

Fluoride Concentration of Water Supply in Eastern Saudi Arabia: A Preliminary Study

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Abstract

Background: Community water fluoridation is known to play a significant role in enhancing oral health by reducing the incidence of dental caries. However, the level of fluoride in the supplied public water in the Eastern Province of Saudi Arabia is unknown.

Objective: To determine water fluoride levels at the main sources supplying water to households and schools in two major cities (Dammam and Al-Khobar) of the Eastern Province of Saudi Arabia.

Methods: From the Directorate of Water Agency and Directorate of Education, the following were identified as the main sources of public water supply in Dammam and Al-Khobar: the water agency, public water tanks and four contracted companies. Two samples were collected from each of these six identified water sources at two different time points (in January and July 2016; 2 samples/site/time point; $N = 24$) using 500 mL polythene bottles. Each sample was analyzed using an ion chromatography system at different detection limits (including the lowest detection limit of 0.065 ppm) to determine the fluoride level.

Results: There was no fluoride detected in any sample even at the lowest detection limit, indicating that fluoride levels in the studied water samples were <0.065 ppm.

Conclusion: This study found that in the cities studied, fluoride levels, if any, are considerably below the optimum recommended level for the prevention of dental caries (i.e., 0.7 ppm).

Keywords: Dental caries, drinking water, Eastern Province of Saudi Arabia, fluoride, prevention, water fluoridation

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INTRODUCTION

Community water fluoridation plays a significant role in enhancing oral health by reducing the burden of tooth decay.^[1] In fact, the Centers for Disease Control and Prevention has distinguished community water fluoridation as one of the ten greatest public health achievements of the twentieth century.^[2]

The first water fluoridation study conducted in Grand Rapids, Michigan, found that community water fluoridation reduced dental caries by about 60%.^[3] A review of studies conducted in the United States between 1976 and 1987 showed that water fluoridation reduced the incidence of dental caries by 60% in primary teeth and 35% in permanent teeth.^[4] Recently, it has been shown that water fluoridation reduces dental caries by around 20%–40% in the United States; the decrease from earlier percentages can

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be attributed to an overall lower tooth decay prevalence rate and/or exposure to other sources of fluoride.^[4-6] In the United Kingdom, water fluoridation has been found to reduce dental caries by 44% in preschool children aged 5 years.^[7] The reduction in dental caries was more evident in children from lower socioeconomic backgrounds.^[8]

In Saudi Arabia, dental caries is a significant public health problem, affecting the primary dentition of about 95% children aged 3–7 years, about 91% adolescents aged 12–19 years and about 98% of adults aged 30–45 years.^[9] Specifically, in the Eastern Province, the overall prevalence of dental caries among children aged 6–9 years and 10–12 years is 73% and 68%, respectively.^[10]

Water fluoridation is considered the most cost-effective mean for caries prevention among individuals of moderate-to-high caries risk. In addition, it has a strong safety profile, with the only side effect being a low risk of very mild fluorosis (~2%), which itself may not necessarily be due to exposure to high levels of fluoride alone.^[5,6,11,12] Regulations have been set to fluoridate water in the major cities of Saudi Arabia.^[13] However, despite its benefits, in general, water fluoride levels are not monitored in Saudi Arabia, although there have been a few region-specific studies. A study found that 75% of public water supplied in the Central Province cities of Riyadh and Qassim has fluoride levels between 0 and 6 ppm.^[14] Another study conducted in three cities of the Western Province of Saudi Arabia revealed differing fluoride levels, ranging from 0.3 to 2.5 ppm, depending on the water supply source.^[15] However, the US Department of Health and Human Services recommends that the optimal water fluoride level for caries prevention with minimal risk is 0.7 ppm.^[16]

Given the high prevalence of tooth decay among the Saudi population, optimal fluoride levels in water supplied in Saudi Arabia could lead to a significant reduction in tooth decay. However, there are no data available on the level of fluoride in the public water supplied to households and schools in the Eastern Province of Saudi Arabia. To fill this gap in the literature, this study was conducted to establish baseline data regarding water fluoride levels at the main sources supplying water to households and schools in Dammam and Al-Khobar, two major cities of the Eastern Province of Saudi Arabia.

METHODS

The strategy of water sampling in this cross-sectional study was based on the distribution of sources from which public water is supplied to households and schools in Dammam and Al-Khobar.

Public schools were included in this study because in Dammam and Al-Khobar, they are located mainly in populated areas, and thus indicate population density. The list of public schools in Dammam and Al-Khobar and their source of drinking water was obtained from the Directorate of Education. All public schools of both genders are located in the same neighborhood and their source of water is also the same. Accordingly, for considering the water source supplying to schools, the authors chose to assess only public primary boys' schools, as there was representative for both genders and all grades in each neighborhood.

Information regarding the source of public water supply to households in Dammam and Al-Khobar was obtained from the Directorate of Water Agency in the Eastern Province, which regulates the supply of public water. Subsequently, area-specific sources of public water supply were identified.

