FLUORIDE CONTENT OF COMMERCIALLY PACKAGED SACHET WATER IN IBARAPA LAND, SOUTHWEST, NIGERIA

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ABSTRACT

Background: **Fluoride concentration (F conc) in water is a major determinant for the occurrence of dental caries and dental fluorosis. In most homes of rural communities, especially in developing countries, there is a major reliance on sachet water as an alternate low-cost drinking water. This study aims to determine the fluoride concentrations of common commercially packaged sachet water in Ibarapa land, Southwestern, Nigeria.**

Methods: **An observational study was conducted using convenience sampling of all commercially packaged sachet water for drinking in Ibarapa land, Southwestern, Nigeria. Thirteen samples of sachet water were obtained from Ayete (2), Igboora (6) and Lanlate (5). F conc of the sachet water was determined in triplicate using the Fluoride Ion-Selective Electrode by direct analysis. Temperature and pH of water were also measured. Results were analysed using SPSS version 23.**

Results: **The F conc, temperature and pH range were 0.03 mgF/l - 2 mgF/l, 26.4^{O}C – 27.2^{O}C and 6.90 – 8.19 respectively. The minimum F conc in all samples was 0.03ppm at pH 6.90 while maximum was 2ppm at pH 7.78. F conc in 2 (15.4%), 8 (61.5%) and 3 (23.1%) water samples were 0.5-0.6 mgF/l, <0.5 mgF/l and >0.6 mgF/l respectively. No sachet water had fluoride levels printed on their labels.**

Conclusion: **F conc of the sachet water varied, with the majority of samples having low concentrations. Attention needs to be paid to both low levels and high levels of fluoride in drinking water to ensure safety and protective benefit.**

Keywords: Fluoride, Commercial, Sachet, Water, Nigeria

INTRODUCTION

The concentration of fluoride in water utilised for drinking and cooking is a major determinant for the burden of fluoride related disorders in individuals depending on their exposure rates.[1] Reduced concentration of fluoride in water is a cause for dental caries and increased concentrations cause dental fluorosis. When fluoride is ingested in high quantity, it affects bones, teeth and some other soft tissues in the body like the kidney and the brain.[2] One of the discoveries of the twentieth century was the actions of fluoride in the prevention of dental caries during the posteruptive phase and as topical applications, not just in children but also in adult demineralised teeth.[3] In teeth and bones, fluoride displaces hydroxyl ions from hydroxyapatite giving rise to fluoroapatite or fluorohydroxyapatite limiting demineralisation. Dental caries, an infectious, multifactorial disease has been associated with tooth pain, loss of school hours and tooth loss [4] while dental fluorosis has been associated with quality of life in individuals.[5,6] Until the advent of water fluoridation, the rate of tooth decay was high. However, this subsequently reduced with diverse fluoride applications along with public fluoridated water. Though, communities without water fluoridation continue to suffer the adverse effect of either too little or too high fluoride content of water. This is especially so in rural communities with major reliance on groundwater for drinking and cooking.

Commercially sold bottled water and sachet water are highly favored for drinking in both urban and the rural communities, as a means of achieving the Sustainable Development Goals for safe water. The people living in rural communities tend to drink more of water made in sachet bags because of its ease of accessibility and low cost of purchase.[7] In Nigeria, the sachet water is mainly referred to as 'Pure Water' for the fact that it is believed to be processed water fit for drinking and

are therefore in high demand, though its purity is in doubt.[8] Previous studies undertaken in Ibarapa communities reported high fluoride content of groundwater.[9,10] In these communities, water from deep wells and boreholes after undergoing some purification processes are used to produce sachet water which are then sold. Though regulation exist through National Agency for Food and Drug Administration and Control (NAFDAC Act 1993) and Standard Organisation of Nigeria (SON Act 2015), for citing of factories and infection control in safe handling and processing of sachet water in Nigeria[8], there has been no effort to regulate the fluoride content of commercially packaged water. It is therefore important to investigate the fluoride content of locally produced sachet water for policy formulation to ensure critical limits are considered and adhered to by producers especially in dental fluorosis endemic regions. Therefore, the aim of this study is to determine the fluoride concentration of all commercially produced sachet water in the three local government areas of Ibarapa (Ibarapa North, Central and East), Southwestern, Nigeria.

