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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi 2024; 10 (2): 1-12 Araştırma Makalesi/Research Article

Şerefiye (Zara-Sivas) Barajı'nın Su Kalitesi İndekslerine Göre Değerlendirilmesi

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Öz

Sivas ili Şerefiye Baraj gölünün su kalitesinin belirlenmesi üzerine yapılmış olan bu çalışma; Ocak 2014 ile Aralık 2014 tarihleri arasında 3 istasyondan aylık olarak toplanan numuneler üzerinde gerçekleştirilmiştir. 25 değişkenin incelendiği analizlerde su kalitesi, Dünya Sağlık Örgütü içme suyu standartları, su kalite indeksi (WQI), sodyum absorbsiyon oranı (SAR), sodyum yüzdesi, geçirgenlik indeksi (PI), magnezyum indeksi, sulama indeksi ve Türkiye Cumhuriyeti Yüzey Suyu Kalitesi Yönetmeliği (SWQR) Orman ve Su İşleri Daire Başkanlığı değerlerine göre belirlenmiştir. Barajdaki su kalite indeksinin ortalama değeri 46,82, sulama suyu değerleri ortalama 3,90 olarak bulunmuştur. Burada elde edilen sonuçlar Şerefiye Barajı'nın su kalite indeksi ve sulama suyu kalitesi açısından "çok iyi" sınıfta olduğunu göstermiştir.

Evaluation of the Şerefiye (Zara-Sivas) Dam According to Water Quality Indexes

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Abstract

Evaluation of the Şerefiye (Zara-Sivas) Dam According to Water Quality Indexes With the aim of determining the water quality of Şerefiye Dam, Sivas province, the present study was carried out on the samples collected monthly from 3 stations between January 2014 and December 2014. In the analyses, which examined 25 variables, water quality was determined using the World Health Organization drinking water standards, water quality index (WQI), sodium absorption ratio (SAR), sodium percentage, permeability index (PI), magnesium index, irrigation index, and the Surface Water Quality Regulation (SWQR) of the Turkish Ministry of Forestry and Water Affairs. The mean value of water quality index in the dam was found to be 46.82 and the mean value of irrigation water was found to be 3.90. The results obtained here showed that Şerefiye Dam was in the "very good" class in terms of water quality index and irrigation water quality.

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INTRODUCTION

Water is of significant importance for a sustainable life. The continuity of freshwater resources is very important for the world and the quality of life (Manjare et al., 2010). Freshwater is used 5% for domestic purposes, 20% for industrial purposes, and 75% for agricultural purposes. However, water resources are threatened by many pollutants nowadays. Those pollutants cause changes in the physicochemical quality of water . These pollutants have either natural (erosion, flood, etc.) or industrial, agricultural, or domestic origins (Kumar and Thakur, 2017 a, b; Kumar et al., 2015; Yu et al., 2015; Wu et al., 2018; Mutlu,2019; Mutlu, 2021). Lakes, dams, ponds, and rivers offer many benefits for humankind for drinking water, irrigation water, usage water, hydroelectricity generation, fishing, and recreational purposes (Varadharajan et.al., 2023). At the same time, these water masses can be polluted by various pollutants due to agricultural and industrial activities and anthropogenic factors (Mutlu, 2021).

In lakes, dams, and lagoons, there might be decreases in the water quality due to point flow inputs such as domestic and industrial wastewaters and non-point inputs such as agricultural flow (Mutlu and Aydin Uncumusaoglu, 2018). Moreover, pollutants brought by the atmospheric movements to those water masses also deeply affect the water quality. Intense anthropogenic activities might cause eutrophication in lakes, dams, and lagoons, whereas the agricultural activities, lumbering, construction, and mining around them create siltation (Subramaniam et al., 2023). Moreover, nitrogen and phosphor passing from the soil into the water cause pollution in surface waters (Smith, 2016; Mutlu and Kutlu, 2017). Thus, studies developing monitoring programs aim to protect the water quality and make plans in order to determine the water quality parameters (Yisa and Jimoh, 2010; Mullai et al., 2013; Phung et al., 2015; Mutlu and Aydin Uncumusaoglu, 2017).

In management of freshwater sources, it is very important to monitor the water quality. Besides being near a wetland that is very important for Türkiye, the current study area, the Şerefiye Dam, is also a very important ecotourism destination.

