Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 9(3) pp. 053-058, March, 2020 Issue.
Available online http://garj.org/garjas/home

Full Length Research Paper

Determination of Water Quality According to the Inorganic Parameters in Water of Özen Spring, Sivas, Turkey

Seher Dirican

Sivas Cumhuriyet University, Sivas Vocational Training School, Department of Crop and Animal Production TR-58140 Sivas, Turkey
Email: sdirican@cumhuriyet.edu.tr

Accepted 10 March, 2020

The present study is the first attempt to identify dissolved inorganic parameters in Özen Spring. The dissolved inorganic parameters of Özen Spring in the Central Anatolian region of Turkey were analysed using by inductively coupled plasma optical emission spectrometry with standard method. The water samples taken from Özen Spring has a mean concentrations of arsenic 2.80±0.28, barium 12.00±16.97, beryllium 0.50±0.71, boron 95.50±20.51, cadmium 0.20±0.28, cobalt 1.00±1.41, copper 6.20±1.70, iron 103.50±4.95, lead 0.15±2.12, manganese 5.40±2.26, mercury 0.35±0.07, nickel 0.50±0.71, selenium 1.00±1.41 and zinc 9.20±2.55 in µg/L. The obtained results were compared in terms of national and international standard values. In conclusion, the results of the inorganic water quality indicators obtained in Özen Spring show that inorganic pollution not exist in the study area except for mercury. It was suggested that there should be regular monitoring and control to protect the Özen Spring from contaminations.

Keywords: Inorganic, Parameters, Water, Quality, Özen Spring

INTRODUCTION

Water is an essential component of human life and it is a universal solvent which has the ability to dissolve many substances of organic or inorganic compounds. With this outstanding property, nevertheless it is almost impossible to have water in its pure form since it cannot be held up in a vacuum. Water sources, including surface, ground and rain are supporting drinking water supply, livestock needs, irrigation, industrial and many other commercial and domestic purposes. The quality of water sources depends on the various chemical constitutes and their concentration, which are mostly derived from natural and anthropogenic activities (Bernard and Ayeni 2012; Alemu et al. 2015). Also, water is an important source of inorganic elements. Many inorganic elements are essential nutrients however certain inorganic elements such as arsenic, cadmium, lead and mercury are known to be persistent environment contamination and highly toxic to most form of life. Inorganic elements are generally present in small concentration in natural aquatic ecosystems. Their occurrence in groundwater and surface water can be due

to natural sources such as dissolution of naturally occurring minerals containing inorganic elements in the soil zone or the aquifer material or to human activities such as mining, fuels, smelting of ores and improper disposal of industrial wastes (Jinwal et al. 2009). Inorganic elements is one of the most important causes to water pollution. They naturally found in environment but owing to human develepment activities, their amounts has been increasing rapidly and released into aquatic ecosystems (Choi et al. 2011). The quality of Özen Spring is vital for the surrounding community for proper and safe use of the water. The present study was conducted to determination of water quality in terms of dissolved inorganic parameters of Özen Spring in Turkey.

MATERIALS AND METHODS

Study Area

Suşehri is one of the 17 districts in Sivas province. Sivas is located in the Central Anatolian region of Turkey and intensive agricultural activities are conducted around the province, because of contained rich soil and much freshwater resources. Suşehri district has a potential for production of many crops, vegetables and fruits and favorable for livestock husbandry and aquaculture. Özen Spring is located in the east of the Suşehri. It is about 7 km far from Suşehri, and approximately 147 km far from Sivas province centre. The minimal flow rate of Özen Spring is 90 lt/s in the summer season. One of the main source of drinking waters is Özen Spring in Suşehri. Özen Spring is a major source of water for drinking and agricultural uses. Its topography is about 1500 meters from above sea level (Dirican, 2017).

