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Determination of concentration and carcinogenic risk of arsenic tap drinking water; City of Minab, Iran

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

[1]*Social Determinants in Health Promotion Research Center, Hormozgan University of Medical Sciences, Bandar Abbas, Iran.*
[2]*Research Center for non-communicable disease, Fasa University of Medical Sciences, Fasa, Iran*
[3]*Food and Drugs Research Center, Bam University of Medical Sciences, Bam, Iran*
[4]*Department of health public, Kermanshah University of Medical Sciences, Kermanshah, Iran*
[5]*Student's research committee, Shahid beheshti University of Medical sciences, Tehran, Iran*
[6]*Environmental Health Research Center, Kurdistan University of Medical Science, Sanandaj, Iran*
[7]*Department of Environmental Health Engineering, School of Public Health, Qom University of Medical Sciences, Qom, 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: *The main route of entry of metalloid arsenic into the human body is drinking of drinkable water. Long-term consumption of drinking water containing arsenic can cause of the urinary bladder, liver and kidney cancers and also skin lesions in humans. In this descriptive cross-sectional study, 100 samples of tap drinking water of Minab were collected from 10 constant points during the months of December and January of 2014. Then, concentration of arsenic was measured with hydride method and by graphite flame atomic absorption spectroscopy (AAS8000 model). Chronic daily intake and carcinogenic risk of arsenic was calculated by equations of EPA. The mean concentration of arsenic in the areas of Azadegan, Ahmad Abbad, Valiasr, City center, Pakoh, Shaykh Abbad, 95 Dastgah, Almahdi town, Zohaki and Soleghan is ND, 6.1, 8.2, ND, ND, 5.6, 7.3, ND, ND and ND, respectively. The mean and rang concentration of arsenic is 7.18±0.83 µg/l and ND-9.3 µg/l, respectively. Chronic daily intake and carcinogenic risk of arsenic are 0.00021 mg/kg-d and 0.000314, respectively. The mean of arsenic concentration of Minab city is lower than WHO standard limit. Arsenic carcinogenic risk in population of Minab city is higher than WHO and EPA standard limits.*

Key words: *Drinking water, Arsenic concentration, daily intake, carcinogenic risk*

I. Introduction

Heavy metals are the elements with specific gravity of 4 to 5 times of water which enter the body through skin contact, inhalation and oral route, but their entry through oral route is much more [4-1]. Heavy metals (Mercury, Lead, Cadmium and etc.) and certain metalloids (Arsenic) have the properties of biological accumulation, toxicity and environmental stability .[6 ,5] So in the recent years, contamination of water resources with heavy metals is dragged the special attention of environment researchers. Heavy metals entry to the water resources can be resulted from natural activities (soil erosion, sediments and etc.) and or human activities (urban, industrial and agricultural wastewater discharges, chemical fertilizers and etc) .[10-7] Small amounts of heavy metals are useful and essential for the body, but at high concentration can be really toxic to humans .[11] Epidemiologic studies show that there is a significant relationship between heavy metals and tooth decay, cardiac diseases, kidney and neurological disorders and cancers .[13 ,12]Meanly, 35E6 kg/y of arsenic enters to the water resources, soil and atmosphere . [14]Long-term entry of arsenic to the body may lead to urinary bladder, liver and kidney cancers and skin lesions .[17-15] One of the very effective factors on occurrence of black foot disease (BFD) is using of water containing arsenic .[19 ,18] Based on WHO and EPA standards, concentration of arsenic in water is classified to the class 1 (safe): 0-5 µg/l, class 2 (alarming): 5-10 µg/l and class 3 (unsafe):>10 µg/l .[21 ,20] WHO standard for concentration of arsenic in drinking water is 10 µg/l .[20]In many studies, measuring of heavy metals concentration and Assessment of their carcinogenic or non-carcinogenic risks are considered .[25-22 ,8] Many of studies have shown that arsenic can enter to the water resources and soil through chemical fertilizers .[27 ,26]Extent use of pesticides and chemical fertilizers by farmers in the vicinity of the supply drinking water wells of Minab and also, lack of urban sewage collecting system, increase the possibility of drinking water contamination of this city with heavy metals and the metalloid

arsenic. So, it is tried to measure the arsenic concentration by Graphite Flame Atomic Absorption Spectroscopy (GFAAS) and calculate and assess its carcinogenic risk through the available equations, in this study.