Gradually increasing tourism activities and intense agricultural activities around the Şerefiye affect the water quality in the dam. Thus, controlling the water quality of this dam is very important in order to protect the ecosystem since the dam is of vital importance for human health and dam's sustainability because it meets the usage water needs of several villages around.

MATERIAL AND METHOD

Study Area

Şerefiye Dam (40°07′55.04′′ N 37′13.62′′ E) is located in Upper Kızılırmak basin, 1km west to center of Serefiye town, and within the Scotch pine forests. The dam is 33 km away from Zara district and 103 km from Sivas city center. The water sources of Şerefiye dam are Egridere and the waters coming from under the earth. Şerefiye dam has 1.7 hm^3 of storage volume, and was constructed for irrigation purposes. While determining the sampling stations on the dam, we considered the points that homogenously represent the characteristics of dam. Station 1: The entrance point of Eğridere into the dam Station 2: Western side of the dam (Şerefiye town) Station 3: Center of the dam water analysis.

In this study starting from January 2014, samples used in analyses of some chemical and physical parameters constituting the water quality were monthly collected during 12 months from 3 stations. From January 2014 to December 2014, surface water sampling was carried out monthly at four stations considered to represent the entire lake. The water samples were taken in acid-cleaned 2.5 L sampling bottles from 15 to 20 cm below the water surface.

The water samples for heavy metal analysis were taken in polyethylene bottles, which were previously washed with 50% HNO_3 and deionized water and acidified with 10 mL HNO_3 per liter. The samples were transported to the laboratory in iceboxes, and stored in the refrigerator at 4 °C until analysis. Water temperature, dissolved oxygen (DO), pH, salinity, and electrical conductivity (EC) values were measured in-situ with YSI 556 MPS. Chemical oxygen demand (COD), biological oxygen demand (BOD), total hardness (TH), nitrite-nitrogen (NO_2^{2-}-N), nitrate-nitrogen (NO_3^{2-}-N), ammonium-nitrogen (NH_4^+-N), total alkalinity (TA), orthophosphate (PO_4^{3-}), sulfite (SO_3^{2-}), sulfate (SO_4^{2-}), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), and potassium (K^+) analyses were performed using standard methods (APHA, 1998). Iron, lead, cadmium, zinc, nickel, copper, and mercury analyses were performed using the PerkinElmer Optima 2000 DV ICP-OES.

Water quality index (WQI)

Water quality index (WQI) is defined as a grading technique that measures the combined effect of each of the water quality parameters to evaluate the overall water quality for human consumption (Horton 1965; Kangabam et al. 2017). It has been used extensively in recent years to analyze the potential of water resources to be used for drinking and domestic purposes (Khanoranga, 2019). WQI based on the nineteen parameters (pH, EC, BOD, Cl, SO_4, Na, K, TH, Ma, Ca, NO_2, NO_3, Fe, Pb, Cu, Cd, Hg, Ni, and Zn) that are important for the analysis of water quality was determined using their seasonal and average values. An actual weight (AW) between 1 and 5 was assigned to each parameter, depending on its effect on the water quality, and its significance on human health. The relative weight (RW) value was calculated by the following formula (Eq. 1).

$$RW = \frac{AW}{\sum_{i=1}^{n} AW} \qquad (1)$$

After calculating RW, each of the analyzed parameters is divided by drinking water values (S_i) permitted by the World Health Organization (WHO, 2011), and then multiplied by 100 to calculate the quality rating (Qi) (Eq.2).

$$Q_i = \left(\frac{C_i}{S_i}\right) \times 100 \quad (2)$$

Later, the sub-indices (SI) were calculated (Eq. 3) and added to determine WQI (Eq. 4).

$$SI_i = RW \times Q_i \quad (3)$$

$$WQI = \sum_{i=1}^{n} SI_i \quad (4)$$

IWOI$\frac{1}{N}\sum_{i=1}^{N} WOI$

According to WQI, it is further evaluated by

$$SAR = \frac{Na^{+}_{meq}}{\sqrt{\frac{Ca^{2+}_{meq} + Mg^{2+}_{meq}}{2}}} \quad (5)$$

Sodium percentage (%):