MATERIALS AND METHODS

An observational study was undertaken in October, 2021 at Ibarapa, a rural community comprising of three local government areas: Ibarapa North, Ibarapa Central and Ibarapa East. A convenience sampling of all commercially packaged sachet water used for drinking by inhabitants of these communities was done. Samples of all commercially packaged well-sealed sachet water found in Ayete, Igboora and Lanlate headquarters of the 3 LGAs respectively were purchased from shops and supermarkets in these communities. The samples were kept on bench in the Analytical Chemistry Laboratory, Department of Chemistry, University of Ibadan, Nigeria. Fluoride concentrations of the sachet water were determined in triplicates using the Fluoride Ion-Selective Electrode (Thermo Scientific Orion 9609BNWP, Orion Research, USA) and meter (Thermo Scientific Orion Star A214 Benchtop pH/ISE Meter, Orion Research USA) by direct method after addition of TISAB II or low level TISAB as the stabilizer.[11] (Low-level TISAB was used in samples with F conc <0.4 mgF/l while TISAB II was used in samples between F conc >0.4 mgF/l and d+10 mgF/l). Twenty milllitres of TISAB II (or Low Level TISAB) were added to every 20mls of sampled water to keep the dilution ratio of TISAB II solution consistent for samples <10mgF/l. The validity and accuracy of the fluoride analysis by direct method was estimated by re-analysis of 8% of water samples. The temperature d pH of water was also measured using Automatic Temperature Control (ATC) Stainless Steel Probe and pH/ISE meter respectively. Prior to the fluoride analysis, standard buffers of 4, 7 and 10 was used for the calibration of the pH electrode.

Descriptive statistics such as proportions of relevant variables was undertaken to describe the trends in the different brands of sachet water. This present study did not involve directly or indirectly the participation of human subjects but it was undertaken in compliance with the ethical principles of the Declaration of Helsinki. Ethical Approval was sought from the Institution Ethical Review Board as a part of large-scale study on Groundwater and drinking water fluoride studies in Ibarapa, Southwest, Nigeria.

RESULTS

Thirteen samples of sachet water were found and bought from shops in the 3 locations (Table 1). The fluoride content ranged from 0.03 mgF/l to 2.00 mgF/

Table 1: Fluoride concentration, temperature and pH of sachet water by location

S/N	Name of sachet water	Location	Fluoride concentration (mgF/l)	Temperature (^{0}C)	pH
1	Mo	Igboora	0.30	26.60	7.82
2	Ib	Igboora	0.09	27.20	7.42
3	Tw	Igboora	0.10	27.10	7.27
4	Ol	Igboora	0.60	26.90	7.95
5	Ga	Igboora	0.50	26.40	7.78
6	Am	Igboora	0.70	26.40	8.19
7	Eb	Lanlate	0.04	27.00	7.33
8	(Sa	Lanlate	0.03	27.10	6.90
9	Iba	Lanlate	2.00	27.10	7.78
10	Mr	Lanlate	0.20	27.10	7.15
11	Do	Lanlate	0.08	27.00	7.43
12	Bo	Ayete	0.70	26.70	7.74
13	Il	Ayete	0.10	26.80	7.42

l and the mean (±SD) fluoride concentration was 0.42 (±0.54) mgF/l. The median (range) of temperature and pH records were 27.0^{0}C (26.4^{0}C to 27.2^{0}C) and 7.43 (6.90 to 8.19), respectively. The minimum fluoride concentration was 0.03 mgF/l at pH 6.90 while the highest was 2 mgF/l at pH 7.78. The lowest (0.03 mgF/l) and the highest (2 mgF/l) fluoride concentrations were gotten from water sachet water in Lanlate. Ten sachet water samples contained between 0.03 mgF/l – 0.6 mgF/l.

