DOI: 10.5455/msm.2014.27.52-55
Published online: 21/02/2015 Published print:02/2015
Received: 04 December 2014; Accepted: 05 February 2015

ORIGINAL PAPER Mater Sociomed. 2015 Feb; 27(1): 52-55

The Non-carcinogenic Risk of Cadmium in Bottled Water in Different Age Groups Humans: Bandar Abbas City, Iran

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ABSTRACT

Introduction: The presence of heavy metals such as cadmium in drinking water resources can be dangerous for human because of toxicity and biological accumulation. The consumption of water which contains Cd in high concentration can lead to Bone and Kidney diseases. **Material and Methods:** In this present study, the researcher collected 432 samples of bottled water in the popular marks in summer and winter from the surface of Bandar Abbas. The cadmium concentration was measured by atomic absorption Spectrophotometer in model DR2800 through the Dithizone method. CDI, R and HQ which are caused by Cd for adult men, women and children, have been calculated and evaluated through the equations of EPA and WHO. **Results:** Mean of 1.73±0.19 µg/l (M±SE) is lower than the standard of WHO and EPA. However, 33.2% of all the samples have concentrations more than the standard limit of WHO, and the concentrations of 22.4% of the samples are more than EPA's standard. The CDI for different age groups is as following manner; Children>adult women>adult men. The CDI in children is more than twice as much as in the CDI for adult men and women. The mean of HQ order for different age groups is children>adult men>adult women. Since HQ of adult men (34E-5), adult women (31E-5) and children (84E-5), is lower than 1. **Conclusion:** It can be said that the population of Bandar Abbas is in a safe area regarding the HQ of the bottled water's cadmium.

Key words: Cadmium, Bottled Waters, Non-carcinogenic, Drinking water, age groups

1. INTRODUCTION

The metals with densities over 5 gr/cm^3 are called heavy metals (1). In recent years, the presence of these metals such as Arsenic(As), Cadmium (Cd), Mercury (Hg), lead (Pb), Nickel (Ni), and Chrome (Cr) in drinking water have become an international environmental and health concern (2-4). The entry of the heavy metals in water resources can be due to the natural processes such as wastewater municipal, industrial, and agricultural sewage (5). The heavy metals naturally exist in small amount in water. Many of these elements have a dual role in the human body (6).

The heavy metals could be dangerous for human health at higher values than the standard (7, 8). These elements have biological accumulation, toxicity, and environmental sustainability properties (9).The epidemiological studies show that there is a significant relationship between tooth decay, kidney disorders, neurological disorders, and cancers with heavy metals (10-12). Cadmium can enter into the drinking water by the penetration of industrial wastewater containing cadmium into water distribution network and also penetration via polyethylene tubes and containers (water bottles) (13, 14). The International Agency for Research on Cancer (ICRP) has classified cadmium as a group "A" carcinogen (15). Cadmium's biological half-life in bone and kidney is 38 and 10 years, respectively (16). Chronic exposure to cadmium causes kidney failure and itai-itai disease (osteoporosis and severe pain) (17, 18). The standard limit of WHO and EPA for Cd in bottled drinking water is 3 and 5 µg/lrespectively (19, 20). In the last 30 years, the use of bottled water has been growing in many nations (21, 22). The packed water is divided into two groups of mineral water and bottled water (23, 24). In many

studies, the concentration of heavy metals in bottled water and their carcinogenic and non-carcinogenic risks in different age groups have been measured (25- 31). Due to the health hazards of cadmium and high water consumption in Bandar Abbas, especially the bottled water (due to hot and humid weather), in this study, we have tried to evaluate the non-carcinogenic risk in adult men and women, and children.

2. METHODS

2.1. Area study

The coastal city of Bandar Abbas (Center of Hormozgan Province) is located at the south of Iran (54°22′7"E and 27°11′53" N) and at a height of 9 meters above the sea level (25). The climate of this city is hot and humid and its population is growing by the day because of economic and industrial development.

2.2. Sample collection

This descriptive sectional study was conducted in summer and winter 2013. The sample collection was made from 8 marks of popular packaged water in Bandar Abbas at 13 different places. Per month 9 number of 1.5 liter was selected randomly from each mark. 216 samples of water were collected in summer and 216 samples were collected in winter (totaling 432 samples of bottled water). The samples were transferred to the chemistry laboratory of health faculty of Medial Science, University of Hormozganin 4-6°C in order to measure the heavy metals concentration (26).

