ANALYSIS OF TOXIC AND TRACE METAL CONTAMINANTS IN BOTTLED WATER BY USING ATOMIC ABSORPTION SPECTROMETRY

***GholamReza JAHED KHANIKI [1], Mansoor GHADERPOORI[1], Mohammad Hadi DEHGHANI [1], Shahrokh NAZMARA [1]**
[1]Department of Environmental Health Engineering , School of Public Health, Tehran University of Medical Sciences, Tehran, Poorsina Street, Tehran, Iran, P.O.Box:14155-6446,
e-mail: ghjahed@tums.ac.ir
*Corresponding author
Received 12 April 2011, accepted 10 June 2011

Abstract: *Heavy metals are toxic elements for human and they may enter the human body through polluted water. Consumption of bottled water is a proper choice when no safe water is available or water treatment is difficult, but the safety of bottled water is important and it is necessary to monitor toxic and trace metal contaminants. This study was conducted for the measurement and determination concentrations of toxic metals such as cadmium (Cd), chromium (Cr) and lead (Pb) in bottled water. A descriptive- analytical and cross-sectional study was conducted for the determination of Cd, Cr and Pb in thirteen brands of bottled water available at the Tehran stores. After sampling, the toxic trace elements were extracted and then their contents (or concentrations) were determined using in bottled water samples by using Atomic Absorption Spectrometry. The results showed that mean concentrations of Cd, Cr and Pb in examined samples of bottled water were 1.5± 0.34, 1.06± 0.72 and 3.18±0.44 µg/l, respectively. All of the examined samples had these trace elements in concentration below WHO guidelines, EPA standards and Iranian drinking water standards. It can be may be assumed that there is no basic public health problem by consumption of examined bottled water in regarding these toxic metals.*

Keywords: *Heavy metals, cadmium, chromium, lead, bottled water, drinking water standards*

1. Introduction.

Consumption of bottled water is a proper choice when no safe water is available or water treatment is difficult. Use of bottled water has considerably increased around the world in recent years [1]. Nowadays, bottled water is being used in many places due to its availability, low cost, better quality and taste. Water is a vital material for human being and it is one of the main sources of trace elements intake in the body. Thus, its quality considerably affects our health. Trace elements such as cobalt, copper, iron, manganese, molybdenum, selenium and zinc can be classified as essential elements for human life while some other trace elements (silver, mercury, aluminum, arsenic, cadmium, chromium, lead and nickel) are potentially toxic [2,3,4]. Many inorganic elements have a dual role in body physiologies and they are essential in low concentrations but toxic in high amounts [5]. Epidemiological studies in recent years have indicated that there are relations between content of trace elements in drinking water with some kidney and heart disorders and also different types of cancer [6]. Cadmium life time in bones is thirty years and this element is a carcinogen. Also, lead is a neurotoxin and it is responsible for many toxic effects in human body [7]. The Polluting of bottled water can arise from filling by contaminated water or leakage raw materials through packaging to water in to bottles. According to many studies, toxic metals may release from PET (Poly ethylene tere-phthalate) into the water bottle [6,7,8].Usually, water bottles are kept at room temperature and a large number of consumers may keep many water bottles for necessary cases that it may cause the increased risk of leakage of metals from bottle wall into stored water [7]. The aim of this study was to analyse and evaluate content of toxic trace metals including cadmium (Cd), chromium (Cr) and lead (Pb) in domestic brands of bottled water available at the Tehran market by using Atomic Absorption Spectrometry and to compare our results with international guidelines and Iranian standards.

2. Materials and methods

2.1. Sample collection

26 samples of 1.5L bottled water of thirteen different commercial domestic brands were randomly collected from shops and supermarkets of Tehran City, Iran. Two samples with different production dates of each brand were collected. The bottles were sent to laboratory and they were preserved at 4°C until analyses (not more than a week). The commercial brands of bottled water were Damavand, Kooh Dasht, Damash, Zam Zam, Nestle, Polur, Kooh Rang, Hobab, Bidestan, Dasani, Siva, Vata and LuBon.

