Abstract

Background and aims. As a result of poor quality of public water supply in many countries, people have recently turned to bottled water consumption, the fluoride content of which is not generally consistent among different brands. This study sought to measure the fluoride concentration of public water supply in comparison with commercial brands of mineral bottled water available in Tehran, Iran.

Materials and methods. Eight different brands of locally produced bottled mineral water and samples of tap water were evaluated for fluoride content. All samples were collected in five equal containers in two summer and winter seasons. The fluoride content in parts per million (ppm) was determined using a fluoride Ion Selective Electrode. The data were analyzed using two-way ANOVA. For comparison of the fluoride content between three different brands of bottled water, one-way ANOVA was employed. Sample t-test was used to compare the label and laboratory values of bottled water.

Results. The highest concentration of fluoride in a bottled water brand was found to be 0.409 ppm with a pH of 6.67 in summer. There was a significant difference between the mean fluoride level of tap water (0.229 ± 0.079 ppm) and bottled water (0.111 ± 0.122 ppm) (P < 0.001). The measured fluoride concentrations of bottled water were significantly lower than those printed on the labels (P < 0.001).

Conclusion. Our findings revealed that the mean fluoride level of both bottled and tap water samples evaluated is considerably lower than accepted standards.

Key words: Caries control, drinking water, fluoride, water.

Introduction

Fluoride has been considered a valuable source of oral health promotion in children and adults over the past fifty years. The primary mode of action of fluoride in reducing dental caries is that it promotes remineralization and inhibits demineralization of tooth structure, predominantly effective in restraining incipient caries. Therefore, post-eruptive absorption of fluoride throughout one’s life should be emphasized. Adjustment of daily fluoride intake should be taken with special considerations since a low...
amount of fluoride is not effective in preventing dental caries, and higher concentrations lead to dental fluorosis and, in more severe cases, may have adverse effects on bones, the kidneys, and the thyroid gland. Hence, it is crucial that oral health practitioners monitor the amount of fluoride intake, especially in children.

Water fluoridation is considered as one of the most efficient methods in reducing dental caries on a public health level and has its greatest influence on socially disadvantaged children with higher prevalence of tooth decay. A systematic review provided strong evidence that water fluoridation was effective in reducing overall dental caries in communities. The U.S. Centers for Disease Control listed water fluoridation as one of the ten great public health achievements of the twentieth century.

A common trend in recent years has been the replacement of purified tap water for drinking with bottled water. Different studies have reported inconsistency between the actual fluoride content of bottled water and the amount mentioned on its container label.

Although countries have close surveillance on the manufacturers of bottled water regarding the concentrations of different elements, there is evidence supporting the inaccuracy of the reported fluoride content of tap and bottled water.

The present study aimed to evaluate the fluoride content of public tap water as well as available commercial brands of bottled water in Tehran, Iran.

Materials and Methods

Eight commercially available brands of locally produced bottled mineral water were randomly selected and considered for fluoride content evaluation. Samples of tap water were also collected from different residential areas of Tehran, representing the four main water plants i.e. Karaj dam, Latian dam, and Lar dam. Samples were collected in five equal containers in two different seasons (summer and winter). All samples were stored sealed in their original containers until the fluoride analysis was performed. After shaking the sample container, 1 mL was taken and mixed with 0.1 mL of Total Ionic Strength Adjusting Buffer III (TISAB II, Orion, MA, USA). The fluoride concentrations of all 125 samples were determined using Fluoride Ion Selective Electrode (model 96-09, ATI Orion) in conjunction with an ISE Meter (Model 720A, ATI Orion). Fluoride standards ranging from 0.001 to 10.00 mgL\(^{-1}\) were used to calibrate the measurement. The pH of the water samples was also measured using a pH-meter (Model 240, Corning). 10 samples were randomly selected and re-analyzed to assess the reliability of the method. All samples were number coded so that the investigators were blind to the type of water contained in the bottles.

In order to compare fluoride content of tap water with bottled water in two different seasons, the data were analyzed using two-way ANOVA. For comparison of the fluoride content between three different brands of bottled water, one-way ANOVA was employed. Sample t-test was used to compare the label and laboratory values of bottled water. All measurements were analyzed using SPSS 15.0.

Results

Table 1 demonstrates the mean fluoride content and the pH values of the samples. The lowest fluoride concentration for bottled mineral water collected in summer was 0.009 ppm with a pH of 7.54 and the highest concentration was 0.409 ppm with a pH of 6.67. Among the bottled water samples collected in winter, the lowest and the highest fluoride contents were seen to be 0.002 ppm and 0.387 ppm, respectively. The results also indicated that of the water plants supplying the tap drinking water of Tehran,
In order to measure the fluoride concentration, we employed Ion Selective Electrode method as a reliable device previously utilized by Zohouri et al. and Cochrane et al. However, other investigators applied spectrophotometer which is said to be prone to potential errors.

