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

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Received: 30 Nov. 2023 || Revised: 9 July 2024 || Accepted: 19 Sept. 2014
Available online: 07 Oct. 2024

ISSN: 1656-4707
E-ISSN: 2467-5903
Homepage: www.palawanscientist.org

How to cite:
Demir M. 2025. Determination of water quality characteristics of Süphan and Hıdırmenteş Lakes (Van-Eastern Türkiye). The Palawan Scientist, 17(1): 50-58. https://doi.org/10.69721/TPS.J.2025.17.1.06

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^{-1}, electrical conductivity (EC) was 785.12 µS/cm, suspended solids (SS) was 181.01 mg L^{-1}, turbidity was 152.33 NTU, pH was 8.17, dissolved oxygen (DO) was 8.14 mg L^{-1}, nitrite (NO_2^-) was 0.01 mg L^{-1}, nitrate (NO_3^-) was 6.23 mg L^{-1}, ammonia (NH_3) was 0.57 mg L^{-1}, ammonium (NH_4) was 0.60 mg L^{-1}, phosphate (PO_4^{-3}) was 1.22 mg L^{-1}, phosphorus (P) was 0.41 mg L^{-1}, and iron (Fe^{+2}) was 2.877 mg L^{-1}. For Süphan Lake, the average water temperature was 14.57°C, salinity was 0.23 mg L^{-1}, EC was 453.13 µS/cm, SS was 156.00 mg L^{-1}, turbidity was 125.33 NTU, pH was 8.35, DO was 8.19 mg L^{-1}, NO_2^- was 0.12 mg L^{-1}, NO_3^- was 8.03 mg L^{-1}, NH_3 was 0.96 mg L^{-1}, NH_4 was 1.01 mg L^{-1}, PO_4^{-3} was 0.03 mg L^{-1}, P was 0.01 mg L^{-1}, and Fe^{+2} was 0.377 mg L^{-1}. 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 m³ per person. By the 2000s, with the population reaching 70 million, this figure had decreased to 2,000 m³ per person. Today, with a population exceeding 85 million, the per capita water use right has further decreased to around 1,500 m³. 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 m³ (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 (Kapluhan 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 km³), Lake Erçek (31 km³), Morgedik Dam (102 hm³), Sarımemet Dam (134 hm³), Koçköprü Dam (86 hm³), and Zernek Dam (104 hm³). The water potential of the Van Lake Basin sub-basins is as follows: Ahlat-West (452.96 hm³ year^{-1}), Bendimahi-East (457.16 hm³ year^{-1}), Deliçay-East (275.63 hm³/year), Engil (309.78 hm³ year^{-1}), South (418.36 hm³ year^{-1}), Karasu-East (551.11 hm³ year^{-1}), and Zilan-North (869.83 hm³/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 km², receives an average annual rainfall of 474 mm and has an average annual flow of 95.32 m³ s^{-1}. The basin's annual average yield is 6.25 L s^{-1} km$^{3-1}$, 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 Hıdırmenteş (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 Hıdırmenteş 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).