2.2. Metals Analysis

Using standard methods [9], concentration of cadmium, chromium and lead was measured by atomic absorption spectrometer Varian Techtron **(**Model 1200). The measurements were done at a specific wave length for each element (cadmium at 288.8, chromium at 357.9 and lead at 217 nm) and the instrument was calibrated by distilled water and also by the standard solutions. To achieve a suitable detection limit for desired elements, all standard and sample solutions were concentrated twenty times by means of a hot plate to evaporat.

The mean absorbance produced by the standards (corrected for the standard blank) was plotted vs the concentration of the analyte in the sample to produce an external calibration curve. The concentration of the analyte in the sample was calculated from the following equation: $[M]= (C \times V)/SV$; where [M] is the concentration (µg/l) of in original sample, C is the concentration of metal in the analytical sample as calculated from standard curve in units of µg/l, V is the volume of the analytical sample in units of ml and SV is the volume of the sample employed to concentrate in units of ml.

Detection limit was about 0.1µg/l after concentration. All the recoveries of the metals studied were over 95%.

2.3. Statistical analysis

For the analyzing data, SPSS 11.5 and descriptive statistics (mean standard deviation) and analytical statistics (ANOVA and TUKEY with POST HOC method) were used. A probability level of $p<0.05$ was considered statistically significant.

3. Results and discussion

The results show that the mean concentration of cadmium, chromium and lead in bottled water in Tehran was 1.5± 0.34, 1.06± 0.72 and 3.18±0.44µg/l respectively (Table 1). ANOVA test showed that mean concentrations of these trace elements is significantly different in all the samples ($p<0.5$).Also, TUKEY test with POST HOC method showed that there is a significant difference in concentrations of cadmium, chromium and lead in some samples ($p< 0.5$).

Table 1.

Standard deviation and mean for trace metal concentrations in bottled water samples

Brand	**Cadmium* Mean(±SD)**	**chromium* Mean(±SD)**	**Lead* Mean(±SD)**
Damavand	ND	0.88 ±0.02	5.1 ±0.64
Kooh Dasht	1.7 ±0.24	0.5 ±0.11	1.85 ±0.61
Damash	0.43 ±0.15	1.32 ±0.6	1.85 ±0.62
Zam Zam	1.72 ±0.44	2.22 ±0.67	3.7 ±1.28
Nestle	1.7 ±0.34	1.4 ±0.56	ND
Polur	1.72 ±0.84	1.8 ±0.56	7.55 ±0.78
Kooh Rang	ND	0.7 ±0.28	2.77 ±0.92
Hobab	1.72 ±0.44	0.9 ±0.18	5.55 ±3.23
Bidestan	8.05 ±0.78	2.1 ±0.14	6.8 ±0.85
Dasani	0.85 ±0.2	0.92 ±0.6	1.85 ±0.61
Siva	1.4 ±0.78	0.5 ±0.11	0.49 ±0.01
Vata	ND	0.15 ±0.05	0.4 ±0.56
LuBon	0.45 ±0.59	0.38 ±0.16	0.45 ±0.28
Total	1.55 ±0.34	1.06 ±0.72	3.18 ±0.44
Iranian standards	10	50	10
WHO guideline	3	50	10
EPA standard	5	100	15

∗ Means are given in µg/l
ND: Not detectable

Concentrations of cadmium, chromium and lead in different brands are compared in Fig.1.

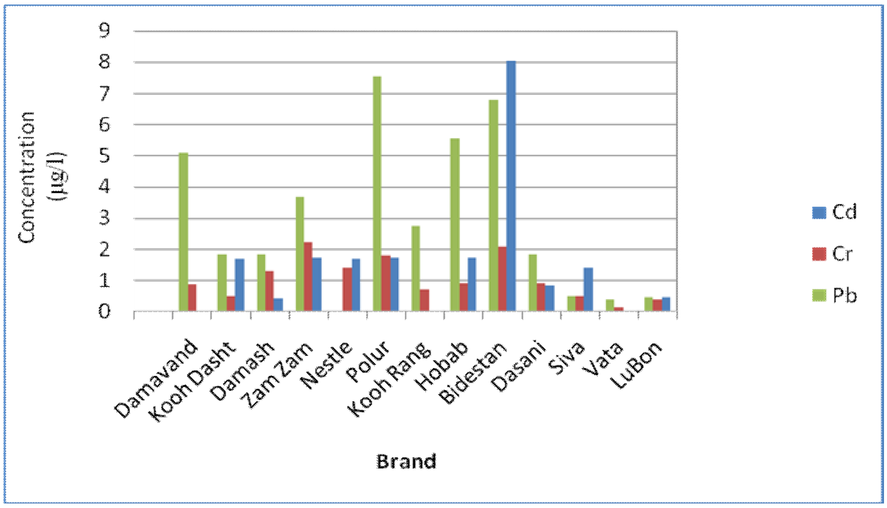

Fig 1. Comparisons of toxic metals analysis in different brands of bottled water.

