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Retrospective Study of Fluoride Distribution in Ethiopian Drinking Water Sources

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ABSTRACT

This retrospective study aimed to investigate the distribution of fluoride in selected drinking water source of Ethiopia. The study includes data from 2003 to 2011, which was tested in Environmental Public Health Chemistry Laboratory at Ethiopian Public Health Institute (EPHI). This study used 977 water samples that collected from different regions of the country and from these 548 were from the well water, 191 from spring water and the remaining 238 were from tap water samples. The results of the water samples analysis indicate that the fluoride concentration in the water sample varied from 0.0 mg/L to 40 mg/L. Generally in analyzed data, 32.8 % (n = 180) of the well water, 46.1 % (n = 88) of the spring water and 53.4 % (n = 127) of the Tap water samples are below 0.5 mg/L of fluoride concentration. On the other hand, 38.5 % (n = 211) of the well water, 15.18 % (n = 29) of the spring water and 12.18 % (n = 29) of the Tap water samples had fluoride concentration higher than the WHO and national standards maximum allowable fluoride concentration (1.5 mg/L). Based on the result obtained, the water sources need a sustainable remedial action in order to mitigate the effect of fluoride in human health. Therefore, the result of this retrospective study will use as a base to health authorities as well as other responsible body for the management of water supply regarding fluoride.

Keywords: Fluoride distributions, drinking water, well water, spring water, Tap water, retrospective study and Ethiopia

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INTRODUCTION

Fluoride is notably occurring in drinking water sources, especially with high concentration in groundwater sources. Consumption of water with high fluoride concentration exposes for risk of fluorosis. This problem faces many country including India, Sri Lanka, China, the Rift Valley in East Africa, and parts of South Africa (Coetzee et al., 2006). The East African Rift Valley, which cuts through Ethiopia, is geomorphologically still an active volcanic region.

The volcanic rocks, particularly in the young basalt, contain high concentrations of fluoride and fluorapatite. Large fault systems in the Valley create conditions that allow very deep percolation of infiltrating surface water. The floor of the Rift Valley that is characterized by high hydrothermal activity accelerates the solubility of fluoride. The hot climate and high fluoride waterbed of the Rift Valley, therefore, favor the development of endemic fluorosis. The water supplies in the Ethiopian Rift Valley region come mainly from boreholes with depths from 10 to 100 meters (Haimanot et al., 1987).

In Ethiopia, well water, spring water, and Tap water are the common water supply source used in both urban and rural areas (Gebrekidan & Samuel, 2011). The amount of fluoride present naturally in non-fluoridated drinking water is highly variable, being dependent upon the individual geological environment from which the water is obtained (Facts, 2007). However, water is epidemiologically most essential sources of fluoride in most areas, considerable exposure risk is also associated with the consumption of fish bones, canned meat, vegetables, grains and other staples, local salt, drinks (especially tea) and air (WHO, 1984; Smet, 1990; Helderman et al., 1997). Contrarily, in some African and Asian communities, intake of fluoride from food has been found to be higher than from water (Mabeleya et al., 1999).

Fluoride in drinking water could be beneficial or detrimental health depending on its concentration, and total amount ingested. The important effects on human are growth being incorporated in to the mineral part of bones and in teeth in the form of fluorapatite at low concentrations. On the other hand, excessive exposure to fluoride can causes for dental and skeletal fluorosis (D'Alessandro, 2006; Stefanie et al., 2009; Rongshu et al., 1995). Skeletal fluorosis was first reported in Ethiopia in 1973 in the Wonji-Shoa sugar estates in the Ethiopian Rift Valley (Lester, 1974). Several studies, during the last 5-6 years, revealed that life-long impact and accumulation of fluorides causes not only human skeletal and teeth damage, but also changes in the DNA-structure, paralysis of volition, cancer, etc.(Johnston and Heijnen, 2002). The essentially of fluoride for human health is still opposed by some people and no data indicate the minimum nutritional requirement of fluoride amounts. Besides, its toxicity has caused considerable concern in many countries where fluoride is found in excessive quantities in drinking water.

