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Water Quality and Heavy Metal Pollution in Kayacik Dam (Gaziantep, Turkey)

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Research Article

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Abstract

The present study was the first conducted to determine the water quality and heavy metal pollution in Kayacik Dam (Gaziantep, Turkey) to assess its suitability and safety for irrigation. For this purpose, water sampling from 6 stations was performed in spring 2019 and samples taken into polyethylene bottles were used to determine the presence of heavy metals (Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) using ICP-OES. The water temperature, pH, dissolved oxygen, and conductivity were measured *in situ* via 8405 Combo Water Meter. The average values of water temperature, pH, dissolved oxygen, and conductivity were as follows; 20.53^{o}C, 8.30, 12.57 mg/L, and 723.7 µS cm^{-1}, respectively. Kayacik Dam was found to be first-class water quality in terms of temperature, pH, and dissolved oxygen while it can be evaluated as a second class in terms of conductivity. Among heavy metals analyzed levels of Cd, Co, Cr, Cu, and Pb were under the detection limit of 0.05 mg/L. The order of heavy metal levels in Kayacik Dam was found as Mn>Fe>Al>Zn>Ni. A general increasing or decreasing trend was not determined in heavy metal levels among stations. According to recommended maximum element concentrations for irrigation purposes by United Nations Food and Agricultural Organization (FAO), Mn and Ni levels were found to be higher than the maximum recommended level while Fe, Al, and Zn were in the allowable range.

Keywords: Heavy metal, Kayacik Dam, pollution, water quality

Kayacık Barajı'nda Su Kalitesi ve Ağır Metal Kirliliği (Gaziantep, Türkiye)

Özet

Bu çalışma sulama açısından uygunluğunu ve güvenirliliğini değerlendirmek amacıyla Kayacık Barajı'nın (Gaziantep, Türkiye) su kalitesini ve ağır metal kirliliğini belirlemek üzere yürütülen ilk çaraştırmadır. Bu amaçla, 2019 bahar döneminde 6 istasyondan alınan su örnekleri ICP-OES ile ağır metallerin (Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb ve Zn) varlığının belirlenmesi için polietilen şişelere alınmıştır. Su sıcaklığı, pH, çözünmüş oksijen ve iletkenlik 8405 Combo Water Meter ile *in situ* ölçülmüştür. Ortalama su sıcaklığı, pH, çözünmüş oksijen ve iletkenlik değerleri sırasıyla 20,53^{o}C, 8,30, 12,57 mg/L and 723,7 µS cm^{-1}'dir. Sıcaklık, pH ve çözünmüş oksijen derğerleri açısından Kayacik Barajı birinci sınıf su kalitesine sahipken iletkenlik değerine göre ikinci sınıf su kalitesine sahiptir. Analiz edilen ağır metaller arasında Cd, Co, Cr, Cu ve Pb düzeyleri belirleme sınırının altında ölçülmüştür (0,05 mg/L). Kayacık Barajı'nda ağır metal derişimlerinin Mn>Fe>Al>Zn>Ni şeklinde olduğu bulunmuştur. İstasyonlar arasında ağır metal derişimlerinde genel olarak azalan ya da artan yönde bir değişim gözlenmemiştir. Gıda ve Tarım Örgütü (FAO) sulama suları için önerilen maksimum element derişimlerine göre değerlendirildiğinde Mn ve Ni düzeylerinin önerilen maksimum sınırın üzerinde olduğu, Fe, Al ve Zn değerlerinin izin verilen aralıkta olduğu değerlendirilmiştir.

Anahtar kelimeler: Ağır metal, Kayacık Barajı, kirlilik, su kalitesi

INTRODUCTION

Heavy metals are naturally occurring elements existing throughout the earth's crust however they are introduced in different environmental compartments in large quantities due to anthropogenic activities like mining, industrial production, and use of metal or metal-containing compounds in industrial production, agricultural and domestic applications (Salomons et al., 1995). The main natural sources of heavy metals in an aquatic ecosystem are weathering of soils and rocks and volcanic eruptions. Some of the heavy metals (Cu, Zn, and Fe) are beneficial and essential for living organisms, however, others like Pb, Cd, and Al are toxic causing serious damage to metabolic, physiological, and structural systems of organisms. These heavy metals are continuously added into aquatic systems, causing serious threat not only ecosystems and aquatic organisms but also human life through bioaccumulation and biomagnification in the food chain due to their toxic and persistent nature (Moore et al., 2011; Masindi and Muedi, 2018).

Water quality presents the physical, chemical, and biological contents of water which influence the aquatic environment as limiting factors for aquatic organisms. To protect aquatic ecosystems and specific water uses, the water quality guidelines state scientific information about quality parameters and toxicological threshold values (Wyatt et al., 1998; Lawson et al., 2011; Kasımoğlu and Yılmaz, 2014; Klake et al., 2016; Ucun Özel and Gemici, 2016). Due to the importance of the availability of quality water, contamination of water sources should be monitored to take needed precautions to sustain the suitability of water by preventing, controlling and reducing the pollution (Gautam et al., 2014). Kayacik Dam, is a favorite picnic and line fishing area for local people, and it is surrounded by agricultural areas and there is no investigation/data in the literature related to its quality parameters or pollution. Therefore the main objectives of this study are (1) to determine the physicochemical properties of water, (2) to investigate the extent and degree of heavy metal contamination in Kayacik Dam, Gaziantep.

