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Research Article

Elimination of Urinary Fluoride in the Population of Diamaré in Relation to Water Contamination

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Abstract

Introduction: Fluorosis, also known as fluorine poisoning is a disease caused by the disruption of various metabolic pathways, one of which includes calcium metabolism implicated in dental and bone formation due to the replacement of calcium by fluoride ions in bone matrix. The aim of study was to determine the presence of fluorine of the population consuming water contaminated at the Diamaré Division.

Method: A cross sectional analytic study design in 7 villages at the Diamaré division from 1st December 2021 to 30th May 2022 was carried out. Participants who gave consent and filled the selection criteria were included. The socio-demographic characteristics, medical history, eating habits and clinical characteristics of the participants were obtained using a questionnaire. Samples of urine, blood of participants and water were collected for analysis at the Centre for Study and Control of Communicable Diseases at the Faculty of Medicine and Biomedical Sciences of the University of Yaoundé. Fluoride concentration in water and urine. Data entry and analysis was done using Epi info; Associations were derived from bivariate analysis.

Results: We had bore holes, wells and river as water sources used of water for drinking, cooking and household activities. 152 participants were recruited and the most common water source used was bore holes (N=94; 61.84.7 %). Some used water from one source only; others from two sources or more. Majority had Joint pains (78.7 %). Dental fluorosis accounted for 26%., bowed legs 4.7%, skeletal deformities 6%, immobilization of joints 41.3% and knocked knees 1.3%. A mean water fluoride concentration of 1.30 ±1.68 mg/l ranging from 0.04-5.75 mg/l was obtained from 30 samples of water collected while that of 2.89 ±2.87 mg/l ranging from 0.05-14.35 mg/l was obtained from urine.

Conclusion: The majority of water sources (wells and boreholes) used by our study population for consumption are contaminated with fluoride which is eliminated in urine by the entire population.

Keywords: Fluorosis; Population; Fluorine; Sources Of Water.

INTRODUCTION

The element fluorine is a gas which exists only in a combined state in fluoride compounds of the earth crust [1, 2]. The intake of fluorine beyond safe limits leads to fluorine poisoning which can be acute or chronic according to the amount and period of consumption [1]. Acute toxicity is related to a single ingestion of a large amount of fluoride leading to diffuse abdominal pain, respiratory arrest, cardiac depression, neurotoxicity, diarrhea, vomiting, excess salivation and thirst [1-4]. Whereas chronic toxicity is related to a long-term ingestion of smaller amounts of fluoride in drinking water leading to dental fluorosis, skeletal fluorosis, non-skeletal fluorosis in soft tissues, bone fractures, kidney damage, chromosome damage, thyroid changes, growth retardation, infertility, skin lesions, cardiovascular disorders and neurological defects associated with reduced IQ in children [1-5].

A study carried out in 2017 estimated that about 200 million individuals worldwide are exposed to fluorine poisoning, with India and China being the most exposed [5], exceeding the WHO safe limits of 1,5 mg/l [6].

Whereas in Africa, studies on fluorine poisoning were carried out in certain countries like Tanzania, Kenya, Uganda, Nigeria, Ethiopia, Sudan and South Africa [7-10]. A study done in 2010 in Tanzania revealed that more than 90% of children aged from 7-10 years had dental and skeletal fluorosis with dental fluorosis in majority [9].

To the best of our knowledge, we have not seen any study on the impact of fluorine toxicity in the calcium metabolic pathway in the country. Chronic fluorosis can be linked to a broad number of problems with many reports on dental and skeletal fluorosis. Hence, we had an aim to evaluate the level of bone troubles related to chronic fluorosis at the Diamaré Division.

METHOD

A cross sectional analytic study design in 7 villages at the Diamare division from 1st December 2021 to 30th May 2022 was carried out. Participants who gave consent and filled the selection criteria were included. The socio-demographic characteristics, medical history, eating habits and clinical characteristics of the participants were obtained using a questionnaire. Samples of urine, blood of participants and water were collected for analysis at the Centre for Study and Control of Communicable Diseases at the Faculty of Medicine and Biomedical Sciences of the University of Yaoundé. Fluoride concentration in water and urine, calcium and ALP levels in serum of participants were obtained.

