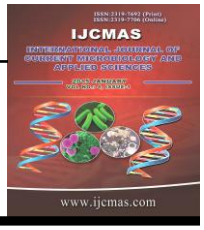
International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 4 Number 3 (2015) pp. 1024-1034**
http://www.ijcmas.com



Original Research Article

Concentration of arsenic in drinking water in Bandar Abbas city and quantitative risk assessment

Yadolah Fakhri[1], Ghazaleh langarizadeh[2], Bigard Moradi[3], Yahya Zandsalimi[4], Leila rasouli amirhajeloo[5], Saeedeh Jafarzadeh[6], Athena Rafieepour[7] and 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 Sciences, 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, M.Sc of Critical Care Nursing, Jahrom University of Medical Sciences, Jahrom, Iran
**Corresponding author*

Keywords

Arsenic, Bottled water, Carcino-genicity risk, Non-carcinogenic risk

A B S T R A C T

The presence of heavy metals like arsenic in drinking water sources can endanger human health because of being toxic and carcinogenic. In this study, 432 samples of eight brands of bottled water consumed during the summer and winter in 2013 were collected from the city of Bandar Abbas. Concentration of arsenic were measured by atomic absorption device, spectrophotometer DR2800 model and according to the method Silver Diethyldithiocarbamate. CDI, R and HQ for adult men, adult women, and children was evaluated and calculated through the EPA and WHO equations. Mean and range of arsenic are 5.67±0.73 µg/l and 0.9-16.3 µg/l. The mean arsenic concentration is below WHO and EPA standard (10 µg/l). The order arsenic concentration in bottled water brands is almost BW7> BW8> BW6>BW1>BW5 > BW2 >BW3> BW4. CDI, R and HQ in children is 2 times more than adult men and women (p value<0.05). Carcinogenic risk of arsenic for children (67E-5), adult men (30E-5) and adult women (28E-5) is more than acceptable R level of EPA (1E-6) and WHO (1E-4). Hence, all age groups are at carcinogen risk range. Since HQ for adult men (0.67) and adult women (0.62) is less than 1 and for children (1.52) is more than 1, hence, adult men and women are in non-carcinogenic risks area and children are in non-safe area.

Introduction

Heavy metals have properties such as biological accumulation, toxicity and environmental sustainability .[1] In recent years, the presence of heavy metals such as arsenic (As), cadmium (Cd), mercury (Hg), lead (Pb), nickel (Ni) and chromium (Cr) in

drinking water has become an environmental and health concern [4-2]. Entering heavy metals into water resources can be from natural processes such as erosion or caused by human activities, such as municipal, industrial or agricultural sewage discharges [5]. Heavy metals exist naturally in small amounts in water. Many of these elements have a dual role in the human body [6]. Even they are harmless at low concentrations and in some cases even beneficial to health, but they can be hazardous to human health at higher concentrations than the standard level [8 ,7]. Epidemiological studies show that there is a significant relationship between tooth decay, heart disease, kidney disorders, neurological disorders and cancers and heavy metals ,9] [10. Arsenic entry into the body caused by eating and drinking in a long term can cause skin cancer, Lung cancer, bladder, liver and kidney cancer [13-11]. epidemiological study by Chen et al show with increase arsenic in drinking water increase A very important factor in causing black foot disease is drinking water contaminated with arsenic .[15 ,14] Also, entering arsenic for a long time can cause skin lesions in people (50 µg/l ≥) [16]. The World Health Organization (WHO) is recommended 10 µg/l guidelines level for arsenic [17]. Also Recently United States Environmental Protection Agency (EPA) adopted the maximum allowable concentration of 10 µg/l in drinking water total arsenic (organic and inorganic) [18]. In the past 30 years, bottled water consumption has been rising in many populations [20 ,19]. Packaged water is classified into two mineral water and bottled water [21]. Packaged water adds various additives such as trace elements, etc. into water, but in mineral water, bottled water is filled with spring water without additives [22]. Many studies have measured concentrations of heavy metals in bottled water and have evaluated and calculated non-carcinogenic and carcinogenic risks in different age groups [29-23] . Due to the importance of arsenic health risks in drinking water and high use of water, especially bottled water (due to the hot and humid weather) at Bandar Abbas, it has been attempted in this study to calculated and evaluate carcinogenic and non-carcinogenic risk in adult men and women and children.

Materials and Methods

Study area

The coastal city of Bandar Abbas (the capital of Hormozgan Province) is located in southern Iran (N "53'11°27 and E"7'22°54) at an elevation of 9 meters above sea level (Figure 1) [30]. The city's climate is hot and humid and the population is increasing day by day due to business growth[31].

