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Fluoride in Water Intake and Prevalence of Dental Fluorosis Stains among Children in Central Benin

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ABSTRACT

Dental fluorosis is caused by excessive uptake of fluoride, characterized by brown enamel mottling that starts with white spots, while bones and virtually every organ can be affected by well-known anti-thyroid characteristics of the flourine. The aim of our work, was to establish the relationship between the consumption of fluoride-rich water and the prevalence of dental fluorosis in school children aged between 6 and 12 years old in Djidja (Benin). ***Methods:*** *An investigation of fluorosis case-finding was conducted by a dentist and water points near the schools were collected to determine their fluoride concentration.* ***Results:*** *A prevalence of 20.53% (115 over 560 school children sample) were reported to have severe dental fluorosis, a. The fluorine content analysis of the water sample collected from the seven water points close to each school or residence in the target population revealed an average fluoride ion content of 2.20 mg/L in the drinking water of schoolchildren in the study area. The values vary from 1.51 mg/L to 3.02 mg/L and largely higher than the recommendations of WHO (0.7 mg/L to 1.2 mg/L). From this study, it should be remembered that fluorosis does not vary with sex. The highest frequencies are obtained with schoolchildren in the 8 to 11 age group, and fluorine water levels vary from place to place. These results are in fact consistent with the results of a good number of authors. In addition, body surfaces between 1501 and 1520 have the highest prevalence of dental fluorosis in our study population. It is therefore urgent to treat these waters in order to reverse the thorny public health problem of dental fluorosis.*

Keywords: Dental fluorosis, Prevalence, Water, Grade, Fluoride, School children

INTRODUCTION

Dental fluorosis, also known as mottled enamel, is a developmental disturbance of dental enamel, caused by successive exposure to high concentrations of fluoride during tooth development. It is a form of enamel hypoplasia leading to enamel with lower mineral content and increased porosity [1]. Thus, for example, nearly 12 million out of the 85 million tons of fluoride deposits on the Earth's crust are found in India resulting in as many as twenty states being affected by endemic fluorosis [2]. The same situation may be observed in most of the developing countries in Africa. In addition, this is a major public health problem rural population depends on groundwater for their domestic needs [2].

Fluorosis is a result of extended exposure to fluoride resulting in deficient formation and maturation due to metabolic alterations in the ameloblasts during the period of teeth formation. It is characterized by the presence of bilateral, diffuse, thin, and horizontal white striations and stained plaque areas. In the most severe cases, the enamel may become discolored and/or pitted. Histologically, the tissue presents hypomineralized subsurface areas confined to few micrometers from the external mineralized surface, which increases its porosity [3].

Various methods of therapy have been advocated for the treatment of fluorosis-stained teeth which range from invasive ceramic veneer bonding restorations to abrasive chemical treatments. However, the problem with invasive treatments is that most patients are young adults and the use of procedures in the form of prosthetic approach with veneers or crowns result in an excessive sacrifice of tooth material, thus accelerating the destruction of the tooth at an early age. Furthermore, the restorative approach is time consuming and expensive [4].

Although fluoride is widely promoted for the prevention of dental caries, its overconsumption in infancy may lead to dental fluorosis and other adverse effects [5,6]. Several health effects are associated with fluoride ingestion, ranging from nausea to neurotoxic effects to death [7,8]. According to the US Centers for Disease Control and Prevention recommend a careful monitoring and control of F intake levels in order to avoid overexposure [9]. The combination of dental bleaching techniques and micro-abrasion appears an excellent conservative solution to reestablish health in fluorosis-affected teeth and provide highly satisfactory results along with low cost [10]. But it will important to take into account the preventive precautions. So, considering the water problem in the central part of Benin particularly in the department of Zou/Collines, this study was conducted to investigate on one hand the prevalence dental fluorosis among students and the contend of the drinking water on fluoride.

MATERIAL AND METHODS

Study Area and Sampling

The present study was conducted in the commune of Djidja (7°20′40″ North, 1°56′00″ EST) in southern Benin (Figure 1). The study population was composed of children age from 6 to 13 years, born in the municipality and had lived there since birth. Thus, students from the 4 primary schools (Hanagbo, Dridji, Assegon and Akazounnongon) of the commune who agreed to participate, and who completed the questionnaire were included. Water samples were collected from 8 drilling point close to the investigated schools (Figure 1).

