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PROOF
RESEARCH PAPER

Evaluation of the Seasonal Changes Associated with the Water Quality of Karacaören I Dam Lake Using Water Quality Index (WQI) Method

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Abstract

Karacaören I Dam Lake, a potential source of drinking water, is under significant threat from human activities. This study aimed to determine the seasonal variations of certain physicochemical and nutrient parameters and to use the water quality index (WQI) to assess the seasonal water quality of the lake. Some physicochemical parameters, including dissolved oxygen (DO), temperature, salinity, total dissolved solids (TDS), chemical oxygen demand (COD), biological oxygen demand (BOD), electrical conductivity (EC), transparency, and nutrients such as phosphate, sulphate, nitrite, and nitrate, were monitored seasonally across seven sampling points. The mean values observed for pH, DO, temperature, TDS, EC, SO_4^{2-}, NO_2^-, NO_3^-, PO_4^{3-}, BOD and COD were 7.81±0.39, 8.9±1.62 mg/L, 21.99±6.28°C, 177.70±33.39 mg/L, 352.92±70.63 µS/cm, 17.36±2.70 mg/L, 0.06±0.10 mg/L, 4.60±3.41 mg/L, 0.30±0.94 mg/L, 3.19±0.54 mg/L and 15.50±2.51 mg/L, respectively. All examined parameters except for PO_4^{3-}, BOD, and COD showed significant differences from season to season ($P \leq 0.05$). According to the water quality classification outlined in the Turkish Water Pollution Control Regulation, the nitrite levels were found to be at a critical level, rendering the water unsuitable for human consumption. The Water Quality Index (WQI) results indicated that the water in the dam lake is in good conduction, but it is not classified as excellent for human consumption. Therefore, necessary protective measures should be implemented regarding the planned use of the dam lake's water.

Introduction

The quest to sustain available natural resources, particularly freshwater, continues as the demand for these resources increase. Freshwater, one of the most essential natural resources, faces several challenges, including the rising human population, increased agriculture production, industrialization, landfilling and land reclamation, waste disposal, and other human factors (Stange et al., 2019). It is pertinent to note that freshwater resources play an essential role as water sources for humanity. They also provide critical ecosystem services, such as supporting agricultural activities, aquaculture, tourism, recreation, and transportation (Chen et al., 2019). According to Bhateria and Jain (2016), lake ecosystems comprise more than 50% of all terrestrial surface waters worldwide, with 49.8% of these being liquid and fresh surface waters. Despite these facts, the lake ecosystem is one of the most impacted water bodies by pollution from anthropogenic factors. This pollution renders these water systems uninhabitable to the flora and fauna found within them and has a concomitant effect on humans who rely on these aquatic organisms for food. To determine the extent to which human activities impact aquatic ecosystems, pollution studies that monitor and assess of the physicochemical parameters are being conducted (Leiva-Tafur et al., 2022).

Physicochemical parameters are essential in pollution studies, as even minor changes in water quality can significantly impact these parameters. The physicochemical properties of lakes not only provide insights into the health of the lake but also reflect ecological changes in the surrounding environment of the lake basin (Qiao et al., 2017; Matunguru et al., 2022). Studies of the physicochemical composition and seasonal distribution patterns in Lakes can more fully reveal the source factors that impact the lake's water, the relationship between the lake and its natural environment, and the influence of human activities (Tripathee et al., 2014; Matunguru et al., 2022).

Karacaören I Dam Lake is located within the boundaries of Antalya, Isparta, and Burdur in the Mediterranean region of Türkiye. It was initially constructed for irrigation, hydroelectricity, and flood control (Kir et al., 2014). It is now being considered as a potential source of drinking water for Antalya, the tourism capital of Türkiye (DSİ, 2016). According to the EU Water Framework Directive and international standards, certain criteria must be met for a water body to considered a potential source of drinking water for humans and other animals. Therefore, the assessment of water quality based on physicochemical properties is paramount (Rizk et al., 2020). The results ofthis evaluation will significantly contribute into ensuring a very high quality of water from theKaracaören I Dam Lake. Hence, this study aims to assess and determine the seasonal changes inthe physicochemical parameters of Karacaören I Dam Lakeand to usethe Water Quality Index (WQI) to evaluatethe water quality of the lake. The physicochemical parameters of the Karacaören I Dam Lake were assessed across four seasons at seven stations, each potentially influenced by different sources of pollution.