Sample collection

This cross-sectional study is conducted in the summer and winter of 2013. Samples collection was conducted out of high-consumed eight brands of packaged water in Bandar Abbas from (Figure 1). This 13 locations was selected According to density dwelling and population in the city. In each month, nine 1.5 liter bottles were randomly collected from each brand. 216 water samples in summer and 216 samples in winter (a total of 432 samples of bottled water) were collected (table 1). Samples were transferred to the Chemical laboratory at Hormozgan University of Medical Sciences according to the chemical sampling procedure, at 4-6 C ° for measuring the concentration of heavy metals [32].

Arsenic concentration analysis

In the laboratory, ml 1 nitric acid (65%) per liter of water sample, to reach 2 PH <

(for maintaining heavy metals in water samples up to 28 days) was added to the water samples. To concentrate, water samples were passed through Whatman glass microfiber filter (GF/C) [33]. Measurement arsenic concentration was done by atomic absorption spectrophotometry DR2800 model in Method 8013 silver diethyldithiocarbamate method detection limit (0-200 µg/l)[34] [35].

Statistical analysis

The difference of mean arsenic concentration in different brands of bottled water, difference arsenic concentrations in summer and winter, carcinogenic and non-carcinogenic risk difference in different age groups using T test and One Way ANOVA were analyzed by SPSS16 software. Error of five percent (α= 5) was considered as significant level.

Risk analysis

Chronic Daily Intake (CDI) was calculated by the calculation presented by United States Environmental Protection Agency [36]:

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

In this equation, CDI is chronic daily intake (mg/kg-d), C; concentration of contaminants (arsenic) in drinking water (mg/l), DI; average daily water consumption (l/d) and BW and body weight is (kg). DI for adult men (65-17 years), adult women (65-17 years) and children (14.4 years) is 2.723, 2.129 and 1.8 l/d, respectively and BW is 76, 64 and 22.3 kg, respectively .[38 ,37] Carcinogenic risk of heavy metals is caused by eating or drinking can be calculated by Equation 2 [39].

Equation 2 $R=CDI\times SF$

In this equation, R is carcinogenic risk from lifetime exposure to contaminants (As); CDI is chronic daily intake (mg / kg-d) and SF, pollutant slope factor (kg-d/mg) depending on the pollutant concentration or dose). SF for arsenic is 1.5 kg-d / mg. Acceptable levels of R based on EPA and WHO is less than 1E-6 (one cancer per million people) and less than 1E-4 (one cancer per 10,000 people) .[41 ,40 ,17]

Hazard Quotient) HQ): to calculated non-carcinogenic risk of arsenic in water, it is calculated by Equation 3:

Equation 3 $HQ=CDI/RfD$

In Equation 3, RfD is pollutants reference dose (mg/kg-d). RfD for arsenic is 0.0003 mg/kg-d [3]. A population is in a safe area when HQ<1 [42].

Results and Discussion

Mean (M ± SE) and range arsenic concentrations is 5.67±0.73 µg/l and 0.9-16.3 µg/l. mean arsenic concentrations of is less than the standard of WHO and EPA (10.1 µg). Mean arsenic concentrations in brands BW1, BW2, BW3, BW4, BW5, BW6, BW7 and BW8 are 6.33±0.93, 5±0.68, 3±0.37, 1.33±0.39, 6±0.76, 7.83±1.23, 11.33±1.39 and 10.5±1.2 µg/l (Table 2). A significant relationship was observed between mean arsenic concentrations of in summer and winter in brands BW2، BW3، BW4 and BW5 (p value < 0.05). This difference could be due to changes in water supply, changes in the type of clean-up and entry of probable pollution in one season. Given the mean arsenic concentrations, the brands of bottled water are BW7>BW8 BW6>BW1>BW5> BW2> BW3>BW4, respectively. The highest and

lowest mean arsenic concentrations relates to BW7 and BW4 (Table 2). Arsenic concentrations for brands BW1, BW2, BW3, BW4, BW5, BW6, BW7 are 3.9-11, 4.9-5.3, 3-3.1, 0.9-5.2, 5-11.3, 4.9-16, 2.8-16.3 and 4.9-15.3 µg/l. According to WHO guidelines and maximum permissible concentrations of EPA (10 µg/l), Mean arsenic concentrations in BW8 and BW7 brands is higher than the standard level .[43 ,16] In addition, concentration range of brands BW1, BW6, BW8, BW7 and BW5 in some cases is higher than the standard level (Figure 2).

