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Seasonal Change of Physicochemical Properties of Kayalıköy Reservoir (Kıklareli/Turkey) and Determination of Water Quality

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ABSTRACT

This study was carried out in the Kayalıköy reservoir (Kırklareli, Turkey), that is used for agricultural irrigation and aquaculture and to provide drinking and domestic water supply of Edirne province. The study was performed at 3 stations determined in the reservoir during a year from May 2018 to April 2019. The water samples were taken with Ruttner water sample bottles from 15 to 20 cm below the water surface. Water temperature, Secchi disk depth, conductivity, pH, and dissolved oxygen were measured on-site simultaneously with the sampling time. Other physicochemical parameters were analyzed in the laboratory. A total of 43 physicochemical parameters were measured in the Kayalıköy reservoir. Analysis results obtained are compared with Regulation on Modification of Surface Water Quality Management (RSWQM) and Regulation on the Quality and Treatment of Water Provided for Drinking Water (RDWQ). According to the average values of the analysis results the water quality in Kayalıköy reservoir determined generally to be Class I and A1 water. In conclusion, Kayalıköy reservoir has water suitable for drinking, agricultural irrigation, and aquaculture and was classified as having oligomesotrophic character.

Keywords: Reservoir, water quality, physicochemical

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Kayalıköy Barajı'nın (Kırklareli/Türkiye) Fizikokimyasal Özelliklerinin Mevsimsel Değişimi ve Su Kalitesinin Belirlenmesi

Öz: Bu çalışma, Edirne ilinin içme ve kullanma suyu ile birlikte tarımsal sulama ve su ürünleri yetiştiriciliğinde kullanılan Kayalıköy baraj gölünde yapılmıştır. Su kalitesini belirlemeye yönelik olan bu araştırma, Mayıs 2018-Nisan 2019 tarihleri arasında bir yıl boyunca baraj gölünde seçilen 3 istasyonda gerçekleştirilmiştir. Bazı fizikokimyasal parametreler (su sıcaklığı, ışık geçirgenliği, iletkenlik, pH ve çözünmüş oksijen) araştırma sırasında ölçülürken diğer analizler için su örnekleri, su yüzeyinin 15-20 cm altında Ruttner şişesi ile alınmış ve analizleri laboratuvarda yapılmıştır. Toplam 43 fizikokimyasal parametreler ölçülmüştür. Elde edilen analiz sonuçları, Yüzeysel Su Kalitesi Yönetiminde Değişiklik Yapılmasına Dair Yönetmelik (RSWQM) ve İçme Suyu İçin Sağlanan Suyun Kalitesi ve Arıtımı Yönetmeliği (RDWQ) ile karşılaştırılmıştır. Analiz sonuçlarının ortalamalarına göre Kayalıköy rezervuarındaki su kalitesi genel olarak I sınıf ve A1 su olarak belirlenmiştir. Sonuç olarak, Kayalıköy rezervuarı içme, tarımsal sulama ve su ürünleri yetiştiriciliği için uygun suya sahip olduğu ve baraj gölünün oligomesotrofik karakterde olduğu tespit edilmiştir.

Anahtar kelimeler: Baraj gölü, su kalitesi, fizikokimyasal

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Introduction

Reservoirs are water bodies formed or modified by human activity for specific purposes to provide a reliable and controllable resource. Historically, reservoirs were built to serve a single purpose, i.e. irrigation. The present-day dam reservoirs, which are constructed for various reasons including flood control, water storage for water supply and irrigation, hydropower, fisheries, and recreation, show the characteristics of both rivers and lakes.

The physicochemical and biological properties of water in reservoirs often vary depending on the characteristics of the streams that feed the reservoir and the hydraulic residence time in the reservoir (Gikas et al. 2009).

Reservoir differs from natural lakes due to high external nutrient input, large drainage basin, water level changes, and human activity (Thornton et al. 1990). Freshwater pollution is a matter of serious global concern today and unfortunately, water resources subject to continuous pollution increasing gradually day by day (Strobl and Robillard 2008). Many researches showed that water sources are mostly contaminated as a result of human activities, particularly with domestic and industrial wastes, in addition to natural factors like rainwater, material transport with surface waters, atmospheric transport, and plant pollens (Samian et al. 2015; Loukas 2010). Pollutants discharged into water disturb the balance of the ecosystem and lead to significant problems in terms of public health by impairing the quality of domestic and drinking water. Since rivers and lakes are the major water resources for domestic use and human consumption, the accumulation of contaminants here constitute a global health problem (Das Kangabam and Govindaraju 2017).

It is required to assess a large number of physicochemical water quality data for effective contamination control. Water quality assessment is also useful and necessary for effective management of water resources (Dixon and Chiswell 1996; Köse et al. 2014). For this purpose, many studies have been conducted to determine the water quality of freshwater ecosystems such as streams, lakes, dams (Kükrer and Mutlu 2019; Mutlu et al. 2016; Minareci and Çakır 2018; Uncumusaoğlu and Mutlu 2017; Bulut and Kubilay 2018; Tepe and Kutlu 2019).

In this study, it was aimed to determine the water quality of Kayalıköy reservoir located in Kırklareli Province, Turkey by examining the physicochemical parameters of reservoir water which is used as domestic and drinking water of Edirne province.

Materials and Methods

Kayalıköy Reservoir was built 1981-1986 for irrigation and flood control on Teke Stream and it takes the name from Kayalı village to the west of the dam. The reservoir is west of Kırklareli and 12 km from Kırklareli city center. (400 48’51’’N, 260 47’43’’E). Because it is surrounded by rock formations, both the lake and the littoral region lack water plants. Kayalıköy Reservoir has volume is 144.2 hm^3 and a surface area of 10.20 km^2. Although the reservoir is fed mainly by the Teke stream, it is also replenished by other small streams in the region and rainfall. Although the reservoir was built for irrigation and flood control, it is also provides drinking and domestic water of Edirne.

The samples were collected monthly during the year May 2018 to April 2019 in three different stations in the reservoir that were considered to represent the entire lake (Figure 1 and Table 1).

Table 1. Sampling stations and coordinates in the Kayalıköy reservoir

Sampling stations	Explanations	Geographic coordinates
1st station	This station is located on the western branch of the lake and where Teke stream feeding the lake is located.	41°49'30.5" N 27°06'30.3" E
2nd station	This station is the middle part of the reservoir. Water in the reservoir is discharged in this area for irrigation and drinking water supply.	41°47'28.3" N 27°08'07.3" E
3rd station	This sampling station is located on the eastern branch of the lake	41°48'06.0" N 27°09'13.1" E

The water samples were taken with Ruttner water sample bottles from 15 to 20 cm below the water surface. Some physicochemical parameters (water temperature, Secchi disk depth, conductivity, pH, and dissolved oxygen) were measured on-site simultaneously with the sampling time in with Orion Star S/N 610541. The samples were transported to the laboratory in iceboxes and stored in the refrigerator at 4 °C until analysis. The values of Chlorophyll-a (Chl-*a)*, Total dissolved solids matter (TDS), Nitrite nitrogen (NO_2-N), Nitrate nitrogen (NO_3-N), Phosphate (PO_4), Chlorine (Cl_2), Sulphate (SO_4^{2-}), Fluoride (F^-), Chloride (Cl-), Bromide (Br-), Bromate (BrO_3), Sodium (Na), Magnesium (Mg), Potassium (K), Calcium (Ca), Lithium (Li), Beryllium (Be), Boron (B), Aluminium (Al), Iron, (F) Stronsiyum (Sr), Vanadium (V), Chromium (Cr), Manganese (Mn), Cobalt (Co), Nickel (Ni), Copper (Cu), Zinc (Zn), Arsenic (As), Selenium (Se), Molybdenum (Mo), Cadmium (Cd), Antimony (Sb), Barium (Ba), Thallium (Tl) and Lead (Pb) were measured in laboratories of Trakya University Technology Research Development Application and Research Center (TUTAGEM). A total of 43 parameters were analyzed in reservoir water. The analysis of the ions was performed by

Metrohm Ion Chromatography System using EPA 300.1 method. Metal analyzes were read on the Agilent Technologies 7700 ICP-MS System using EPA 200.7 and EPA 200.8 methods (EPA 2001).

The results were compared by National Standart for Turkish inland water Regulation on Modification of Surface Water Quality Management (RSWQM 2015) and Regulation on the Quality and Treatment of Water Provided for Drinking Water (RDWQ 2019) and the water quality of Kayalıköy reservoir was classified accordingly. Besides, besides, Spearmans Correlation was used to determine the related environmental parameters with each other (Krebs 1999). Statistical analyses were performed using SPSS 17.0.

