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Original Article

Analysis of Dental Fluorosis in Kaltungo

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Abstract

Dental fluorosis, also referred to as Colorado brown stain or mottled enamel is a condition resulting from excessive intake of fluoride during the developmental stages of teeth, usually between the ages of zero to eight. It is characterized by the appearance of white streaks, spots, or, in severe cases, brown stains and surface pitting on the enamel. This condition is often linked to the consumption of water with high fluoride levels. This research is aimed at measuring the fluoride levels in soil and groundwater sources and assessing the level of social damages of the fluorosis among the inhabitants. The study was conducted in Kaltungo Local Government Area, Gombe State, Nigeria. A total of 27 samples of soil, well water, and borehole water were collected. Results indicate that drinking water was identified as the major source of fluoride and that fluoride levels in hand-dug borehole and well water in places of Poshere, Kalargu, Ture, Kulishi, Lapan, Zing, Zango all have fluoride concentrations below 1.5 mg/L which is a recommended standard by WHO. However, Lampaditai has fluoride level of 3.19 a concentration higher than WHO recommendation. The severity of dental fluorosis may vary according to location and source.

Keywords: ***dental fluorosis, fluoride, groundwater, Kaltungo, soil.***

Introduction

Dental fluorosis is a condition resulting from the excessive intake of fluoride during the developmental stages of teeth, usually between the age of zero to eight (Bettren-Aguilar, Barker & Dye, 2010). It is characterized by the appearance of white streaks, spots, or, in severe cases, brown stains and surface pitting on the enamel. This condition is often linked to the consumption of water with high fluoride levels, which is a common issue in regions with naturally occurring fluoride in groundwater (Akpata, 2014 & Ada, 2021). While fluoride plays a crucial role in preventing dental caries, its excess can lead to fluorosis, raising concerns regarding public health, particularly in communities dependent on local water supplies with high fluoride concentrations (World Health Organization, 2006). The World Health Organization (WHO) guideline for permissible fluoride concentration in drinking water is set at 1.5 mg/L (WHO, 2011). Fluorosis is endemic in areas where the fluoride content in drinking water exceeds acceptable levels, particularly in arid and semi-arid zones where groundwater is the main source of drinking water (Fejerskov et al., 2015).

Kaltungo, a region in northeastern Nigeria, is primarily dependent on groundwater sources for drinking water, making it potentially susceptible to issues related to fluoride exposure. Studies conducted in various parts of Nigeria have revealed significant prevalence rates of dental fluorosis, especially in areas where fluoride concentrations in drinking water exceed the recommended limits set by the World Health Organization (Ozoh et al., 2017). According to Dabiri & Oyedeji (2018), the concentration of fluoride in Kaltungo water is high. Dental fluorosis in Kaltungo poses a significant public health challenge. A significant number of children experience tooth damage, affecting both the aesthetic appeal and functional integrity. This has led to a growing concern among health professionals and policymakers about the long-term effects of fluorosis on oral health and the need for preventive measures.

Various researchers have posited that apart from the physical discoloration of the physical teeth, dental fluorosis causes social damage such as stigmatization, low self-esteem, and painful enamel due to cavities especially in children and adolescents (see DenBesten & Li, 2011, & Thylstrup & fejerskov, 2019). Under severe conditions, individual with discoloration of teeth feels uncomfortable upon exposing out their teeth or smiling. This greatly affects their confidence and self-esteem (Hassebrauck, 1998, as cited in Molina-Frechero, et al., 2017).

Despite the numerous works done on dental fluorosis so far in Kaltungo, the menace is still prevalent among the people. Most of the research carried out in Kaltungo were based on water as the only source of fluoride, without considering soil and other contributory factors. Consequently, the concentration of fluoride in water and soil within the study area are studied to identify the major contributors to dental fluorosis in the area. This study seeks to contribute to the existing body of knowledge on dental fluorosis in Nigeria, providing data that can guide interventions such as the defluoridation of water supplies, public health education, and the promotion of alternative sources of safe drinking water.

