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Research Paper

Chemical quality of groundwaters and fluoride concentrations in the district of Dassa-Zoume, Southern Benin

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ABSTRACT

Like many African countries, the groundwaters of some regions in Benin have fluoride concentrations above the WHO guidelines (0.7 to 1.5 mg/L). The fluoride is useful against caries and hardens the enamel. At higher concentrations, it weakens the bones or causes crystallization points implying the appearance of arthritis deforming joint: it is fluorosis. Fluorosis is a public health problem due to its complication in bone fluorosis. It becomes an aesthetic problem and a daily concern for the patients. People discover spotted, brownish and disharmonious teeth when the patient smiles. We propose to carry out a study on a sample of the populations of the district of Dassa-Zoumè in order to evaluate the fluoride rate contained in groundwaters and the impacts on teeth. A transversal, descriptive and analytical study was conducted. It covered 1,002 pupils from 4 to 18 years of primary and secondary schools in Dassa-Zoume. The study was carried out in two phases: wells and well water extraction from Dassa-Zoume; a total of 24 boreholes were analyzed. Questionnaires directly about dental examination were administered and filled. The fluoride concentration ranged between 0.29 and 4.3 mg/L with a mean of 1.87 mg/L. The statistical analysis carried out for $p < 0.05$ showed no correlation between the F and the four major elements (Ca^{2+}, NO^{3-}, NO^{2-} and NH^{4+}), but this correlation is positive with the evolution of pH between 6.44 and 7.08 for an average of 6.83. There was an overall prevalence of 12.2% with 95% CI: [10.2 to 14.3%], a CAD of 0.23 with 139 decayed teeth, 86 teeth absent and 01 tooth closed. The distribution of fluorosis at the sample level showed that 61.4% of the pupils had an evident fluorosis. The results of our survey showed the importance of treatment towards the Dassa-Zoume populations' needs. Only preventive programs could reduce the number of oral diseases.

Keywords: Fluoride - fluorosis - prevalence - Dassa – Benin.

INTRODUCTION

Water is source of life, but it can also cause illness and even death. In Benin, groundwaters represent a major source of potable water, particularly in urban areas (NEST, 1191). Nowadays, potable water is one of the major concerns of the people, about 70% use water through public wells or boreholes for domestic purposes.

The populations of several districts of Benin are faced with the problems of quality and quantity of water. In the past, the quality problems were linked to microbiological risks. Today, there are chemical hazards with diverse and varied origins.

The higher concentration of fluoride in potable water should be 1.5 mg/L according to the European Economic Community (OCT of 5 December 1998). The guideline value varies according to climate and in a temperate climate it must be 1.5 mg/L for WHO (2002). The fluorides in small

Figure 1: Location map of the District of Dassa Zoume.

amounts have an evident role in protecting the tooth (Ahmed et al., 2003). However, its excessive intake can result in several health impairs. The dental fluorosis is the first sign of toxicity (Triller, 1991).

In terms of prevalence in sub-Saharan Africa, Ahmed et al. (2003) attempted to establish an epidemiological tracking. Although there are many outbreaks of fluoride poisoning, few epidemiological studies addressed this issue. Nevertheless, in West Africa, a study in Nigeria revealed a prevalence of fluoride poisoning on tooth lesions estimated at 51% for a fluoride content of water varying between 0.1 and 0.4 mg/L (Akosu, 2009). A study conducted between 2006 and 2007 revealed that 312 among the 1,129 people surveyed had dental fluorosis, that is, 27.63% (Dovonon et al., 2011). Dental fluorosis is endemic in the Great Lakes region, a factor related to the presence of fluoride in potable water.

In fact, fluorosis is a real public health problem from an aesthetic point of view for dental fluorosis, but also bone fluorosis because people who drink this water suffer from joints ailing after a few years (Diawara et al., 2004). The aim of this work is to study the fluoride content of drilling waters and the prevalence of dental fluorosis and its associated factors in primary schools in the district of Dassa-Zoumè.