Range arsenic concentrations in the study of Bakirdere et.al (8.51-11.54 µg/l) in our study range (0.9-16.3µg/l). Mean arsenic concentration in our study (5.67±0.73 µg/l), such as the study conducted by Bakirdere et.al is less than WHO and EPA standard level (10 µg/l) [44] . Concentration range of arsenic in bottled water in the study of Ficket et.al (0.143-2.999 µg/l) is in our study range .[6]

Arsenic can be seen in Figure 3, 28.4% (123 samples) of total samples (432 samples) have concentrations greater than the WHO and EPA standards. Chronic daily intake (CDI) for the age groups of adult men, adult women, and children, is 20E-5, 18E-5 and 45E-5 mg/kg-d. The highest and lowest CDI relates to BW7 brands (91E-5) for children and BW4 (4E-5) for adult women (Table 3). CDI order for different age groups is children> male> female adult. CDI for children approximately 2.25 times more than CDI in adult men and women (p value <0.05). CDI in the study of Rajai and his colleagues (9.7E-5 in autumn and spring season's 4.1E-5 mg/kg-d) is lower than our study (20E-5, adult male) due to lower arsenic concentration .[27] Mean risks of arsenic carcinogenicity (R) for adult men, adult women, and children are 30E-5, 28E-5 ،68E-5, respectively (Table 3). The order of carcinogenic risk is children> male> female adult.

Table.1 The number of sample water in summer and winter seasons 2013

	Summer			winter		
Locations	July	August	September	January	February	March
1	6	9	NC[1]	9	6	6
2	3	3	6	9	3	6
3	NC	3	6	9	6	6
4	6	6	6	6	6	NC
5	9	3	6	3	3	NC
6	3	6	9	6	6	6
7	3	6	9	6	6	9
8	6	6	3	3	6	6
9	6	6	9	6	6	9
10	9	6	6	NC	3	6
11	12	9	6	NC	9	6
12	3	6	3	6	9	3
13	12	3	3	9	3	9
SUM	72	72	72	72	72	72
SUM		216			216	

[1] Not colected

Table.2 Mean, standard deviation and range arsenic concentrations in eight brands of bottled water in Bandar Abbas in summer and winter 2013

	Summer			Winter					
	August	July	June	February	January	December	Mean of two seasons	SD[2]	Range
BW1	0.7662±.7	6±0/65	6.11±1	74.6±0	44.4±0	64.5±0	93.33±0.6	42.2	9−11.3
BW2	ND[3]	ND	ND	ND	ND	68.5±0	68.5±0	2.4	3.9−5.4
BW3	ND	ND	ND	53.4±0	ND	37.3±0	37.3±0	83.1	1.3−3
BW4	ND	ND	ND	12.1±0	59.5±0	26.2±0	39.33±0.1	97.1	2.9−5.0
BW5	2.±110.3	57.5±0	11±1/65	ND	ND	55.5±0	76.6±0	6	3.5−11
BW6	5±0/57	ND	71.12±1	3.11±1	9.16±1	63.5±0	23.8±1.7	11.6	−164.9
BW7	21.10±1	48.12±1	0.333±	1.16±2	5.13±1	98.8±0	39.3±1.11	05.5	16.3−2.8
BW8	34.11±1	0.938±	42.12±1	5.5±0	75.15±1	03.9±1	2.5±1.10	83.3	15.3−4.9

Table.3 CDI, R and H in adult men, adult women, and children caused by arsenic in bottled water in Bandar Abbas

	C (µg/l)	CDI mg/kg-d			R			HQ		
		Children	Adult women	Adult men	Children	Adult women	Adult men	Children	Adult women	Adult men
BW1	6.33	−5E51	−5E21	−5 E23	−5E76	−5E31	−5 E34	1.7	0.7	0.75
BW2	5	−5E40	−5E17	−5 E18	−5E60	−5E24	−5 E26	1.34	0.55	0.59
BW3	3	−5E24	−5E41	−5 E11	−5E26	−5E14	−5 E14	0.8	0.33	0.35
BW4	1.33	−5E11	−5E4	−5E5	−5E16	−5E6	−5E7	0.35	0.14	0.15
BW5	6	−5E48	−5E20	−5 E21	−5E72	−5E29	−5 E32	1.61	0.66	0.71
BW6	7.83	−5E63	−5E26	−5 E28	−5E94	−5E39	−5 E42	2.1	0.86	0.93
BW7	11.3	−5E91	−5E38	−5 E41	−5E137	−5E56	−5 E60	3.04	0.25	1.39
BW8	10.5	−5E85	−5E35	−5 E38	−5E127	−5E52	−5 E56	2.85	1.16	1.35
MEAN	5.67	−5E45	−5E18	−5 E20	−5E68	−5E28	−5 E30	1.52	0.62	0.67

