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Araştırma Makalesi (Research Article)

Ankara Karşıyaka ve Karapürçek'teki Su Kaynaklarının Ağır Metal Tahmini ve Kalite Güvence Parametreleri

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Öz

Son yıllarda artan ekonomik büyüme hızı, tarımsal faaliyetlerdeki artış, sanayileşme ve nüfus artışı, ülkemizdeki tüm doğal kaynaklar gibi su kaynaklarının da aşırı kullanımını ve kirlenmesini beraberinde getirmiştir. Bu nedenle su kaynaklarının kirlilik kontrolü, su kalitesinin korunması ve izlenmesinde önem arz etmektedir. Bu çalışmada, evsel ve endüstriyel faaliyetler ile atık suların artan baskısı altında olan ve ayrıca önemli bir sel riski altında bulunan Ankara'nın Karşıyaka ve Karapürçek ilçelerinin su kalitesinin analizi amaçlanmıştır. Bu amaç doğrultusunda iki kaynak için tuz stresi ve ağır metal kirliliği araştırılmıştır. Bu su örneklerindeki ağır metalleri belirlemek için ICP-OES (İndüktif Eşleşmiş Plazma Optik Emisyon Spektroskopisi) tekniği kullanılmıştır. Yöntemin validasyonu yapılmış ve ağır metallerin uygunluğu Türkiye İçme Suyu Standardı (TS 266, 2005) ve Dünya Sağlık Örgütü (WHO, 2022) içme suyu standartlarıyla karşılaştırılmıştır. Örneklerdeki ağır metal konsantrasyonları standartlarda verilen sınır değerler içinde bulunmuştur. Kentsel dönüşüm kapsamında bu mahallelerdeki yüzey suyu kaynaklarının kalitesine ilişkin literatürde herhangi bir çalışma bulunmamakla birlikte, dönüşümün yerleşim planlamasında topluluklara yenilikler getireceği açıktır.

Anahtar Kelimeler: *Ağır metal, Tuz stresi, Su kalitesi*

Makale Hakkında

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Heavy Metal Estimation and Quality Assurance Parameters of Water Resources in Karşıyaka and Karapürçek, Ankara

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Abstract

The increasing economic growth rate in recent years, increasing agricultural activities, industrialization, and population growth have brought about the excessive use and pollution of water resources, like all natural resources in our country. Therefore, pollution control of water-bodies is significant in protecting and monitoring water quality. This study aims to analyze the water quality of two different districts in Ankara which are Karşıyaka, and Karapürçek under increasing pressure from domestic and industrial activities and wastewater in addition to a significant flood risk. The salt stress and heavy metal contamination for two sources were investigated in accordance with this purpose. The ICP-OES (inductively coupled plasma-optical emission spectroscopy) technique was used to determine the heavy metals in these water samples. The validation of the method was performed, and the suitability of heavy metals was compared with the drinking water standards of the Turkish Drinking Water Standard (TS 266, 2005) and the World Health Organization (WHO, 2022). The concentrations of the heavy metals in the samples were found within the limit values given in the standards. There are no studies in the literature on the quality of surface water resources in these neighborhoods within the scope of urban transformation, and it is obvious that the transformation will bring innovations to the communities in the settlement planning.

Keywords: *Heavy metal, Salt stress, Water quality*

About Article

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Ethical Statement

It is declared that scientific and ethical principles have been followed while carrying out and writing this study and that all the sources used have been properly cited (Deniz ŞAHİN).

