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RESEARCH ARTICLE

Investigation of Beyler Dam Lake water quality in terms of some physical and chemical parameters.

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ABSTRACT

This study was carried out for a period of 12 months from September 2016 to August 2017 at 4 stations determined in Beyler Dam Lake in Kastamonu, Turkey. In this study, some parameters such as temperature, pH, conductivity, dissolved oxygen, ammonium, nitrate, nitrite, phosphate, chemical oxygen demand (COD), biological oxygen demand (BOD) were investigated. Temperature, pH, conductivity, turbidity and the amount of dissolved oxygen of the water samples were measured by multi parameter measurement device in the field during sampling. Chemical parameters such as ammonium, nitrate, nitrite, phosphate, BOD and COD were determined by spectrophotometric methods in laboratory conditions. Study indicates such results as; the temperature was between 0.70 and 23.50 ºC and the mean temperature was 11°C, pH was between 7.46 and 9.50 and average pH was 8.34, amount of dissolved oxygen varied from 7.48 to 12.16 mg/l and the average dissolved oxygen amount was 9.73 mg/l, conductivity was between 102.50 and 240 µS cm^{-1} and the average conductivity was 157.68 µS cm^{-1}, turbidity changed from 1.23 to 5.57 FNU/NTU and the average turbidity was 3.0 FNU/NTU, nitrate varied from 0.003 to 1.0 mg/l and the average nitrate was 0.35 mg/l, nitrite was between 0.001 and 0.007 mg/l and the average nitrite was 0.003 mg/l, ammonium changed from 0.009 and 0.130 mg/l and the average ammonium was 0.052 mg/l, phosphate was between 0.24 and 5.21 mg/l and the average phosphate was 2.541 mg/l, COD which is an important water quality parameters, was detected as the lowest 0.04 mg/l and the highest 28.1 mg/l and the average was found 9.45 mg/l, BOD was detected between 2.50 and 6.0 mg/l and the average BOD was calculated 4.17 mg/l. The results of the study revealed that there is no significant difference between the measured parameters according to the Surface Water Quality Regulation (SWQR) in Turkey. Although Beyler Dam Lake was evaluated as Class I for most parameter values, in total it can be classified as Class II according to water quality classification.

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Introduction

Currently, environmental problems are the most important threats to the ecological balance. Environmental pollution emerged for the first time with the beginning of urban life and increased in line with industrial development. In particular, in the second half of the 20th century, the environmental pollution increased because of the accelerated growth rate of population, causing more pollution of living resources. Consequently, ecosystem degradation has become a considerably serious issue. As a matter of fact, when water

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environment, which is a part of the ecosystem, is used as a receiver and remover for used water and other wastes, it becomes the most intensively contaminated part of the ecosystem compared to air and soil. These polluting elements disrupt the natural balance and can be classified as follows: organic wastes, industrial wastes, petroleum derivatives, artificial agricultural fertilizers, detergents, radioactive materials, pesticides, inorganic salts, artificial organic chemicals, and waste heat. According to this classification, heavy metals fall under industrial wastes and some pesticides and they reach a level that can threaten the ecological balance (Kaya et al., 1998; Yarsan et al., 2000).

Different factors contribute to pollution, and the levels of quality parameters vary according to the areas in which they are used. Based on their sources, contaminants can exhibit a physical, chemical, or biological character. In this context, many parameters, including temperature, pH, oxygen level, electrical conductivity (EC), turbidity, nitrate content, nitrite content, phosphate content, biological oxygen demand (BOD), and chemical oxygen demand (COD) can be considered as the basic criteria for determining the water quality and pollution level, particularly in surface waters. These criteria are considerably important in terms of the lifecycle of the biodiversity of a water resource and are directly related to human health due to their use as drinking and irrigation water. An increase in the number of pollution elements and their dynamic structure in accordance with the changes in the characteristics of these elements require repetition of studies on ecosystems at periodic intervals. The determination of water quality parameters of water resources is important as they serve as a guide for the decision-making mechanisms and effective water management.

In line with the above aspects, some physicochemical water quality parameters of the Beyler Dam Lake, which is located within the boundaries of Devrekâni District in Kastamonu Province with a significant biodiversity, were monitored for a year and an attempt was made to determine the pollution level and the physicochemical quality of the dam lake.

