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Evaluation of Heavy Metals Concentration in the Drinking Water Distribution Network in Kurdistan Villages in the Year 2012.

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ABSTRACT

Prevalence of toxic chemicals in drinking water could have a negative impact on human health causing cancer and other chronic diseases. The aim of this study was to measure concentrations of heavy metals, mercury, arsenic, chromium and lead in drinking water in rural households of Kurdistan, Iran to identify possible threats posed by high levels of heavy metal concentration. Kurdistan province of Iran is located in western Iran. It has 10 cities including Sanandaj, Saghez, Bane, Marivan, Ghorveh, Bijar, Kamyaran, Diwandareh, Sarouabad and Dehgolan. Drinking water supply comes from groundwater in these rural areas. Due to lack of information on the chemical state of drinking water in rural areas of Kurdistan, to identify the presence of heavy metals and their concentration during spring 2012, 84 water samples were randomly collected to measure concentrations of heavy metals like chromium, cadmium, lead and mercury. Then the samples were taken from water taps of rural households and transferred to the laboratory in 500 ml bottles. Samples were analyzed using the method presented in standard books in Chemical Water and Wastewater Reference Laboratory of Hamedan Health departments affiliated to Hamedan University of Medical Sciences using Polarograph Manufacturing at Metrohm, Switzerland. Continuous monitoring of supplier networks plumbing and water storage tanks to identify sources of pollution with heavy metals should be part of a routine job in related organs.

Keywords: Heavy Metals, drinking water, Kurdistan

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INTRODUCTION

Prevalence of toxic chemicals in drinking water could have a negative impact on human health causing cancer and other chronic diseases [1]. Among environmental pollutants, because of potentially toxic effects of heavy metals, potential bioaccumulation in aquatic ecosystems is of particular importance [2]. This metals enter water reservoirs either artificially after combustion of fossil fuels, mining, agricultural wastewater, surface runoff, wastewater treatment plants, landfills, chemical accidents, etc. [3-5] or by natural ways, such as rainfall, soil erosion and dissolution of soluble salts [6, 7]. According to epidemiological studies there is a statistical association between tooth decay, heart disease, kidney and neurological disorders and many forms of cancer associated with heavy metals [8, 9]. Heavy metals are elements with atomic weights of 63.546 to 200.590 and a specific gravity greater than 4, which are at least 5 times than that of water [10-12]. Heavy metals include lead, cadmium, cobalt, zinc, arsenic, mercury, chromium, copper, iron and platinum [13]. Lead exposure can slow and even stops the essential physiological enzyme reactions and direct into blood after its saturation in the bone [14]. Lead reduces IQ, learning ability, and mental and physical growth of children and adults [15]. According to the World Health Organization and US Environmental Protection Agency guidelines, maximum allowable concentration of lead in drinking water are 0.01 mg/l and 0.015 mg/l , respectively [16, 17]. Arsenic is present in abundance in underground water. From the other side, earth crust *arsenicosis* is becoming an urgent epidemic in Asian countries [18]. During respiration, arsenic combines with coenzyme complex and after production of adenosine triphosphate it causes protein coagulation. Carcinogenic nature of arsenic can be fatal at high levels of exposure [11]. Guidelines of the World Health Organization and the US Environmental Protection Agency determined maximum allowable concentration of arsenic in drinking water of up to 0.01 mg / l [16, 19]. While toxicity of mercury can lead to brain disorders, problems with speech, hearing, vision and mobility, lead and mercury can cause development of autoimmune conditions. In this case, the immune system attacks the body cells [20]. Maximum allowable concentrations of mercury and chromium in drinking water as recommended by the World Health Organization and US Environmental Protection Agency are 0.001 mg/l and 0.002 mg/l for mercury and 0.05 mg/l and 0.1 mg/l for chrome [16, 19]. In a study conducted by Mahram on Effects of heavy metals, particularly lead in reducing IQ level in children in Zanjan mines. Intelligence level of children in areas with high lead levels has a significant difference with children in areas with lower levels of lead [21]. So far, there have been no studies on heavy metal concentrations in drinking water in the rural areas of Kurdistan and few studies have only been conducted on the Arsenic in the water supply of Bijar and Qorveh cities in Kurdistan Provinice of Iran. Therefore, the aim of this study was to measure concentrations of heavy metals, mercury, arsenic, chromium and lead in drinking water in rural households of Kurdistan, Iran to identify possible threats posed by high levels of heavy metal concentration.