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Introduction

Today, the population growth, urban, industrial, and agricultural activities increase the demand for water at the same rate while quality of water supplies decrease (Foti et al. 2012; Brown et al. 2019; Liu et al. 2020; Heidari et al. 2020; Heidari et al. 2021). One consequence of likely reductions in water resources by lower expected rainfall, climate change, higher levels of water withdrawal from water sources and non-point source pollution; access to water will become almost a limiting factor for humanity (MA, 2005; CA, 2007; Adam and Lettenmaier, 2008). Some 3 in 10 people worldwide, or 2.1 billion people, lack off access to safe water, according to a report by the WHO and UNICEF (WHO, 2017). For this reason, water quality management which involves pollution control measures is important as well as the existence of water (Karadavut et al., 2011; Mdee et al., 2024). Water quality management also refers the assessments of numerous water quality parameters (physical, microbiological, anions, and heavy metals etc.) and effective pollution control strategies (Hajigholizadeh and Melesse, 2017; Li et al., 2018). Researchers call out periodic monitor assessment of water quality, identify main causes of water pollution, and appropriate measures, in order to protect and control the water-related ecosystem services, evolve and continue of the ecological balance, and use water resources wisely (Karadavut et al., 2011). In particular, point and nonpoint source dischargers around streams, dams and lakes used as drinking and utility water should be brought under control (Kalipci et al., 2017).

Heavy metals (HMs) are the most prominent among the dischargers that may enter the environment. These HMs are natural constituents of the Earth's crust, but anthropogenic activities (mining operations, mineral extraction, industrial production, agricultural applications etc.) profoundly alter biogeochemical cycles and change the balance of these metals in our ecosystems. Volcanic eruptions and break down of rocks containing metals are regarded as the main natural sources of heavy metals entrance into an aquatic ecosystem. Heavy metal contamination in aquatic ecosystems is a growing worldwide problem because proliferation of these heavy metals into aquatic systems may cause toxic and harmful effect not only aquatic organisms but also people who consumes it (Malik et al., 2010). Some HMs including copper (Cu), zinc (Zn), nickel (Ni), and iron (Fe) are beneficial and essential for living organisms, but others like lead (Pb), cadmium (Cd), aluminium (Al), and arsenic (Ar) cause serious damage to the nervous system and internal organs. Due to the harmful effects on the aquatic ecosystems of HMs, point sources of these heavy metals should be monitored (Liao et al., 2017). Heavy metal pollution in aquatic ecosystems has been systematically recorded since the mid-1950s, when there were mercury intrusion disaster into the coastal, river, and irrigation systems in Minamata, which took place in Japan, from a chemical factory wastewater (McCormac, 1991; Dos Santos et.al., 2018). The rate of heavy metal input to the world's waterways is still very high and the dumping of heavy metal-containing wastewater into the ocean is still disturbing (McCormac, 1991; Lattemann and Hopner 2008). Permissible limits for surface waters according to standards of the Republic of Türkiye Ministry of Agriculture and Forestry/Regulations for Water Pollution Control Regulations (WPCR) are presented in Table 1 (WPCR 2004).

Table 1

Allowable Upper Limit Values of Various Heavy Metals According to Water Quality Classes

Heavy Metals (µg/L)	Water Quality Class				Heavy Metals (µg/L)	Water Quality Class			
	I	II	III	IV		I	II	III	IV
Ag	-*	-	-	-	Fe	300	100	500	>500
As	≤20	50	100	>100	Mn	100	500	300	>3000
B	1000	1000	1000	1000	Ni	20	50	20	>200
Be	-	-	-	-	Pb	10	20	50	>50
Cd	3	5	10	>10	Sb	-	-	-	-
Co	≤10	20	200	>200	Tl	-	-	-	-
Cr	≤20	50	200	>200	V	-	-	-	-
Cu	≤20	50	200	>200	Zn	200	500	2000	>2000

* No guideline

According to the WPCR, inland surface waters include rivers, streams, lakes, springs, etc. are divided into four general classes: 1st class water: quality is good, 2nd class water: lightly contaminated water, 3rd class water: contaminated water and 4th class water: very contaminated water.