Materials and Methods

Study Location

Karacaören I Dam Lakeis located 35 Km southeast of Bucak, within the borders of Isparta and Burdur provinces (Özvarol & Ikiz, 2008), and 28 km southwest of the Sütçüler district of Isparta province. The lake lies between latitude 37.3974° N and longitude 30.8556° E in the Mediterranean region of Turkey (Figure 1). The dam was constructed in 1989 on the Aksu River for irrigation, flood prevention, and energy generation. It has a volume of 1234 hm^3 and a reservoir area of 4550 hectares (Süel et al., 2018. The Karacaören I Dam Lake serves as a water source for the villages in the Sütçüler district, including Çandır, Melikler, Şeyhler, as well as the surrounding agricultural areas (Süel et al., 2018). The primary sources of water for the lake are Göksu Spring, Aksu Stream, Kizılli Stream, Ballıtaş Stream, Köy Stream, along with rainwater, snow, and runoff from the nearby villages (Özvarol & Ikiz, 2009). The annual energy production from the lake is 142 GWh/year (Süel et al., 2018). In addition to the services provided by this Lake, cage fishing is also conducted there.

Physicochemical Parameters and Nutrient Analysis

Dissolved Oxygen (DO), pH, conductivity, salinity, temperature, and Total Dissolved Solids (TDS) were measured in situ using the AZ COMBO Multi-function Waterproof pH/Conductivity/TDS/Salt/DO meter, model 84051. At the same time, the transparency of the water was measured using a Secchi disc. The disc was submerged and the depth at which it disappeared and reappeared was recorded with a measurement tape (David et al., 2013).

Water samples were collected in airtight containers and taken to the laboratory for the analysis of nutrients (nitrate, nitrite, phosphate, and sulfate), Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD). Biological Oxygen Demand (BOD), Chemical Oxygen Demand, nitrate (NO_3^-), nitrite (NO_2^-), sulphate (SO_4^{2-}), and phosphate (PO^{3-}) were measured in the laboratory following standard methods (APHA, 1998).

Consumption Effect Approach

Because the water is considered a potential source of drinking water for the inhabitants of Antalya province, the levels of nutrients and physicochemical parameters were compared with the permissible limits set by the Water Pollution Control Regulation (SKKY, 2008) and the World Health Organization (WHO, 2017).

According to the Water Pollution Control Regulation, which was prepared in accordance with the Environment Law No. 2872 by the Ministry of Environment of the Republic of Turkey, inland water resources are classified into four quality classes based on physicochemical data.

Determination of Water Quality Index (WQI)

The water quality index (WQI) was used to assess the water quality of the Karacaören I Dam Lake during different seasons. The WQI is a rating system that considers various water quality parameters (Sahu & Sikdar, 2008). Values are assigned to parameters based to their importance for the survival of aquatic life and domestic and drinking purposes. The most relevant parameters (such as DO, TDS, $SO_4^{2=}$ NO_2^-, NO_3^-, BOD, and COD) are assigned the maximum value of 5 (Yidana & Yidana, 2010; Varol & Davraz, 2015; Şener et al., 2017). The relative weight (Wi) of each parameter is calculated as follows:

$$W_i = \sum \frac{w_i}{\sum_{i=1}^{n} w_i}$$

Where, W_i= relative weight, w_i= weight of each parameter, and n= number of parameters.

To determine the quality rating scale for each parameter, the concentration of each parameter in the water sample is divided by the World Health

Organisation (WHO, 2017) limits for drinking water and then multiplied by 100.

$$q_i = \left(\frac{C_i}{S_i}\right) n * 100$$

Where, q_i is the quality rating, C_i is the concentration of each monitored parameter, and S_i is the WHO standard limit for drinking water for each parameter (Table 1).

To determine the WQI, it is essential calculated Si first using the formula below:

$$SI_i = W_i * q_i$$

Where, SI_i= subindex of the ith parameter, while q_i= quality rating based on the concentration of the ith parameter (Ramakrishnaiah et al., 2009).

The water quality index (WQI) is then calculated using the following relationship:

$$wqi = \sum_{i=}^{n} SI_i$$

The water quality is classified into five classes based on the calculated water quality index (WQI) values, as presented in Table 2.

Statistical Analysis

Data and results were presented in tables and figures as mean plus/minus standard deviation. All statistical analyses were conducted using Excel, PAST version 4.03, the Statistical Package for Social Sciences (SPSS) version 23, and R version 4.3.1. A A one-way analysis of variance (ANOVA) was used to determine the relationships between the monitored parameters across the four seasons, while the Pearson correlation was employed to assess the linear relationships between pairs of parameters.

Results

Physicochemical Parameters and Nutrient Concentration in Karacaören I Dam Lake

Seasonal analysis of all the physicochemical parameters examined in this study revealed that the mean concentrations of pH, DO, temperature, salinity, TDS, EC, transparency, SO_4^{2-}, NO_2^-, and NO_3^- varied significantly from season to season ($P \leq 0.05$). In contrast, the mean concentrations of three parameters (PO_4^{3-}, BOD, and COD) did not show any significant difference among the seasons ($P \geq 0.05$) (Table 3).