MATERIALS AND METHODS

Kurdistan province of Iran is located in western Iran. It has 10 cities including Sanandaj, Saghez, Bane, Marivan, Ghorveh, Bijar, Kamyaran, Diwandareh, Sarouabad and Dehgolan. Drinking water supply comes from groundwater in these rural areas. Due to lack of information on the chemical state of drinking water in rural areas of Kurdistan, to identify the presence of heavy metals and their concentration during spring 2012, 84 water samples were randomly collected to measure concentrations of heavy metals like chromium, cadmium, lead and mercury. Then the samples were taken from water taps of rural households and transferred to the laboratory in 500 ml bottles.

Figure 1: sampling location of drinking water in rural areas of Kurdistan

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Samples were analyzed using the method presented in standard books in Chemical Water and Wastewater Reference Laboratory of Hamedan Health departments affiliated to Hamedan University of Medical Sciences using Polarograph Manufacturing at Metrohm, Switzerland [23]. Data were analyzed by SPSS using normality tests including correlation test, one sample t- test, one-way ANOVA and one way paired t test at a significance level of 0.05.

RESULTS

Maximum concentrations of heavy metals, mercury, arsenic, chromium and lead are shown in tables 1 to 4 respectively. As shown in Table 1, in 43 (51.2%) water samples from 84 samples, metallic mercury was detected. According to Figure 1, maximum mercury concentrations in four samples of water samples in Bijar, Ghorveh, Diwandareh, and Dehgolan were above the maximum allowable concentration by World Health Organization and US Environmental Protection Agency. The highest measured concentrations were related to Villages of Bijar city (0.0032 mg/l).

Table 1: Summary of statistical analysis related to measuring of mercury in the rural distribution network

Provinces	Number of samples	samples containing Mercury	Maximum allowable measured concentrations	Samples with values above MCL
Bijar	10	9	0.0032	1
Kamyaran	8	2	0.0002	0
Ghorveh	4	4	0.0023	1
Dehgolan	2	2	0.0021	1
Baneh	10	1	0.0004	0
Divandarreh	12	11	0.0018	1
Sarvabad	7	0	0	0
Saghez	11	5	0.0005	0
sanandaj	10	0	0	0
Marivan	10	9	0.0005	0
Total	84	43	0.0032	4

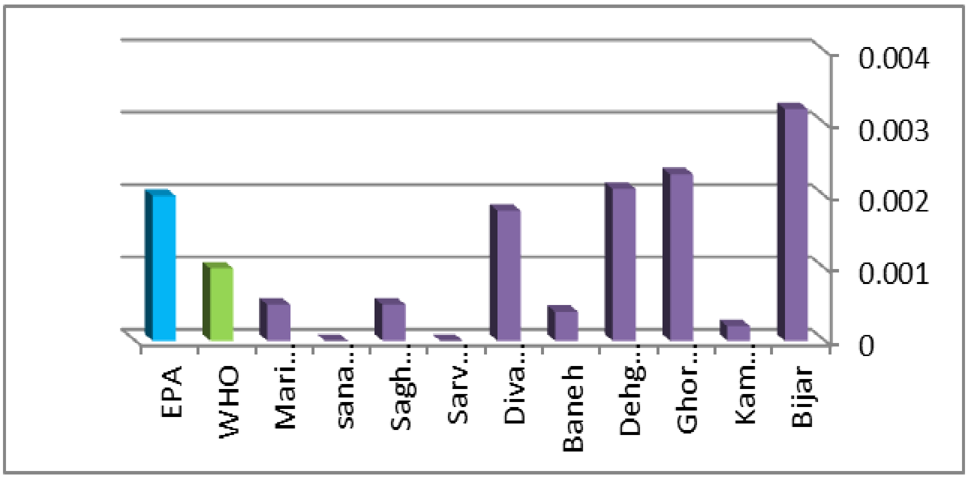

Figure 1: Comparison of the maximum permissible concentration of mercury in water samples with the guidelines of World Health Organization and US Environmental Protection Agency