Many academics have investigated the water quality change in recent years, including analyzing the effects of salinity and discharge heavy metal on water quality (Eaton et al., 2005) (Many academics have investigated the water quality change associated with risks of salinity and discharge heavy metals in recent years.). Abd Byty et al., studied heavy metal ion concentrations in the groundwater samples taken from Rutba City, Iraqi and compare them to WHO and IEPA drinking water guideline values (Abd Byty et al., 2021). Yalcin et al., investigated the water quality in Nigde, Türkiye using Hydrogen Ion Concentration (pH), electrical conductivity (EC), dissolved oxygen (DO), and nine heavy metals, and showed that water polluted with industrial and residential waste (Yalcin et al., 2008). Mokarram et al., analyzed 21 water quality parameters such as DO, heavy metals, nutrients, and microbial pollution in the water of the Kor River basin, Iran and found that flatter regions generally had more pollution by (due to) water stasgnation (Mokarram et al., 2022). Dinka reported the water quality on the Awash River in Ethiopia, using physicochemical parameters like pH, EC, and calcium (Ca), magnesium (Mg), sodium (Na), potassium (K) ions and evaluated the statistical correlation between these parameters (Dinka, 2022). In another study by Al-humairi and Rahal on Al-Dujaila River in Iraqi, were reflected the presence of Na%, Mg% that indiced the drainage water quality, and showed that diluted drainage water is not suitable for either irrigation or human use (Al-humairi and Rahal 2023).

While surface water and groundwater naturally contains major ions (Na, K, Ca, Mg, Cl, and more), dramatic increases in concentration of these ions occur depending on geochemical structure of a catchment area, type and intensity of water supply, and weather conditions,soil type (Wons et al. 2012). The complex interaction between salt ions and chemical, biological, and geologic parameters and consequences on the environment is termed Freshwater

Salinization Syndrome (FSS) (Kaushal et al. 2019; Kaushal et al. 2021). FSS leads to undesirable health, environmental, and economic ramifications (Kaushal et al. 2016; Khan et al. 2011). One example of these ramifications is that high salinity damages water-distribution piping and can increase the rate of metals mobilizing from pipes to groundwater and surface water. Salinization can also mobilize nitrogen from soils, thereby increasing nutrient concentration, which can cause hypoxic zones, algal blooms in lakes and rivers. Beyond dramatically reducing biodiversity, Saline water is unsuitable for drinking, as well as for domestic, agricultural, and industrial purposes. The consumption of water with excessive salt may lead to kidney disease. One of the most well-documented cases of risks of FSS on human health occurred in a coastal area of China; groundwater salinization increased the mobility of arsenic (As), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), and nickel (Ni) in this area, significantly increasing cancer risk, mostly children (Wen et al. 2019).

Inductively coupled plasma-optical emission spectroscopy (ICP-OES) is an advanced analytical technique that allows multiple determination of elements even at very low concentrations (μg L^{-1}, ngL^{-1}) in natural spring water, drinking water, seawater and wastewater samples. Chechet et al. determined 15 mineral elements in drinking water which came to the laboratory from the settlements of Ukraine using the ICP–OES method (Chechet et al. 2021). In another study , Ostrega et al. used the ICP–OES method to determine some elements in water samples collected near Pb-Zn mining (Chechet et al. 2021). Baralkiewicz et al. compared ICP-OES and ICP-MS data in the determination of trace elements (Al, Sr, Li, Cu, Pb, Cr, V, and Ni) in lake water (Baralkiewicz et al. 2007).

In the present study aimed to assess the surface water quality of two different districts in Ankara focusing on the presence of heavy metal contamination. Heavy metals were investigated in Karşıyaka and Karapürçek surface water in Ankara by using heavy metal pollution index (HPI).

Material and Method

Study Area

The water samples were collected from two different districts in Ankara, the capital city of Türkiye (44°44′21″ N, 36°44′83″ E) (Figure 1). Karapürçek neighborhood remains the city's most populous, accommodating roughly 83.893 residents.