To overcome any variability across seasons, two water samples were collected from each identified water source (for both households and schools) at two different time points: January and July 2016. Aldosari *et al.*'s^[14] water collection method and protocol were used in this study: water was allowed to run for 3 min, after which the 500 mL polythene bottles used for collection were rinsed three times and then 300 mL of the sample was collected. Each sample was analyzed using an ion chromatography system (Thermo Scientific™ Dionex™ ICS-5000+ Reagent-Free™ HPICTM systems, Waltham, MA, USA) after calibration, and according to the manufacturer's instructions. To ensure consistency in measurements, the system was set at different detection limits, including 2 ppm, 1 ppm, 0.5 ppm and the lowest detection limit of 0.065 ppm, and readings were recorded if fluoride was detected in the sample at the selected detection limit. Multiple readings at the same detection limit were carried out and all samples were analyzed within 3 days of collection.

RESULTS

There are three major sources of drinking water in Dammam and Al-Khobar: commercial bottled water, the water agency and contracted companies. The overall distribution of the sources of drinking water and its collection points in these cities is presented in Figure 1. The water agency supplies two types of water to households: nondrinkable and drinkable water. Drinkable water constitutes either pure desalinated water or a mixture of groundwater and desalinated water. It is supplied at discounted rates to two-thirds of households in the region. In addition, the water agency supplies drinking water to

public water tanks for free as well as to four contracted companies, namely, Al-Kawthar, Zaid Al Hussain, Al Saeedi and Al Amer [Figure 1]. These contracted companies further treat the water according to Presidency of Meteorology and Environment standard before supplying it to their customers. Contracted companies supply water for a fee to schools, households and private hospitals. In addition to these, commercial companies also provide multisite bottled water.

There are a total of 94 public primary boys’ schools in these cities, of which 71 are in Dammam and 23 in Al-Khobar. All these schools were supplied water either directly from the water agency or from Al-Kawthar.

Based on the identified sources of water supplying to schools and households in the two cities, the collection points were determined to be: the water agency (collection point at the source before distribution), public water tanks (collection point at delivery site) and all four contracted companies (collection point at the source after processing). Therefore, from these six water supply points (at the source or delivery point), a total of 24 water samples were collected (two samples/site/time point). Fluoride concentration was not detected in any of the 24 water samples at any detection limit, including the lowest

detection limit of 0.065 ppm. There were no discrepancies noted between the measurements across the two time points [Table 1].

DISCUSSION

Community water fluoridation is known to play a significant role in enhancing oral health by reducing the incidence of dental caries.^[1,3-6] In addition, it is a safe and cost-effective approach to target large-scale population to reduce dental caries,^[4,5,17] especially where the prevalence of tooth decay is high such as in Saudi Arabia.^[9] However, the level of fluoride in the supplied public water in the Eastern Province of Saudi Arabia was not known. This study provides information about the fluoride levels in water supplied to households and schools in Dammam and Al-Khobar, two major cities in the Eastern Province of Saudi Arabia. As this is the first-of-its-kind study in the region, it establishes baseline records.

The Kingdom of Saudi Arabia has two major sources of drinking water: traditional source, including groundwater (40%) and surface water such as rain and unconventional sources, including desalinated water (50%) and treated wastewater (10%).^[18] Saudi Arabia relies mainly on desalinated water because of the large areas of deserts and lack of sufficient natural water resources.^[19] According to the Joint Monitoring Program for Water Supply and Sanitation by World Health Organization and United Nations International Children’s Emergency Fund, it was estimated that the entire population of Saudi Arabia has access to improved source of drinking water, as of 2015.^[20] The Eastern Province receives desalinated water as its main source of domestic water from water treatment plants at Al Jubail.^[21] However, the water agency in Dammam regulates water additives and distribution of water in the area.

This study found that in Dammam and Al-Khobar, drinking water is supplied to schools and households through three major sources: (1) the water agency, which supplies mixed water (groundwater and desalinated seawater) to households and desalinated seawater to public water tanks; (2) contracted companies, which provide desalinated

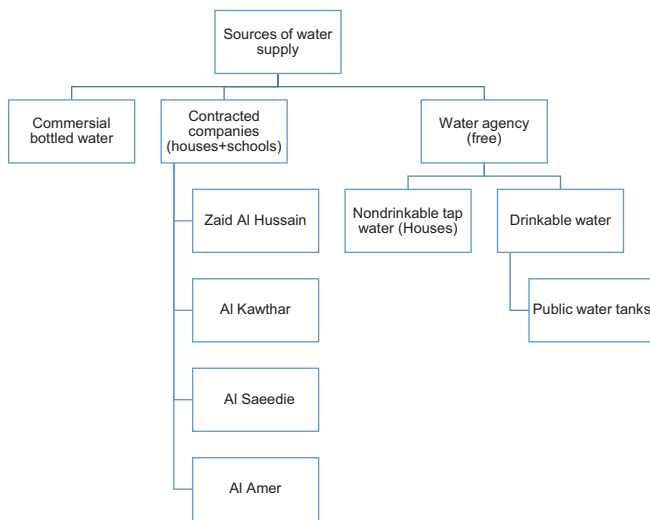


Figure 1: Sources of water supply to households and schools in Dammam and Al-Khobar