Results of table 2, arsenic metal concentrations in rural water sources, shows that in 37 of cases (44%) , 84 samples arsenic were identified. Figure 2 show that arsenic concentrations in five samples exceeded the maximum allowable concentration (0.01 mg / l). Concentrations of 0.014, 0.027, and 0.032 milligrams per liter were related to Villages of Bijar and concentration of 0.07 mg was related to villages of Qorveh. Maximum allowable concentration of arsenic in the examined samples was 0.07 mg/l which is about seven times the allowable concentration.

Table 2: Summary of statistical analysis to measure arsenic in rural distribution network

Provinces	Number of samples	samples containing Mercury	Maximum allowable measured concentrations	Samples with values above MCL
Bijar	10	7	0.032	3
Kamyaran	8	2	0.001	0
Ghorveh	4	4	0.07	2
Dehgolan	2	1	0.0001	0
Baneh	10	6	0.0015	0
Divandarreh	12	7	0.0031	0
Sarvabad	7	1	0.001	0
Saghez	11	4	0.0032	0
sanandaj	10	1	0.004	0
Marivan	10	4	0.004	0
Total	84	37	0.07	5

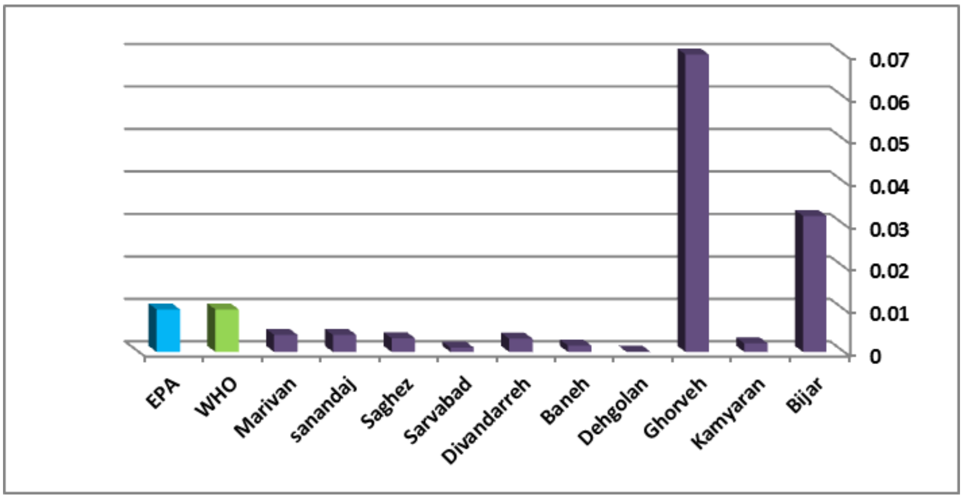

Figure 2: Comparison of the maximum permissible concentration of arsenic in water samples with guidelines of World Health Organization and US Environmental Protection Agency

According to table 3 in 80% (95.2%) of 84 samples, Chromium was detected. Maximum concentration detected in all samples was less than the maximum permissible concentration of chromium (0.05 mg / l). According to Figure 3, the highest concentration of the metal was measured on samples taken from one of the villages of Bane city with an amount of 0.009 milligrams per liter.