Dental fluorosis characterize by discolored, blackened, mottled or chalky-white teeth. These symptoms are connected with an overexposure to fluoride during childhood when teeth were developing. Fluorine intake above the safe limit for very long time or in very high amounts can lead to skeletal fluorosis, with severe and permanent bone and joint deformations (D'Alessandro, 2006). As Olsson (1979) reported that dental fluorosis in 99% of 239, 6-7-years-old children examined living in Wonji and Awassa the fluoride concentration was 12.4 and 3.5 mg/L, respectively (Olsson, 1979). A study conducted by Haimanot et al. (1987) found dental fluorosis in more than 80% of sampled children resident in the Rift Valley since birth 1,221 out of 1,456. The maximum prevalence saw in the 10-14-years-old age-group and 32% of the children showed severe dental mottling.

Males were affected more than females (Haimanot et al., 1987). Moreover, this dental fluorosis surveys carried out among elementary and high school students in two Rift Valley towns and it revealed that significantly lower rates among students born in non-endemic areas that had recently arrived from the highlands (Gilamichael, 1986; Abdo, 1978).

Thus, in Ethiopia a continuous assessment of fluoride in water sources is mandatory for informed decision making. Therefore, the purpose of this retrospective study is to examine the distribution of fluoride concentration in well water, spring water and Tap water samples of Ethiopia in water samples that was brought to the environmental health laboratory of EPHI between the years, 2003 - 2011 and to generate informative data set to the health and water sources managing authorities.

MATERIAL AND METHODS

Country Description

Ethiopia found in the Horn of Africa and located between 33° E and 48°E longitudes and 3°N and 15°N of the equator. Ethiopia is country with a great geographical variation. its topography ranging from 4550 meters above sea level to 110 meters below and bordered by five countries: on the north and northeast by Eritrea, on the east by Djibouti and Somalia, on the south by Kenya, and on the west and southwest by Sudan. Ethiopia is a Federal Democratic Republic composed of nine National Regional States: namely Tigray, Afar, Amhara, Oromia, Somali, Benshangul-Gumuz, Southern Nations Nationality and People Region (SNNPR), Gambella and Harari, plus two Administrative States (Addis Ababa and Dire Dawa City Administration). The national regional states as well as the two cities Administrative councils are further divided in eight hundred woredas and around 15,000 Kebeles (5,000 Urban and 10,000 Rural) (FDRE, 1995).

Sample Collection and Analysis

The retrospective study used 977 water samples data, which were tested in Environmental Public Health Chemistry Laboratory at Ethiopian Public Health Institute from a year 2003 to 2011. The data includes 548 samples from the well water, 191 from the spring water and the remaining 238 from tap water. The water samples were collected and submitted for analysis by Federal Ministry of Health, Regional, Zonal, and factory owners for the quality control purpose by using the plastic container. The fluoride concentration in the water sample were measured using the Colorimetric SPADNS Method, under acidic condition fluorides (HF) react with zirconium SPADNS solution and the lake (color of SPADNS reagent) gets bleaching due to formation of ZrF_6. Since bleaching is a function of fluoride ions, it is directly proportional to the concentration of fluoride. It obeys Beers law in a reverse manner and calculated as mg F^- /L present in the sample using standard curve, according to Standard Method of Water and Wastewater analysis (APHA, 1992). Hence, the concentrations of fluoride in the water samples were compared with WHO guideline value.

RESULT AND DISCUSSION

Fluoride concentration in the water sample that collects from different regions of the country varied from 0.0 mg/L to 40 mg/L. The concentration of the sample classified into five groups based on WHO guidelines for fluoride in drinking water (WHO, 1971).

Table 1: Fluoride concentration in **well** water collected from different regions of Ethiopia

Region	Total *No	Concentration of Fluoride (mg/L)											
		< 0.5		[0.5 - 1.5]		(1.5 – 4]		(4 - 10]		> 10		Mean Value	Max. Value
		*No	(%)	*No	(%)	*No	(%)	*No	(%)	*No	(%)		
Addis Ababa	96	60	62.5	26	27.1	9	9.4	1	1.0	-	-	0.64	9
Dire Dawa	8	2	25.0	6	75.0	-	-	-	-	-	-	0.47	0.7
Afar	68	10	14.7	12	17.6	27	39.7	9	13.2	4	5.9	3.22	16.25
Amhara	32	14	43.8	13	40.6	2	6.3	2	6.3	1	3.1	1.51	15.2
Benishangul Gumz	1	1	100	-	-	-	-	-	-	-	-	0.34	0.34
Somali	22	4	18.2	11	50.0	5	22.7	-	-	2	9.1	2.32	12.12
Harari	14	6	42.9	8	57.1	-	-	-	-	-	-	0.63	1.5
Oromia	269	69	25.7	71	26.4	59	21.9	50	18.6	26	9.7	3.55	40
SNNPR	21	4	19.0	5	23.8	3	14.3	6	28.6	3	14.3	4.9	24
Tigray	17	10	58.8	5	29.4	2	11.8	-	-	-	-	0.69	2.83

