IMPACT AND IMPLICATION OF FLUORIDE IN DIFFERENT SOURCES OF DRINKING WATER

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Abstract
Fluoride is a chemical element that has shown to cause significant effects on human health through drinking water. Different forms of fluoride exposure are of importance and have shown to affect the body's fluoride content and thus increasing the risks of fluoride-prone diseases. Fluoride has beneficial effects on teeth at low concentration of 1mg/l by preventing and reducing the risk of tooth decay. Concentration lower than 0.5mg/l of fluoride had shown to intensify the risk of tooth decay. Analysis of well water, tap water, rain water and borehole water was carried out using colorimetric method to determine the amount of fluoride in the four different water samples in Muu Road, Offa Local government area of Kwara State, Nigeria. The problem observed was that some people living in the area were suffering from skeletal deformation and dental fluorosis. This necessitates the study of fluoride content in the four samples sources of water. From the result, well water has 0.6mg/l, tap water has 0.6mg/l, rain water has 0.5mg/l and borehole water has 0.6mg/l. It was discovered that the four different samples have a value of fluoride content lower than the safe limit value recommended by the World Health Organization standard for the amount of fluoride that should be present in a given portable water which is 1.0-1.5mg/l. Hence, people in the study area should analyze their drinking water and there should be public enlightenment to this regard.

***Keywords**: fluoride, concentration, colorimetric, fluorosis, deformation.*

INTRODUCTION
Fluoride is one of the very few chemicals that have been shown to cause significant effects in people through drinking water. Fluoride has beneficial effect on teeth at low concentrations in drinking water, but excessive exposure to fluoride in drinking water, or in combination with exposure to fluoride from other sources,

can give rise to a number of adverse effect. These range from mild dental fluorosis to crippling skeletal fluorosis as the level and period of exposure increase. Crippling skeletal fluorosis is a significant cause of morbidity in a number of regions of the world (Fawell et al, 2006).

Fluoride is known to occur at elevated concentrations in a number of parts of the world and in such circumstance can have, and often has, a significant adverse impact on public health and well-being (Fawell et al, 2006). There is now a continuing process of updating the Guideline for Drinking Water Quality (GDWQ). Through which it was concluded that there was a need for a monograph on fluoride in drinking water that would be useful to a wide range of individual, including health workers and sanitary engineers who may require a broad introduction to the subject, but would still provide more introduction and background information, and indicate where other more detailed information could be obtained. The primary focus of the monograph is the prevention of adverse effects from excessive levels of fluoride in drinking water.

Fluoride is a naturally occurring substance and is present in virtually all water, usually at very low levels. Higher concentrations of naturally occurring fluoride often are associated with well water, where fluoride has dissolved from the rock formations into the groundwater. (Fawell et al, 2006). Community water fluoridation began in 1945, after scientists discovered that higher natural levels of fluoride in a community water supply were associated with fewer dental caries (cavities) among the residents. However, there are also other sources of fluoride.

Processes such as desalination and some membrane and anion exchange water treatment processes will remove virtually all fluoride from water. In terms of using such sources for drinking water, the implications for public health will strongly depend on local circumstances. However, the public health requirement is to maximize the beneficial effects of fluoride in drinking water supplies for caries prevention, whilst minimizing the unwanted dental and potential general health effects.

Fluoride has been found to have a significant effect against dental caries. However, ingestion of Excess fluoride, most commonly through drinking water, can cause fluorosis that affects the teeth and bones (Lalumandier & Jones, 1999). Moderately large amounts lead to dental problems, but long-term ingestion of large amounts can lead to potentially severe skeletal problems. Health impacts from long-term use of high fluoride concentration in drinking water have been summarized as follows: less than 0.5 mg/L dental caries 0.5-1.5 mg/L promotes dental health 1.5-4 mg/L dental fluorosis. Greater than 4 mg/L dental, skeletal fluorosis. (NHMRC and ARMCANZ, 1996). A study by UNICEF shows that fluorosis is endemic in at least 27 countries across the globe (Qian et al, 1999). These countries are: Iraq, Turkey, Syria, Jordan, Palestine, Morocco, Algeria, Libya, Egypt, Senegal, United Arabia Emirate, Iran, Pakistan, Sri lanka, India, Uganda, Kenya, Tanzania, Ethiopia, Japan, China, Bangladesh, Thailand, Australia, New Zealand, Mexico, Argentina. Fluoride in water is mostly of geological origin.

RESEARCH MATERIALS AND METHODOLOGY

MATERIAL

Description of Sampling Site

Water samples were collected from four different locations in Muu Road, Offa local government area, Kwara state. Nigeria.The samples collected are as follows

Sample 1: Rain water from Muu Road Junction.
Sample 2: well water from Oladodo compound
Sample 3: Public Tap water beside Dagote house
Sample 4: Private Borehole water from Dagote house

Sample Collection

Well water sample was collected in the morning at about 7.30am into a plastic bottle of 75cl capacity. Rain water was collected directly from the atmosphere and sealed in air tight plastic bottles to prevent contamination. The private borehole and public tap water were allowed to rush for a minute in order to clean the rust from the mouth of the tap to prevent contamination.