Evaluation of sodium percentage (%) is important because high sodium rates in irrigation waters cause stunted growth in plants. For this reason, the sodium rate was calculated (Ghalip, 2017).

$$\%\, Na = \frac{(Na^{+}_{meq} + K^{+}_{meq}) \times 100}{Na^{+}_{meq} + Ca^{2+}_{meq} + Mg^{2+}_{meq} + K^{+}_{meq}} \quad (6)$$

Magnesium hazard (MH)

Generally, Ca^{2+} and Mg^{2+} are present in equal amounts in water. Mg^{2+} is present in high amounts in some water sources and controls its alkalinity, which affects the growth of plants. The Mg concentration (MH) was determined using the following equation (Abdulhusseyin, 2018; Khanoranga, 2019).

$$MH = \left(\frac{Mg^{2+}_{meq}}{Ca^{2+}_{meq} + Mg^{2+}_{meq}}\right) \times 100 \quad (7)$$

Permeability index (PI)

If water, which is rich in minerals, is continuously used for irrigation, the transmittance of the earth decreases. Permeability index was calculated as follows (Falowo et al., 2017).

PI = $(Na^{+} + \sqrt{HCO3}) * 100/(Ca2 + +Mg2 + +Na+)$

Residual sodium carbonate (RSC)

RSC= (Alkalinity x 0:0333) – (Ca^{2}+Mg^{2+})

The factor, correlation, and clustering analyses were performed to determine the processes occurring in the ecosystem, identify the relationship between calculated values, and relate the sources.

RESULT AND DISCUSSION

In the present study, surface water samples taken from an important irrigation dam in Sivas province were examined in terms of water quality parameters including the physicochemical parameters and nutrient and heavy metal concentrations. Given the results achieved here, surface water contamination value (by using WQI index) and irrigation parameters and indices (IWOI) of Şerefiye (Zara) dam were determined and, by using water quality parameters of WHO and Turkish Ministry of Forestry and Water Affairs and multivariate statistics, the relationship between contamination resources and diversity was detected. Consequently, the usability as drinking water and irrigation water will be specified.

The physicochemical parameters of Şerefiye Dam were analyzed. pH value of Şerefiye Dam was within the limits set by WHO (2011) and SWQR (6.8 - 8.5). The mean pH value of Şerefiye Dam was found to be 8.05, which suggests alkali character. Given SWQR (2016), the dam is in the class "very good water quality" in terms of pH (Rasol et al., 2017; Ali et al., 2017, Arshad and Imran, 2017). pH score was in Class I in SWQR (2016) (Tables 1 and 2). The results achieved are in parallel with those reported by Ekrem et al., (2014) examining this dam.

EC values of Şerefiye Dam (153.78 µS/s 31.44) were within the acceptable limits set by WHO (2011). Electrical conductivity (EC) is the ability to conduct electric current in relation to the dissolved ionized matter concentration in water. EC is an indicator of salinity in water. Moreover, pollutant matters might cause an increase in EC values of surface waters (Şener et al., 2017). In case of use as irrigation water, increasing EC values might cause physiological drought and plants' inability to compete with ions in soil solution (Naseem et al., 2010). High EC levels are related to animal farms, agricultural wastes, canalization, and discharge wastes (Kanhabam et al., 2017). Moreover, in the present study, EC values increased with increases in temperature. As a result of an increase in salinity, EC increases due to vaporization (Jiang et al., 2015; Zhang et al., 2016). This finding is in parallel with those reported by (Ekrem et al., 2014). Using the SWQR classification, the dam was in Class I in terms of EC value and in "clean water" class (Tables 1 and 2).

Table 1. Descriptive statistics of variables.