Where *No stands for Number of Sample

SNNPR- Southern Nation Nationality People Region

Table 2: Fluoride concentration in spring water collected from different regions of Ethiopia

Region	Total *No	Concentration of Fluoride (mg/L)											
		< 0.5		[0.5 - 1.5]		(1.5 – 4]		(4 - 10]		> 10		Mean Value	Max. Value
		*No	(%)	*No	(%)	*No	(%)	*No	(%)	*No	(%)		
Addis Ababa	9	6	66.7	1	11.1	2	22.2	-	-	-	-	0.99	3.53
Dire Dawa	1	1	100	-	-	-	-	-	-	-	-	0.36	0.36
Afar	4	-	-	1	25.0	2	50.0	1	25.0	-	-	3.24	8
Amhara	22	17	77.3	5	22.7	-	-	-	-	-	-	0.37	0.82
Benishangul Gumz	1	1	100	-	-	-	-	-	-	-	-	0.1	0.1
Somali	5	1	20.0	2	40.0	2	40.0	-	-	-	-	1.5	2.94
Harari	3	2	66.7	1	33.3	-	-	-	-	-	-	0.5	1.15
Oromia	83	23	27.7	48	57.8	8	9.6	3	3.6	1	1.2	1.19	14.2
SNNPR	27	16	59.3	4	14.8	2	7.4	3	11.1	2	7.4	2.19	13.25
Tigray	36	21	58.3	12	33.3	2	5.6	1	2.8	-	-	0.63	6.52

Where *No stands for Number of Sample

Table 3: Fluoride concentration in Tap water collected from different regions of Ethiopia

Region	Total *No	Concentration of Fluoride (mg/L)											
		< 0.5		[0.5 - 1.5]		(1.5 – 4]		(4 - 10]		> 10		Mean Value	Max. Value
		*No	(%)	*No	(%)	*No	(%)	*No	(%)	*No	(%)		
Addis Ababa	87	71	81.6	15	17.2	1	1.1	-	-	-	-	0.31	2.46
Dire Dawa	8	1	12.5	7	87.5	-	-	-	-	-	-	0.57	0.72
Afar	12	-	-	11	91.7	1	8.3	-	-	-	-	1.17	2
Amhara	3	-	-	3	100	-	-	-	-	-	-	0.66	0.93
Benishangul Gumz	2	1	50.0	1	50.0	-	-	-	-	-	-	0.34	0.7
Somali	-	-	-	-	-	-	-	-	-	-	-	-	-
Harari	4	1	25.0	2	50.0	1	25.0	-	-	-	-	1.27	3.49
Oromia	80	35	43.8	35	43.8	7	8.8	3	3.8	-	-	0.89	8.61
SNNPR	30	10	33.3	5	16.7	2	6.7	13	43.3	-	-	3.93	9.45
Tigray	12	8	66.7	3	25.0	1	8.3	-	-	-	-	0.55	2.38

Where *No indicates Number of Sample

Table 4: Fluoride concentration in well, Spring and Tap water collected from different regions of Ethiopia that exceeded the WHO guideline (1.5 mg/L)

Region	Well Total *No	> 1.5 mg/L		Spring Total *No	> 1.5 mg/L		Tap Total *No	> 1.5 mg/L	
		Well *No	(%)		Spring *No	(%)		Tap *No	(%)
Addis Ababa	96	10	10.4	9	2	22.2	87	1	1.1
Dire Dawa	8	-	-	1	-	-	8	-	-
Afar	68	46	67.6	4	3	75.0	12	1	8.3
Amhara	32	5	15.6	22	-	-	3	-	-
Benishangul Gumz	1	-	-	1	-	-	2	-	-
Somali	22	7	31.8	5	2	40.0	-	-	-
Harari	14	-	-	3	-	-	4	1	25.0
Oromia	269	129	48.0	83	12	14.5	80	10	12.5
SNNPR	21	12	57.1	27	7	25.9	30	15	50.0
Tigray	17	2	11.8	36	3	8.3	12	1	8.3