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Data entry and analysis was done using Epi info; Associations were derived from bivariate analysis.

RESULTS:

Enrolment Process

One hundred and fifty three participants were enrolled at the chosen villages with high fluoride concentration at the Diamare division. One participant was excluded because of a short term residence (<1 year) in the area of study. The Figure 1 below shows the flowchart of the enrolment of participants.

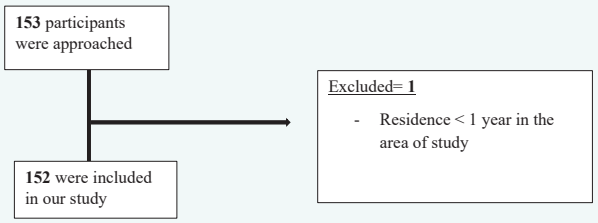

Figure 1: Flow Chart of Enrolment Process.

A total of 152 participants were included in our study. Their socio-demographic data distribution is seen on Table 1.

Most of the participants were in the age group of 41-50 years (N=34; 22.4%). The mean age was 48.7(±16.5) years and ranging from 20-19 years old. Most of the participants came from the Tchere village (N=53; 34.9%). The sex ratio was 105:47 (2.23) with the majority of participants being males (N=105; 69.1%) and most of them were Muslims (N=78; 51.3%). In addition, 64.5% of them had no formal education.

Water Sources and Uses by Inhabitants

We identified rivers, wells and bore holes as water sources used by the inhabitants at the Diamare division. The most common water source used by the participants was bore holes (N=94; 61.84 %) as shown in table VIII. Some of the participants used water from one source only, two sources or more. 12% of them (N= 18) used water from the three kinds of sources identified. They all (N=150; 100%) used the water sources for drinking, cooking, bathing, laundry, dish washing, farming and animal rearing (Table 2).

Joint pains was the most common symptom experienced by most of the participants (N=119; 78.29%).7 people (4.6%) had bowed legs while 9 participants (6%) had skeletal deformities. More so, 26% of them had dental fluorosis. Part of the participants (40.79%) suffered from immobilization of joints while 1.32% presented with knocked knees. 23.68% of the participants had dental caries (Table 3).

The proportion of participants drinking milk on a daily basis was 29.61% (n=45). 70.4% of the participants did not consume milk at all (Table 4).

Mean Concentration and Standard Deviation of Fluoride Concentration in Water

Q1: 1st quartile, Q3:3rd quartile

The mean concentration of fluoride ions in all the water samples was 1.30 ±1.68 mg/l ranging from 0.04-5.75 mg/l with median 0.05mg/l and mode 0.05mg/l.

Table 1: Socio-Demographic Characteristics of Participants

Variables	Frequency (N=152)	Percentage(%)
Age Group (Years)		
20-30	25	16.45%
31-40	29	19.08%
41-50	34	22.37%
51-60	29	19.08%
61-70	19	12.50%
>70	16	10.53%
Total	152	100%
Sex		
Male	105	69.08%
Female	47	30.92%
Village		
Tchere	53	34.87%
Meri	9	05.92%
Douvangar	14	09.21%
Guinlaye	28	18.42%
Baouli	11	07.24%
Mikiri	20	13.16%
Gouzoulam	17	11.18%
Religion		
Islam	78	51.32%
Christianity	51	33.55%
None	23	15.13%
Level of Education		
Primary	41	26.97%
Secondary	13	8.55%
No Formal Education	98	64.47%

Table 2: Frequencies and Proportions of General and Detailed Water Usage by Participants (N=150)

Source	Frequency (N)	Percentage (%)
General water usage per source		
Well	70	46.05%
Bore hole	94	61.84%
River	24	15.79%
Detailed water usage		
Bore hole only	77	50.66%
Well only	34	22.37%
River only	2	1.32%
Well, Bore hole and River	3	1.97%
Bore hole and Well	17	11.18%
Bore hole and river	1	0.66%
Well and River	18	11.84%
Total	152	100.00%

Table 3: Clinical Features of Chronic Fluoride Toxicity Presented By the Participants