Figure 1 show that fluoride concentrations of 8 (61.5%) sachet water were low, 2 (15.4%) were normal and 3 (23.1%) were high. No sachet water had fluoride levels printed on their labels.

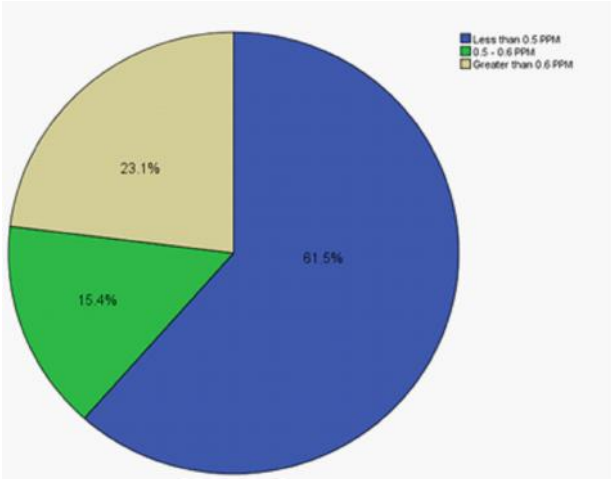

Figure 1: Distribution of fluoride concentrations in sachet water samples

DISCUSSION

Water is a major source of fluoride and is mainly consumed as a drink in bottles or sachets. The increased consumption of sachet water in a tropical country like Nigeria either as an alternative or as a supplement to the public water supply can affect the safety and effectiveness of fluoridation thus posing risk to human health. Sachet water is one of the sources of fluoride ingestion which is considered a health promotion strategy especially in terms of formation of hard dental tissues. Optimal levels of fluoride in water when ingested may result in dental caries prevention, if ingested sub optimally or at high levels may cause increased incidence in dental caries or dental fluorosis respectively. Therefore, assessment of fluoride concentration in drinking water is essential for an effective fluoride regimen for the prevention of dental caries in children. In this present study, the fluoride concentration varies widely from 0.03 mgF/l to 2.00 mgF/l as reported in similar studies on fluoride concentration in packaged water both in Nigeria[12,13,14], Saudi Arabia[15], Brazil[16] and in United Arab Emirate.[17] The wide variation in fluoride concentration in water in these different countries shows that fluoridation of municipal water is not well regulated. The wide variability of fluoride concentration in this present study is greater than 0.0131 – 0.1754 mgF/l[12], 0.10 mgF/L – 0.561 mgF/l[15] and 0.239 mgF/l – 0.271 mgF/l[14] reported in other previous Nigerian studies. The range of fluoride level of sachet water samples in this present study was higher than 0.00 – 0.37 mgF/l and 0.01 – 0.1 mgF/l obtained in packaged drinking water in Iran[16] and Australia[17] respectively. The upper limit of this range was lower than the upper limit of 4.8 mgF/l obtained in packaged drinking water in Greece[18] and 1103 mgF/l obtained in domestic water supply in Tanzania.[19] These differences in fluoride level of packaged drinking water might be due to differences in methods of fluoride analysis, geographical characteristics of the locations, sources of packaged water and seasonal fluctuations. The fluoride level of 3, 4 and 6 sachet water samples fell within results obtained in bottled drinking water in India, 0.27 – 0.59 mgF/l[20], Iraq 0.13 – 0.50 mgF/l[21] and Iran, 0.07 – 0.31 mgF/l[16] respectively.