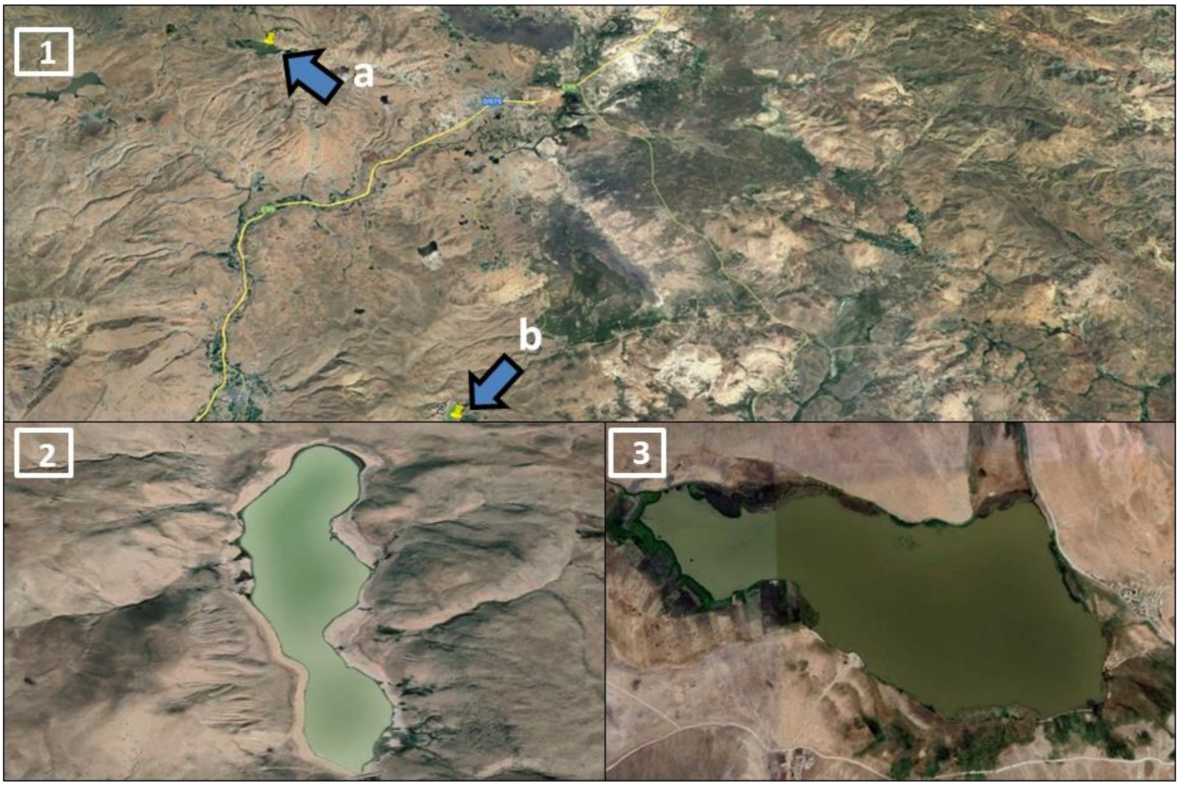

Figure 2. The locations of the Lakes Hıdırmenteş (1a, 3) and Süphan (1b, 2) in Van Lake Basin (Türkiye).

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

Lakes	**District**	**Coast length (km^2)**	**Surface area (km^2)**	**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 Hıdırmenteş 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 (YSKYY 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 Hıdırmenteş and Süphan Lakes in Van province are presented in Table 2.

In Hıdırmenteş 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 Hıdırmenteş Lake was lower. Both lakes exhibited similar average readings for DO (Table 2).

Regarding mineral content, Hıdırmenteş 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 Hıdırmenteş Lake than in Süphan Lake: nitrite, nitrite nitrogen, nitrate, nitrate nitrogen, ammonium, and ammonia, phosphate (Table 2).

