



ORIGINAL ARTICLE

Estimation of fluoride concentration in drinking water and common beverages in United Arab Emirates (UAE)



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Abstract Objective: To assess fluoride concentration in drinking water which include tap water of 4 emirates - Abu Dhabi, Dubai, Sharjah and Ajman plus bottled water, commonly available soft drinks & juices in United Arab Emirates.

Methods: Five different samples of tap water collected from each of the four emirates of UAE: Ajman, Sharjah, Abu Dhabi and Dubai; twenty-two brands of bottled water and fifteen brands of popular cold beverages, purchased from different supermarkets in U.A.E were tested using ion selective electrode method and the fluoride concentration was determined.

Results: The mean fluoride content of tap water samples was 0.14 mg F/L with a range of 0.04–0.3 mg F/L; with Ajman tap water samples showing the highest mean fluoride content of 0.3 mg F/L. The mean fluoride content for both bottled drinking water and beverages was 0.07 mg F/L with a range of 0.02–0.50 mg F/L and 0.04–0.1 mg F/L respectively. Majority (68.2%) of the bottled water are produced locally within U.A.E while a few (31.8%) are imported.

Conclusions: The tap water, bottled water and beverages available in U.A.E show varying concentrations of fluoride, however none showed the optimal level necessary to prevent dental caries. Dental professionals in U.A.E should be aware of the fluoride concentrations before prescribing fluoride supplements to children.

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1. Introduction

Fluoride intake has always been considered a key factor for prevention of dental caries and improvement of public dental health. Fluoride makes the tooth-enamel surface acid resistant by preventing bacterial demineralization and promotes

remineralization of initial non-cavitated carious lesions. It also shows antimicrobial activity; in low concentrations it prevents bacterial adhesion to tooth structure while in high concentration the fluoride ion is highly toxic to certain oral microorganisms (Theodore et al., 2006).

Several methods of fluoride delivery are available; either in the form of systemic fluoride or topical fluoride. Of all available methods, addition of fluoride to public drinking water has been identified the most economical and the safest delivery system (Mužinić et al., 2009). The main source of systemic fluoride in children is from drinking water (tap + bottled), carbonated beverages and other juice drinks (Rodrigues et al., 2009). Worldwide, vast majority of consumers that include children are replacing their daily water intake by bottled water, probably attributed to the fear of less purity of natural water supply and the presence of contaminants such as micro-organisms or sand particles (Ahiropoulos, 2006). The United Arab Emirates (UAE) is the fifth leading country in terms of per capita bottled water consumption, with 37.3 gallons per person as compared to 9.9 gallons per person of the global average (Beverage Marketing Corporation, 2014).

The recent recommendation of US Public Health Service (USPHS) for optimal fluoride concentrations in community water systems is 0.7 mg/l, as this concentration not only prevents dental caries but also lowers the risk of dental fluorosis (USPHS, 2015). Bottled water manufacturers by law are not required to mention fluoride concentrations on the outer label of their product however they do mention the concentration of added fluoride which may not necessarily be accurate. Systematic review undertaken on fluoride concentration in bottle water (Ceci and Paulo, 2015) concluded that many researchers have reinforced a common warning that there is a discrepancy between the found amount of fluoride and the informed concentration in the label. Precise concentration of fluoride levels in drinking water along with other drinks consumed by general public carries a great significance. It can affect decision of dental health professionals while prescribing their patients with any additional fluoride supplements. Additional sources of unintentional fluoridation through soft drinks and beverages may put children at risk of high fluoride intake (Jackson et al., 2002; Machiulskiene et al., 2009) taking into consideration that majority of cold beverage manufacturers do not mention the water source in their preparation.

In a hot climatic country such as UAE, consumption of water and other drinks increases tremendously. Bottled water consumption was doubled between 2003 and 2008 in the middle-eastern countries (Saleem, 2008).