MATERIALS AND METHODS

Scope of the study

The study was carried out in the municipality of Dassa-Zoumè surrounded in the south by municipalities like Djidja, Covè and Zagnanado, in the north by Glazoué, in the east by Savè and Kétou and in the west by Savalou (Figure 1). The municipality covers an area of 1722.5 km^2. Dassa-Zoumé is subdivided into ten suburbs (Dassa 1, Dassa 2, Akofodjoule, Gbaffo, Kéré, Kpingni, Lema, Paouignan, Soclogbo and Tré). Its population is 535,923 inhabitants and its average density is 38 inhabitants per km^2. 78.0% of the population lives in rural areas versus 22.0% in the city. The municipality has health infrastructures, 38 maternities, 4 health centers, 33 sub-district health centers and 82 clinics for the 297 villages. There are 145 public elementary schools, 21 undergraduate and 5 post-graduate colleges (secondary schools).

Water sampling and analytical method

A preliminary random selection of 24 wells and boreholes was carried out in the Epi 6 software. The fieldwork was carried out in 2 phases. The first consisted of a prospective field visit. The second was to measure the physico-chemical parameters of *in-situ* water (electrical conductivity, temperature and pH) using a multi-parameter and taking samples of water from 1000 ml polyethylene bottles. Once rinsed *in situ*, filled with water and hermetically sealed, the samples are conditioned at about 4°C in a cooler and transported without delay to the laboratory where analyzes is carried out on the "major and minor" elements measured by a liquid ion chromatograph and a spectrophotometer. These are: Ca^{2+}, NH^{4+}, F^-, NO^{3-} and NO^{2-}.

Fluorosis sampling and related factors

It was a transversal, descriptive and analytical study.

Study population

It was constituted of all pupils aged from 4 to 18 years enrolled in the public primary and secondary schools of the

selected classes of Dassa-Zoumè in 2014 (Table 1).

Inclusion criteria

The learners of the municipality of Dassa-Zoumè included in the study were:

- Aged 4 to 18 years on the day of the survey;
- Living in the district of Dassa-Zoumè;
- Drinking from wells and boreholes of the district.

Exclusion criteria

Excluded from the study were:

- Learners who are seriously ill and unable to answer questions;
- Students arriving in Dassa-Zoumè after their 16th birthday (end of the amelogenesis);
- Students did not give their consent to participate in the survey.

The sample size was calculated by using Schwartz formula:

$N = [Z\ a2 \times p \times q] / i2 = 911$

N = Sample size, α = Risk granted (5%), Zα = reduced-risk deviation = 1.96, P = 68.5%: prevalence of fluorosis in Dakar (Senegal) I = desired accuracy for our results = 0.03. This sample size was increased by 10%, or 1,002 students to provide a margin for non-respondents. The study was conducted using a 4-degree probing technique. The sampling frame consisted of a list of all the primary and public schools in the municipality of Dassa-Zoumè. The choices were made at random using Epi 6 software.

Data processing and analysis

The statistical ratio between the *in situ* measured parameters, the major and minor elements is determined from the correlation coefficient for $p < 0.05$. All statistical analysis were carried out in software R. We checked first the quality of the collected data (search for aberrant data, missing data, inaccurate and inconsistent) which were entered using the Epi data 3.1 software and the analysis was done using the Stata 12 software.

The prevalence of dental fluorosis was estimated. 95% confidence intervals (CI) around estimates of dental fluorosis prevalence were calculated according to the method described by Bennett et al. (1991) taking into account the sampling method used. The description of the qualitative variables was made using proportional calculations such as quantitative variables by means ± standard deviation. The comparison of frequencies was made using the Chi^2 test or Fisher's exact test, when this was appropriate. Factors associated with the appearance of fluorosis at the 20% threshold at univariate analysis were introduced in a multivariate logistic regression model to investigate potential indicators of risk of fluorosis. We assumed that there is a statistically significant association between the two variables for $p < 0.05$.

RESULTS

Variation of fluoride in water

Groundwaters of 12 villages had contents exceeding 1.5 mg/L or 57%. The contents were oxidized between 0.29 and 4.3 mg/L with an average of 1.87 mg/L. All the analyzed samples from the drillings of the Dassa 1 suburb, Tré and some samples of Kéré (Okéméré and Tangbé) and Lèma (Zankoumadon) were unsuitable for consumption. Those from the district of Akofodjoulé were below the norm and therefore intended for drinking (Figure 2).