Sampling and Analysis

The present study was carried out to by using the datas about assessment of water quality of Özen Spring from Suşehri Municipality. In this respect, water samples were collected at yearly intervals in July 2009 and May 2011. Two and five litter polyethylene bottles were used to determine the inorganic properties of Özen Spring. The water samples were analysed for 14 inorganic parameters, namely; arsenic (As), barium (Ba), beryllium (Be), boron (B), cadmium (Cd), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se) and zinc (Zn). All inorganic parameters were determined in laboratory according to the Turkish standard protocol TS EN ISO 11885. The standard TS EN ISO 11885 specifies a method for the determination of dissolved elements, elements bound to particles and total content of elements in different types of water. Concentrations of arsenic, barium, beryllium, boron, cadmium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium and zinc were analysed by inductively coupled plasma optical emission spectrometry (ICP-OES). All of the inorganic parameters were expressed in micrograms per litre (µg/L) in the study. SPSS for windows version 17.5 statistical software was used for all data analysis.

Data Comparisons

The results were compared with concentrations of inorganic parameters obtained by researchers in similar studies. Also, classification of inorganic water quality parameters was performed according to European Communities Drinking Water Directive 98/83/EC, ECDWD (1998); Turkish Waters Regulation for Human Consumption, TWRHC (2005); Turkish Water Pollution Control Regulation, TWPCR (2008); World Health Organization, WHO (2011) and Environmental Protection Agency, EPA (2014).

RESULTS

The variations in the concentration of selected dissolved inorganic parameters in water were investigated from Özen Spring. The basic statistics for all of the dissolved inorganic water quality parameters measured at Özen Spring are summarized in Table 1. The values of the dissolved inorganic parameters recorded were as follows; arsenic (2.6-3.0 µg/L), barium (BDL-24.0 µg/L), beryllium (BDL-1.0 µg/L), boron (81.0-110.0 µg/L), cadmium (BDL-0.4 µg/L), cobalt (BDL-2.0 µg/L), copper (5.0-7.4 µg/L), iron (100.0-107.0 µg/L), lead (BDL-3.0 µg/L), manganese (3.8-7.0 µg/L), mercury (0.3-0.4 µg/L), nickel (BDL-1.0 µg/L), selenium (BDL-2.0 µg/L) and zinc (7.4-11.0 µg/L) in Özen Spring (Table 1). The results of the present study showed that the distribution of dissolved inorganic parameters in water of Özen Spring exhibits variations.

The variations of inorganic water quality parameters among the water samples from Özen Spring were ranged from BDL to 110.0 µg/L. Iron was the major element in Özen Spring followed by boron and the overall mean concentration of other dissolved inorganic parameters was observed in the following order Fe > B > Ba > Zn > Cu > Mn > As > Co ≥ Se > Be ≥ Ni > Hg > Cd > Pb. Possible sources of these inorganic parameters in water may be attributed to natural and anthropogenic in Özen Spring.

DISCUSSION

The present study inorganic concentrations in the water are a good indicator for determination of water quality in Özen Spring. It is a part of a pilot for integrated research on Suşehri Drinking Water Package Treatment Plant Project. For the presentation of a initial overview on the

Table 1. Basic statistics of dissolved inorganic parameters in Özen Spring.

Elements	Units	Range	Mean	±SD
Arsenic	µg/L	2.6–3.0	2.80	0.28
Barium	µg/L	BDL–24.0	12.00	16.97
Beryllium	µg/L	BDL–1.0	0.50	0.71
Boron	µg/L	81.0–110.0	95.50	20.51
Cadmium	µg/L	BDL–0.4	0.20	0.28
Cobalt	µg/L	BDL–2.0	1.00	1.41
Copper	µg/L	5.0–7.4	6.20	1.70
Iron	µg/L	100.0–107.0	103.50	4.95
Lead	µg/L	BDL–3.0	0.15	2.12
Manganese	µg/L	3.8–7.0	5.40	2.26
Mercury	µg/L	0.3–0.4	0.35	0.07
Nickel	µg/L	BDL–1.0	0.50	0.71
Selenium	µg/L	BDL–2.0	1.00	1.41
Zinc	µg/L	7.4–11.0	9.20	2.55

*BDL: Below detected limit, SD: standard deviation in the table.