Karşıyaka and Karapürçek (Table 2) surface water resources are evaluated from salinity and heavy metal pollution. Surface waters of these districts are open to pollution due to human activities, agricultural activities, and livestock.

Figure 1

The Locations of the Sampling Sites

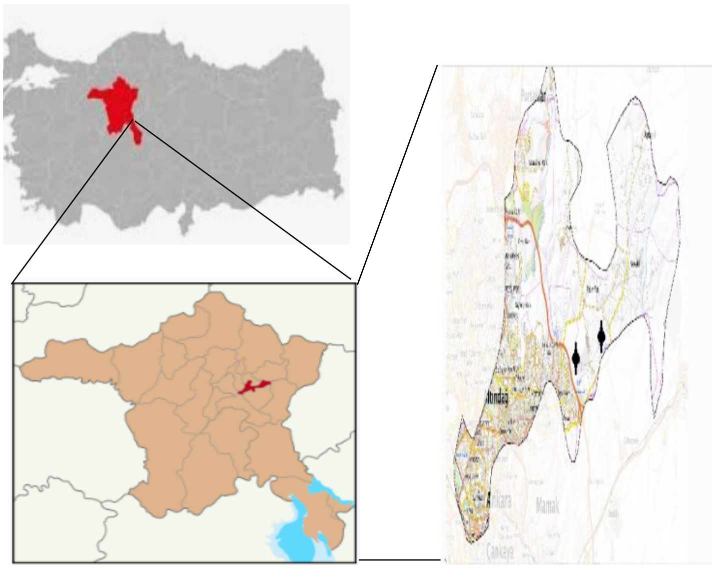

Table 2

Names and the Coordinates of Sampling Sites

Station number	Name	Coordinates North East
N1	Karapürçek Surface	39.971237 32.959071
N2	Karşıyaka Surface	39.963247 33.113312

Sample Collection

In our study, surface water samples at the sampling sites were taken during the summer months. Surface water samples for the analysis of water quality parameters were collected from the near-surface layer at depths no greater than 0.5 m. Water samples were collected below the water surface into 1 L polyethylene bottles and were transported to the Ministry of Health-Ankara Public Health Laboratory in accordance to "Standard Methods for the Examination of Water and Wastewater/1060 Collection and Preservation of Samples" (Eatn et.al., 2005). The purpose of determining metal content, water samples were filtered through membran filters having 0.45 µm pore size to remove sediments and debris. Samples were preserved by adding 1 mL of 1:1 diluted nitric acid (from %65 HNO_3, Merck). All samples were maintained at 4°C in ice containers until analysis.

Standard Solutions and Reagents

A multi-element st*andard* solution- ICP multi-element st*andard* solution XVI (Merck, Certipur®), and %65 nitric acid (Merck, Suprapur®) were used during analyses. The ultra-pure water (18.2 MΩ cm^{-1}) was produced using a Milli-Q Deionizing System (Millipore, Bedford, MA). All experimental solutions, samples and reference materials, were prepared in 1% v/v HNO_3.

ICP- OES Instrumental Parameters and Validation

The analysis was carried out using an Agilent 720 ICP-OES instrument (Agilent, Santa Clara, CA 95051 United States) with a CCD detector and a nebulizer One-Neb. The instrumental and operating parameters for the instrument are listed in Table 3. Sample uptake time of 30.0 sec, delay time of 5 sec, rinse time of 30 sec, instrument stabilization time of 15 sec and time between replicate analysis of 3 sec was maintained *during* the studies for ICP-OES. The wavelengths of the elements measured in the devices were 167.19 nm, 328.068 nm, 188.980 nm, 249.772 nm, 313.042 nm, 214.439 nm, 238.892 nm, 267.716 nm, 327.395 nm, 238.204 nm, 184.887 nm, 257.610 nm, 231.604 nm, 220.353 nm, 206.834 nm, 196.026 nm, 190.794 nm, 292.401 nm, 213.857 nm which corresponds to the most sensitive emission wave length of Al, As, Ag, B, Be, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, Se, Tl, V, Zn respectively. Each analysis was made 3 times on the ICP- OES device, and the mean value of these 3 measurements was calculated.

