DETERMINATION OF CONTAMINANTS IN DRINKING WATER IN YOZGAT, TURKEY

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ABSTRACT

The aims of this study were to (1) ascertain the quality of diffused spring (drinking) water supplied to the city of Yozgat-Turkey for human consumptionby measuringthe major and trace elements, (2) compare the quality of the drinking water with valid international limit values, and (3) evaluate compliance with respect to International Agency for Research on Cancer (IARC) and World Health Organization (WHO) guidelines considering the occurrence of toxic and harmful elements in drinking water. All collected drinking water samples were analyzed in the Bozok University Science and Technology Application and Research Center (BILTEM) toxicology laboratory. The anions and cations of the water samples were analyzed by ion chromatography and the selected elements of the water samples were investigated using inductively coupled plasma–mass spectrometry (ICP-MS). The concentrations of contaminants were evaluated, and the levels of some parameters were above the WHO-specified maximum contaminant levels. This is the first study to investigate drinking water data for the province of Yozgat. It is also the first study to evaluate comprehensive parameters for drinking water in Turkey.

Key words: Contamination, Drinking water, Toxicity, Turkey

INTRODUCTION

Water is a precious resource for sustaining life and ensuring the preservation of ecosystems. Its quality is influenced by climate, weather, soil geology, and discharges from agriculture and industry (Cidu et al., 2011; Cohen and Cantor

2014). Water is a superb solvent and potentially a medium for human exposure to a large number and variety of carcinogens (Cantor, 1997; Aydin and Soylak, 2009; Hu et al., 2010). Population growth coupled with rapid urbanization is puttingincreasing pressure on water resources. Exposure to drinking water with certain water contaminants can lead to adverse health effects varying from shortness of breath to several types of cancers (stomach, lung, and thyroid) (Cantor, 1997; Dogan and Soylak 2002; Kavcar et al., 2009; Smith and Steinmaus, 2010). Iron, copper, manganese, and zinc are essential for living organisms at specific concentrations, and toxic effects are observed when their concentrations increase (Kavcar et al., 2009). There are rising public concerns related to human health-based guideline values for overall elements whosehealth-affecting concentrations are not known (Schriks et al., 2010). Some trace elements such as As, Cr, Pb, Br, and NO_3 in drinking water have the ability to cause adverse health effects after prolonged periods of exposure, according to resolutions of the International Agency for Research on Cancer (IARC) and World Health Organization (WHO) (Matsuoka et al., 1999; Jackson 2001; Soylak et al., 2002; IARC 2004; Akbulut and Akbulut, 2010; WHO 2011; Cohen and Cantor 2014; Karakulak et al., 2017; Büyükşekerci et al., 2017). These trace elements are major drinking water pollutants, and their presence is usually a result of industrial pollution from tanning factories, steel works, industrial electroplating, wood preservation, and artificial fertilizers (Aydin and Soylak, 2009). Chromium has two species (Cr^{III} and Cr^{VI}) that are soluble in water with stableoxidation states (Sun et al., 2006; Ren et al., 2007). Hexavalent chromium is classified as a class A carcinogen and causes lung and stomach cancer following ingestion of drinking water (Mondal et al., 2002;Sun et al., 2006; Ren et al., 2007; Meeravali and Jiang, 2009; Hu et al., 2010). On the other hand, Cr^{III} isrelatively non-toxic (inert) and essential for the proper functioning of mammals (maintenance of glucose, lipid, and protein metabolism), but $Cr^{III}$is interconvertible to Cr^{VI} in natural water (Sun et al., 2006; Ren et al., 2007; Aydin and Soylak, 2009). It has been reported that Cr^{VI} is easily reduced by Fe^{2+}, dissolved sulfides, and certain organic compounds with sulfhydryl groups (Matsuoka et al., 1999). Cr^{VI} in fresh water can also be reduced at a considerable rate by organic matter such as tannic acid and some humic substances even at neutral pH. On the other hand, Cr^{III} is oxidized rapidly by a large excess of MnO_2 and slowly by dissolved oxygen at conditions approximating natural water. The two species of chromium depend mainly on the redox potential and the pH of natural water; above a pH of 7, Cr^{III} predominates, while below pH 6, Cr^{VI} is the major species (Mondal et al., 2002).

