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RESEARCH ARTICLE

Heavy Metal Levels in the Beyler Dam Lake, Kastamonu (Turkey)

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ABSTRACT

In this study, some heavy metal concentrations (Cu, Cd, Pb, Cr, Mn and Zn) were seasonally determined in water to evaluate of the quality of the Beyler Dam Lake. The average concentrations of heavy metals analyzed in water samples for cold and hot season were Cu: 11.53, 13.23; Cd: 0.85, 0.97; Pb: 13.77, 16.26; Cr: 2.88, 3.48; Mn: 1.94, 1.71; and Zn: 7.57, 8.20 ppb, respectively. The annual average (AA) concentrations of heavy metals were Cu: 12.38; Cd: 0.91, Pb: 15.01, Cr: 3.18; Mn: 1.82; and Zn: 7.88 ppb. In general, the heavy metal concentrations were found to be higher in hot season than the cold season. It was observed that none of the heavy metals assessed exceeded the limits specified in the Turkish Water Pollution Control Regulation. The Beyler Dam Lake was classified as Class I for all the heavy metals except Pb for which it was classified as Class II. These results indicate that the lake is not polluted by the heavy metals. However, relatively high Pb levels seek further research to identify the source. The lake water can be used for agricultural activities but should continue to be monitored.

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Introduction

Water is arguably the most important compound on earth. It is an essential resource for all organic life. Lakes and surface water reservoirs are the most important water resources on earth, as they are used for many purposes such as drinking and irrigation and provide ecosystems for aquatic life, especially fish farming, and thus provide a good source of protein. It also has important social and economic benefits as a result of tourism and recreation, and is culturally and aesthetically important to people all over the world (Dirican, 2015; Arain et al., 2008). Studying some physical and chemical parameters and estimating heavy metals are very necessary and important for water quality testing, before using it for any purpose (Elmacı et al., 2010). Water quality analysis is also important for protecting the natural ecosystem (Karim & Panda, 2014; Patil et al., 2012).

The toxicity of heavy metals depends on the type of metal, the amount of material in which it is deposited and the time. The temperature is also directly proportional to the toxicity of some heavy metals (Terzi & Verep, 2012). The water quality of rivers and lakes varies with the change of seasons and the existing aquatic life (Suski et al., 2006). There are basic scientific standards and information on water quality assessment and environmentally relevant toxicants' threshold values to protect the physical and chemical factors that have an impact on the aquatic environment such as temperature, precipitation, pH and heavy metal contaminants. The quality of rivers and lakes changes with seasons and biota (Suski et al., 2006; Lawson, 2011). The presence of minerals in aquatic ecosystems is mainly influenced by direct or indirect human activities. The pH affects the quality of the water body through the concentration of many minerals by changing their availability and toxicity, so the adverse environmental effects of cadmium (Cd), for example, increases at low pH. Temperature and pH are two important factors that control the methylation of elements such as lead (Lawson, 2011).

The selection of the tested parameters depends on the purpose of using that water and the extent to which we need its quality and purity. (Hisseien et al., 2015). Heavy metals, especially those which are toxic even at low concentrations, play a crucial role in the aquatic environment (Elmaci et al., 2007). According to the water quality guidelines directive (2008/105/EC) of the EPC (2008), Cd and Pb are on the list of

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priority, while Cu and Cr on the list of other specific dangerous substances. Therefore, their content should be known for the evaluation of the ecological and overall status of a particular water body. Metals are omnipresent in the aquatic ecosystems in trace amounts and their natural concentration depends on the type of rocks and soil in the respective basin (Evenset et al., 2007). However, various anthropogenic activities could considerably increase their level. It is important to assess the heavy metal levels of a water body to understand whether the water of it can be used for any purpose. Therefore, in the present study, it was aimed to determine the heavy levels in the water of the Beyler Dam Lake.

