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Assessment non-carcinogenic risk of Cadmium in tap drinking water; City of Minab, Iran

Yadolah Fakhri[1], Ghazaleh langarizadeh[2], Bigard Moradi[3],Yahya Zandsalimi[4], Leila rasouli amirhajeloo[5], Saeedeh Jafarzadeh[6], Athena Rafieepour[7], Maryam Mirzaei[8]*

[1]*Social Determinants in Health Promotion Research Center, Hormozgan University of Medical Sciences, Bandar Abbas, Iran.*
[2]*Food and Drugs Research Center, Bam University of Medical Sciences, Bam, Iran*
[3]*Department of health public, Kermanshah University of Medical Sciences, Kermanshah, Iran*
[4]*Environmental Health Research Center, Kurdistan University of Medical Science, Sanandaj, Iran*
[5]*Department of Environmental Health Engineering, School of Public Health, Qom University of Medical Sciences, Qom, Iran.*
[6]*Research Center for non-communicable disease, Fasa University of Medical Sciences, Fasa, Iran*
[7]*Student's research committee, Shahid beheshti University of Medical sciences, Tehran,Iran*
[8]*Research Center for non-communicable disease, Msc of critical care nursing, Jahrom University of Medical Sciences, Jahrom, Iran*
**Corresponding author, Email: Maryammirzaei32@yahoo.com*

Abstract:*Heavy metals have the properties of biological accumulation, toxicity and environmental stability, hence consumption of drinking water containing heavy metals can jeopardize human health. One of these heavy metals is cadmium that its long-term exposure causes kidney diseases, osteoporosis, cancer and cardiovascular disease. In this cross-sectional study which was conducted in Minab, 100 samples of tap water were collected from 10 regions during December and January of 2014. Cadmium concentration was measured by graphite flame atomic absorption spectrophotometry of AAS8000 model. Then, its non-carcinogenic risk was calculated through EPA equations. Range and mean concentration of Cadmium in December and January is ND-4.6 µg/l, 1.8±0.69 µg/l and ND-3.6 µg/l, 1.6±0.6 µg/l, respectively. So, the mean concentration of Cadmium is 1.7±0.64 µg/l. The mean of daily chronic intake and non-carcinogenic risk of Minab population is 0.00005 µg/kg-day and 0.095. The mean concentration of Cadmium tap drinking water is lower than WHO and EPA standard limits. Since the non-carcinogenic risk is lower than 1, thus it can be said that Minab city is in the safe area in terms of non-carcinogenic risk of Cadmium of the drinking water. But, Valiasr and Soleghanareashave the highest and lowest non-carcinogenic risk, respectively.*
Keywords:*concentration of Cadmium, drinking water, chronic daily intake and non-carcinogenic ris*

I. Introduction

One of the important chemical parameters of drinking water is heavy metals (Cadmium, Chrome, Manganese, Lead, Arsenic,Mercury and etc.) [2 ,1]. Heavy metals enter the body from various routes such as skin contact, inhalation and oral, but their entrance by oral rout is much more.[4 ,3]Heavy metals have the properties of biological accumulation, toxicity and environmental stability [5]. So in the recent years, water resources contamination with heavy metals has been dragged the attention of environment researchers.Heavy metals entrance to the water resources can be caused by natural activities (soil erosion, sediments, etc) and or because of humanactivities (urban, industrial, agricultural waste water or chemical fertilizers dischargesand etc.) [9-6]. Small amounts of heavy metals are useful and essential for the body, but at high concentrations can be toxic to humans .[10]International Agency for Research on Cancer (ICRP) has classified Cadmium as the A-group carcinogenic material .[11] Biological half-life of Cadmium in bone and kidney are 38 and 10 years, respectively .[12]So, exposure to Cadmium can also have chronic effects on organisms in addition to the acute effects.[13]Chronic exposure to Cadmium causes kidney disease, ItaiItai (osteoporosis and sever pain), cancer (liver and kidney) and cardiovascular diseases .[16-14] The standard limitation of WHO and EPA for Cadmium in drinking water are 3 and 5 µg/l, respectively .[18 ,17]Measurement of heavy metals concentrations and evaluation their risks of human health have been studied in several studies

.[19 ,7 ,1] Farmers ' extent use of pesticides and agricultural fertilizers and being in the vicinity of drinking water supply wells Minab city and also the lack of urban wastewater collection system had raised the likelihood of contamination of pipeline drinking water of this city with heavy metals. According to the health risks of heavy metals in drinking water resources, in this study it was attempted to measure the concentration of

Cadmium by graphite flame atomic absorption Spectrometry (GFAAS) and evaluate and calculate its non-carcinogenic risk through the available equations.