[2] Standard Deviation
[3] Not Detected or zero

Figure.1 Locations of bottled water sample collected at the city of Bandar Abbas in southern Iran

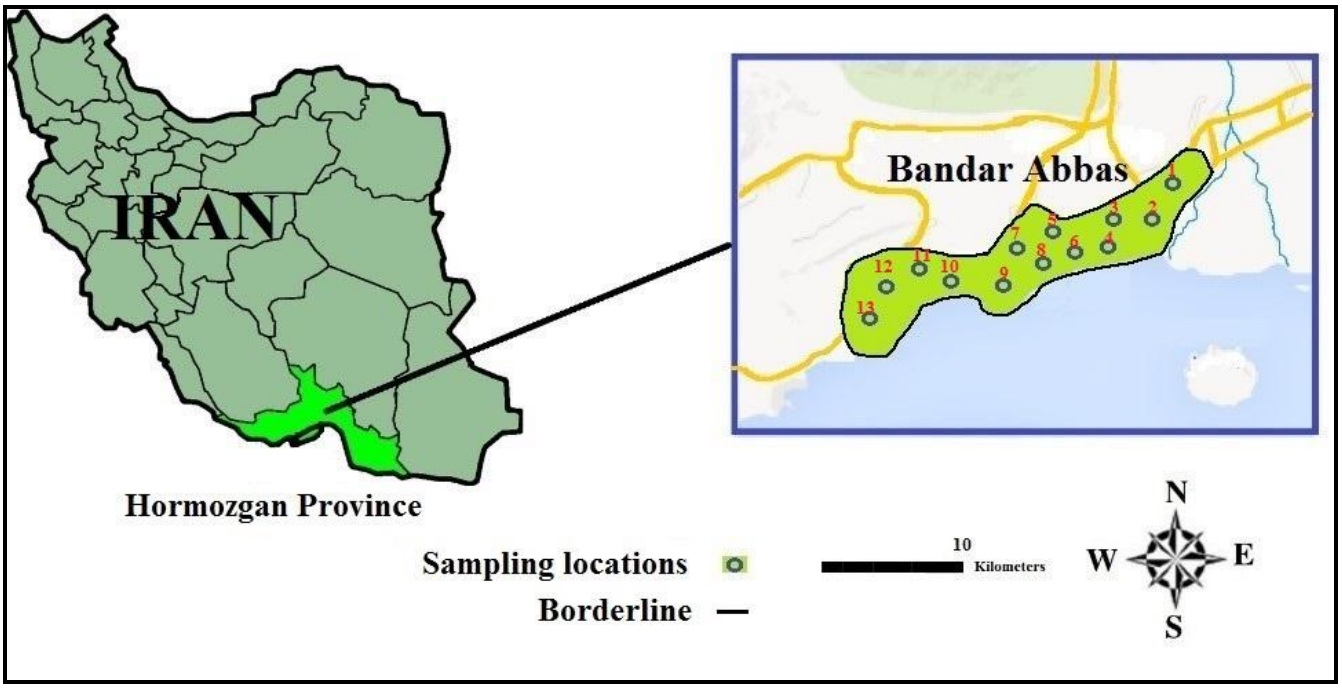


Figure.2 comparing the mean and range arsenic concentrations in bottled water by WHO and EPA standards