Variables	Frequency (n)	Percentage (%)
Dental Flourosis	39	25.66%
Dental Caries	36	23.68%
Skeletal Deformities	9	5.92%
Bowed Legs	7	4.61%
Knocked Knees	2	1.32%
Joint Pains	**119**	**78.29%**
Immobilization of Joints	62	40.79%

Table 4: Milk Consumption by Participants

Milk Consumption	Frequency(n)	Percentage (%)
No	107	70.39%
Yes	45	29.61%
Total	152	100%

The mean concentration in wells was 1.64mg/l while that of bore holes was 1.02mg/l. Both are superior to national norm of 0.7mg/l but only the concentration of fluoride in wells was superior to the WHO norm of fluoride water levels (Table 5).

COMPARISON OF CONCENTRATIONS OF FLUORIDE IONS IN WATER TO NATIONAL NORMS VALUE.

From the concentrations obtained, 17(56.66%) samples of water had concentrations inferior to the national norm value of 0.7mg/l, 13(43.33%) were superior. Majority of samples in Meri (80%) and Mikiri (100%) had concentrations above the national norm of 0.7mg/l (Table 6).

COMPARISON OF CONCENTRATIONS OF FLUORIDE IONS IN WATER TO WHO NORMS VALUE

From the concentrations obtained, 21(70%) samples of water had concentrations of fluoride in water inferior to the WHO norm value of 1.5mg/l, 9(30%) were superior. Majority of samples in Meri (80%) had concentrations of fluoride in water superior to the WHO norm value of 1.5mg/l norm (Table 7).

VARIATION OF FLUORIDE IN URINE SAMPLE WITH AGE.

Figure 2 shows that the presence of fluoride in urine is not linked to age and was unevenly distributed among all ages.

Variation of Fluoride in Urine Sample with Sex.

Fluoride in urine samples of our participants was unevenly distributed among all sexes. The absence of fluoride in urine was the same for all sexes but majority of those who had fluoride in their urine were males (71 Percent). So Figure 3 shows that fluoride is more present in males than in females.

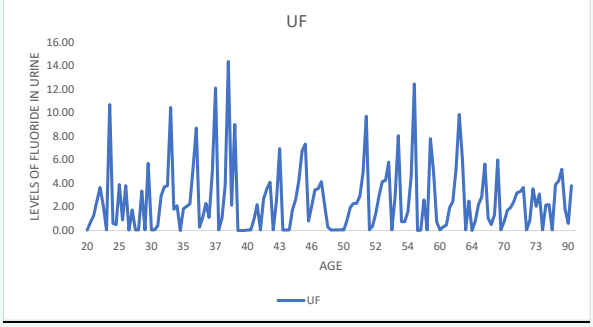

Figure 2: **Distribution curve of fluoride in urine samples against age.**

Table 5: Mean and SD of Fluoride Concentration in Water

Mean	Standard deviation	Coefficient of variation (%)	Minimum	Q1	Median	Q3	Maximum	Mode
1.30	1.68	124.15	0.04	0.05	0.275	2.15	5.75	0.05

Table 6: Proportions of Levels Fluoride Concentration in Water per Village Compared to National Norm

Village	National Norm(0.7mg/l) of Fluoride in Water		
	<0.7mg/L	>0.7mg/L	Total
Baouli	1 (100%)	0 (0.00%)	1 (100%)
Douvangar	7 (53.85%)	6 (46.15%)	13 (100%)
Gouzoulam	1 (50%)	1 (50%)	2 (100%)
Guinlaye	1 (100%)	0 (0.00%)	1 (100%)
Meri	1 (20.00%)	4 **(80.00%)**	5 (100%)
Mikiri	0 (0.00%)	1 **(100%)**	1 (100%)
Tchere	6 (85.71%)	1 (14.29%)	7 (100%)
Total	**17(56.66%)**	**13(43.33%)**	**30(100%)**

Table 7: Proportions of Levels Fluoride Concentration in Water per Village Compared to WHO Norms