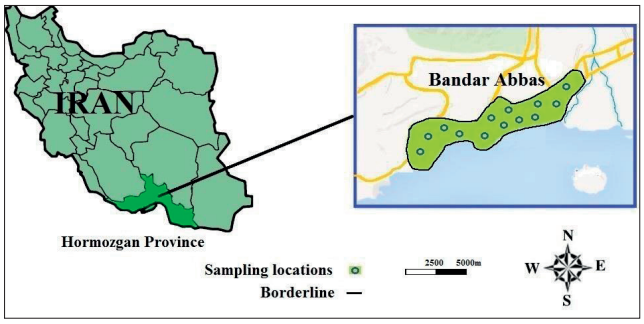

Figure 1. Areas of collecting samples of bottled water in the surface of Bandar Abbas in the South of Iran

2.3. Measurement concentration of Cd

1 ml nitric acid was added to water samples per each liter of sample water in a laboratory to get to PH<2 (to save up the Cd up to 28 days in the water samples). For condensation, water samples were passed through whatsman glass micro-fiber filter (GF/C) (27).Cd concentration was measured by atomic absorption Spectrophotometer in model DR2800 through the Dithizone method (28).

2.4. Statistical Analysis

The difference of mean concentration of Cdin different marks of the bottled water, the difference of Cdconcentration in summer and winter, the difference of R and HQin different age groups was analyzed byT- test and ANOVA test by software SPSS16. An error of 5% (α=5) was considered as significant level.

2.5. Risk Assessment

The calculation of the Chronic Daily Intake (CDI) was performed through the equation which was presented by the United States Environmental Protection Agency (USEPA);

(1)CDI=C×DI/BW

In this equation, CDI is Chronic Daily Intake (mg/kg-d), C is the concentration of Cd in drinking water (µg/l), DI is mean daily intake water(l/d), and BW is a body weight (kg).

Because of, not exist data about the mean daily water consumption and the weights of different age groups population in Bandar Abbas; we used date suggested by WHO and EPA. Hence, DI for adult men (17-65 years old), adult women (17-65 years old) and children (4-14 years old) 2.723, 2.129, 1.8 l/d and BW 76, 64 and 22.3 kg, are respectively(29, 30). Since the safety factor (SF) for the carcinogenic risk from oral exposure to cadmium has not been estimated by EPA (Integrated Risk Information System), the carcinogenic risk of cadmium was not calculated (31).

Hazard Quotient (HQ) for the calculation of non-carcinogenic risk of Cd in water was calculated using equation 2;

2 HQ=CDI/RfD

In equation 3, RFD is dose of polluter's reference (mg/kg-d) which was considered 0.0005 mg/kg-d forCd(3).A population is located in a safe area when Hazard Quotient is less than 1: HQ<1(32).

3. RESULTS

The (M±SE) mean and range of cadmium (Cd) concentration is 1.73±0.19 µg/l and 0-7.1 µg/l, respectively. The mean concentrations of cadmium in marks BW1, BW2, BW3, BW4, BW5, BW6, BW7 and BW8 are 1.33±0.17, 0.68±0.09, 0.77±0.13, 0.95±0.17, 1.32±0.17, 0.67±0.09, 4.8±0.43, and

	Summer			Winter					
Marks	July	August	September	January	February	March	Mean	SD	Range
BW1	0.4±0.04	1.5±0.16	1.9±0.24	2.8±0.31	0	1.4±0.15	1.33±0.17	1.02	0-2.9
BW2	0	0.3±0.04	0.6±0.09	2.6±0.28	0.4±0.05	0	0.68±0.09	1.06	0-2.7
BW3	1.3±0.14	0.6±0.08	0.6±0.08	0.6±0.07	0	1.9±0.22	0.77±0.13	0.71	0-2.1
BW4	0.5±0.05	0.1±0.03	0	1.4±0.18	2.1±0.23	0.6±0.2	0.95±0.17	0.87	0-2.3
BW5	1.9±0.22	2.1±0.23	3.9±0.38	0	0	0	1.32±0.17	1.6	0-4.1
BW6	1.6±0.18	0.6±0.07	0.6±0.07	0.9±0.15	0	0	0.67±0.09	0.61	0-1.7
BW7	2.1±0.22	5.8±0.69	5.9±0.71	3.6±0.37	4.8±0.46	5.9±0.72	4.8±0.43	1.44	1.9-6.1
BW8	1.9±0.23	1.7±0.2	1.7±0.2	4.1±0.31	4.1±0.31	6.8±0.77	3.37±0.32	1.89	1.5-7.1

