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Effect of home-used water purifier on fluoride concentration of drinking water in southern Iran

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ABSTRACT

Background: Fluoride in drinking water plays a key role in dental health. Due to the increasing use of water-purifier, the effect of these devices on fluoride concentration of drinking water was evaluated.

Materials and Methods: Drinking water samples were collected before and after passing through a home water-purifier, from four different water sources. The fluoride, calcium and magnesium concentration of the samples were measured using the quantitative spectrophotometery technique. Data were analyzed by the Wilcoxon test. P value < 0.1 was considered as significant.

Results: The result showed that the concentration of fluoride was 0.05-0.61 ppm before purification and was removed completely afterward. Furthermore, other ions reduced significantly after treatment by the water purifier.

Conclusion: This study revealed that this device decreases the fluoride content of water, an issue which should be considered in low and high-fluoridated water sources.

Key Words: Drinking water, fluoride, water-purifier

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INTRODUCTION

Fluoridation of drinking water in controlled concentration (0.7-1.2 ppm) is one of the safest and effective methods in prevention and remineralization of early dental caries.[1] Although, topical sources are considered to be more important in fluoride (F) intake nowadays,[2,3] in some countries where topical supplements are not used, systemic F specially in drinking water has crucial significance since it reduces caries and decreases the oral health gap between all social groups.[4,5] Moreover, it has been recognized that fluoride increases the bone density. While this element plays an important role in dental health, high concentration of fluoride in the blood can lead to dental and bone fluorosis and pathological changes in the brain, liver, kidney, and spinal cord. It is also shown that long-term exposure to excessive fluoride can alter the DNA structure.[6-9] Therefore, intake of controlled concentration of fluoride is necessary to render F as a beneficial element. Defluoridation of drinking water is a practical option for enhancing water quality, which can be carried out by several methods with both advantages and limitations.[10]

Currently, water purifiers are used at home (home-use) frequently. These purifiers decrease water hardness by reverse osmosis of water through an organic membrane or by using ion exchange resins and the unpleasant water odor and microorganisms are removed by carbon powder bed filters.[11]

Despite these benefits, it is necessary to investigate the effect of these systems on useful elements such as fluoride in drinking water. The present study planned for: (a) evaluation of fluoride concentration in

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drinking water in four areas in Shiraz, southern Iran (considered as a warm area) with the different water sources and (b) analyzing the fluoride concentration changes before and after water purification.

MATERIALS AND METHODS

Fluoride ion concentration was determined by the spectrophotometric method. In this technique zirconium oxychloride and a derivative of a dye named alizarin red produce a red complex. Fluoride ion forms a colorless compound with this complex. Changes in the color of solution, with regards to standard fluoride ion solution, are tracked with a visible light spectrophotometer.

A total of 0.75 g alizarin red indicator was dissolved in distilled water in a 1,000 ml volumetric flask. Moreover, 0.345 g of zirconyl chloride was dissolved in distilled water and then 33.3 ml and 101 ml of concentrated sulfuric acid and hydrochloric acid was added to the solution, respectively. The final volume of the solution reached to 1,000 ml by adding distilled water.

Spectroscopic determination of fluoride ion

Four samples of drinking water with different sources were collected from the most crowded regions of Shiraz city. 5 ml of prepared alizarin alizarin red and zirconyl chloride in acid solutions were added to 100 ml of each water sample. When chemical reaction was completed and the water samples were colored, the light absorbance of solutions was read at 520 nm with a spectrophotometer (Jasco, V-570). Fluoride concentration was determined by the light absorbance of each solution, compared to the standard fluoride solution ($NH_4F.HF$ in distilled water).[12]

The collected water samples were purified by a home-used water purifier (Aqua win A-102-6, Taiwan). The fluoride ion concentration of purified water was determined as described above.

Water hardness measurement

The concentration of calcium (Ca) and magnesium (Mg) ions (causing water hardness) of pre- and post-purification samples was measured by an ion selective electrode (Ca-ISE, Metrohm) with potentiometric measurement.[12]

Data were analyzed by the Wilcoxon test. P value < 0.1 was considered as significant.

RESULTS

Table 1 shows the drinking water specifications. Table 2 shows fluoride, Ca, and Mg concentration in water samples. The findings show that fluoride was eliminated completely through water purifying. By

Table 1: The water samples specification, before treatment with water purifier

Ions	Fluoride (mgl^{-1})	Calcium (mgl^{-1})	Magnesium (mgl^{-1})	Turbidity NTU
Sample #1	0.32	57.7	31.1	0.25
Sample #2	0.22	56.1	31.1	1.27
Sample #3	0.05	104.1	37.6	0.77
Sample #4	0.61	127.1	59.5	0.72

NTU: Nephelometric turbidity units

Table 2: The water samples specification, after treatment with water purifier

Ions	Fluoride (mgl^{-1})	Calcium (mgl^{-1})	Magnesium (mgl^{-1})	Turbidity NTU
Sample #1	0.0	10.1	5.1	NM
Sample #2	0.0	4.2	7.8	NM
Sample #3	0.0	12.3	6.9	NM
Sample #4	0.0	20.1	15.1	NM

NM: Not measured; NTU: Nephelometric turbidity units

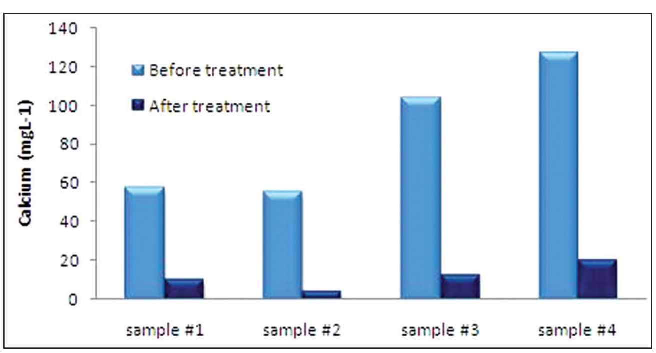

Figure 1: Calcium ion concentration of water samples, before and after water purification