Village	WHO Norms (1.5mg/l) of Fluoride In Water		
	<1.5mg/L	>1.5mg/L	Total
Baouli	1 (100%)	0 (0,00%)	1 (100%)
Douvangar	9 (69.23%)	4 (30.77%)	13 (100%)
Gouzoulam	2 (100%)	0 (0.00%)	2 (100%)
Guinlaye	1 (100%)	0 (0.00%)	1 (100%)
Meri	1 (20.00%)	**4 (80.00%)**	5 (100%)
Mikiri	1 (100%)	0 (0.00%)	1 (100%)
Tchere	6 (85.71%)	1 (14.29%)	7 (100%)
Total	**21(70%)**	**9(30%)**	**30(100%)**

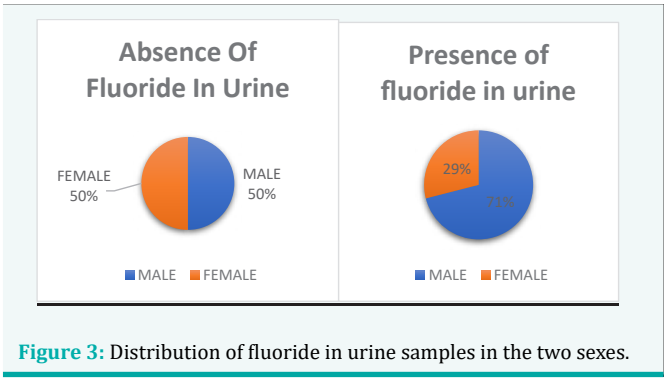

Figure 3: Distribution of fluoride in urine samples in the two sexes.

Distribution of Fluoride Ions in Urine samples.

From the dosage of fluoride ions in urine of participants, 10.53% did not have fluoride in their urine while 89.47% had fluoride in their urine samples. All participants in Gouzoulam (100%) had fluoride in their urine. More than 70% of participants in each village had fluoride in their urine (Table 8).

MEAN CONCENTRATION AND STANDARD DEVIATION OF FLUORIDE IN URINE

Q1: 1st quartile, Q3:3rd quartile

The mean concentration of fluoride ions in urine was 2.89 ±2.87 mg/l ranging from 0.05-14.35 mg/l with median 2.2mg/l and mode 0.05mg/l (Table 9).

DISCUSSION

Fluorine poisoning is a public health issue in the world and also has an impact in Cameroon, more precisely in the Far North region [12]. There is paucity of data on its impact on calcium levels implicated in both dental and bone health as in the case of our study. Hence, the aim of our study was to assess the impact of chronic fluorosis on the levels of calcium and alkaline phosphatases at the Diamaré division .This will help us provide a global approach to improve their health and lifestyle.

Socio-Demographic Characteristics

Our study population included adults of 20-90 years. The mean age in our study was 48.7 years. Similar findings was seen in Canada with a mean age of 46.49 years [14-17]. However, a lower mean age of 39.8 years was found in a study by Eklund et al [18]. This difference could be explained by the study population where only women were included while we recruited both males and females. Majority of our participants were males (N=105; 69.1%). However, another study had more women than men (sex ratio=1.04) [19].This difference is because most women were resilient to participate and most of them remained indoors in our study.

Table 8: Distribution of Fluoride Ions in Urine samples, N=152

Village	Presence N (%)	Absence N (%)	Total
Baouli	**50 (94.34%)**	3 (5.66%)	53 (100%)
Douvangar	**8 (88.89%)**	1 (11.11%)	9 (100%)
Gouzoulam	**14 (100%)**	0 (0.00%)	14 (100%)
Guinlaye	**23 (82.14%)**	5 (17.86%)	28 (100%)
Meri	**8 (72.73%)**	3 (27.27%)	11 (100%)
Mikiri	**19 (95%)**	1 (5%)	20 (100%)
Tchere	**14 (82.35%)**	3 (17.65%)	17 (100%)
Total	**136(89.47%)**	16(10.53%)	152(100%)

Table 9: Representation of Mean and Range of Fluoride Concentration in Urine Samples

Mean	Standard deviation	Coefficient of variation (%)	Minimum	Q1	Min	Q3	Max	Mode
2.89	2.87	99.32	0.05	0.75	2.2	3.85	14.35	0.05

Various Sources of Water and Their Uses by the Inhabitants

Boreholes, wells and a river were identified as water sources in our study. Similar findings were reported in a study done in Tanzania having bore holes, well, river as well as pipe water as sources [9]. The most used water source in our study was boreholes probably because of the recent increasing number of boreholes construction through water management projects. This is also due to the fact that bore hole water is more potable than the other sources used in the village. In contrast, the most used source in another study was wells because of partial access to other sources [9].