Material and Methods

Beyler Dam Lake supplies irrigation water to the area of 5137 ha field for agricultural usage (Ugış et al., 2016). Therefore, it is an important water resource for the agricultural activities and production. In this study, sampling stations were chosen to demonstrate whole characteristics of the lake and samples were collected from 4 stations that illustrated in Figure 1. The physical structure of the dam lake, the area where it is fed, and the places where fishery facilities are located were considered while determining the location of the stations.

To investigate the physicochemical properties of the content of the lake water, water samples were collected for 12 months and stored in dark polyethylene bottles. First, the pre-washed bottles were rinsed with distilled water. Then, the closed bottles were immersed in the lake at a depth of 1m and opened and closed again to expel the surface.

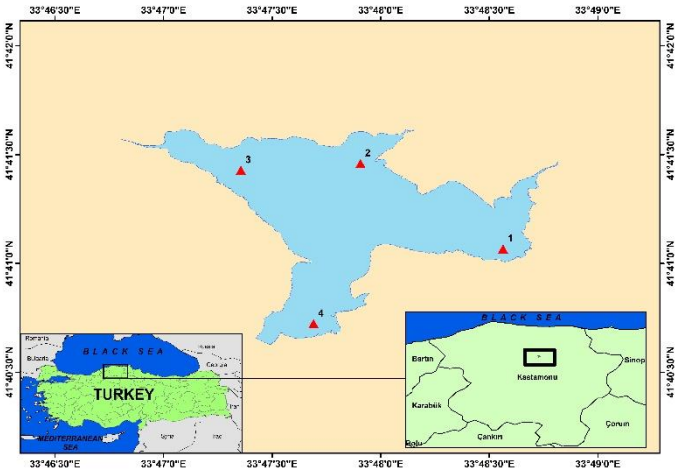

Figure 1. The location of sampling stations

Table 1. Quality classes of the intra-continental surface water sources according to the surface water quality regulation.

Water Quality Parameters	Water Quality Classes			
	I	II	III	IV
Temperature (°C)	≤ 25	≤ 25	≤ 30	> 30
pH	6-9	6-9	6-9	6-9
Conductivity (µS/cm)	< 400	1000	3000	> 3000
Dissolved oxygen (mg O_2/L)	> 8	6	3	< 3
Chemical oxygen demand (COD) (mg/L)	< 25	50	70	> 70
Biological oxygen demand (BOD) (mg/L)	< 4	8	20	> 20
Ammonium nitrogen (mg NH_4^+-N/L)	< 0.2	1	2	> 2
Nitrite nitrogen (mg NO_2--N/L)	< 0.01	0.06	0.12	> 0.3
Nitrate nitrogen (mg NO_3--N/L)	< 3	10	20	> 20
Total phosphorus (mg P/L)	< 0.03	0.03-0.16	0.16-0.65	> 0.65

The parameters temperature, dissolved oxygen, pH level, and EC were recorded with the Hach Lange brand HQ40D model digital multicenter simultaneously with water sampling. Turbidity was also recorded momentarily with the WTW brand Turb® 430 turbidity meter during the collection of water samples. The parameters nitrate content, nitrite content, phosphate content, ammonium content, BOD, and COD were determined using a spectrophotometric method, and the same samples were analyzed at the same day using the Hach Lange UV-VIS spectrophotometer and Hach Lange LT200 the thermo reactors.

Water quality classes and interpretation of the measured water parameters were revised in 2012 based on the "Quality Criteria According to Classes in terms of General Chemical and Physico-chemical Parameters of Intra-continental Surface Water Resources" specified in the "Surface Water Quality Regulation" published in the official gazette in Turkey

(Anonymous, 2015; 2016).

Results and Discussion

Water temperature is one of the most important physical properties of the water ecosystems. It depends on the sun to a large extent as is the case for the pieces of land. Therefore, it changes according to the seasons, various hours of the day, air temperature, precipitation, its geographical position, and water depth. The water temperature directly and indirectly affects the water biology. Furthermore, water temperature is a decisive factor in terms of the water quality parameters because it indirectly affects some other water quality parameters (Sönmez et al., 2008).

In the study, the data for the water temperature is consistent with the data reported in the literature; however, it shows a variation over time, possibly because of the continuous fluctuations of the lake water in certain seasons, the lack of depth, the amount of precipitation, and the climatic conditions of the region. The overall average temperature was determined as 12.72°C, and the water quality of the dam lake was evaluated as Class I according to the Surface Water Quality Regulation. The changes in the temperature values are shown in Figure 2.