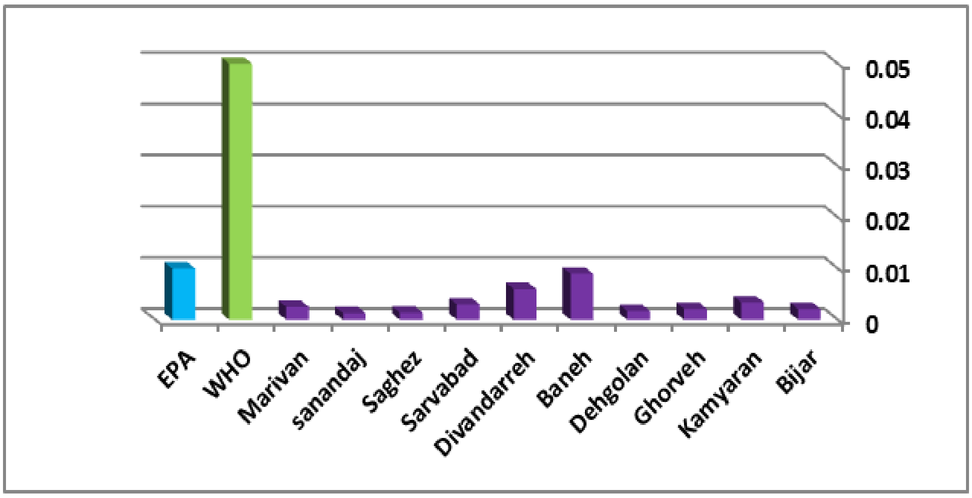

Figure 3: Comparison of the maximum permissible concentration of chromium in water samples with the guidelines of World Health Organization and US Environmental Protection Agency

Table 3: Summary of statistical analysis for assessment of chromium in the rural distribution network.

Provinces	Number of samples	samples containing Mercury	Maximum allowable measured concentrations	Samples with values above MCL
Bijar	10	10	0.0021	0
Kamyaran	8	8	0.0034	0
Ghorveh	4	4	0.0021	0
Dehgolan	2	1	0.0017	0
Baneh	10	10	0.009	0
Divandarreh	12	10	0.006	0
Sarvabad	7	7	0.003	0
Saghez	11	10	0.0014	0
sanandaj	10	10	0.0013	0
Marivan	10	10	0.0025	0
Total	84	80	0.009	0

Table 4 shows that lead was found in 81 cases (% 96.4) of 84 analyzed samples. Maximum measured concentration of the metal in 80 cases was below the maximum allowable concentration (10.01 mg / l) and in a sample it was more than the maximum allowable concentration for lead (0.016) and the samples were from the villages of Bijar city. Figure 4 compares the maximum allowable concentration of lead in water samples with the guidelines of the World Health Organization and US Environmental Protection Agency.

Table 4: Summary of statistical analysis for the measurement of lead in rural distribution network

Provinces	Number of samples	samples containing Mercury	Maximum allowable measured concentrations	Samples with values above MCL
Bijar	10	10	0.016	1
Kamyaran	8	8	0.002	0
Ghorveh	4	4	0.003	0
Dehgolan	2	2	0.001	0
Baneh	10	10	0.007	0
Divandarreh	12	10	0.003	0
Sarvabad	7	7	0.007	0
Saghez	11	10	0.002	0
Sanandaj	10	10	0.001	0
Marivan	10	10	0.002	0

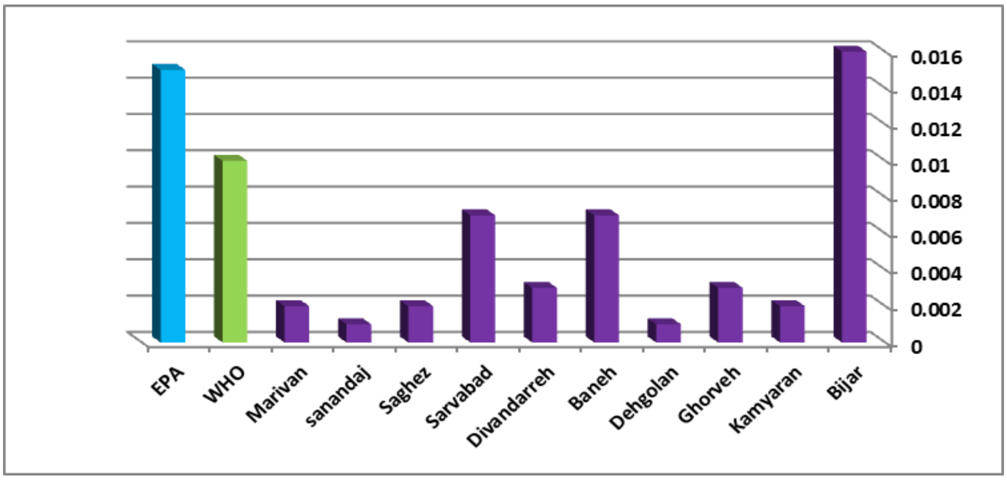

Figure 4: Comparison of maximum permissible concentration of lead in water samples with guidelines of World Health Organization and the US Environmental Protection Agency

