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Environmental distribution of fluoride in drinking waters of Kaltungo area, North-Eastern Nigeria

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Abstract: This study focus on the distribution of fluoride in natural drinking water sources in Kaltungo area North-Eastern Nigeria. Forty five water samples were analyzed to determine the concentration levels of fluoride using Atomic Absorption Spectrometer. The result revealed that fluoride ranges from 0.52 to 4.4 mg/L in surface waters and from 0.1 to 3.95 mg/L in ground waters, while in plant tissue the fluoride content ranges from 1.2 to 1.96 mg/L. The average value of fluoride is 2.8 mg/L in both surface and ground waters. This results indicates that inhabitants of Kaltungo area at high risk of high fluoride exposure. Ingestion of high fluoride water results in manifestation of dental fluorosis in some of the inhabitants.

Keywords: Fluoride, Ingestion, Fluorosis, Kaltungo, Nigeria

1. Introduction

Fluoride is the most electronegative of all chemical elements and is therefore never encountered in nature in the elemental form. It is seventeenth in the order of frequency of occurrence of the elements, and represents about 0.06 to 0.09% of the earth's crust (Kotra, 2013). Fluoride is a typical lithophile element under terrestrial conditions. The bulk of the element is found in the constituents of silicate rocks, where the complex fluorophosphates like apatite (Ca10 (PO4)6F2), seems to be one of the major fluoride minerals (Rutherford et al., 1995).

Fluoride is a naturally occurring chemical substance present in minor quantities in air, water, soil, plants, animals and humans. The main source of fluorine in groundwater is basically from mafic minerals which are concentrated in rocks. Robinson and Edington in 1964 reported the main sources of fluoride in ordinary soil consist of clay minerals. Fluoride rich minerals which are present in rocks and soils, when in contact with water of high alkalinity are released into groundwater by hydrolysis. The effect of fluoride could either be beneficial or harmful. Fluoride has dual significance. It helps in the normal mineralisation of bones and formation of dental enamel. Fluoride when consumed in inadequate quantities (less than 0.5ppm) causes health problems like dental caries, lack of formation of dental enamel and deficiency of mineralization of bones, especially among the children. On the contrary, when fluoride consumed in excess (more than 1.0ppm), it leads to several health complications observed in all ages (Vaish, 2002).

Being a cumulative bone seeking mineral, the resultant skeletal changes are progressive. Higher fluoride concentration exerts a negative effect on the course of metabolic processes and an individual may suffer from skeletal fluorosis, dental fluorosis, nonskeletal manifestation or a combination of the above (Wagner et al., 1993). The incidence and severity of fluorosis is related to the fluoride content in various components of environment, viz. air, soil and water. (Chen et al., 1994) stated that, out of these, groundwater is the major contributor to the problem. If dental caries is affected in the front row (Canines) of the teeth it becomes a cosmetic feeling to the individual as they expose while talking or smiling, which may cause Psychological effect like inferiority complex before others thus leading in decrease of self-esteem (Susheela, 1994).

2. The Study Area

The study area is defined by Latitudes 9°45' and 9°52' N and Longitudes 11°15' and 11°21' E which fall within Yola basin and situated in Gombe State, Nigeria (fig. 1). It is located in the Upper Benue Trough Nigeria and has been

described as part of a rift basin in central West Africa that extends NNE–SSW for about 800 km in length and 150 km in width. The southern limit is the northern boundary of the Niger Delta, while the northern limit is the southern boundary of the Chad Basin (fig. 2). The trough contains up to 6,000 m of Cretaceous – Tertiary sediments of which those predating the mid-Santonian have been compressionally folded, faulted, and uplifted in several places. Compressional folding during the mid-Santonian tectonic episode affected the whole of the Benue Trough and was quite intense, producing over 100 anticlines and synclines (Benkhelil, 1989). The study area consists of basement complex and partly cretaceous sediments that were deposited during the major transgressive episode in the Upper Benue Trough (fig.3). This transgressive episode caused the deposition of Yolde, Dukul, Jessu, Sekule and Numanha sedimentary Formations, all of which outcrop as inliers to Bima Formation in Dadiya syncline. These Formations are shallow marine depositions of limestone, shale and mudstone and they are found mainly as narrow strips of rocks in the study area, such as Banju, Guyuk, and Shellen. The Longuda Basalt of tertiary age terminates the lithological succession in the area. According to Ntekim and Orazulike (2004) that the present tectonic setting of the area is influenced by the late Cretaceous intense compressional earth movements dominated by series of long and narrow simple fold structures. The reactivation of the major basement faults is responsible for sinistral faults in Kaltungo, Teli-Wuyo and Gombe areas. Bassey (2006) identified the Chibok lineaments which align N50E to be similar to the trend of the Mapping of Water Quality Index Using GIS in Kaltungo. Coarse Porphyritic Granite, Biotite Granite, Bima Sandstone and Basalts represent the rocks of the Kaltungo area (fig. 4). Groundwater occurs in the weathered portion of the basement rock as well as fractures in the basement rocks.