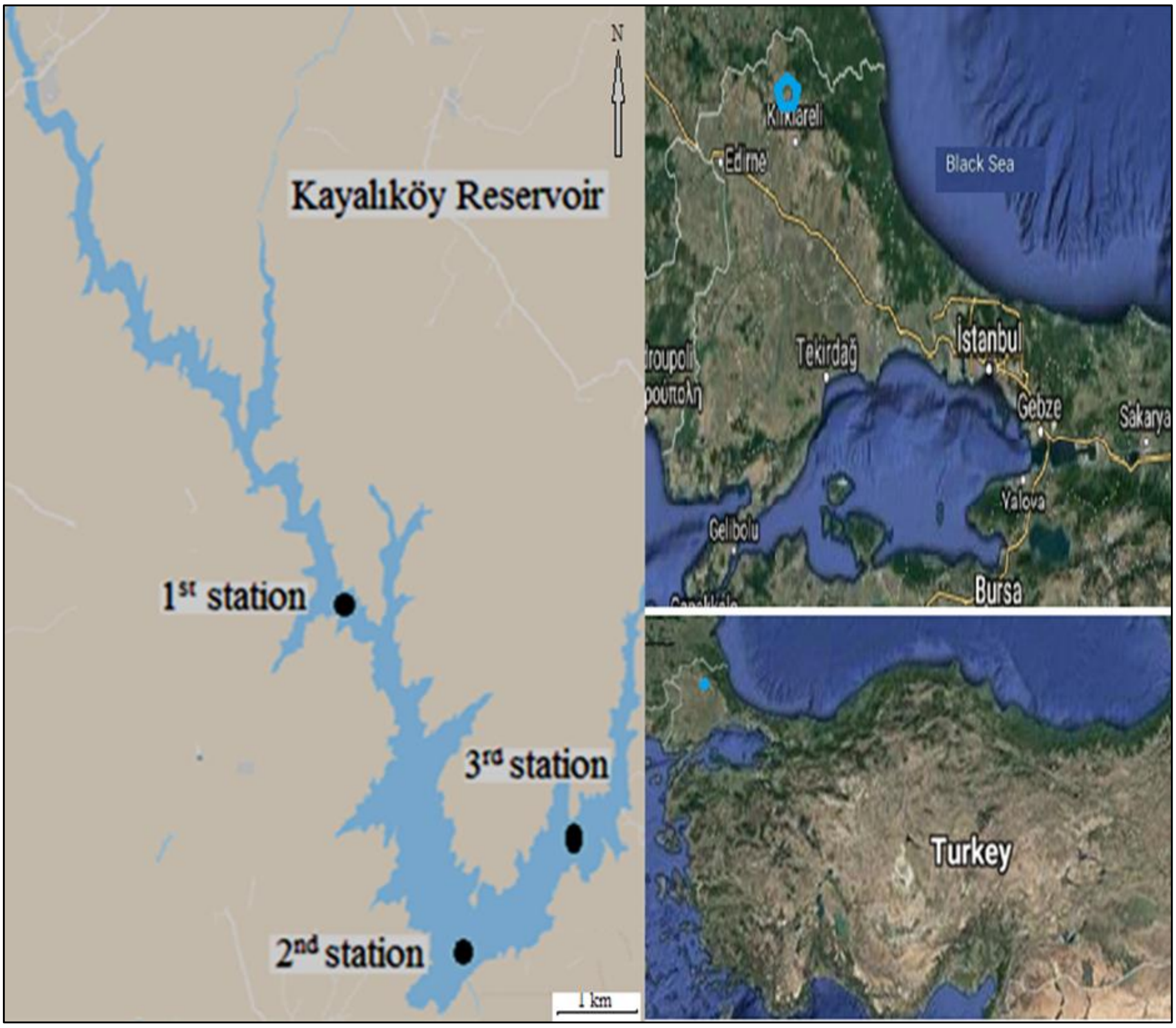

Figure 1. Location of Kayalıköy reservoir and the sampling stations

Results

According to the analysis results, regardless of difference of seasons and stations, the annual mean values of water quality parameters were found as Water temperature (WT) (15.530±7.74 °C), Secchi disk depth (SD) (94.242±39.34 cm), Chlorophyll-a (Chl-*a)* (10.713±7.00 µg/L), Total dissolved solids matter (TDS) (126.395±21.09 mg/L), Nitrite nitrogen (NO_2-N) (0.054±0.05 mg/L), Nitrate nitrogen (NO_3-N) (2.458±1.67 mg/L), Phosphate (PO_4) (0.126±0.24 mg/L), Chlorine (Cl_2) (15.675±6.38 mg/L), Sulphate (SO_4^{2-}) (15.999±0.78 mg/L), Fluoride (F^-) (0.155±0.01 mg/L), Chloride (Cl^-) (0.122±0.11 mg/L), Bromide (Br^-) (0.044±0.02 mg/L), Bromate (BrO_3) (0.243±0.20 mg/L), Sodium (Na) (7.304±4.08 mg/L), Magnesium (Mg) (5.613±2.71 mg/L), Potassium (K) (8.691±8.58), Calcium (Ca) (12.060±6.34 mg/L), Lithium (Li) (3.261±1.89 µg/L), Beryllium (Be) (0.230±0.33 µg/L), Boron (B) (40.342±23.61 µg/L), Aluminium (Al) (139.261±163.34 µg/L), Iron (F) (0.142±0.09 µg/L), Stronsiyum (Sr) (89.538±42.51 µg/L), Vanadium (V) (3.362±3.55 µg/L), Chromium (Cr) (2.786±3.00 µg/L), Manganese (Mn) (5.078±3.93 µg/L), Cobalt (Co) (0.186±0.09 µg/L), Nickel (Ni) (1.509±0.62 µg/L), Copper (Cu) (1.769±1.74 µg/L), Zinc (Zn) (3.585±2.52 µg/L), Arsenic (As) (0.726±0.42 µg/L), Selenium (Se) (7.046±5.56 µg/L), Molybdenum

(Mo) (4.071 ± 10.85 µg/L), Cadmium (Cd) (0.097±0.07 µg/L), Antimony (Sb) (22.191±59.28), Barium (Ba) (23.482±11.91 µg/L), Thallium (Tl) (0.119±0.08 µg/L) and Lead (Pb) (0.873±0.73 µg/L) (Table 2).

The minimum and maximum values of the physicochemical parameters measured in the Kayalıköy reservoir are given in Table 2 in a monthly and seasonally manner. Besides, according to months the change of physicochemical parameters is given in Figure 2.

According to the Spearmans Correlation, While water temperature (WT) showed positive significant relationship with SD (r=752), Chl-*a* (r=882), SO_4 (r=882) ($p<0,01$); Fe (r=724), Cr (r=627) and Tl (r=645) ($p<0,05$), it showed negative relationship with DO (r=809), Al (r=845) ($p<0,01$) and Fe (r=724) ($p<0,05$) (Table 3). While Secchi disk depth (SD) showed positive significant relationship with NO_3 (r=806), SO_4 (r=916), Cr (r=765) ($p<0.01$); Chl-*a* (r=620), Na (r=706), Mg (r=656), Cu (r=615) and Se (r=638) ($p<0,05$), it showed negative relationship with DO (r=852) ($p<0.01$) (Table 3). While Chlorophyll-a (Chl-*a*) showed positive significant relationship with WT (r=882), SO_4 (r=727), Tl (r=764) ($p<0.01$) and SD (r=620) ($P<0.05$), it showed negative relationship with Al (r=791) ($p<0.01$), DO (r=682), NO_3 (r=655), PO_4 (r=639) and Fe (r=620) ($P<0.05$) (Table 3). While Dissolved oxygen (DO) showed positive significant relationship with Al (r=791) ($p<0.01$), it showed negative relationship with WT (r=809), SD (r=852), SO_4 (r=936), Cr (r=754) ($p<0.01$), Chl-a (r=682), NO_2 (r=664), Na (r=618), and Tl (r=609) ($p<0.05$) (Table 3). According to the Spearmans Correlation, the relationship of the other parameters with each other is given in Table 3.