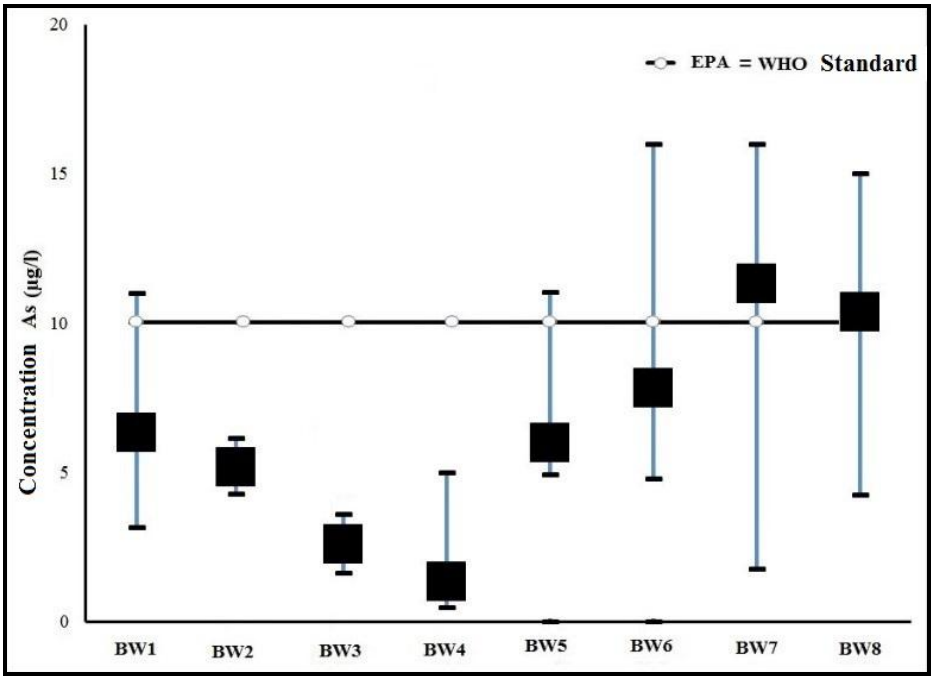


Figure.3 Relative percentage frequency distribution of arsenic concentrations in 432 samples of bottled water in Bandar Abbas

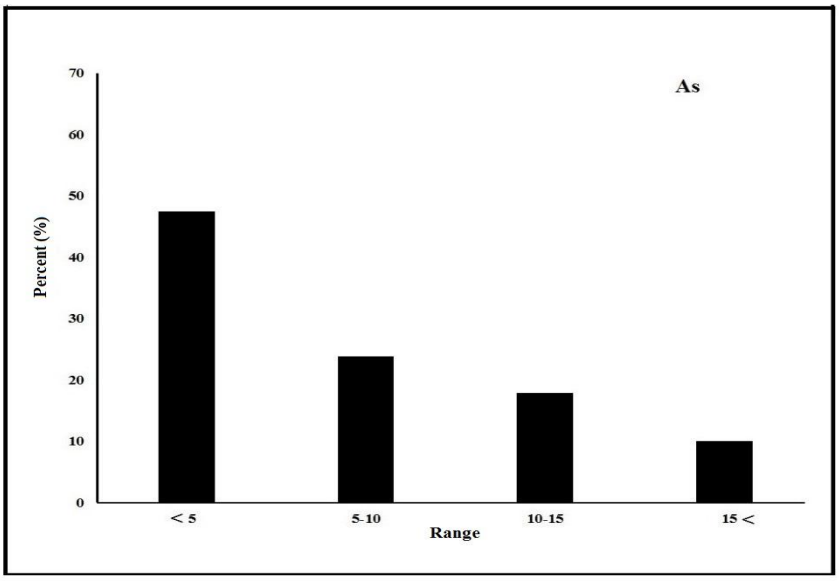


Figure.4 comparison of the carcinogenic risk of adult men, adult women, and children to the acceptable levels of EPA and WHO