Materials and Methods

Study Area

Beyler Dam Lake in the district Devrekani of Kastamonu (Turkey) is a dam that was built for irrigation between 1987-1994 on İncesu river. Water samples were taken from four locations determined on the lake as shown in Figure 1.

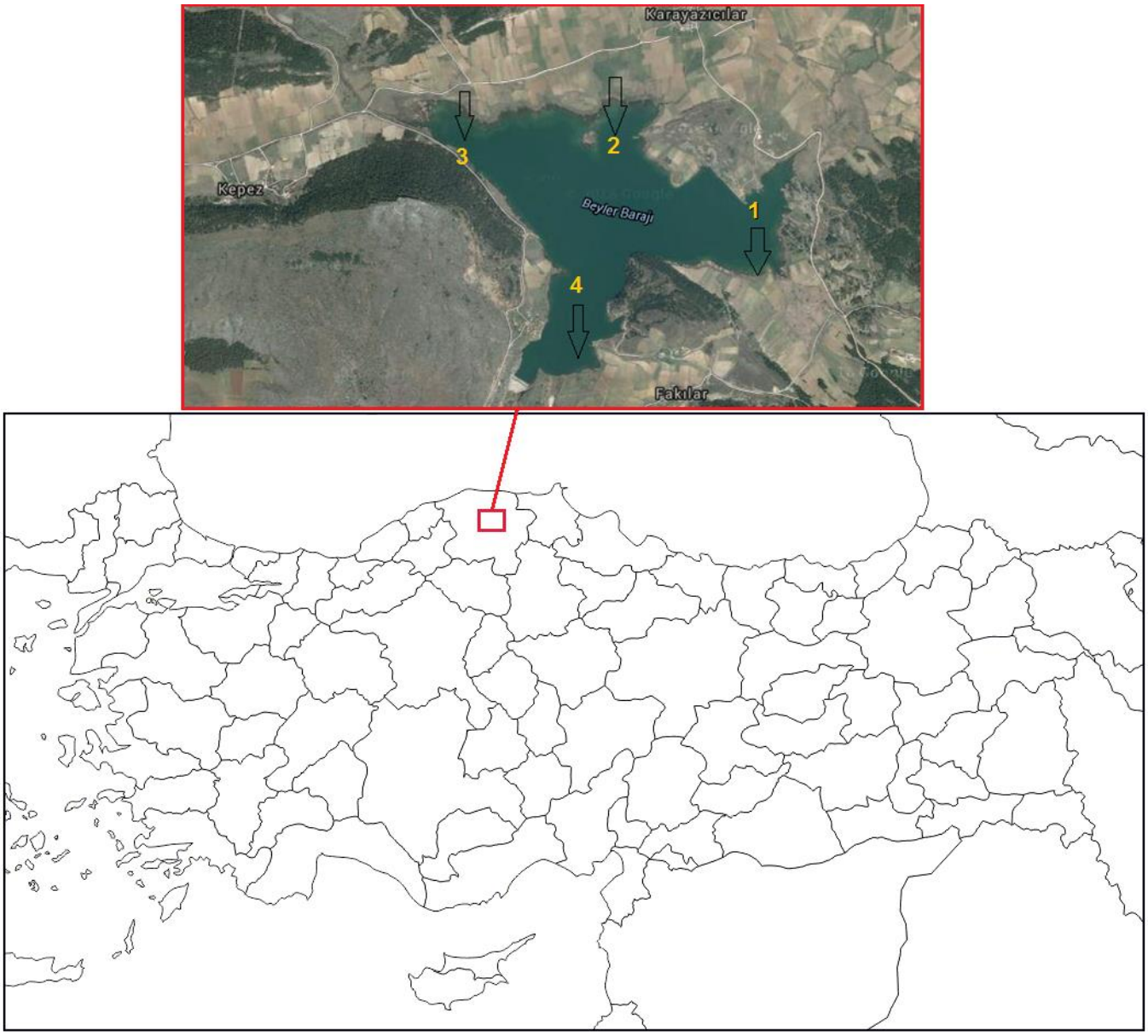

Figure 1. Sampling locations on the Beyler Dam Lake (41°41'06"N, 33°47'48"E).