Table 1. Mean (M±SE), Standard deviation (SD), the range of cadmium concentration (µg/l), in 8 marks of the bottled water in Bandar Abbas in summer and winter 2013 (n=432)

	C (µg/l)	CDI (Mg/kg-d)			HQ		
Marks		Adult men	Adult women	children	Adult men	Adult women	children
BW1	1.33	17E-7	16E-7	39E-7	0.034	0.032	0.077
BW2	0.68	14E-7	13E-7	31E-7	0.027	0.025	0.061
BW3	0.77	8E-7	8E-7	18E-7	0.016	0.015	0.036
BW4	0.95	4E-7	3E-7	8E-7	0.0072	0.006	0.016
BW5	1.32	16E-7	15E-7	37E-7	0.032	0.030	0.073
BW6	0.67	21E-7	20E-75	48E-7	0.042	0.039	0.093
BW7	4.8	31E-7	29E-7	70E-7	0.061	0.057	0.139
BW8	3.37	29E-7	27E-5	64E-7	0.057	0.053	0.128
Mean	1.73	17E-7	18E-7	39E-7	0.034	0.032	0.078

Table 2. CDI, R and HQ in adult men, adult women and children due to cadmium in the bottled water of Bandar Abbas

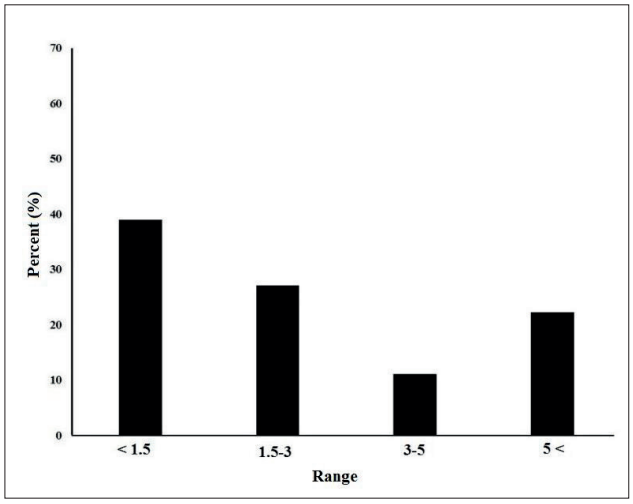

Figure 3. The Percentage of relative frequency distribution of cadmium concentration in the bottled water of Bandar Abbas (n=432)

3.37±0.32 µg/l, respectively (Table 1). The orders of the bottled water marks with respect to the mean cadmium concentration are BW7>BW8>BW1>BW5>BW4>BW3>BW2>BW6. The most and the least mean cadmium concentration goes to the marks BW7 (3.37±0.32 µg/l) and BW6 (0.67±0.09 µg/l), respectively (table1). The range of cadmium concentrations in brands BW1, BW2, BW3, BW4, BW5, BW6, BW7 and BW8 are 0-2.9, 0-2.7, 0-2.1, 0-2.3, 0-4.1, 0-1.7, 1.9-6.1 and 1.5-7.1 µg/l, respectively.

The mean CDI for age groups of adult men, adult women and children is 17E-7, 18E-5 and 39E-7 mg/kg-d, respectively. The most and the least CDI goes to marks BW7 (70E-7, children) and BW4 (3E-7, adult women), respectively (table 2). The CDI order for different age groups is as the following manner: Children>adult women>adult men. The CDI for children is 2.22 times the CDI for adult men and women (p value<0.05).