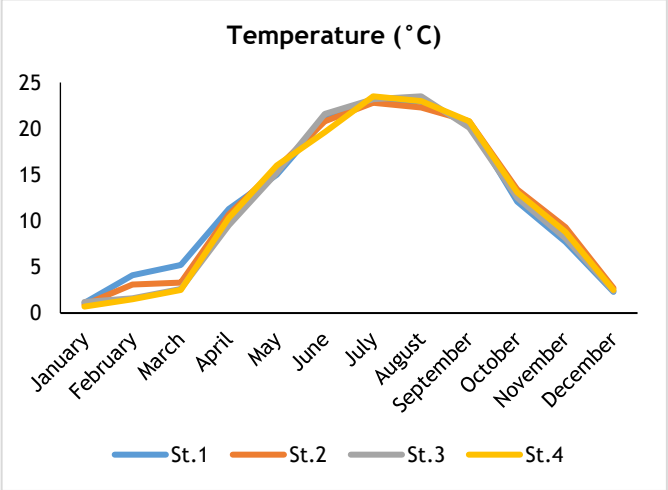

Figure 2. Monthly variation of temperature

The pH level is a measure of the acidity and alkalinity of a solution. It usually corresponds to the concentration of hydrogen ions and greatly affects the aquatic flora and fauna. The pH level in the range 6-8.5 usually constitutes the ideal living environment for many aquatic plants and animals. In particular, in the lakes, the value of the pH level affects the ratio of ammonium-ammonium dioxide. For this reason, the pH level is a considerably important water quality parameter. There is an increase in the pH level in the summer months. The value of the pH level largely depends on the amount of carbon dioxide in water and is inversely proportional to it. When the amount of carbon dioxide decreases, the pH level increases, whereas when the amount of carbon dioxide increases, the pH level decreases. Therefore, in summer, carbon dioxide is less soluble in water; thus, the pH level is higher. However, it is lower in winter (Sönmez et al., 2008). In terms of the pH level, the dam lake was rated as Class I according to the Surface Water Quality Regulation. The monthly changes in the pH level at each station are shown in Figure 3.

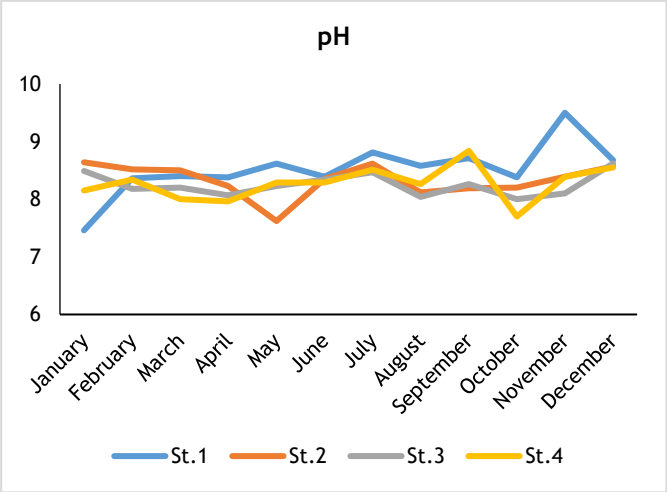

Figure 3. Monthly changes of the pH level

Dissolved oxygen is one of the most important parameters in the water quality assessment and reflects common biological and physical processes in the water. It is an important element for the life of water and the physical environment characteristics (Egemen, 2006). Additionally, it is of great importance to all living organisms and is regarded as the only parameter that can reveal the ecology of the whole water body. Eutrophic water bodies have a large dissolved oxygen range, while oligotrophic water bodies have a narrow dissolved oxygen range (Rucinski et al., 2010).