Table 2. According to months and seasons maximum and minimum values of physicochemical parameters measured in Kayalıköy reservoir

		According to months		**According to the seasons**		
	Abbreviation	**Min**	**Max**	**Min**	**Max**	**Average of reservoir**
Air temperature	AT (°C)	3.333	30.000	5.111	27.333	17.136 ± 9.06
Water temperature	WT (°C)	4.167	26.500	5.722	25.056	15.530 ± 7.74
Secchi disk depth	SD (cm)	36.667	186.667	50.000	130.000	94.242 ± 39.34
Chlorophyll-a	Chl-*a* (µg/L)	4.333	23.833	4.833	16.257	10.713 ± 7.00
Dissolved oxygen	DO (mg/L)	8.487	13.760	8.653	13.760	10.277 ± 1.66
pH	pH	6.360	9.477	8.173	9.108	8.435 ± 0.79
Salinity	Salinity (psu)	0.138	0.201	0.152	0.182	0.171 ± 0.02
Electrical conductivity	EC (µS/cm)	177.233	319.767	201.967	278.167	249.936 ± 41.91
Total dissolved solids matter	TDS (mg/L)	88.010	157.200	100.967	136.789	126.395 ± 21.09
Nitrite nitrogen	NO_2-N (mg/L)	0.002	0.131	0.008	0.120	0.054 ± 0.05
Nitrate nitrogen	NO_3-N (mg/L)	0.062	4.967	0.726	3.937	2.458 ± 1.67
Phosphate	PO_4 (mg/L)	0.000	0.839	0.004	0.422	0.126 ± 0.24
Chlorine	Cl_2 (mg/L)	8.859	25.767	9.635	21.583	15.675 ± 6.38
Sulfate	SO_4^{2-} (mg/L)	14.665	17.076	14.830	16.594	15.999 ± 0.78
Fluoride	F^- (mg/L)	0.140	0.166	0.146	0.163	0.155 ± 0.01
Chloride	Cl^- (mg/L)	0.040	0.338	0.049	0.227	0.122 ± 0.11
Bromide	Br^- (mg/L)	0.000	0.059	0.027	0.056	0.044 ± 0.02
Bromate	BrO_3 (mg/L)	0.000	0.560	0.146	0.351	0.243 ± 0.20
Sodium	Na (mg/L)	1.894	12.695	2.215	11.010	7.304 ± 4.08
Magnesium	Mg (mg/L)	1.349	8.899	2.969	7.930	5.613 ± 2.71
Potassium	K (mg/L)	0.718	25.019	1.622	18.135	8.691 ± 8.58
Calcium	Ca (mg/L)	2.646	23.479	6.736	17.633	12.060 ± 6.34
Lithium	Li (µg/L)	0.773	5.530	0.773	4.774	3.261 ± 1.89
Beryllium	Be (µg/L)	0.035	1.120	0.045	1.120	0.230 ± 0.33
Boron	B (µg/L)	15.236	101.169	15.971	68.927	40.342 ± 23.61

Tablo 2. Devamı.

	Abbreviation	According to months		According to the seasons		Average of reservoir
		Min	Max	Min	Max	
Aluminum	Al (µg/L)	6.475	612.883	41.961	323.348	139.261 ± 163.34
Iron	Fe (mg/L)	0.072	0.401	0.088	0.222	0.142 ± 0.09
Stronsiyum	Sr (µg/L)	22.133	144.727	53.945	129.161	89.538 ± 42.51
Vanadium	V (µg/L)	0.391	11.978	0.727	7.885	3.362 ± 3.55
Chromium	Cr (µg/L)	0.408	11.465	1.142	6.500	2.786 ± 3.00
Manganese	Mn (µg/L)	1.659	14.601	3.303	8.702	5.078 ± 3.93
Cobalt	Co (µg/L)	0.039	0.333	0.073	0.269	0.186 ± 0.09
Nickel	Ni (µg/L)	0.418	2.485	0.971	1.866	1.509 ± 0.62
Copper	Cu (µg/L)	0.348	6.796	0.866	3.572	1.769 ± 1.74
Zinc	Zn (µg/L)	0.818	9.145	1.987	6.597	3.585 ± 2.52
Arsenic	As (µg/L)	0.077	1.386	0.394	1.183	0.726 ± 0.42
Selenium	Se (µg/L)	0.270	19.148	2.134	10.310	7.046 ± 5.56
Molybdenum	Mo (µg/L)	0.602	33.543	0.909	20.698	14.071 ± 10.85
Cadmium	Cd (µg/L)	0.008	0.260	0.024	0.167	0.097 ± 0.07
Antimony	Sb (µg/L)	0.053	199.900	0.279	104.403	22.191 ± 59.28
Barium	Ba (µg/L)	5.486	42.963	16.058	34.938	23.482 ± 11.91
Thallium	Tl (µg/L)	0.012	0.260	0.033	0.191	0.119 ± 0.08
Lead	Pb (µg/L)	0.122	2.790	0.369	1.775	0.873 ± 0.73

Table 3. According to the Spearmans Correlation analysis, the relationship between environmental parameters with each other in Kayalıköy reservoir

	WT	SD	Chl-a	DO	pH	EC	NO_2	NO_3	PO_4	SO_4	Na	Mg	K	Ca	Fe	Sr	Cr	Mn	Cu	Zn	As	Cd	Ba	Pb
WT	1																							
SD	.752**	1																						
Chl-a	.882**	.620*	1																					
DO	-.809**	-.852**	-.682*	1																				
pH	0.264	0.196	0.345	0.027	1																			
EC	-0.536	-0.191	-0.409	0.427	-0.155	1																		
NO2	.636*	.806**	0.345	-.664*	0.091	-0.255	1																	
NO_3	-0.382	0.059	-.655*	0.018	-0.136	-0.036	0.273	1																
PO_4	-0.452	0.021	-.639*	0.032	-0.082	0.128	0.041	.904**	1															
SO_4	.882**	.916**	.727*	-.936**	0.173	-0.409	.782**	-0.055	-0.123	1														
Na	0.445	.706*	0.527	-.618*	-0.155	0.2	0.427	-0.236	-0.21	.664*	1													
Mg	0.4	.656*	0.509	-0.527	-0.127	0.391	0.391	-0.336	-0.297	0.564	.945**	1												
K	0.309	0.483	0.464	-0.155	0.282	0.427	0.127	-0.427	-0.306	0.273	0.582	.691*	1											
Ca	0.155	0.588	0.227	-0.364	-0.073	0.564	0.309	-0.045	0.018	0.4	.809**	.891**	.745**	1										
Fe	-.724*	-0.356	-.620*	0.483	-0.433	0.601	-0.342	0.301	0.304	-.620*	-0.146	0.009	0.082	0.282	1									
Sr	0.164	0.469	0.291	-0.355	-0.1	0.555	0.191	-0.209	-0.123	0.391	.845**	.909**	.664*	.945**	0.15	1								
Cr	.627*	.765**	0.418	-.745**	-0.264	-0.255	.655*	0.1	-0.014	.682*	0.473	0.473	0.327	0.455	-0.014	0.291	1							
Mn	-0.018	0.419	0.036	-0.236	-0.173	.655*	0.127	0.027	0.137	0.209	.627*	.755**	.664*	.945**	0.469	.873**	0.427	1						
Cu	0.245	.615*	0.173	-0.6	0.027	0.055	0.273	0.327	0.434	0.555	0.536	0.473	0.336	.673*	0.014	.618*	0.518	.691*	1					
Zn	-0.1	0.141	0.109	-0.136	-0.3	.664*	-0.091	-0.282	-0.178	0.091	.682*	.791**	0.455	.800**	0.351	.909**	0.082	.800**	0.409	1				
As	0.091	0.228	0.245	-0.182	-0.309	0.391	-0.064	-0.345	-0.329	0.191	.700*	.745**	0.591	.773**	0.273	.836**	0.327	.764**	0.482	.827**	1			
Cd	0.391	0.21	0.455	-0.4	-0.318	-0.018	-0.091	-0.491	-0.447	0.355	0.536	0.527	0.345	0.436	-0.118	0.573	0.4	0.455	0.445	0.564	.818**	1		
Ba	0.027	0.287	0.164	-0.264	-0.173	0.5	-0.055	-0.127	0.009	0.218	.636*	.700*	0.6	.855**	0.31	.900**	0.291	.882**	.718*	.845**	.855**	.664*	1	
Pb	0.2	0.287	0.4	-0.3	-0.018	0.309	-0.2	-0.382	-0.169	0.255	0.591	.627*	.691*	.709*	0.096	.773**	0.273	.727*	.655*	.691*	.809**	.764**	.909**	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed

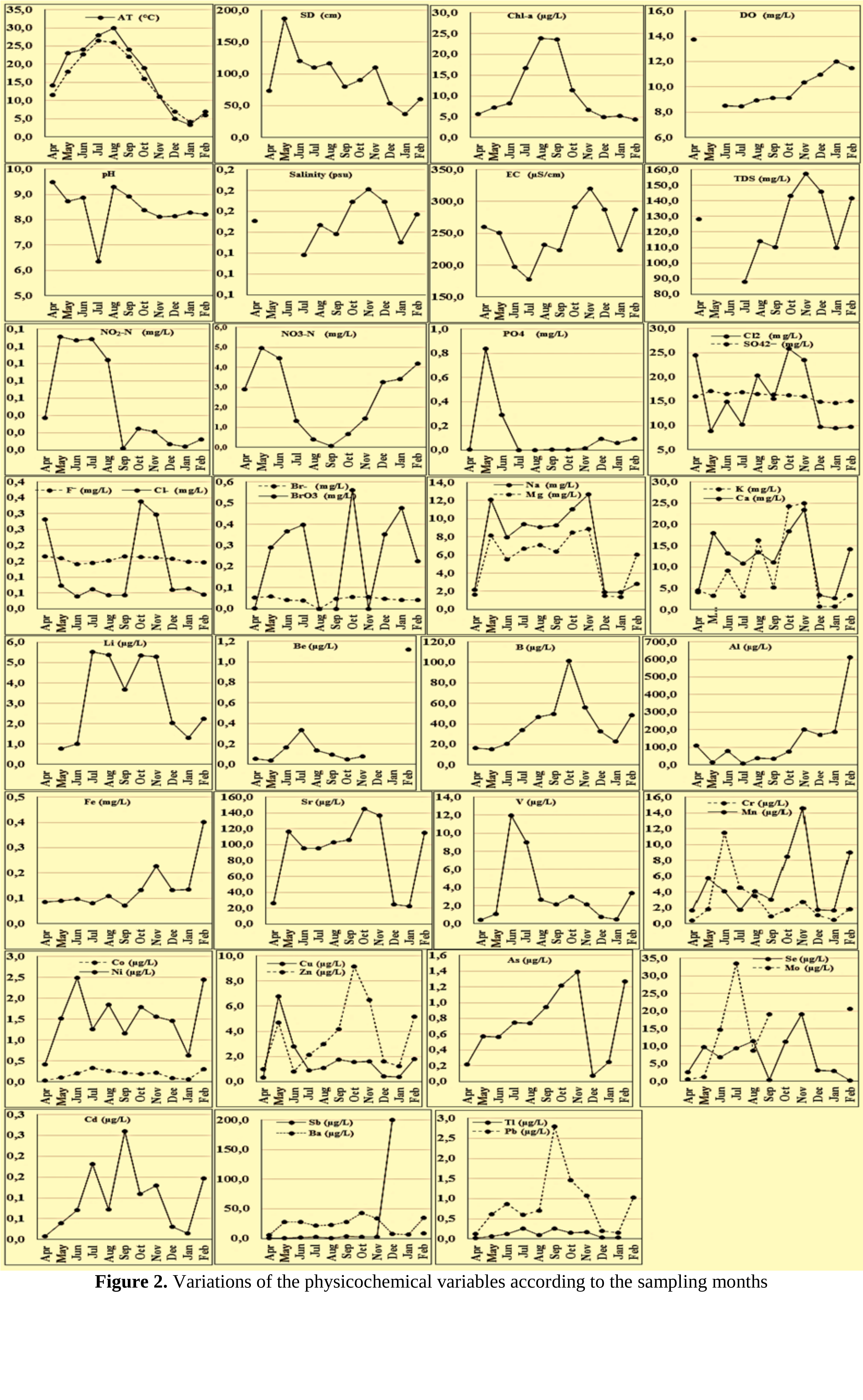

Figure 2. Variations of the physicochemical variables according to the sampling months

Discussion

The water samples taken from three stations determined in Kayalıköy reservoir for one year were examined in terms of some physicochemical parameters and heavy metal concentrations. The results were compared with RSWQM (National Standart for Turkish inland water Regulation on Modification of Surface Water Quality Management) and RDWQ (Regulation on the Quality and Treatment of Water Provided for Drinking Water).

Water temperature

The highest and the lowest water temperature values were recorded as 26.500 °C in July in the summer season and 4.167 °C in January in the winter season, respectively. The mean water temperature in the reservoir was 15.530±7.74°C (Table 2 and Figure 2). Water temperature affects the biological, chemical, and physical activities in water increases the metabolic and respiratory rates of aquatic organisms, and affects the dissolubility of gases. When the temperature increases, then the metabolic rate increases, and the level of oxygen decreases (Ünlü et al. 2008). These results indicate that the temperature differences between the months and the seasons were within acceptable levels for the survival of aquatic organisms. When the results of the physicochemical analysis were compared with RSWQM (2015), the water temperature in the reservoir was found to be Class I quality.

Secchi disk depth

Secchi disk in the reservoir was measured between 36.67-186.67 cm. Maximum light permeability was recorded in May in the spring season and the minimum in January in the winter season. The general mean Secchi disk depth in the reservoir was 94.24±39.34 cm (Table 2 and Figure 2). The lake is considered as eutrophic if the measured Secchi disk is between 0.8 and 1.5 m, mesotrophic if it is between 1.4 and 2.4 m, and oligotrophic if it is between 3.6 and 5.9 m (Ryding and Rast 1989). According to RSWQM (2015), the lake is considered as eutrophic if the measured Secchi disk is between 1.0 and 1.9 m, mesotrophic if it is between 2.0 and 4.0 m and oligotrophic if it is >4 m. According to this classification based on Secchi disk depth, Kayalıköy reservoir could be categorized as eutrophic.

Chlorophyll-a

The highest and the lowest chlorophyll-*a* values recorded as 23.833 µg/L in August in the summer season and 4.333 µg/L in February in the winter season, respectively. The mean chlorophyll-*a* in the reservoir was 10.713±7.00 µg/L (Table 2 and Figure 2). For ponds and dam lakes, the amount of chlorophyll-*a* in oligotrophic lakes is <3.5 µg/L, between 3.5-9.0 µg/L in mesotrophic lakes and between 9.1-25 µg/L in eutrophic lakes (RSWQM 2015). The lake is considered as eutrophic if the average value of the measured chlorophyll-a 14.3 µg/L; mesotrophic if it is 4.7 µg/L and oligotrophic if it is 1.7 µg/L (Caspers 1984). According to the chlorophyll-a values in Kayalıköy reservoir could be classified as mesotrophic.

Dissolved oxygen

The maximum dissolved oxygen concentration was determined as 13.76 mg/L in April in the spring season and the minimum as 8.49 mg/L in July in the summer season with an annual average of 10.28±1.66 mg/L (Table 2 and Figure 2). Dissolved oxygen is one of the important parameters in water quality assessment and reflects the biological and physical processes that are common in water (Egemen and Sunlu 2006) and is inversely proportional to the water temperature (Öztürk and Akköz 2014). According to RSWQM (2015), Kayalıköy reservoir was Class I quality levels, which means it is clean water.

pH

pH is one of the important factors affecting living life in water. Many species of fish and aquatic organisms develop well in waters with a pH range of 6.5-8.5 (Arrignon 1976; Dauba 1981). In the present study, pH values in Kayalıköy reservoir were measured between 6.360 to 9.477 (average 8.435±0.79). The maximum pH value was recorded in April in the spring season and the minimum in July in the summer season (Table 2 and Figure 2). The pH value of the lake was moderately alkaline varying from 7.5 to 8.2 (Berzins and Pejler 1987). According to the average pH values, Kayalıköy reservoir was rated as an alkaline water-bearing reservoir. Besides, according to RSWQM (2015) and RDWQ (2019) was Class I and Class A1 quality.

Salinity

Salinity is a dynamic indicator of the water ecosystem such as other parameters and it is expressed as the total concentration of charged ions in water. The salinity of the Kayalıköy reservoir was recorded as 0.138 psu in July in the summer season as the minimum and 0.201 psu in November in the autumn season as the maximum with the average value 0.171±0.02 psu (Table 2 and Figure 2). According to salinity measurements, it was concluded that Kayalıköy Reservoir is suitable for aquatic life. While Salinity showed positive significant relationship with EC (r=858), TDS (r=998) ($p<0.01$) and B (r=648) ($p<0.05$), it showed negative relationship with SO_4 (r=603) ($p<0.01$).

Electrical conductivity

The electrical conductivity of water depends on both geological factors and external influences (Barlas et al. 1995). Electrical conductivity in freshwater varies between 10-1000 µS/cm. The acceptable electrical conductivity value for aquatic organisms is in the range of 250-500 µS/cm (Yücel 1990). The electrical conductivity in Kayalıköy reservoir was measured as 177.233-319.767 µS/cm (average 249.936±41.91 µS/cm). The maximum electrical conductivity was recorded in November in the autumn season and the minimum in July in the summer season. According to RSWQM (2015) and RDWQ (2019), the reservoir water was assigned to have Class I and Class A1 quality and it was concluded that Kayalıköy reservoir is suitable for aquatic life. The Electrical conductivity (EC) showed a positive significant relationship with TDS (r=847), Salinity (r=858) ($p<0.01$), Mn (r=655) and Zn (r=664) ($p<0.05$) (Table 3).

Total dissolved solids matter

The highest and the lowest total dissolved solids values were recorded as 157.200 mg/L in November in the autumn season and 8.010 mg/L in July in the summer season, respectively. The mean total dissolved solids in the reservoir was 126.395±21.09 mg/L. (Table 2 and Figure 2). According to total dissolved solids measurements, it was concluded that Kayalıköy reservoir is suitable for aquatic life. While Total dissolved solids matter (TDS) showed a positive significant relationship with Salinity (r=998) and B (r=620), it showed a negative relationship with SO_4 (r=620) ($p<0.05$).