Ten sachet water samples contained between 0.03 mgF/l – 0.6 mgF/l of fluoride which is below 0.7 – 1.2 mgF/l, the accepted standard for optimally fluoridated water.[22,23,24] This is also below 1.5 mgF/l, the Nigerian and WHO maximum permissible limits for fluoride.[22,25] Similarly, about half of the sachet water samples (53.9%) were found to contain between 0.03 and 0.2 mgF/l which is also less than the accepted standard for optimally fluoridated water. The dental health of a child who drinks sachet water containing low concentration of fluoride as the main source of drinking water might be affected as a result of receiving a sub-optimal level of fluoride. To ameliorate this situation, the American Academy of Pediatric Dentistry recommends that fluoride supplements should be considered for children drinking water containing less than 0.6 mgF/l.[26] The daily fluoride supplement dosage can be determined using the dietary fluoride supplementation schedule which takes into account the fluoride level in community water supplies, other dietary fluoride sources and the child's dental caries risk.[26] Excessive fluoride ingestion by infants and children and its attendant effect of dental fluorosis will not occur since the majority of the sachet water in this present study contain low fluoride concentration. According to the regulations on fluoride concentration in drinking water, for water to be considered optimally fluoridated, its fluoride concentration should be 0.70 mgF/l[27] or 0.5 – 1.5 mgF/l.[25] The minimum concentration at which the protective effect of fluoride

is achieved in drinking water was 0.5mgF/l.[28] For tropical countries like Nigeria with mean maximum ambient temperature higher than 27°C, the recommended concentration of fluoride in drinking water should be in the range of 0.6 to 0.7 mgF/l[9] due to large amount of water consumption in hot climate. Two of the sachet water samples contained 0.70 mgF/l, the recommended fluoride level by U.S. Department of Health and Human services (USPHS) which also falls within the accepted fluoride level for optimally fluoridated water areas. Four sachet water samples contained between 0.50 and 0.70 mgF/l which falls within 0.5 and 1.5 mgF/l, the recommended fluoride concentration by the WHO.

Standard Organization of Nigeria stipulates that labelling of products should cover their physical, organic and inorganic constituents[28] but there is no official regulation that requires water packaged into polyethylene bottles or sachets to add fluoride. However, if it is added it should be stated on their labels so as to inform consumers about fluoride levels in them. In this study, no sachet water had the fluoride levels printed on their labels as reported in previous studies in Nigeria[14] and India.[29]

The range of pH values obtained in this study (6.90 - 8.19) was in the range of the normal pH of water found in previous documented research in surface water (6.5-8.5) or groundwater (6-8.5) systems.[27,28] Neutral pH has been found to have no destructive effect on teeth (6.2-7.0) as dental erosion has been found to occur from 5.5 when ingested in drinks and juices.[30]

The range of temperatures from packaged water in this study was also within normal range 26.4^{0}C–27.2^{0}C for fluoride adsorption (25^{0}C±2^{0}C). While it has been shown in laboratory studies that increasing temperature of fluoride solution caused increased fluoride uptake by enamel from 25^{0}C-43^{0}C[31], another study had earlier reported increased absorption of fluoride with increase in room temperature.[32]

In view of the estimated differences in fluoride concentration in packaged water, it is important that dentists should identify the source of drinking water when prescribing fluoride therapy for children. They should also ensure that the quantity of packaged water consumed per day, fluoride intake from other sources and usage of packaged water in meal preparation, baby formula and infant food dilution are known when evaluating the effect of packaged water consumption on total fluoride intake.

This study was limited to the dental fluorosis endemic zone of Ibarapa land. More studies on fluoride concentration in packaged and groundwater in both urban and rural communities in Southwest Nigeria are needed.

CONCLUSION

Fluoride concentration of sachet water samples varied widely and the majority of them had fluoride concentrations much lower than the standard permissible values. Consumption of sachet water containing low amount of fluoride might result in less optimal fluoride ingestion in young individuals. Though, the protective benefit of fluoride at low levels are important, attention should be given to dangerous levels that can predispose to dental and skeletal fluorosis. No sachet water had the fluoride levels printed on their labels.

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