Where *No stands for Number of Sample
SNNPR- Southern Nation Nationality People Region

Table5: Fluoride concentrations that have 0.00 mg/L in their water source of the region of Ethiopia

Region	Zone, wereda or another village	Source of Sample	Fluoride Concentration (mg/L)
Addis Ababa	Bole Sub city, East Africa Boiling company, Kazanchis health center, and Yeka Sub-city (Ayat)	Tap	0.0
	Gulelle, Semen hotel, Aqua Addis and Bole	well	
Afar	Fentale-A and Fentale-B	well	
Amhara	Injibara	Spring	
Somali	Shinile-Adigala, Alisagenta	well	
Oromia	Kossed, Senkele	Spring	
	Ginchi, Ameya, Sembo, Addis Alem and Horogudru	Tap	
	Sululta, wolmera, Ambo mineral water factory and Geferssa	well	
SNNPR	Yem woreda- B	Spring	
	Yem special woreda-3	Tap	
	Yem Fofa- A	well	
Tigray	Mekele Hamlin Festula	Tap	
	Atsibi city, Mekele	Spring	

Table 6: Fluoride concentrations that have exceeded more from WHO guideline in their drinking water source

Region	Zone, wereda or another village	Source of Sample	Fluoride Concentration (mg/L)
Addis Ababa	Kotebe w2	well	3.35
	Yeka sub-city (Medeksu)	well	3.36
Afar	Hugub (Awash 7 kilo)	well	8.5
	Awash 7thCamp	well	7.25
	Segento	well	10.3
	Metehara Suger Factory	well	16.25
Amhara	Dalecha D. birhan	well	5.53
	Hara dembele	well	7.88
	Malima Biri	well	15.2
Somali	Afder, Bare town Kebele 01	well	12.12
	Afder, Bare	well	3.23
Oromia	Wonchi Gadam	Spring	7.75
	Arsi	Spring	8.5
	Wonji- xabel	Spring	14.2
	Gilgel gibe	Tap	5.5
	Salini gibe district	Tap	8.5
	Dugdaworeda Tejitu	Well	8.67
	Dodo woreda, Jerme bora, East Shoa and Abo no2	Well	10
	Gedema Kufa (Adama)	Well	26.25
	Dugda woreda Jido	Well	33.67
	Dugda woreda Urgi Mechefera	Well	36
	Meki Bole Elementary School	Well	40
SNNPR	Wondogenet	Spring	7.75
	Awassa Aw-1	Spring	11.25
	Hawassa Lake	Tap	9.45
	Hawassa (Doga)	Well	13.32
	Hawassa 01(HD1)	Well	24
Tigray	Atsgede Tsimbla	Spring	6.52

