Advances in Bioresearch
Adv. Biores., Vol 6 (5) September 2015: 156-162
©2015 Society of Education, India
Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
ICV 7.20 [Poland]

Advances in Bioresearch

ORIGINAL ARTICLE

Evaluation of Heavy Metals Concentration in Drinking Water Resources in the cities of Kurdistan province

Seyyed Jamal Aldin Ebrahimi[1], Leila Ebrahimzadeh [2§]
[1] Department of Environmental Health Engineering, water and wastewater health, Kurdistan University of Medical Sciences, Sanandaj, Iran
[2] Department of Environmental Health Engineering, water and wastewater health, Kurdistan University of Medical Sciences, Sanandaj, Iran
Email addresses: Leila.e980@gmail.com

ABSTRACT
Because of solubility in water and lack of appropriate mechanisms for removal from the body, heavy metals are extremely toxic, even in small quantities. The main threats of heavy metals to human health are caused by exposure to lead, cadmium, mercury, and arsenic. The aim of this study was to measure the concentrations of the heavy metals, including mercury, arsenic, chromium, and lead in drinking water resources in different cities of Kurdistan province. This study was a cross sectional descriptive study which was carried out in the spring of 2012. In this study, 96 samples were taken from 96 water resources in different cities of Kurdistan province. The samples were moved to the laboratory in 500 ml glass containers; they were analyzed in the reference laboratory of water chemicals and waste water using a Polarograph manufactured by Metrohm company, Switzerland, and the method recommended by standards book was utilized for the analysis. The collected data was analyzed using SPSS software; given the normality of the data, they were analyzed via statistical correlation tests of one sample t- test, one way ANOVA, and paired t-test at a significance level of 0.05. The results of this study showed that all the four heavy metals i.e. lead; chromium, arsenic, and mercury were simultaneously present in 79 out of the 96 drinking water resources of the cities of Kurdistan province; however they differed in distribution and concentration. We found chromium in 84 resources, arsenic in 82 resources, and lead and mercury in 79 resources out of the 96 studied resources of drinking water in the cities of Kurdistan province. The concentrations of mercury, lead, and arsenic in 3.8%, 3.7%, and 2.1% of the resources, respectively, were more than the maximum contaminant level by the World Health Organization. The amount of lead in a number of wells in Bijar, Ghorveh, Bane, and Sarvabad, the amount of arsenic in one of the wells supplying the water of Bane and Diwandareh, and the amount of mercury in a number of water resources in Diwandareh, Sanandaj, Sarvabad, and Sanandaj dam exceeded the maximum contaminant level determined by the World Health Organization. The concentrations of the studied metals in the water resources of Saghez, Marivan, Kamyaran, and Dehgolan did not exceed the maximum allowable concentration.
Keywords: *heavy metals, resources of water supply, drinking water, Kurdistan*

Received 04.05.2015 Accepted 24.08.2015

How to cite this article:
Seyyed Jamal A E, Leila E. Evaluation of Heavy Metals Concentration in Drinking Water Resources in the cities of Kurdistan province. Adv. Biores., Vol 6 [5] September 2015:156-162**.** DOI: 10.15515 /abr.0976-4585.6.5.156162

INTRODUCTION

Due to the increasing need for safe drinking water, the quality management of ground water in developing countries is very critical and important [1]. Heavy metals are among the most important pollutants of water resources and their high concentrations may have dangerous effects on the environment and especially on human health [2, 3, and 4].

Because of solubility in water and lack of appropriate mechanisms for removal from the body, heavy metals are extremely toxic, even in small quantities [5]. The main threats of heavy metals to human health are caused by exposure to lead, cadmium, mercury, and arsenic [6]. Arsenic can enter human body in various ways, including air, water, and food; water is the most popular route [7]. Arsenic contamination of drinking water resources has been reported in more than 70 countries and it has led to serious toxicity in 150 people all over the world [8].

Studies on populations exposed to arsenic through drinking water have found that arsenic can increase the mortality from lung, bladder, and kidney cancers; it has been shown that increased exposure leads to the increased risk [9]. According to a study in Chile by Liaw et al., exposure to arsenic through drinking water during childhood can increase the number of deaths from liver cancer [10]. According to World Health Organization guidelines and Environmental Protection Agency of the United States, the maximum allowable concentration of arsenic in drinking water is 0.01 mg/l [11, 12].