Table 1: Fluoride level of water samples

Water sample	Number of samples (2 samples/time point)	Fluoride level (ppm)
Water agency (source before processing)	4	<0.065
Public water tanks (delivery site)	4	<0.065
Zaid Al Hussain Company (source after processing)	4	<0.065
Al Amer Company (source after processing)	4	<0.065
Al Saeedi Company (source after processing)	4	<0.065
Al-Kawthar Company (source after processing)	4	<0.065

water and (3) commercial companies, which provide bottled water. The current study collected samples from all these sources, except commercially bottled water. Bottled water was excluded because previous studies have shown the fluoride levels in bottled water supplied in Saudi Arabia to be highly variable.^[22,23] The mean fluoride level in 15 local bottled water brands was found to be 0.79 ppm, while that of three imported brands was 0.67 ppm.^[23] Meanwhile, the current study focused on the sources of publicly supplied water that are available to the public at very nominal prices. Contracted companies supply water to households for about 6 Saudi Riyals (US\$1.5) for every cubic meter, which is more expensive than water supplied by the water agency.^[24] However, water supplied to most schools through the contracted companies is free of charge, provided through the water agency; therefore, they were included in our study.

Our study found that fluoride level in all sources of water supply in Dammam and Al-Khobar is well below the recommended level of 0.7 ppm.^[16] These results are in contrast with the varying results of similar studies conducted in other regions of Saudi Arabia. In the Western region of Saudi Arabia, fluoride levels in drinking water were found to be 2.5 ppm in Makkah, 0.8 ppm in Rabagh and 0.3 ppm in Jeddah. In Riyadh, Hail and Qassim and it greatly varied and were found to be 0.00, 2.8 and 6.20 ppm, respectively.^[2,14,15] The nature of ground rocks, which affect the salts elements in water, in regions such as Mecca and Qassim could possibly explain these variations in fluoride levels. The Eastern Province has a few sources of groundwater supply, which contains an average of 1.33 ppm natural fluoride.^[25] Although groundwater has naturally occurring fluoride, about 88% of desalination water plants use multistage flash system, while the remaining use reverse osmosis, which possibly results in the removal of fluoride.^[18] This would explain the low level of fluoride level found in our study despite the water agency mixing the desalinated water with groundwater.

Based on the results of this study, it can be stated that the population of Dammam and Al-Khobar receive very low levels of fluoride from the supplied public water. Although this study did not measure caries prevalence or experience in the study area, the low level of fluoride may be associated with the high prevalence of tooth decay in the Eastern Province.^[10] In the Western Province of Saudi Arabia, Al-Khateeb *et al.*^[15] found that water fluoride levels were associated with prevalence of caries. In contrast, in Riyadh and Qassim, no linear relationship was found between water fluoride level and caries.^[26] However, in the Hail region, high levels of water fluoride were found to be correlated with dental fluorosis.^[27] Given the great variability in the fluoride

levels in drinking water supplied to different areas of Saudi Arabia and in different commercially bottled water,^[14,15,22,23,25] there is a need to monitor and regulate the fluoride level in water in Saudi Arabia based on the recommended level of 0.7 ppm for caries prevention.

A limitation of this study is that because the study only included two cities, the results may not be representative of the entire Eastern Province. Future studies should include other urban and nonurban cities in the Eastern Province and investigate if variation in fluoride levels exists between different areas. Another limitation is that this study did not measure caries in the area to assess if any linear relationship exists between fluoride level and caries prevalence, and thus future studies should be conducted to determine the same.

The authors recommend that the General Directorate of Water in the Eastern Province should consider adjusting the fluoride level in water supplied to households and schools and spread awareness about the importance of fluoridated public water supply. In addition, the General Directorate must monitor the fluoride levels of the contracted and commercial companies that supply drinking water in the region. However, before setting standards for regulating water fluoride level, it is important to determine the amount of daily water intake by the population and evaluate their use of publicly supplied water in addition to their exposure to other fluoride sources. Therefore, the authors recommend conducting a comprehensive analysis including all cities in the Eastern Province to determine the percentage of population who use drinking water through the identified sources in this study.

CONCLUSION

This study revealed that the fluoride concentration in all identified sources of water at Dammam and Al-Khobar was well below the recommended level for caries prevention. This study could serve as a pilot for a wider study assessing the fluoride level in public water supplied throughout the Eastern Province of Saudi Arabia.

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Conflicts of interest

There are no conflicts of interest.

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