The seasonal mean values indicated that most of the examined physicochemical parameters had their lowest concentrations during the summer. The average

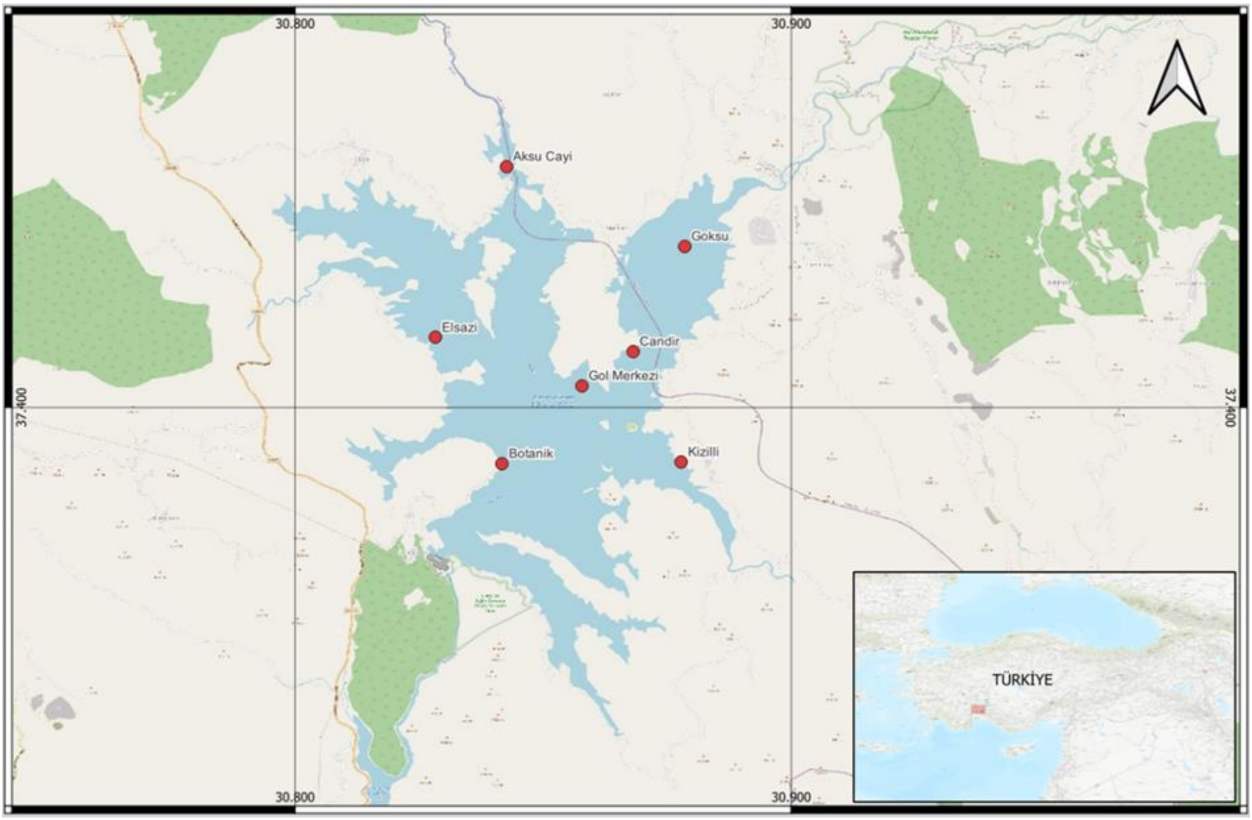

Figure 1. Sampling sites.

summer concentrations of pH, DO, salinity, TDS, EC, transparency, NO_2^-, NO_3^-, PO_4^{3-}, BOD, and COD were 7.50±0.56, 7.48±1.53 mg/L, 0.16±0.01 ppt, 151.93±2.84 mg/L, 304.64±5.85 µS/cm, 157.36±51.95 cm, 0.01±0.01, 1.27±0.17 mg/L, 0.05±0.03 mg/L, 3.05±0.60 mg/L, and 14.70±2.77 mg/L respectively. During the winter, parameters such as salinity, TDS, EC, NO_3^-, PO_4^{3-}, BOD, and COD recorded their highest values of0.22±0.06 ppt, 213.64±48.79 mg/L, 427.79±103.66 µS/cm, 9.90±0.40 mg/L, 0.75±1.56 mg/L, 3.34±0 .71, and 16.13±3.39 mg/L, respectively. For pH, sulphate, and nitrite, the largest mean concentrations were observed in the autumn, with values of 8.18±0.40, 19.00±2.11 mg/L, and 0.11±0.18 mg/L respectively. In contrast, DO and transparency were highest in spring, with values of 10.77±1.42 mg/L and 250.50±43.98 mg/L, respectively.

According to the Turkish Water Pollution Control Regulation (SKKY, 2008) as shown in Table 4, the water's pH, TDS, BOD, and COD were classified as Class I in all seasons. The seasonal means for DO and temperature in spring, autumn, and winter were within the range for Class I water; however, the DO and temperature values for summer fell within Class II category. The EC recorded for all seasons, except winter, season was within Class I category, while winter was classified as Class II.