Lead is one of the most common metals that have some effects on the central nervous system. Lead can cause negative effects and is associated with physical, learning, and memory defects and disorders; it even can cause cognitive, behavioral, and mental health problems in children [13]. According to World Health Organization guidelines and Environmental Protection Agency of the United States the maximum allowable concentration of lead in drinking water is 0.01 mg/l and 0.015 mg/1, respectively [11, 12]. Exposure to mercury can also lead to mental disorders and impaired speech, hearing, vision, and movement [15]. According to World Health Organization guidelines and Environmental Protection Agency of the United States, respectively, the maximum allowable concentration of mercury and chromium in drinking water is 0.001 mg/l and 0.002 mg/l for mercury, and 0.05 mg/l and 0.1 mg/l for chromium [11, 12].

No study has been conducted yet to investigate heavy metal concentrations in drinking water resources of the cities of Kurdistan province. Hence, this study was aimed to evaluate and measure the concentration of heavy metals including mercury, arsenic, chromium and lead in drinking water resources of the cities of Kurdistan province, to identify potential threats posed by high levels of heavy metals.

MATERIALS AND METHODS

This study was a cross sectional descriptive study that was carried out to collect some information about the chemical status of drinking water in different cities of Kurdistan province in the spring of 2012. Kurdistan province has 10 cities including Sanandaj, Saghez, Bane, Marivan, Ghorveh, Bijar, Kamyaran, Diwandareh, Sarvabad, and Dehgolan. The drinking water for residents of these cities is provided by 96 water resources and reservoirs which are listed in Table 1.

Table 1: Number and type of drinking water resources in different cities of Kurdistan province

City	Number of water resources		Total	Number of samples
	Ground	Surface		
Bijar	16	-	16	16
Kamyaran	9	-	9	9
Ghorveh	19	-	19	19
Dehgilan	3	-	3	3
Baneh	9	1	10	10
Divandarreh	7	-	7	7
Sarvabad	3	-	3	3
Saghez	4	1	5	5
sanandaj	2	1	3	3
Marivan	21	-	21	21
Total	93	3	96	96

Given the importance of measurement and assessment of heavy metals in drinking water, the present study was aimed to determine the concentration of heavy metals including lead, chromium, mercury, and arsenic in drinking water resources of the cities of Kurdistan province. Accordingly, a total of 96 samples were taken from 96 water resources and were moved to the laboratory in 500 ml glass containers.

As shown in figure1 the samples were analyzed in the reference laboratory of water and wastewater chemicals using a Polarograph manufactured by Metrohm Company, Switzerland, and the method recommended by Standard methods for the examination of water & wastewater (15). The collected data was analyzed using SPSS software; given the normality of the data, they were analyzed via statistical correlation tests of one sample t- test, one way ANOVA, and paired t-test at a significance level of 0.05.

RESULTS

The results of this research are presented in Tables 2 to 5 and Figures 2 to 5. According to the results, the maximum concentrations of heavy metals in drinking water resources of the cities of Kurdistan province for lead, chromium, arsenic and, mercury are 0.0336, 0.0092, 0.0161 and, 0.0014 mg/l respectively.

As shown in Table 2, lead was found in 79 samples (82.3%) of all collected samples. The maximum concentration of lead in ground water was 0.0336 and, 0.0093 mg/l in surface water. Concentration of lead ions in all the three surface water resources located in different parts of the province was lower than the maximum contaminant level of lead set by the WHO and EPA. However, in 7 ground water resources (7.3%), it was more than the maximum contaminant level set by the WHO, and in four (4.2%) samples collected from ground water resources, lead concentration exceeded the maximum contaminant level set by EPA.