II. Materials and Methods

2.1. Study of Area

City of Minab is in the southeastern of Hormozgan province and in a distance of 100 km of Bandar Abbas (center of the Hormozgan province) and in the geographical coordinates of 27º11′53″N and 54º22′7″E (Figure 1). The height of this city is 27 meters above the sea level and has a warm and humid climate [20]. Drinking water of the residents of this city is supplied from the groundwater sources. This city is one of the largest producers of agricultural products in the province, so pesticides and chemical fertilizers are widely used in the vicinity of the city's drinking water supply wells. On the other hand, lack of urban wastewater collection system causes that the residents of this city use absorbing wells for sewage disposal which can contaminate tap and ground water.

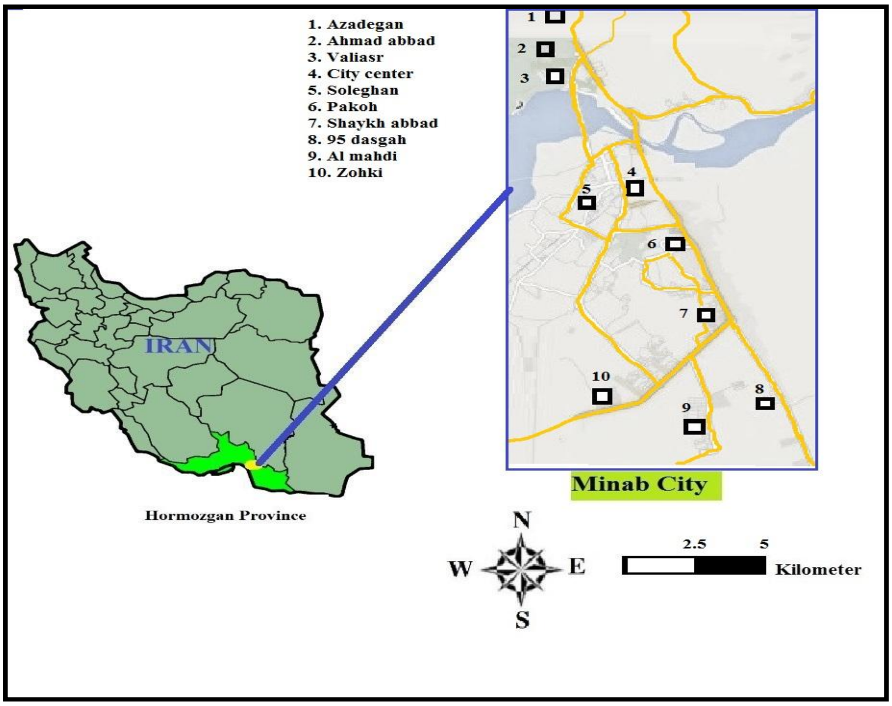

Figure 1.Areas of collection of tap drinking water collection of Minab city of Iran.

2.2. Sample collection

In this cross-sectional study which was conducted in December and January of 2014, to get a good mean of Cadmium concentration of drinking water in city of Minab based on the extent and density of population, city was divided into 10 areas of Azadegan, Ahmad Abbad, Valiasr, City center, Pakoh, Shaykhabbad, 95 Dastgah, Almahdi town, Zohki and Soleghan (figure 1). To compare the meanof concentration Cadmium of in December and January, collecting samples was done in two time stages in the middle of December and January. According to the conducted similar studies in Iran, 5 samples were collected in each stage and each area. Thus, totally 50 samples in the first stage (December) and 50 samples in the second stage (January) were gathered from the whole city .[21 ,1]

2.3. Measurement concentration of Cadmium

According to the recipe of chemical sampling of water, the tap water samples were transferred into the washed polyethylene bottles with 20% nitric acid during the first and second stages, consecutively. Also, one milliliter of nitric acid (65%) to per liter of water sample was added to the sample to deliver PH<2 (to preserve heavy metals in the sample of water). Then, the samples were transferred to the analysis device laboratory at health Faculty of Hormozagan Medical Science University in4ºc temperature. In the laboratory, to concentrate, water samples were filtered through Whatman glass microfiber filter (GF/C) .[22 ,3 ,1]The Cadmium concentration in concentrated samples, were measured by graphite flame atomic absorption Spectrophotometer (AAS8800 model) in µg/l. Five solutions of 1, 3, 5, 7 and 9 µg/l were made by the stock solution of Cadmium (1000 ppm). Then, the calibration curve of Cadmium was obtained by measuring the concentration of the made solutions.

3 volumes of 10µl of each sample were injected by injector into the graphite furnace. The mean of concentration of three measurements was registered as the concentration of Cadmium water sample. Limit of detection of AAS8000 device when using graphite furnace is 0.2 – 3000 µg/l.