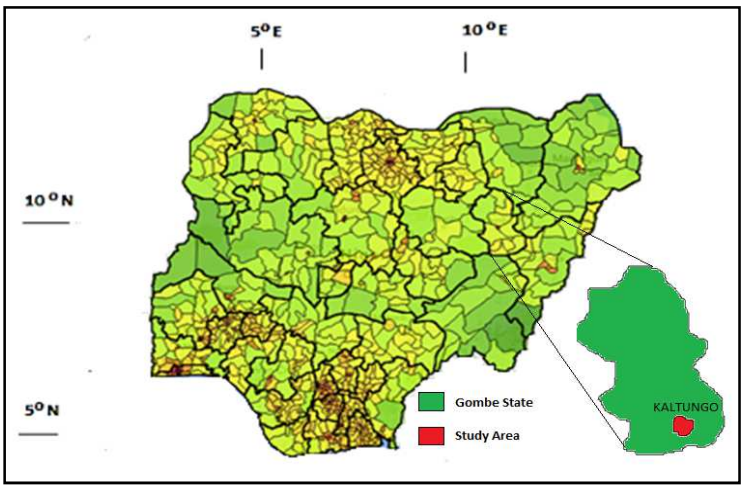

Figure 1. *Map of Nigeria showing the location map of the study area.*

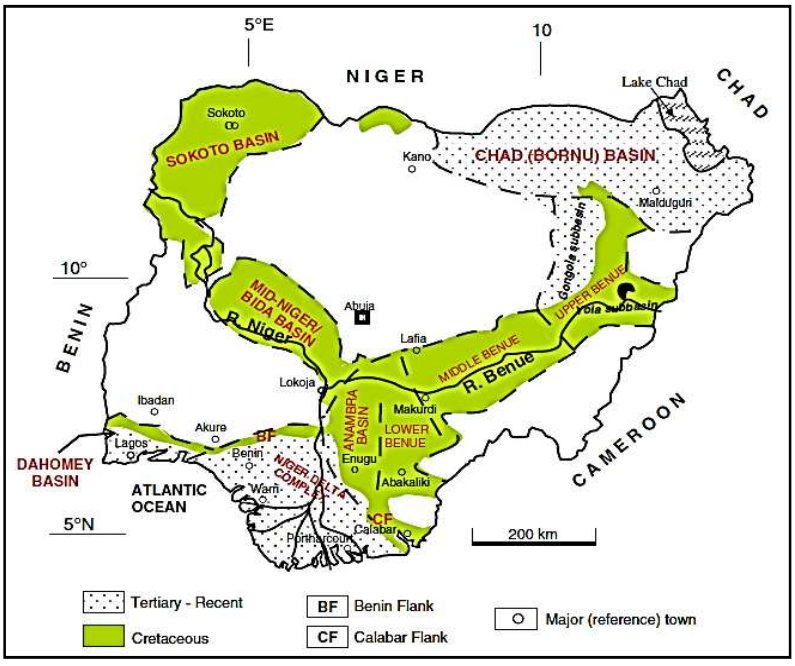

Figure 2. *Sedimentary Basins of Nigeria (after Obaje, 2009).*