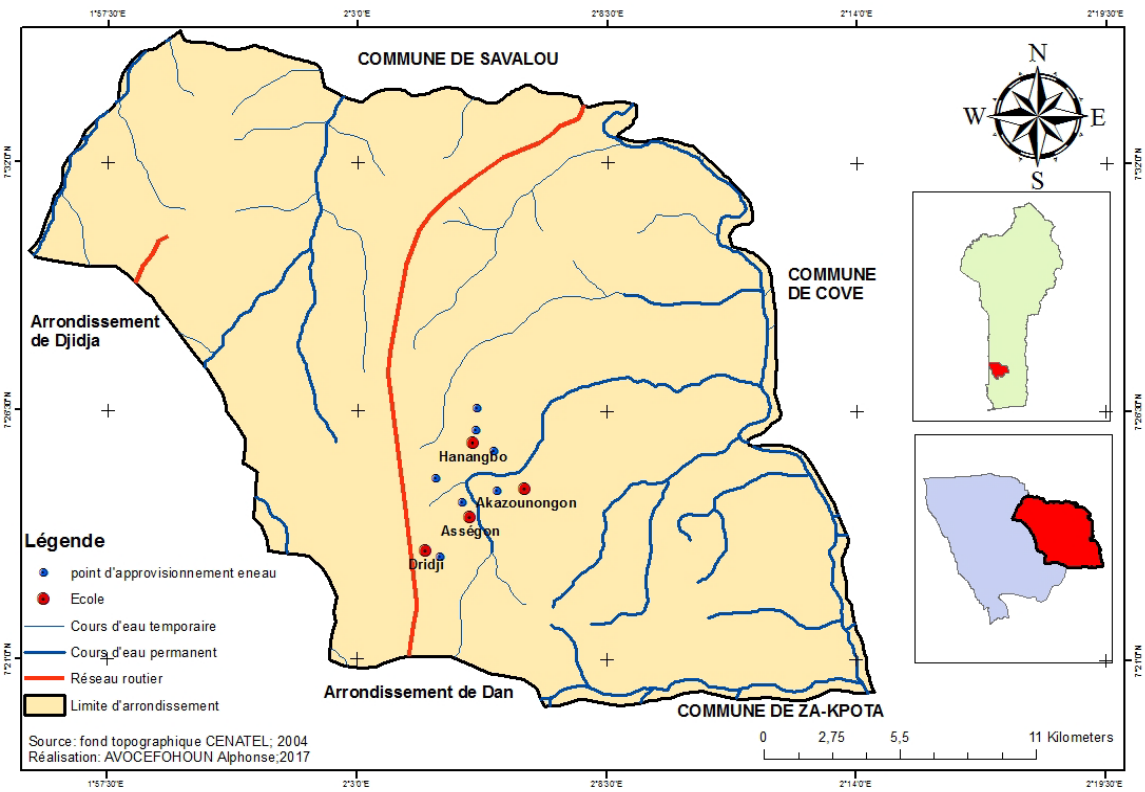

Figure 1 Map showing the study area

The school authorities and children's guardians were informed of the objectives of the study and the procedures to follow. A note was sent to the children's parents requesting permission for their children to participate in the study. We excluded children with fixed orthodontics, who presented a condition that would make the oral examination difficult, and also, children who were not present on the days of the study. A total of 560 children of the two genders were then enrolled in the present study (Table 1).

Table 1 Repartition of the samples collected according to the schools

Gender	Public Primary School				Total
	Hanagbo	Dridji	Assegon	Akazounnongon	
Male	132	114	43	31	320
Female	102	80	34	24	240
Total	234	194	77	55	560

