Lakes are classified as 2<sup>nd</sup> class waters according to YSKYY (2015), A1 class waters according to İSY, and low value waters according to TSE (2005). In previous studies, the EC value was reported as 662 µS/cm in Dolutaş, 515 µS/cm in Değirmigöl, 579 µS/cm in Yumruklu, 488 µS/cm in Dönerdere (Atıcı 2020), 434.20 µS/cm in Nemrut Crater Lake (Sepil 2020), and 578.0 µS/cm in Kabaklı Pond (Kaya and Şen 2022). The EC value obtained in this study is higher than the reported values for Hidirmenteş but similar to the reported values for Süphan.

The average pH values of Hidirmenteş and Süphan Lakes are lower than the parametric value according to TSE (2005), but classified as 1st class quality waters according to WKY (2008), YSKYY (2015), and İSY (2019), and within mandatory values according to ASSKY (2014). In different limnological

studies conducted in Turkey (Çavuş 2018) and in this study, it was observed that these lakes have a slightly alkaline structure. In some scientific studies, the pH value was reported to be between 7.50-8.20 in Bendimahı Stream (Bulum 2015), 7.73 in Koçköprü, 7.79 in Sarımemet, and 7.17 in Zerne (Demir 2023b). The pH values obtained were found to be higher than the reported values.

The average SS values of Hidirmenteş and Süphan lakes were determined as inappropriate according to ASSKY (2014). According to YSKYY (2015), the SS value should be less than 5 mg L<sup>-1</sup> for eutrophication monitoring in dam lakes. In some scientific studies, the SS value was reported as 110.0 mg L<sup>-1</sup> in Dolutaş (Atıcı 2020) and 46.2 mg L<sup>-1</sup> in Kabaklı Pond (Kaya and Şen 2022). The obtained values are higher than the reported values.

The average turbidity values of Hidirmenteş and Süphan Lakes are classified as A3 waters

according to İSY (2019). In some scientific studies conducted in Turkey, the turbidity value was reported as 106 NTU in Dolutaş (Atıcı 2020), an average of 180 NTU in Karasu Stream (Atıcı, 2020), and 71.3 NTU in Kabaklı Pond (Kaya and Şen 2022). SS values are directly proportional to turbidity. On-site water measurements revealed that the waters of Hidirmenteş and Süphan lakes were quite turbid due to soil particles carried by rain.

High SS values cause organisms to sink into the sediment, prevent adequate respiration, and can cause death, reduce the amount of light entering the water, impair fish feeding efficiency, alter behavior, and change species distribution by altering the substrate (Donahue and Irvine, 2003). The obtained turbidity values are close to those reported.

The nitrite values of Hidirmenteş and Süphan Lakes were low according to WHO (1993), classified as A1 waters according to İSY (2019), while Hidirmenteş was low and Süphan was high according to ASSKY (2014). In some scientific studies, the nitrite value in Aygır Lake was determined as 0.018 mg L<sup>-1</sup> (Çavuş 2018), 0.070 mg L<sup>-1</sup> in Akköprü Stream, 0.021 mg L<sup>-1</sup> in Güzelkonak Stream (Bayram, 2016), and 0.024 mg L<sup>-1</sup> in Karasu Stream (Atıcı 2017), 0.004 mg L<sup>-1</sup> in Değirmigöl, 0.009 mg L<sup>-1</sup> in Yumruklu, and 0.081 mg L<sup>-1</sup> in Dönerdere (Atıcı 2020). The higher nitrite amount in Süphan compared to Hidirmenteş is likely due to fertilizers used in agriculture.

According to YKYY (2015) the average nitrite nitrogen values of Hidirmenteş and Süphan lakes are classified as 2<sup>nd</sup> class and 3<sup>rd</sup> class quality waters, respectively, according to YSKYY (2015). In some scientific studies, the nitrite nitrogen value has been reported as 0.006 mg L<sup>-1</sup> in Aygır Lake (Çavuş 2018), 0.000 mg L<sup>-1</sup> in Dolutaş, 0.003 mg L<sup>-1</sup> in Yumruklu, and 0.025 mg L<sup>-1</sup> in Dönerdere (Atıcı 2020). Based on the obtained nitrite and nitrite nitrogen values, Hidirmenteş is lower than the values stated in the reports, while Süphan is higher. The high nitrite value in Süphan is likely due to the shrinking water surface areas from recent droughts.

According to İSY (2019) the nitrate values of Hidirmenteş and Süphan Lakes are classified as A1 class waters but WHO (1993) and TSE (2005) classified the low value as low. In some scientific studies, the nitrate value is reported as 4.98 mg L<sup>-1</sup> in Kabaklı Pond (Kaya and Şen 2022), 4.5 mg L<sup>-1</sup> in Değirmigöl, and 7.9 mg L<sup>-1</sup> in Yumruklu (Atıcı 2020). In non-agricultural areas, nitrate levels are between 0-10 mg L<sup>-1</sup> in surface and groundwater (Olhan and Ataseven 2009). The obtained values are similar to those reported.