Correlation of data

From the statistical analysis of the *in situ* and laboratory data, only the pH could be correlated to the fluorine water content with a p-value of 0.03. Nevertheless, it was found that in the waters of the suburb of Akofodjoulé recommendable for drinking are recorded low values in pH, with a conductivity temperature near the average of all samples. In this area, the Ca content of all groundwaters was also below the norm. Only the nitrate content exceeds the accepted standards in Benin.

The survey covered 1,002 individuals aged from 4 to 18 years. The mean age of the children was 11.50 ± 4.17 years. The number of boys outnumbered girls (51.20%). The prevalence of fluorosis in this sample was 61.14% at 95% CI = [58.36; 64.40]. In the group of children with dental fluorosis, 178 had opaque spots covering less than 1/3 of the tooth, the incisal edge or cuspidus were 28.9% and 13 had pits that communicated with each other, anatomy altered with dark brown spots usually present, that is, 2.1%.

Prevalence of fluorosis per individual characteristics

This characteristic depends on the consumed water at home. Then we noted 44.6%, 37.6% and 17.8%, respectively, consuming drilling, tap and well water. Almost half (48.1%) of the pupils were used to drilling water at school (Figure 3).

DISCUSSION

The level of fluorosis fluctuates considerably in the district. It fluctuates between 0.29 and 4.3 mg/L with an average of

Table 1: Univaried analysis of fluoride according to the behaviour of the pupils in Dassa-Zoumè in 2014.

Variables	Total		Fluorise	Odd ratio	95% CI†	P-value
Frequency of brushing	n	%	%			
No everyday	156	15.57	53.21	1		
In the morning	617	61.58	63.37	1.52	1.06 - 2.16	0.1466
Morning and evening	191	19.06	61.78	1.42	0.92 - 2.18	
Morning, afternoon and evening	38	3.79	60.53	1.34	0.65 - 2.77	
Type of denture						
Temporary	73	7.29	15.07	1	-	
Mixte	394	39.32	59.39	8.24	4.21 - 16.14	0.0000
Permanent	535	53.39	69.16	12.64	6.49 - 24.63	
Tools for brushing						
Tooth brush	477	47.60	61.22	1	-	
Vegetal brush	521	52.00	61.42	1.00	0.78 - 1.30	0.8443
Fingers	4	0.40	75.00	1.90	0.19 - 18.40	
Rate of Fluoride						
Low	172	17.17	32.60	1	-	0.0000
High	830	82.83	67.30	0.23	0.16 - 0.33	
Type of source (in home)						
Drill/ boreholes	447	44.60	47.32	1	-	
Wells	377	37.60	16.26	0.68	0.48 - 0.79	0.0722
Potable water	178	17.80	36.42	0.78	0.59 - 1.04	
Type of source (in school)						
Boreholes	482	48.10	52.52	1	-	
Wells	431	43.00	7.32	0.50	0.31 - 0.79	0.0010
Potable water	89	8.90	40.55	0.66	0.50 - 0.86	