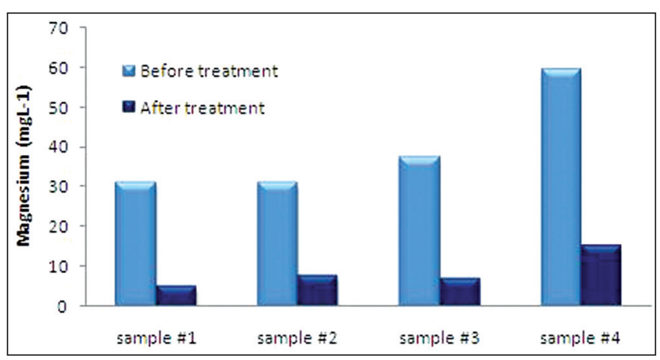

Figure 2: Magnesium ion concentration of water samples, before and after water purification

using this device, the concentration of Ca, and Mg ions decreased significantly. Figures 1 and 2 illustrate graphically the Ca and Mg concentrations, before and after water purification, separately.

DISCUSSION

Drinking water is the most important source of fluoride intake for the human beings.[13] Fluoride concentration was described as an important property of the drinking water in the many studies. World Health Organization (WHO) has stated that 1-1.5 ppm is a suitable range for fluoride concentration. The higher concentration leads to the dental fluorosis and lower concentrations increases risk of dental caries.[13]

In Fars, dental fluorosis was prevalent in the past but recently this condition is rare, therefore we evaluated the fluoride content of drinking water. Our findings revealed that fluoride concentration in all selected areas was less than the concentration recommended by WHO. This reduction may lead to a decline in the prevalence of dental fluorosis. Low and high F level has been reported in other parts of Iran and many countries. Mesdaghinia *et al*., have measured fluoride concentration in groundwater resources in an urban area of Iran and they have reported Fars as a low fluoridated area with mean fluoride concentration of 0.5 mg/l. Although fluoride content has shown variations: 94% of samples have demonstrated fluoride <1 ppm and only fluoride concentration in 4% of samples have been in a suitable range. In their study, majority of urban areas have exhibited low fluoride concentration and only in Bushehr the mean was higher than 1.5 ppmb.[13] Furthermore, high fluoride level in drinking water has been reported in other parts of the world such as India, China, and Northern Mexico.[10,14,15]

Improvement of drinking water quality and quantity is an important strategy concerned by governments and it has been evident that the water purifier is a cost-effective method to reach this goal. This system removes many elements and microbial water-borne pathogens. Matsui *et al*. have demonstrated that purifiers could remove the cryptosporidium parvum oocytes (that were responsible for parasitic disease of the intestinal tract), by multilayer filters.[11] Furthermore, another study in India has reported that water was cleaned from arsenic and coliform bacteria contamination and fluoride was removed through a cheap homemade sand filter media composed of various-sized sand and pebbles.[16] Therefore, water purifier can reduce morbidity and mortality rate of some conditions such as arsenic toxicity and diarrheal diseases.

The present study evaluated fluoride concentration changes after purification in the areas where dental fluorosis was prevalent in the past but rarely observed today. This study showed that treatment of drinking water with home-used purifiers removed fluoride completely. This quality may be an advantage in the some countries where fluorosis is a problem. However, in areas where fluoride concentration is low and intake of fluoride from topical sources is not current, systemic fluoridation remains a legitimate choice for the prevention of dental caries.[4,5] Therefore, in such areas this device reduces dental health indices. In these cases, it is suggested strongly that topical fluoride supplements to be used in a regular program, especially for children and adolescents.

Water hardness is determined by measurement of Ca and Mg and/or iron in water. It has been shown that water hardness specially Mg concentration has some effects on the cardiovascular status and the kidney diseases[17] and low concentration of Mg may increase the risk of cardiovascular disease or stroke.[18] Although, the previous studies have shown controversies. Moreover, it is demonstrated that increasing water hardness resulted in a decrease in uranium toxicity.[19] Our findings showed that drinking water in the selected area was moderately hard. Whilst purifier reduces water hardness and it was resulted from our study too, the effects of the device on renal and dental diseases have not been investigated since this study is carried out. However, discussion about water hardness was not the aim of the present study and further studies focusing on this matter should be designed.

In the previous studies, it has been discovered that water purifier is a useful system but its usage inconvenience, poor durability, high-cost and post-purification contamination are important factors limiting its use.[20] In addition to these disadvantages, removal of useful elements is also an issue of concern. Another research applied homemade filter media composed of pebbles and sand in some layers for removing high-concentration of 5 ppm in different times and revealed that these filters remove 85.6% of fluoride in 10 h.[16] Because all our samples had low concentration of fluoride, it is possible that in high-concentrations, our method could reduce the fluoride content to an acceptable level, but not remove it completely.

CONCLUSION

The present study showed low-levels of fluoride in drinking water and complete removal of this useful element after purification. Thus, although this device has benefits in some countries, probably it leads to an increase in dental caries in areas with low concentration of fluoride, although, the use of topical supplements is always strongly recommended. It is suggested that a further study evaluate fluoride removal effect of water purifiers in areas where drinking water includes high concentration of fluoride.

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