Materials and Methods

Study Area

This study was conducted in Kaltungo Local Government Area, Gombe State, in the northeastern Nigeria, which has an area of 881 km² (881000000 sq m) and a population of 149,805 (see NPC, 2006 as cited in Media Nigeria, 2022). Its headquarters is in the town of Kaltungo in the west of the area at 90 48'51" N 110 18'32" E. The dominant tribe in Kaltungo is the Tangale, which account for a higher percentage of the population size. Other tribes include Waja, Hausa, and Fulani. Majority of local residents are farmers mostly subsistence farmers, while some engage in petty trading. The major sources of water in the town are hand dug well and bore hole. Economically, the majority of the community members are low-income earners who can only afford ordinary water (untreated), local foods, and locally made beverages. It hosts the Federal Polytechnic in Gombe state.

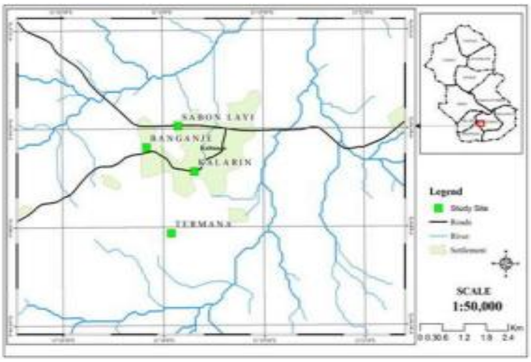

Figure 1: map of Kaltungo LGA showing the location of well and borehole water (green spots) (Gimba et al., 2015).

Sample collection

Samples for this research were collected from several locations within Kaltungo. They include Poshere, Kalargu, Ture, Kulishi, Lapan, Lampanditai. In addition, the data were also collected from certain places outside the study area in order to make comparisons using adequate statistical techniques. Some of these areas have similar problems based on previous researches carried out, the areas include Shongom Local Government Area of Gombe state, Zing Local Government of Taraba state, Maiduguri Municipal of Borno state, and Zango Local Government of Katsina.

In all areas of study, source of water is well and borehole. A total of 27 samples which includes soil, well, and borehole water sample for each of the area was collected. The soil samples were collected in a precleaned polytene leather while the water samples were collected in sterilize plastic bottles. All samples were collected and kept in a cooler with an ice block to maintain their freshness within 24hrs before transported to the laboratory for analysis. A GPS camera was used to get the coordinates of the locations where samples were taken.

Table 1: The table below shows the coordinates of the location of sample collected.

	Coordinates		
Location	**Well water**	**Borehole water**	**Soil sample**
Poshere	Lat N9^{o}47^{1}44.9628” Long E11^{o}18^{1}39.88872” Alt 526m a.s,l	Lat N9^{o}47^{1}44.9628” Long E11^{o}18^{1}39.88872” Alt 526m a.s,l	Lat N9^{o}47^{1}45.0078” Long E11^{o}18^{1}39.8322” Alt 526m a.s,l
Lapan	Lat Lat N9^{o}46^{1}49.69452” Long E11^{o}17^{1}1.08294” Alt 552m a.s,l	Lat Lat N9^{o}46^{1}49.07388” Long E11^{o}17^{1}9.7988” Alt 565m a.s,l	Lat Lat N9^{o}46^{1}48.83772” Long E11^{o}16^{1}59.81016” Alt 565m a.s,l
Boh	Lat N9^{o}46^{1}49.69452” Long E11^{o}17^{1}1.08294” Alt 552m a.s,l	Lat N9^{o}46^{1}48.6948” Long E11^{o}17^{1}1.08294” Alt 552m a.s,l	Lat N9^{o}46^{1}48.6948” Long E11^{o}17^{1}1.08294” Alt 552m a.s,l
Lapandi	Lat N9^{o}49^{1}39.26388” Long E11^{o}17^{1}44.41812” Alt 468 m a.s,l	Lat N9^{o}49^{1}33.94344” Long E11^{o}17^{1}41.77824” Alt 477 m a.s,l	Lat N9^{o}49^{1}34.25988” Long E11^{o}17^{1}41.568” Alt 477 m a.s,l
Ture	Lat N9^{o}51^{1}5.496” Long 11.283634 E 11^{0}21^{1}39.481” Alt 458 m a.s,l	Lat N9^{o}49^{1}15.87756” Long 11.283634 E11^{o}19^{1}9.5736” Alt 483 m a.s,l	Lat N9^{o}51^{1}6.858” Long 11.283634 E11^{o}2135.59” Alt 453 m a.s,l
Kalarogu	Lat N9^{o}49^{1}39.26388” Long E11^{o}17^{1}44.41812” Alt 468 m a.s,l	Long E11^{o}17^{1}41.77824” Alt 477 m a.s l	Long N9^{o}49^{1}38.65836” Long E11^{o}17^{1}44.83752” Alt 468 m a.s,l
Kulishi	Lat N9^{o}48^{1}24.58908” Long E11^{o}16^{1}19.48404” Alt 528 m a.s,l	Lat N9^{o}48^{1}30.23388” Long E11^{o}16^{1}24.64608” Alt 523 m a.s,l	Lat N9^{o}48^{1}25.1244” Long E11^{o}16^{1}19.80012” Alt 543 m a.s,l
Zango	Lat N12^{0}51^{1}56.81988” Long E8^{0}30^{1}58.635” Alt 451 m a.s,l	Lat N12^{0}51^{1}56.82024” Long E8^{0}30^{1}58.635” Alt 451 m a.s,l	Lat N12^{0}51^{1}56.77488” Long E8^{0}30^{1}58.7556” Alt 451 m a.s,l

