Alarming Fluoride Concentrations of Water Samples from Boreholes in Bama Community and Remediation with Moringa oleifera

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ABSTRACT

This study was designed to examine the alarming fluoride concentrations of water from boreholes and remediation with Moringa oleifera. Water samples from three boreholes in Bama community of Borno State, Nigeria were analyzed for conductivity, total dissolved solids, hardness and fluoride concentration. Two seasonal samples were taken (dry season samples were taken in April and wet season samples were taken in September). All the samples reveal alarming levels of fluoride concentration in excess of 1.5 mg/l, the World Health Organization standard. It was recommended that the treatment of the water samples with Moringa Oleifera seed powder will adjust the fluoride concentrations to WHO acceptable levels.
Keywords: Fluoride, water standard, boreholes, Moringa oleifera

INTRODUCTION

Water is important to human life, and the quality of every drinking water needs continuous analysis. The three boreholes in this study have no records of such assessments and the residents of the immediate community have been using water from these boreholes without knowing it physical and chemical profiles. These boreholes date back to 1985 when they were constructed, and to the best of the knowledge of the authors, people in the various communities have since that time consumed water from the indicated boreholes. The boreholes are located in Bama, for a number of the Inhabitants; residence here may be for a lifetime. The effects of any contaminants in these boreholes may be cumulative. It is observed for instance, that those who were born in Bama and spent their entire childhood in the area up to the age of ten years usually have molted teeth (fluorosis).

Profiles of the fluoride (among other parameters) of such water bodies are therefore essential. Fluoride has a long biological half-life; its accumulation in hard tissues often exhibits a non-linear relationship with age (NAS, 1974; WHO, 1984a). In the body, fluoride is almost exclusively found in teeth and other bones, where it is incorporated into their structures along with calcium, phosphorus and other minerals. It has the overall effect of strengthening bones and helping teeth resist the decay caused by mouth bacteria. The study therefore, set out, to assess the number of physical and chemical parameters of three boreholes that serve three different communities of Bama.

MATERIALS AND METHODS

Sampling: Sampling was carried out in line with ASTM standard methods. The study was carried out in April and September 2009 to correspond to dry and wet sessions, respectively. Three boreholes that serve the three different communities of Bama were studied. The three communities are Senior Staff Quarters of College of Education (SSQ), Low Cost Housing Bama (LCH), and Borno State Agncultura1 Development Programme Quarters (BSP). Each of the boreholes serves, exclusively, each of the communities.

Instrumentation and Method: The standard procedure described by the United States Environmental Protection Agency (USEPA, 1991) was employed for the analysis. The instruments used were Conductivity meter and Spectrophotometer (DR/2000 model 1690001-01 91-1-91 Ed) from Hach Company USA. This report gives the results of the measured parameters (conductivity, total dissolved solids, hardness, and fluoride concentration) of the water samples.

Preparation of Moringa oleijera Seeds: The pods were split open to release the seeds, which were then sun-dried to constant weight. The seed coats and wings were carefully removed, manually, and the kernels were inspected. Only kernels, which were white or yellow, with no sign of softening, desiccation and discolouration, were selected for use. The seeds were then thoroughly pounded in a mortar with a pestle into an oily, yellowish powder.

Water Treatment with Moringa oleijera Powder: 0.5, 1, 2, 3 and 4 grammes of the powder were weighed, and were respectively added to 1 litre of each water sample in a container. The water mixture in each container was shaking to ensure proper mixing. The shaking was repeated after every hour for six hours; when 25 ml was filtered from each container separately and at other time intervals as indicated on table 4.

Determination of the Fluoride Content of the Treated Water: 25 ml of the treated water was taken in a sample cell and 5 ml of Spadn reagent was added. The cell was then placed in the spectrophotometer, after standardization with distilled water and the concentration of fluoride left in the sample recorded at 6 hours. The procedure was repeated after 40, 36, 48 and 60 hours, respectively for each of the treated water samples.