2.4. Calculation of non-carcinogenic risk

2.4.1. Chronic daily Intake (CDI)

To calculate chronic daily intake (CDI) through drinking of water, the below equation was used:

Equation 1 $$CDI=C\times DI/BW$$

C: concentration of Cadmium water in µg/l, DI: Water daily Intake (2l/d) and body weight (72 kg).[23 ,7]Since, there were no information about the exact used water and the mean of people's body weights in Minab, so the presented information by EPA was used.

2.4.2. Calculation of Hazard quotient (HQ) indices

Hazard quotient (HQ) index to evaluate the non-carcinogenic risk is calculated by below equation:

Equation 2 $$HQ = CDI/RfD$$

Oral toxicity reference dose values (RfD) of Cadmium is 0.0005mg/kg-day .[24] A society is in the safe area whileHQ for each heavy metal is lowers than 1 .[25]

III. Results

The mean concentration of Cadmium in December is 1.8 µg/l. Also, the mean concentration of Cadmium inAzadegan, Ahmad Abbad, Valiasr, City center, Pakoh, Shaykhabbad, 95 Dastgah, Almahdi town, Zohki and Soleghan are 1.1, 1.4, 3.5, 2.1, 1.8, 1.9, 1.46, 1.76, 1.86 and 0.96 µg/l, respectively (Table 1).

Region	December	January	Mean
Azadegan			
Mean	[2]1.1	1.1	1.1
Rang	ND-1.6	ND-1.3	
SD[1]	0.24	0.19	
Ahmad abbad			
Mean	1.4	1.16	1.28
Rang	1.2-1.6	0.9-1.6	
SD	0.2	0.38	
Valiasr			
Mean	3.5	2.8	3.15
Rang	ND-4.6	2.1-3.6	
SD	0.1	0.7	
City center			
Mean	2.1	2.4	2.3
Rang	2-2.3	2.1-2.9	
SD	0.08	0.6	
Pakoh			
Mean	1.8	2.1	1.95
Rang	ND-2	ND-2.3	
SD	0.08	0.2	
Shaykhabbad			
Mean	1.9	1.8	1.85
Rang	1.7-2.3	ND-2	
SD	0.5	0.3	
95-Dasgah			
Mean	1.46	1.54	1.5
Rang	1.2-1.9	ND-1.8	
SD	0.2	0.56	
Al Mahdi			
Mean	1.76	1.3	1.53
Rang	1.6-1.8	ND-1.5	
SD	0.07	0.3	
Zohki			
Mean	1.86	1.56	1.71
Rang	ND-1.9	1.3-1.8	
SD	0.1	0.6	
Soleghan			
Mean	0.96	0.79	0.87
Rang	ND-1.1	0.6-0.9	
SD	0.1	0.2	
Mean	1.8	1.6	1.7
SD	0.69	0.6	0.64

Table 1. The mean of Cadmium concentration in 10 areas of Minab city in December of 2014 (µg/l)

[1]Standard Deviation
[2] Mean of 5 sample

The mean concentration of Cadmium in January is 1.6±0.6 µg/l. The meanconcentration of Cadmium in the areas of Azadegan, Ahmad Abbad, Valiasr, City center, Pakoh, Shaykhabbad, 95 Dastgah, Almahdi town, Zohki and Soleghan is 1.1, 1.16, 2.8, 2.4, 2.1, 1.8, 1.54, 1.3, 1.56 and 0.79 µg/l, respectively (Table 1).

Table 2. Chronic daily intake and non-carcinogenic risk of Cadmium tap drinking water in December and January and the mean

December		January		Mean	
CDI[3]	HQ	CDI	HQ	CDI	HQ
0.00005	0.099	0.00005	0.091	0.00005	0.095

In December, CDI and HQ for Cadmium are 0.00005 µg/kg-day and 0.099, respectively. Also, in January they is 0.00005 µg/kg-day and 0.091, respectively. In both months (December, January), the mean concentration of Cadmium in the areas of Azadegan, Ahmad Abbad, Valiasr, City center, Pakoh, Shaykhabbad, 95 Dastgah, Almahdi town, Zohki and Soleghanis 1.1, 1.28, 3.15, 2.3, 1.95, 1.85, 1.5, 1.53, 1.71 and 0.87 µg/l, respectively. The mean concentration of Cadmium in 10 areas under study is 1.7 µg/l.