It becomes imperative to estimate whether fluoride levels in drinking water are within the recommended and accepted levels to prevent dental caries and reduce the risk of dental fluorosis. To our knowledge this is the first study conducted in U. A.E. to determine the fluoride content in drinking water and commonly consumed beverages by children.

The aim of the present study was to (1) assess fluoride concentration in tap water, bottled water and popular soft drinks and juices consumed in UAE, (2) confirm accuracy of the labeling of fluoride levels on bottled water and (3) compare fluoride concentration in water bottles of same company in different batches.

2. Materials and methods

The study estimated the fluoride levels in tap water, mineral bottled water and popular cold beverages available in U.A. E. Five different samples of tap water were collected from each of the four emirates of UAE: Ajman, Sharjah, Abu Dhabi and Dubai. Twenty-two brands of mineral bottled water and fifteen brands of popular cold beverages were purchased from different supermarkets in U.A.E. Three samples from each brand of bottled water with different batch numbers and date of bottling; and two samples of each brand of cold beverage were obtained (Table 1). All samples were stored in a dark place at room temperature; the mineral water and beverages were kept in their original closed plastic container, until the fluoride analysis was made.

Orion 4-Star pH/ISE Benchtop Meter and Orion ionplus® fluoride electrode (Orion Cat No. 1010103, Thermo Electron Corporation, Beverly, MA, USA) was used to estimate the fluoride levels in the collected samples (Christian et al., 2013). Prior to sample testing, the machine was calibrated for accurate results.

After shaking the containers, 50 ml of sample was obtained from each mineral water, tap water and beverage samples and was transferred in a coded glass container so that the person testing the sample remains unaware of the brand to prevent any bias. Fluoride standards ranging from 0.2 to 1.00 mg/L⁻¹ of fluoride were used to calibrate the measurement. The sample and fluoride standard solutions (0.2, 0.4, 0.6, 0.8 and 1 ppm) were diluted with equal quantities of TISAB II (Total Ionic Strength Adjustment Buffer). These solutions containing 25 ml of sample and 25 ml of TISAB were mixed for two minutes with benchtop stirrer (Orion Cat. No.096019). The electrode potentials of the sample solutions were directly compared with those of fluoride standard solutions. The fluoride ion concentration was determined using the Orion Ionplus Fluoride Electrode (Orion Cat. No. 9609BNWP) which was immersed in the solution until the reading was displayed on the 4-Star benchtop pH/ISE meter. Two readings were taken for each sample and the average was recorded. One sample from each tap water, mineral bottled water and beverages was selected randomly and the fluoride content was re-estimated to assess accuracy of the method.

The data obtained were analyzed using SPSS version 22. Comparison of two readings for each sample was done by Paired t-test and correlation analysis while ANOVA was used to compare the fluoride concentration in the samples.

3. Results

Table 2 shows fluoride concentration in 20 different tap water samples collected from four emirates of UAE: Abu Dhabi, Ajman, Dubai and Sharjah. The mean fluoride content of tap water samples was 0.14 mg F/L. Tap water samples collected from Ajman showed the highest fluoride concentration with mean fluoride content of 0.3 mg F/L, followed by Sharjah followed by Abu Dhabi and Dubai; with no significant difference in fluoride levels in tap water between different emirates.

The fluoride concentration in twenty-two most popular brands of bottled mineral water available in U.A.E ranged between 0.02 and 0.50 mg F/L (Table 3). Mean fluoride concentration of mineral bottled water is 0.07 mg F/L. Zula bottled water had the highest fluoride concentration of 0.50 mg F/L; while the lowest fluoride concentration was

Table 1 Samples obtained for estimation of fluoride content.

