

Quantitative Assessment of Bisphenol A in Multiple Brands of Bottled Drinking Water in Iran

Mahmood Alimohammadi¹, Maryam Mehrabegi², Shahrokh Nazmara¹, Mohsen Haghghi Dashtappeh³, Vahid Kazemi Moghaddam*³

Received: 15.11.2013

Accepted: 29.12.2013

ABSTRACT

Background: Bisphenol A (BPA) is one of the hazardous materials causing disruption of endocrine pathways. Due to water contamination by this component from multiple sources and the associated health problems, BPA has been the focus of multiple studies. It has been proved that BPA may cause harm because of its impact on estrogenic receptors in human and other organisms.

Methods: In this study, the presence of Bisphenol A in bottled drinking water in Iran was evaluated by solid phase extraction (SPE) and gas chromatography (GC). Compared to other studies measuring the level of Bisphenol A in milk, surface water, and wastewater, the present study focused on the levels of Bisphenol A in bottled drinking water to determine the safety risk level of BPA as a possible public health issue.

Results: The results showed no evidence of BPA at levels above the standard within all analyzed samples.

Conclusion: It seems that BPA is a low-risk component in bottled drinking water.

Keywords: Bisphenol A, Bottled Drinking Water, Gas Chromatography, Iran, Solid Phase Extraction.

IJT 2014; 1037-1040

INTRODUCTION

In recent years, a number of studies have focused on detection, measurement, assessment, and recognition of pharmaceuticals and personal care products (PPCPs) and endocrine disrupting chemicals (EDCs) in different countries [1-5]. These components can be harmful at low concentrations [6]. One of these hazardous materials is Bisphenol A [7]. BPA is used in polymerized plastic materials and has widespread applications [8], particularly in building epoxy resins and polycarbonate plastics used for packaging water [9]. BPA can be disseminated and leached into water from packaging materials. This can happen faster over time and in higher temperatures [10]. It has been proven that BPA may affect estrogenic and estrogen-related receptors in fish and insects [11, 12]. BPA has been shown to have the capability to transfer from

pregnant mice to their embryos [13]. It has also been proved that BPA is a component with multiple effect on many tissues of females and males [14]. According to reports of European Food Safety Authority (EFSA), the specified Tolerable Daily Intake (TDI) is in the range of 50-0.5 µg BPA/kg body weight /day(µg b.w-1 d-1) at different ages [15, 16].

As many health issues had been attributed to BPA, several studies have been performed on this chemical component on different scales. Some researchers have focused on the detection and measurement of BPA and others on its effects on human and laboratory animals [17]. For example, in the UK, Grover et al. examined the ability of three methods to measure ECDS [18]. Another study by Chinese researchers was done to determine BPA levels [19]. A study in the United States has evaluated the

1. Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran.

2. Students' Scientific Research Center, Tehran University of Medical Sciences, Tehran, Iran.

3. Department of Environmental Health Engineering, School of Public Health, Kashan University of Medical Sciences, Kashan, Iran.

*Corresponding Author: E-mail: vahidkazemi29@yahoo.com

presence of BPA in packaged water [20]. In Iran Rastkari et al. and Jafari et al. investigated the present of BPA in canned foods and surface water and wastewater, respectively [21, 22].

However, it seems that no study has been done on the measurement of BPA in bottled drinking water in Iran. Therefore, the objective of present study is to identify the level of BPA in bottled drinking water and to determine whether this component is a risk in bottled water or not.

MATERIALS AND METHODS

Five different brands of bottled drinking water were randomly selected among existing 18 brands in the market and 39 random samples were collected from those brands for further analysis of chemical substances. As an ethical consideration, the names of the brands were reported by code numbers. Table 1 shows the characteristics of the examined bottled drinking waters, including mineral composition (mg/lit) and pH value.

In this study, solid-phase extraction with vacuum system was employed for the extraction of BPA. Cartridges containing C18 bonded-phase silica adsorbent were situated on the vacuum manifold and conditioned with methanol (10 mL) (MERCK, Germany) for 10-15 minutes. Then, the deionized water (10 mL) was passed using vacuum system.

To analyze the samples, bottled drinking water (1L) was passed through C18

cartridges (10 mL/min). Having percolated the total amount of the sample, the cartridges were dried for 10-15 minutes under vacuum. The remaining compounds were eluted using methanol (3 mL). The extracts were then evaporated to dryness using high purity N₂ (99.9999%) and reconstituted methanol (0.5 mL) in a vial (1.5 mL).