Parameter	Mean	Min	Max	Standard error	Coeff. of Variation	WHO
DO (mg/L)	11.40	10.35	12.40	0.70	6.19	
Salinity (‰)	0.05	0.02	0.09	0.01	38.68	
pH	8.05	7.83	8.24	0.12	1.55	**6.5-8.5**
T (°C)	13.46	4.20	22.7	6.13	45.52	
EC (µS/s)	153.78	136.82	172.66	10.89	7.08	**1500**
TSS (mg/L)	0.69	0.28	1.94	0.33	48.20	
COD (mg/L)	0.98	0.42	1.42	0.33	34.13	
BOD (mg/L)	0.44	0.11	0.76	0.20	45.62	**5**
CI (mg/L)	7.43	6.80	8.12	0.46	6.25	**250**
PO_4(mg/L)	0.009	0.003	0.018	0.003	39.56	
SO_4 (mg/L)	46.68	26.08	70.56	15.04	32.23	**250**
SO_3 (mg/L)	1.52	1.1	1.92	0.29	1.30	
Na (mg/L)	67.48	56.28	84.48	9.39	13.92	**200**
K (mg/L)	6.43	4.97	8.5	1.10	17.24	**12**
TH(mg/L)	298.61	275.32	329.96	14.52	4.86	**100**
TA (mg/L)	298.62	272.44	330.42	14.72	4.93	
Mg (mg/L)	43.82	39.52	52.48	4.60	10.51	**50**
Ca (mg/L)	44.09	39.80	53.16	4.77	10.82	**75**
NO_2 (mg/L)	0.0007	0.00	0.0019	0.0005	69.68	**3**
NO_3 (mg/L)	1.23	0.96	1.54	0.19	15.79	**50**
NH_4(mg/L)	0.00095	0.000	0.002	0.00069	66.92	
Fe (µg/L)	0.039	0.00	0.011	0.002	66.92	**300**
Pb (µg/L)	0.003	0.00	0.008	0.002	66.69	**10**
Cu (µg/L)	0.002	0.00	0.007	0.001	14.00	**2000**
Cd (µg/L)	0.23	0.20	0.23	0.10	0.40	**3**

The highest temperature was found in August and the lowest one in February. Besides that, a negative relationship was found between temperature and oxygen (Tables 1 and 2). In conclusion, it was determined that no level of temperature threatening the aquatic life was observed in any month of the year. From the aspect of temperature, the dam was found to be in Class I. In waters, temperature affects solubility by influencing the biological, chemical, and physical activities and increasing the metabolic and respiratory rates of aquatic organisms (Kutlu et al., 2017). Surface water temperature changes in parallel with atmospheric temperature changes.

The mean value of suspended solid matter, which causes physical pollution in water after a specific threshold level and can consequently increase the turbidity, density, and toxicity, decrease the light transmittance and oxygen level, and damage the aquatic organisms by precipitating on the fauna and flora, was found to be (Tables 1 and 2).

Chemical oxygen demand (COD) is one of the important parameters used in determining the pollution level of domestic and industrial wastewaters. COD values increased in October and reached the lowest level in March. The increase observed particularly in the autumn season is thought to be due to the chemical pollutant in agricultural lands (Imneisi and Aydın, 2016). Biological oxygen demand (BOD) values increased during December and reduced during March. This finding is thought to be related with anthropogenic activities, as well as domestic wastes and fish activities (Sallam and Elsayed 2018).

In the present study carried out on Şerefiye dam, it was determined that sodium concentration (Na) values were within the limits set by the WHO (2011). The highest value in the dam was seen in June, whereas the lowest one was seen in February. Cation change is related to the geological characteristics of the lithogenic sodium solution (Guo et al., 2007; Rafigue et al., 2008). The results were in parallel with the present study. High levels of cation might arise from the calcium-sodium exchange in the soil. Calcium concentrations were found to be within the limits recommended by the WHO (2011). In waters, sodium exists in the forms of chloridee or calcium carbonate. The results achieved were in parallel with those reported by Rapant et al., (2017) and Alam et al., (2017). Chloride concentration is generally low in natural waters, but its concentration is very important for drinking water, industrial waters, and irrigation waters (Tepe and Kutlu, 2019). Magnesium concentration was found to be within the limits set by WHO (2011). The highest level was observed in May and the lowest one in February. Magnesium is the 8th most abundant element. Magnesium is the most abundant element in the earth's crust. It is found most commonly in mineral rocks and enters the waters through natural and anthropogenic pathways. High concentrations of magnesium negatively affect human health (Daud et al., 2017; Rasol et al., 2017). Potassium concentration was also found to be within the limits set by the WHO (2011). Its highest level was seen in June and the lowest one in February. The potassium concentration might arise from the potassium source of potassic rocks and agricultural fertilizers (Mumtaz et al., 2017). Examining the cations in Şerefiye dam, the result is Na >Ca Mg>K.