Tap water		Mineral water		Beverages	
Emirate	Number of samples	Brands	Number of samples	Brands	Number of samples
Abu Dhabi	5	Ahlan	3	Pepsi	2
		Alain	3	Coca Cola	2
		Arwa	3	Seven up	2
		Crystal	3	Shani	2
		Gulfa	3	Mirinda	2
Dubai	5	Jeema	3	Mountain Dew	2
		Masafi	3	Almarai Fresh Laban	2
		Mass	3	Almarai Orange Juice	2
		Oasis	3		
		Zulal	3	Almarai Apple Juice	2
		Acqua Panna	3		
Sharjah	5	Aquafina	3	Almarai Mango Juice	2
		Cool Blue	3		
		Evian	3	Lacnor Peach Juice	2
		Spring Aqua	3		
		Volvic	3	Lacnor Cocktail Juice	2
Ajman	5	Alpin	3		
		Ice Berg	3	Laban up	2
		Viva	3	Lacnor Chocolate Milk	2
		Mai Dubai	3		
		LuLu	3	Lacnor Strawberry Milk	2
		First	3		

Table 2 Fluoride concentration (mg F/L) in Tap water of U.A.E.

Emirate	Reading number	Fluoride concentration (mg F/L) ^a					Mean (mg F/L)	Standard deviation
		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5		
Abu Dhabi	I	0.05	0.04	0.04	0.04	0.04	0.04	0.00
	II	0.05	0.04	0.04	0.04	0.04	0.04	0.00
Ajman	I	0.3	0.3	0.2	0.3	0.3	0.28	0.04
	II	0.3	0.3	0.2	0.3	0.3	0.28	0.04
Dubai	I	0.07	0.05	0.04	0.04	0.05	0.05	0.01
	II	0.07	0.05	0.04	0.04	0.05	0.05	0.01
Sharjah	I	0.3	0.07	0.09	0.2	0.2	0.17	0.08
	II	0.3	0.07	0.09	0.2	0.2	0.17	0.08

^a mg/L fluoride is equivalent to ppm fluoride.

noted in Mass bottled water with a fluoride concentration of 0.02 mg F/L. Majority (68.2%) of bottled water is produced locally within U. A.E while a few (31.8%) are imported.

Regarding quality of labeling of bottled waters, eight brands out of twenty-two did not state fluoride concentration on the label and all these eight brands had some amount of fluoride ranging from 0.02 to 0.1 mg F/L. Three local brands (Gulfa®, Viva® and Lulu®) had significantly higher level of fluoride concentration than the labeled nil amount. There is no statistically significant difference in fluoride levels between the different sources of bottled water ($p < 0.05$).

Fluoride concentrations of fifteen most common brands of beverages consumed in U.A.E. are shown in Table 4. These included six carbonated drinks, five fruit juices, two different brands of Laban and two brands of flavored milk. Mean fluoride content of beverages was 0.07 mg F/L. Almarai orange juice and Almarai apple juice showed the highest fluoride content of 0.10 mg F/L followed by Pepsi and Laban up. The lowest fluoride concentration was noted in Mountain dew, Lacnor peach juice and Lacnor cocktail juice; all three beverages contained 0.04 mg F/L of fluoride.

4. Discussion

Water is a vital source of fluoride, which may be consumed either directly as a drink or indirectly when added to food or beverages. Fluoride may affect the consumer in any of the three ways: optimal levels of fluoride in water and beverages will result in caries prevention, suboptimal levels will cause increase in dental caries incidence; whereas high level of fluoride can result in fluorosis. Therefore, determination of exact concentration of fluoride in drinking water is essential for an effective fluoride regimen for prevention of dental caries in children.

Different methods and instruments have been used to estimate fluoride levels in drinking water such as Ion Chromatography (Cochrane et al., 2014), Colorimetric (Gail et al., 1987) Potentiometric (Egorov et al., 2008) and Spectrophotometric method (Zaher and Sameer, 2012). However, majority of

Table 3 Fluoride concentration (mg F/L) in three batches of mineral bottled water.