distribution of the inorganic parameters in Özen Spring, the sampling was limited to just two period. The results of the present study showed that the distribution of inorganic parameters in water of Özen Spring exhibits variations. The analysis by ICP-OES allows estimating the degree of water quality of Özen Spring. The arsenic concentration has a mean of 2.80±0.28 µg/L and shows ranges from 2.6 to 3.0 µg/L (Table 1). There are various studies on arsenic concentrations in water from different freshwater ecosystems. The mean arsenic concentrations in water obtained in the present study were lower than those obtained by Li et al. (2008) from Danjiangkou Reservoir, China; Elmacı et al. (2010) from Ulubat Lake, Turkey; Lim et al. (2012) from Langat River, Malaysia and Meng et al. (2016) from Dan River Drainage, China. The mean arsenic concentrations in water obtained in the present study were higher than those obtained by Varol (2013) from Batman and Dicle Reservoir, Turkey. Arsenic concentrations were similar to these reported in water from Kralkızı Reservoir, Turkey (Varol, 2013). According to classifical continental inland water sources of the Turkish water pollution control regulation TWPCR (2008) if arsenic is 20 µg/L, the water is class-I; if it is 50 µg/L, the water is class-II; if it is 100 mg/l, the water is class-III and if arsenic is >100 µg/L, the water is class-IV. According to those limits, in Özen Spring could be categorized as class-I or high water quality. The arsenic values of all the water samples under the 10 µg/L permissible limit recommended by ECDWD (1998), TWRHC (2005), WHO (2011) and EPA (2014) for drinking water in Özen Spring.

The mean value of barium was found to be 12±16.97 µg/L in Özen Spring (Table 1). The mean barium values from different habitats in the world were reported as 219.31±666.18 µg/L in Danjiangkou Reservoir, China (Li et al. 2008) and 112.61±79.06 µg/L in Dan River Drainage, China (Meng et al. 2016). According to the TWPCR (2008) if barium is 1000 µg/L, the water is class-I; if it is 2000 µg/L, the water is class-II; if it is 2000 µg/L, the water is class-III and if barium is >2000 µg/L, the water is class-IV. According to those limits, water containing 12±16.97 µg/L barium is class-I or high water quality. The barium values are limited under the 700 µg/L recommended by WHO (2011) for drinking water.

The levels of boron in Özen Spring ranged from 81.0 to 110.0 µg/L (Table 1). The boron concentrations of all the water samples under the 2400 µg/L permissible limit recommended by WHO (2011) for drinking water. The boron levels are limited under the 1000 µg/L recommended by TWRHC (2005) and EPA (2014) for drinking water in Özen Spring.

The mean value of cadmium was found to be 0.20±0.28 µg/L in Özen Spring (Table 1). The mean cadmium values from different habitats in the world were reported as 0.047±0.011 µg/L in Taihu Lake, China (Tao et al. 2012); 0.11±0.12 µg/L in Langat River, Malaysia (Lim et al. 2012); 0.70±2.42 µg/L in Dan River Drainage, China (Meng et al. 2016) and 0.28±0.15 µg/L in Çiğdem Pond, Turkey (Kurnaz et al. 2016). These values are similar to those found in the present study. According to the TWPCR (2008) if cadmium is 3 µg/L, the water is class-I; if it is 5 µg/L, the water is class-II; if it is 10 µg/L, the water is class-III and if cadmium is >10 µg/L, the water is class-IV. According to those limits, Özen Spring could be categorized as class-I or high quality water. Cadmium levels in Özen Spring were below the guideline value of 3 µg/L for drinking water (WHO, 2011). The cadmium levels are limited under the 5 µg/L recommended by TWRHC (2005) and EPA (2014) for drinking water.

The mean value of cobalt was found to be 1.00±1.41 µg/L in Özen Spring (Table 1). The mean cobalt values from different habitats in the world were reported as 1.08±2.34 µg/L in Danjiangkou Reservoir, China (Li et al.

2008); 0.64±1.14 µg/L in Langat River, Malaysia (Lim et al. 2012) and 0.15±0.74 µg/L in Dan River Drainage, China (Meng et al. 2016). According to the TWPCR (2008) if cobalt 10 µg/L, the water is class-I; if it is 20 µg/L, the water is class-II; if it is 200 µg/L, the water is class-III and if cobalt is >200 µg/L, the water is class-IV. According to those limits, water containing 1.00±1.41 µg/L cobalt is class-I or high water quality.