Table 2. Quality criteria of the Intra-continental Surface Water Resources Regulation (SWQR 2016)

Water quality parameters	Water quality classes			
	I (very good)	II (good)	III (medium)	IV (poor)
pH	6–9	6–9	6–9	6–9
Conductivity (µs/cm)	< 400	1000	3000	> 3000
Dissolved oxygen (mg/L)	> 8	6	3	< 3
Chemical oxygen demand (COD) (mg/L)	< 25	50	70	> 70
Biochemical oxygen demand (BOD_5) (mg/L)	< 4	8	20	> 20
Ammonium nitrogen (mgNH_4 -N/L)	< 0.2	1	2	> 2
Nitrate nitrogen (mgNO_3 -N/L)	<3	10	20	> 20
Orthophosphate phosphor (mg PO_4-P/L)	< 0.05	0.16	0.65	> 0.65
Sulfur (µg/L)	≤ 2	5	10	> 10
	Acceptable annual mean for metals (µg/L)			
opper	1.6			
Zinc	5.9			

Iron	36
Lead	1.2
Mercury	0.07 (max)
Nickel	4
Cadmium	0.25

In this study, the highest level of sulfate in Şerefiye dam was found in May and the lowest one in February. The results did not exceed the limits set by the WHO (2011). The main sources of sulfate include bacterial degradation of sulfate compounds and formation of sulfate fertilizers (Yamamura, 2008; Varol and Davraz, 2015). Chloride concentration in Şerefiye dam was found to be much lower than the desired levels specified by the WHO (2011). It peaked in October and reached the lowest level in January. Chloridee is an element that is widely seen in all types of rocks. Examining the anions, it was determined that HCO_3>$S0_4$>Cl.

It was determined that phosphate concentrations (Class I) did not exceed the limits set by SWOR (2016). The high concentration of phosphate is thought to be because mainly phosphatic fertilizers are used in agricultural activities. Nitrite concentration was found to be much lower in winter and autumn in comparison to the other seasons. The concentration reached the highest level in the spring season. Nitrate concentration showed a similar change pattern. Nitrite is a byproduct between ammonium and nitrate but has a toxicity effect on the animals, when compared to the others (Belal et al., 2016). Moreover, high nitrate concentration in drinking water is very important because high nitrate concentration causes methemoglobinemia, blue baby syndrome, stomach cancer, abnormal pain, central neural system disorders, and diabetes (Belal et al., 2016). The nitrate concentration found in the present study was lower than the concentration of drinking water in many places (Soomro et al., 2017). Moreover, the nitrate concentrations were lower than the limits set by WHO (2016) and do not pose risk to human health. On the other hand, ammonium is very toxic to fishes with pH and temperature (Debels et al., 2005). Ammonium, which is an organic biologic degradation, is a nitrogen product and directly used by plants. Ammonium-sulfate fertilizers are used commonly as organic and inorganic fertilizers in agricultural lands by farmers (Vega et al., 1998). Fertilizers are conveyed to lakes and dams through irrigation water. As a result, this process results in an excessive increase in nitrogen and phosphor content in rivers and an excessive growth in the population of phytoplankton, the first ring of the food chain (Kutlu and Demir, 2018). The heavy metal concentrations found in the present study were slightly higher than the limits set by WHO, except for Fe (Tablo 2). The reason for these high concentrations is thought to be agricultural activities, mineral deposits, and anthropogenic sources, as well as the rocks (Kumar et al., 2017a-b). Cu, Pb, and Cd concentrations were lower than the limits set by WHO. The results achieved here are in parallel with those reported in the literature (Fatmi et al., 2009; Podgorski et al., 2016). Heavy metals can accumulate in the livers, kidneys, and muscle tissues of aquatic organisms. The secondary sources of heavy metals are the atmosphere and underground waters (Ali et al., 2017).