METHODOLOGY

COLORIMETRIC METHOD FOR FLUORIDE DETERMINATION

In analytical chemistry much attention has been given to fluoride due to its importance and the difficulty in its accurate determination, which is indicated by the numerous reports on fluoride analysis. Experience has shown the superiority of colorimetric methods for the quantitative determination of fluoride. The reliability of the method is dependent upon the elimination of foreign substance. Therefore, it is recommended first to isolate fluoride by means of distillation, diffusion or ion-exchange. Until now it has not been possible without such purification to get accurate fluoride values in substance containing inorganic or organic compound.

Formation of Zirconium-Alizarin Lake and its bleaching by fluoride

Zirconium Colourless + Alizarin yellow

↓

Zirconium Alizarin Lake red

↓

Zirconium fluoride (ZrF_6) Colorless

A colorimetric procedure is proposed for the estimation of fluoride ions in µg range in aqueous samples. The method involves the use of a solid analytically reagent and exhibits an operational simplicity. The detection limit of 1 ppm in an aqueous sample is conveniently ions are initially removed in an ion exchange step, which also serves as a concentration step for fluoride present in low concentration.

Preparation of Standard Fluoride Solution

Apparatus

1. **100 ml volumetric flasks:** A volumetric flask (measuring flask or graduated flask) is a piece of laboratory glassware, a type of laboratory flask, calibrated to contain a precise volume at a particular temperature. Volumetric flask is used for precise dilution and preparation of standard solutions.

Reagent

I. **Alizarin Red:** Dissolve 0.75 g of Alizarin Red in 1000 ml of distilled water

II. **Standard Fluoride Solution:** Dissolve 1.949 g of NH4F in 1000 ml of water. Dilute 10 ml to 100 ml. This solution contains 100 mg/1 Fluoride.

From standard fluoride solution: 1.949g of NH4f was dissolved in 1000ml of water. 10 ml of this solution was diluted to 100ml with distilled water. The concentrations of this solution contain 100mg/l fluoride.

0, 2, 4, 6, 8 and 10ml aliquots of the standard solution the mark with distilled water. The new concentrations was calculated using dilution formular (i.e. $M_1V_1 = M_2V_2$) where M_1= concentration before dilution, M_2= concentration after dilution, V_1= volume before dilution and V_2= volume after dilution.

From dilution formular $m_1v_1= m_2v_2$.

For 0mg/l

$$m_2 = \frac{m_1v_1}{v_2} = 100 * \frac{0}{100} = omg/l$$

For 2mg/l

$$m_2 = \frac{m_1v_1}{v_2} = 100 * \frac{2}{100} = 2mg/l$$

For 4mg/l

$$m_2 = \frac{m_1v_1}{v_2} = 100 * \frac{4}{100} = 4mg/l$$

For 6mg/l

$$m_2 = \frac{m_1v_1}{v_2} = 100 * \frac{6}{100} = 6mg/l$$

For 8mg/l

$$m_2 = \frac{m_1v_1}{v_2} = 100 * \frac{8}{100} = 8mg/l$$

For 10mg/l

$$m_2 = \frac{m_1v_1}{v_2} = 100 * \frac{10}{100} = 10mg/l$$

The new concentrations are 0, 2, 4, 6, 8 and 10mg/l.

These concentrations were treated by the following steps

I Add 5ml of Alizarin Red reagent and then rapidly 5ml of Zirconyl choloride

II Mix for about 30 seconds and allow the samples to stand for 60 minutes

III Measure absorbance at 520nm.

Procedure for Sample Analysis

Apparatus:

Spectrophotometer: is an instrument used to determine the absorbance of a sample or solution.

Reagent:

I. Alizarin Red: Dissolve 0.75 g of Alizarin Red in 1000 ml of distilled water

II. **Zirconyl Acid Solution**: Dissolve 0.345g of Zirconyl Chloride in 800ml distilled water, then 33.3ml of conc. H_2SO_4 was slowly added and stirred, followed by the

a) 100ml of the water sample was measured into 1000ml volumetric flask.
b) 5ml of Alizarin Red reagent was added
c) 5ml of Zironly chloride was also added
d) The mixture was mixed for about 30 seconds and allowed to stand for 60 minutes
e) The absorbance was measured at 520nm using uv/visible spectrophotometer.

RESULTS AND DISCUSSION

Required Dosage of Fluoride Needed in Drinking Water

Health Canada has established a maximum acceptable concentration (MAC) of 1.5 milligrams per litre (mg/l) for fluoride in drinking water. This is the same value used in Manitoba as a standard for all public (municipal) drinking water supplies. The optimal level for fluoride in drinking water to prevent dental cavities is 0.7mg/L

Health Implications of Amount of Fluoride in Drinking Water

The health implications of fluoride depend on the duration and level of exposure. In low doses, fluoride is beneficial and can prevent the development of dental cavities. In children under the age of eight, ingestion of elevated amounts of fluoride can result in dental fluorosis. This condition causes white areas or brown stains on the teeth. This affects the appearance of the teeth but not their function. Over the age of eight, enamel formation is complete and dental fluorosis will not occur.