Table 2: Summary of statistical analysis of the concentration of lead in drinking water resources of the cities of Kurdistan province

	Ground water	Surface water	total
Number of samples (%)	93(%96.9)	3(%3.1)	96(%100)
Number of samples with Pb (%)	76(%79.2)	3(%3.1)	79(%82.3)
Minimum concentration of Pb (mg/l)	0	0.00141	0
Maximum concentration of Pb (mg/l)	0.0336	0.0093	0.0336
Number above WHO Maximum Contaminant Level (MCL)	7(%7.3)	0	7(%7.3)
Number above EPA Maximum Contaminant Level (MCL)	4(%4.2)	0	4(%4.2)

As shown in Table 3, the heavy metal of chromium was detected in 84 samples (87.5%). The maximum concentration of this heavy metal was 0.0092 mg/l in ground water and 0.0021 mg/l in surface water resources. In none of the samples, the concentration of chromium ion exceeded the maximum contaminant level set by the WHO and EPA.

Table 3: Summary of statistical analysis of the concentration of chromium in drinking water resources of the cities of Kurdistan province

	Ground water	Surface water	total
Number of samples (%)	93(%96.9)	3(%3.1)	96(%100)
Number of samples with Cr (%)	81(%84.4)	3(%3.1)	84(%87.5)
Minimum concentration of Cr (mg/l)	0	0.0003	0
Maximum concentration of Cr (mg/l)	0.0092	0.0021	0.0092
Number above WHO Maximum Contaminant Level (MCL)	0	0	0
Number above EPA Maximum Contaminant Level (MCL)	0	0	0

As shown in Table 4, the heavy metal of arsenic was detected in 82 samples (85.4%) taken from the drinking water resources of the cities of Kurdistan province. The maximum concentration of this heavy metal is 0.0161 mg/l in ground water and 0.0093 mg/l in surface water resources. The concentration of arsenic ion in three surface water resources of the cities of Kurdistan province was more than the maximum contaminant level set by the WHO and EPA. However, in two samples (2.1%) taken from ground water resources, the concentration of this metal was more than the maximum contaminant level set by the WHO and EPA.

Table 4: Summary of statistical analysis of the concentration of arsenic in drinking water resources of the cities of Kurdistan province

	Ground water	Surface water	total
Number of samples (%)	93(%96.9)	3(%3.1)	96(%100)
Number of samples with As (%)	79(%84.4)	3(%3.1)	82(%85.4)
Minimum concentration of As (mg/l)	0	0.0014	0
Maximum concentration of As (mg/l)	0.0161	0.0093	0.0161
Number above WHO Maximum Contaminant Level (MCL)	2(%2.1)	0	2(%2.1)
Number above EPA Maximum Contaminant Level (MCL)	2(%2.1)	0	2(%2.1)

As shown in Table 5, mercury was detected in 79 samples (82.3%). The maximum concentration of this heavy metal was 0.0014 mg/l in ground water and 0.0007 mg/l in surface water resources. The

concentration of mercury ion in 3surface water resources was more than the maximum contaminant level set by the WHO and EPA. However, in 8 samples (8.3%) taken from ground water resources, the concentration of mercury was more than the maximum contaminant level set by the WHO.

Table 5: Summary of statistical analysis of the concentration of mercury in drinking water resources of the cities of Kurdistan province

	Ground water	Surface water	total
Number of samples (%)	93(%96.9)	3(%3.1)	96(%100)
Number of samples with As (%)	77(%80.2)	2(%2.1)	79(%82.3)
Minimum concentration of As (mg/l)	0	0	0
Maximum concentration of As (mg/l)	0.0014	0.0007	0.0014
Number above WHO Maximum Contaminant Level (MCL)	8(%8.3)	0	8(%8.3)
Number above EPA Maximum Contaminant Level (MCL)	0	0	0

Figures 1 to 4, respectively, present the measured concentrations of the heavy metals including lead, chromium, arsenic, and mercury in water samples taken from drinking water resources of the cities of Kurdistan province.

Figure 1: Comparison of the lead concentration in water resources with the WHO and the EPA guidelines

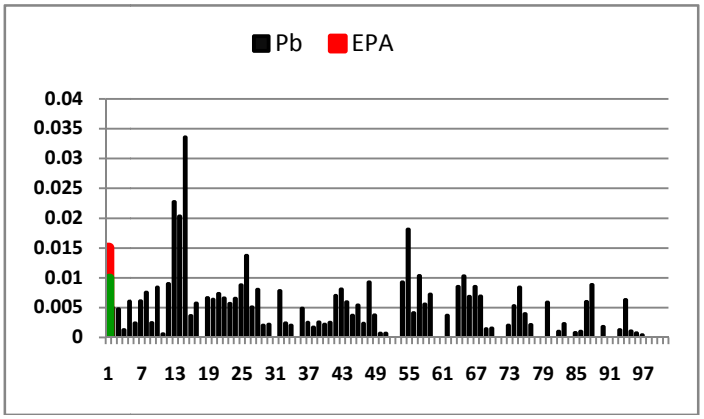


Figure 2: Comparison of the chromium concentration in water resources with the WHO and the EPA guidelines