The classification of the water quality based on nutrient concentration indicatedthat sulphate concentrations inthe dam lake watersfell into Class I. However, nitrite concentrations wereconcerning, as the spring, summer, autumn, and the seasonal mean values categorized them as Class IV waters according to the SKKY 2008 classification, while Winter values were classified as Class III. On the other hand, the phosphate concentration during winter was classified asin Class IV, while the seasonal mean phosphate concentration fell within Class III waters. Nitrate concentrations in this study exhibited two different class categories, with the seasonal concentration falling into the Class I waters category.

Pearson Correlation of Physicochemical Parameters and Nutrient Concentration

The Pearson linear correlation analysis showed a strong relationship between dissolved oxygen (DO) levels and water transparency during the various seasons. In addition, salinity, total dissolved solids (TDS), electric conductivity (EC), and water transparency exhibited strong positive correlations with NO_2^-, NO_3^-, PO_4^{3-}, BOD, and COD across different seasons. The relationship between salinity, TDS, and EC with NO_2^-, NO_3^-, PO_4^{3-}, BOD, and COD were statistically significant ($P \leq 0.05$). Salinity, TDS, and EC were perfectly correlated with NO_3^-, PO_4^{3-} (r^2=1). COD and BOD exhibited a robust, statistically significant positive correlation ($P \leq 0.05$). Conversely temperature showed a strong negative correlation with all parameters except for SO_4^{2-} and NO_2^-. However, the relationships between temperature and the other parameters were not statistically significant ($P \geq 0.05$) (Table 5).

Water Quality Index (WqI) of Karacaören I Dam Lake

Figure 2 shows the mean water quality index (WQI) of the waters of Karacaören I Dam Lake during the different seasons. The annual mean WQI of the lake was 55.45. The highest WQI value, recorded in spring was 59.15, while the lowest WQI value, of 52.80 was observed in the summer, was 52.80.

Table 1. Relative weights of each water quality parameter (Ramakrishnaiah et al., 2009)

Parameters	WHO Standards (2008)	Weight (w_i)	Relative weight (wi)
pH	6.5–8.5	4	0.0870
Temperature (°C)	25	4	0.0870
DO mg/L	8	5	0.1087
TDS (mg/L)	500	5	0.1087
EC (µS/cm)	400	5	0.1087
Sulphate (SO_4^{2-}) mg/L	250	5	0.1087
Nitrite (NO_2^-) mg/L	3	5	0.1087
Nitrate (NO_3^-) mg/L	50	5	0.1087
BOD (mg/L)	5	4	0.0870
COD (mg/L)	10.00	4	0.0870
		$\sum w_i$= 46	$\sum w_i$= 1.0000

Table 2. Water quality classification based on the calculated WQI (Sahu & Sikdar, 2008; Yidana & Yidana, 2010; Nabizadeh et al., 2013; Abbasnia et al., 2017)

WQI Range	Classification
<50	Excellent Quality
50-100	Good quality
100-200	Poor Quality
200-300	Very Poor Quality
>300	Unsuitable for drinking/Irrigation purposes

Discussion

Physicochemical Parameters of Karacaören I Dam Lake

Water pH is a critical parameter monitored in agricultural, industrial, and drinking water contexts (Şener et al., 2017). The pH value of the water determines its acidity or basicity and significantly influences various factors, such as the solubility of metals (Osibanjo et al., 2011). This study found that the pH of the dam lake varied from 7.50 in the summer to 8.18 in the winter. These results indicate that the water in the dam lake is alkaline. The results agree with other studies conducted in various lakes and freshwater bodies in this region, such as study by Şener et al. (2017), which observed pH values ranging from 7.60 to 9.18 in the Aksu River, a significant source of water for the Karacaören I Dam Lake. Although the results of this study varied from thoseof Şener et al. (2017) in terms of seasonal pH concentrations, with Şener et al. (2017) recording their highest pH values in the dry seasons and the lowest in the wet season, the opposite was observed in this study. However, the results of this study were in complete agreement with those studies of Tekin-Özan et al. (2008), which also recorded the lowest pH values in the summer in Kovada Dam Lake.