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

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

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

DISCUSSION

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

The average temperature values measured in Hıdırmenteş 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 Hıdırmenteş 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^{-1} in Yumruklu Pond (Atıcı 2020) and 8.10±0.4 mg L^{-1} 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^{-1} in Kabaklı Pond (Kaya and Şen, 2022) and 0.21±0.003 mg L^{-1} in Aygır Lake (Çavuş 2018). The average salinity value obtained is similar to the values reported for Süphan Lake, while Hıdırmenteş 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^{-1}). 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 Hıdırmenteş					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^{-1})	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^{-1})	339.50	338.50	342.70	340.23	±2.19	216.53	223.91	235.10	225.18	±9.35
	SS (mg L^{-1})	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^{-1})	10.18	7.39	6.86	8.14	±1.78	9.70	7.52	7.36	8.19	±1.31
	Alkalinity (mg L^{-1})	T1-A1	T1-A1	T1-A1	T1-A1	-	T1-A1	T2-A1	T1-A1	T1-A1	-
	Cl_2 (mg L^{-1})	19.53	28.75	24.14	24.14	±4.61	41.18	31.95	30.53	34.55	±5.78
	Ca^{+2} (mg L^{-1})	16.80	10.60	13.20	13.53	±3.11	14.60	12.00	8.40	11.67	±3.11
	Mg^{+2} (mg L^{-1})	5.76	6.72	1.68	4.72	±2.68	7.80	14.48	3.84	8.71	±5.38
	Ca^{+2}+Mg^{+2} (mg L^{-1})	42.24	34.88	25.60	34.24	±8.34	44.16	48.48	23.68	38.77	±13.25
	CO_3^{2-} (mg L^{-1})	0.00	0.00	0.00	0.00	±0.00	0.00	0.00	0.00	0.00	±0.00
	HCO_3^- (mg L^{-1})	31.11	35.38	38.43	34.97	±3.68	18.30	26.27	50.2	31.59	±10.44
	Total Hardness (mg L^{-1})	6.59	5.46	4.02	5.36	±1.29	6.90	23.18	3.71	11.26	±10.44
	NO_2^- (mg L^{-1})	0.01	0.01	0.01	0.01	±0.00	0.13	0.10	0.14	0.12	±0.02
	NO_2–N (mg L^{-1})	0.01	0.01	0.01	0.01	±0.00	0.03	0.03	0.04	0.03	±0.01
	NO_3^- (mg L^{-1})	5.40	6.20	7.10	6.23	±0.85	6.10	8.00	10.00	8.03	±1.95
	NO_3–N (mg L^{-1})	1.35	1.30	1.60	1.42	±0.16	1.90	2.05	2.30	2.08	±0.20
	NH_3 (mg L^{-1})	0.56	0.55	0.60	0.57	±0.03	0.96	0.98	0.93	0.96	±0.03
	NH_3-N (mg L^{-1})	0.50	0.50	0.55	0.52	±0.03	0.80	0.81	0.79	0.80	±0.01
	NH_4 (mg L^{-1})	0.58	0.58	0.64	0.60	±0.03	1.00	1.01	1.02	1.01	±0.01
	PO_4^{-3} (mg L^{-1})	0.98	1.11	1.68	1.22	±0.40	0.03	0.02	0.05	0.03	±0.02