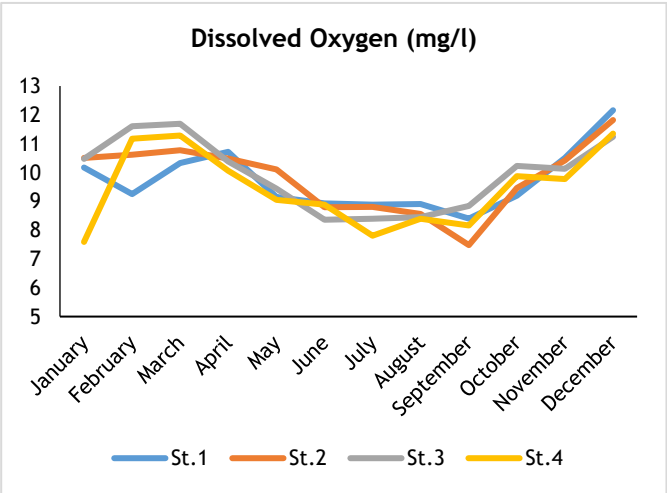

Figure 4. Monthly changes of dissolved oxygen (mg/l)

Ultimately, determining the level of dissolved oxygen is important in the quality assessment of all water resources. The lowest temperature value at the Beyler Dam, which was examined in terms of the dissolved oxygen level, was measured at the first station in September (7.48 mg/l), while the highest level of oxygen was detected in January (12.16 mg/l). In terms of the oxygen level, the dam lake water was evaluated as Class I. The results related to dissolved oxygen were consistent with those of research conducted by (Verep et al., 2002, 2005; Tepe, 2009; Taş et al., 2010; Ates et al.

2016). Temporal distribution of dissolved oxygen is shown in Figure 4.

The main nitrogen compounds found in water according to the decreasing oxidation level were nitrate nitrogen (NO_3-N), nitrite nitrogen (NO_2-N), ammonia nitrogen (NH_3-N), and organic nitrogen (Org-N). The water quality can be determined by measuring these nitrogenous compounds. Nitrite is the intermediate product of the nitrogen cycle, does not accumulate in the environment, and quickly converts into nitrate. Nitrite also contributes to the development of plankton, such as nitrate. Taş (2011) and Nisbet and Verneaux (1970) reported that water pollution begins when the amount of nitrite in water exceeds 1 mg/l. Nitrogen compounds are important for determining the pollution level of water. In our study, the ammonium, nitrate, and nitrite content averages were determined as 0.051, 0.43, and 0.01 mg/l, respectively. Although there was an increase in some seasons within the year, in general terms, the parameter values were observed to be well below the reference values. In terms of all three parameters, the dam lake water was ranked as Class I. The monthly changes in the amounts of nitrate, nitrite, and ammonium at each station are shown in Figure 5.

The amount of phosphate in the dam reservoir varied between 0.235 and 5.21 mg/l, and the average was determined to be 2.31 mg/l. Phosphorus is the most basic element in eutrophication that occurs in the water environment (Harper, 1992). It has been reported that in most lakes, the average total phosphor content varies between 0.010 and 0.030 mg/l. Tanyolaç (2004) and Nisbet and Verneaux (1970) suggested that when phosphate content is 0.115–0.30 mg/l in water, productivity is high, but when this value is higher than 0.30 mg/l, water is considered to have polluted. According to (Thomann and Mueller, 1987), the lake is oligotrophic when the total amount of phosphorus is less than 10 µg/l, mesotrophic when this amount is 10–20 µg/l, and eutrophic when this amount is greater than 20 µg/l. The amount of phosphate obtained in the study was above the limits specified in the Surface Waters Quality Regulation; therefore, the lake water has Class IV water quality. Monthly changes of phosphate content are shown in Figure 6.

The turbidity data obtained in this study varied between 1.23 and 15.5 NTU. In a study conducted by (Ates et al., 2016) at the Germeçtepe Dam, turbidity varied between 0.74 and 8.17 NTU. In a similar study conducted by (Alp et al. 2010) at the lakes of the Atatürk Dam, Birecik Dam, Karkamış Dam, and Hacı Hıdır Dam located in the Southeastern Anatolian Region, turbidity varied between 5 and 20 NTU. They also reported that there was a high correlation between turbidity–TSS levels and sodium, potassium, and sulfate levels in particular, which tend to increase in seasons when the precipitation increases. In a study conducted by (Bayram and Kenanoglu, 2016) at the Borçka Dam, turbidity was reported to be 46 NTU. Our data are consistent with those reported in the literature and below the results reported in the literature in general. The increases in the transition seasons were evaluated as the addition of materials into the water through the rainfall. Although no category related to turbidity is