Physicochemical parameters such as Water temperature, dissolved oxygen, biological oxygen demand, chemical oxygen demand, total dissolved solids, electric conductivity, and salinity are crucial factors that influence the survival, growth, and distribution of fish in a water body. Additionally, these parameters helpto to determine the usability of water for industrial, agricultural, or human consumption

Table 3. Seasonal concentration of physicochemical parameters in Karacaören I Dam Lake

Parameters		Seasons				
		Spring	Summer	Autumn	Winter	Average
pH	min.–max.	7.75–8.16	7.17–7.65	7.81–8.49	6.73–8.28	6.73–8.49
	Mean±SD	**7.97±0.33^{b} (I)**	**7.50±0.56^{a} (I)**	**8.18±0.40^{b} (I)**	**7.61±0.32^{a} (I)**	**7.81±0.39 (I)**
DO mg/L	min.–max.	9.40–14.50	6.50–8.80	6.30–10.30	7.30–11.00	6.30–14.50
	Mean±SD	**10.77±1.42^{c} (I)**	**7.48±1.53^{a} (II)**	**8.72±1.88^{b} (I)**	**8.70±1.40^{b} (I)**	**8.9±1.62 (I)**
Temperature (°C)	min.–max.	21.3–24.80	29.10–31.80	18.70–24.60	11.70–14.50	11.70–31.80
	Mean±SD	**22.94±7.06^{c} (I)**	**30.48±6.34^{d} (II)**	**21.36±6.98^{b}**	**13.18±6.19^{a} (I)**	**21.99±6.28 (I)**
Salinity (ppt)	min.–max.	0.18–0.9	0.15–0.16	0.16–0.17	0.19–0.37	0.15–0.37
	Mean±SD	**0.19±0.00^{b}**	**0.16±0.01^{a}**	**0.17±0.01^{ab}**	**0.22±0.06^{c}**	**0.18±0.04**
TDS (mg/L)	min.–max.	179.00–186.00	149.00–159.00	160.00–170.00	183.00–333.00	149.00–333.00
	Mean±SD	**182.50±1.74^{b}**	**151.93±2.84^{a}**	**162.71±2.84^{a}**	**213.64±48.79^{c}**	**177.70±33.39 (I)**
Conductivity (EC) (µS/cm)	min.–max.	359.00–372.00	298.00–319.00	308.00–329.00	363.00–672.00	298.00–672.00
	Mean±SD	**364.79±3.73^{b} (I)**	**304.64±5.85^{a} (I)**	**314.64±5 .85^{a} (I)**	**427.79±103.66^{c} (II)**	**352.92±70.63 (I)**
Transparency (cm)	min.–max.	181.00–294.00	43.5.00–199.00	94.00–301.00	183.00–310.00	43.50–310.00
	Mean±SD	**250.50±43.98^{b}**	**157.36±51.95^{a}**	**213.96±69.76^{b}**	**236.96±48.16^{b}**	**214.70±63.90**
Sulphate (SO_4^{2-}) mg/L	min.–max.	11.00–22.00	14.00–20.00	15.00–23.00	15.00–20.00	11.00–23.00
	Mean±SD	**15.14±3.55^{a}**	**17.43±1.79^{b}**	**19.00±2.11^{b}**	**17.86±1.46^{b}**	**17.36±2.70 (I)**
Nitrite (NO_2^-) mg/L	min.–max.	0.050–0.150	0.002–0.019	0.013–0.520	0.018–0.12	0.002–3.000
	Mean±SD	**0.07±0.03^{ab} (IV)**	**0.01±0.01^{a} (IV)**	**0.11±0.18^{b} (IV)**	**0.04±0.03^{ab} (III)**	**0.06±0.10 (IV)**
Nitrate (NO_3^-) mg/L	min.–max.	4.60–5.30	0.91–1.54	1.10–3.03	9.23–10.25	0.93–10.25
	Mean±SD	**5.02±0.20^{c} (II)**	**1.27±0.17^{a} (I)**	**2.20±0.56^{b} (I**	**9.90±0.40^{d} (II)**	**4.60±3.41 (I)**
Phosphate (PO_4^{3-}) mg/L	min.–max.	BDL	0.01–0.10	0.05–0.14	0.08–4.45	0.01–4.45
	Mean±SD	**BDL**	**0.05±0.03^{a} (II)**	**0.11±0.03^{a} (II)**	**0.75±1.56^{a} (IV)**	**0.30±0.94 (III)**
BOD mg/L	min.–max.	2.74–4.05	2.55–4.35	2.20–3.75	2.40–4.50	2.20–4.50
	Mean±SD	**3.25±0.42^{a} (I)**	**3.05±0.60^{a} (I)**	**3.12±0.40^{a} (I)**	**3.34±0.71^{a} (I)**	**3.19±0.54 (I)**
COD mg/L	min.–max.	13.15–19.64	12.24–20.88	13.68–18.19	11.69–21.60	11.69–21.60
	Mean±SD	**15.71±2.02^{a} (I)**	**14.70±2.77^{a} (I)**	**15.42±1.50^{a} (I)**	**16.13±3.39^{a} (I)**	**15.50±2.51 (I)**

BOD= biochemical oxygen demand, COD= chemical oxygen demand, TDS= total dissolved solids, SD= standard deviation, min= minimum, max= maximum. Colours and Roman numerals in brackets indicate water class, according to SKKY, 2008.