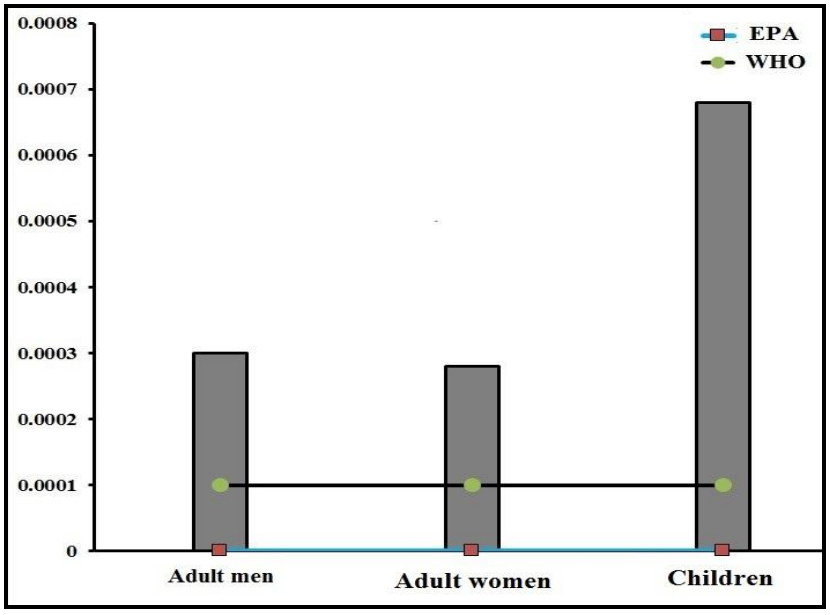
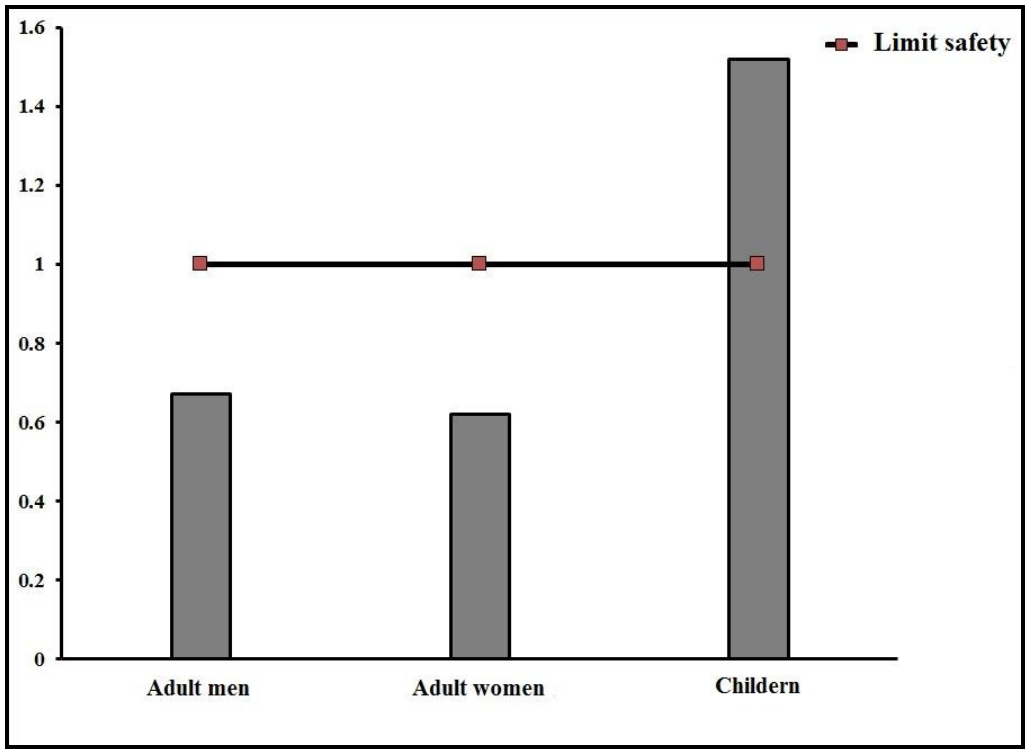


Figure.5 Comparing the non-carcinogenic risk of arsenic for age groups of adult men, adult women, and children with a safe level



Carcinogenic risk among children is approximately 2.26 times more than adult women and men (p value<0.05). Because children have less weight than that of adult men and women (less than 60-40%), hence, CDI, followed by R, is higher than the other groups (weighted inversely with the CDI, Eq. 1) [38]. The highest carcinogenic risk relates to brand BW7 (children, 137E-5) and the lowest one relates to mark BW4 (adult female, 6E-5). Mean carcinogenic risk for all age groups, due to higher water consumption, is higher than acceptable levels of EPA (1E-6) and an acceptable level of WHO (1E-4) (Figure 4) .[41 ,40]

The carcinogenic risk in the study conducted by Wang and colleagues for children (46E-5) and adult (21.4E-5) was less than the one obtained in our study due to lower arsenic concentrations (3.8µg/l). Also, in the study of Wang et.al as our study, carcinogenic risk for children is more than 2 times for [3]. The carcinogenic risk in the study done by Rajaie et.al was 2.32E-4 , which due to lower arsenic concentration (2.28 µg/l in autumn and 0.97 µg/l in spring) was quite lower than our study (30E-5, adult men), (Table 3) [27]. The carcinogenic risk in the study done by Kavcar et.al (adults, 0.000151) was less than that of our study (adult men, 0.0003). Although the mean arsenic concentration in the study by Kavcar (6.47 µg/l was more than our study (5.167 µg/l), due to the consideration of lower water consumption (2 l/d), compared to our study (2.723 1/d), there is also less risk of carcinogenicity [36].