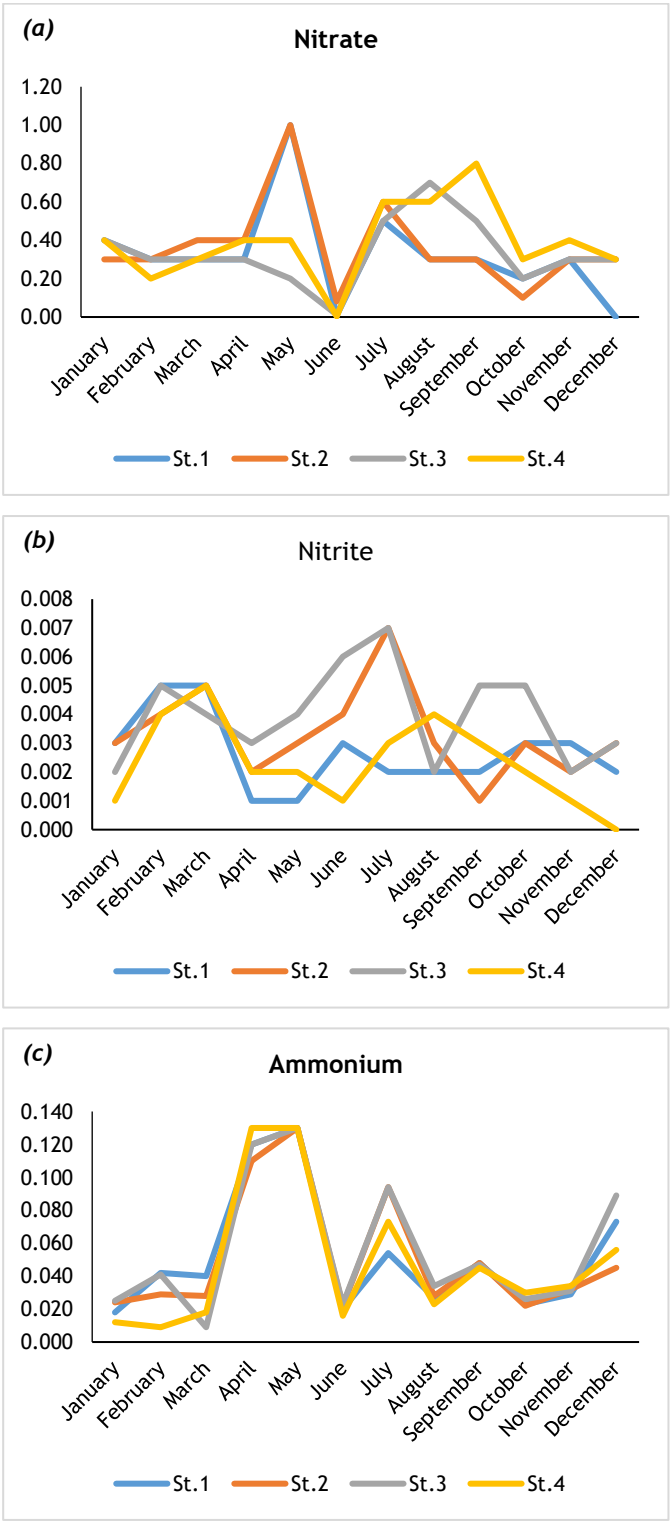

Figure 5. Monthly changes of the nitrate (***a***), nitrite (***b***), and ammonium (***c***) contents (mg/l)

mentioned in the Surface Waters Quality Regulation, it was found to be within the tolerable limits according to the WHO (2008) classification and high according to the US Environmental Protection Agency classification and the European Union (Anonymous, 1998) classification. The monthly changes in turbidity at each station are shown in Figure 7.

Based on our study data, we determined that the general electrical conductivity of the water in the Beyler Dam Lake

was between 102.50-240 µScm^{-1} and the water quality of this lake was evaluated as Class I according to the Surface Waters Quality Regulation. It was reported that the minimum and maximum EC values for the Ataturk Dam, Birecik Dam, Karkamış Dam, and Hacı Hıdır Dam were determined as 295-4345 µScm^{-1}, 314-447 µScm^{-1}, 310-479 µScm^{-1}, and 254-400 µScm^{-1}, respectively (Alp et al., 2010). The EC values measured for the Caspian Lake had a general average value of 2260 µm Hos/cm, and the water quality of this lake was evaluated as Class IV, indicating that the water of this lake was not suitable for irrigation (Ünlü et al., 2008). The conductivity in Eğrigöl was reported to vary between 210 and 291 µScm^{-1} and exhibited a homogeneous distribution in the lake (Başaran-Kaymakçı and Egemen, 2006). It was observed that the results of our study were below the general results reported in the literature. Temporal distribution of conductivity is shown in Figure 8.