Level of fluoride in drinking water below 1.5 mg/l is unlikely to produce any significant dental fluorosis in children age 1 to 14 years of age from development moderate effects of fluorosis where some dental discoloring may occur. Standard levels are set considering all usual sources of exposure to fluoride, including diet.

In adults, high levels of fluorides consumed for every long period of time may lead to skeletal fluorosis. Skeletal fluorosis is a progressive disease, in which bones increase in density and become more brittle. In mild cases, the symptoms may include difficulty in moving. Deformed bones and a greater risk of bone fractures. Ingestion of very high doses of fluoride, (concentrations not normally found in drinking water), may result in acute poisoning effects.

Current science does not show a link between fluoride and cancer. This is based on scientific reviews conducted by a number of international agencies and by Health Canada which are in agreement that the weight of evidence from all currently available studies does not support a link between exposure to fluoride in drinking water and cancer.

Table 4.1: Effect of fluoride in water on Health

Fluoride concentration (mg/L)	**Effect**
< 1.5	Safe limit
1.5-3.0	Dental fluorisis (discoloration, mottling and pitting of teeth)
3.0-4.0	Stiffened and brittle bones and joints
4.0-6.0 and above	Deformities in knee and hip bones and finally paralysis making the person unable to walk or stand in straight posture, crippling fluorosis

Source: WHO 2006

IMPACT OF FLUORIDE IN HUMAN HEALTH

1. That water is safe and health at levels used for water fluoridation or naturally occurring fluoride in water in the range 0.7-1.2mg/l.
2. Community water fluoridation is safe and effective for preventing tooth decay. The balance of evidence suggests that rate of dental decay are lower in fluoridated than non-fluoridated communities.
3. Communities living in area with natural fluoride at 2 mg/l or greater put children 8 years old and younger at increased risk of severe enamel fluorosis. A condition that causes staining and putting of enamel surface of teeth.
4. Communities living in area where fluoride levels greater than 4 mg/l with a lifetime exposure to fluoride is likely to increase fracture rate in the population particular in some demographic subgroups that are prone to accumulate fluoride into their bones (e.g. people with renal diseases)(EPA recommendation 2006).
5. There is some evidence that water fluoridation reduces the inequalities in the dental health 3cross social classes in 5 and 12 years old using dmft/DMFT measure.

6. This effect was not seen in the proportion of caries free children among 5 years old (NHS study 2002)
7. There is no clear association between water fluoridation and incidence or mortality of bone cancer, thyroid cancer or all cancer found.

Results

Table 4.2 **Percentage amount of Fluoride in Well water, Tap water, Borehole water and Rain water**

No	Samples	Locations	Mg/l Fluoride	% of Fluoride	Min./Max. Value of Fluoride (WHO)
1	Rain water	Muu Road junction, Offa Kwara State.	0.5272	0.0005272	0.7-1.2 mg/l
2	Well water	Oladodo Compound Muu Road, Offa Kwara States.	0.5614	0.0005614	
3	Tap water	Beside Dagote House Muu road, Offa kwara state	0.5576	0.0005576	
4	Borehole water	Dagote House Muu Road, Offa Kwara State	0.5500	0.0005500	

The fluoride content of the water samples from well, borehole, rain and tap water were shown in table 4.2. Comparing the results obtained in table 4.2, well water had highest value of fluoride levels of 0.5614 mg/l which is lower than the minimum safe level specified by the world health organization and standard organization of Nigeria. On the other hand, borehole water has a fluoride level of 0.5500 mg/l, rain water has a fluoride level of 0.5272 mg/l and tab water has a fluoride level of 0.5576 mg/l which is below the specified minimum level.

CONCLUSION AND RECOMMENDATION

CONCLUSIONS

While establishing national standard for drinking water it is essential to put in mind the possible health risks associated with fluoride exposure. It can be seen that fluoride concentration at both lower and higher levels within the drinking water, may pose health risks to human. There is more of a threat however to the higher concentration due to the severity of the disease posed by such levels within the water.

In areas in which drinking water is fluoridated, fluoride level in drinking water generally ranges from 0.7 to 1.2 mg/L. In this study, it was established that the mean fluoride levels in the Muu Road drinking water was approximately 0.6mg/L except for Rain water that has fluoride level of 0.5mg/l which was below the stipulated standard. Therefore fluoridation is required in order to prevent dental carries especially among children in the area.

RECOMMENDATIONS

I hereby recommend that Adsorption method, ion exchange method, Precipitation method and Membrane separation (reverse osmosis) method should be used to improve the quality of this work for future purposes. Hence, compare all the methods to know the most suitable one.

The knowledge of parents, healthcare instructor in school, and student should be promoted concerning fluorosis prevention, the etiologic factor involved, its side effect, and its treatment.

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