Zing	Lat N8^{0}59^{1}19.35276” Long E11^{0}45^{1}50.2398” Alt 451 yd a.s,l	Lat N8^{0}59^{1}24.8658” Long E11^{0}45^{1}45.9558” Alt 568 yd a.s,l	Lat N8^{0}59^{1}28.04352” Long E11^{0}44^{1}56.77332” Alt 451 yd a.s,l
Maiduguri Municipal	Lat N11^{0}52^{1}55.71048” Long E13^{0}8^{1}16.00728” Alt 967 ft a.s.l	Lat N11^{0}52^{1}55.59024” Long E13^{0}8^{1}16.45008” Alt 966 ft a.s.l	Lat N11^{0}52^{1}55.542” Long E13^{0}8^{1}16.2474” Alt 996 ft a,s,l

The study population consist of all aged group under 18 to over 60 years, both educated and uneducated. This study also took care of both the inhabitants and visitors who reside in the area of study. A structured questionnaire was constructed with both close and open-ended questions and was issued to the target population. A total of over 100 questionnaires was issued and collected. A personal interview was also conducted for some people of old age to inquire information about the history of the menace in the area. Middle-aged and school children across the various wards and secondary schools were equally interviewed. The interview method also helps to collate information about the social damages in the area such as shyness, and stigmatization among others. It will also check the drinking habits, dental hygiene, and level of health awareness of the inhabitants. Here, the targets are mostly uneducated people and younger children who were born and raised within the communities. The interview was conducted on 12 individuals from kaltungo and shongom environs. This study was performed by a trained group composed of two examiners and one person who took care of the recordings of the results. Collection of samples took a minimum of 14 days, including sample collection, personal interviews, and distribution and collection of questionnaires.

Laboratory Analysis

Fluoride concentration was determined spectrophotometrically using Electrode, spectrophotometer CE7.400, Handheld Hanna meters for PH, conductivity, TDS, and salinity.

Analytical Technique

The data collected from various sources was analyzed using statistical tools. The statistical methods of analysis are Analysis of variance (ANOVA), Regression analysis, correlation, t-test and Post-hoc test i.e Turkey test was used to compare the means of the different locations.

Results and Discussion

Table 2: One sample t-test for mean response of Awareness of dental fluorosis

	Test Value = 0.5					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Awareness of Dental fluorosis	11.227	101	0.000 (5.5915×10^{-47})	.37255	.3067	.4384

Table 2 above indicates that the sample mean for Awareness of dental fluorosis is significantly different from 0.5. The p-value of 0.000 suggests strong evidence against the null hypothesis which states that there is no significant difference between the mean response (Yes = 1, No = 0) and some test value, indicating that participants' awareness is not equal to 50%, rather, it is significantly higher, and hence most of the inhabitants are aware of dental fluorosis.