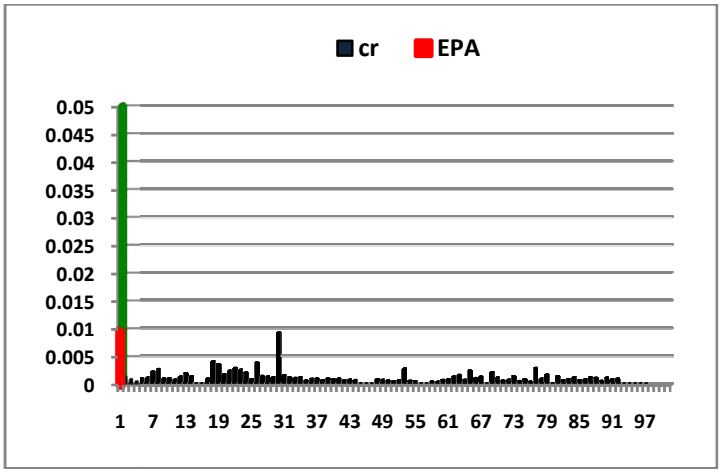


Figure 3: Comparison of the arsenic concentration in water resources with the WHO and the EPA guidelines

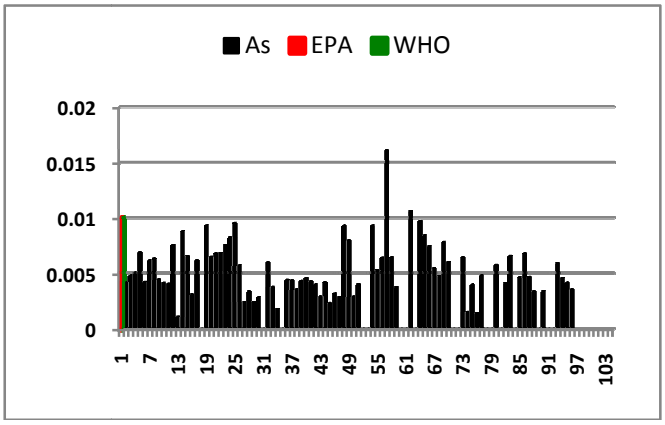
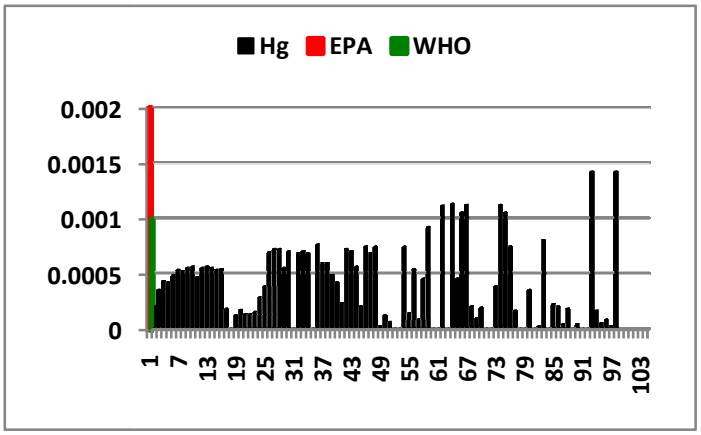


Figure 4: Comparison of the mercury concentration in water resources with the WHO and the EPA guidelines



Also, linear regression model was used to investigate the relationship between arsenic, chromium, and mercury and lead ions. Table6 shows correlation matrix of heavy metals in water samples.