MATERIALS and METHODS

Kayacik Dam was constructed between 1993-2006 with irrigation purposes and it is located on Aynifar Stream next to Kayacik village being 17 km south of Oguzeli (Gaziantep).

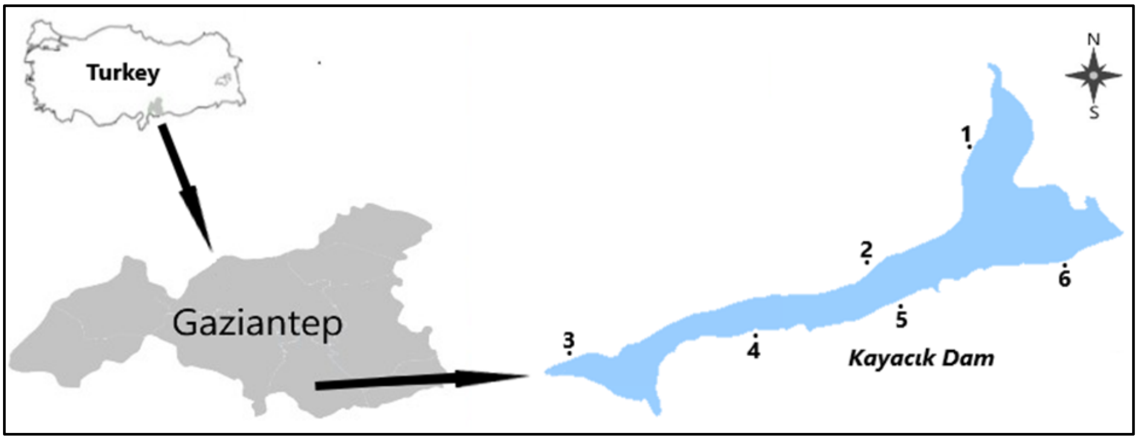

Figure 1. Sampling stations

The water samples were collected in spring 2019 from six stations selected based on accessibility by involving all sides with the intention of reflecting the characteristics of the water (Figure 1). At each station, triplicate samples were taken according to standard sampling methods (APHA, 1998). The water temperature, pH, dissolved oxygen and conductivity were measured *in situ* (8405 Combo Water Meter). The water samples were taken into 1000 mL polyethylene bottles and were brought to the laboratory in cold conditions for Physico-chemical analysis. For metal analyses, water samples were filtered through 0.45 µm pore size membrane filters to remove sand and debris. pH of the filtrate was adjusted to pH < 2 with nitric acid (1+1). Samples were maintained at +4 °C until analysis (APHA, 1998). Heavy metal (Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn) levels of samples were determined according to the method of EPA 6020A via ICP-OES (PerkinElmer Optima 5300 DV) with the detection limit of 0.05 mg/L.

Statistical Analysis

Statistics were performed using the SPSS 22 computer program (SPSS Inc. Chicago, Illinois, USA). The statistical difference between mean values of groups was determined by Post Hoc LSD multiple comparison test considering the values at $p<0.05$ were significant. Pearson correlation analysis was used to quantify the strength of association between two variables. Results were expressed as means ± standard deviation.

RESULTS and DISCUSSION

In aquatic ecosystems, water temperature is a very important parameter affecting the growth and distribution of aquatic species. Temperature alters depending on flow rate, volume, depth, geological, and chemical structure of waterway, and an increase in the value decreases the dissolved gasses and accelerates the chemical reactions (Wetzel, 2001). According to the criteria of Water Pollution Control Regulation in Turkey (SKKY 2004), ≤25 °C is evaluated as first-class water quality and Kayacik Dam was found to be first-class water quality in terms of temperature (Table 1). pH is one of the significant parameters and in a balanced ecosystem, pH is sustained between 5.5 and 8.5 (Chandrasekhar et al., 2003). The estimated average pH values of Kayacik Dam of 8.30 demonstrates the existence of a well-balanced ecosystem.

Conductivity shows the ability of water to conduct electricity and it is used as a quick parameter to locate the potential water quality problems (Moore et al., 2011; Adeniji et al., 2016). For a water source to be classified as the first quality for conductivity, the measured value should be <400 μS cm^{-1}(SKKY, 2004). The average conductivity of Kayacik Dam was measured as 723.7 μS cm^{-1} and it results in water being classified as second class. One of the indicators of the presence of pollutants, conductivity is affected by dissolved substances in the water like salts and heavy metals. Therefore second class water quality in terms of conductivity means that the water is slightly polluted and there is a potential dissolved ion source in the vicinity (Kar et al., 2008; Alsaffar et al., 2016).