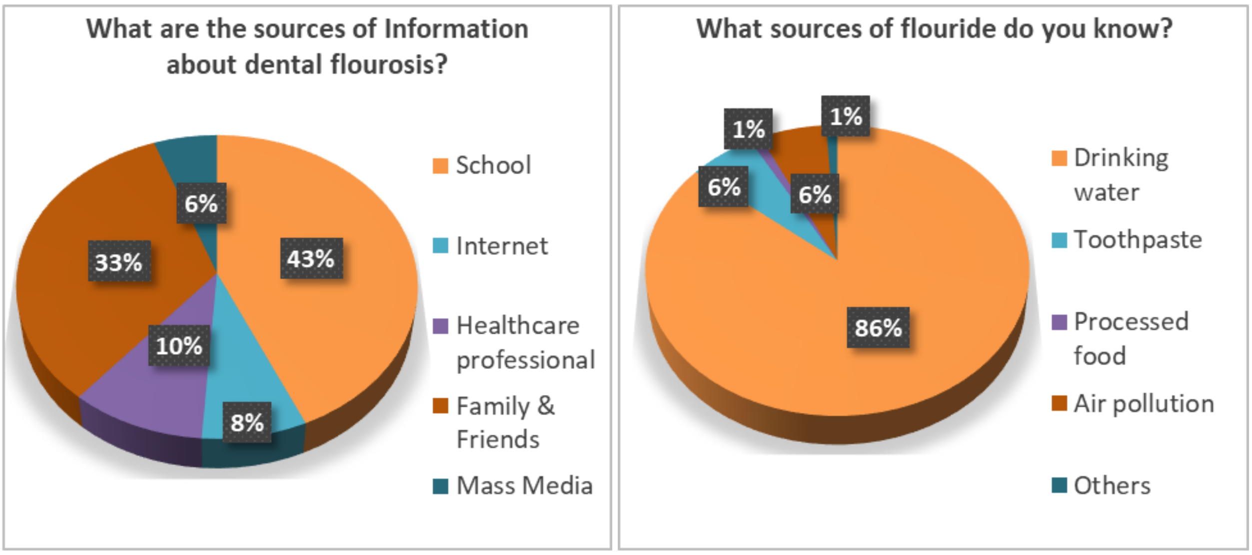

Fig. 2: Distribution of different means of awareness and sources of fluoride

The figure above presents the distribution of different means of awareness and perception among the inhabitants of the study area, it can be observed that school was the prominent source of information, followed by family & friends, and mass media has the lowest prominence. While the highly perceived source of fluoride is drinking water which accounts for more than 80%.