Nitrite nitrogen and Nitrate nitrogen

During the study period in Kayalıköy reservoir, the nitrite nitrogen concentration was 0.002-0.131 mg/L (average 0.054±0.05) and the minimum value was recorded in September in the winter season and the maximum in May in summer season (Table 2 and Figure 2). Nitrate nitrogen concentration was measured between 0.062 to 4.967 mg/L (average 2.458±1.67) and the minimum value was recorded in September in the autumn season and the maximum in May in the spring season (Table 2 and Figure 2). Nitrogen derivatives such as nitrite (NO_2-N) and nitrate (NO_3-N) play an important role in the process of water pollution. The nitrite and nitrat sources in water are the organic matters, fertilizers used in agriculture, the wastewaters, and some minerals. The nitrite concentration in surface water higher than 1 mg/L indicates the presence of pollution (Taş 2011). A high concentration of nitrate in surface waters indicates the pollution. According to RSWQM (2015), the total nitrogen content is ≤0.35 mg/L in oligotrophic lakes, 0.35-0.65 mg/L in mesotrophic lakes and 0.65-1.2 mg/L in eutrophic lakes. According to the average nitrite nitrogen and nitrate nitrogen values, Kayalıköy reservoir was rated as oligotrophic and Class I. The Nitrite nitrogen (NO_2-N) showed a positive significant relationship with SD (r=806), SO_4 (r=782) ($p<0.01$), WT (r=636) and Cr (r=655) ($p<0.05$), it showed a negative relationship with DO (r=664) ($p<0.01$). Also, While Nitrate nitrogen (NO_3-N) showed positive significant relationship with PO_4 (r=904) ($p<0.05$), it showed negative relationship with Chl-*a* (r=655), Cl_2 (r=645) and B (r=673) ($p<0.05$) (Table 3).

Phosphate

Phosphate concentrations fluctuated during the study from 0.000 to 0.839 mg/L (average 0.126±0.24 mg/L). The maximum phosphate concentration was recorded in May in the spring season and the minimum in July, August in the autumn season (Table 2 and Figure 2). Phosphate concentration was below the detection limit during these months. If the total phosphorus is less than 10 µg/L, the lake is oligotrophic, if between 10-20 µg/L it is mesotrophic and if it is greater than 20 µg/L, it is eutrophic (Thoman and Mueller 1987). RSWQM (2015) reported that phosphate concentration is 00.01 mg/L in oligotrophic lakes, 0.01-0.03 mg/L in mesotrophic lakes and 0.03-0.1 mg/L in eutrophic lakes. RDWQ (2019) reported the concentration of phosphate as 0.4 mg/L in Class A1 and 0.7 mg/L in Class A2. Based on these results, Kayalıköy reservoir was rated as oligotrophic and Class I and A1. While Phosphate (PO_4) showed positive significant relationship with NO_3 (r=904) and K (r=809) ($p<0.01$), it showed negative relationship with Chl-*a* (r=639) ($p<0.05$) (Table 3).

Chlorine

The values of chlorine fluctuated during the study from 8.859 to 25.767 mg/L (average 15.675±6.38 mg/L). The maximum value of chlorine was recorded in October in the autumn season and the minimum in May in the winter season. (Table 2 and Figure 2). Considering the taste threshold for chlorine in drinking water is below 5 mg/L (WHO 2017), the chlorine value is high in the reservoir. Therefore, care must be taken during the disinfection of water. While Chlorine (Cl_2) showed positive significant relationship with Na (r=664) and Cr (r=682) ($p<0.05$), it showed negative relationship with Al (r=827) ($p<0.05$), NO_3 (r=645) and Fe (r=620) ($p<0.05$).

Sulfate

Sulphate concentration in the reservoir was measured between 14.665-7.076 mg/L. The maximum value of sulfate was recorded in May in the spring season and the minimum in January in the winter season. The mean value of sulfate in the reservoir was 15.999±0.78 mg/L (Table 2 and Figure 2). The sulfate (SO_4^{-2}) among natural anions of waters should exist in natural waters for biological productivity to increase (Taş et al. 2010). The level of sulfate in natural waters varies between 5 and 100 mg/L. The maximum sulfate level required for aquatic products is 90 mg/L and it is more than 250 mg/L indicates serious pollution (Nisbet and Verneaux 1970). RDWQ (2019) reported the concentration of sulfate as 250 mg/L in Class A1 and 1250 mg/L in Class A3 waters. According to these results, Kayalıköy reservoir has clean water characteristics and Class A2. While Sulphate (SO_4) showed positive significant relationship with WT (r=882), SD (r=916), NO_2 (r=782) (p<0.01), Chl-a (r=727), Na (r=664) and Cr (r=682) (p<0.05), it showed negative relationship with DO (r=936), Al (r=827) (p<0.01), Salinity (r=603) and Fe (r=620) (p<0.05) (Table 3).

Fluoride

The presence of fluoride in drinking water at certain concentrations is important for bone and dental health. In the present study, fluoride values in Kayalıköy reservoir were measured between 0.140-0.166 mg/L (average 0.155±0.01 mg/L). The maximum fluoride value was recorded in April in the autumn season and the minimum in June in the summer season (Table 2 and Figure 2). The optimum concentration of fluoride is 1 mg/L, but regulations allow a maximum concentration of 1.5 mg/L in drinking water. If fluoride concentration is less than 1000 µg/L the water is Class I if between 1500 µg/L it is Class II and if it is 2000 µg/L, it is Class III. (RSWQM 2015). RDWQ (2019) reported the concentration fluoride as >200 µg/L in Class A1, 5000 µg/L Class A2, and 7500 µg/L in Class A3. According to these results, Kayalıköy reservoir has been water Class II and A1. While Fluoride (F) showed positive significant relationship with Br (r=663) (p<0.01), it showed negative relationship with Cr (r=638) (p<0.05).

Chloride

The chloride which exists in all natural waters is an important component of natural waters, and affects the distribution, diversity, and abundance of organisms in water. In the present study, chloride value in Kayalıköy reservoir was measured between 0.040-0.338 mg/L (average 0.122±0.11 mg/L). The maximum chloride value was recorded in October in the autumn season and the minimum in June in the summer season (Table 2 and Figure 2). Chloride ion is present in natural waters at a rate of 0-30 mg/L, while it is present at concentrations of 0.2-1 mg/ L in disinfected drinking water (White 1978). According to these data, Kayalıköy reservoir is suitable for aquaculture, drinking, and domestic water. While Chloride (Cl) showed positive significant relationship with Br (r=645) (p<0.01), it showed negative relationship with Mo (r=620) (p<0.05).

Bromide

The ionic form, bromide, Br^-, is generally found in a variety of salts and is highly soluble in water. Bromide salts are more soluble than chloride salts, thus evaporation induced precipitation produces solids that are enriched in chloride and residual brines that are enriched in bromide. Bromide is rarely observed at significant concentrations in surface freshwater systems and its concentration is between 0.014-0.2 mg/L (Bowen 1979). RDWQ (2019) reported the concentration of bromide as 2000 µg/L in Class A1, 4000 µg/L in Class A2, and 6500 µg/L in Class A3. In the present study, the bromide value was detected the maximum 0.059 mg/L and the minimum 0.000 mg/L. The maximum bromide value was recorded in May in the spring season the minimum in August in the summer season. It was below the detection limits this month (Table 2 and Figure 2). The average of bromide concentration in the reservoir was measured as 0.044±0.02 mg/L in the reservoir. In terms of bromide values, the Kayalıköy reservoir is suitable for drinking and domestic water and Class A1 water.

Bromate

Bromate is an inorganic ion. It is not normally present in water but enters the water as disinfection by-product that occurs when the naturally occurring bromide ion reacts with ozone (O_3). The concentration of the bromate was reported as 2.9 µg/L with a range of <0.2-25 µg/L for surface water sources (WHO 2008). RDWQ (2019) reported the concentrations of bromate as 10 µg/L in Class A1, 12 µg/L in Class A2, and 100 µg/L in Class A3. In the present study, bromate values in Kayalıköy reservoir were measured between 0.000-0.243 mg/L (average 0.243±0.20 mg/L). The maximum bromate value was recorded in October in the winter season and the minimum in August in the spring season. The bromate concentration was below the detection limit in August (Table 2 and Figure 2). In terms of bromate average values, the Kayalıköy reservoir has Class A3 water which is not suitable for drinking purposes.