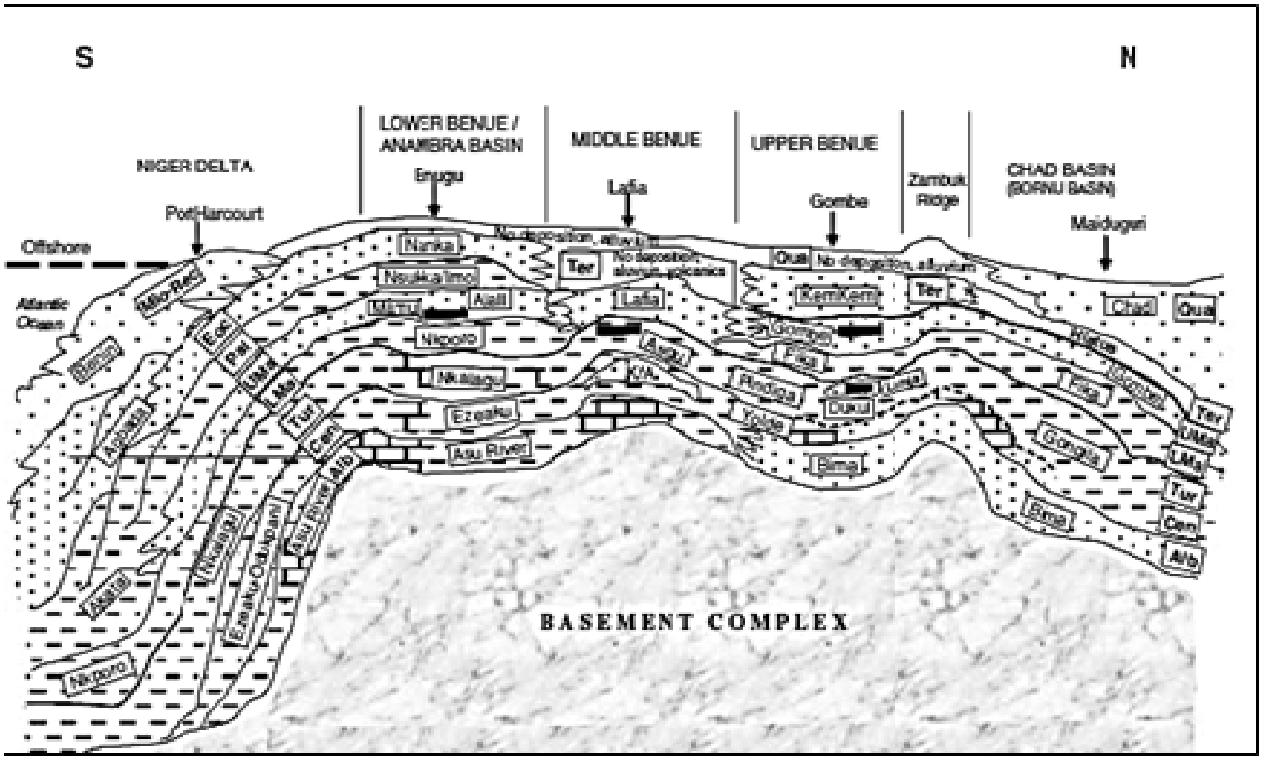

Figure 3. *North – South Stratigraphic cross section across the Benue trough and the relationship with the Niger Delta and Chad basin (after Obaje, 2009).*