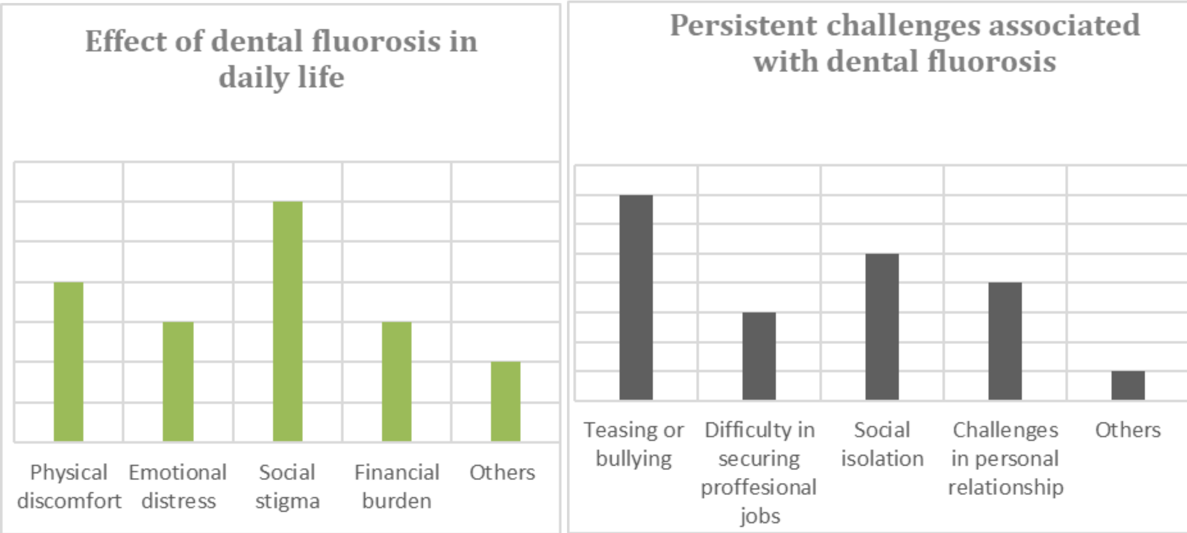

Figure 3: Effect and challenges of dental fluorosis

The charts above entail that social stigma is the most common personnel effect among the people with dental fluorosis disorder, this has persistently affected their self-confidence in public space such as shyness. However, physical discomfort is another significant effect their social lives, other reasons include time taken for medication and cultural perception. While Teasing and bullying is considered the major issue faced by the people suffering from dental fluorosis, although they also experience myriads of challenges that leads to social isolation.

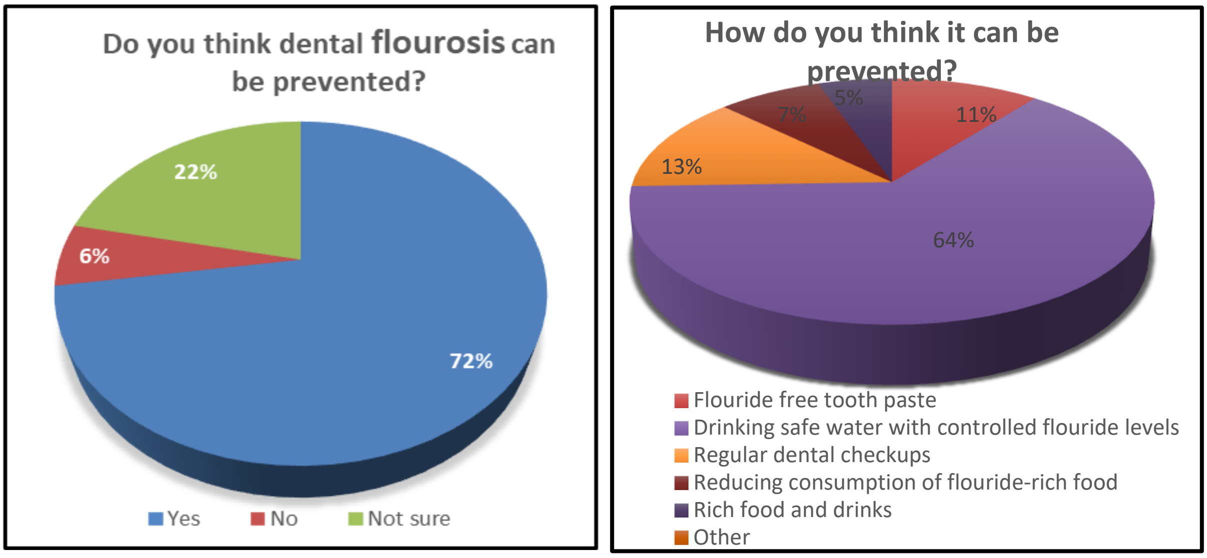

Figure 4: Prevention of dental fluorosis

The result on the charts in Figure 3 above demonstrate that most of the respondents agree that the disorder can be prevented leveraging on myriads of measures. However, the highly recommended measure is by drinking safe water with regulated concentration of fluoride which accounts for more than 60% of the responses recorded.

Table 3. Logistic regression of dental fluorosis awareness and causes

Call: glm(formula = y ~ x1 + x2, family = binomial, data = data)				
	Estimate	**Std. Error**	**z value**	**Pr(>|z|)**
Intercept	0.2796	0.5482	0.510	0.61011
x1	1.8722	0.6597	2.838	0.00454 **
x2	1.0555	0.8270	1.276	0.20182
Significance. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
(Dispersion parameter for binomial family taken to be 1) Null deviance: 77.828 on 101 degrees of freedom				
Residual deviance: 67.785 on 99 degrees of freedom				
AIC: 73.785 Number of Fisher Scoring iterations: 5				

According to the result of the logistic regression above, at 95% confidence interval, awareness of the primary cause of fluorosis (x1) is a strong and significant predictor of Knowledge about dental fluorosis. However, awareness of treatments (x2), does not significantly contribute to predicting whether someone has Knowledge about the condition (y). This regression analysis provides insights into the key factors influencing public awareness of dental fluorosis and can help in advocating educational campaigns against the disorder.