The copper concentration has a mean of 6.20±1.70 µg/L and shows ranges from 5.0 to 7.4 µg/L (Table 1). There are various studies on copper concentrations in water from different freshwater ecosystems. The mean copper concentrations in water obtained in the present study were lower than those obtained by Duman (2005) from Sapanca Lake; Duman et al. (2007) from Abant Lake, Turkey; Li et al. (2008) from Danjiangkou Reservoir, China and Elmacı et al. (2010) from Ulubat Lake, Turkey. The mean copper concentrations in water obtained in the present study were higher than those obtained by Canberk et al. (2007) from Porsuk River, Turkey; Agtaş et al. (2007) from Yıldız River, Turkey; Tao et al. (2012) from Taihu Lake, China; Varol (2013) from Dicle Reservoir and Meng et al. (2016) from Dan River Drainage, China. Copper concentrations were similar to these reported in water from Değirmen Stream, Turkey and Çiğdem Pond, Turkey (Bulut et al. 2009; Kurnaz et al. 2016). According to classifical continental inland water sources of the Turkish water pollution control regulation TWPCR (2008) if copper is 20 µg/L, the water is class-I; if it is 50 µg/L, the water is class-II; if it is 200 µg/L, the water is class-III and if copper is >200 µg/L, the water is class-IV. According to those limits, in Özen Spring could be categorized as class-I or high water quality. The copper concentrations are limited under the 2000 µg/L recommended by TWRHC (2005), WHO (2011) and EPA (2014) for drinking water in Özen Spring.

The iron was found in the highest concentrations ranged from 100.0 to 107.0 µg/L, and its concentrations were also higher than those of other in organic parameters in Özen Spring (Table 1). The mean iron concentrations in water obtained in the present study were lower than those obtained by Bulut et al. (2009) from Değirmen Stream, Turkey. The mean iron concentrations in water obtained in the present study were higher than those obtained by Canberk et al. (2007) from Porsuk River, Turkey; Agtaş et al. (2007) from Yıldız River, Turkey; Tao et al. (2012) from Taihu Lake, China; Varol (2013) from Batman Reservoir and Meng et al. (2016) from Dan River Drainage, China. According to classifical continental inland water sources of the Turkish water pollution control regulation TWPCR (2008) if iron is 300 µg/L, the water is class-I; if it is 1000 µg/L, the water is class-II; if it is 5000 µg/L, the water is class-III and if iron is >5000 µg/L, the water is class-IV. According to those limits, water containing between 100.0 and 107.0 µg/L iron is class-I or high water quality. The iron concentrations are limited under the 200 µg/L recommended by TWRHC (2005) and EPA (2014) for drinking water in Özen Spring.

The mean value of lead was found to be 0.15±2.12 µg/L in Özen Spring (Table 1). Lead concentrations were similar to these reported in water from Değirmen Stream, Turkey and Keban Dam Lake, Turkey (Bulut et al. 2009; Topal and Topal, 2017). According to the TWPCR (2008) if lead is 10 µg/L, the water is class-I; if it is 20 µg/L, the water is class-II; if it is 50 µg/L, the water is class-III and if lead is >50 µg/L, the water is class-IV. Özen Spring is in the class-I water with regard to TWPRC (2008). The lead concentrations are limited under the 10 µg/L recommended by TWRHC (2005), WHO (2011) and EPA (2014) for drinking water in Özen Spring.

The manganese level in Özen Spring varied from 3.8 to 7.0 µg/L. The mean manganese in Özen Spring has been found to be 5.40±2.26 µg/L (Table 1). There are various studies on manganese levels in water from different freshwater ecosystems. The mean manganese levels in water obtained in the present study were lower than those obtained by Duman (2005) from Sapanca Lake; Duman et al. (2007) from Abant Lake, Turkey and Canberk et al. (2007) from Porsuk River, Turkey. The mean manganese levels in water obtained in the present study were higher than those obtained by Tao et al. (2012) from Taihu Lake, China. Manganese levels were similar to these reported in water from Danjiangkou Reservoir, China and Dan River Drainage, China (Li et al. 2008; Meng et al. 2016). According to the TWPCR (2008) if manganese is 100 µg/L, the water is class-I; if it is 500 µg/L, the water is class-II; if it is 3000 µg/L, the water is class-III and if manganese is >3000 µg/L, the water is class-IV. According to those limits, Özen Spring could be categorized as class-I or high quality water. Manganese levels in Özen Spring were below the maximum permissible level of 50 µg/L for drinking water (TWRHC, 2005; EPA, 2014).