Yozgat is a city in the Middle Anatolia Region of Turkey (Figure 1). The main industries in Yozgat are textiles, food, cement, manufacturing, and metallurgy. The population in Yozgat city center is approximately 100,000 (Soylak et al., 2002).

According to the WHO drinking water quality guidelines and IARC monographs on the evaluation of carcinogenic risks to humans in drinking water, the permissible limits of major elements are Ca: 75.000 mg L^{-1}, K: not available, Mg: 50.000 mg L^{-1}, Na: 200.000 mg L^{-1}, F: 1.500 mg L^{-1}, Cl: 200.000 mg L^{-1}, NO_3: 50.000mg L^{-1}, and SO_4: 200.000 mg L^{-1}. The permissible limits of trace elements are Al: 0.200 mg L^{-1} , Cr: 0.050 mg L^{-1}, Mn: 0.400 mg L^{-1}, Fe: 1.000-3.000 mg L^{-1}, Ni: 0.070 mg L^{-1}, Cu: 2.000 mg L^{-1}, As: 0.010 mg L^{-1}, Se: 0.010 mg L^{-1}, Cd: 0.003 mg L^{-1}, Sb: 0.020 mg L^{-1}, Pb: 0.010 mg L^{-1}, Br: 0.010 mg L^{-1} , PO_4:not available,and NH_4: 1.500mg L^{-1}(IARC 2004; WHO 2006; Akoto and Adiyiah 2007; Bhattacharya et al., 2009; Ramakrishaiah et al., 2009; Abdel Baki et al., 2011; Muhammad et al., 2011; WHO 2011; Kumar and Puri 2012; Khan et al., 2013).



Figure 1. A map of Yozgat province, Turkey

The aims of this study were (1) to ascertain the quality of diffused spring (drinking) water supplied to the city of Yozgat-Turkey for human consumption by evaluating the major and trace elements, (2) to compare the quality of drinking water with valid international limit values, and (3) to evaluate compliance with IARC and WHO guidelines for the occurrence of toxic and harmful elements in drinking water. Inductively coupled plasma-mass spectroscopy (ICP-MS) and ion chromatography (IC) were used to evaluate the accumulation levels of the major elements (Ca, K, Mg, Na, F, Cl, NO_3, and SO_4) and trace elements (Al, Cr, Mn, Fe, Ni, Cu, As, Se, Cd, Sb, Pb, Br, PO_4, and NH_4) in the collected drinking water samples.

MATERIALS AND METHODS

Study Area. Water samples were collected from 23 different natural spring water fountains located in different areas of Yozgat city center, Turkey (Figure 2 and Figure 3). The samples were directly placed into 50 mL falcon tubes on the same day and were stored at 4°C for one night before analysis.



Figure 2. A natural spring (drinking) water fountain examples



Figure 3.Locations of natural spring water fountainsin Yozgat

Sample Preparation. For IC analysis, the collected water samples were used directly to measure anions (F^-, Cl^-, NO_2, Br^-, NO_3^-, PO_4^{3-}, and SO_4^{2-}) and cations (Li^+, Na^+, NH_4^+, K^+, Mg^+, and Ca^+). Multi-element solutions (anion: Dionex-Seven Anion Standard II; cation: Dionex-Six Cation-II Standard) diluted with ultrapure water (Merck Millipore - Direct-Q® 8 UV) were used to prepare calibration solutions.

For ICP-MS analysis, the collected water samples were acidified (1:1 ratio) with HNO_3 (2%, v/v, ultrapure grade Merck) for determination of selected elements. Single-element (Sr, Chem-Lab-CL01.1967.0500; Si, Chem-Lab-CL01.1936.0500) and multi-element (Mo and Sb, Inorganic Ventures-Denge-24; Bi, Li, and Tb, Inorganic Ventures-

Denge-26; Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Tb, Th, Tm, U, Y, and Yb, Inorganic Ventures-CMS-1; Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, and Zn, Inorganic Ventures-6020CAL-1; B, Hg, Rb, and Te, Chem-Lab-CL01.39205.0100) solutions diluted with ultrapure water (Merck Millipore - Direct-Q® 8 UV) were used to prepare calibration solutions.