Personal interview

Correlations

Table 4. Correlation analysis of different variables from the personal interview data

		Severity	Visits Dentist	Awareness of Dental fluorosis	Age_ Category	Source of information	DF as health issue	Self conscious
Severity of dental fluorosis	Pearson Correlation	1	-.577	-.184	-.361	-.202	-.361	-.447
	Sig. (2-tailed)		.081	.611	.305	.631	.305	.196
	N	10	10	10	10	8	10	10
Visits to Dentist	Pearson Correlation	-.577	1	.070	.559	.366	.319	.349
	Sig. (2-tailed)	.081		.848	.093	.372	.368	.324
	N	10	10	10	10	8	10	10
Awareness about Dental fluorosis	Pearson Correlation	-.184	.070	1	.067	-.113	-.218	.048
	Sig. (2-tailed)	.611	.848		.512	.286	.545	.896
	N	10	10	102	99	91	10	10
Age Category	Pearson Correlation	-.361	.559	.067	1	.166	-.250	.055
	Sig. (2-tailed)	.305	.093	.512		.122	.486	.881
	N	10	10	99	99	88	10	10
Source of information	Pearson Correlation	-.202	.366	-.113	.166	1	-.189	.577
	Sig. (2-tailed)	.631	.372	.286	.122		.654	.134
	N	8	8	91	88	91	8	8
DF as health issue	Pearson Correlation	-.361	.319	-.218	-.250	-.189	1	.509
	Sig. (2-tailed)	.305	.368	.545	.486	.654		.133
	N	10	10	10	10	8	10	10
Self-conscious	Pearson Correlation	-.447	.349	.048	.055	.577	.509	1
	Sig. (2-tailed)	.196	.324	.896	.881	.134	.133	
	N	10	10	10	10	8	10	10

It can be deduced from the table above that severity of dental fluorosis has negative correlations with visits to the dentist, age, awareness, and self-consciousness, though none of these correlations are statistically significant.

The relationship between severity and being self-conscious is the strongest negative correlation (-0.447), suggesting that more severe cases might lead to increased self-consciousness, but this result lacks statistical significance. Awareness of dental fluorosis, age category, and source of information do not show strong or significant relationships with the severity of the condition.

Table 5: ANOVA test of water fluoride across different locations in Kaltungo

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Poshere	2	107.75	53.875	0.11045		
Kalarugu	2	144.63	72.315	1.86245		
Ture	2	253.97	126.985	4.06125		
Kulisa	2	63.95	31.975	0.61605		
Lampandi	2	294	147	0.1568		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	19075.68	4	4768.921	3502.953	0.0000000084092	5.192168
Within Groups	6.807	5	1.3614			
Total	19082.49	9				

The result of the analysis of variance in the table above indicates that there is enough evidence to conclude that there significant difference in the amount fluoride concentration tested across different boreholes in Kaltungo area.

Table 6: Post hoc test among the different locations

Kaltungo						
Tukey HSD[a]						
Locations	N	Subset for alpha = 0.05				
		1	2	3	4	5
Kulishi	2	31.9750				
Poshere	2		53.8750			

Kalarugu	2			72.3150		
Ture	2				126.9850	
Lampandi	2					147.0000
Sig.		1.000	1.000	1.000	1.000	1.000

The post-hoc test presents that there is statistically significant mean difference of fluoride concentration in the soil, across different locations, however, Kulishi has the lowest concentration while Lampandi has the highest. Hence, the locations with higher fluoride require further scrutiny in order to manage the soil for healthy agriculture practice that can help mitigate dental fluorosis.