Bottled water brand	Source	Labeled content (mg F/L)	Fluoride concentration (mg F/L)			Mean (mg F/L)	Standard deviation
			Batch 1	Batch 2	Batch 3		
Ahlan	Umm Al Quwain	NM ^a	0.07	0.05	0.04	0.053	0.011
Alain	Alain	< 0.1	0.10	0.07	0.07	0.080	0.012
Arwa	Alain	< 0.1	0.05	0.04	0.04	0.043	0.004
Crystal	Fujairah	NM	0.07	0.05	0.04	0.053	0.011
Gulfa	Ajman	Nil	0.04	0.04	0.04	0.040	0.000
Jeema	Dubai	0.2	0.04	0.03	0.04	0.038	0.004
Masafi	Ras Al Khaimah	NM	0.04	0.03	0.03	0.033	0.004
Mass	Dubai	NM	0.03	0.02	0.02	0.023	0.004
Oasis	Abu Dhabi	< 0.2	0.06	0.04	0.03	0.043	0.011
Zulal	Sharjah	0.4	0.50	0.50	0.50	0.500	0.000
Acqua Panna	Italy	< 0.1	0.07	0.07	0.07	0.070	0.000
Aquafina	New York	NM	0.09	0.06	0.06	0.070	0.012
Cool Blue	New Zealand	0.2	0.09	0.09	0.09	0.090	0.000
Evian	France	NM	0.10	0.10	0.10	0.100	0.000
Spring Aqua	Finland	NM	0.08	0.08	0.08	0.080	0.000
Volvic	France	NM	0.03	0.03	0.03	0.030	0.000
Alpin	Turkey	0.05	0.08	0.1	0.2	0.120	0.047
Ice Berg	Dubai	< 0.03	0.04	0.05	0.05	0.048	0.004
Viva	Ajman	Nil	0.03	0.03	0.03	0.030	0.000
Mai Dubai	Dubai	0	0.05	0.04	0.04	0.043	0.004
LuLu	Ajman	Nil	0.04	0.03	0.03	0.033	0.004
First	Dubai	0.02	0.03	0.03	0.03	0.030	0.000

^a Not mentioned.

Table 4 Fluoride concentration (mg F/L) in beverages.

Beverage	Fluoride concentration (mg F/L)		Mean (mg F/L)	Standard deviation
	Sample 1	Sample 2		
Pepsi	0.09	0.09	0.09	0.00
Coca Cola	0.08	0.08	0.08	0.00
Seven up	0.06	0.07	0.07	0.01
Shani	0.07	0.07	0.07	0.00
Mirinda	0.05	0.04	0.05	0.01
Mountain Dew	0.04	0.04	0.04	0.00
Almarai Fresh Laban	0.06	0.06	0.06	0.00
Almarai Orange Juice	0.1	0.09	0.1	0.01
Almarai Mango Juice	0.09	0.09	0.09	0.00
Almarai Apple Juice	0.1	0.1	0.1	0.00
Laban up	0.09	0.09	0.09	0.00
Lacnor Peach Juice	0.04	0.04	0.04	0.00
Lacnor Cocktail Juice	0.04	0.04	0.04	0.00
Lacnor Chocolate Milk	0.05	0.05	0.05	0.00
Lacnor Strawberry Milk	0.05	0.05	0.05	0.00

research studies (Aldrees and Al-Manea, 2010; Christian et al., 2013; Cochrane et al., 2006; Consuelo et al., 2009), have used ion selective electrode method to measure fluoride content of drinking water as this method is simple, quick, accurate and reliable (Bratovic et al., 2009; Burton et al., 1992; Rajkovic and Novakovic, 2007).

Although majority of U.A.E population uses bottled water for drinking (Marqa and Ghoudi, 2015) but tap water still is being used in many households for cooking purposes and is thus added to food (Wait, 2008). The fluoride concentration of tap water from four different emirates in U.A.E was found to range between 0.04 and 0.3 mg F/L. Tap water samples of Abu Dhabi and Dubai showed very low levels of fluoride, whereas tap water samples of Ajman had slightly higher

fluoride levels. Varied fluoride level in tap water indicates that fluoridation of municipal water is not well regulated in U.A.E.