Sample analysis. All collected drinking water samples were analyzed in the Bozok University Science and Technology Application and Research Center (BILTEM) toxicology laboratory.
IC: The anions and cations of the water samples were analyzed with a DIONEX ICS-5000. A Dionex™ IonPac™ AS19columnandaDionex EGC III KOH mobile phase were used for anion separation. A Dionex™ IonPac™ CS12A column and a Dionex EGC III MSA mobile phase were used for cation separation.
ICP-MS: The selected elements of the water samples were analyzed using a Thermo Scientific Icap-Qc. All standard and sample solutions were analyzed three times, and the average of three responses isreported.

RESULTS

In our study, we determined the quality of the water consumed as drinking water, which has gained importance in recent years, and evaluated it in terms of various contaminants. Descriptive statistics including the mean, standard deviation, median, minimum, and maximum values of the collected drinking water samples are summarized in Table 1. The analysis results of some cations (ammonium (NH_4^+)) and anions (nitrite (NO_2^-), bromide (Br^-), phosphate (PO_4^3) are not included in Table 1 because of insufficient levels of detection.

Table 1. Descriptive statistics for drinking water obtained from different places in Yozgat province, Turkey

Elements (N=23)	Unit	Mean	Std. Deviation	Median	Minimum	Maximum	Limit*	LOD
Silver (Ag)	µg/L	0.30	0.08	0.30	0.13	0.41	100	0.011
Aluminium (Al)	µg/L	71.04	137.39	11.08	0.00	567.01	200	4.307
Arsenic (As)	µg/L	1.89	1.87	0.50	0.00	5.66	10	0.026
Boron (B)	µg/L	78.15	53.47	56.60	21.20	217.27	2400	6.507
Barium (Ba)	µg/L	32.18	46.89	12.51	1.64	206.59	700	0.072
Beryllium (Be)	µg/L	0.02	0.01	0.02	0.01	0.04	0.2	0.011
Bismuth (Bi)	µg/L	0.00	0.00	0.00	0.00	0.01	0.00	0.005
Calcium (Ca)	mg/L	80.71	47.70	67.71	0.00	165.18	75	11.626
Cadmium (Cd)	µg/L	0.04	0.04	0.03	0.00	0.20	3	0.024
Cerium (Ce)	µg/L	0.04	0.14	0.00	0.00	0.67	0.00	0.006
Chloride (Cl)	mg/L	27.20	32.14	15.83	2.05	134.54	250	0.028
Cobalt (Co)	µg/L	0.19	0.24	0.09	0.00	1.04	5	0.303
Chromium (Cr)	µg/L	1.92	2.03	1.75	0.00	7.19	5	0.021
Copper (Cu)	µg/L	1.10	1.12	0.70	0.07	4.51	2000	0.002
Disprosium (Dy)	µg/L	0.01	0.03	0.01	0.00	0.16	0.00	0.004
Erbium (Er)	µg/L	0.01	0.02	0.01	0.00	0.11	0.00	0.004
Europium (Eu)	µg/L	0.01	0.02	0.01	0.00	0.06	0.00	3.784
Fluoride (F)	mg/L	0.14	0.05	0.13	0.04	0.32	1.5	Yok
Iron (Fe)	µg/L	624.41	321.08	612.9	156.08	1205.43	200	0.003
Gadolinium (Gd)	µg/L	0.02	0.03	0.01	0.00	0.17	0.00	0.00
Mercury (Hg)	µg/L	1.22	0.78	0.92	0.60	3.76	6	0.004
Holmium (Ho)	µg/L	0.00	0.01	0.00	0.00	0.04	0.00	1.299
Potassium (K)	mg/L	44.84	26.69	35.09	7.67	97.23	12	0.008
Lanthanum (La)	µg/L	0.04	0.11	0.01	0.00	0.55	0.00	0.038