Dissolved oxygen is used as another important quality criteria due to its regulatory function on metabolic pathways in aquatic ecosystems. In the freshwater ecosystem, the minimum value of dissolved oxygen is 5 mg/L for maintenance of aquatic life (EPA, 1997) and pollution is expected to cause a decrease in the values. In Kayacik Dam, the average value for dissolved oxygen is 12.57 mg/L and it shows the properties of class one water quality (SKKY, 2004). It can be stated that Kayacik Dam is not under the serious threat of pollution and thus no important negative impacts on aquatic life is predicted when findings for water quality parameters considered together.

Table 1. Physicochemical parameters of Kayacik Dam's stations

Physicochemical parameters	**Stations**								
	1	**2**	**3**	**4**	**5**	**6**	**Min.**	**Mean**	**Max.**
Temperature (°C)	19.1	21.5	20.4	19.1	20.1	23	19.1	20.53	21.5
pH	8.32	7.95	8.23	8.14	8.17	8.96	7.95	8.3	8.96
Conductivity (μS cm^{-1})	787	762	695	718	704	676	676	723.7	787
Dissolved Oxygen (mg/L)	19.1	7.9	12.4	9.7	11	15.3	7.9	12.57	19.1

Due to the increase in usage and processing of heavy metals, metal sourced contamination is becoming a serious issue of concern around the world, and water is one of the major environmental compartments being affected. The concentrations of Al, Fe, Mn, Ni and Zn levels of Kayacik Dam are given in Table 2. Among heavy metals analyzed levels of Cd, Co, Cr, Cu and Pb were under the detection limit of 0.05 mg/L possibly the result of increased water volume due to heavy raining in the season study conducted. According to the Food and Agriculture Organization, levels of Al, Fe, and Zn were found to be within maximum permissible limits for irrigation purposes which makes water suitable for irrigation purposes. On the other hand, Mn and Ni levels were determined to be above the maximum permissible limit (FAO, 2002). There was no determined increasing or decreasing trend in metal concentrations among stations selected.

Table 2. Heavy metal levels (mg/L) in Kayacik Dam

	Stations							
	1	2	3	4	5	6	Min.	Max.
Al	2.14±0.38^{ab}	1.27±0.23^{ac}	1.38±0.70^{ac}	2.50±1.22^{b}	1.14±.13^{ac}	0.79±0.08^{c}	0.70	3.91
Fe	3.18±0.45^{a}	1.70±0.05^{b}	0.92±0.31^{c}	2.43±0.69^{d}	1.38±.17^{bc}	0.90±0.26^{b}	0.62	3.69
Mn	4.73±0.24^{a}	2.40±1.18^{b}	1.23±.093^{bc}	2.18±0.38^{b}	1.7±1.04^{bc}	0.80±0.13^{c}	0.65	4.99
Ni	0.26±0.02^{a}	0.22±0.04^{ab}	0.19±.028^{ab}	0.23±0.02^{ab}	0.19±0.03^{b}	0.18±0.01^{b}	0.15	0.28
Zn	2.41±0.53^{a}	1.01±0.64^{b}	1.25±0.31^{b}	0.81±0.52^{b}	0.51±0.12^{b}	1.12±0.54^{b}	0.27	2.73

Values are given as mean±standard deviation (n=3). Different superscript letters in the same line indicate significant difference in mean values among stations (p<0.05).

Correlation coefficients of heavy metals and water quality parameters (Table 3) resulted in a significant negative correlation between temperature and heavy metals of Al and Fe ($p<0.01$). Zn and pH were positively correlated to oxygen ($p<0.01$). Besides, a significant positive relation was found between conductivity and heavy metals of Fe and Mn ($p<0.01$). In similar studies, the strong relationship and the potentiation of metal toxicity via increased water temperature or lowered dissolved oxygen levels were reported (Lou et al., 2017; Hertika et al., 2018).

Table 3. Correlation coefficients of heavy metals and water quality parameters

	Al	Fe	Mn	Ni	Zn	Temp.	pH	Oxygen	Conductivity
Al	1								
Fe	0.803**	1							
Mn	0.481*	0.852**	1						
Ni	0.518*	0.609**	0.749**	1					
Zn	0.266	0.541*	0.687**	0.584*	1				
Temp.	-0.652**	-0.677**	-0.575*	-0.395	-0.217	1			
pH	-0.326	-0.311	-0.309	-0.242	0.136	0.594**	1		
Oxygen	0.059	0.305	0.416	0.307	0.678**	-0.076	0.600**	1	
Conductivity	0.393	0.765**	0.850**	0.582*	0.528*	-0.472*	-0.517*	0.181	1

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

Consequently, the water quality of Kayacik Dam was found to be second class according to SKKY. Heavy metals of Mn, Fe, Al, Zn, and Ni were in the limit of detection and they were within the permissible levels for irrigation except for Mn and Ni. Even in trace amounts, it is known that heavy metals can still be toxic causing serious health problems to exposed organisms, including humans. Therefore it is imperative to continuously monitor and identify the levels of pollution and water quality of Kayacik Dam. In addition to the given parameters in the present study, future investigations could focus on the agricultural activity sourced existence/extend of organic pollution and their potential effects on living organisms.

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