Sampling and Determination of Heavy Metal Levels

Samplings were carried out in December 2016, January and February 2017 for cold season, and in July, August and September 2017 for hot season. The water samples were taken with sterile glass containers by submerging the enclosed container to 0.1 m below the surface and uncapping under the water. The containers were pre-treated with HNO_3 and rinsed with the ambient water 3 times before taking the samples (Alam et al., 2001; Sönmez et al., 2012). After taking the samples, 1 ml of NHO_3 was immediately added at the collection site to acidify the sample. The samples were transported to the laboratory in maximum two hours and filtered through 0.45 µm membran filters (Sönmez et al., 2013). The heavy metal

concentrations (Cu, Cd, Pb, Cr, Mn and Zn) were assessed using ICP/OES (SpectroBlue, Spectro) at the Central Laboratory of Kastamonu University on the sampling day. The mean values for the data obtained were computed using descriptive statistics in SPSS version 25.0 for Windows (IBM).

Results and Discussion

The Lakes are one of the most important freshwater resources and also, they are very important natural areas with many features such as natural beauties, biological diversity, fishing, tourism and recreation. However, technological developments, rapid population growth, industrial and agricultural pollutants are major constraints on the water quality of the lakes. The most common ecological problem is human activity induced pollution worldwide and lakes' pollution caused by neighboring agricultural activities which eventually leads to worsening of water quality and significant reduction in biodiversity (Kristensen & Hansen 1994; Dodson et al., 2000). A large part of surface water resources are the areas where industrial, agricultural and domestic wastes are discharged in developing countries and they are sources used in drinking, irrigation and aquaculture. Therefore, it is important to know the physical, chemical and biological properties of these waters and these should be monitored periodically (Yılmaz Öztürk & Akköz, 2014).

The heavy metal concentrations assessed in the present study are as shown in Table 1.

Table 1. Heavy metals levels in the water of the Beyler Dam Lake (ppb)

		Cu	Cd	Pb	Cr	Mn	Zn
Cold Season	**Mean±SE**	11.53±1.15	0.85±0.13	13.77±1.37	2.88±0.87	1.94±0.48	7.57±1.17
	Min-Max	9.62-13.40	0.65-1.31	13.71-16.06	2.54-3.16	1.84-2.00	4.67-8.62
Hot Season	**Mean±SE**	13.23±1.32	0.97±0.32	16.26±1.62	3.48±0.48	1.71±0.37	8.20±1.21
	Min-Max	11.35-16.01	0.83-2.67	15.64-24.17	3.05-4.00	1.17-1.99	7.72-8.71
AA		12.38	0.91	15.01	3.18	1.82	7.88

Water Pollution Control Regulation (WPCR, 2004)

	Cu	Cd	Pb	Cr	Mn	Zn
Class I	20	3	10	20	100	200
Class II	50	5	20	50	500	500
Class III	200	10	50	200	3000	2000
Class IV	>200	>10	>50	>200	>3000	>2000

AA: Annual average, SE: Standard error.

In the present study, the annual average (AA) value of copper (Cu) was found to be 12.38 ppb. The lake was classified as Class I according to the WPCR (2004). In a similar study, Kayrak and Ozan (2018) found that the average Cu concentration in the Kovada Lake water was 0.54 ppb. On the other hand, Nergiz and Şamat (2019) observed that the Cu concentration in the Hazar Lake water was 8.1 ppb and in the Kara Lake, the Cu was below the detection limit (Keser et al., 2020). These results show that the Cu concentration in the Beyler Dam Lake is higher than the other lakes reported in the literature but still within the permissible limits.