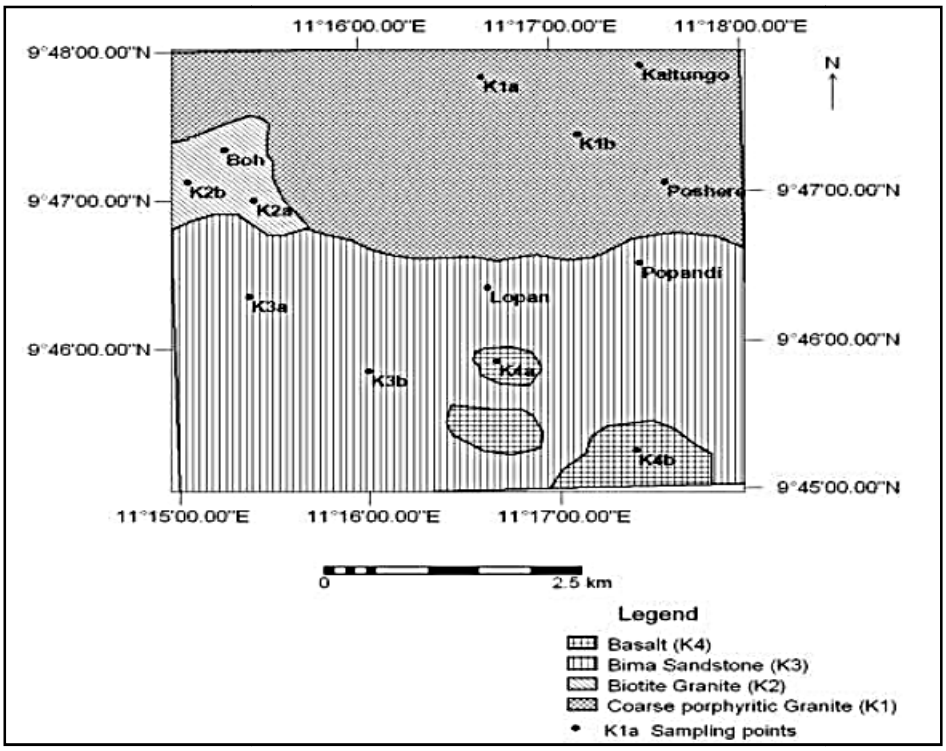

Figure 4. *The Geological map of the study area showing sampling location (after Adeyinka, 2013)*

Borehole lithologic sections revealed fracture aquifer which range from 12m to 24m. Boreholes in the area generally have average depth of 30m while hand-dug wells have depths ranging from 3m to 6m. The weathered and the bima sandstone serve as aquifers. (Gombe State Rural Water Supply, 2003).

3. Materials and Methods

3.1. Field Sampling

All the water samples were collected between 8th to 16th March, 2004 from boreholes, springs and hand dug wells

using standard sampling procedure and stored in low density polyethylene container after measurement for pH, conductivity, temperature and total dissolved solids. After these measurements, samples were acidified, brought to the laboratory and refrigerated prior to analysis. Plant samples mostly grass and African Fan Palm (Locally called Kanje) were obtained at stream channels. The analysis of the fluoride in plants and water samples was carried out using Atomic Absorption Spectrometer.

4. Results and Discussion

A total of forty (45) water samples were collected during this study and interpretation and analysis was carried out based on these data. The fluoride concentration from different water sources and plant tissues are presented in Table 1 and 2.

Range of fluoride concentration in surface water is from 0.52 to 4.4 mg/L. The lowest value of 0.52 mg/L was observed in Nasarawa while the highest concentration of 4.4 mg/L was detected Lapan. Fluoride concentration in groundwater samples from various locations ranges from 0.1 to 3.95 mg/L. Highest concentration of 3.95 mg/l was observed in Posherang and the lowest value of 0.1 mg/L in Popandi (Table 1).

Table 1. *Fluoride concentrations in Natural water*

Sample code	Locality	F (mg/l)
GW1	Popandi	2.78
GW2	Popandi	3.84
GW3	Popandi	0.1
GW4	Popandi	3.42
GW5	Posherang	3.72
GW6	Posherang	3.95
GW7	Posherang	3.7
GW8	Posherang	3.92
GW9	Kaleh	3.36
GW10	Okrah	3.64
GW11	Okrah	3.02
GW12	Okrah	3.74
GW13	Okrah	3.18
GW14	Lapandin Tai	2.68
GW15	Tarmana	2.68
GW16	Nasarawa	3.66
GW17	Posherang	1.7
GW18	Posherang	2.9
GW19	Posherang	1.6
GW20	Posherang	1.42
GW21	Posherang	1.86
GW22	Posherang	1.48
SW1	Posherang	2.68
SW2	Tarmana	2.3
SW3	Tarmana	3.7
SW4	Tarmana	2.7
SW5	Nasarawa	2.44
SW6	Nasarawa	2.88
SW7	Nasarawa	2.16
SW8	Nasarawa	3.46
SW9	Nasarawa	3.56
SW10	Nasarawa	0.52
SW11	Lapan	1.62
SW12	Lapan	2.84
SW13	Lapan	3.24
SW14	Lapan	3.22
SW15	Lapan	2.96
SW16	Lapan	3.56
SW17	Lapan	3.12
SW18	Lapan	2.82
SW19	Lapan	4.4
SW20	Lapan	3.42
SW21	Posherang	1.72
SW22	Posherang	1.28
SW23	Posherang	3.4

Plants samples collected at different stream channels displayed lowest concentration of 1.2 to 1.96 mg/L. The lowest concentration was observed in Popandi and highest in Lapan village (Table 2).