Table 3

The Operating Parameters of ICP-OES

Component	Parameter
Instrument type	Agilent 720
RF forward power	1000 W
Coolant gas flow	15.0 L/min
Auxiliary gas flow rate	1.50 L/min
Nebulizer gas flow rate	0.6 L/min
Nebulizer type	One-Neb
Nebulizer pump	0.10 rps
Detector type	CCD

Salinity

The determination of Na, K, Ca, and Mg concentration levels was done with an ICP-OES instrument. Multi-element standards solutions from VHG LABS (Manchester, NH, USA) were used to calibrate the graphs, with a concentration of 10 mg/L for each element. An internal standard multi-element solution to control the instrument's quantification stability was obtained from. An internal standard multi-element stock solution to control the instrument's quantification stability was obtained from Agilent®, USA. To create calibration standards and sample solutions, nitric acid (HNO_3, 65% v/v) was bought from Merck (Darmstadt, Germany). The assay's validity was examined using the certified reference material (CRM), UME CRM 1201 Spring Water (Tubitak, Türkiye). Lastly, an indigenous Turkish provider delivered argon gas with an analytical purity of 99.999%.

Heavy Metal Pollution Index (HPI)

In order to determine the degree of contamination by heavy metals, the heavy metal pollution index (HPI) was used. The HPI proposed by Mohan et al. is one of the best methods by which to indicate the total water quality bases on heavy metals (Mohan et al., 1996; Tamasi and Cini, 2004). The HPI employs weighted arithmetic quality mean method and includes a two-phase process. Initially, a rating scale with weightage (Wi) for each selected parameters is established. Afterwards, a pollution parameter is selected to reflect as the foundation for the index. The rating scale is an arbitrarily value, ranging from 0 to 1, and its selection depends upon the relative importance of individual quality considerations or their inverse proportionality to the permissible limit value given in the standard (S_i) for each factor (Tamasi and Cini, 2004; Prasad and Bose 2005). HPI is computed using equations (1), (2) and (3):

$$HPI = \frac{\sum_{i=1}^{n} WiQi}{\sum_{i=1}^{n} Wi} \quad (1)$$

where Wi is the unit weightage of the parameter; Q_i is the sub-index element; and n is the number of parameters considered.

The unit weightage of each parameter (W_i) is calculated by the following equation:

$$Wi = \frac{k}{Si} \quad (2)$$

Here, k is the factor of proportionality, k is taken equal to one for all metals in the literature (Mohan et al. 1996; Prasad and Mondal 2008), and Si is the permissible limit value in according to WHO guidelines for the assessment of elements (WHO 2011).

The subindex Q_i can be calculated through using the following expression:

$$Q_i = \left(\frac{ci}{Si}\right) x\ 100 \quad (3)$$

Where, c_i is the measured concentration in µg/L.

This index helps estimate the result of the effect of individual heavy metal *concentrations* on water quality and human health. A high Heavy Metal Pollution Index (HPI) value of 100 indicates that the critical threshold for water pollution, with respect to human health, has been reached. If the HPI is greater than 100, the water poses a high-risk water to human health. If the index is less than 100, there is no deleterious pollution for consumers and the water is considered suitable for drinking purposes.

Results and Discussion

Water salinity

The sodium, potassium, calcium, magnesium ion concentrations make up of the salinity, and a coparison with the relative guidelines and standards, are presented in Table 4.