Non-carcinogenic risk for adult men, adult women, and children are 0.67, 0.62 and 1.52, respectively. The order of non-carcinogenic risk is children>male> female adult. Non-carcinogenic risk for children is

2.33 times more than adult men and women (p value<0.05). Mean non-carcinogenic risk in children is more than 1 but less than 1 in adult men and women (Table 3). Non-carcinogenic risk in the study done by Kawcar and colleagues (HQ=0.5, adults) due to lower CDI, is lower than our study (HQ=0.67, male) .[36] Non-carcinogenic risk in the study by Rajaie et.al is 2.53E-4 that is much lower to our study (Fig. 5) [27].

Although the mean arsenic concentration of in bottled water is less than the WHO and EPA standard, carcinogenic risk of arsenic for adult men, adult women, and children is higher than acceptable levels of EPA (1E-6) and WHO (1E-4). Non-carcinogenic risk for adult men and women is less than 1 but greater than 1 for children. Carcinogenic and non-carcinogenic risk for children is 2 times more than adult men and women. All age groups, especially children, are at risk in terms of carcinogenic risk of arsenic bottled water. Also, the non-carcinogenic risk in men and women over age group is in a safe range (1>HQ) but children are unsafe in this limit (1<HQ).

Acknowledgements

The authors thank and appreciate Chemical Laboratory Scholars, Health Faculty of Hormozgan University of Medical Sciences.

References

1. Pekey, H., D. Karakaş, and M. Bakoglu, Source apportionment of trace metals in surface waters of a polluted stream using multivariate statistical analyses. Marine Pollution Bulletin, 2004. 49(9): p. 809-818.
2. Dogaru, D., et al., Community perception of water quality in a mining-affected area: A case study for the Certej catchment in the Apuseni mountains in Romania. Environmental management, 2009. 43(6): p. 1131-1145.
3. Wang, Z., et al., Potential health risk of arsenic and cadmium in groundwater near Xiangjiang River, China: a case study for risk assessment and management of toxic substances. Environmental monitoring and assessment, 2011. 175(1-4): p. 167-173.
4. Ghaderpouri, M., G. JahedKhaniki, and S. Nazmara. Determination of toxic trace elements in bottled waters consumption in the of Tehran. in 12th environmental health national congress. 2009.
5. Demirak, A., et al., Heavy metals in water, sediment and tissues of< i> Leuciscus cephalus</i> from a stream in southwestern Turkey. Chemosphere, 20 :(9)63 .06p. 1451-1458.
6. Fiket, Ž., et al., Determination of arsenic and other trace elements in bottled waters by high resolution inductively coupled plasma mass spectrometry. Croatica chemica acta, 2007. 80(1): p. 91-100.
7. Ahmad, A., I. Mushrifah ,and M.S. Othman, Water quality and heavy metal concentrations in sediment of Sunagi Kelantan, Kelantan, Malaysia: A baseline study. Sains Malaysiana, 2009. 38(4): p. 435-442.
8. Khan, M.A., I. Ahmad, and I.U. Rahman, Effect of environmental pollution on heavy metals content of Withania somnifera. Journal of the Chinese Chemical Society, 2007. 54(2): p. 339-343.
9. Soupioni, M., B. Symeopoulos, and H. Papaefthymiou, Determination of trace elements in bottled water in Greece by instrumental and radiochemical neutron activation analyses. Journal of radioanalytical and nuclear chemistry, 2006. 268(3): p. 441-444.