Clinical features of chronic fluorosis presented by the participants

Most of our participants (78%) experienced severe joint pains as a clinical feature of chronic fluorosis. This could be explained by the fact that fluorine poisoning is known to cause joint pains, skeletal deformities, mottling of teeth and immobilisation of joints as a result of disorders of calcium/phosphorus metabolism occurring during growth [20].

THE CONCENTRATION OF FLUORIDE IONS IN WATER AND URINE, AND THE CONCENTRATION OF CALCIUM AND ALKALINE PHOSPHATASES IN BLOOD.

Concentration of fluoride obtained in water sources

The mean concentration of fluoride obtained in water sources was 1.3mg/l with the highest concentration of 5.75mg/l obtained from a well (P13) in Douvangar. The mean concentration in wells was 1.64mg/l and that of boreholes was 1.02mg/l. This shows that there is more fluoride at the surface than in deeper levels since bore holes are deeper but does not exclude the fact that it is still high in boreholes. The fact that majority use water from boreholes in search of potable water is a matter of concern. However, a higher mean concentration of 2.22mg/l was seen in a study in India [13]. This is due to the difference in the rock types bearing different quantities of fluoride-bearing minerals. 30% of our samples exceeded the WHO norm of fluoride levels which is similar to the study done by Fantong et al., at the Mayo Tsanaga river basin which was 26.7% above the WHO limit of 1.5 mg/l [11]. Geological sources and fertilizers used in agriculture can be the possible contributors of fluoride in groundwater in our study whereas. Industrial input was absent due to lack of industries in our area of study.

Concentration of fluoride in urine

The mean concentration of fluoride in urine obtained was 2.89-±2.87 mg/l ranging from 0.05-14.35mg/l. The presence of fluorine in our samples of urine reflects the fluorine exposure of our participants in our area of study. The quantity of water we take in depends on the atmospheric temperature; so extremely hot conditions present in our study area make the inhabitants consume more water and thus accumulate fluoride more than the normal range in the body. In 2016, *Carmen et al* reported a mean concentration of 1.27 ± 1.2 mg/l [21] lower than what we obtained. This is because of the difference in the study population, which included only children. Fluoride excretion rate is considerably lower in children than adults [22].

CONCLUSION

Our participants used water from boreholes, wells and river for consumption and household activities. They used water mostly from bore holes. Some used water from one source while others used water from two or more sources. Thus, they used underground water for all their different activities where water is implicated.

Our participants presented clinical features of chronic fluorine poisoning with joint pains being the most experienced symptom by majority of the participants. These clinical symptoms, precisely skeletal deformities and immobilisation of joints were exacerbated by a lack of milk consumption due to poor diet. Thus, troubles linked to bone metabolism are frequent in this population.

The different water sources identified in our study are contaminated with fluoride with many sources having concentrations of fluoride superior to the safe limits of national and international norms. Fluoride has been found to be eliminated in urine by the entire population. The levels of fluoride in urine increased with age and eliminated more in men than women. The levels of calcium and ALP showed majority of them being hypocalceamic and having high ALP levels.

REFERENCES

1. Dhar V, Bhatnagar M. Physiology and toxicity of fluoride. Indian J Dent Res. 2009; 20: 350-5.
2. Prystupa J. Fluorine--a current literature review. An NRC and ATSDR based review of safety standards for exposure to fluorine and fluorides. Toxicol Mech Methods. 2011; 21: 103-70.
3. Guth S, Hüser S, Roth A, Degen G, Diel P, Edlund K, et al. Toxicity of fluoride: critical evaluation of evidence for human developmental neurotoxicity in epidemiological studies, animal experiments and in vitro analyses. Arch Toxicol. 2020; 94: 1375-1415.
4. Choi AL, Sun G, Zhang Y, Grandjean P. Developmental fluoride neurotoxicity: a systematic review and meta-analysis. Environ Health Perspect. 2012; 120: 1362-8.