The mercury concentration has a mean of 0.35±0.07 µg/L and shows ranges from 0.3 to 0.4 µg/L (Table 1). Mean mercury values have been reported to be in Çiğdem Pond, Turkey 0.006±0.004 µg/L (Kurnaz et al. 2016) and in Saobo Lake, China 0.042±0.029 (Liu and Li, 2011). According to the TWPCR (2008) if mercury is 0.1 µg/L, the water is class-I; if it is 0.5 µg/L, the water is class-II; if it is 2 µg/L, the water is class-III and if mercury is >2 µg/L, the water is class-IV. According to those limits, Özen Spring could be categorized as class-II or slightly polluted water. Mercury concentrations in Özen Spring were below the guideline value of 6 µg/L for drinking water (WHO, 2011). Mercury concentrations are limited under the 1 µg/L recommended by ECDWD (1998), TWRHC (2005) and EPA (2014) for drinking water.

The mean value of nickel was found to be 0.50±0.71 µg/L in Özen Spring (Table 1). The mean manganese concentrations in water obtained in the present study were lower than those obtained by Lim et al. (2012) from Langat

River, Malaysia; Tao et al. (2012) from Taihu Lake, China; Varol et al. (2013) from Dicle Dam Lake, Turkey and Topal and Topal (2017) from Keban Dam Lake, Turkey. According to the TWPCR (2008) if nickel is 20 µg/L, the water is class-I; if it is 50 µg/L, the water is class-II; if it is 200 µg/L, the water is class-III and if nickel is >200 µg/L, the water is class-IV. According to those limits, Özen Spring could be categorized as class-I or high quality water. Nickel concentrations in Özen Spring were below the guideline value of 70 µg/L for drinking water (WHO, 2011). Nickel concentrations are limited under the 20 µg/L recommended by EPA (2014) for drinking water.

The mean value of selenium was found to be 1.00±1.41 µg/L in Özen Spring (Table 1). The mean selenium values from different habitats in the world were reported as 15.36±18.80 µg/L in Danjiangkou Reservoir, China (Li et al. 2008) and 0.003±0.001 µg/L in Dabie Male Lake, Poland (Tomza-Marciniak et al. 2016). World Health Organization provisional guideline for selenium was set at 40 µg/L in drinking water (WHO, 2011). Selenium limit in drinking water is 10 µg/L in (ECDWD, 1998) and EPA (2014). In Özen Spring, selenium values are below the ECDWD (1998), WHO (2011) and EPA (2014) the permissible limits for drinking water.

The zinc concentration in Özen Spring varied from 7.4 to 11.0 µg/L (Table 1). Mean zinc values have been reported to be in Değirmen Stream, Turkey 6.6 µg/L (Bulut et al. 2009), in Yangtze River, China 9.4 µg/L (Wu et al. 2009); in Taihu Lake, China 8.778±4.426 µg/L (Tao et al. 2012); in Dan River Drainage, China 7.83±24.25 µg/L (Meng et al. 2016) and in Çiğdem Pond, Turkey 10.36±6.99 µg/L (Kurnaz et al. 2016). These values are similar to those found in the present study. According to the TWPCR (2008) if zinc is 200 µg/L, the water is class-I; if it is 500 µg/L, the water is class-II; if it is 2000 µg/L, the water is class-III and if zinc is >2000 µg/L, the water is class-IV. According to those limits, Özen Spring could be categorized as class-I or high quality water.

According to the TWPCR (2008) arsenic, barium, cadmium, cobalt, copper, iron, lead, manganese, nickel and zinc values in the Özen Spring should be categorized in water quality class-I or high quality water while to mercury values in water quality class-II or slightly polluted water. In water quality class-I, it can be said that Özen Spring water can be used not only for drinking purpose by disinfecting it, but also for recreational aims, trout aquaculture, animal production and other aims. Also, for mercury in water quality class-II, it can be said that Özen Spring water can be used not only for drinking water purpose by high disinfecting it, but also for recreational aims, aquaculture outside the trout, animal production and other aims (TWPCR, 2008). Generally, the concentrations of arsenic, barium, boron, cadmium, copper, lead, mercury, nickel and selenium of water were detected to be so much lower from ECDWD (1998), TWRHC (2005) and WHO (2011) guidelines for drinking water standards. Thus, water quality of Özen Spring is suitable for drinking water. Therefore, the Özen Spring can be used as a drinking water. Özen Spring was affected by the climatic and geologic of the region rather than with the effects of human activities and environmental pollution. The results of the present study have indicated that inorganic parameters have made their entry into the Özen Spring and are a no matter of great concern.