10. Babaji, I., N. Shashikiran, and S. Reddy, Comparative evaluation of trace elements and residual bacterial content of different brands of bottled waters. Indian SOC, 2004. 22(4): p. 201-204.
11. LYON, F., IARC monographs on the evaluation of carcinogenic risks to humans. 1982.
12. Steinmaus, C., et al., Case-control study of bladder cancer and drinking water arsenic in the western United States. American Journal of Epidemiology, 2003. 158(12): p. 1193-1201.
13. Majumdar, K., et al., Systemic manifestations in chronic arsenic toxicity in absence of skin lesions in West Bengal. Indian Journal of Medical Research, 2009. 129(1): p. 75.
14. Shekoohiyan, S., et al., Determination of lead, cadmium and arsenic in infusion tea cultivated in north of Iran. Iranian journal of environmental health science & engineering, 2012. 9(1): p. 1-6.
15. Chen, H.-W., Gallium, indium, and arsenic pollution of groundwater from a semiconductor manufacturing area of Taiwan. Bulletin of environmental contamination and toxicology, 2006. 77(2): p. 289-296.
16. Organization, W.H., Guidelines for drinking-water quality: First addendum to volume 1, Recommendations. Vol. 1. 2006 :World Health Organization.
17. Organization, W.H., Guidelines for drinking-water quality: recommendations. Vol. 1. 2004: World Health Organization.
18. Environmental Protection Agency, U.S., Basic Information about Arsenic in Drinking Water. January 22, 2.001
19. Karamanis, D., K. Stamoulis, and K. Ioannides, Natural radionuclides and heavy metals in bottled water in Greece. Desalination, 2007. 213(1): p. 90-97.
20. Jakus, P.M., et al., Risk perceptions of arsenic in tap water and consumption of bottled water. Water Resources Research, 2009. 45(5.(
21. Ong, C.N., A. Grandjean, and R. Heaney, The mineral composition of water and its contribution to calcium and magnesium intake. Calcium and Magnesium in Drinking-water, 2009: p. 37.
22. .22 Cybulska, E.B. and P.E. Doe, 3 Water and Food Quality. Chemical and functional properties of food components, 2006: p. 29.
23. Arab, S. and A. Alshikh, Estimating Of Some Trace Elements In Mineral Water In The Kingdom Of Saudi Arabia. Life Science Journal, 2010. 7(3)
24. Shotyk, W. and M. Krachler, Lead in bottled waters: contamination from glass and comparison with pristine groundwater. Environmental science & technology, 2007. 41(10): p. 3508-3513.
25. Dabeka, R., et al., Survey of bottled drinking waters sold in Canada for chlorate, bromide, bromate, lead, cadmium and other trace elements. Food Additives & Contaminants, 2002. 19(8): p. 721-732.
26. Ikem, A., et al., Chemical quality of bottled waters from three cities in eastern Alabama. Science of the total environment :(1)285 .2002 ,p. 165-175.
27. Rajaei, Q., A. POURKHABBAZ, and S. HESARI MOTLAGH, Assessment of Heavy Metals Health Risk of Groundwater in Ali Abad Katoul Plian. Journal Of North Khorasan University Of Medical Sciences, 2012.
28. Majumdar, K.K., Effect of drinking arsenic-contaminated water in children. Indian journal of public health, 2012. 56(3): p. 223.
29. Caylak, E., Health risk assessment for arsenic in water sources of Cankiri

Province of Turkey. CLEAN–Soil, Air, Water, 2012. 40(7): p. 728-734.
30. Darvishsefat, A.A. and M. Tajvidi, Atlas of protected areas of Iran. 2006: Ravi.
31. Cadène, P. and B. Dumortier, Atlas of the Gulf states. 2013, Brill: Leiden; Boston.
32. Federation, W.E. and A.P.H. Association, Standard methods for the examination of water and wastewater. American Public Health Association (APHA): Washington, DC, USA, 2005.
33. Muhammad, S., M.T. Shah, and S. Khan, Health risk assessment of heavy metals and their source apportionment in drinking water of Kohistan region, northern Pakistan. Microchemical Journal, 2011. 98(2): p. 334-343.
34. Company, H., DR 2800 Spectrophotometer. June 2007 Edition 2.
35. Hach, D., 2800 Spectrophotometer: Procedures Manual. Hach Company, Germany, 2007.
36. Kavcar, P., A. Sofuoglu, and S.C. Sofuoglu, A health risk assessment for exposure to trace metals via drinking water ingestion pathway. International Journal of Hygiene and Environmental Health, 2009. 212(2): p. 216-227.
37. Agency, E.P., stimated Per Capita Water Ingestion and Body Weight in the United States–An Update. October, 2004. p. 40-45.
38. Chen, L.G., G.J. Chen, and H.L. Feng, Water source quality safety evaluation based on health risk assessment. . Journal of Hydraulic Engineering, 2008. 39: p. 235–239.
39. Patrick, D.R., Risk assessment and risk management. Toxic Air Pollution Handbook, 1994: p. 341-59.
40. US, E.P.A. Human Health Risk Assessment. 2010; Available from: http://www.epa.gov/reg3hwmd/risk/human/index.htm.
41. Environmental Protection Agency, U.S., Water Quality Standards Regulations and Federally Promulgated Standards. 2006.
42. Hashmi, M.Z., et al., Risk Assessment of Heavy Metals Pollution in Agricultural Soils of Siling Reservoir Watershed in Zhejiang Province, China. BioMed research international, 2013. 2013.
43. Environmental Protection Agency, U.S., Drinking Water Contaminants. may 2009.
44. Bakırdere, S., et al., Determination of As, Cd, and Pb in tap water and bottled water samples by using optimized GFAAS system with Pd-Mg and Ni as matrix modifiers. Journal of Spectroscopy, 2013. 2013.