RESULTS AND DISCUSSION

The results reveal a number of increasing trends. As is evident from Figure 1, the fluoride levels in all three boreholes are above the World Health Organization's acceptable fluoride level in drinking water, and the level is highest in the borehole located at the senior staff quarters. The three other parameters that were measured (conductivity, total dissolved solids, and water hardness) fall within WHO acceptable levels for drinking water. The removal of fluoride from water is normally done through chemical treatments. Alum was one of the chemicals investigated for use in removing fluoride from drinking water (Larry, Joseph and Barron, 1982). Alum reacts with hydroxide ion in the aqueous medium to produce insoluble aluminum hydroxide, $Al(OH)_3$, according to the equation: $Al_2(SO_4)_3$.

$$14.3H_2O + 3Ca(HCO_3)_2 \rightarrow Al(OH)_3 + 3CaSO_4 + 14.3H_2O + 6CO_3$$

$Al_2(SO_4)_3$ compound is believed to adsorb fluoride ions from solution. The report by Larry, Joseph and Barron (1982) a1so claimed that bone char functions in fluoride ion removal by ion-exchange process in which the carbonate radical of the aspatite containing bone, $Ca(PO_4)_6.CaCO_3$, is replaced by fluoride ion to form an insoluble fluorapatite.

$$Ca(PO_4)_6.CaCO_3 + 2F^- \rightarrow Ca(PO_4)_6.CaF_2 + CO_3^{2-}$$

Studies conducted by Folkard, Mudi and Mawal (2000) showed that water treatment with *Moringa oleifera* seeds gave results which were similar to those obtained with commercial chemicals, like alum, in reducing turbidity. Since Moringa oleifera is a common plant in Bama, the authors considered expedient to treat the various water samples with the powdered seeds of *Moringa oleifera*. Bactohem Laboratories (2000) reported that Calcium, Copper, Iron, Potassium, Magnesium, Phosphorus, Sulphur and Selemum are present in pods, seeds and leaves of *Moringa oleifera*. These may exist as complexes, which may abstract the fluoride ion in water or the fluoride maybe adsorbed on surfaces of the compounds in the *Moringa oleifera* powder. The adsorbed particles coagulate and settle down as precipitate as was seen in the process of purification in this work.

The longer the time of reaction, the larger the precipitation and the higher the amount of fluoride removed from the water as can be seen on the Figure 3. The treatment of the samples with the powdered seeds of *Moringa oleifera* reduced fluoride concentration in the water samples with time and, also, as the amount of the powdered seeds increased. Both of these trends are shown in Figures 2 arid 3. It may be observed that the effectiveness of seeds of *Moringa oleifera* in mediating fluoride concentration improves with time. However, the decrease to WHO acceptable level is not achieved until after a certain weight of the powdered seed is applied to water samples and after a certain time period. Reduction of fluoride concentration to 1.5 mg/l (WHO acceptable level) or less was achieved only after the application of 4g of the powdered seeds to water sample had been left for 36 hours, or the treatment of the water sample with 2g of the powdered seeds had been left for at least 48 hours, as revealed by Figure 4.

Seed Powder: There seemed to be no noticeable alteration of the water samples after treatment with the powdered seed samples of *Moringa oleifera*, except for the observed increase in conductivity of the samples. For the weight range applied, the observed conductivities are within WHO acceptable conductivity level of drinking water. As shown in Figure 5, there is increase in conductivity with increase in the amount of the applied powdered seeds. This is expected since the *Moringa oleifera* powder is known to contain protein ions.

Although, there were no attempts in this study to monitor any changes in taste, there were no noticeable odours after treatment. According to Lu, Yen, Taurew and Ruwn (1985) the regular use of fluoridated toothpaste or mouth brush can decrease tooth decay in children by approximately 40%. However, extensive studies on fluoride ions also reveal that repeated exposture to excess fluoride ion can affect teeth (enamel damage - fluorosis, mottled areas and hypoplasia), bones (increased radio-density, thickening and periosteal growth), kidneys, reproductive system and blood. Mottled teeth may be unattractive but they are highly resistant to decay (Dean and Elvove, 1973; Singh, Jolly, Bansal and Mathur, 1961; WHO, 1984b; Boulton and Cooke, 1994; NAS, 1974). Apart from cosmetic concern, fluorosis appears to have no undesirable effect (Judith, 1990).

Fluorosis is a common occurrence in Barna, and the suspicion of the authors is that the common occurrence may not be unconnected with the source of drinking water. In young animals, a much higher proportion of fluoride intake from the diet is retained in bones and teeth than in the case of older individuals. It has also been revealed that fluoride accumulation in the teeth of rat was comparatively rapid in juveniles, but was considerably diminished in mature animals. This appears to be consistent with the observation of the authors in Bama where more of the youths suffer from fluorosis (Zipkin and McClure, 1952).