Table 4. Water quality classification by the Turkish Water Pollution Control Regulation (SKKY, 2016)

Water Quality Parameters	Water Quality Classes			
	I (Blue)	II (Green)	III (Yellow)	IV (Red)
pH	6.5–8.5	6.5–8.5	6.0–9.0	<6.0–9.0
Temperature (°C)	25	25	25	>30
Dissolved Oxygen	8	6	3	<3
Chloride ion (mg/Ll)	25	200	400	>400
Nitrite (NO_2^-) mg/L	0.2	1	2	>2
Nitrate (NO_3^-) mg/L	0.002	0.01	0.05	>0.05
Total phosphorus (mg/L)	0.02	0.16	0.65	>0.65
COD (mg/L)	25	50	70	>70
BOD (mg/L)	4	8	20	>20

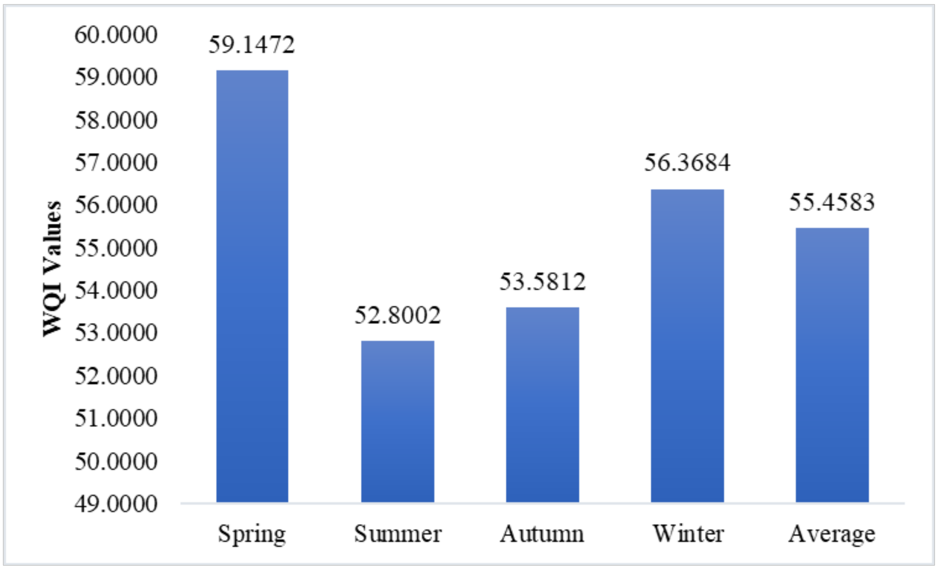

Figure 2. Calculated seasonal Water Quality Index (WQI) of Karacaören I Dam Lake water.

Table 5. Pearson correlation of physicochemical parameters and nutrients

	pH	DO	Temp.	Salinity	TDS	EC	Transp.	SO_4^{2-}	NO_2^-	NO_3^-	PO_4^{3-}	BOD	COD
pH		0.45	0.86	0.84	0.84	0.77	0.52	0.92	0.02	0.77	0.81	0.98	0.78
DO	0.55		0.71	0.63	0.63	0.64	0.14	0.30	0.51	0.69	0.63	0.45	0.42
Temp.	-0.14	-0.29		0.10	0.10	0.14	0.26	0.80	0.70	0.11	0.30	0.13	0.06
Salinity	-0.16	0.37	-0.90		0.00	0.00	0.26	0.84	0.96	0.00	0.05	0.02	0.07
TDS	-0.16	0.37	-0.90	1.00		0.00	0.26	0.86	0.96	0.00	0.06	0.02	0.07
EC	-0.23	0.36	-0.86	1.00	1.00		0.30	0.80	0.88	0.00	0.00	0.03	0.10
Transp.	0.48	0.86	-0.74	0.74	0.74	0.70		0.63	0.48	0.32	0.44	0.15	0.09
SO_4^{2-}	0.08	-0.70	-0.20	-0.16	-0.14	-0.20	-0.37		0.78	0.87	0.89	0.71	0.88
NO_2^-	0.98	0.49	-0.30	-0.04	-0.04	-0.12	0.52	0.22		0.89	0.90	0.93	0.67
NO_3^-	-0.23	0.31	-0.89	1.00	1.00	1.00	0.68	-0.13	-0.11		0.01	0.04	0.10
PO_4^{3-}	-0.29	0.55	-0.89	1.00	1.00	1.00	0.77	-0.18	-0.15	1.00		0.10	0.29
BOD	-0.02	0.55	-0.87	0.98	0.98	0.97	0.85	-0.29	0.07	0.96	0.99		0.04
COD	0.22	0.58	-0.94	0.93	0.93	0.90	0.91	-0.12	0.33	0.90	0.90	0.96	