The AA of the cadmium (Cd) in the Beyler Dam Lake was found to be 0.91 ppb. According to the WPCR (2004), the lake was classified as Class I in terms of cadmium. Various levels of Cd have been reported from different lakes. In the Kovada Lake, the average Cd concentration was 0.19 ppb (Kayrak & Ozan, 2018). It was reported to be below the detection limit in the Kara Lake (Keser et al., 2020) and 9.1 ppb in the Hazar Lake (Nergiz & Şamat, 2019).

The AA of the lead (Pb) in the present study was 15.01 ppb. While it was reported to be below the detection limit in the Kovada Lake (Kayrak & Ozan, 2018) and Kara Lake (Keser et al., 2020), Nergiz and Şamat (2019) documented that the average concentration of the Pb was 4.6 ppb in the Hazar Lake. The average Pb value determined in the present study is higher compared to the literature data and the Beyler Dam Lake is classified as Class II in terms of Pb according to the WPCR (2004).

The AA of chromium (Cr), on the other hand, was calculated as 3.18 ppb and the lake was classified as Class I according to the WPCR (2004). Similarly, the average Cr values in the waters of Kovada Lake and Hazar Lake were 0.92 and 7.7 ppb, respectively (Kayrak & Ozan, 2018; Nergiz & Şamat, 2019).

In the present study, the AA of manganese (Mn) was found to be 1.82 ppb. In similar studies, the Mn was reported to be 14.56 ppb in the Kovada Lake (Kayrak & Ozan, 2018) and 3 ppb in the Hazar Lake (Nergiz & Şamat, 2019). It seems that the Mn concentration in the Beyler Dam Lake water is lower than the data presented in the literature and the lake is classified as Class I as per the WPCR (2004).

Lastly, the AA value of the zinc (Zn) was found to be 7.88 ppb. Zn was found to be below detection limit by Keser et al. (2020) in the Kara Lake. In the Hazar Lake, it was reported to be 14.6 ppb (Nergiz & Şamat, 2019) and the average Zn concentration in the Kovada Lake was reported to be 5.18 ppb

(Kayrak & Ozan, 2018). According to the WPCR (2004), the Beyler Dam Lake is also classified as Class I for zinc.

These results show that the Beyler Dam Lake is not contaminated by copper, cadmium, chromium, manganese, or zinc. However, there seems to be a low level of lead contamination in the lake. Lead has no biological role, is toxic even at very low concentrations (Bryan, 1976), and may affect a variety of mechanisms in aquatic organisms such as nervous system, blood parameters, immunity, and enzyme activities (Elbeshti et al., 2018; Lee et al., 2019). Lead may enter the environment through various ways but the main source of the excessive lead concentration is human activities such as smelting, mining, industrial waste, and domestic waste (EPA, 2021). Cosmetics, ammunition, batteries, gasoline, solders, plumbing materials, pipes, ceramics, and paint may contain lead and lead compounds (EPA, 2021). Since there is no industrial activity that may have caused lead pollution near the Beyler Dam Lake, the high concentrations of lead in the water may have been resulted from domestic waste discharged into the lake by the local community.

Furthermore, for all the heavy metals assessed, the variation in the observed results in the stations did not show a significant difference, indicating the spatial and temporal homogeneity in the lake. The results also showed that the average concentration of heavy metals was higher in the hot season than it was in the cold season, except for Mn, which was low in the hot season (1.71 ppb) and high in the cold season (1.94 ppb).

Conclusion

In this study carried out in the Beyler Dam Lake, according to the analysis results of the water samples taken for six months, it was determined that the dam lake was classified as Class I for all heavy metals analyzed (Cu, Cd, Cr, Mn, Zn) except for Pb. The lake was classified as Class II for Pb. These results suggest that the lake is a clear water body that is not contaminated by heavy metals. Therefore, the water is safe for agricultural activities such as aquaculture and irrigation. However, since the Pb is very toxic at low concentrations, the relatively high concentrations of Pb indicate that the source of the Pb in the lake needs identification. Further studies should monitor the water quality of the lake to track the status of the water.

Conflict of Interest

The author declares that he has no conflict of interest.

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