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 .[28] Drinking water of the residents of this city is supplied from the groundwater sources (Tricyclic 300 meters deep wells). 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.

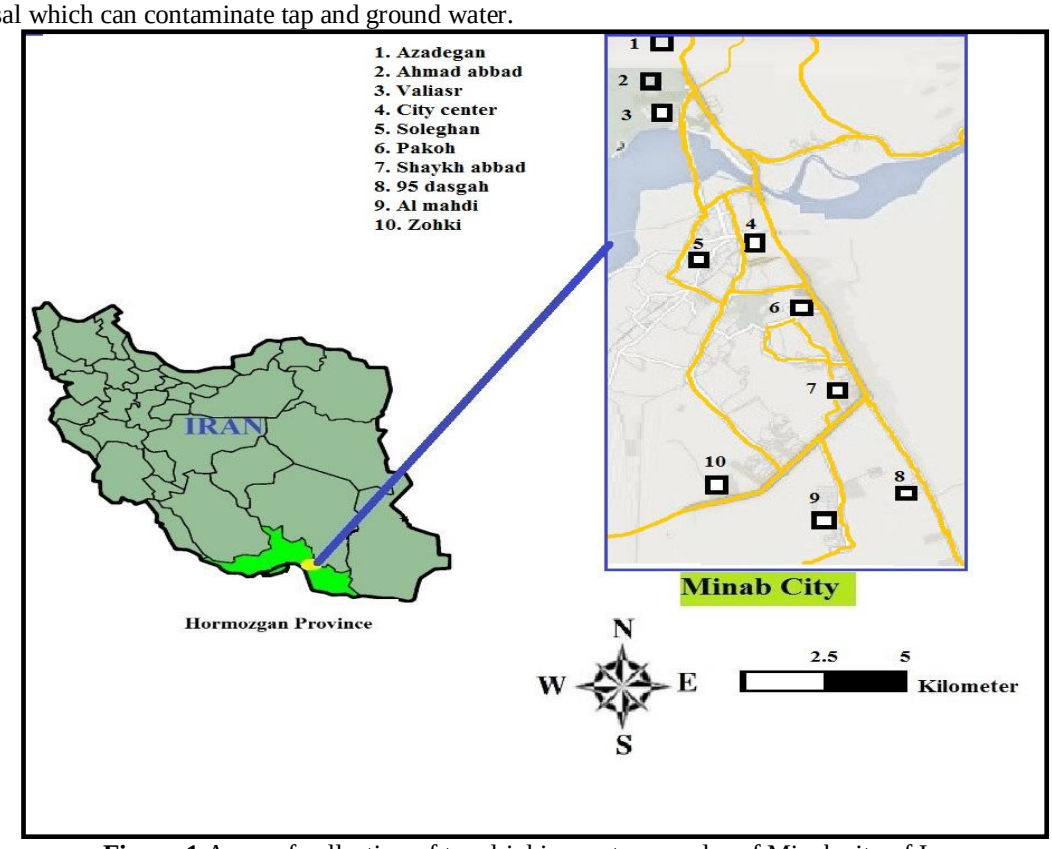

Figure 1. Areas of collection of tap drinking water samples of Minab city of Iran.

2.2. Sample collection

In this cross-sectional study which was conducted in December and January of 2014, to get a good mean concentration of arsenic of tap 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, Zohaki and Soleghan (figure 1). To compare the mean of heavy metals concentrations 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 .[29 ,23]