	P (mg L^{-1})	0.37	0.31	0.55	0.41	±0.12	0.01	0.00	0.02	0.01	±0.01
	SO_4^- (mg L^{-1})	29.28	11.92	10.00	17.07	±10.62	12.40	11.28	5.00	9.56	±3.99
	K (mg L^{-1})	3.51	5.07	4.29	4.29	±0.78	0.39	1.95	2.34	1.56	±1.03
	Na (mg L^{-1})	5.98	4.60	6.21	5.60	±0.87	2.79	9.20	5.52	5.84	±3.22
	Organic matter (mg L^{-1})	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
Heavy Metals	B (mg L^{-1})	0.75	0.05	0.04	0.28	±0.41	0.75	0.10	0.02	0.29	±0.40
	Co (mg L^{-1})	DLA	DLA	DLA	DLA	-	DLA	DLA	DLA	DLA	-
	Cr^{+6} (mg L^{-1})	0.003	0.001	0.002	0.002	0±.001	0.002	0.002	0.002	0.002	±0.000
	Fe^{+2} (mg L^{-1})	3.760	2.800	2.070	2.877	±0.848	0.530	0.270	0.330	0.377	±0.136
	Mn^{+2} (mg L^{-1})	0.039	0.030	0.010	0.026	±0.015	0.001	0.005	0.020	0.009	±0.010
	Cu (mg L^{-1})	0.003	0.001	0.003	0.002	0±.001	0.001	0.001	0.001	0.001	0±.000
	Ni (mg L^{-1})	DLA	DLA	DLA	DLA	-	DLA	DLA	DLA	DLA	-
	Zn (mg L^{-1})	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 Hıdırmenteş						Parameters	Lake Süphan					
		YSKYY	WKY	ASSKY	İSY	TSE	WHO	Ave	YSKYY	WKY	ASSKY	İSY	TSE	WHO
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^{-1})	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^{-1})	8.14	1	1	Suitable	-	-	-	8.19	1	1	Suitable	-	-	-
Cl_2 (mg L^{-1})	24.14	-	1	-	A1	Low	-	34.55	-	1	-	A1	Low	-
NO_2^- (mg L^{-1})	0.01	-	-	Low	A1	-	Low	0.12	-	-	High	A1	-	Low
NO_2–N (mg L^{-1})	0.01	-	2	-	-	-	-	0.03	-	3	-	-	-	-
NO_3^- (mg L^{-1})	6.23	-	-	-	A1	Low	Low	8.03	-	-	-	A1	Low	Low
NO_3–N (mg L^{-1})	1.42	1	1	-	-	-	-	2.08	1	1	-	-	-	-
NH_3 (mg L^{-1})	0.57	-	-	High	-	-	-	0.96	-	-	High	-	-	-
NH_4 (mg L^{-1})	0.60	-	-	Suitable	A2	High	-	1.01	-	-	Suitable	A2	High	-
PO_4^{-3} (mg L^{-1})	1.22	-	-	High	-	-	-	0.03	-	-	Suitable	-	-	-
P (mg L^{-1})	0.41	3	3	-	-	-	-	0.01	1	1	-	-	-	-
SO_4^- (mg L^{-1})	17.07	-	1	-	A1	Low	Low	9.56	-	1	-	A1	Low	-
Na (mg L^{-1})	5.60	-	1	-	A1	Low	Low	5.84	-	1	-	A1	Low	-
B (mg L^{-1})	0.28	1	1	-	A1	Low	Low	0.29	1	1	-	A1	Low	Low
Co (mg L^{-1})	DLA	1	1	-	A1	-	-	DLA	1	1	-	A1	-	-
Cr^{+6} (mg L^{-1})	0.002	2	1	-	A1	Low	Low	0.002	2	1	-	A1	Low	Low
Fe^{+2} (mg L^{-1})	2.877	3	3	-	A3	High	-	0.377	2	2	-	A1	High	-
Mn^{+2} (mg L^{-1})	0.026	1	1	-	A1	-	-	0.009	1	1	-	A1	-	-
Cu (mg L^{-1})	0.002	1	1	Low	A1	Low	Low	0.001	1	1	Low	A1	Low	Low
Ni (mg L^{-1})	DLA	1	1	-	A1	Low	Low	DLA	1	1	-	A1	Low	Low
Zn (mg L^{-1})	0.009	1	1	Low	A1	-	Low	DLA	1	1	Low	A1	-	Low