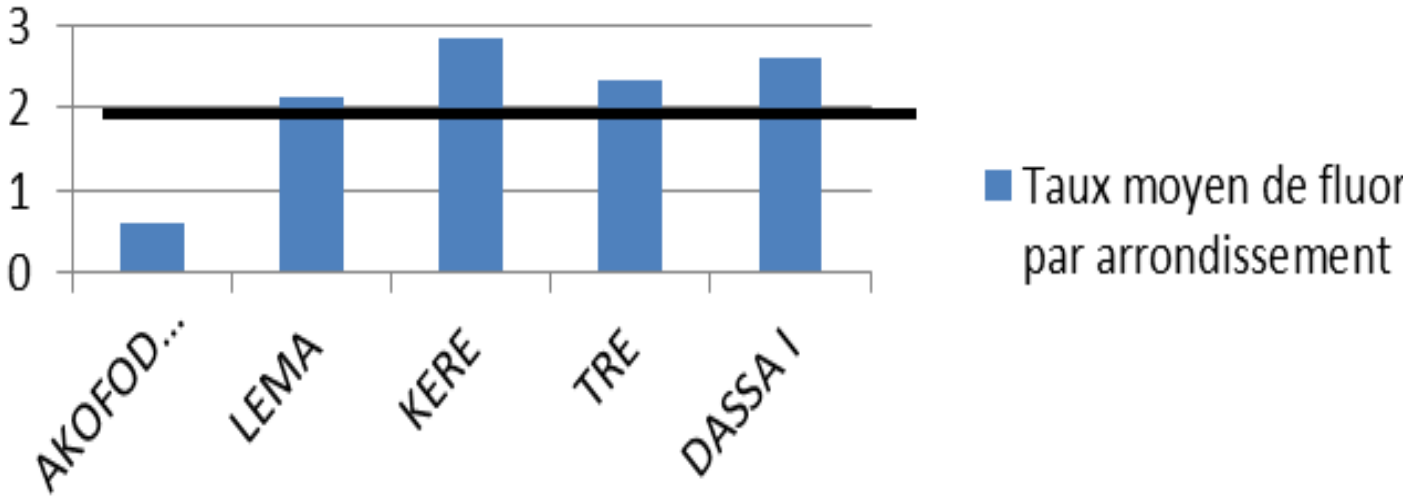

Figure 2: Fluoride rate of per sub-district.

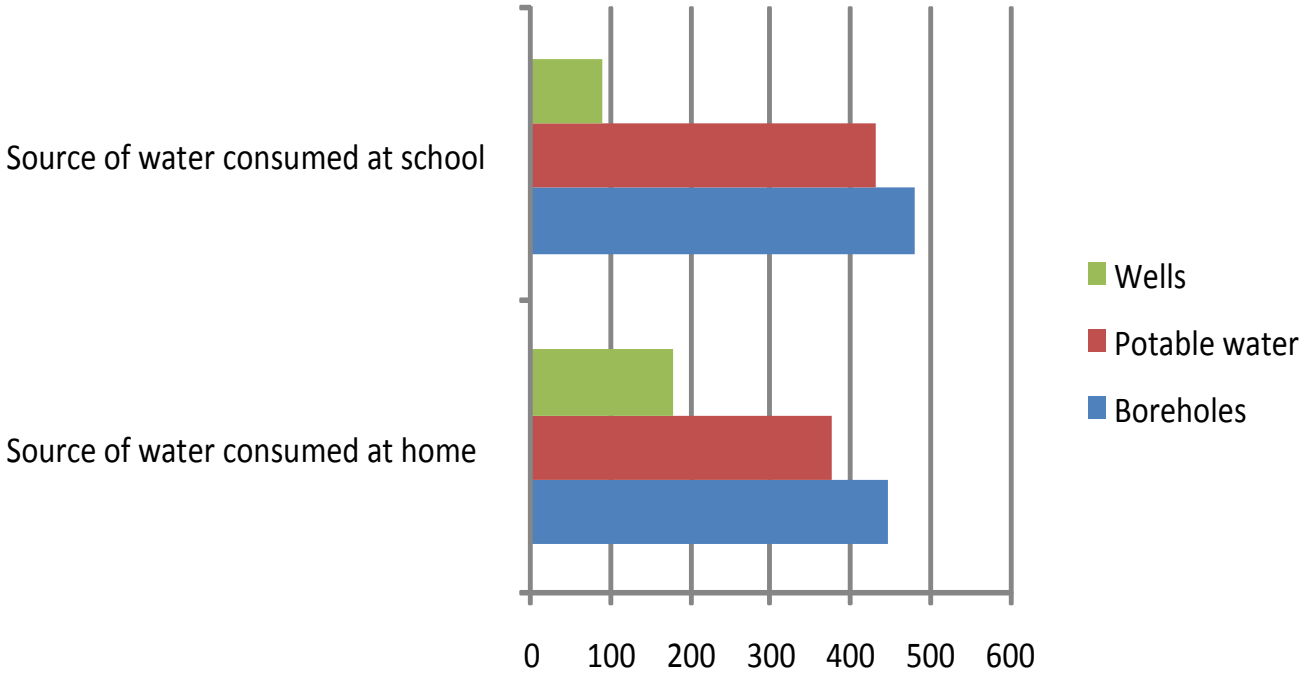

Figure 3: Distribution of pupils according to the source of water at school and at home in the district of Dassa-Zoumè in 2014.