Table 4

Descriptive Statistics of The Chemical Attributes of The Surface Water Samples

Metal (mg/L)	Karapürçek surface water	Karşıyaka surface water	WHO (2022)	TS 266 (2005)
Sodium (Na^+)	0.607580	0.631020	200	175
Potassium (K^+)	0.010224	0.185169	-	12
Magnesium (Mg^{2+})	0.631020	0.956023	-	50
Calcium (Ca^{2+})	3.198252	3.028978	100	200

Ca^{2+}: Calcium is the most abundant member of the salinity metal group of studied water samples. The maximum concentration of Ca^{2+} is ~3.2 mg/L, reported in Karapürçek stream water. Neither samples exceeds the maximum permissible limits of calcium of recommended standards of WHO (2022) and TS 266 (2005).

Mg^{2+}: Magnesium is the fourth most common element in the Earth and founds naturally and in high concentrations in surface and ground water. The maximum amount of magnesium is found in the Karşıyaka water sample, ~0.95 mg/L. The magnesium content of both districts are below the maximum permissible limit of TS 266 (2005).

Na^{+}: Sodium is a highly most abundant member of the metal group distributed widely throughout seawater, lakes, and inland water. Sodium concentrations are similar to each other in both samples of the investigated districts, and are within the permissible limit for WHO (2022) and TS 266 (2005).

K^{+}: Potassium induced the least toxicity among all four salts in the water samples of the investigated area. Potassium is resulted from the chemical decomposition of the sylvite (KCl) and silicates especially clay minerals. The concentrations of potassium are lower than that of sodium concentrations because of slower weathering rate of potassium bearing rocks than those of sodium. Potassium can be added to groundwater through the application of fertilizer and municipal and industrial sewage discharges.

The following crescent order of cation toxicity was observed: $K^{+} < Na^{+} < Mg^{2+} < Ca^{2+}$. Correlating with WHO (2022) and TS 266 (2005) guideline values for drinking water and public health, it may be concluded that the water of the study area is suitable for all drinking and domestic purposes.

Quantification of metal levels

Analysis of nineteen heavy metals (lead, zinc, chromium, manganese, vanadium, copper, cadmium, cobalt, nickel, aluminum, mercury, arsenic, antimony, selenium, boron, beryllium, silver, barium, and thallium) has been conducted during the experimental period for water samples and analysis results obtained are listed in Table5. Results were evaluated by using the limit values given in TS 266 standard, Turkish Water Pollution Control Regulation (TS 266 2005), and WHO (WHO 2022) for drinking water quality.

Table 5

Heavy Metal Concentrations in Karşıyaka, and Karapürçek Surface Water (µg/L)

Metal (µg/L)	Karapürçek surface water	Karşıyaka surface water	WHO (2022)	TS 266 (2005)
Al	0.119342	0.123752	200	200
As	0.041339	0.041002	10	10
Ag	0.004200	0.191206	100	No guideline
B	2.088524	14.913667	2400	1000
Be	<0.000	<0.000	No guideline	No guideline
Cd	<0.000	<0.000	3	5
Co	<0.000	<0.000	No guideline	2000

Cr	0.044974	0.079509	50	50
Cu	0.001104	0.0162129	2000	2000
Fe	0.411341	0.488559	No guideline	200
Hg	0.000365	0.000455	6	0.5
Mn	<0.000	<0.000	200	50
Ni	0.012205	0.044529	20	20
Pb	<0.000	<0.000	10	10
Sb	<0.000	<0.000	20	-
Se	<0.000	0.010570	40	10
Tl	<0.000	<0.000	No guideline	No guideline
V	0.278067	0.172818	No guideline	No guideline
Zn	0.091334	0.112082	No guideline	3000

Be, Cd, Co, Mn, Pb, Sb, Se, Sb, Tl elements could not be detected in the Karapürçek surface water sample and Be, Cd, Co, Mn, Pb, Sb, Tl elements could not be detected in any of the Karşıyaka water. Concentration of heavy metals measured were within WHO (2022) and TS 266 (2005) limits in both districts.