The samples were analyzed with a Varian CP-3800 (Australia) gas chromatograph (GC) equipped with flame ionization detector (FID). The GC was fitted with a CP-Sil 8 CB capillary column (30 m, 0.32 mm id, 0.25 μm film thickness). The temperature of both the injector and the FID was set at 250°C; initial oven temperature was 35°C (being held for 1 min) increased to 250°C at a rate of 16°C min⁻¹ (being held for 15 min). The inlet was operated in 20% split mode and helium (99.999%) was used as the carrier gas (1.3 mL min⁻¹).

RESULTS

The quantities of BPA in all samples were less than the detection limit of GC system and according to the variables (mineral composition, pH, and time after product), no change was observed. In addition, for making certain about the method, some samples with known density were tested by GC system; the accuracy of the method was 98% in this assay. Table 2 shows BPA levels of the samples.

Table 1. Characteristics of the examined bottled drinking waters.

Brand number	Mineral composition (mg/lit)	PH value
Brand 1	Ca(78.5), Mg(18.7), K(0.8), SO ₄ ²⁻ (20.0), N(1.8)	7.2
Brand 2	Ca(68), Mg (10.25), K(0.59), SO ₄ ²⁻ (47.0),N (0.71)	7.3
Brand 3	Ca(25), Mg(6), N(17.5), K(3.5), SO ₄ ²⁻ (15), N(3)	7.0
Brand 4	Ca(16.5), Mg(11.8), K(1.6), SO ₄ ²⁻ (32.5), N(4.6)	7.3
Brand 5	Ca(62.72), Mg(20.30), K(1.37), SO ₄ ²⁻ (20.98), N(4.04)	7.5

Table 2. BPA levels in the samples.

Brand number	Time range between the date of manufacturing and testing of brands (days)	Bisphenol A concentration
Brand 1	9-65	ND*
Brand 2	5-48	ND
Brand 3	6-20	ND
Brand 4	6-50	ND
Brand 5	8-90	ND

DISCUSSION

The findings of this study were similar to those of some other studies. Shao et al studied quantities of BPA in beverages in which it was ND [23]. However, Li et al detected low concentrations of BPA in water [24]. This difference is most likely related to the time intervals between production and testing; the method and limits of detection were also different. Since the TDI of BPA in water is 50-0.5 $\mu\text{g b.w-1 d-1}$, it is unlikely that levels less than 10 $\mu\text{g L-1}$ could not pose any health risks for adults, but it should be considered in the case of children.

CONCLUSION

In this study, BPA was detected according to the specified limits of human exposure to BPA. The results showed no detectable (ND) BPA (<10 $\mu\text{g L-1}$) in all samples. Some studies have emphasized that the detectable levels of BPA in bottled water are within low risk range; however, in some others use of "BPA free" bottles is recommended particularly for Children. It seems this discrepancy is due to different conditions of the experiments and the fact that the permissible amount of BPA in water is not clear.

ACKNOWLEDGEMENTS

The authors wish to thank Students' Scientific Research Center of Tehran University of Medical Sciences and Tehran University of Medical Sciences for their financial support to perform this study.