Sodium

Sodium concentrations fluctuated during the study from 1.894 to 12.695 mg/L (average 7.304±4.08 mg/L). The maximum sodium concentration was recorded in November in the autumn season and the minimum in December in the winter season (Table 2 and Figure 2). The sodium ion is ubiquitous in water. Most water supplies contain less than 20 mg/L but in some countries, levels can exceed 250 mg/L. Sodium salt concentration varies between 2-100 mg/L in natural waters (Tepe 2009). RDWQ (2019) reported the concentration of sodium as 200 mg/L in Class A1 and 2000 mg/L in Class A3. In terms of sodium average values, the Kayalıköy reservoir has Class A1 water which is suitable for drinking purposes. While Sodium (Na) showed positive significant relationship with Mg (r=945), Ca (r=809), Sr (r=845) ($p<0.01$), SD (r=706), SO_4 (r=664), Mn (r=627), Zn (r=682), As (r=700), Se (r=655), Ba (r=636) and Tl (r=664) ($p<0.05$), it showed negative relationship with DO (r=618) ($p<0.05$) (Table 3).

Magnesium

Magnesium is one of the ions that make up the hardness of the water. Because magnesium is present in the composition of chlorophyll, it is vital for chlorophyll plants and found in the in natural waters as 10-50 mg/L. In the present study, magnesium value was detected the maximum 8.899 mg/L in November and the minimum 1.349 mg/L in January. The average magnesium values was determined as 5.613±2.71 mg/L in the reservoir (Table 2 and Figure 2). According to these data, Kayalıköy reservoir is suitable for drinking and domestic water. The Magnesium (Mg) showed positive significant relationship with Na (r=945), Ca (r=891), Sr (r=909), Mn (r=755), Zn (r=791), As (r=745) ($p<0.01$), SD (r=656), K (r=691), Se (r=727) and Pb (r=627) ($p<0.05$) (Table 3).

Potassium

Potassium is one of the inorganic salts that give water taste. Potassium is found in the natural waters between 1-10 mg/L (Tepe 2009). In the present study, the average potassium value was determined as 8.691±8.58 mg/L in the reservoir. The potassium value was detected the maximum 25.019 mg/L in November in the autumn season and the minimum 0.718 mg/L in January in the winter season (Table 2 and Figure 2). According to these data, Kayalıköy reservoir is suitable for drinking, agricultural irrigation, and aquaculture. The Potassium (K) showed positive significant relationship with Cl_2 (r=809), Ca (r=745) ($p<0.01$) Mg (r=691), Sr (r=664), Mn (r=664) and Pb (r=691) ($p<0.05$) (Table 3).

Calcium

Calcium is an important determinant of water hardness, and it also functions as a pH stabilizer because of its buffering qualities. Calcium also gives water a better taste. When the amount of calcium in water is about 25 mg/L, the productivity increases to a maximum but below 12 mg/L the productivity decreases (Bremond and Vuichard 1973; Nisbet and Verneaux 1970). While the amount of calcium suitable for fishing is 30-40 mg/L, it can reach natural waters to a value of 150 mg/L. In the present study, the maximum calcium concentration was measured as 23.479 mg/L in November in the autumn season and the minimum as 2.646 mg/L in January in the winter season. The average calcium concentration in the reservoir was measured as 12.060±6.34 mg/L (Table 2 and Figure 2). According to these data, Kayalıköy reservoir is suitable for drinking, agricultural irrigation, and aquaculture. The Calcium (Ca) showed positive significant relationship with Na (r=809), Mg (r=891), K (r=745), Sr (r=945), Mn (r=945), Zn (r=800), As (r=773), Ba (r=855) ($p<0.01$), Ni (r=659), Cu (r=673) and Pb (r=709) ($p<0.05$) (Table 3).

Lithium

Seawater contains approximately 0.17 ppm lithium. Rivers generally contain only 3 ppb, whereas mineral water contains 0.05-1 mg/L. The lithium reacts with water, forming lithium hydroxide and hydrogen. The lithium concentration in Kayalıköy reservoir was measured between 0.773-5.530 µg/L. The maximum lithium value was recorded in July in the autumn season and the minimum in May in the spring season. The average of lithium values was determined as 3.261±1.89 µg/L in Kayalıköy reservoir (Table 2 and Figure 2).

Beryllium

Beryllium values were detected as 1.120 µg/L in February in the winter season as the maximum and 0.035 µg/L in May in the spring season as the minimum. The average of beryllium concentration was determined as 0.230±0.33 µg/L in the reservoir (Table 2 and Figure 2). There are only limited data on beryllium concentrations in water except the USA. The concentration of beryllium in surface waters has been reported as 0.001 mg/L by USEPA (2002). According to these data, it can be said that Kayalıköy reservoir contains beryllium under the limit values.

Boron

Boron concentration in Kayalıköy reservoir was measured as 15.236-101.169 µg/L (average 40.342±23.61µg/L). The maximum boron value was recorded in October in the autumn season and the minimum in May in the spring season (Table 2 and Figure 2). The amount of boron in freshwater depends on such factors as the geochemical nature of the drainage area, proximity to marine coastal regions, and inputs from industrial and municipal effluents (Butterwick et al. 1989). Boron concentrations in fresh surface water range from <0.001 to 2 mg/L in Europe, with mean values typically below 0.6 mg/L. Similar concentration ranges have been reported for water bodies within

Pakistan, Russia, and Turkey, from 0.01 to 7 mg/L, with most values below 0.5 mg/L (WHO 1998). RSWQM (2015) reported the concentration of boron as ≤1000 µg/L in Class I, II, III, and >1000 µg/L in Class IV waters. RDWQ (2019) reported the concentration of bromate as >1000 µg/L in Class A1, 1250 µg/L in Class A2, and 5000 µg/L in Class A3 waters. According to these data, Kayalıköy reservoir is suitable for drinking, agricultural irrigation, and aquaculture.

Aluminum

The maximum and the minimum aluminum values were determined as 612.883 µg/L and 6.475 µg/L in February in the winter season and in July in the summer season, respectively, and the average was determined as 139.261±163.34 µg/L (Table 2 and Figure 2). The concentration of aluminum in natural waters can significantly depend on various physicochemical factors. Dissolved aluminum concentrations in waters with near-neutral pH values usually range from 0.001 to 0.05 mg/L (WHO 1998). For ponds and dam lakes, the aluminum concentration is ≤0.3 mg/L in Class I and Class II, 0.3 mg/L in Class III, and >1 mg/L in Class IV waters (RSWQM 2015). RDWQ (2019) reported the concentrations of aluminum as is 200 µg/L in Class A1, 500 µg/L in Class A2, and 2000 µg/L in Class A3 waters. According to these results, Kayalıköy reservoir has Class II and A1 water and is suitable for drinking, agricultural irrigation, and aquaculture. While Aluminium (Al) showed positive significant relationship with DO (r=791) and Fe (r=834), it showed negative relationship with WT (r=845), Chl-*a* (r=791) and SO_4 (r=827) (p<0.01).

Iron

Iron concentrations fluctuated during the study from 0.072 to 0.401 mg/L (average 0.142±0.09 mg/L). The maximum iron concentration was recorded in February in the winter season and the minimum in September in the spring season (Table 2 and Figure 2). Iron concentrations in drinking water are normally less than 0.3 mg/L but may be higher in some countries (WHO 1998). For ponds and dam lakes, the iron concentration is ≤300 µg/L in Class I, 1000 µg/L in Class II, 5000 in Class III, and >5000 µg/L in Class IV waters (RSWQM 2015). Also, RDWQ (2019) reported the concentration of iron as 2000 µg/L in Class A1, 1000 µg/L in Class A2 and 2000 µg/L in Class A3 waters. According to these results, Kayalıköy reservoir has Class I and A1 water and is suitable for drinking, agricultural irrigation, and aquaculture. While Iron (Fe) showed positive significant relationship with Al (r=834) (p<0.01), it showed negative relationship with WT (r=724), Chl-*a* (r=620) and SO_4 (r=620) (p<0.05) (Table 3).

Strontium

Because strontium is naturally occurring throughout the earth, it shas detected in all surface waters. The maximum acceptable concentration of 7.0 mg/L is proposed for total strontium in drinking water (FPTC 2018). The US Environmental Protection Agency (EPA) recommends the concentration of strontium in drinking water as 4 mg/L (NWQMC 2016). In the present study, strontium value was detected the maximum 144.727 µg/L and the minimum 22.133 µg/L. The average concentration of strontium was determined as 89.538±42.51 µg/L in the reservoir. The maximum of the strontium concentration was recorded in October in the autumn season and the minimum in January in the winter season (Table 2 and Figure 2). According to these results, Kayalıköy reservoir is suitable for drinking, agricultural irrigation, and aquaculture. While strontium (Sr) showed positive significant relationship with Na (r=845), Mg (r=909), Ca (r=945), Mn (r=873), Zn (r=909), As (r=836), Ba (r=900), Pb (r=773) (p<0.01), K (r=664) and Cu (r=618) (p<0.05).