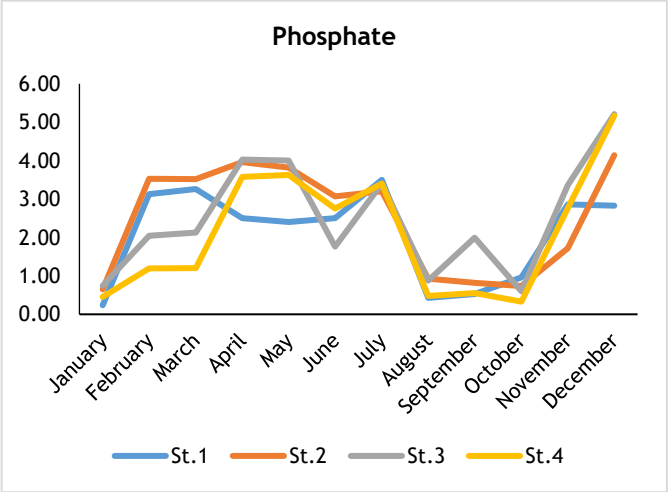

Figure 6. Monthly changes of phosphate content (mg/l)

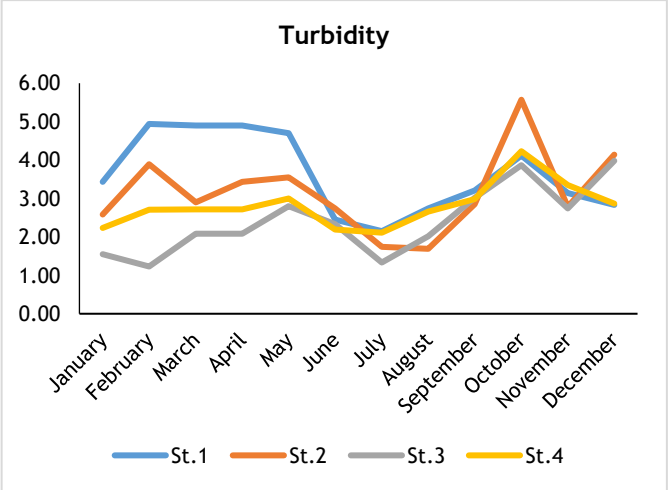

Figure 7. Monthly changes of turbidity (FNU/NTU)

The minimum and maximum COD values for the Beyler Dam were 0.1 and 28.1 mg/l, respectively. The dam reservoir water was evaluated as Class I in terms of the COD value, with an average value of 9.45 mg/l. In another study conducted to determine the water quality of the Uluabat Lake, the COD level value was found to be 49.33 mg/l in the summer, 56 mg/l in spring, 37.33 mg/l in winter, and 53.13 mg/l in autumn (İleri et al., 2014). In a study conducted at the Uluabat Lake, the annual average of the COD value was reported to be 35.74 mg/l (Elmacı et al., 2010). In various other studies, the COD value was reported as 16.32 and 20.23 mg/l for the Görentaş Lake (Tepe et al., 2004), 7.80-42.19 mg/l for the Karagöl Lake (Mutlu et al., 2013), and 18-41 mg/l for the Reyhanlı Lake (Tepe, 2009). The data obtained in this study are consistent with those reported in the literature. The COD, which tended to increase in summer, exhibited a stable course in other months. COD is an important parameter that exhibits the extent of organic pollution in water. Due to an increase in the microbial activity in spring and summer, the rate of degeneration of organic substances increases, thereby increasing the COD value (İleri et al., 2014). The COD data are shown in Figure 9.

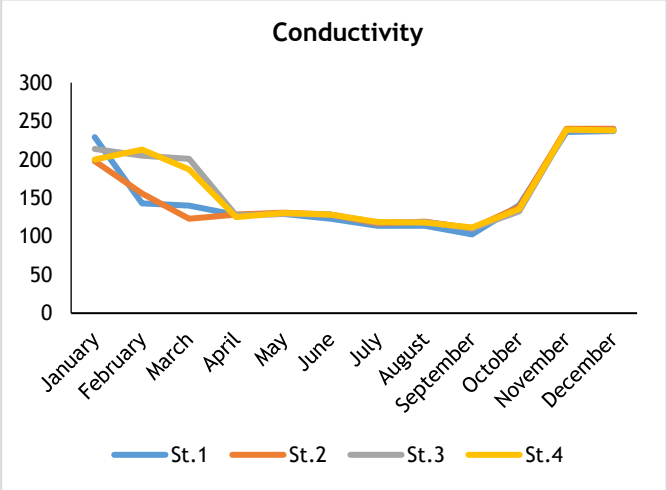

Figure 8. Monthly changes of conductivity (µS cm^{-1})