Table 6: Correlation matrix of heavy metals in water samples

		Chromium	Arsenic	Lead	Mercury
Chromium	correlation coefficient	1	.016	.028	-.047
	P- value		.879	.784	.652
Arsenic	correlation coefficient	.016	1	.442	.307
	P- value	.879		.000	.002
Lead	correlation coefficient	.028	.442	1	.326
	P- value	.784	.000		.001
Mercury	correlation coefficient	-.047	.307	.326	1
	P- value	.652	.002	.001	

DISCUSSION AND CONCLUSION

The results of this study showed that all the four heavy metals include lead, chromium, arsenic, and mercury was simultaneously present in 79 out of the 96 drinking water resources of the cities of Kurdistan province; however they differed in distribution and concentration. Chromium was found in 84 resources, arsenic in 82 resources, and lead and mercury in 79 resources out of the 96 studied resources of drinking water in the cities of Kurdistan province. The concentrations of mercury, lead, and arsenic, respectively, in 3.8%, 3.7%, and 2.1% of the resources were more than the maximum allowable concentrations set by the WHO.

The amount of lead in a number of wells in Bijar, Ghorveh, Bane, and Sarvabad, the amount of arsenic in one of the wells supplying the water of Bane and Diwandareh, and the amount of mercury in a number of water resources in Diwandareh, Sanandaj, Sarvabad, and Sanandaj dam exceeded the maximum acceptable concentration set by the World Health Organization. The concentrations of the studied metals

in the water resources of Saghez, Marivan, Kamyaran, and Dehgolan did not exceed the maximum allowable concentration.

In a research conducted by Pirsaheb et al. [16] explained a total of 165 samples, which were taken from drinking water supplied by the Kermanshah water distribution network, were examined for the presence of heavy metals. The results indicated that the concentrations of all the studied heavy metals, except for aluminum, iron, and manganese in drinking water resources, piping network, and water reservoirs of Kermanshah were lower than the levels set by the national standards and guidelines recommended by the World Health Organization. Accordingly, their findings are different from the results of our study.

The results of our study are consistent with the results of a study conducted by Momodu and Anyakora. In their study, they examined the concentrations of heavy metals including aluminum, cadmium, and lead in ground water resources of Lagos and they had detected different amounts of the three metal. Overall, of all 60% of samples containing lead, the concentration of lead in 7.36% of samples had exceeded the maximum allowable concentration. However, of all 76% samples containing lead which were taken from ground water resources of Kurdistan province, only 7% of the samples had a lead concentration higher than the maximum allowable level [14].

In a research entitled "The evaluation of the risk of heavy metals absorption from water on human health" which was conducted by Kavcar in 2009, in 50% of all 100 collected samples the heavy metals including chromium, copper, manganese, nickel, and zinc were detected. The concentrations of nickel and arsenic in more than 20% and 58% of the samples, respectively, were consistent with the standards [17].

Berg et al, in 2007, studied the contamination of water resources in delta plains of Mekang. The analysis of samples showed that the concentration of arsenic in more than 37% of wells exceeded the standards set by the World Health Organization guidelines. Compared with the results of our research, it is different from the levels found in our study, since only in 2% of our water samples the concentrations of arsenic was above the standards set by the World Health Organization guidelines [18].

The increasing growth of population and industrial expansion are followed by increased need for water resources, however they are also the cause of increasing environmental pollution by different contaminants such as heavy metals. In view of the results of this study, it is suggested to further evaluate the concentrations of heavy metals in soil and crops of the cities where the concentrations of heavy metals in drinking water resources are more than the maximum allowable concentrations.

COMPETING INTERESTS

The authors declare that they have no competing interest.

AUTHORS' CONTRIBUTIONS

All authors have equal contribution in the study. All authors read and approved the final manuscript.

ACKNOWLEDGEMENTS

This study was a research priority in Kurdistan University of Medical Sciences. Hereby, many thanks go to the Deputy of Research and Deputy of Health, Kurdistan University of Medical Sciences for their cooperation and assistance.