CONCLUSION

Boreholes are an important source of drinking water to a number of communities in developing countries, and this is particularly true for rural areas. The quality assessment of the three boreholes in this study reveals that the fluoride concentrations in these water bodies are higher than the World

Health Organization standard value of 1.5 mg/l. The observed incidence of fluorosis experienced by the children born and brought up in Bama may not be unconnected with the repeated drinking of water from the boreholes mentioned in this study. The treatment of water from these boreholes with de-fatted Moringa oleifera seed powder sufficiently removes fluoride in the water samples to bring the fluoride level to acceptable WHO standard. It should, however, be mentioned that such treatments also reveal increase in the conductivity of the treated water samples.

Table 1: Means of the Concentrations of Parameters for April Samples compared with WHO Standard

Parameter	SSQ	LCH	BSP	WHO standard
Conductivity	950.942±0.4811	200.78±0.6274	320.96±0.5004	1000
Fluoride - F-(mg/l)	2.732 ± 0.432	2.210 ± 0.137	2.401± 0.024	1.5
TDS (mg/l)	475.72±0.4534	100.84±0.6741	160.88±0.2482	1500
Hardness (mg/l)	85.288±0.1039	63.58±0.415	79.05±0.0075	500

Source: Fieldwork, 2009

Table 2: Means of the Concentrations of Parameters for September Samples Compared with WHO Standard

Parameter	SSQ	LCH	BSP	WHO standard
Conductivity	940.231 +2.473	187.234+3.234	311.130+2.327	1000
Fluoride - F-(mg/l)	2.632 ± 0.732	2.048 ± 0.827	2.153 ± 0.638	1.5
TDS (mg/l)	467.721+3.237	101.853+0.827	158.912+1.237	1500
Hardness (mg/l)	82.378+ 1.054	58.412+348	74.053+2.372	500

Source: Fieldwork, 2009

Table 3: Increasing conductivity with increasing amount of M. Oleifera Powder

Gramme wt. of M. Oleifera	Conductivity
$^1/_2$	944.453+0.023
I	944.972+ 1.427
2	955.734+0.728
3	972.104+ 1.342
4	980.342+2.002

Source: Fieldwork, 2009

Table 4: Amount of Fluoride Remaining at Various Times after the Addition of the Defatted M. Oleifera Powder

Gramme Weight of M. Oleifera	Time in hours				
	6	20	36	48	60
0.5	2.635	2.605	2.583	2.436	2.092
1.0	2.635	2.465	2.282	2.071	1.8728
2.0	2.574	2.032	1.847	1.472	1.187
3.0	2.341	1.995	1.588	1.253	1.063
4.0	2.245	1.915	1.473	1.131	0.941