REFERENCES

1. Kuster M, López de Alda MJ, Hernando MD, Petrovic M, Martín-Alonso J, Barceló D. Analysis and occurrence of pharmaceuticals, estrogens, progestogens and polar pesticides in sewage treatment plant effluents, river water and drinking water in the Llobregat river basin (Barcelona, Spain). *Journal of hydrology*. 2008;358(1):112-23.
2. Solomon GM, Schettler T. Environment and health: 6. Endocrine disruption and potential human health implications. *Canadian Medical Association Journal*. 2000;163(11):1471-6.
3. Fürhacker M, Scharf S, Weber H. Bisphenol A: emissions from point sources. *Chemosphere*. 2000;41(5):751-6.
4. Shokrzadeh lamuki M, Saedi Saravi S, Otadi N. Evaluation of Residues of D.D.T and D.D.A in Fish Collected from Caspian Sea, Iran. *IJT*. 2012; 6 (18) :704-8. [Persian]
5. Feyzi Dehkhargani S, Malekinejad H, Shahrooz R, Ali Sarkhanloo R. Detrimental Effect of Atrazine on Testicular Tissue and Sperm Quality: Implication for Oxidative Stress and Hormonal Alterations. *Iranian Journal of Toxicology*. 2011;5(12):426-35.
6. Melnick R, Lucier G, Wolfe M, Hall R, Stancel G, Prins G, et al. Summary of the National Toxicology Program's report of the endocrine disruptors low-dose peer review. *Environmental health perspectives*. 2002;110(4):427-8.
7. Bucher JR. Bisphenol A: where to now? *Environmental health perspectives*. 2009;117(3):A96-7.
8. Vandenberg L, Chahoud I, Heindel JJ, Padmanabhan V, Paumgarten FJ, Schoenfelder G. Urinary, circulating, and tissue biomonitoring studies indicate widespread exposure to bisphenol A. *Environmental health perspectives*. 2010;118(8):1055-70.
9. Staples CA, Dome PB, Klecka GM, Oblock ST, Harris LR. A review of the environmental fate, effects, and exposures of bisphenol A. *Chemosphere*. 1998;36(10):2149-73.
10. Nam S-H, Seo Y-M, Kim M-G. Bisphenol A migration from polycarbonate baby bottle with repeated use. *Chemosphere*. 2010;79(9):949-52.
11. Park K, Kwak I-S. Molecular effects of endocrine-disrupting chemicals on the *Chironomus riparius* estrogen-related receptor gene. *Chemosphere*. 2010;79(9):934-41.
12. Vethaak AD, Lahr J, Schrap SM, Belfroid AC, Rijs GB, Gerritsen A, et al. An integrated assessment of estrogenic contamination and biological effects in the aquatic environment of The Netherlands. *Chemosphere*. 2005;59(4):511-24.
13. Zalko D, Soto AM, Dolo L, Dorio C, Rathahao E, Debrauwer L, et al. Biotransformations of bisphenol A in a mammalian model: answers and new questions raised by low-dose metabolic fate studies in pregnant CD1 mice. *Environmental health perspectives*. 2003;111(3):309-10.

14. Rubin BS. Bisphenol A: an endocrine disruptor with widespread exposure and multiple effects. *The Journal of steroid biochemistry and molecular biology*. 2011;127(1):27-34.
15. EFSA E. Opinion of the scientific panel on food additives, flavourings, processing aids and materials in contact with food on a request from the commission related to 2, 2-bis (4-hydroxyphenyl) propane (Bisphenol A). *EFSA J*. 2006;428:1-75.
16. Castoldi AF. Bisphenol A: state of play at the European Food Safety Authority. *South African Food Science and Technology*. 2012(2):46-7.
17. Chang H-S, Choo K-H, Lee B, Choi S-J. The methods of identification, analysis, and removal of endocrine disrupting compounds (EDCs) in water. *Journal of hazardous materials*. 2009;172(1):1-12.
18. Grover D, Zhang Z, Readman J, Zhou J. A comparison of three analytical techniques for the measurement of steroidal estrogens in environmental water samples. *Talanta*. 2009;78(3):1204-10.
19. Jin X, Jiang G, Huang G, Liu J, Zhou Q. Determination of 4-tert-octylphenol, 4-nonylphenol and bisphenol A in surface waters from the Haihe River in Tianjin by gas chromatography–mass spectrometry with selected ion monitoring. *Chemosphere*. 2004;56(11):1113-9.
20. Cooper JE, Kendig EL, Belcher SM. Assessment of bisphenol A released from reusable plastic, aluminium and stainless steel water bottles. *Chemosphere*. 2011;85(6):943-7.
21. Rastkari N, Yunesian M, Ahmadkhaniha R. Levels of bisphenol a and bisphenol f in canned foods in iranian markets. *Iranian Journal of Environmental Health Science & Engineering*. 2011;8(1):95-100.
22. Jafari A, Abasabad R, Salehzadeh A. Endocrine disrupting contaminants in water resources and sewage in Hamadan City of Iran. *Iranian Journal of Environmental Health Science & Engineering*. 2009;6(2):89-96.
23. Shao B, Han H, Hu J, Zhao J, Wu G, Xue Y, et al. Determination of alkylphenol and bisphenol A in beverages using liquid chromatography/electrospray ionization tandem mass spectrometry. *Analytica Chimica Acta*. 2005;530(2):245-52.
24. Li X, Ying G-G, Su H-C, Yang X-B, Wang L. Simultaneous determination and assessment of 4-nonylphenol, bisphenol A and triclosan in tap water, bottled water and baby bottles. *Environment international*. 2010;36(6):557-62.