Data Collection

Samples of drinking waters were collected in separate bottles and labelled, and carried to the laboratory for analysis. The fluorine content in the collected water was determined by fluoride ion selective electrode (Metrohm Co., Switzerland) method [11]. To 50 ml of the water to be analyzed was added 1 ml of 70% perchloric acid (ice-cold). The cap of a 1.5 ml polypropylene microcentrifuge tube was used as a boat containing 50 µl of 2.5 M NaOH and floated in the test tube. Hexamethyldisiloxane (HMDS) reagent (5%) was added to the sample in the tube, and the tube was capped tightly. After diffusion at room temperature (~25°C) for 20-24 hours, the contents of the boat containing the F trapped by the NaOH were transferred and rinsed with deionized water to another tube containing 50 µl of 2.5 M perchloric acid and then mixed with an equal volume of Total Ionic Strength Adjusting Buffer solution (TISAB II, JENEWAY, England). After calibration of the F^- ion selective electrode against an Ag/AgCl reference electrode with standards prepared with exact amounts of fluorine, the potentials of the samples were read directly. The determinations were repeated three times for each sample, and the final results presented as mean ± SD.

Diagnosis of Dental Fluorosis

International standards for controlling infection were used during the oral examination. The dental examination was performed during the day in natural light using a periodontal probe and mirror after prior removal of plaque via brushing or cleaning with toothpick. An experienced and trained examiner measured the index of dental fluorosis in the permanent dentition by applying the WHO criteria [12]. Ten percent of examinations were duplicated, and the resulting Kappa values were greater than 0.92. The diagnosis of fluorosis was determined using the modified Dean Index criteria [12-14] with a range of 0 (normal) and 1 (severe). Cases with a questionable, very mild, mild, and moderate index were incorporated into the normal category.

Statistical Analysis

Based on data from previous studies, a sample size calculation was performed using a proportional population model with an interval of 95% and an error of 7%. Of 263 initially approached students, 99% agreed to participate and provided informed consent, and 239 children completed the questionnaire to meet all of the inclusion criteria.

Measures of central tendency and dispersion were calculated for each variable. Frequencies and percentages were calculated for each categorical variable. Bivariate analysis was performed to evaluate the associations between the prevalence of dental fluorosis and the independent variables. The chi-squared test was used to evaluate associations between the prevalence of dental fluorosis and the independent variables. Finally, logistic regression analysis was performed to evaluate the possible association between dental fluorosis and risk factors.

RESULTS

Out of the 560 students, 115 showed appearance of dental fluorosis (Figure 2). Thus, about 20% of the investigated students displayed dental fluorosis.

Figure 2 Pictures of students with dental fluorosis

The appearance of the fluorosis was observed among the two sex populations. However, it was noticed that the distribution of those students varies according to the sex from a school to another (Figure 3).

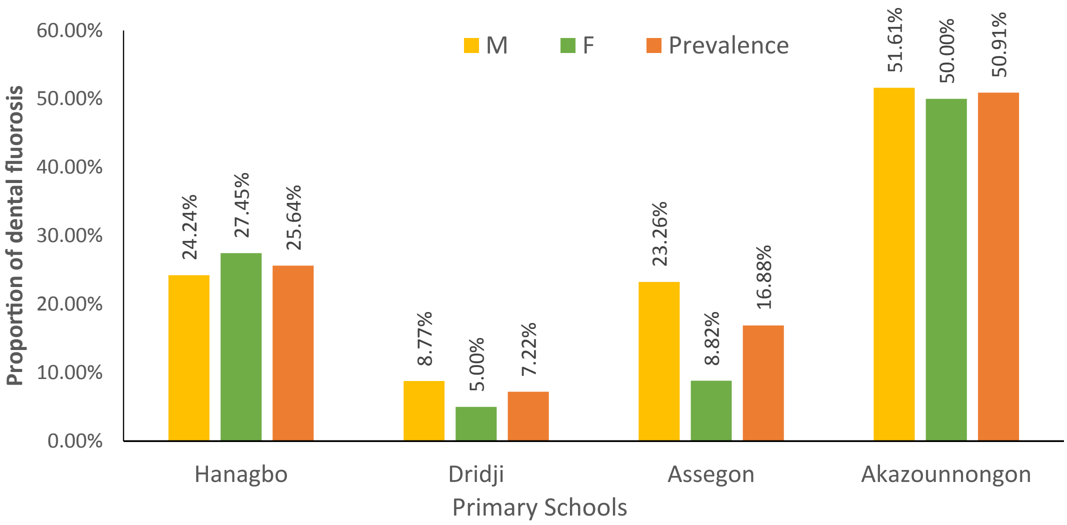

Figure 3 Distribution of the dental fluorosis among students according to schools

Our data shows that the major part (68.68%) of the students with dental fluorosis are belonging 8 to 11-year-old. Also, it appears that most (84.35%) of those students have body ranging from 1501 m^2 to 1520 m^2 (Table 2). Those observations are the same from an investigated school to another ($p<0.05$).