According to WKY (2008) and YSKYY (2015), the nitrate nitrogen value of the lakes is classified as 1<sup>st</sup> class quality waters. In some scientific studies, the nitrate nitrogen value is reported as 1.14 mg L<sup>-1</sup> in Kabaklı Pond (Kaya and Şen 2022), 1.1 mg

L<sup>-1</sup> in Değirmigöl, 1.9 mg L<sup>-1</sup> in Yumruklu, and 3.7 mg L<sup>-1</sup> in Dönerdere (Atıcı 2020).

The ammonium value of the lakes is classified as A2 waters according to İSY (2019), mandatory values according to ASSKY (2014), and low values according to TSE (2005). The ammonium value is reported as 1.85 mg L<sup>-1</sup> in Kabaklı Pond (Kaya and Şen 2022), 0.063±0.001 mg L<sup>-1</sup> in Aygır Lake (Çavuş 2018), and 0.25-0.88 mg L<sup>-1</sup> in Murat River (Elazığ) (Çağlar 2011). The values obtained from the lakes differ from the reported values.

According to ASSKY (2014), the ammonia value of the lakes was above mandatory values. The ammonia value was reported as 1.76 mg L<sup>-1</sup> in Kabaklı Pond (Kaya and Şen 2022) and 0.059 mg L<sup>-1</sup> in Aygır Lake (Çavuş 2018). The resulting values are different from those reported.

According to ASSKY (2014), phosphate levels were found to be elevated in Hidirmenteş Lake and low in Süphan Lake. Specific phosphate readings include Yumruklu at 0.03 L<sup>-1</sup>, Dönerdere at 0.01 L<sup>-1</sup> (Atıcı, 2020), and Hazar (Elazığ) Lake ranging from 0.05 to 1.99 L<sup>-1</sup> (Çoban, 2007). Based on the acquired data, it was concluded that Hidirmenteş exhibited higher levels while Süphan displayed lower readings compared to the notified values.

The phosphorus metrics for the lakes indicate that, based on YSKYY (2015) and WKY (2008), Hidirmenteş falls under the 3<sup>rd</sup> grade whereas Süphan is classified in the 1<sup>st</sup> grade. The phosphorus content was documented as 0.01 mg L<sup>-1</sup> in Yumruklu (Atıcı, 2020) and varying from 0.15 to 2.21 mg L<sup>-1</sup> in Hazar (Elazığ) Lake (Çoban, 2007). These outcomes differ from the ones in the initial report, suggesting that agricultural activities predominantly contribute to the augmented phosphorus levels in Hidirmenteş.

Regarding iron content in the lake waters, Hidirmenteş was classified as 3<sup>rd</sup> class and Süphan as 2<sup>nd</sup> class as per WKY (2008) and YSKYY (2015), while Hidirmenteş got an A3 and Süphan an A1 grade in accordance with İSY (2019). Notably, the lakes exhibit high iron content according to TSE (2005). Various scientific examinations have recorded the iron values as 0.018 mg L<sup>-1</sup> in Kabaklı Pond (Kaya and Şen, 2022), 0.025 mg L<sup>-1</sup> in Bendimahı Stream (Van Province) (Bulum, 2015), and Dolutaş at 0.12 mg/L, Değirmigöl at 0.065 mg/L, Yumruklu at 0.02 mg/L, Dönerdere at 0.02 mg/L (Atıcı, 2020). The proximity of Hidirmenteş Lake to the volcanic Tendürek Mountain is believed to account for its elevated iron levels.

In summary, upon evaluating the average parameter values of the lakes in focus based on water quality classes, it was established that, with the exception of suspended solids, parameters other than those mentioned are deemed suitable for agricultural irrigation. On the contrary, phosphate, ammonia, and suspended solids parameters in Hidirmenteş, as well as

ammonia, suspended solids, and nitrite parameters in Süphan, were found unsuitable for the production of trout and carp, as indicated by various sources. However, ammonia levels in Hidirmenteş and Süphan lakes were not lethal for carp but reached dangerous levels for trout according to different studies. Carp fish introduction by the Provincial Directorate of Agriculture and Forestry for fishing and agricultural purposes was found to be a recurring practice.

The narrative also addresses concerns like water loss due to intensive agricultural irrigation as well as the pressing need for modern irrigation techniques over traditional methods to curtail water wastage. Furthermore, raising awareness amongst farmers and implementing measures to control evaporation in water bodies to sustain aquatic life are emphasized. It is crucial to uphold sufficient water levels in these resources to perpetuate fish and aquatic biodiversity. Furthermore, despite being distant from urban centers and exposed to animal waste, Süphan and Hidirmenteş lakes were noted as suitable for carp farming but posed risks for trout aquaculture.

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## ETHICAL CONSIDERATIONS

The study was carried out following permission Republic of Turkey Ministry of Agriculture and Forestry grand number E-67852565-140.03.03-7215205

## DECLARATION OF COMPETING INTERESTS

The author declares no conflict of interest.

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