2.3. Measurement concentration of arsenic

According to the recipe of chemical sampling of water, the tap water samples were transferred into the washed polyethylene bottles with 20% nitric acid and distilled water 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. Then, the samples were transferred to the analysis device laboratory at Hygiene Faculty of Hormozagan Medical Science University at 4ºc. In the laboratory, to concentrate, water samples were filtered through Whatmanglass microfiber filter (GF/C) .[30 ,23 ,3] The concentrationofarsenicin concentrated samples was measured by graphite flame atomic absorption Spectrophotometer (AAS8800 model) in µg/l. Four solutions

of 7, 9, 11 and 13 µg/l were made by the stock solution of arsenic (1000 ppm) due to the limit of detection of the device is 5 to 100 µg/l. Then, the calibration curve of arsenic was obtained by measuring the concentration of the made solutions. The system was set in the wavelength of 193.7 nm, silt 0.4 nm and the lamp of 8mA. Arsenic ions are resorted by sodium bor and hydride to gas hydride arsenic ASH3 and transferred into the quartz cell by an inert gas which thermal decomposition is performed there and arsenic will be to atomic shape and atomic absorption of arsenic can be measured by atomic absorption spectrometry .[31]Tree volumes of 20 µl of each sample were injected to the graphite furnace by injector. The mean of concentration of three measurements was registered as the arsenic concentration of water sample in 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[32]:

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

C: concentration of Arsenic in water in µg/l, DI: Water daily Intake (2l/d) and body weight (72 kg) .[33 ,8] Since, there were no information about the exact used amount of water and the mean of people's body weights in Minab, so the presented information by EPA was used.

2.4.2Carcinogenic Risk (R)

To calculate carcinogenic risk, below equation was used:

Equation 2 $R = CDI \times SF$

In this equation, R: lifetime risk of developing cancer (carcinogenic risk), CDI: Chronic daily intake and SF: Arsenic contamination slope factor $(mg/kg^{-1}d^{-1})^{-1}$.[34]SF for arsenic is equal to 1.5 $(mg/kg^{-1}d^{-1})^{-1}$.[35]

III. Results

The mean of arsenic in December is 7.38±0.68 µg/l. Also, the mean concentration of arsenic in the areas of Azadegan, Ahmad Abbad, Valiasr, City center,Pakoh, Shaykhabbad, 95-Dasgah,Almahdi, Zohaki and Soleghanis ND[1], ND, 7.5, 6.5, 8.1, 6.7,ND, ND, 7.4 µg/l and ND, respectively (table 1).

Table 1. The mean concentration of arsenic, chronic daily intake and carcinogenic risk in 10 areas of Minab city

Areas	Mean[3] December (µg/l)	Mean January (µg/l)	Range	SD[2]	Mean (µg/l)	CDI (mg/kg-d)	R
Azadegan	ND	ND	ND	NC[4]	NC	NC	NC
Ahmad abbad	ND	6.1	ND-7.3	0.49	6.1	0.000178	0.000267
Valiasr	7.5	8.2	5.4-8.5	1.67	7.85	0.000229	0.000343
City center	6.5	ND	ND-7.9	0.58	6.5	0.00019	0.000284
Pakoh	8.1	ND	ND-9.3	0.69	8.1	0.000236	0.000354
Shaykhabbad	6.7	5.6	5.2-7.2	1.24	6.15	0.000179	0.000269
95-Dasgah	ND	7.3	ND-7.6	0.51	7.3	0.000213	0.000319
Al Mahdi	ND	ND	ND-8.9	0.37	8.1	0.000236	0.000354
Zohki	7.4	ND	ND-7.6	0.16	7.4	0.000216	0.000324
Soleghan	ND	ND	ND	NC	NC	NC	NC
Mean	7.38	6.8			7.18	0.00021	0.000314
SD	0.67	1.17			0.83		

The mean concentration of arsenicin January is 6.8±1.17 µg/l. The mean concentration of arsenic in the areasofazadegan, Ahmad Abbad, Valiasr, City center, Pakoh, Shaykhabbad, 95-Dasgah, Al Mahdi, Zohaki and Soleghan is ND, 6.1, 8.2, ND, ND, 5.6, 7.3, ND, ND and ND, respectively (table 1). In general, the mean and rang concentration of arsenic drinking water are 7.18±0.83 µg/l and ND-9.3 µg/l. Chronic daily intake in the areas azadegan, Ahmad Abbad, Valiasr, City center, Pakoh, Shaykhabbad, 95-Dasgah, Al Mahdi, Zohaki and Soleghan is NC, 0.000178, 0.000229, 0.00019, 0.000236, 0.000179, 0.000213, 0.000236, 0.000216 and NC, respectively. Also, carcinogenic risk in the areas of azadegan, Ahmad Abbad, Valiasr, City center, Pakoh, Shaykhabbad, 95-Dasgah, Al Mahdi, Zohaki and Soleghan is NC, 0.000267, 0.000343, 0.000284, 0.000354, 0.000269, 0.000319, 0.000354, 0.000324 and NC, respectively. In general, chronic daily intake and carcinogenic risk for arsenic are 0.00021 mg/kg-d and 0.000314 (table 1).