IV. Discussion

The ratio concentration of Cadmium to WHO standard is equal to 60% and to EPA standard is equal to 36%. It was observed that concentration of Cadmium in December is close to the limits but lower than WHO and EPA standards (p value < 0.05). The number of samples which are higher that WHO standard limit are 5 samples (Valiasr). Also the mean concentration of Cadmium in all collected samples in December (n=50) is lower than EPA standard. Concentration ofCadmium to WHO and EPA standard limits are 53%and 33%, respectively. Like December, Concentration of Cadmium in January is lower than WHO and EPA standard limits (p value<0.05). In January, number of samples which are higher than WHO standard limit is 3 times of the sample (Valiasr). Also like December, all gathered samples in January (n=50) is also lower than EPA standard limit.

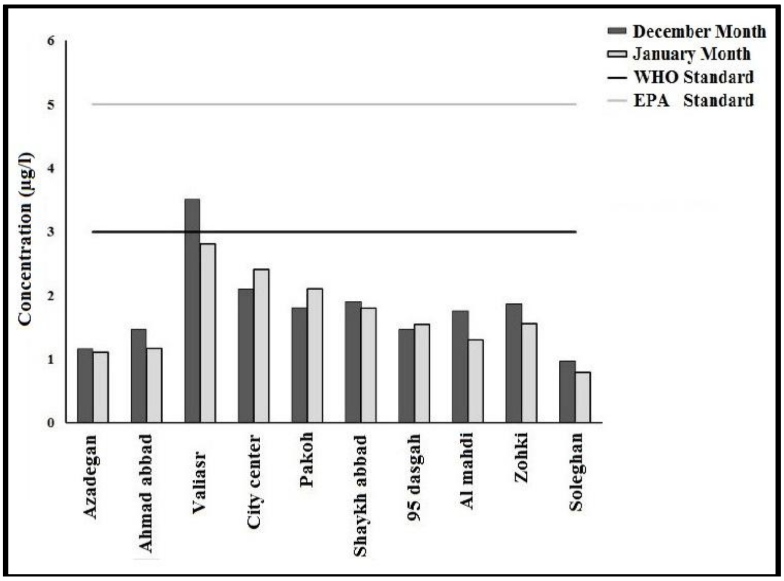

Figure 2. Comparison concentration of Cadmium among different areas of Minab city with WHO and EPA standards

In December, concentration of Cadmium in the areas of Valiasr, city center and Pakoh and in January in the areas of Valiasr, city center, Sheikh Abbad and 95 Dastgah are higher than WHO standard limit (Figure 2). Alsoconcentration of Cadmium in December and January in all areas except Valiasr is lower than WHO and EPA standard limits. The mean concentration of Cadmium (p value=0.03) of Valiasr area in December has a significant relationship compared with January. Also in December, the mean concentration of Cadmium of 95 Dastgah area and city center have a significant relationship compared with January (p value=0.01), but generally, the mean concentration of Cadmium in December and in comparison with January do not have a significant relationship (p value=0.33). The mean concentration of Cadmium in the collected samples of city center (P value=0.001), Valiasr (p value=0.02) and Pakoh (p value=0.02) have a significant difference with

[3] CDI: µg/kg-day

other areas of the city (p value<0.05) (Figure 2). The high concentration of heavy metals compared with other areas can be due to the urban sewage entrance to the distribution network because of the deterioration of the most of network, higher density of population and industries in these areas.

Table 3. Comparison concentration of Cadmium drinking water of Minab with other cities and countries

Concentration (μg/l)	Country	References
0.45± 0.16	Egypt (Dakhlia)	[26]
0.01	Kuwait	[27]
4.7±2.796	Saudi Arabia (Riyadh)	[28]
6 μg/l	Canada	[29]
3.35±0.79	Iran(Yazd)	[30]
1.2	Iran (Ahvaz)	[1]
1.7±0.64	Iran (Minab)	This study

As it is seen in table 3, the mean concentration of Cadmiumin thetap drinking water in our study was greater than Albaji et al study (Ahwaz, Iran), Al Fraij et al (Kuwait) and El-Harouny et al study (Dakhlia, Egypt), but was lower than Al-Saleh et al study (Saudi Arabia), Salmani et al (Yazd, Iran) and Meranger et al (Canada). Similar to our study, the mean of Cadmium concentration of drinking water was lower than WHO standard limit in the studies of Albaji et al (Ahwaz, Iran) and Al Fraij et al (Kuwait).

V. Conclusion

The mean of Cadmium concentration of tap drinking water is lower than WHO and EPA standard limits. The highest and lowest Cadmium concentration of tap drinking water are in the areas of Valiasr and Soleghan, respectively. Since non-carcinogenic risk is lower than 1, so it can be said that consumer population of Minab tap drinking water are in the safe area in terms of non-carcinogenic risk.

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