Table 7: RCBD for the fluoride concentration of different locations

Tests of Between-Subjects Effects					
Dependent Variable: Water fluoride					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.475[a]	5	.095	7.496	.037
Intercept	1.119	1	1.119	88.347	.001
Locations	.442	4	.110	8.722	.030
Samples	.033	1	.033	2.592	.183
Error	.051	4	.013		
Total	1.644	10			
Corrected Total	.525	9			

Analysis of variance (RCBD) highlights that there evidence to conclude a significant blocking effect across different regions, hence location has a statistically significant effect on the fluoride concentration in water samples (p = 0.030), indicating that fluoride concentrations are relatively different across Kaltungo, Shongom, Zing Taraba, and Zango Katsina and Maiduguri Municipal.

Table 8: Post hoc test of the difference in fluoride across location

Water fluoride			
Tukey HSD[a,b]			
Locations	N	Subset	
		1	2
Taraba	2	.0850	
Katsina	2	.1400	
Maiduguri	2	.3650	.3650
Shongom	2	.4100	.4100
Kaltungo	2		.6724
Sig.		.179	.206

The post hoc test demonstrates that Taraba, Katsina, Maiduguri, and Shongom areas do not shows a significant difference among each pair. Likewise, Maiduguri, Shongom, and Kaltungo do not exihibit any significant difference.

Table 9: Analysis of variance of the sources of water

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Borehole water	9	2.69	0.298889	0.022061		
Well water	9	8.96	0.995556	0.762828		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.18405	1	2.18405	5.565246	0.031367	4.493998
Within Groups	6.279111	16	0.392444			
Total	8.463161	17				

From the table above, it can ascertained that there is enough evidence to conclude that there is a significant difference between the fluoride concentration of borehole water and well water across the locations. The F-statistic (5.57) is greater than the critical value (4.49), and the p-value (0.031) is less than 0.05, suggesting a statistically significant difference between the two water sources in terms of fluoride levels.

Table 10. Analysis of variance for soil samples

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	28110.784	9	3123.420	923.435	.000
Within Groups	33.824	10	3.382		
Total	28144.608	19			

Table 11: Post-hoc test for soil sample from different locations

Tukey HSD									
Category	N	Subset for alpha = 0.05							
		1	2	3	4	5	6	7	8
Katsina	2	27.9500							
Kulish	2	31.9750							
Poshere	2		53.8750						
Kalarugu	2			72.3150					
Maiduguri	2				82.5700				
Taraba	2				86.0850				
Kulishin	2					104.5150			
Lapan	2						114.4150		
Ture	2							126.9850	
Lapandi	2								147.0000
Significance level.		.515	1.000	1.000	.665	1.000	1.000	1.000	1.000

In Tables 10 and 11 above, the result of the ANOVA shows a significant difference in fluoride levels in the soil across the different locations. However, according to the post-hoc test, there is no significant difference in fluoride level of sand between Zango in Katsina and Kulishi in Kaltungo, Likewise Maiduguri Muncipal, and Zing in Taraba the fluoride level in sand. The Tukey's HSD test further highlights that Zango-Katsina and Kulishi-Kaltungo have the lowest fluoride concentrations, while Lapanditai has the highest. Other locations fall into different levels of fluoride concentration.

Discussion

Based on the findings of this study, a significant percentage of people in Kaltungo are aware of dental fluorosis, primarily due to education received in schools. This awareness is closely linked to factors such as education level and age, similar to the study by Siddiqui et al. (2024), which highlighted the influence of socio-demographic factors on awareness in Saudi Arabia. In the Kaltungo region, drinking water was identified as the major source of fluoride, aligning with the findings of Dehbandi, Moore, and Keshavarzi (2018), who identified drinking water as a primary source of fluoride, along with soil and rocks.