CONCLUSION

The present study provides background information about the inorganic properties of Özen Spring which might help in the future evaluating the changes, induced through expected increase agriculture, industry and human activities. In decreasing order, the mean concentrations of inorganic parameters were Fe (103.50±4.95 µg/L), B (95.50±20.51 µg/L), Ba (12.00±16.97 µg/L), Zn (9.20±2.55 µg/L), Cu (6.20±1.70 µg/L), Mn (5.40±2.26), As (2.80±0.28 µg/L), Co (1.00±1.41 µg/L), Se (1.00±1.41 µg/L), Be (0.50±0.71 µg/L), Ni (0.50±0.71 µg/L), Hg (0.35±0.07 µg/L), Cd (0.20±0.28 µg/L) and Pb (0.15±2.12 µg/L) in Özen Spring. The concentrations of the evaluated inorganic parameters were below the guideline levels for inland waters execept for mercury, and did not appear to have significant negative impact on the water quality. As a general conclusion, no important inorganic water pollution was identified in Özen Spring. Regular monitoring should be conducted to obtain reliable water quality data in the limnology of inland water ecosystems. For this reason, in order to keep spring water safe from pollution, it takes ample of time to establish the records and knowledge of the water quality processes and predispositions. Advanced researches is crucial for implementing effective rules to protect the Özen Spring. The detailed research should be done for especially Hg in Özen Spring.

REFERENCES

Agtaş Ş, Gey H, Gül S (2007). A concentration of heavy metals in water and chub, *Leuciscus cephalus* (Linn.) from the river Yildiz, Turkey. Journal of Environmental Biology, 28(4): 845-849.

Alemu ZA, Teklu KT, Alemayehu TA, Balcha KH, Mengesha SD (2015). Physicochemical quality of drinking water sources in Ethiopia and its health impact: a retrospective study. Environmental Systems Research, 4: 22. DOI: 10.1186/s40068-015-0049-7.

Bernard E, Ayeni N (2012). Physicochemical analysis of groundwater samples of Bichi Local Government Area of Kano State of Nigeria. World Environment, 2(6): 116-119. DOI: 10.5923/j.env.20120206.02.

Bulut VN, Bayram A, Gündoğdu A, Soylak M, Tüfekçi M (2010). Assessment of water quality parameters in the stream Galyan, Trabzon, Turkey. Environmental Monitoring Assessment, 165: 1-13. DOI: 10.1007/s10661-009-0922-9.

Canberk M, Demir TA, Uyanoğlu M, Bayramoğlu G, Emiroğlu Ö, Arslan N, Koyuncu O (2007). Preliminary assessment of heavy metals in water and some Cyprinidae species from the Porsuk River, Turkey. Journal of Applied Biological Sciences 1(3): 91-95.

Choi JW, Chung SG, Hong SW, Kim DJ, Lee SH (2011). Development of adsorbent for the simultaneous removal of organic and inorganic contaminants from aqueous solution. Water Science and Technology, 64(9): 1821-1827. DOI: 10.2166/wst.2011.749

Dirican S (2017). A study on water quality assessment of Özen spring near Suşehri in Sivas, Turkey. International Journal of Research Studies in Agricultural Sciences, 3 (4): 22-25. DOI: 10.20431/2454-6224.0304003.

Duman F (2005). A comparative investigation of heavy metal concentrations in the water, sediment and aquatic plant samples of Sapanca and Abant lakes. Ankara University, Institute of Sciences, Biology Department, Ph.D. Thesis, pp. 1-227.

Duman F (2007). A comparative analysis of seasonal changing of some heavy metal concentrations in Abant lake water. Anadolu University Journal of Science and Technology, 8(1): 131-138.