Vanadium

Vanadium is an element in general of volcanic origin. Italian Ministry of Health has determined for in drinking water a value which does not exceed 140 mg/L. The California Office of Environmental Health Hazard Assessment proposed a notification level of 15 µg/L in drinking water (USEPA 2008). RDWQ (2019) reported the concentration of vanadium as is 15 µg/L in Class A1, 50 µg/L in Class A2, and 150 µg/L in Class A3 waters. In the present study, vanadium values were detected the maximum 11.978 µg/L and the minimum 0.391 µg/L. The average values of vanadium were determined by 3.362±3.55 µg/L in the reservoir. The maximum of the vanadium value was recorded in July in summer season and the minimum in April in the spring season (Table 2 and Figure 2). Based on these results, Kayalıköy reservoir is suitable for drinking, agricultural irrigation, and aquaculture. The vanadium (V) showed positive significant relationship with Be (r=779), Cr (r=818), Co (r=773), Ni (r=755) (p<0.01) and Cd (r=645) (p<0.05) (Table 3).

Chromium:

The values of chromium fluctuated during the study from 0.408 to 11.465 µg/L (average 2.786±3.00 µg/L) in the reservoir. The maximum chromium values were recorded in June in the summer season and the minimum in April in the spring season. (Table 2 and Figure 2). The total chromium content of surface waters is approximately 0.5–2 µg/L and the dissolved chromium content 0.02–0.3 µg/L

(Slooff 1989). The chromium concentration varies between 0.1-117 µg/L in freshwaters (Shanker et al. 2005). For ponds and dam lakes, the total chromium content is is ≤20 µg/L in Class I, 20 µg/L in Class II, 50 µg/L in Class III, and >50 µg/L in Class IV waters (RSWQM 2015). RDWQ (2019) reported the concentration of chromium as is 50 µg/L in Class A1, 500 µg/L in Class A2, and 1000 µg/L in Class A3 waters. According to these results, Kayalıköy reservoir has water Class I and A1 and is suitable for drinking, agricultural irrigation, and aquaculture. The Chromium (Cr) showed positive significant relationship with SD (r=765), V (r=818) ($p<0.01$), WT (r=627), NO_2 (r=655) SO_4 (r=682) E (r=638), Co (r=645) and Ni (r=709) ($p<0.05$).

Manganese

The maximum manganese concentration was determined as 14.601 µg/L in November in the autumn season and the minimum as 1.659 µg/L in January in winter season with an annual average of 5.078±3.93 µg/L (Table 2 and Figure 2). Maganese which is one of the ions responsible for the hardness of water is present in natural waters with concentrations ranging from 10 to 50 mg/L. Manganese concentration in freshwater is typically 1 to 200 µg/L (Barceloux 1999). For ponds and dam lakes, the manganese concentration is ≤100 µg/L in Class I, 500 µg/L in Class II, 3000 µg/L in Class III and >3000 µg/L in Class IV waters (RSWQM 2015). RDWQ (2019) reported the concentration of manganese as 50 µg/L in Class A1, 100 µg/L in Class A2, and 250 µg/L in Class A3 waters. According to these results, Kayalıköy reservoir has Class I and A1 water and is suitable for drinking, agricultural irrigation, and aquaculture. The Manganese (Mn) showed positive significant relationship with Mg (r=755), Ca (r=945), Sr (r=873, Ni (r=736), Zn (r=800), Ba (r=882) ($p<0.01$), EC (r=655), Na (r=627), K (r=664) Cu (r=691) and Pb (r=727) ($p<0.05$) (Table 3).

Cobalt

The values of cobalt fluctuated during the study from 0.039 to 0.333 µg/L (average 0.186±0.09 µg/L) in the reservoir. The maximum values of cobalt were recorded in July in the summer season and the minimum in April in the spring season (Table 2 and Figure 2). The cobalt concentrations in drinking water are generally <1–2 µg/L (WHO 2008). RSWQM (2015) reported the concentration of cobalt as is ≤10 µg/L in Class I, 20 µg/L in Class II, 200 µg/L in Class III and >200 µg/L in Class IV waters. RDWQ (2019) reported the concentration of cobalt as is 800 µg/L in Class A1 and 2600 µg/L in Class A3 waters. In terms of the cobalt values, Kayalıköy reservoir has Class I and A1 water and is suitable for drinking, agricultural irrigation, and aquaculture. The Cobalt (Co) showed positive significant relationship with Be (r=843), V (r=773), Mo (r=740), Cd (r=882) ($p<0.01$), Cr (r=645) and As (r=691) ($p<0.05$).

Nickel

The maximum and the minimum nickel concentrations were determined as 2.485 µg/L and as 0.418 µg/L in June in summer season and the minimum in April in the spring season, respectively, with an annual average of 1.509±0.62 µg/L (Table 2 and Figure 2). RSWQM (2015) reported the concentration of nickel as ≤20 µg/L in Class I, 50 µg/L in Class II, 200 µg/L in Class III and >200 µg/L in Class IV waters. Besides, RDWQ (2019) reported the concentration of nickel as 20 µg/L in Class A1, 30 µg/L in Class A2, and 200 µg/L in Class A3 waters. According to these results, Kayalıköy reservoir has Class I and A1 water and is suitable for drinking, agricultural irrigation, and aquaculture. The Nickel (Ni) showed positive significant relationship with V (r=755), Mn (r=736) ($p<0.01$), Ca (r=636), Cr (r=709), Cu (r=655) and Ba (r=618) ($p<0.05$).

Copper

The values of copper fluctuated during the study from 0.348 to 6.796 µg/L (average 1.769±1.74 µg/L). The maximum value of copper was recorded in May in the spring season and the minimum in April in the winter season (Table 2 and Figure 2). The copper concentrations in surface waters ranged from 0.0005 to 1 mg/L in several studies in the USA (average 0.01 mg/L) (ATSDR 2002). RSWQM (2015) reported the concentration of copper as ≤20 µg/L in Class I, 50 µg/L in Class II, 200 µg/L in Class III and >200 µg/L in Class IV waters. Also, RDWQ (2019) reported the concentration of copper as 2000 µg/L in Class A1, 5000 µg/L in Class A2, and 20000 µg/L in Class A3 waters. In terms of the copper values, Kayalıköy reservoir has Class I and A1 water and is suitable for drinking, agricultural irrigation, and aquaculture.

Zinc

The concentration of zinc is usually below 10 µg/L in natural surface waters, and 10–40 µg/L in groundwaters (Elinder 1986). RSWQM (2105) reported the concentration of zinc as ≤200 µg/L in Class I, 500 µg/L in Class II, 2000 µg/L in Class III and >2000 µg/L in Class IV waters. RDWQ (2019) reported the concentration of zinc as 3000 µg/L in Class A1, 6000 µg/L in Class A2, and 12000 µg/L in Class A3 waters. In the present study, the maximum and the minimum zinc concentrations were determined as 9.145 µg/L and 0.818 µg/L in October in the autumn season and in June in the summer season, respectively, with an annual average of 3.585±2.52 µg/L. (Table 2 and Figure 2). In terms of the zinc values, Kayalıköy reservoir has Class I and

A1 water and is suitable for drinking, agricultural irrigation, and aquaculture. The Zinc (Zn) showed positive significant relationship with Mg (r=791), Ca (r=800), Sr (r=909), Mn (r=800), As (r=827), Ba (r=845) ($p<0.01$), EC (r=664), Na (r=682), Ba (r=718) and Pb (r=691) ($p<0.05$) (Table 3).

Arsenic

The maximum and the minimum arsenic concentrations were determined as 0.077 µg/L and as 1.386 µg/L in December in the spring season and in November in the autumn season, respectively, with an annual average of 0.726±0.42 µg/L. (Table 2 and Figure 2). In drinking-water supplies, arsenic poses a problem because it is toxic at low levels and is a known carcinogen. The concentration of arsenic in natural waters generally ranges between 1-2 µg/L (USNRC 1999). The current recommended limit of arsenic in drinking water is 10 µg/L (WHO 2017). RSWQM (2015) reported the concentration of arsenic as ≤20 µg/L in Class I, 50 µg/L in Class II, 100 µg/L in Class III and >100 µg/L in Class IV waters. Also, RDWQ (2019) reported the concentration of arsenic as 10 µg/L in Class A1, 40 µg/L in Class A2, and 50 µg/L in Class A3 waters. According to these results, Kayalıköy reservoir has Class I and A1 water and is suitable for drinking, agricultural irrigation, and aquaculture. The Arsenic (As) showed positive significant relationship with Mg (r=745), Ca (r=773), B (r=791), Sr (r=836), Mn (r=764), Zn (r=827) Cd (r=881), Ba (r=855), Pb (r=809) ($p<0.01$), Na (r=700) and Co (r=691) ($p<0.05$) (Table 3).