purposes (Akbulut, 2009). This study's temperature ranged from 11.70ºC in the winter to 31.80ºC in the summer. The minimum temperature recorded in this study is lower than the minimum temperature recorded in Eğirdir Lake by Yağcı et al. (2016). Nevertheless, the maximum temperature recorded in this study is higher than the maximum of 26.8ºC reported forin Eğirdir Lake by Yağcı et al. (2016). The differences in temperatures recorded in these studies can be attributed to the locations of the lakes. For instance, Karacaören I Dam Lake is situated near Antalya, one of the provinces with the highest temperature in Türkiye, while Eğirdir Lake is located in Isparta, a province known for its a cooler climate. Dissolved oxygen is one of the essential parameters in water quality assessment and monitoring, as it provides information on the biological and physical developments within the water body. Dissolved oxygen is an essential factor for aquatic life and the chemical characteristics of the environment. In inland ecosystems, the minimum dissolved oxygen concentration should not be less than 5.0 mg/L for the survival of aquatic biota (Egemen, 2011).

Additionally, for water to be classified as Class I, the DO content must be higher than 8.0 mg/L (SKKY, 2008). Based on the preceding information, the annual mean DO content of Karacaören I Dam Lake was higher than 8.0 MG/l categorizing it as Class I water. Other researchers in different regions of Türkiye have also recorded DO values in other lakes that fall within to Class I (Yağcı et al., 2014; Dirican et al., 2015; Kükrer & Mutlu, 2019). According to WHO (2011), while water conductivity does not directly impact human health, it provides valuable information regarding the overall health of the water. The highest EC was recorded during the winter, while the lowest was observed in the summer. The elevated EC levels during winter may result from domestic, industrial, and other anthropogenic waste that accumulates due to increased rainfall and runoff from the primary water sources into the dam lake. The seasonal mean EC value of 352.92 µS/cm recorded in this study is higher than the 229.88 µS/cm recorded in Saraydüzü Dam Lake by Kükrer & Mutlu (2019) and 179.78 recorded in Terme River by Ustaoğlu et al. (2021).

On the contrary, the EC values recorded in this study are lower than the mean values reported for both the dry and wet seasons (738.69 and 690.37 µS/cm), respectively, for the Aksu River by Şener et al. (2017). Based on the mean concentration of EC in the water, according to the SKKY (2008) water classification system, the water falls under Class I. Salinity defined as the total concentrations of dissolved inorganic ions in water or soil and a vital aspect of all aquatic environments., It is typically measured in parts per thousand (ppt) (Williams & Sherwood, 1994; Canedo-Arguelles et al., 2013). Salinity is often positively correlated with EC and TDS; higher values of EC or TDS generally indicate higher salinity levels (Jiang et al., 2015; Zhang et al., 2016). In this study, there was a perfect correlation between salinity, EC, and TDS. A similar relationship between salinity and EC has been recorded by Mutlu et al. (2016) and Kırker & Mutlu (2019).

Biological and chemical oxygen demand are also critical parameters for evaluating anthropogenic waste concentrations in water bodies (Kükrer & Mutlu, 2019). The presence of inorganic substances that consume oxygen during degradation contributes to increased COD levels. However, human activities such as fishing and runoff of domestic and agricultural waste are the primary causes of increased BOD levels in water bodies (Sallam & Elsayed, 2018; Zhao et al., 2012). The BOD and COD values recorded in this study fall within the limits set by WHO (2017) and SKKY (2008) for drinking water resources. The positive correlation observed between BOD, COD, and DO in this study highlights the impact of human activities on these parameters (Dalakoti et al., 2017).

Assessing water transparency can be likened to monitoring human blood pressure, as primary indicators of their respective statuses (Minnesota Pollution Control Agency, 2006). Low water transparency often indicates the presence of excess nutrients, sediments, or other suspended materials. Generally, water with a transparency greater than 60 cm is considered to be be of good quality (Minnesota Pollution Control Agency, 2006). Based on the results for transparency obtained in this study, Karacaören I Dam Lake can be considered to be in good status. While clear water does not necessarily equate to with clean water, clarity often indicates that the overall often indicates is good in many cases. The minimum value of 43 cm recorded in this study was lower than the 50 cm recorded in Eğirdir Lake by Yağcı et al. (2016), while the maximum value recorded was higher than the maximum of 240 cm also reported in Eğirdir Lake by Yağcı et al. (2016). The average seasonal transparency of Karacaören I Dam Lake, at 214.70 cm, is higher than the mean values recorded in Çamlıgöze Dam Lake by Dirican (2015) and 189.19 cm recorded in Lake Beysehir by Nas et al. (2010).