ECDWD (1998). Drinking water directive 98/83/EC. Official Journal of the European Communities No: L330, 05 December 1998, pp. 32-54.

Elmacı A, Topaç FO, Teksoy A, Özengin N, Başkaya HS (2010). Evaluation of physicochemical characteristics of lake Uluabat in accordance with guidelines. Uludağ Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi, 15(1): 149-157.

EPA (2014). Drinking water parameters - microbiological, chemical and indicator parameters in the 2014, Drinking Water Regulations 2014. Environmental Protection Agency, Johnstown Castle Estate, Wexford Ireland, pp. 1-9.

Jinwal A, Dixit S, Malik S (2009). Some trace elements investigation in ground water of Bhopal & Sehore District in Madhya Pradesh: India. Journal Applied Sciences and Environmental Management, 13(4): 47-50.

Kurnaz A, Mutlu E, Uncumusaoğlu AA (2016). Determination of water quality parameters and heavy metal content in surface water of Çiğdem pond (Kastamonu/Turkey). Turkish Journal of Agriculture - Food Science and Technology, 4(10): 907-913.

Li S, Xu Z, Cheng X, Zhang Q (2008). Dissolved trace elements and heavy metals in the Danjiangkou Reservoir, China. Environmental Geology, 55: 977-983. DOI: 10.1007/s00254-007-1047-5.

Lim WY, Aris AZ, Zakaria MP (2012). Spatial variability of metals in surface water and sediment in the Langat River and geochemical factors that influence their water-sediment interactions. The ScientificWorld Journal, Volume 2012, Article ID: 652150, 1-14. DOI:10.1100/2012/652150.

Liu H, Li W (2011). Dissolved trace elements and heavy metals from the shallow lakes in the middle and lower reaches of the Yangtze River region, China. Environmental Earth Sciences, 62: 1503-1511. DOI: 10.1007/s12665-010-0634-z.

Meng Q, Zhang J, Zhang Z, Wu T (2016). Geochemistry of dissolved trace elements and heavy metals in the Dan River Drainage (China): distribution, sources, and water quality assessment. Environmental Science Pollution Research, 23: 8091-8103. DOI: 10.1007/s11356-016-6074-x.

Mutlu E, Yanık T, Akça İ, Kutlu B, Sönmez AY (2015). Determining the water quality of Lake Delice (İmranli-Sivas). Marine Science and Technology Bulletin, 4(2): 11-19.

Tao Y, Yuan Z, Wei M, Xiaona H (2012). Characterization of heavy metals in water and sediments in Taihu Lake, China. Environmental Monitoring Assessment, 184: 4367-4382. DOI: 10.1007/s10661-011-2270-9.

Tomza-Marciniak A, Marciniak AM, Pilarczyk B, Molenda M (2016). Selenium bioaccumulation in eutrophic lake – Dabie Małe Lake, Poland. Water and Environment Journal, 30: 284–289. DOI: 10.1111/wej.12182.

Topal M, Topal EI (2017). Determination of Concentrations of Lead and Nickel in Keban Dam Lake (Elazığ) within Water Framework Directive. International Journal of Pure and Applied Sciences, 3(1): 41-53.

TWPCR (2008). Turkish water pollution control regulation. (in Turkish), Ministry of Environment and Forest, The Republic of Turkey Official Journal No: 26786, pp. 1-76.

TWRHC (2005). Turkish waters regulation for human consumption. (in Turkish), Official Journal of Turkey Republic, No: 25730, 17 February 2005, pp. 1-32.

Varol M (2013). Dissolved heavy metal concentrations of the Kralkızı, Dicle and Batmandam reservoirs in the Tigris River basin, Turkey. Chemosphere 93: 954-962. DOI: 10.1016/j.chemosphere.2013.05.061.

WHO (2011). Guidelines for drinking water quality. fourth edition, World Health Organization, Geneva, Switzerland, pp. 1-541.

Wu B, Zhao DY, Jia HY, Zhang Y, Zhang XX, Cheng SP (2009). Preliminary risk assessment of trace metal pollution in surface water from Yangtze River in Nanjing Section, China. Bull Environ Contam Toxicol 82: 405–409. DOI: 10.1007/s00128-008-9497-3.