Selenium

The concentration of selenium fluctuated during the study from 19.148 to 0.270 µg/L (average 7.046±5.56 µg/L). The maximum value of selenium was recorded in November in the autumn season and the minimum in February in the winter season (Table 2 and Figure 2). The levels of selenium in groundwater and surface water range from 0.06 µg/L to about 400 µg/L. The current recommended limit of selenium in drinking water is 0.04 mg/L (40 µg/L) (WHO 2017). For ponds and dam lakes, selenium concentration is ≤10 µg/L in Class I, ≤10 µg/L in Class II, 20 µg/L in Class III and >20 µg/L in Class IV waters (RSWQM 2015). RDWQ (2019) reported the concentration of selenium as 10 µg/L in Class A1, 20 µg/L in Class A2, and 100 µg/L in Class A3 waters. According to these results, Kayalıköy reservoir has been Class I and A1 water.

Molybdenum

The concentration of molybdenum was determined by the maximum 33.543 µg/L and the minimum 0.602 µg/L. The average molybdenum concentration in the reservoir was measured as 14.071±10.85 µg/L. The maximum values of molybdenum were recorded in July in the winter season and the minimum in April in spring season (Table 2 and Figure 2). Molybdenum plays an important biological role as a micronutrient for plants and animals. At high levels, it can be toxic to animals. The current recommended limit of molybdenum in drinking water is 0.02 mg/L (20 µg/L) (WHO 2017). According to these results, Kayalıköy reservoir has clean water characteristics.

Cadmium

The maximum and the minimum cadmium concentrations were determined as 0.260 µg/L and as 0.008 µg/L in September in the autumn season and in April in spring season, respectively, with an annual average of 0.097±0.07 µg/L. (Table 2 and Figure 2). Cadmium occurs naturally in zinc, in lead and copper ores, in coal and other fossil fuels, and is released during volcanic action. The concentration of cadmium in drinking water is 0.003 mg/L (3 µg/L) (WHO 2017). RSWQM (2015) reported the concentration of cadmium as ≤2 µg/L in Class I, 5 µg/L in Class II, 7 µg/L in Class III and >7 µg/L in Class IV waters. According to these results, Kayalıköy reservoir has the characteristics of clean water and Class I water. The Cadmium (Ca) showed positive significant relationship with Co (r=882), As (r=818), Pb (r=764) ($p<0.01$), Be (r=670), B (r=709), V (r=645), Sb (r=618), Ba (r=664) and Tl (r=664) ($p<0.05$) (Table 3).

Antimony

Antimony is a metal that is present naturally in small quantities in water, rocks, and soils. In the present study, the maximum and the minimum antimony concentrations were determined as 199.900 µg/L and 0.053 µg/L in December in the winter season and in April in the spring season, respectively, with an average value of 22.191±59.28 µg/L (Table 2 and Figure 2). Concentrations of antimony in groundwater and surface water normally range from 0.1 to 0.2 µg/L (Bowen 1979) and were 0.02 mg/L (20 µg/L) in drinking water (WHO 2017). RDWQ (2019) reported the concentration of antimony as is 5 µg/L in Class A1, 15 µg/L in Class A2, and 50 µg/L in Class A3 waters. According to these results, Kayalıköy reservoir has Class A1 water and is suitable for drinking, agricultural irrigation, and aquaculture.

Barium

Barium is not considered to be an essential element for human nutrition. Barium is a divalent cation and alkaline earth metal that can be found in naturally occurring mineral deposits. In the present study, the maximum and the minimum barium concentrations were determined as 5.486 µg/L and as

42.963 in April in the winter season and in October in the autumn season, respectively, with an annual average of 23.482±11.91 µg/L (Table 2 and Figure 2). Concentrations in drinking water of barium are generally below 100 µg/L, although the acceptable value is 1.3 mg/L (1300 µg/L) in drinking water (WHO 2019). RSWQM (2015) reported the concentration of barium as ≤1000 µg/L in Class I, 2000 µg/L in Class II and III, and >2000 µg/L in Class IV waters. Also, RDWQ (2019) reported the concentration of barium is 2000 µg/L in Class A1 and 20000 µg/L in Class A3 waters. According to these results, Kayalıköy reservoir has Class I and A1 water and is suitable for drinking, agricultural irrigation, and aquaculture. The Barium (Ba) showed positive significant relationship with Ca (r=855), Sr (r=900), Mn (r=882), Zn (r=845), As (r=655), Pb (r= 909) ($p<0.01$), Na (r=636), Mg (r=700), B (r=691), Cu (r=718) and Cd (r=664) ($p<0.05$) (Table 3).

Thallium

Thallium is released into the biosphere from both natural and anthropogenic sources. Thallium is considered toxic for human and animal organisms, microorganisms, and plants. In the present study, the thallium concentrations were detected the maximum 0.260 µg/L and the minimum 0.012 µg/L. The average values of thallium were determined 0.119±0.08 µg/L in the reservoir. The maximum concentration of thallium was recorded in September in the autumn season and the minimum in April in winter season (Table 2 and Figure 2). The concentration of antimony in drinking water is 2 µg/L (USEPA 2008). According to these results, Kayalıköy reservoir has the characteristics of clean water.

Lead

Lead is a naturally occurring metal found in rock, soil, water, and sediment. In the present study, maximum and the minimum lead concentrations were determined as 2.790 µg/L and 0.122 µg/L in September in the autumn season and in April in the spring season with an average value of 0.873±0.73 µg/L (Table 2 and Figure 2). The concentration of lead in drinking water is 2 mg/L (200 µg/L) (WHO 2017). RSWQM (2015) reported the concentration of lead as ≤10 µg/L in Class I, 20 µg/L in Class II, 50 µg/L in Class III and III, >50µg/L in Class IV waters. RDWQ (2019) reported the concentration of lead as 10 µg/L in Class A1, 50 µg/L in Class A2, and 100 µg/L in Class A3 waters. According to these results, the reservoir shows Class I and A1 water characteristics in terms of lead and is suitable for drinking, agricultural irrigation, and aquaculture.

As a result, water samples taken from three stations determined in Kayalıköy reservoir for one year were examined in terms of some physicochemical parameters and heavy metal concentrations. The results were compared with RSWQM (National Standart for Turkish inland water Regulation on Modification of Surface Water Quality Management) and RDWQ (Regulation on the Quality and Treatment of Water Provided for Drinking Water). The water quality properties were assessed, the suitability levels in terms of aquatic life, agricultural irrigation, and aquaculture and drinking water were determined.

The Nitrite nitrogen was determined above the limit values in May, June, and July in the summer season. Also, phosphate in May, chlorine in October, aluminum in February, chromium in June, and selenium in November were determined above the limit values. However, the increase in these values in short periods can be attributed to excessive water withdrawal in the reservoir. The trophic status of Kayalıköy reservoir was classified as eutrophic according to Secchi disc depth and as mesotrophic according to Chlorophyll-a. It can be classified as oligotrophic character according to other parameters. As can be seen in the average values of the analysis results, the water quality in Kayalıköy reservoir is generally considered to be Class I and A1 water according to RSWQM and RDWQ. In short, Kayalıköy reservoir has water suitable for drinking, agricultural irrigation, and aquaculture and was classified as having oligomesotrophic character.

No such a long term and more detailed study have been carried out in the dam lakes in the Thrace region where the Kayalıköy dam is located. However, along with planktonic organisms in Süloğlu and Kadıköy dam lakes, some physicochemical properties of water have also been studied (Güher and Çolak 2015; Tokatlı et al. 2017; Güher 2019). As a result of these studies, it was reported that the water of Süloğlu reservoir is in Class I and II and of oligo-mesotrofic character in most parameters, and that of Kadıköy reservoir is in Class II and of meso-eutrophic character. Also, some physicochemical parameters of water in Kayalıköy reservoir were studied only for two months (November and April) (Kanarya 2013). The results obtained in these studies are in parallel with our results. However, constant monitoring activities should be performed in reservoirs in general.

The fact that no factors are affecting (industry, residential areas, agricultural areas etc.) the lake around Kayalıköy dam lake is a big advantage. Changes in the water level in the reservoir brought on by changes in the evaporation and precipitation amounts depending on seasonal conditions as well as the purpose and amount of water usage are one of the most important factors in the change of physicochemical parameters. Therefore, excessive water outflow in the lake for drinking water and agricultural irrigation are affecting the physicochemical properties of lake water. To protect the water quality of the lake water should be controlled by the absolute output of the lake. To maintain the water quality of the lake, the water outlets in the lake must be controlled.

To protect water quality and to ensure the continuation of aquatic life in this reservoir, it is necessary to make regular observations and to monitor the environmental parameters affecting water quality and aquatic life. Also, the results obtained from this study can be considered as a reference which can be used to evaluate possible future changes in the reservoir and will provide a good reference for setting standards for water quality.

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