[1]Not detected (less than 5 µg/l)
[2]Standard deviation in the tow season
[3]Mean of 5 sample
[4] Not calculated

IV. Discussion

The mean of arsenic concentration of tap drinking water in all areas of Minab city is lower than WHO standard .[20] The highest arsenic concentration is related to Valiasr area and the lowest is for Azadegan and Soleghan areas (5 µg/l <). Considering the arsenic concentration classification of drinking water, its concentration in drinking water of Minab city (7.38±0.68 µg/l) is in warning class (5-10 µg/l).

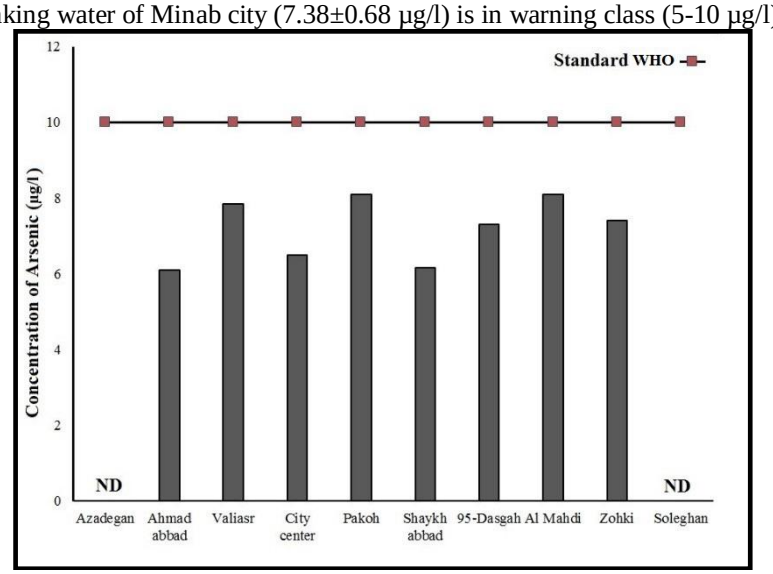

Figure 2. Comparison concentration of arsenic drinking water with WHO standard

The acceptable level of carcinogenic risk, based on EPA and WHO are lower than 1E-6 (on cancer per each one million people) and lower than 1E-4 (one cancer in each 10000 people) [36 ,20]. The mean of carcinogenic risk of arsenic in our study (3.14E-4) is 3.1 times higher than WHO standard and 310 times higher than EPA standard. Of course, this question is still remained that why carcinogenic risk of arsenic is higher than standard while its concentration in drinking water of Minab city is lower than the standard limit. Concentration of Arsenic in Bakirdere et al study (8.51-11.54 µg/l) is higher than our study (ND-9.3 µg/l) .[37] Carcinogenic in Wang et al study (4, 2E-4) because of lower amount of arsenic (3.8 µg/l), is lower than our study [38] . Chronic daily intake in Rajaei et al study (0.97E-4 mg/kg-d) of Autumn and Spring (0.41E-4 mg/kg-d) due to the lower concentration of arsenic is lower than our study (2.1E-4 mg/kg-d) .[39]Carcinogenic risk in Rajaei et study is 2.32E-4 which is lower in comparison with our study (3.14E-4) [39] .Carcinogenic risk of arsenic in Kavcar et al study (1.51E-4) is lower than our study .[40]

V. Conclusion

Although the mean of arsenic concentration in drinking water of Minab city is lower than standard limit, but its carcinogenic risk is higher than WHO and EPA standard limits.

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