Boron is the element with the highest concentration across all samples. The level of boron in Karapürcek surface water, when consumed as drinking water, does not pose a health risk based on the estimated human exposure dose.

Iron and zinc are not of health concern at levels causing acceptability problems in drinking-water according to WHO (2022) regulation. Both iron and zinc contents are below the maximum permissible limit of TS 266 (2005) in investigated districts.

Al, As, Cr, Cu and Ni concentrations are within the permissible limit for WHO (2022) and TS 266 (2005) in study areas.

Although Be is a metal that can cause serious health issues in humans, there is no limit value in WHO, and TS 266 (2005) regulations because Be levels in water are too low. Be content of samples is below detection limits. In Karapürçek surface water, concentrations were: boron > iron > silver > vanadium > aluminum > zinc > chromium > nickel > arsenic> copper > mercury> beryllium = cadmium = cobalt= manganese = lead = antimony = selenium = thallium. In Karsıyaka surface water, concentrations were: boron > iron > silver > vanadium > aluminum > zinc > chromium > nickel > arsenic> copper > selenium > mercury> beryllium = cadmium = cobalt= manganese = lead = antimony = thallium. Consequently, the water quality of both districts was found to be 1st class according to the criteria of WPCR in Türkiye.

To evaluate the quality of water samples, the HPI was calculated. HPI calculations are illustrated in Table 6,7.

Table 6

HPI calculations for Karapürçek surface water sample based on mean heavy metals concentration

Metal (μg/L)	Karapürçek surface water concentration (C_i)	Standard permissible value (S_i)	Weightage ($W_i = 1/S_i$)	Sub-index (Q_i)	$W_i \times Q_i$
Al	0.119342	200	0.0050	0.059670	0.000298
As	0.041339	10	0.100	0.413395	0.041339
Ag	0.004200	No guideline	-	-	-
B	2.088524	2400	0.000416	0.087021	0.000036
Be	<0.000	No guideline	-	-	-
Cd	<0.000	3	-	-	-
Co	<0.000	No guideline	-	-	-
Cr	0.044973	50	0.0200	0.008994	0.000179
Cu	0.001103	2000	0.0005	0.000055	2.7×10^{-7}
Fe	0.411341	No guideline	-	-	-
Hg	0.000365	6	0.1666	0.006087	0.010140
Mn	<0.000	200	-	-	-
Ni	0.012205	70	0.01428	1.7×10^{-4}	0.000002
Pb	<0.000	10	-	-	-
Sb	<0.000	0.005	-	-	-
Se	<0.000	40	-	-	-
Tl	<0.000	No guideline	-	-	-
V	0.278067	No guideline	-	-	-
Zn	0.091334	No guideline	-	-	-
∑W_i: 0.86688	**∑ $W_i \times Q_i$:** 0.051997	**Mean HPI:** 0.059982			

Table 7

HPI calculations for Karşıyaka surface water sample based on mean heavy metals concentration

Metal (μg/L)	Karşıyaka surface water Concentration (C_i)	Standard permissible value (S_i)	Weightage ($W_i = 1/S_i$)	Sub-index (Q_i)	$W_i \times Q_i$
Al	0.123752	200	0.0050	0.000618	0.000003
As	0.041002	10	0.100	0.410020	0.041002
Ag	0.191205	No guideline	-	-	-
B	14.913667	2400	0.000416	0.621402	0.000258
Be	<0.000	No guideline	-	-	-
Cd	<0.000	3	-	-	-
Co	<0.000	No guideline	-	-	-
Cr	0.079509	50	0.0200	0.159018	0.003180
Cu	0.016212	2000	0.0005	8.1×10^{-6}	4.0×10^{-9}
Fe	0.488559	No guideline	-	-	-
Hg	0.000455	6	0.1666	0.007598	0.002658
Mn	<0.000	200	-	-	-
Ni	0.044529	70	0.01428	6.3×10^{-5}	9.0×10^{-7}
Pb	<0.000	10	-	-	-
Sb	<0.000	0.005	-	-	0.072646
Se	0.010570	40	0.025	0.000264	6.6×10^{-6}
Tl	<0.000	No guideline	-	-	-
V	0.172818	No guideline	-	-	-
Zn	0.112081	No guideline	-	-	-
Wi:	**∑ $W_i \times Q_i$:**	**Mean PI:**			
0.33179	0.119756	0.609420			