According to Şener et al. (2013), nutrients in the bioavailable forms such as sulphur, phosphorus, nitrate, and nitrite, are important factors affecting lake water quality. Additionally, these nutrients play a significant role in the eutrophication of surface waters (Soulsby et al., 2001). Plants can quickly absorb orthophosphates, which generally influence eutrophication more than nitrogen does (Sharpley et al., 2000). The WHO (2017) guidelines for drinking water indicate that there is no direct or immediate impact of phosphate on human health; therefore, there are no health-based limits or guidelines for phosphate. In contrast, nutrients such as sulphate, nitrite, and nitrate do have direct impcts on human health and are subject to specific guidelines, particularly for water intended for human consumption.

The annual mean concentration of phosphate in the dam was 0.30 mg/L, which is classified as critical according to the SKKY (2008) classification. Based on this concentration, the water can fall into Class III, indicating that it requires proper treatment before it can be used for domestic purposes. In contrast, the sulfate concentrations observed in this study were well below the WHO (2017) guideline limits and were classified as Class I waters according to SKKY (2008). Nitrite (NO_2^-) is not usually present in high concentrations except in a highly polluted aquatic environment, as nitrate is in a more stable oxidation state. It is formed by the microbial reduction of nitrate and in vivo by reduction from ingested nitrate (WHO, 2011).

On the other hand, NO_3^- is found naturally, is very important for plant survival, and is a part of the nitrogen cycle (WHO, 2011). In this study, the concentration of NO_2^- and NO_3^- were below the guidelines set by WHO (2017) for drinking water. However, according to the SKKY (2008), the NO2- level is critical and classified as Class IV, which indicates that the water is unfit for human consumption or industrial use without proper treatment. The annual mean concentrations of NO_2^- and NO_3^- recorded in this study were higher than the values reported in Çamlıgöze Dam Lake by Dirican (2015) and Karaçomak Dam by Imneisi and Aydin (2016). However, they were lower than the concentrations recorded by Şener et al. (2017) in the Aksu River. The high concentrations of nitrite and nitrate observed in this study may be related to the canalization system that feeds into the dam lake via the Aksu River, as well as runoff from cage fishing and agricultural and animal husbandry activities in the surrounding areas.

Water Quality Index (Wqi) of Karacaören I Dam Lake

One of the important methods for assessing water quality and determining its suitability for various purposes, particularly for drinking, is the Water Quality Index (WQI) (Tiwari & Mishra, 1985; Singh, 1992; Subba Rao, 1997; Mishra & Patel, 2001; Naik & Purohit, 2001; Avvannavar & Shrihari, 2008). The WQI is commonly used to evaluatethe suitability of household water sources. Specifically, the assessment of water quality for drinking purposes relies on the Water Quality Index. The following parameters were considered for the determination of the WQI of the dam lake due to their importance: pH, temperature, DO, TDS, EC COD. BOD. SO_4^{2-}, NO_2^-, and NO_3^-. The results of the Water Quality Index indicated that the quality of the water in Karacaören I Dam Lake is classified as good according to the WQI classification used by many authors (Sahu & Sikdar, 2008; Yidana & Yidana, 2010; Nabizadeh et al., 2013; Abbasnia et al., 2017). The results obtained in this study agree with those from Şener et al. (2017), who studied the water quality of the Aksu River, the main river recharging the Karacaören I Dam Lake. In the study of Şener et al. (2017), the Karacaören I dam lake station had a WQI value of 51.6043, which is very close to the WQI value of 55.4583 obtained in this study. The average of 55.4583 recorded in this study is higher than the value of 22 recorded in Terme River by Ustaoğlu et al. (2021). The WQI values of water bodies are influenced by various factors, particularly anthropogenic activities occurring in and around the water body.

Conclusion

The seasonal changes in various physicochemical parameters of water sampled from seven stations in Karacaören I Dam Lake as well as its suitability for human consumption, were assessed because the dam lake is considered a potential source of drinking water for Antalya province. A total of 28 samples were collected and analyzed seasonally. The physicochemical parameters varied significantly from season to season, as observed in this study. This variation can be attributed to various natural and anthropogenic factors. Additionally, it was also noted that salinity, TDS, and EC are closely related in water bodies; as an increase in one of these parameters typically leads to an increase in the others. Although the WQI values obtained in this study indicated that the water is suitable for human consumption, it was observed that nitrite and nitrate the concentrations of nitrite and nitrate in the dam lake are a significant concern, as their seasonal and annual values fell into the Class IV and Class III water categories, respectively, according to SKKY (2008). It can be concluded that environmental pollutants negatively affect the Karacaören I Dam Lake water. Therefore, necessary protection measures such as proper sewage, waste disposal, and agricultural fertilizers and chemicals properly monitored regarding the planned usage of the dam lake's water.

Ethical Statement

No ethical approval was needed for this study.

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Author Contribution

Edafe ODIOKO carried out the conceptualisation, methodology, fieldwork, laboratory works, data analysis and interpretation, and writing/original draft. Zehra Arzu BECER supervised, reviewed, edited and proofread the manuscript.

Conflict of Interest

The authors have no conflict of interest concerning the study and its publication.

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