REFERENCES

1. Mohammad Mosaferi, Mojtaba Pourakbar, Mohammad Shakerkhatibi, Esmaeil Fatehifar and Mehdi Belvasi. (2014).Quality modeling of drinking groundwater using GIS in rural communities, northwest of Iran. Journal of Environmental Health Science & Engineering, 12:99.
2. Mohammad Arjomandzadegan, Poorya Rafiee, Mostafa Keshavarz Moraveji, Maryam Tayeboon. (2014). Efficacy evaluation and kinetic study of biosorption of nickel and zinc by bacteria isolated from stressed conditions in a bubble column. Asian Pac J Trop Med; 7(Suppl 1): S194-S198.
3. Zhao C, Zhong G, Kim DE,Liu J,Liu X. (2014).A portable lab-on-a-chip system for gold-nanoparticle-based colorimetric detection of metal ions in water. Biomicrofluidics. Aug 28; 8(5):052107. doi: 10.1063/1.4894244. eCollection 2014.
4. Xinghao Wang, Ruijuan Qu, Zhongbo Wei, Xi Yang, Zunyao Wang. (2014). Effect of water quality on mercury toxicity to Photobacterium Phosphoreum: Model development and its application in natural waters. Ecotoxicology and Environmental Safety /Volume 104, Pages 231–238.
5. V.K.Garg& Poonam Yadav & Suman Mor & Balvinder Singh & Vandana Pulhani. Heavy Metals Bioconcentration from Soil to Vegetables and Assessment of Health Risk Caused by Their Ingestion. Biol Trace Elem Res (2014) 157:256–265.
6. Lars Järup. (2003). Hazards of heavy metal contamination. British Medical Bulletin 68: 167–182.

7. Thi Thu Giang Luu, Suthipong Sthiannopkao, Kyoung-Woong Kim. (2009).Arsenic and other trace elements contamination in groundwater and a risk assessment study for the residents in the Kandal Province of Cambodia. Environment International 35; 455–460.
8. Hugh Brammer, Peter Ravenscroft (2009). Arsenic in groundwater: A threat to sustainable agriculture in South and South-east Asia. Environment International. //Volume 35, Issue 3, Pages 647–654.
9. Buschmann J, Berg M, Stengel C, Winkel L, Sampson ML, Trang PTK, et al. (2008). Contamination of drinking water resources in the Mekong delta floodplains: Arsenic and other trace metals pose serious health risks to population. Environ. Int. 34(6):756-64.
10. Liaw J et al. (2008). Increased childhood liver cancer mortality and arsenic in drinking water in northern Chile. Cancer Epidemiol Biomarkers Prev. 17(8):1982-7.
11. WHO, (2008). Guidelines for Drinking-Water Quality", second addendum. Vol. 1, Recommendations. 3rd ed. ISBN 978 92 4 154760 4. World Health Organization.
12. Environmental Protection Agency. (2009). National Primary Drinking Water Regulations. EPA 816-F-09-004.
13. Sabrina Nunes do Nascimento, Mariele Feiffer Charão, Angela Maria Moro, Miguel Roehrs, Clovis Paniz, Marília Baierle, Natália Brucker, Adriana Gioda, Fernando Barbosa Jr, Denise Bohrer, Daiana Silva Ávila, and Solange Cristina Garcia. (2014).Evaluation of Toxic Metals and Essential Elements in Children with Learning Disabilities from a Rural Area of Southern Brazil. *Int. J. Environ. Res. Public Health*, *11*, 10806-10823.
14. Momodu M, Anyakora C. (2010). Heavy metal contamination of ground water: The Surulere case study. Res J Environ Earth Sci. 2 (1):39-43.
15. Eaton AD, Franson MAH. (2005).Standard methods for the examination of water & wastewater. American Public Health Association; 21st Edition.
16. Meghdad Pirsaheb, Touba Khosravi, Kiomars Sharafi, Leila Babajani and Mansour Rezaei.(2013).Measurement of Heavy Metals Concentration in Drinking Water from Source to Consumption Site in Kermanshah – Iran. World Applied Sciences Journal 21 (3): 416-423.
17. Kavcar P, Sofuoglu A, Sofuoglu SC. (2009). A health risk assessment for exposure to trace metals via drinking water ingestion pathway. International Journal of Hygiene and Environmental Health..27-216:(2)12..
18. Buschmann J, Berg M, Stengel C, Winkel L, Sampson ML, Trang PTK, et al. (2008).Contamination of drinking water resources in the Mekong delta floodplains: Arsenic and other trace metals pose serious health risks to population. Environ. Int .34(6):756-64.