Contamination status of water samples was determined through the HPI (Table 6,7). The HPI recorded in the study area for the Karapürçek surface water and the Karşıyaka surface water was 0.0599 and 0.6094 suggesting that the HPI for both samples is within the category of low heavy metal pollution according to Sobhanardakania et al. (Sobhanardakania et al. 2016). Apparently, HPI based on all heavy metals indicated that both of the area had good quality water.

CONCLUSION

As a result, it is crucial to comprehend the water quality and the levels of heavy metals in water resources. The characteristics of water resources affect aquatic life and human well-being. In this study, the salt ions and heavy metal content of surface water samples from the Karşıyaka and Karapürçek neighborhoods in Ankara was investigated in terms of 4 major ions (Na, Ca, K, Mg) and 19 heavy metals (Pb, Zn, Cr, Mn, V, Cu, Cd, Co, Ni, Al, Hg, Ar, Mo, Sb, Se, B, Be, Ag, and Tl).

The mean concentration of major cations in the groundwater samples is $Ca^{+2} > Mg^{+2} > Na^{+} > K^{+}$. Concentrations of calcium, magnesium, sodium, and potassium of all the samples are within the permissible limit. In Karapürçek surface water, concentrations were: B > Fe > Ag > V > Al > Zc > Cr > N > As> Cü > Hg> Be = Cd = Co= Mn = Pb = Sb = Se = Tl. In Karsıyaka surface water, concentrations were: B > Fe > Ag> V > Al > Zr > Zn > Cr > Ni > As> Cu> Se > Hg> Be = Cd = Co= Mn = Pb = Sb = Tl. According to the TS 266 (TS 266, 2005) and the WHO (WHO, 2022) criterias, the surface water of Karşıyaka and Karapürçek neighborhoods were classified as 1st class water for all metals. Both sampling areas show HPI values lower than 100, indicating that these locations were likely to have low pollution from heavy metals.

Further research works can be taken to show the seasonal variation of the parameters of the water resources in the investigated area.

Etik

Bu araştırma insan veya hayvan denekleri içermemektedir ve etik onay gerekmemektedir. Yazarlar, bu çalışma ile ilgili herhangi bir etik endişe olmadığını beyan ederler. Bu araştırma ile ilgili etik sorularınız için lütfen izufbed@izu.edu.tr adresine başvurun.

Katkı Oranı Beyanı

D. Şahin araştırmayı kavramsallaştırdı, çalışmayı tasarladı, makaleyi yazdı ve düzeltti. S. M. Muhammet makaleyi gözden geçirdi. F. Şahin deneysel çalışmaya katkıda bulundu.

Destek ve Teşekkür Beyanı

Çalışma herhangi bir destek almamıştır.

Çatışma Beyanı

Yazarlar bu araştırma makalesinin araştırma, yazma ve/veya yayınlanmasına ilişkin herhangi bir kurum ve/veya kişi ile potansiyel çıkar çatışması beyan etmemiştir.

Ethical Considerations

This research did not involve human or animal subjects, and no ethical approval was required. The authors declare no ethical concerns related to this study. For ethical inquiries regarding this research, please contact: izufbed@izu.edu.tr

Author Contributions

D. Sahin conceptualized the research, designed the study, and wrote and revised the manuscript. S. M. Muhammet reviewed the manuscript. F. Sahin contributed to the experimental work.

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Conflict of Interest

The authors have no conflicts of interest to declare related to the research, writing, or publication of this manuscript.

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