Table 2 Prevalence of the dental fluorosis from a primary school to another according to the age and the body area

Variables	Hanagbo (n=60)	Dridji (n=14)	Assegon (n=13)	Akazounnongon (n=28)	Total (n=115)
			Age (years)		
6 to 7	20.00%	0.00%	23.08%	7.14%	14.78%
8 to 9	36.67%	0.00%	23.08%	50.00%	33.91%
10 to 11	30.00%	71.43%	30.77%	28.57%	34.78%
12 to 13	13.33%	28.57%	23.08%	14.29%	16.52%
			Body area (m^2)		
1490 to 1500	6.67%	0.00%	15.38%	14.29%	8.70%
1501 to 1510	61.67%	14.29%	53.85%	71.43%	57.39%
1511 to 1520	28.33%	50.00%	30.77%	10.71%	26.96%
1521 to 1530	3.33%	14.29%	0.00%	3.57%	4.35%
1531 to 1540	0.00%	21.43%	0.00%	0.00%	2.61%

The investigation of the water content in fluoride content shows a high value in comparison to the standards (Figure 4).

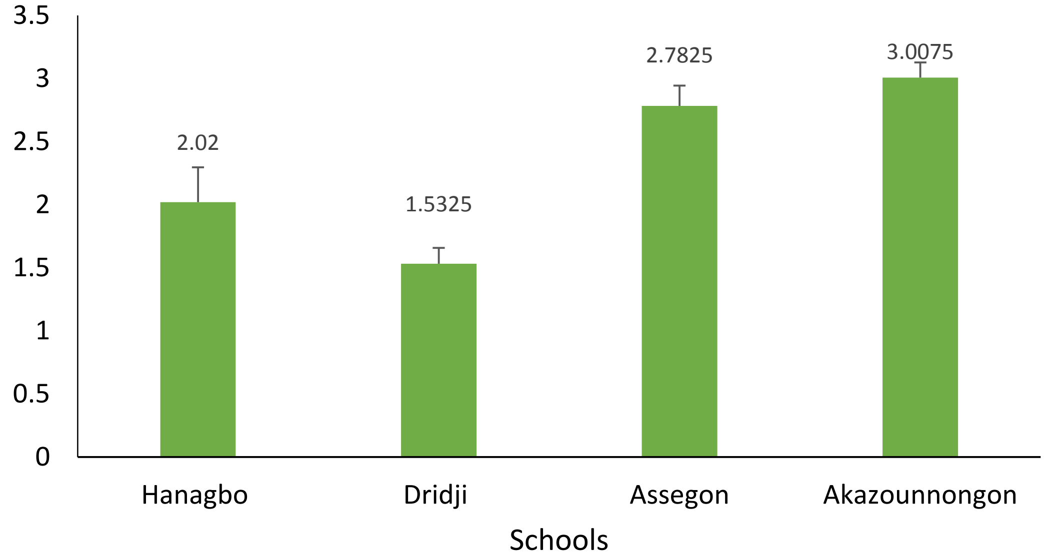

Figure 4 Fluor content of the drilling water collected near the investigated schools

DISCUSSION

Of the 560 surveyed schoolchildren, 115 developed severe fluorosis, thus, a prevalence of 20.53% was recorded. This prevalence has not varied by according to the sex but the factors that influence it are age, body surface area and especially the site of schools in relation to water points. Those results obtained show that fluorosis is not linked to sex as previously reported by Djossou, et al. [15] in Dassa, where the observed 62.2% (boys) and 60.5% (girls) of fluoride during their study. Therefore, it has been concluded that the occurrence of dental fluorosis is not statistically related to sex.