In this study, we attempted to measure the fluoride concentration of tap and bottled mineral water as two major sources of fluoride, which, to the best of our knowledge, is only similar to a previous study by Hurtado & Gardea-Torresday. In most of other studies, the investigators have only assessed the fluoride content in either one of the two water supplies.

In order to assess the role of seasonal variations in the concentration of fluoride, we collected our samples in two different seasons, i.e. summer and winter. Our findings confirmed those of previous studies reporting that higher fluoride concentration is associated with warm and dry climates. This could be related to the chemical reactions of underground waters with volcanic products. However, statistical analysis did not reveal any significant difference in this regard.

The finding that the actual fluoride levels were significantly lower than those displayed on the labels confirms previous reports suggesting that the manufacturers need to enhance their commitment to high standards and pay more attention to the figures stated on their products.

The fluoride concentration of both bottled mineral water and tap water samples in the present study was measured below the standard level. This might be attributed to the type of local soil and its mineral content, seasonal variations and possible presence of volcanic sediments in underground water reservoirs.

**Conclusion**

The results indicate that the fluoride content of mineral bottled water and local tap water in Tehran is lower than the optimal level. Moreover, mean concentration of fluoride in public tap water is significantly higher than mineral bottled water. The actual fluoride content of bottled waters was significantly lower than the figures on their labels.

**References**

1. Clarkson JJ, Mcloughlin J. Role of fluoride in oral health promotion. *Int Dent J* 2000; 50:119-28.
2. Johnson SA, DeBiase C. Concentration levels of fluoride in bottled drinking water. *J Dent Hyg* 2003;77:161-7.
3. Avishek K, Pathak G, Nathawat MS, Jha U, Kumari N. Water quality assessment of Majhiaon block of Garwa district in Jharkhand with special focus on fluoride analysis. *Environ...
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4. Harrison PTC. Fluoride in water: a UK perspective. *J Fluor Chem* 2005;126:1448-56.

5. AIHW Dental Statistics and Research Unit. *The Child Dental Health Survey, Australia 1993*. AIHW Dental Statistics and Research Unit Series No. 7. Adelaide: The University of Adelaide; 1995. Available from: http://www.arcpoh.adelaide.edu.au/publications/report/statistics/pdf_07/cdhs93.pdf

6. Spencer AJ, Davies MJ, Slade GD, Brennan D. Caries prevalence in Australasia. *Int Dent J* 1994;44:415-23.

7. Truman BI, Gooch BF, Sulemana I, Gift HC, Horowitz AM, Evans CA, et al. Reviews of evidence on interventions to prevent dental caries, oral and pharyngeal cancers, and sports-related craniofacial injuries. *Am J Prev Med* 2002;23(Suppl):21-54.

8. Centers for Disease Control and Prevention (CDC). Ten great public health achievements—United States, 1900-1999. *MMWR Morb Mortal Wkly Rep* 1999;48:241-3.

9. Ahiropoulos V. Fluoride content of bottled waters available in Northern Greece. *Int J Paediatr Dent* 2006;16:111-6.

10. Khan NB, Chohan AN. Accuracy of bottled drink water label content. *Environ Monit Assess* 2010;166:169-76.

11. Weinberger SJ. Bottled drinking waters: are the fluoride concentrations shown on the labels accurate? *Int J Paediatr Dent* 1991;1:143-6.

12. Zohouri FV, Maguire A, Moynihan PJ. Fluoride content of still bottled waters available in the North-East of England, UK. *Br Dent J* 2003;195:515-8.

13. Grobler SR, Louw AJ, Chikte UME, Rassouw RJ, van W Kotze TJ. The relationships between two different drinking water fluoride levels, dental fluorosis and bone mineral density of children. *Open Dent J* 2009;3:48-54.

14. Cochrane NJ, Saranathan S, Morgan MV, Dashper SG. Fluoride content of still bottled water in Australia. *Aust Dent J* 2006;51:242-4.

15. Brown MD, Aaron G. The effect of point-of-use water conditioning system on community fluoridated water. *Pediatr Dent* 1991;13:35-8.

16. Dobaradaran S, Mahvi AH, Dehdashti S. Fluoride content of bottled drinking water available in Iran. *Fluoride* 2008;41:93-4.

17. Hurtado R, Gardea-Torresday J. Environmental evaluation of fluoride in drinking waters at “Los Atlas de Jalisco”, in the central Mexico region. *J Toxicol Environ Health A* 2004;67:1741-53.

18. Jeziorska-Madziar M, Pińska P, Golski J. [Seasonal fluctuations in fluoride content in waters of the Warta oxbow lake in Luboń]. *Ann Acad Med Stetin* 2004;50(Suppl 1):54-7. [in Polish]

19. Davraz A, Sener E, Sener S. Temporal variations of fluoride concentration in Isparta public water system and health impact assessment (SW-Turkey). *Environmental Geology* 2008;56:159-70.

20. Bårdsen A, Bjørvatn K, Selvig KA. Variability in fluoride content of subsurface water reservoirs. *Acta Odontol Scand* 1996;54:343-7.