In the examined bottles, mean concentration of cadmium in the brand of Bidestan (8.05µg/l) is significantly different from the other brands ($p< 0.5$) and its concentration is lower than Iranian drinking water standard (<10 µg/l) [10]. This is due to different reasons such as type of source of bottled water or long period of water storage in bottles. Some studies reported that there is probability of increase of cadmium contamination due to the long period of water storage in bottles. They referred that cadmium concentration in some brands was above WHO guidelines and EPA drinking water standards (3 and 5 µg/l, respectively) [11,12]. Comparisons of mean concentrations of toxic metals in bottled water obtained from Tehran market and other countries is shown in Table 2. In present study, cadmium concentration in examined samples is higher than those of other countries. Maximum concentration of chromium was found in Zam Zam brand (2.22µg/l). The mean concentration of chromium in the brands of Zam Zam and Bidestan is significantly different from other brands. This can be caused by different types of source of bottled water but the concentration of chromium is lower than Iranian drinking water standards (50 µg/l) [10]. Chromium concentration in these samples is lower than in the samples from Greece and Kuwait. Also, these concentrations are below WHO guidelines and EPA drinking water standards.

Table 2.

Comparisons of mean concentrations of toxic metals in bottled water obtained from Tehran market and other countries

Country name	Number of brands	cadmium*	chromium*	lead*	reference
Turkey	15	< 0.001	0.0056	< 0.001	[13]
Kuwait	6	0.013	2.95	0.04	[14]
Greece	4	-	2.6	0.02	[4]
India	6	< 0.05	-	< 0.05	[15]
Croatia	18	0.016	0.31	0.091	[2]
Greece	16	-	0.291	0.101	[5]
Canada	34	0.2	-	5.3	[7]
Iran	13	1.52	1.06	3.18	[present study]

* Means are given in µg/l

Concentration of lead in brand Polur is significantly different from other brands. This can be caused by different reasons such as type of source of bottled water or long period of water storage in bottles. According to the studies of Pip [7], EHP [6] and Shotyk and Krachler [8,16], there is a probability of dissolution of metals from the bottles during long storage. In present research, concentration of lead was lower than WHO guidelines and EPA and Iranian drinking water standards (lower than 10 µg/l) [10]. Also, the highest concentrations of cadmium, chromium and lead is determined in brands of Bidestan, Zam zam and Polur, respectively (Fig.1). By comparison of the mean concentration of heavy metals in samples, the maximum concentration in these metals was attributed to lead (3.18±0.44 µg/l) and it is similar to Pip [7] and [17]. Pip [7] reported that 40 brands of imported and local bottled drinking water available in Manitoba, Canada was studied and it was reported that concentration of lead was more than 5 µg/l and from examined bottle water samples.

Typically, all metals are somewhat soluble in water and excess concentrations of any metals can affect human health. Toxic metals can accumulate in body and can be brought into body by water, air and food sources and even low concentration of these metals can be important because of accumulation. Since bottled water is usually stored in polyethylene terephthalate (PET), plastic bottles or glass bottles, the releasing of metals from bottle to inside water can occur. Studies in different countries had shown this problem [8,16,18,19]. Although the low concentrations of these metals are measured in these bottles which are lower than drinking water guidelines and standards but, due to their cumulative and toxic effects, they are important in point view of health. Thus, they are in concern for public consumptions. Therefore, monitoring of these waters usually is necessary to cause the probable concerns.

4. Conclusion

As there is growing use of bottled water, therefore monitoring of its quality is necessary. The study shows that most distributed bottled water brands in Tehran have a good quality considering toxic trace elements and meet drinking water guidelines and standards. But more studies are necessary for determination other toxic metals such as aluminum, mercury, arsenic.