The association between dental fluorosis and age shows a high prevalence in the age group between 8 and 11 years. The highest frequencies are as follows: from 10 to 11 we have a prevalence of 34.78%, from 8 to 9 years have a prevalence of 33.91%. This result is consistent with the research conducted on schoolchildren aged between 9 and 10 years showing dental fluorosis, reporting about 50% of prevalence [16]. But this compliance is not always the conclusion of many authors who agree, however, for most determined a period at risk of the dental is from 6 to 7 years old [17]. For Djossou et al. [15] the risk period is in the age range of 10 to 15 years. In these conditions, it can be concluded that the development of dental fluorosis shows a relation between the latter and the age factor.

The body surfaces with high frequencies are those between 1501-1510 and 1511-1520 giving respectively a prevalence of 57.39% and 26.96%. This association has really not been studied in researchers who attach most of the body surface to the consequences of fluorosis, which are dysfunctions of the thyroid gland. This is the case of Gbaguidi, et al. [18] who, in their study on calculating thyroid ultrasound volumes, found that girls with a body surface area equal to 0.8 m^2 had the lowest thyroid ultrasound volume, while that of equal body surface area 1.2 m^2 have the largest thyroid ultrasound volume. Similarly, in boys the results are similar.

The analysis of water from boreholes for the consumption of schoolchildren at school and at home shows a high content of fluoride in all the localities surveyed. Water points serving Hannagbo school children have fluorine levels ranging from 1.61 mg/L to 2.21 mg/L, Dridji the only drill point has a fluorine content of 1.53 mg/L, in Assegon and Akanzounnongon we have respectively 2.78 mg/L and 3.02 mg/L. For this purpose, the World Health Organization (WHO) has defined the optimal dose of fluoride in drinking water. This dose is that which an individual can ingest daily, depending on his age without running the risk of chronic intoxication whose first manifestation is dental fluorosis. It varies according to the temperature and the altitude. Depending on the region, WHO has set this dose between 0.7 mg/L and 1.2 mg/L. In view of these standards it can be concluded that the various waters analyzed have a fluorine content that exceeds the normal, but this content varies according to the localities and according to the altitudes. These results confirm the research of Comlan Dovonnon, et al. [19] found in the commune of Dassa-Zoumé center of Benin levels of 4.3 mg/L of fluoride ion in the drilling water.

A high level of 3.73 mg/L of fluoride in drinking water resulting in a high prevalence of dental fluorosis in North-East Africa in Eritrea population, specifically in a humid rural area was reported [20]. In Morocco, studies by El Jaoudi, et al. [21] revealed that the average value of the fluoride ion in drinking water in rural areas was 1.84 ± 1.6 mg/L with extremes of 0.42 mg/L and 8.95 mg/L. Another study that concerned the Safi region found a concentration of fluoride ions in water of 1.6 mg/L. In some areas of Tanzania where the fluoride ion content of water is around 21 mg/L, Christie, et al. [22] found significant levels of bone malformation in children under 16 years of age. Similarly, in Ethiopia, it was found fluoride ion levels close to 10 mg/L with radiological bone fluorosis found in the patients examined, 10% of whom had a disability [23-25].

These results show that the higher the fluoride content in water, the more fluorosis intensifies, and the high fluorine levels lead to bone fluorosis. However, it has also been shown that low levels of fluoride ion can also be the basis of dental fluorosis. This is the case in Tanzania where a study by Mabelya [26] found severe dental fluorosis lesions with concentrations of 0.4 mg/L. In Nigeria, according to El-Nadeef, et al. [27] surveys, a prevalence of 51% has been reported for rates ranging from 0.1 mg/L to 0.4 mg/L.

CONCLUSION

From the analysis of the drilling water, the only possibility for the populations to obtain the drinking water in the surveyed zones is that these waters have an average content of 2.20 mg/L in fluoride ion with extremes of 1.53 mg/L and 3.02 mg/L. Dental fluorosis, that is the first apparent consequence of the consumption of these drilling waters, constitutes a danger for this population with a prevalence of 20.53%. The results of our study have established a relationship of this fluorosis with the age; body surface and place of residence or water points serving schools. The association of fluorosis with sex did not stand out as a peculiarity. Finally, our research has the merit of highlighting the risks incurred by the consumers of this drilling water and poses at the same time the urgent and thorny problem of specific treatment of these waters.

DECLARATIONS

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Conflict of Interest

The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

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