4. DISCUSSION

The mean concentration of cadmium in Pip's study (0.2±0.04 µg/l), is much lower than that of our study (33).The cadmium concentration in Yazd's Water Distribution Network in the study of Salmani et al., (3.35±0.79 µg/l), is more than that of ours (34). The maximum cadmium concentration in the bottled water in the research done by Miranzadeh et al., (4.75±1.25 µg/l), is lower than the maximum cadmium concentration in our study (7.1±0.83 µg/l, BW8) (35).The mean concentration of cadmium in all the brands off bottled water is lower than the EPA's maximum allowable concentration (5 µg/l). But, in the mark of BW8 and BW7, the mean concentrations of cadmium are more than WHO guidelines (3 µg/l) (19, 36).Concentration ranges in marks BW5, BW7 and BW8, in some samples are more than the standard limit (Figure 2).

As it is seen in Figure. 3, 33.2% of all the samples (i.e. 144 sample out of 432), have concentrations more than the standard of WHO and 22.4% (i.e. 97 samples) have concentrations more than the EPA standard.

There was a significant difference (p value < 0.05) between the mean concentrations of cadmium during summer and winter in BW5 and BW6 marks. This difference in cadmium concentration could be due to different water sources, variation in the type of processing, possible contamination in the water source or the cadmium leakage from the polymer the bottle into the water (14).

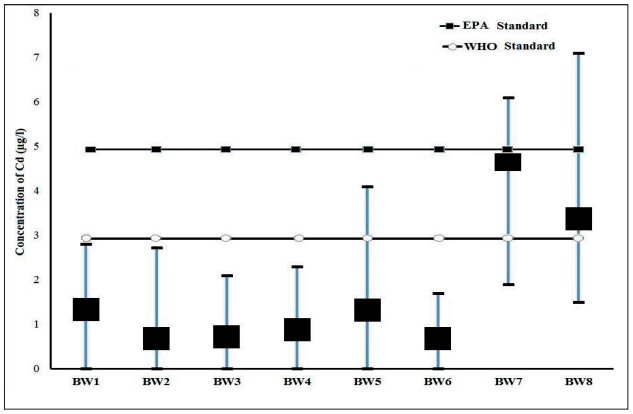

Figure 2. Comparison of mean and range of cadmium concentration in bottled water with standard of WHO and EPA

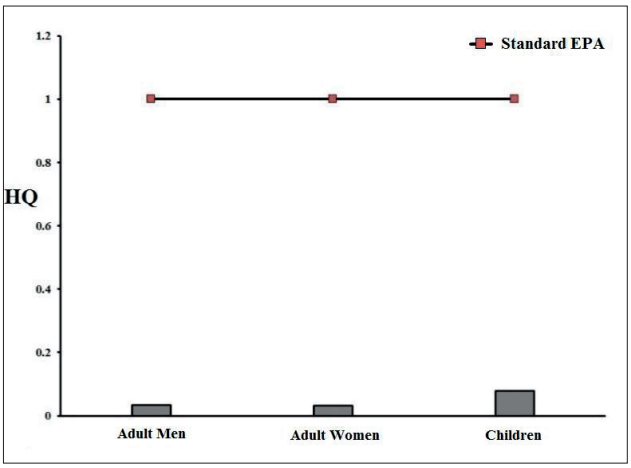

Figure 4. Comparison of HQ in age groups of adult men, adult women and children with the safe limit

HQ for adult men, adult women and children is 0.034, 0.032 and 0.078, respectively. HQ in the study of Muhammed et al., (0.033 in Jijal-Dubair area) is almost equal to that of our study (0.034) (27). On the contrary to our study, HQ was not presented in the study of Rajaeiet al., due to the absence of cad-

mium in water source (zero concentration) (37). The order of the non-carcinogenic risk is children>adult men>adult women. HQ in children is 2.29 times that of adult men and women (p value<0.05). The mean cadmium HQ of the bottled water in age groups of adult men, adult women and children is less than 1 (Figure 4).

5. CONCLUSION

Although, the mean cadmium concentration of the bottled water (1.32±0.19 µg/l) is less than the standard limits of WHO and EPA, some samples have cadmium concentrations more than the standard limit. HQ between the adult men and women is almost equal and there is no significant difference between these two. However, the HQ in children age group is more than that of the adult men and women. As HQ is less than 1 in all the age groups, so it could be inferred that the whole Bandar Abbas population is secure (HQ < 1).

Acknowledgments

The authors would like to thank the Experts of Chemical Laboratory of Health, Faculty of Medical Science University of hormozgan.

CONFLICT OF INTEREST: NONE DECLARED.

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