The average EC values of Süphan and Hıdırmenteş Lakes are classified as 2nd class waters according to YSKYY (2015), A1 class waters according to ISY, 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 Hıdırmenteş but similar to the reported values for Süphan.

The average pH values of Hıdırmenteş 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 ISY (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 Bendimahi Stream (Bulum 2015), 7.73 in Koçköprü, 7.79 in Sarımemet, and 7.17 in Zernek (Demir 2023b). The pH values obtained were found to be higher than the reported values.

The average SS values of Hıdırmenteş 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^{-1} for eutrophication monitoring in dam lakes. In some scientific studies, the SS value was reported as 110.0 mg L^{-1} in Dolutaş (Atıcı 2020) and 46.2 mg L^{-1} in Kabaklı Pond (Kaya and Şen 2022). The obtained values are higher than the reported values.

The average turbidity values of Hıdırmenteş and Süphan Lakes are classified as A3 waters according to ISY (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 Hıdırmenteş 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 Hıdırmenteş and Süphan Lakes were low according to WHO (1993), classified as A1 waters according to ISY (2019), while Hıdırmenteş 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^{-1} (Çavuş 2018), 0.070 mg L^{-1} in Akköprü Stream, 0.021 mg L^{-1} in Güzelkonak Stream (Bayram 2016), and 0.024 mg L^{-1} in Karasu Stream (Atıcı 2017), 0.004 mg L^{-1} in Değirmigöl, 0.009 mg L^{-1} in Yumruklu, and 0.081 mg L^{-1} in Dönerdere (Atıcı 2020). The higher nitrite amount in Süphan compared to Hıdırmenteş is likely due to fertilizers used in agriculture.

According to YKYY (2015) the average nitrite nitrogen values of Hıdırmenteş and Süphan lakes are classified as 2^{nd} class and 3rd class quality waters, respectively, according to YSKYY (2015). In some scientific studies, the nitrite nitrogen value has been reported as 0.006 mg L^{-1} in Aygır Lake (Çavuş 2018), 0.000 mg L^{-1} in Dolutaş, 0.003 mg L^{-1} in Yumruklu, and 0.025 mg L^{-1} in Dönerdere (Atıcı 2020). Based on the obtained nitrite and nitrite nitrogen values, Hıdırmenteş 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 ISY (2019) the nitrate values of Hıdırmenteş 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^{-1} in Kabaklı Pond (Kaya and Şen 2022), 4.5 mg L^{-1} in Değirmigöl, and 7.9 mg L^{-1} in Yumruklu (Atıcı 2020). In non-agricultural areas, nitrate levels are between 0-10 mg L^{-1} 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 1st class quality waters. In some scientific studies, the nitrate nitrogen value is reported as 1.14 mg L^{-1} in Kabaklı Pond (Kaya and Şen 2022), 1.1 mg L^{-1} in Değirmigöl, 1.9 mg L^{-1} in Yumruklu, and 3.7 mg L^{-1} in Dönerdere (Atıcı 2020).

The ammonium value of the lakes is classified as A2 waters according to ISY (2019), mandatory values according to ASSKY (2014), and low values according to TSE (2005). The ammonium value is reported as 1.85 mg L^{-1} in Kabaklı Pond (Kaya and Şen 2022), 0.063±0.001 mg L^{-1} in Aygır Lake (Çavuş 2018), and 0.25-0.88 mg L^{-1} 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^{-1} in Kabaklı Pond (Kaya and Şen 2022) and 0.059 mg L^{-1} 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 Hıdırmenteş Lake and low in Süphan Lake. Specific phosphate readings include Yumruklu at 0.03 L^{-1}, Dönerdere at 0.01 L^{-1} (Atıcı 2020), and Hazar (Elazığ) Lake ranging from 0.05 to 1.99 L^{-1} (Çoban 2007). Based on the acquired data, it was concluded that Hıdırmendeş 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), Hıdırmenteş falls under the 3rd grade whereas Süphan is classified in the 1st grade. The phosphorus content was documented as 0.01 mg L^{-1} in Yumruklu (Atıcı 2020) and varying from 0.15 to 2.21 mg L^{-1} 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 Hıdırmenteş.

Regarding iron content in the lake waters, Hıdırmenteş was classified as 3rd class and Süphan as 2nd class as per WKY (2008) and YSKYY (2015), while Hıdırmenteş 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-1 in Kabaklı Pond (Kaya and Şen 2022), 0.025 mg L-1 in Bendimahi 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 Hıdırmenteş 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 Hıdırmenteş, 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 Hıdırmenteş 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 Hıdırmenteş lakes were noted as suitable for carp farming but posed risks for trout aquaculture.

FUNDING

This study received funding support from the Ministry of Agriculture and Forestry.

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.

ACKNOWLEDGMENTS

I am grateful to the reviewers whose anonymous constructive comments throughout the research process greatly contributed to the improvement of this manuscript. Also, I would like to thank Prof. Dr. Tamer ERYİĞİT and Assistant Prof. Dr. Ahmet SEPİL for their support in translation. I am also grateful to the Ministry of Agriculture and Forestry for providing the necessary resources for this research project.

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