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Investigations of Fluoride Concentration in Drinking Water Samples from Selected Villages in Eritrea

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Abstract : Fluoride is one of the few chemical contaminants in drinking water, even though; it is known as an essential chemical component in water due to its beneficial effect at a very low concentration. However, when present excessively in drinking water it has detrimental effects on human health in terms of the prevalence of dental caries, skeletal fluorosis and bone fractures. Endemic fluorosis, especially dental mottling and discoloration has been prevalent in many parts of Eritrea. However, no well-established study has been carried out to ascertain the fluoride content in the groundwater of the affected villages, except a couple of researches conducted to estimate fluoride level in drinking water of the villages around Keren and Elabered, where dental mottling and fluorosis is prevalent. According to the researches the fluoride level in the underground water was found to be higher than the maximum WHO limit of 1.5 mg/L. Butthe fluoride content of other places (villages) with endemic dental fluorosis has not been determined and documented, and therefore it is necessary to conduct this research in the affected areas to ascertain the fluoride level in the drinking water of the community and compare it with the WHO standards.
Keywords : Dental caries, Chemical contamination, Skeletal fluorosis, Dental mottling.

Introduction

The chemical nature of water is one of the most important criteria that determines its usefulness for a specific need and as such not all the waters are fit for drinking; hence the problems of scarcity of drinking water [1-3]. Fluoride is one of the few chemical contaminants in drinking water,even though, it is known as an essential chemical component in water due to its beneficial effect at a very low concentration [4]. However, when present excessively in drinking water it has detrimental effects on human health in terms of the prevalence of dental caries, skeletal fluorosis and bone fractures [5]. Similar to any other pollutant, the fluoride pollution can also occur due to both natural and manmade reasons [3]. Fluoride commonly occurs in the earth's crust

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making groundwater more susceptible to contamination. Fluoride at elevated concentration is known to occur in a number of parts of the world and in such circumstances can have adverse impact on public health and wellbeing [5]. Although, the World Health Organization (WHO) has set the fluoride guideline limit of 1.5 mg/L in drinking water [6,7], over 260 million people globally consume drinking water with high fluoride concentration above the WHO standard.

Fluoride has been reported to be among natural pollutant of water in Africa particularly in those countries traversed by the Great East African Rift Valley. Eritrea is situated in East Africa and shares part of the Rift Valley. It has a total area of 125,000 km^2 and a population of 3.2 million. It is located in arid and semiarid region of Africa. It is bordered by Ethiopia in the South, Sudan in the West, Djibouti on the South Eastern flank and the Red Sea to the East [5, 8]. The need of water in both urban and rural parts of Eritrea is highly imperative for household and agricultural activities. In Eritrea there are no perennial rivers except Setit River and although the government of Eritrea is constructing dams across the country, fresh water is a scarce commodity in Eritrea and the demand is gradually growing in the country due to increase in population growth, economic activity, rapid urbanization, and improved standards of living of the population [5, 9]. Thus majority of the population, more than 80%, depends on groundwater for their consumption and will remain the main realistic domestic sources for the next 15 – 20 years [9].

Fluoride is an essential micronutrient for human health, 96% of fluoride in the human body is found in bones and teeth. Fluorine is essential for the normal mineralisation of bones and formation of dental enamel [10-12]. Although drinking water is usually the largest contributor to the daily fluoride intake of humans but fluoride is also found in vegetables, sea fish, fruit, tea and other crops. Fluoride release in an environment occurs through two channels, namely: natural and anthropogenic sources [10,13,14].

Endemic fluorosis is commonly observed in many parts of Eritrea, in the regions of Anseba, Debub, and SemenawiKeyihBahri (SKB). In Anseba region besides the villages around Keren and Elabered, it is observed in the villages Sheftoque and Sequar - Hagaz sub-region. In SKB region it is observed in Gahtelay and Adi-Shumay - Gindae sub-region. In Debub region it is observed in Akrur - Segeneyti sub-region. But the concentration of fluoride in the drinking water of these villages has not yet been determined. To this end any controlling measure has not been taken so far for the treatment of the fluoride content from the drinking water of all the villages in Eritrea. Therefore it is necessary to conduct this research in the affected areas to ascertain the fluoride level in the drinking water of the community and compare it with the WHO standards.

Experimental

Some of the common methods of estimation of fluorides are titrimetric, colorimetric, potentiometric and ion chromatography. Among the many methods suggested for the determination of fluoride ion in water, the colorimetric method (SPANDS) and the ion selective electrode method are the most satisfactory and applicable to variety of samples [15]. Spectrophotometric method of water analysis was employed in this research. The model used for this analysis was DR/2000 Spectrophotometer. Water samples were collected in 500 mL polyethylene bottles. Filter papers and measuring cylinders were also used. SPADNS reagent for fluoride test, HCl for washing the bottles and distilled water were used. All the reagents used were analytical grade reagents.

Selection of Study area

Five villages from three different regions: Anseba, SKB, and Debub were selected for study after conducting a preliminary field analysis to identify villages with prevalent dental fluorosis. The preliminary field survey includes interviewing dentists, local administrators and locals, and personal observations. The villages selected are Sheftoque and Sequre from Anseba region, Gahtelay and Adi-Shumay from SKB region, and Akrur from Debub region.

Sample collection and Preservation

A total of 8 water samples were collected from the sources of drinking water (wells/ bore hole/ surface water) of the five villages selected for study in the dry season from the last week of April to the first week of May 2018 in a 500 mL polyethylene bottles prewashed thoroughly with dilute HCl and deionized water. In the field, the sampling bottles were rinsed three times with the water to be sampled prior to sampling. The samples were kept in a refrigerator to avoid any contamination until the analysis was done.