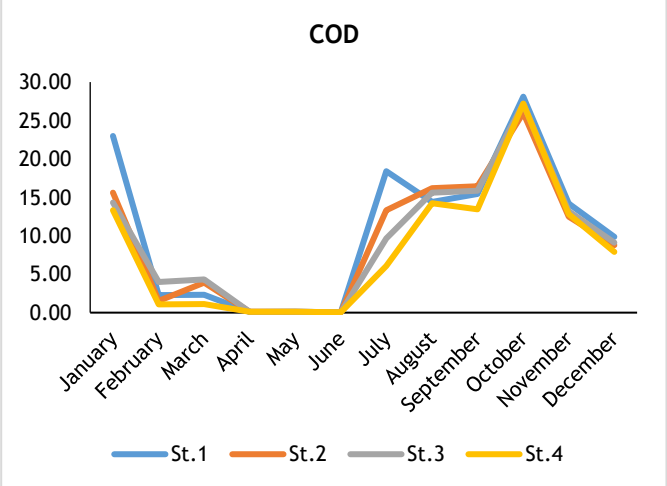

Figure 9. Monthly changes of chemical oxygen demand (mg/l)

BOD is an important parameter and is considered as a general measure of the organic pollution effect in the receiving waters. According to our BOD measurements results, the BOD value for the Beyler Dam varied between 2.50 and 6 mg/l. The dam reservoir water was evaluated as Class I in terms of BOD, with an average value of 4.17 mg/l. In a study conducted to determine the water quality of the Caspian Lake, the BOD value was reported to be 8.9 mg/l

(Ünlü et al., 2008). In another study conducted at the Germeçtepe Dam, the average BOD value was reported to be 21.26 mg/l (Ates et al., 2016). In the studies conducted at the Atatürk Dam, Birecik Dam, Karkamış Dam, and Hacı Hıdır Dam to determine their water quality, the BOD values varied in the ranges of 1–2.4 mg/l, 0.6–1.8 mg/l, 1.1–2.7 mg/l, and 2.3–6.8 mg/l, respectively (Alp et al., 2010). The data obtained in this study were consistent with those reported in the literature, and it was interpreted that there was no organic pollution load at a level that could cause pollution. The monthly changes in BOD at each station are shown in Figure 10.

Figure 10. Monthly changes of biological oxygen demand (mg/l)

Conclusion

Our study was conducted at the Beyler Dam Lake, the lake water of which was found to belong to the Class I water quality for the most parameters. But on the whole, it can be classified as Class II due to exception of phosphate content parameter, for which the lake water was evaluated as Class IV according to SWQR in Turkey. Phosphorus consistence in natural waters depends on morphometry of the basin, chemical context of the region's geological structure, organic matter that enters into the water, domestic flow (especially if it is detergent) and organic metabolism in the water (Taş, 2011). Since there is not any industrial activity around the lake, the source of phosphorus surplus may be domestic wastes or agricultural activities.

When the overall water quality of the dam lake was assessed, there usually was no difference between the stations. This was attributed to the fact that the area of the lake was small and the distance between the stations was less. The occurrence of seasonal parameter variations from time to time was explained by the fact that the lake volume is small and there is no strong source to feed the lake.

Nevertheless, analyzing the overall water quality of the lake, we found that the lake is not under intense pollution pressure and that it remains considerably virgin. This virginity is primarily attributed to the fact that the lake has an almost closed structure, so the weak water supply does not result in much pollution. In contrast, there are no settlements in the vicinity of the dam lake and the amount of agricultural land is limited. It is also close to other pollutants due to road conditions. The lake water was considered to be a convenient environment for the biological life it hosts.

Acknowledgement

This study has been summarized from Khalifa Moftah Abdelali's PhD thesis study at Kastamonu University Institute of Natural and Applied Sciences Aquaculture Department.

Conflict of Interest

The authors declare that there is no conflict of interest.

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