Source: Fieldwork, 2009

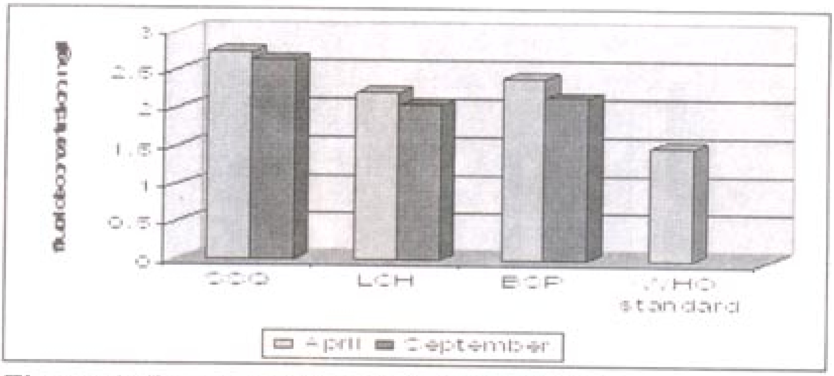

Figure 1: Borehole Fluoride Concentrations

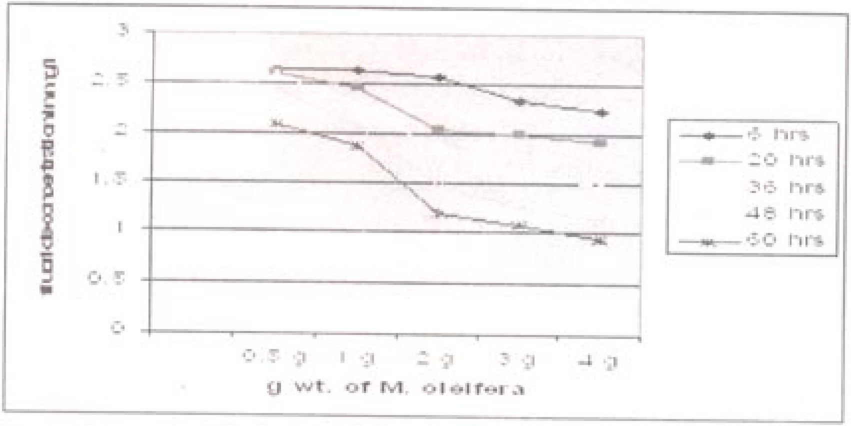

Fig 2: Drop in Fluoride Concentration with Increasing Weight of Moringa oleifera

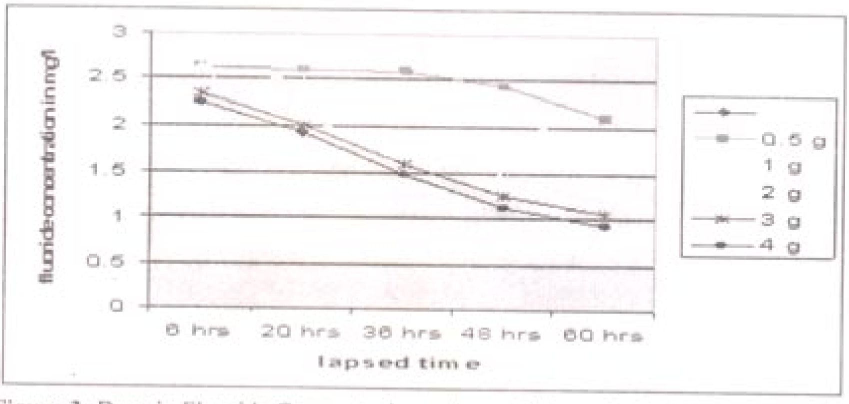

Figure 3: Drop in Fluoride Concentration vs Lapsed Time after Treatment with oleife

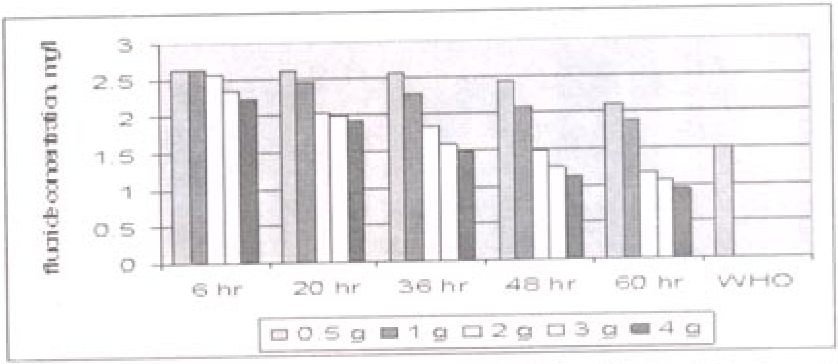

Figure 4: Fluoride Concentration after Treatment with Various Weights of Moringa oleifera

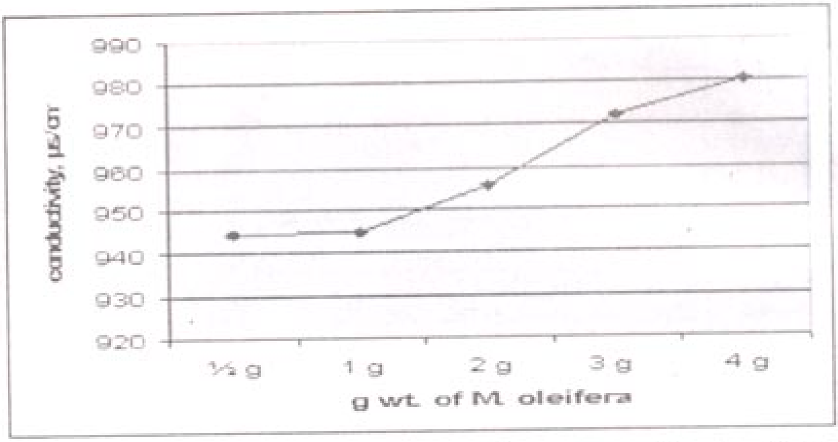

Figure 5: Increasing Conductivity with Increasing Amounts of Powdered Moringa oleifera Seeds

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