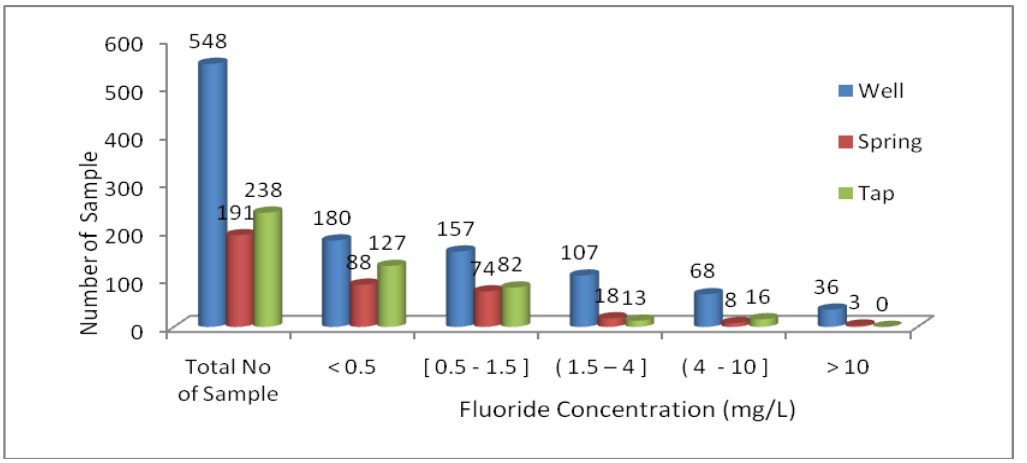

Figure 1: Number of Sample versus Fluoride Concentration at different level

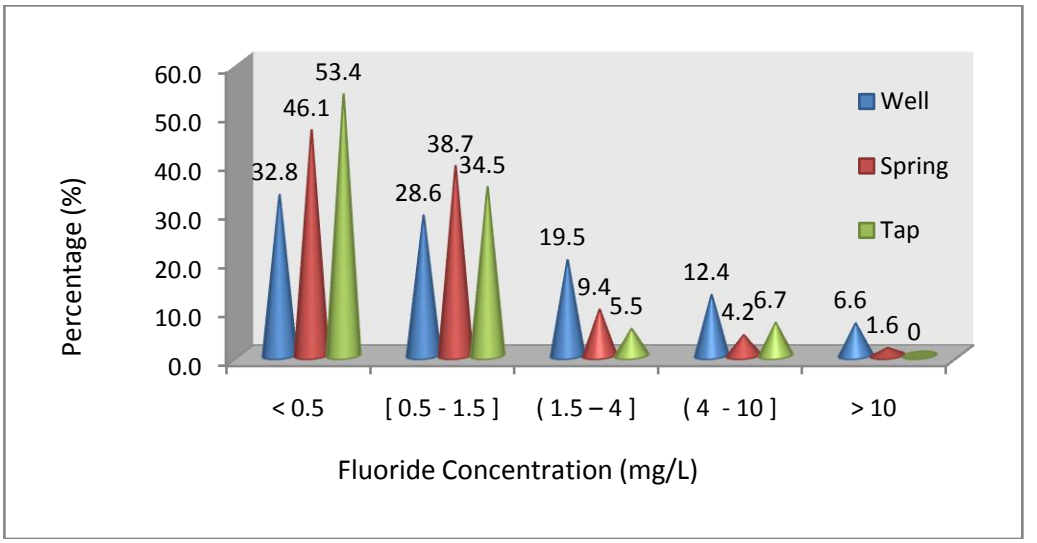

Figure 2: Percentage of samples versus Fluoride Concentration at different level

A fluoride concentration in drinking water in the low class indicates samples with no risk for human health. However, water samples higher than the maximum allowable fluoride concentration adversely affects the public health due to excessive consumption of fluoride. Generally in the country, 38.5 % (n = 211) of the well water samples, 15.18 % (n = 29) of the springs water samples and 12.18 % (n = 29) of the Tap water samples had fluoride concentration higher than the maximum allowable fluoride concentration (i.e. 1.5 mg/L) and 28.6 % (n = 107) of the well water samples, 38.7 % (n = 18) of the springs water samples and 34.5 % (n = 13) of the Tap water samples had fluoride concentration between 0.5 mg/L and the WHO recommendation guideline value (i.e. 1.5 mg/L). In addition to this 32.8 % (n = 180) of the well water samples, 46.1 % (n = 88) of the springs water samples and 53.4 % (n = 127) of the tap water samples are below 0.5 mg/L of fluoride concentration. The information is further broken down by Sample number and Percentage of fluoride concentration as indicated in Figure1 and Figure2.

In the country particularly in the Rift Valley of the region, fluoride problem is more acute. For instance, the well water sample in Afar region (3.22 mg/L), Somali region (2.32 mg/L), Oromia region (3.55 mg/L) and Southern Nation Nationality People Region (4.9) that had average fluoride concentration more than the WHO maximum allowable standard of fluoride (Table1). Moreover, as groundwater passes through the earth and comes into contact with fluoride containing minerals, fluoride is dissolved and enters the water. The deeper the water flows through the earth, the more fluoride-containing minerals it will come in contact with, and the greater fluoride concentration in the water will be. Several studies conducted in the Rift valley have shown that groundwater contains excess fluoride contents where it adversely affects the health of the surrounding community. Fluoride concentration higher than the WHO guideline value 1.5 mg/L causes dental fluorosis or mottling of teeth. Few studies of dental fluorosis prior to 1985 in Ethiopia reported high prevalence rates in several communities in the central part of the Rift Valley (Abdo, 1978; Olsson, 1979).