Elements (N=23)	Unit	Mean	Std. Deviation	Median	Minimum	Maximum	Limit*	LOD
Lithium (Li)	µg/L	1.10	0.89	0.88	0.12	4.13	200	0.004
Lutetium (Lu)	µg/L	0.00	0.00	0.00	0.00	0.02	0.00	1.377
Magnesium (Mg)	mg/L	21.05	10.18	19.4	3.46	38.46	50	0.048
Manganese (Mn)	µg/L	7.94	13.73	2.96	2.30	51.78	400	0.022
Molybdenum (Mo)	µg/L	1.16	1.03	1.03	0.01	4.81	70	5.282
Sodium (Na)	mg/L	13.81	8.16	11.52	3.85	42.51	200	0.008
Neodymium (Nd)	µg/L	0.05	0.12	0.02	0.00	0.56	0.00	0.345
Nickel (Ni)	µg/L	13.39	1.90	12.99	10.63	17.10	70	0.028
Nitrate (NO_3)	mg/L	14.52	12.39	12.15	0.61	44.10	50	0.004
Lead (Pb)	µg/L	0.07	0.29	0.00	0.00	1.38	10	0.001
Praseodymium (Pr)	µg/L	0.01	0.03	0.00	0.00	0.13	0.00	0.004
Rubidium (Rb)	µg/L	0.87	0.51	0.76	0.14	2.74	0.00	0.333
Antimony (Sb)	µg/L	0.04	0.02	0.04	0.01	0.10	20	0.005
Selenium (Se)	µg/L	0.72	0.58	0.56	0.00	1.73	10	0.053
Samarium (Sm)	µg/L	0.01	0.03	0.00	0.00	0.13	0.00	0.004
Sulphate (SO_4)	mg/L	41.52	31.54	26.76	7.31	94.94	200	0.023
Strontium (Sr)	µg/L	401.04	197.47	417.73	54.92	856.05	0.00	0.009
Terbium (Tb)	µg/L	0.00	0.01	0.00	0.00	0.03	0.00	0.003
Tellurium (Te)	µg/L	0.17	0.04	0.16	0.09	0.27	0.00	0.003
Thorium (Th)	µg/L	0.01	0.03	0.00	0.00	0.10	0.00	0.003
Thallium (Tl)	µg/L	0.01	0.01	0.01	0.00	0.02	2	0.043
Thulium ™	µg/L	0.00	0.00	0.00	0.00	0.02	0.00	0.006
Uranium (U)	µg/L	1.79	1.30	1.92	0.06	5.62	30	0.004
Vanadium (V)	µg/L	10.37	8.26	8.63	0.61	29.65	100	1.599
Yttrium (Y)	µg/L	0.15	0.26	0.09	0.01	1.30	0.00	0.011
Ytterbium (Yb)	µg/L	0.01	0.02	0.00	0.00	0.10	0.00	4.307
Zinc (Zn)	µg/L	3.46	5.46	1.83	0.00	24.68	5000	0.026

** Schrauzer et al. 1990; FDH-BEH, 2015; WHO, 2000, 2006, 2011*

Surface and ground waters such as rivers, lakes, and reservoirs are main sources of drinking water (US EPA, 2010). These sources are in continuous contact with each other, rainfall, and other natural deposit systems (Winter ve Ark, 1998). Underground waters are one of the most important natural resources.Most US citizens use underground water as drinking water; therefore, it is important to protect these sources against various contaminants (Halberg et al., 2014). In some cases, groundwater can contain hazardous chemical components that threatenhealth. In Turkey, especially in the Central Anatolia Region, fountains that are fed from underground water sources are a significant source of drinking water for people and animals.

Contaminated underground drinkingwater poses a great risk to humans (Chanpiwat et al., 2011). Many people are at risk of metal poisoning because of the natural presence of metal contaminants in many parts of the world. Heavy metal pollution in the aquatic ecosystem has reached alarming proportions and has become a major problem worldwide (Malik et al., 2010). There have been many studies conducted to evaluate various contaminants in drinking water in terms of community and public health. The heavy metal concentrations in underground drinking water are reported to be above the limits defined by the WHO (World Health Organization) in many Asian countries such as India, Bangladesh, Nepal, Mongolia, China, Thailand, Myanmar, Cambodia, Indonesia, and Vietnam (Buschmann et al., 2008; Winkel et al., 2008; Frisbie et al., 2009; Luu et al., 2009; Pokhrel et al., 2009; Rahman et al., 2009; Mondal et al., 2010; Chanpiwat et al., 2011).