Table 3. Water quality classification based on Na %, SAR, MH, and WOI

Na %	Water quality	SAR (meq/L)	Water Quality	Water quality	MH (meq/L)	Water quality	WOI Range
< 20	Excellent	0-6	Good	Good	< 50	Suitable	< 50 Excellent
20–40	Good	6-9	Doubtful	Doubtful	> 50	Unsuitable	50–100 Good
40–60	Permissible	> 9	Unsuitable	Unsuitable			100–200 Poor
60–80	Doubtful						200–300 Very Poor
> 80	Unsuitable						> 300 water unsuitable for drinking purpose

Sodium absorption ratio (SAR):EC and sodium absorption ratio (SAR) values are used in determining the water quality for irrigation waters. SAR value of Şerefiye (Zara) dam was found to be 1.73 meq/L (Table 4). SAR values higher than 9 cannot be used as irrigation water (Awais et al., 2017). Using these waters poses a sodium risk. Given the results achieved, SAR value was within the safe range. High SAR values might pose a salinity risk by reducing the values of soil. It might prevent plant growth by reducing the concentrations of calcium and magnesium required for plants to grow (Vasantvigar et al., 2010; Rasool et al.,2016). The results achieved showed that the water of Şerefiye Dam is suitable for irrigation use.

Table 4. Şerefiye Dam water quality classification based on WOI, MH, Na %, SAR, PI, RSC and IWOI.

Station	WOI	MH	Na%	SAR	PI	RSC	IWOI
S1	35.22	49.83	31.10	1.72	54.52	-216.2	4.53
S2	50.81	49.85	30.98	1.75	47.42	251.1	4.23
S3	54.43	49.86	31.17	1.71	42.40	251.7	2.93
Mean	46.82	49.85	31.08	1.73	48.12	-257.1	3.90

Sodium percentage (%): The mean sodium percentage (%) in the study area was found to be 31.08% (Table 4). In this field, the water was classified by many researchers by using sodium percentage (Srinivas et al., 2017; El Aziz, 2017; Islam et al., 2017). As seen in Table 4, the water is in the "Good Water" class. High sodium percentage in water might be because of the fertilizers used in the surrounding agricultural lands. High (9%) sodium percentage in the soil negatively affects the soil in terms of impermeability, air circulation, and structure (Singara et al.,2014). In agricultural products grown using high-sodium waters, yield decreases since the osmotic pressure between soil and plant is affected and the mineral intake from soil by plant is prevented (Naseem et al., 2010).

Permeability index (PI): Introduced by Doneen (1975), this index was developed in order to classify the waters. Accordingly, the classification is as follows: if > 75, then Class I, if between 25 and 75, then Class II, and if <25, then Class III (Doneen, 1975; Raju et al., 2007). In the present study, the permeability index (PI) was found to be 48.12% and the water is Class I in terms of PI index (Table 4).

Thus, soil permeability depends on the mineral content in the water (Ca, Mg, Na, HCO_3). High concentrations of these minerals prevent the water to permeate the lower levels of the soil (Sing et al., 2008). Thus, the permeability index alters the water quality by disintegrating the agricultural soil (Obiefuna and Sheriff, 2011). Use of water that is rich in minerals, in agriculture prevents the ventilation of soil, mixing, and seedling growth.

Magnesium hazard (MH): In the present study, the mean magnesium concentration was found to be 49.85 meq/L (Table 4). Classifying the risk of magnesium is necessary to determine if the water is suitable for agricultural purposes. High magnesium concentration in water is a factor threatening the productivity (Kharonga and Khaid, 2019) because magnesium and lime particles prevent the water absorption (Hussain et al., 2016a; 2016b). The results achieved here are lower in comparison to those reported for other developing countries (Patel et al., 2017; Golekar et al., 2017; Padhi et al., 2017).

Water quality index (WOI): Water quality of Şerefiye dam was determined using the water quality index (WOI). This index is calculated using Cd, Cl, Cu, Pb, Na, hardness, pH, SO_4, and Zn values. The limit values set by WHO (2011) were used as seen in Table 2. Given the WOI results, it can be seen that the lowest value was found in Station I (48.55), whereas the highest one was found in Station II (64.12). It was determined that water quality parameters did not exceed the recommended limit levels. Accordingly, Şerefiye dam was found to have Good Class water quality.