Table 2. *Fluoride Concentration in the plants*

Sample Code	Locality	F (mg/l)
P1	Popandi	1.2
P2	Popandi	1.83
P3	Popandi	1.55
P4	Popandi	1.55
P5	Posherang	1.42
P6	Posherang	1.53
P7	Posherang	1.29
P8	Posherang	1.89
P9	Posherang	1.65
P10	Okrah	1.47
P11	Okrah	1.62
P12	Okrah	1.71
P13	Okrah	1.4
P14	Lapandin	1.92
P15	Tarmana	1.49
P16	Lapan	1.96
P17	Lapan	1.83
P18	Lapan	1.2
P19	Lapan	1.55
P20	Posherang	1.63
P21	Posherang	1.87
P22	Posherang	1.75
P23	Posherang	1.56

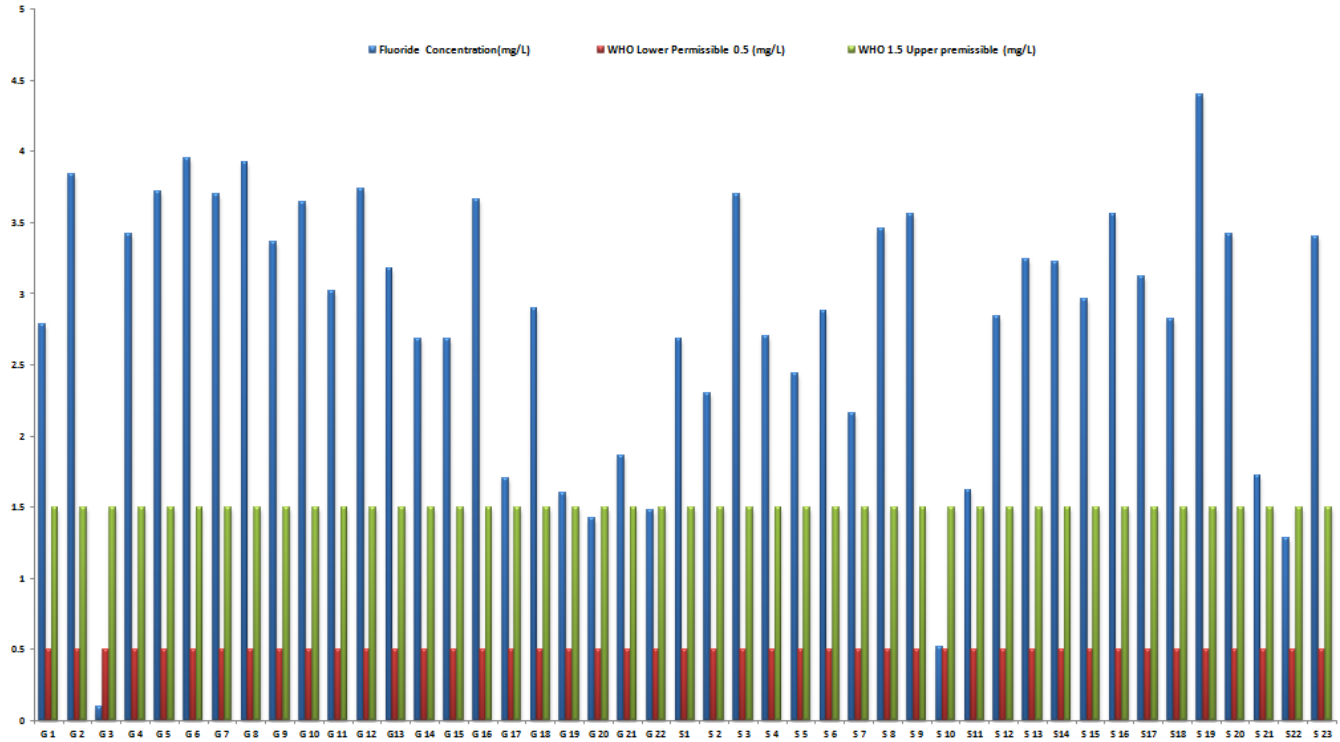

Figure 5. *Distribution of Fluoride in all water sources in Kaltungo Area*

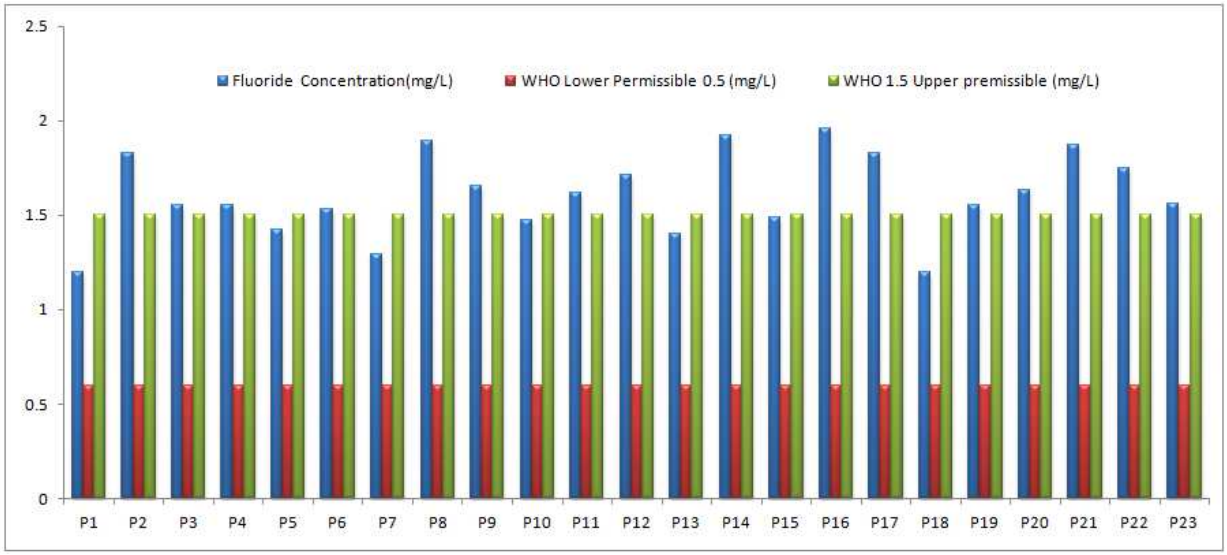

Figure 6. *Distribution of Fluoride in all sampled plant tissues in Kaltungo Area*

Concentrations of fluoride in water and plant samples are presented in (fig.5 and 6).

4.1. Health Effect of Fluoride in Kaltungo Area

In all the water sources collected only (5) 11% out of 45 water sources analysed for fluoride content falls below WHO lower permissible limit of 0.05 mg/L recommended for dental carries prevention. Consumption of water by the inhabitants from these sources may not be at risk of dental caries. 89% of the water sources have high concentration of fluoride above permissible level of 1.5 mg/L set by (WHO, 2004). Areas affected by fluoride concentration between 2.5-3.9 mg/L experience mottling of teeth. This shows that the inhabitants of Kaltungo Area are overexposed to fluoride toxicity due to ingestion of fluoride water.

5. Summary and Conclusion

The present study was carried out to understand the variation in the concentration of fluoride in Kaltungo Area.

This study revealed considerably high proportions of sampling points with F concentration greater than the permissible limits, especially in groundwater. Plants sample shows appreciable concentration of fluoride in their tissues indicating that they serve as pathway for fluoride exposure. The high exposure of fluoride through the ingestion of food and water will results in formation of various diseases such as dental fluorosis, mottling of teeth, cardiovascular disorder, gastro-intestinal disorder, endocrine effects, neurological, reproductive effects, developmental inhibition, genetic damages and effects on the pineal gland. Areas identified with high fluoride shows that the inhabitant of these areas shows symptoms of fluoride exposure.

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