In particular, heavy metals bioaccumulate through food chains and create a variety of health risks in humans (Agah et al., 2009). High heavy metal concentrations were also detected in various regions in Turkey (Caliskan et al., 2009; Coskun et al., 2012). Tanir et al. compared 80 spring (drinking) samples with respect to 11 parameters and found that the high values of heavy metals in collected samples were due to exposure to waste and pesticides (Tanir et al., 2011). In another study conducted in water wells, various contaminants were detected at high concentrations (Akbaba et al., 1998). The aim of this study was to investigate the levels and causes of pollutants in water used as

drinking water by people in Turkey. For this purpose, we selected the fountains most commonly used by people for drinking water in the center of Yozgat. The samples were collected and analyzed, and the results were statistically evaluated. For all contaminants, calibration curves were obtained using standards (7-11 standard points for each parameter) over a range of concentrations. While some of the calibrations were not included in the zero point of the curves, the calibration starts at a point close to the detection limit. Ultra-pure water was used as a control variable. For this analysis, Hafnium (Hf) was used as an internal standard for various contaminant parameters. The comparison of data obtained for the Central Anatolian Region of Yozgat Province and various water sample results from around the world is presented in Table 2.

Table 2. Comparison of the concentrations of contaminants obtained from the scientific literature and this study

Location	Type	n	Ag [b]	Al [b]	As [b]	B [b]	Ba [b]	Be [b]	Bi [b]	Ca [m]	Cd [b]	Ce [b]	References
Yozgat, Turkey	Groundwater	23	0.30±0.08	71.04±137.4	1.89±1.87	78.15±53.15	32.18±46.89	0.02±0.01	0.00±0.00	80.71±47.7	0.04±0.04	0.04±0.14	Our study
Tarkwa, Ghana	Borehole	12	0.15±0.11		1.3±1.1		69±143		0.02±0.04		0.06±0.05		Asante et al., 2007
	Well	6	0.18±0.06		0.2±0.4		47±36		<0.01		0.06±0.01		
Accra, Ghana	River/stream	12	0.21±036		18.0±24.0		30±18		<0.01		0.04±0.05		
	Tap	1	0,01		<0.1		38		<0.01		<0.01		
Gia Lam-Hanoi, Vietnam	Groundwater	11	<0.01		10.8±14.2		410±240		<0.01		0.04±0.05		Agusa et al., 2006
Thanh Tri-Hanoi,Vietnam		14	0.06±0.20		44.0±88.2		250±170		0.01±0.02		0.12±0.21		
Riyadh, Saudi Arabia	Households	101			n.d			0.13±0.22			1.36±2.82		Al-Saleh and Al-Doush, 1998
South Phnom Penh,Cambodia	Groundwater	132			<1-1300		12-4200			1.1-220	<0.1-2.3		Buschmann et al., 2007
North Phnom Penh,Cambodia		108			<1-1150		19-970			1-220	<0.1-0.2		Buschmann et al., 2008
Mekong, South Vietnam		112			<1-850		1-2900			0.5-620	0.1-5.0		Buschmann et al., 2008
Tuskegee,AL, USA	Lake	1	0.19±0.35	173.2±52.6	0.06±0.23		47.49±9.5	n.d		4.88±1.26	n.d		Ikem et al., 2003
		1	0.53±0.52	155.1±153.3	0.6±2.2		22.0±7.7	0.1±0.2		6.82±1.89	0.001±0.005		
Nanjing, China	Yangtze River	101		89±122	10.0±8.0	10±8	59±12			35.57±4.9			Wu et al., 2009
South Norway	Groundwater	28		15-431	<0.1-2.5	n.d.-44	42-84	0.04-2.0	0.05-0.09	25.95-43.27	0.01-0.09		Banks and Reimann, 1995
Pu-Tai, Taiwan	Well water	18			671±149		146±116			25.2±13.4	0.09±0.02		Chen et al., 1995
I-Lan, Taiwan					653±71		11±6			15.7±4.25	0.06±0.01		
Hsin-Chu, Taiwan					<0.7		47±30			55.2±38.7	0.10±0.04		
Attapeu, Laos	Mekong River	10	<0.02	20.72-31.18	n.d	88.06-339.90	179.2-800.9						Chanpiwat et al., 2011
Bolikhamxai, Laos		7	<0.02-1.67	6.16-110.6		16.43-130.70	95-1539						
Champasak, Laos		26	<0.02-1.49	13.16-518.2		22,73-1926	<0.03-2.59						
Saravane, Laos		11	<0.02-1.25	8.40-80.91		24,65-853	174,5-3107						
Savannakhet, Laos		4	<0.02-0.60	<0.44-73.63		127-1997	335,1-5174						
Vientiane, Laos		3	<0.02-	31.36-334.3		5.17-20.91	20.47-109.7						

As seen in Table 2, we obtained valuesclose to or lower than the average values of drinking waters from different regions of the world. For example, in the study conducted by Asubiojo et al. (1997) in Nigeria, arsenic concentrations in drinking water are close to our values, while in the Banks and Reimann (1995) study, the values were twice as low in Norway. Our boron levels are similar to the results of the Chanpiwat et al. (2011) study conducted in Laos. However, the levels of cadmium in our drinking waters are similar to those obtained in Ghana (Asante et al., (2007)) and Vietnam (Agusa et al., (2006)), while our values were 30 times lower than those obtained in studies conducted in China (Li et al., (2008)) and Saudi Arabia (Al-Saleh and Al-Doush, (1998)).