CONCLUSIONS

The results of this study shows that concentrations of heavy metals in drinking water are dissimilar in different areas, of which lead with 96.4 percent, chromium with 95.2 percent, mercury with 51.2 percent, and arsenic with 44 percent in the samples had the highest to lowest frequency, respectively. From the measured metal, concentrations of arsenic, lead and mercury in some cases exceeded the standard of World Health Organization and US Environmental Protection Agency.

High concentrations of arsenic were probably due to the presence of gold mine, granite stone and etc. in the towns of Bijar and Qorveh. High concentration of lead in a sample exceeds maximum permissible concentration and presence of metal in % 96.4 of the number of samples could be related to the old and worn-out rural water system. Therefore, possibility of leaking pipe elements like lead is very likely. In a study conducted by Pirsaheb et al. in 2013, 165 Samples of drinking water from distribution network in Kermanshah were examined for the presence of heavy metals. Results showed that concentration of all heavy metals, except aluminum, iron and manganese in drinking water supplies, network of pipes and storage tanks in Kermanshah were lower than the national standards and guidelines recommended by the World Health Organization [22]. Albaji and colleagues in 2013 took 100 samples of drinking water in the city of Ahvaz. They investigated the Samples for contamination by lead, cadmium and mercury. According to their study results, concentration of cadmium in all samples was below the limit of WHO standards. Average lead of 0.02 milligrams per liter was the highest value recorded for samples. Approximately 33% of the samples demonstrated high concentrations of mercury compared to the national standard of 0.006 milligrams per liter [23]. In 2006, Soylak and Tuzen investigated concentration of chromium, nickel, copper, manganese, zinc, iron, cobalt, cadmium and aluminum in drinking water of Tokat, Turkey. All ion concentrations measured in the samples were below the threshold limit value of Turkey and that of the World Health Organization [24]. Chinedu and Ifenna in 2012 examined heavy metal concentrations in drinking water of the state of Nnewi in Nigeria. The results indicated that cadmium was not found in any samples and lead concentrations was above the limits recommended by the World Health Organization for drinking water but Fe, Cu and Zn concentration were within the recommended limits [25]. In a study conducted by Kavcar in 2009 with the title of risk evaluation of heavy metals of water on human health, from 100 samples of metals such as chromium, copper, manganese, nickel, and zinc In 50% of identified cases, levels of nickel and arsenic concentrations were in accordance with the relevant standards in 20 to 58 percent of the cases [26]. Miranzadeh et al. in a study conducted on Kashan drinking water network in 2010 showed that concentration was lower than the standard and risk of heavy metals did not threaten consumers' health [27]. In another study conducted by Rajaei et al in 2010, drinking water wells on the plains of Ali Abad Katoul in Iran showed that there was a significant correlation between measured concentration with national and international standard [28]. In 2007 Buschmann conducted a study on heavy metal concentrations in 364 private water wells of Batynay in Oman resulting in above standard levels for lead and chromium in 80% of the wells. Pollution was due to the industrial activities in the region and destroying reefs due to bad weather conditions [29].

In a study in 2009 by Kavcar with the purpose of risk assessment for heavy metals through water on human health, from 100 samples of metals such as chromium, copper, manganese, nickel, and zinc, 50% were detected. Nickel and arsenic concentrations in 20% and 58% of the samples were in accordance with relevant standards [26].

Another study by Ahmad et al. investigating the distribution of heavy metals in the river water of Bvryganga in Nigeria showed that concentrations of Cd, Cr, Cu, Ni, Pb in the river water varied are different seasons. They suggested that the highest concentration of heavy metals in the river was related to cadmium and the lowest concentration was related to nickel [30].

Continuous monitoring of supplier networks plumbing and water storage tanks to identify sources of pollution with heavy metals should be part of a routine job in related organs.

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