5. Rasool A, Farooqi A, Xiao T, Ali W, Noor S, Abiola O, Ali S, Nasim W. A review of global outlook on fluoride contamination in groundwater with prominence on the Pakistan current situation. Environ Geochem Health. 2018; 40: 1265-1281.

6. Ghosh A, Mukherjee K, Ghosh SK, Saha B. Sources and toxicity of fluoride in the environment. Research on Chemical Intermediates. 2013; 39: 2881-915.

7. Beltrán-Aguilar ED, Barker L, Dye BA. Prevalence and severity of dental fluorosis in the United States, 1999-2004. NCHS Data Brief. 2010; 1-8.

8. Wondwossen F, Astrøm AN, Bårdsen A, Bjorvatn K. Perception of dental fluorosis amongst Ethiopian children and their mothers. Acta Odontol Scand. 2003; 61: 81-6.

9. Shorter JP, Massawe J, Parry N, Walker RW. Comparison of two village primary schools in northern Tanzania affected by fluorosis. Int Health. 2010; 2: 269-74.

10. Okoye LO, Ekwueme OC, Sote EO, Amaechi BT. Prevalence of dental fluorosis among 12-15-year-old students in Enugu Metropolis, Nigeria. Indian J Dent Res. 2019; 30: 462-467.

11. Fantong WY, Satake H, Ayonghe SN, Suh EC, Adelana SM, Fantong EB et al. Geochemical provenance and spatial distribution of fluoride in groundwater of Mayo Tsanaga River Basin, Far North Region, Cameroon: implications for incidence of fluorosis and optimal consumption dose. Environ Geochem Health. 2010; 32: 147-63.

12. Fantong WY, Satake H, Ayonghe SN, Aka FT, Asai K. Hydrogeochemical controls and usability of groundwater in the semi-arid Mayo Tsanaga River Basin: far north province, Cameroon. Environmental geology. 2009; 58: 1281-1293.

13. Kumar S, Lata S, Yadav J, Yadav JP. Relationship between water, urine and serum fluoride and fluorosis in school children of Jhajjar District, Haryana, India. Applied Water Science. 2017; 7: 3377–3384.

14. Patil MM, Lakhkar BB, Patil SS. Curse of Fluorosis. Indian J Pediatr. 2018; 85: 375-383.

15. Yadav A. Dental Fluorosis and Periodontal Disease: An Overview. Int J Adv Res. 2020; 8: 913–921.

16. Yadav A, Sahu YK, Rajhans KP, Sahu PK, Chakradhari S, Sahu BL, et al. Fluoride Contamination of Groundwater and Skeleton Fluorosis in Central India. Journal of Environmental Protection. 2016; 7: 784–92.

17. Khairnar MR, Dodamani AS, Jadhav HC, Naik RG, Deshmukh MA. Mitigation of Fluorosis - A Review. J Clin Diagn Res. 2015; 9: ZE05-9.

18. Eklund SA, Burt BA, Ismail AI, Calderone JJ. High-fluoride drinking water, fluorosis, and dental caries in adults. J Am Dent Assoc. 1987;114: 324-8.

19. Torra M, Rodamilans M, Corbella J. Serum and urine fluoride concentration: relationships to age, sex and renal function in a non-fluoridated population. Sci Total Environ. 1998; 220: 81-5.

20. Cook FJ, Seagrove-Guffey M, Mumm S, Veis DJ, McAlister WH, Bijanki VN, et al. Non-endemic skeletal fluorosis: Causes and associated secondary hyperparathyroidism (case report and literature review). Bone. 2021; 145: 115839.

21. Del Carmen AF, Javier FH, Aline CC. Dental fluorosis, fluoride in urine, and nutritional status in adolescent students living in the rural areas of Guanajuato, Mexico. J Int Soc Prev Community Dent. 2016; 6: 517-522.

22. Dharmaratne RW. Fluoride in drinking water and diet: the causative factor of chronic kidney diseases in the North Central Province of Sri Lanka. Environ Health Prev Med. 2015; 20: 237-42.