Our chlorine concentration results are almost the same as those obtained in thestudy conducted by Banks and Riemann (1995) in Norway (2.05-134.54 µg/L and 0.1-101 µg/L, respectively). The same similarity is observed in the Agusa et al. (2006) study regarding the average chromium concentrations (1.92±2.03 µg/L (our study), 2.1±0.37 µg/L, and 2.2±0.45 µg/L).

It was determined that almost all of the analyzed samples had iron levels far above the international permissible values (about 3 times). As seen in Table 2, our results are also 4 to2 times higher than the results of other studies (Al-Saleh and Al-Doush, 1998; Ikem et al., 2003, respectively). At the same time, it was also found that the iron levels obtained at the other locations were much higher than those measured in our study. The fluoride level in our

drinking water, which is important in terms of reduced stature in children, wasfound to be much lower than those obtained in Norway (Banks and Reimann, 1995) and Ethiopia (Reimann et al., 2003) (0.04-0.32 mg/L, 0.05-4.5 mg/L, and 0.05-11.6 mg/L, respectively).

Similar to the iron levels, ourmercury levels also exceeded the international permitted values (average 1.22±0.78 µg/L). The results shown in Table 2 are relatively higher than those obtained in previous studies except forriver samples analyzed by Li and Zhang (2010).

There were similarities between our study and other studies in terms of nickel and nitrate concentrations (Ni: 12.99±1.9 µg/L and 10.79±25.80 µg/L (Al-Saleh and Al-Doush, 1998); NO_3: 0.61-44.1 mg/L and <0.2-43 mg/L, respectively) (Buschmann et al., 2007). Similar results were obtained for lead levels (0.07±0.29 µg/L and 0.08±0.09 µg/L, respectively) (Agusa et al., 2006). In terms of sulfate concentrations in drinking water, a value of 41.52±31.54 (7.31-94.94) mg/L was obtained in our study, whereas the result was 0.07-4.25 mg/L in a study conducted in Argentina (Nicolli et al., 1989). In other words, although the levels of sulfate were below the international permitted values (<200 mg/L) in Yozgat drinking water, they were well above the results of other studies (Ikem et al., 2003; Banks and Reimann 1995) listed in Table 2. However, in Buschmann's (2008) study carried out in Cambodia and Vietnam, much higher results were obtained compared to our study (<5-210 mg/L and <5-360 mg/L, respectively). The zinc levels obtained in our study were much lower than levels obtained in previous studies (average 3.46±5.46 µg/L). There were highly positive (for example, Pb with Bi, Cd, Cu,Sm,Pr; Cr with Fe, SO_4, NO_3,Ni; $p<0.01$), positive (for example, Cd with Co, Ni, Eu; $p<0.05$), highly negative (for example, Ag with Hg, F, Mo; $p<0.01$),and negative (for example, Th with Ni, Se, Sr; $p<0.05$) significant correlations among the various contaminants.

CONCLUSIONS

In conclusion, the data obtained in our study are considered the first of their kind in Turkey, and this is also the first study to include spring (drinking) water data published for Yozgat province. Although these results provide a general indication of contamination, it is worth noting that certain parameters were above the maximum levels of pollutants specified by theWHO. Look-alike concentration heights are encountered in the world, in other words the levels of contaminations in the spring (drinking) water is similar to other studies. However, closer monitoring of these values for more severe fluctuations is important for public health, because these water sources have been used as drinking water widely by region people. We expectedthe results to be higher for some parameters but believe that it is a normal situation to obtain some low levels because we performed the study during a month of heavy rains (March, 2017), which makes spring (drinking) water more diluted. It is envisaged that the etiology of the above relations can be explained and that more resources of spring (drinking) water are to be studied so that the region can be fully represented in terms of the values found.

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