Results and Discussion

Description of the Study area

Sheftoque and Sequar are located in the low lands, 8 km East of Asmara-Teseney main road at about 110 km from the Asmara city. These villages use the same water sources for drinking. The total population of the villages is 1800. Gahtelay is located in the low land along the Asmara-Massawa main road at 63 km from Asmara. It has a total population of 2500. And Adi-Shumy is located 7 km North West of Gahtelay and has a population of 2100.Akrur is located in the Eastern escarpments 9 km East of Segeneyti, which is 65 km from Asmara. It has a total population of 3200. Table 1 shows the location, average daily temperature and annual rain fall of the villages under study.

Table 1. Location, average daily temperature and annual rain fall of study villages

Village	Region	Sub region	UTM		Elevation (m)	Temp (^{o}C)	Annual rain fall (mm)
Sheftoque	Anseba	Hagaz	429660E	1733537N	915	35	300 - 400
Sequr	Anseba	Hagaz	429555E	1735651N	930	35	300 - 400
Gahtelay	SKB	Gindae	516293E	1716065N	319	42	500 - 600
Adishum	SKB	Gindae	509241E	1720635N	367	36	500 - 600
Akrur	Debub	Segeneyti	525370E	1667175N	1840	30	400-500

Fluoride Level in Water samples from Study area

The water samples from the sources of drinking water of the five villages selected for study were analyzed for fluoride level in mg/L. The findings of the present investigation are presented in Table 2. The result of this study indicated that the fluoride levels in most of the sources analysed were found to be higher than the optimum level of 1.5 mg/L recommended by the WHO guideline for drinking water, except in Adi-Shumay (where it was 0.75mg/L). The fluoride levels ranged from 0.75 mg/L which is the lowest to 4.9 mg/L as the highest concentration. Maximum fluoride levels were found in Akuar (4.9 gm/L) and May-hiwet (4.78 mg/L) which are the alternative water sources of Adi-Shumay and the main water source of Gahtelay respectively.

Table 2.Concentration of fluoride in the selected villages with the name and type of Source.

Village	Source	Source type	F^- (mg/L)
Sheftoque and sequar	Sheftoque	Bore hole	1.99
	RubaSequar*	Shallow pit	2.00
Gahtelay	May-hiwet	Bore hole	4.78
Adi-Shumay	Grat-tsaeda	Bore hole	0.75
	Akuar*	Hot spring	4.90
Akrur	Limamle	Bore hole	1.98
	May-denayis*	Spring water	2.06
	May-chea*	Shallow pit	2.09

The sources with * are alternative water source for the villages

Unpublished report on the quality of drinking water monitoring in Eritrea, shows that dental fluorosis is not a widespread problem in the country [16]. However, there are certain pockets of the country which are known to have high levels of fluoride in water. This study has revealed that the dental mottling and fluorosis observed in the villages selected for this study is associated with the consumption of water containing excessive level of fluoride. Studies carried out in villages around Keren and Elabered also showed that the dental mottling and fluorosis observed in the villages is associated with high level of fluoride in drinking water of the community [5,8].

It is evident that, there is a direct relationship between the level of fluoride in drinking water and magnitude and severity of fluorosis as it is revealed by dental mottling and fluorosis in children and skeletal disorders in adults in those villages. Table 3 shows typical fluoride concentrations with the associated potential health effects arising from consuming excess fluoride.

Table 3. Typical fluoride concentration and their potential health effects

F^- conc. (mg/L) in drinking water	Potential health effects
<0.5	Minimal effect in prevention of dental carries
0.5-1.5	Beneficial effects in preventing dental carries
1.5-4	Dental fluorosis
4-10	Dental and skeletal fluorosis
>10	Crippling fluorosis

Source: Dissanayake (1991) taken from [5]

Studies carried out in India revealed that the amount of water consumed is as significant as the concentration of fluoride in water, and problems of dental fluorosis occurs even when fluoride concentration in drinking water is less than 1 mg/L [2]. The day temperatures of the villages under study are high, which ranged from 30 to 42 ^{o}C, throughout the year which results in a high consumption of drinking water which in turn increases vulnerability to fluoride toxicity. Generally, the rural communities of Eritrea including the villages under study belong to lower economic strata and are engaged in farming for their subsistence. Majority of the people also suffer from malnutrition and low dietary calcium and magnesium. Low concentration of calcium and magnesium in groundwater and diet inhibits the excretion of fluoride as calcium fluoride or magnesium fluoride from the gastrointestinal track and aggravates the fluorosis problem as much of the fluoride retain in the body [17].

The excess fluoride level in the sources of water of these villages may be attributed to the geological location of the villages and factors that favour the dissolution of fluorine-bearing minerals such as high rate of evapo-transpiration, comparatively low rainfall, low rate of dilution and longer residence time of water in the weathered aquifer zone. Since fluorite, apatite, mica and various other minerals take part during rock–water interaction and liberate fluoride into water, it is imperative to assess the lithological units and constituent minerals of the villages.

Conclusion

In the present study, the fluoride level of eight water sources from five villages was estimated and it was found that except one source all the other sources registered fluoride levels ranging from 1.98 to 4.90 mg/L, that exceeds the maximum permissible limit of 1.5 mg/L prescribed by WHO for safe drinking water. Therefore, the dental mottling and fluorosis observed in these villages is associated with the consumption of water with high level of fluoride. Besides the day temperature of the villages under study is high, ranging from 30 to 42 ^{o}C throughout the year, which results in high consumption of drinking water which in turn increases vulnerability to fluoride toxicity. Considering the fact that fluorosis is an irreversible condition and has no cure, prevention is the only solution for this menace, using various intervention measures.

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