1.87 mg/L. The analysis shows the lowest rates in the district of Akofodjoulé with values ranging from 0.29 to 0.98 mg/L, while the highest rate is obtained in Keré and more precisely in the village of Okéméré, with a value of 4.3 mg/L. In addition to the district of Akofodjoulé, average fluoride levels were higher than the recommended standard for drinking water (WHO, 2002) in Dassa 1, Tré and some samples of Kéré (Okéméré and Tangbé) and Lèma (Zankoumadon). These values also corroborate the results of Dovonou's work (2012) which revealed a mean grade of 1.63 mg/L.

In our study, among the 1,002 students, 615 had fluorosis, a prevalence of 61.4% with 95% CI = [58.3 to 64.4]. This prevalence did not vary significantly according to the type of food, ethnicity, religion, sex, brushing habit and age. As soon as the individual grows in age, the prevalence of fluorosis increased. The factors associated with fluorosis were: place of residence, length of stay in the medium and the type of teeth. It is important to note that all the surveyed children were born in the municipality of Dassa and lived there by using regular water continuously, either drilling water or well water. The type of diet and the oral hygiene habits are identical; the sole factor that can explain the high prevalence of dental fluorosis in Dassa children is the presence of fluoride in the drinking water.

Comparison of our results with other authors

The context of our study was the prevention of oral diseases, the methodology used and the specificity of the data collection allowed us to get information in line with our objectives. The World Health Organization (WHO) defined the optimal dose of fluoride in drinking water. The rate is that which an individual can ingest on a daily basis, according to his age without running the risk of chronic poisoning with primary manifestation being dental fluorosis (Bennett, 1991). It varies according to temperature and altitude. Depending on the region, WHO fixed this rate between 0.7 and 1.2 mg/L (Burt, 2000).

In Dassa-Zoumè, the optimal dose of fluoride in drinking water was 4.3 mg /L, which is lower than that found (0.8 mg /L) by Ndiaye (2004) in Senegal.

In our study, the prevalence of fluorosis was 61.4% lower than that found in Gandiaye by Ndiaye (2004). It is interesting to note, however, that the present results are consistent with previous studies in Africa (Gizaw, 1996). A study carried out in by Cholab (1959) quoted by Srikanth in Northeastern Africa in Eritrea, specifically in a humid rural area along the Anseba River, showed a high content of fluoride in drinking water. The results of this study revealed a concentration of 3.73 mg /L of fluoride in this water, leading to a high prevalence of dental fluorosis in this population (Srikanth, 2002). This strongly indicates that in "moderate" and "high" fluoride levels and concentrations, the existence of dental fluorosis increases significantly with increasing fluoride content in drinking water.

The results show that students consume both water at school and at home on a daily basis, but most of them drink drilling water at school and at home with 67.0 and 65.1%, respectively.

Furthermore, there was an association between the occurrence of fluorosis and the consumption of drilling water. The distribution of fluorosis according to the residence time shows a clear predominance in the natives of Dassa over those born outside. The pupils born in Dassa-Zoumè accounted for 72.36% versus 28.85% for the natives of other localities and it was more at risk of developing dental fluorosis. Several studies demonstrated the association between the degree of fluorosis and the amount of fluoride in drinking water (Ene, 2014). According to some authors, dental fluorosis is sensitive to even minor changes in exposure to fluorides in potable water.

Although the appearance of fluorosis was associated with the type of consumed water, it is not determined by the occurrence of fluorosis because in our study one of the associated factors was the time spent in the borough. This assumes that the number of years spent in the district is equivalent to the number of years they consumed that type of water in the locality. This confirms the conclusion that dental fluorosis is the result of prolonged exposure of dental tissues to high concentrations of fluoride during tooth development (Gizaw, 2014; Triller, 1991).

The prevalence of fluorosis is higher among pupils who consume drilling water at school.

Conclusion

In the town of Dassa, located in an area of endemic fluorosis, fluoride carioprotecteur role when consumed according to an optimal dose is confirmed. The problem of the defluoridation of water in endemic fluorosis arises because dental fluorosis is a real public health problem in this area.

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