Social stigma, teasing, and bullying were found to be significant challenges faced by individuals suffering from dental fluorosis (DF), a point also noted by Mao and Wang (2021) in their study on the psychological and social effects of DF. The results of our study suggest that consuming fluoride-regulated water can be an effective preventive measure, with defluoridation as a recommended treatment method to meet the WHO standard pegged at 1.5 mg/L as the drinking water. However, techniques like the Nalgonda method and electrochemical methods have been explored in various studies, including a conceptual review by Ayob et al. (2006). In addition, Gandhi et al. (2012) demonstrated that inexpensive adsorbents can effectively remove fluoride from both drinking and wastewater in India. Recently, Jangid et al. (2024) reviewed several studies leverage the use of Nano-composites for fluoride ion removal from water. In another West African country close to Nigeria, Kazapoe et al. (2024) stated that techniques like Bone Charcoal and Contact Precipitation have shown promise for fluoride remediation in Ghana. Patrocínio et al. (2019) also emphasized the cost-effectiveness of Electro-Dialysis Reversal (EDR) for defluoridation in Brazil. Exploring similar techniques in Nigeria could help identify the most suitable method for both large bodies of water and smaller household volumes, mitigating the adverse effects of fluoride in affected areas such as Kaltungo, Zango, and some parts of Maiduguri Municipal.

Furthermore, statistical analyses including regression and correlation tests, were carried out to determine associations among various response and also the data from the spectrometric test, these statistical techniques align with the analyses used by Ogbudu (2021) in the study of dental fluorosis prevalence among children in Nigeria. The regression results in this study, suggest that respondents' knowledge of fluoride causes can be predicted based on their level of awareness, however, awareness of treatments did not yield statistically significant contribution in the analysis. Analysis of Variance (ANOVA) test in fluoride concentration indicates a significant difference between boreholes and wells as the two water sources, likewise across different locations in Kaltungo, this indicates that the severity of dental fluorosis may vary according to location and source. When comparing towns as blocks to determine the effect, a slight difference in fluoride levels cx was observed between Kaltungo, Zing-Taraba, and Zango-Katsina, which mirrors the findings of Gamarra et al. (2024) regarding regional variations in fluoride concentration in Mexico. Our results further indicates significant difference between in concentration of fluoride in soil samples collected from different locations thus, Lapanditai in Kaltungo has highest concentration, although soil is considered as a contributing source of fluoride. Soil releases more fluoride to groundwater than rocks through chemical weathering among others, hence contributes immensely to groundwater fluoride levels (Dehbandi et at., 2018).

Overall, the findings in the study are vital for the Kaltungo community, by providing both awareness and actionable solutions for mitigating dental fluorosis through education at various levels. Likewise presents various water treatment techniques, and the pose the need for community-level intervention.

Conclusions

Dental fluorosis has caused both aesthetic and psychosocial effects on Kaltungo. Areas with higher fluoride concentrations in soil such as Lapanditai and Lapan pose a greater risk for dental fluorosis due to the potential for groundwater contamination and other crops like the deep-rooted plants. Results also show that the fluoride level in hand-dug bore hole and well water in places of Poshere, Kalargu, Ture, Kulishi, Lapan, Zing, Zango all have fluoride concentration below 1.5 mg/L which is a recommended standard by WHO. However, Lampaditai has fluoride level of 3.19 a concentration higher than WHO recommendation. Analysis of Variance (ANOVA) test in fluoride concentration indicates a significant difference between borehole and well water sources, likewise across different locations in Kaltungo, which indicate that the severity of dental fluorosis may vary according to location and source. Social stigma, teasing, and bullying were found to be significant challenges faced by individuals suffering from dental fluorosis.

Ethics approval and consent to participate

This study was approved by the Institutional Based Research Committee (IBR) of federal polytechnic, Kaltungo

List of abbreviations

WHO: World Health Organization
UV: Ultraviolet
Vis: Visible
PH: Potential of hydrogen
TDS: Total Dissolved Solids
ANOVA: Analysis of Variance
SS: Sum of Squares
MS: Mean Squares
Df: Degrees of freedom
RCBD: Randomized Complete block design
DF: Dental fluorosis
EDR: Electro-Dialysis Reversal
TETFUND: Tertiary Education Trust Fund
IBR: Institutional Based Research

Data Availability

The datasets generated and analysed in the course of this study are available from the corresponding author upon reasonable request. You may contact Hassan Ibrahim Imafidor.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Authors' contributions

HI wrote the introduction as well as the summary, conclusion and compilation of the project. JW performed the methodology of the research and she was a major contributor to the sample collection process. YI performed the literature review of this study. He played a key role in the personal interview form of data collection aspect of the research. AS analysed and interpreted the data. He was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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