Table 5. Factor loading matrix after varimax rotation

	Factor	Factor	Factor
	1	2	3
DO (mg/L)	0.12	0.48	0.54
Salinity (‰)	**0.94**	0.18	0.16
pH	**0.89**	0.20	0.31
T (°C)	**0.92**	-0.08	0.29
EC (µS/s)	**0.97**	0.07	0.15
TSS (mg/L)	**0.88**	0.08	-0.03
COD (mg/L)	**0.91**	0.31	0.09
BOD (mg/L)	**0.94**	0.25	0.12

CI (mg/L)	**0.95**	0.09	-0.00
PO_4(mg/L)	0.28	-0.16	**0.89**
SO_4 (mg/L)	0.48	**0.86**	-0.01
SO_3 (mg/L)	0.60	**0.76**	-0.07
Na (mg/L)	0.07	**0.98**	-0.05
K (mg/L)	0.16	**0.94**	-0.04
TH (mg/L)	0.21	**0.94**	0.00
TA (mg/L)	0.18	**0.95**	0.01
Mg (mg/L)	-0.12	**0.97**	0.06
Ca (mg/L)	-0.12	**0.97**	0.06
NO_2 (mg/L)	**0.80**	0.50	-012
NO_3 (mg/L)	**0.92**	0.25	0.15
NH_4(mg/L)	**0.81**	0.51	-0.13
Fe (µg/L)	0.34	**0.82**	0.12
Pb (µg/L)	**0.92**	0.07	0.15
Cu (µg/L)	0.35	**0.72**	0.47
Cd (µg/L)	**0.96**	-0.00	0.05
Eigenvalues	0.15	6.41	1.45
Variability (%)	60.08	25.74	5.82
Cumulative %	60.08	85.82	91.64

Four eigenvalues were calculated. These four factors explain 91.64% of the total variation (Table 5). The first factor was found to explain 60% of the variation. Salinity (%o), pH, T(°C) TSS, COD, BOD, EC, BOD, NO_2, NO_3, NH_4, Pb, Cd, Ca, and Ni were found to be positive, whereas Mg and Ca were found to be negative. Nitrite, nitrate, ammonium, and temperature were in the first factor and it suggests that there were two main indicators for the primary production (Kutlu et al. 2017). Among the primary production, it can be seen that phytoplankton preferred ammonium among the nitrate forms (Sönmez et al., 2017, Tepe and Kutlu, 2019). Such effects of BOD and COD on the dam water might be related with the excessive inlet of organic matter. The organic matter in lakes/dams might originate from domestic wastes and wide use of chemicals and fertilizers. Ammonium-sulfate fertilizers are widely used in agricultural activities (Vega et al. 1998). In conclusion, fertilizers might have been conveyed via different ways and also the discharge of agricultural wastes and organic wastes into the dam increased. BOD and COD influence the organic particles in the water. The second factor explains 25% of the variation and it includes SO_4, SO_3, Na, K, TH, TA, Mg, Ca, Fe, and Cu. It can be seen that the effect on Şerefiye dam originates from domestic and agricultural sources. Organic and inorganic fertilizers containing nitrate are used very widely. These variables did not reach the critical level and were in harmony with the standards set by WHO and Turkish Standards.

Factor 3 (F_3) explains 5.82% of the variation and has a strong positive load with PO_4 (Table 5). It is because of the discharges into Şerefiye dam and intense use of fertilizers. The presence of phosphate in the third factor can be related to the domestic and fertilizer wastes. Moreover, transfer of total phosphor from agricultural lands into dam basin causes pollution in lakes/ponds.Pearson's correlation test results showed that there was a strong positive correlation between DO, pH, T, EC, TSS, COD, BOD, Cl, PO_4, SO_4, and SO_3.

CONCLUSION

Dams are water resources, usability and quality of which are important for human needs and the next generations and which should be protected. The water quality of the dam, which is located in Sivas province and surrounded by functional mining zones, agricultural lands, and animal farms, was examined using water quality index and multivariate statistical approaches. The results achieved revealed that the water quality parameters were within the limit values set by WHO and SWQR. Moreover, future modeling studies would play an important role in determining the measures to be taken in order to monitor and assess the changes in water quality

COMPLIANCE WITH ETHICAL STANDARDS

a) Authors' Contributions

Each of the authors contributed 50%.

b) Conflict of Interest

The authors declare that there is no conflict of interest.

c) Statement of Human Rights

Work does not require a legal permit.

d) Statement of Human Rights

This study does not involve human participants.

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