None of the bottled water samples tested contained recommended optimal fluoride level of 0.70 mg F/L (USPHS, 2015) except locally produced Zulal brand (0.5 ppm). Majority of bottled waters available in U.A.E were found to contain less than 0.1 ppm of fluoride which is much lower in comparison with fluoride content of bottled water recorded in the previous studies conducted all over the world from 2000 to 2010 (Ahiropoulos, 2006; Aldrees and Al-Manea, 2010; Johnson and DeBiase, 2003; Thippeswamy et al., 2010). Decline in added concentration of fluoride in bottled water these days can be attributed to a change in the optimal fluoride recommendations, from 1 mg F/L to 0.7 mg F/L in order to reduce

the risk of dental fluorosis as recommended by United States Public Health Service Reports and Recommendations (USPHS, 2015). The fluoride concentration in brand Volvic in our study was found to be 0.03 mg F/L, which is lower than fluoride concentration ranging from 0.2 to 0.7 mg F/L recorded for the same brand in previous studies (Aldrees and Al-Manea, 2010; Johnson and DeBiase, 2003). Another brand Arwa (produced locally in UAE) showed fluoride content of 0.04 mg F/L which is much lower than 0.5 mg F/L tested in a study where the water source was from Riyadh, Saudi Arabia (Aldrees and Al-Manea, 2010). Similarly, fluoride content of brand Evian found in our study was 0.1 mg F/L, which was again lower than seen in other studies conducted in a last decade (Aldrees and Al-Manea, 2010; Cochrane et al., 2014; Johnson and DeBiase, 2003; Zohouri et al., 2003).

Around 65% of the bottled water brands tested had labeled their fluoride content however most of them were inaccurate (Table 3). Two brands, Jeema and Cool blue showed significantly lower fluoride levels of 0.04 mg F/L and 0.09 mg F/L respectively than their stated levels of 0.20 mg F/L. On the contrary Alpin bottled water showed almost twice the fluoride content of 0.1 mg F/L while the label stated 0.05 mg F/L.

As per UAE law, there is no official regulation that requires bottle drinking water manufacturers to add fluoride; however, if it is added, it becomes mandatory to mention and inform consumers about fluoride levels on the label. Some of manufacturers of locally UAE produced bottled water don't mention fluoride content on labels, thereby implies that these brands have no fluoride, although on testing with ISE method, all these non labeled brands had less than 0.1 mg F/L. The present study also showed that there were very minor differences in fluoride content between different batches of same brand of bottled water. Seasonal variations such as hot weather and rainy seasons can account for these differences in fluoride content of the same brand (Grobler et al., 2001).

The fluoride content of fifteen popular beverages (fruit juices and carbonated drinks) available in U.A.E varied between 0.04 and 0.10 mg F/L. These findings again are lower in comparison with values of 0.08–1.42 mg F/L (Jiménez-Farfani et al., 2004), 0.2–0.4 mg F/L (Thippeswamy et al., 2010) and 0.06–0.15 mg F/L (Quock and Chan, 2009) respectively. This difference in fluoride levels can be attributed to the fact that different water sources containing different fluoride levels have been used by manufacturers of the beverages.

5. Conclusions

Fluoride levels in drinking water should be within the recommended and accepted levels to prevent dental caries and reduce the risk of dental fluorosis. The less than recommended fluoride level in drinking water (both tap + bottled) as well as beverages poses wider implications for an effective and comprehensive fluoride program for caries prevention in children. Oral health care professionals in UAE should always be aware of reduced levels of fluoride in drinking water (both tap + bottled) as well as beverages.

Conflict of interest

The authors declare that there are no conflicts of interest associated with this study.

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