5. References

1. SALVATO, J., MAGARDY, N., AGARDY, F., *Environmental Engineering Sanitation*. John Wiley and Sons Publication. 5 ed, Pp. 469-47, 2005.

2.FIKET, Z., ROJE, V., MIKAX, N., KNIEWALK, G., *Determination of Arsenic and Other Trace Elements in Bottled Waters By High Resolution Inductively Coupled Plasma Mass Spectrometry.* CCACAA, 80: 91-10, 2007.

3. MISUND, A., FRENGSTAD, B., SIEWERS, U., REIMANN, C., *Variation of 66 elements in European bottled mineral waters.* The Science of the Total Environment, 243-244:21-41, 1999**.**

4. SOUPIONI, M.J., SYMMEOPOULOS, B.D, PAPAEFTHYMIOUS, H.V., *Determination of Trace Elements in Bottled Water in Greece by Instrumental and Radiochemical Neutron Activation Analyses.* Journal of Radio analytical and Nuclear Chemistry, 268: 441-444, 2006.

5. WHO., *Guideline Values for Drinking Water Quality.* 2ed, Geneva, 1993.

6.EHP., Forum: *Is Bottled Water Better? Environmental Health Perspectives*, 103: 322-32, 1995.

7. PIP, E., *Survey of Bottled Drinking Water Available In Manitoba, Canada*. Environmental Health Perspective, 108: 863-866, 2000.

8. SHOTYK, W., KRACHLER, M., *Contamination of Bottled Waters With Antimony Leaching From Polyethylene Terephthalate(PET) Increases Upon Storage.* Environmental Sciences and Technology, 41: 1560-1563, 2007.

9. EATON, A.D., CLESCERI, L.S., RICE, E.W., *Standard Methods for the Examination of Water and Wastewater, American Water Works Association* (AWWA) Washington D. C, 21ed, **p**p. 5-50, 2005.

10. ISIRI., *Physical and Chemical Properties of Drinking Water*: Institute of Standards and Industrial Research of Iran (ISIRI). No. 1053, 5ed, 1997.

11.EPA., *Drinking Water Standards; office of Drinking Water,* US Environmental Protection Agency Washington DC, 2003.

12. WHO., *Guideline for Drinking Water Quality*; World Health Organization: Geneva, 2004.

13. BABA, A., EREES, F.S., CAM, H.S., *An Assessment of The Quality of Various Bottled Mineral Water Marketed in Turkey.* Environmental Monitoring & Assessment, 139: 277-285, 2008.

14. KHALEFA, A., MOHAMMED, A., HAMAD, A., *Comparative Study of Potable and Mineral Waters Available In the State of Kuwait.* Desalination, 123*:* 253-264, 1999.

15. BABIJI, P., SHASHIKIRAN, N., REDDY, S.V., *Comparative Evaluation of Trace Elements and Residual Bacterial Content of Different Brands of Bottled Waters*. Journal of Indian Society of Pedodontics and Preventive Dentistry, 22: 201-204, 2004.

16. SHOTYK, W., KRACHLER, M., *Lead in Bottled Water: Contamination from Glass and Comparison with Pristine Groundwater.* Environmental Science and Technology, 41: 3508-351, 2007.

17. DABEKA, R.W., CONACHER, H.B.S., LAWRENCE, J.F., NEWSOME, W.H., MCKENZIE, A., WANGER, H.P., CHADHA, R.K.H., PEPPER, K., *Survey of Bottled Drinking Waters Sold in Canada For Chlorate, Bromide, Bromate, Lead, Cadmium, and other Trace Elements.* Food Addatives & Contaminants, 19: 21-72, 2002.

18. SHOTYK, W., KRACHLER, M., CHEN, B., *Contamination of Canadian and European Bottled Waters with Antimony from PET Containers.* Journal of Environmental Monitoring, 8: 288-292, 2006.

19. WESTERHOFF, P.M., PRAPAIPONG, P., SHOCK, E., HILLAIREAU, A., *Antimony Leaching Polyethylene Terephthalate(PET) Plastic Used For Bottled Drinking Water.* Water Research, 42: 551-556, 2008.