In the region of Afar (3.24 mg/L) and Southern Nation Nationality People Region (2.19) where the average fluoride concentration level are remarkably high in the spring water samples as indicated in Table2. In addition to this fluoride content analyzed in the Tap water sample in the regions had mean value of fluoride concentration less than the WHO maximum allowable standard of fluoride (1.5 mg/L) except the average fluoride concentration of Southern Nation Nationality People Region (3.93) as indicated in Table3. On the other hand, in the administrative city (Addis Ababa and Dire Dawa) and some regions of Ethiopia (Benishangule Gumuz, Harari, and Tigray) recorded fairly low average content of fluoride in all the well, spring and Tap water samples was below the WHO maximum allowable standard of fluoride (1.5 mg/L) as indicate in Table1, Table2 and Table3. People in several areas of the Ethiopian Rift Valley are consuming water with up to 33 mg/l of fluoride (Kloos & Haimanot, 1993). So it is required to implement appropriate water treatment procedures using local resources that are accessible to the rural community with technically simple, cost wise feasible and easily transferable technology.

In Amhara region, 32 well water, 22 spring water and 3 Tap water samples were analyzed. The average and maximum value of fluoride concentration detected were 1.51 and 15.2 mg/L; 0.37 and 0.82 mg/L; 0.66 and 0.93 mg/L for well water, Spring water and Tap water source samples respectively (Table1, Table2 and Table3). Water samples from 5 of those wells (15.6 %) had fluoride concentration above the WHO maximum allowable value of the fluoride concentration (Table 4).

Two hundred sixty nine well water, eighty three spring water and eighty Tap water samples were collected and analyzed from different part of Oromia region. The average and maximum value of fluoride concentration were 3.55 and 40 mg/L for well water, 1.19 and 14.2 mg/L for spring water, 0.89 and 8.61 mg/L for Tap water (Table1, Table2 and Table3). Fluoride concentration above the national standard value were detected in 48 % of the well water samples (n = 129), 14.5 % of the spring water samples (n = 12) and 12.5 % of the Tap water (n = 10) as indicated in Table 4.

Fluoride above the national standard was detected in some area of the Oromia region (Table 6). In wonchi Gadom, Arsi and Wonji-xabel samples from spring water, Dugda woreda Jido, Dugdaworeda Urgi mechefera and Meki bole elementary school from well water had fluoride concentration which exceeded 1.5 mg/L, two Tap water samples from Gilgel gibe district had also concentration of fluoride above the standard value. Several cases of fluorosis have been reported from this area. Concentrations of fluoride greater than the WHO guideline value of1.5 mg/l have been found in ground waters from several parts of Ethiopia, but are recognized to be highest in the Rift Valley zone (Kloos & Haimanot, 1993).

According to Rango, et al. (2012), in the Ziway–Shala basin in particular, wells had high fluoride levels (mean: 9.4 ±10.5 mg/L; range: 1.1 to 68 mg/L), with 48 of 50 exceeding the WHO drinking water guideline limit of 1.5 mg/L.

In Addis Ababa, 96 well water, 9 spring water and 87 Tap water samples were collected from all parts of the city. The average concentration fluoride in well water, spring water and Tap water samples were very low than national standard value (1.5 mg/L). The mean and maximum value of fluoride concentration detected were 0.64 and 9 mg/L; 0.99 and 3.53 mg/L; and 0.31 and 2.46 mg/L for well water, spring water and Tap water samples respectively as indicated in the Table1, Table2, and Table3.

Twenty one, eighteen and four water samples were analyzed from Harari, Dire Dawa, and Benshangul Gumuz regions respectively. The average and maximum value of fluoride concentration detected were lower than the WHO maximum allowable standard value except in Harari, which was about 3.49 mg/L in Tap water sample as indicated in Table1, Table2 and Table3.

The Tigray region, 17 well water, 36 spring water and 12 Tap water samples were analyzed. The average and maximum value of fluoride detected were 0.69 and 2.83 mg/L; 0.63 and 6.52 mg/L; and 0.55 and 2.38 mg/L for well water, spring water and Tap water samples respectively as depicted at Table1,Table2 and Table3. Three samples from the spring water (8.3 %); two from well water (11.8 %) and one Tap water sample (8.3 %) had fluoride concentration above the maximum allowed levels for drinking water (Table 4). Moderately high or unacceptable concentrations have also been found in ground waters from volcanic rocks in the highlands. Concentrations in ground waters from the ancient basement rocks are typically low for instance in Mekele area (Chernet and Eshete, 1982).

In Somalia region, fluoride levels 12.12 mg/L were also recorded in some parts of the region. More than 22 water samples were analyzed for fluoride content and the result depicted that about 31.8 % of well water and 40 % spring water samples had more than 1.5 mg/L of fluoride.

The number of well water, spring water and Tap water samples collected from different parts of the Afar regions were 68, 4 and 12 respectively. The average and maximum value of fluoride concentration in the samples were 3.22 and 16.25 mg/L for well water, 3.24 and 8 mg/L for spring water and 1.17 and 2.0 mg/L for Tap water samples (Table1, Table2 and Table3). Fluoride concentration above the national standard value were detected 67.6 % of the well water (n = 46), 75 % of the spring water (n = 3) and 8.3 % of the Tap water samples (n = 1) as indicated in Table 4.In Hugub (Aash 7 kilo), Awash 7th Camp and Segento had fluoride concentration which exceeded the WHO maximum allowable of fluoride standard (Table 6). The problematic fluoride concentrations were derived from hot springs (high temperature) and by weathering of the volcanic bedrocks (Ashley & Burley, 1994). Water sources with Fluoride content above 5.0mg/L in the Rift Valley were found mostly in hot spring (100% of all sources), lakes (78%), shallow wells (54%) and boreholes (35%) and the lowest concentrations less than 1.5 mg/L observed in springs and rivers (Kloos and Haimanot, 1999).

The Southern Nation Nationality People Region is another region where the fluoride problem is prevalent. Twenty-one well water, twenty-seven spring water and thirty Tap water samples were collected and analyzed. In this region, drinking water sources with fluoride contents exceeding 1.5 mg/L were recorded in 57.1 % (n = 12); 25.9 % (n = 7); and 50 % (n = 15) for well water, spring water and Tap water samples respectively as showed in Table 4. Both dental and skeletal fluorosis is prevalent in the Rift Valley region of Ethiopia because of high fluoride waters that originate from springs and boreholes.

CONCLUSION

The result of this retrospective study indicated that fluoride concentration in the water sample varied from 0.0 mg/L to 40 mg/L. Generally in water samples that was brought to the environmental health laboratory of EPHI in the year between 2003-2011, 38.5 % of the well water samples, 15.18 % of the spring water samples and 12.18 % of the taps water samples had fluoride concentration higher than the maximum allowable concentration (i.e. 1.5 mg/L) and 28.6 % of the well water samples, 38.7 % of the springs water samples and 34.5 % of the taps water samples had fluoride concentration between 0.5 mg/L and 1.5 mg/L. In addition fluoride concentration in 32.8 % of the well water samples, 46.1 % of the spring water samples and 53.4 % of the tap water samples are below 0.5 mg/L.

A concentration of fluoride below 0.5 was recorded in 70.27%, 50% and 55% of samples collected from Addis Ababa, Tigray and Amhara regional states respectively. Hence, more research is needed on the importance of fluoride and water fluoridation in the prevention of Dental Caries or Tooth decay for water sources with fluoride concentration of 0.0 mg/L or below 0.5 mg/L. However, water fluoridation is still opposed by some scholars; reasons for opposition include concerns about possible long-term harmful effects such as a high risk of Osteoporosis.

The concentration below 1.5mg/L carry an increasing risk of dental fluorosis, and higher concentrations lead to skeletal fluorosis especially to the Rift Valley area. Rift Valley areas of Afar, SNNPR and Oromia are characterized with a highest concentration of fluoride. It was also recognized that in areas with high natural fluoride levels, some of the treatment technologies might not be efficient bringing the allowable concentration. As a result, it is imperative to reconsider the climatic conditions and/or the volume of water intake, treatment options and intake of fluoride from other matrixes (e.g. from food and air), while formulating and enacting the guideline in Ethiopian context.

Moreover, based on the result obtained, the water sources need a sustainable remedial action in order to mitigate the effect of fluoride in human health. Therefore, the result of this retrospective study will use as a base to health authorities as well as other responsible body for the management of water supply regarding fluoride.

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