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Water Defluoridation Efficiency of Clays From North Central Nigeria: Preliminary Reportfrom Langtang And Environs

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ABSTRACT
Cases of fluorosis caused by ingestion of water with high fluoride content in parts of northern Nigeria have been confirmed and the use of clays in defluoridation of water in other parts of the world is documented. Thispilot study was conducted in an attempt to view the efficiency of locally sourced clays for remediation of fluoridated water. Three clays were chosen based on their availability close to Langtang, an area of endemic fluorosis which is located around latitude 9°9ˈN and longitude 9°48ˈE in the southern part of Plateau State, North Central Nigeria. Clays from Shendam, Pushit and Mper with fluoride contents 495, 390 and 601 ppm respectively were selected for fluoride remediation. Results of physical and chemical parameters observed on the 2nd, 4th, 6th and 8th day showed, that the clays from Mper bestremediated the fluoride content in water having reduced it from 5.9 ppm to 1.20 ppm (within WHO acceptable standard of 1.5 ppm). On the other hand, clays from Shendam and Pushit reduced the fluoride content in the water after 8days from 5.90 ppm to 4.9 and 3.4 ppm respectively. The clay from Mper was thus recommended for use in defluoridation of water.
***Keywords**: Fluorosis, fluoride, defluoridation, remediation*

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I. Introduction

Fluorosis, an endemic disease caused by drinking excess of fluoride in drinking water and foods, is present in Nigeria. A detailed study of its occurrence in parts of Northern Nigeria has been carried out by [1].Fluoride is considered as a double edged sword, because, when consumed in drinking water and in foods in correct dosage, it strengthens the enamel and prevents dental caries. But when consumed in excess, it causes ugly brown stains on the teeth, called dental fluorosis [2, 3]. Long-term ingestion of excessive fluoride has a chronic effect on the kidneys as well [3]. The optimum level suggested by [4] is 0.5 mg/l from infancy to 16 years. Concentrations of fluoride in drinking water above optimum concentration result in a number of health effects, including skeletal fluorosis, dental fluorosis and crippling fluorosis. The upper limit for fluoride in drinking water is fixed at 1.5mg/l: above this limit, the water needs treatment for its removal [4]. The source of fluoride in water is related primarily to the geology and climatic conditions of a place [5]. Drinking water with high fluoride content is the main reason for development of fluorosis, but food items may also contribute in areas with high concentration of fluoride in soil [3]. For communities in developing countries where the groundwater is rich in fluoride and provision of alternative water supply is difficult, defluoridationwater is the only option to provide safe drinking water [6].Medically, fluorides play an important role in the prevention of tooth decay and may be applied locally in the form of toothpaste or ingested through drinking fluoridated water [6]. Previously, chlorine was added in drinking water but now common additives include hexafluorosilicic acid (H_2SiF_6) and sodium hexafluorosilicate (Na_2SiF_6).

[7] noted that fluoride concentration ranging from 0-0.5mg/l results in dental caries; 0.5-1.5mg/l concentration promotes dental health and prevents tooth decay; 1.5-4.0mg/l concentrations results in dental fluorosis (mottled teeth); 4.0-10mg/l concentrations causes dental fluorosis and skeletal fluorosis; while concentrations greater than 10 mg/l result in crippling fluorosis.Plates I below shows cases of fluorosis stains on the enamel and dental fluorosis (mild, moderate, severe and chronic cases) occurring in the Langtang area and environs.Additionally, [8] recently noted that excessive fluoride intake can affect the nervous system having observed significant relationships between water fluoride levels and Intelligence Quotient of school children in India.This

researchisset out to determinethe effectiveness of clayeypots from Langtang andits environs in thedefluoridationof

Plate I: Extents of Fluorosis in the area: (A) Mild; (B) Moderate; (C) Severe; and (D) Chronic

water.

II. The Study Area

The study area is located in the North Central Nigeria around latitude 9°9'N and longitude 9°48'E,occurring in the southern zone of Plateau State in Langtang North Local Government (Fig. 1).The area is characterized by a continental tropical climate, which is a climatic condition characterized by wide seasonal variations of temperature [9]. The rain which begins around April is heaviest in July through August with an annual average of about 1300 mm (Maximum in August, 296 mm) [10]. The mean annual temperature is 29°C with the hottest months being March and April with temperatures reaching 38°C, the coolest time is at the end of December and early January, when temperatures fall to 18°C [10].

III. Methodology

After literature review and reconnaissance geological investigation, three clayey soil samples were collected from Tunfung (NTA Kawo) in Shendam L.G.A, Pushit and Mper (Kunbum) in Mangu L.G.A(Fig. 2, Plate II). The samples were kept in a polyethylene bag and samples points were located on the map. Clay samples were pulverized using agate mortar and piston. Sieving was done using 6.3µm sieve. pH of the soil was determined while the samples were analysed for fluoride content at ACME Laboratories, Canada, using Fusion method.

The clays were then used for moulding of clayey pots (Plate III) that were to be used for storage of water with high fluoride concentration (as earlier determined by [1]. Having moulded the three pots from the clays, the water with high fluoride concentration was collected after in-situ measurement of temperature, conductivity, pH, and TDS (using four in one measuring equipment), and stored in the clayey pots with observation of physical parameters and water collection from the respective clayey pots on the 2nd, 4th, 6th, and 8th days. Collected watersamples were again analysedat ACME Laboratories, Canada, for their fluoride using fusion method.

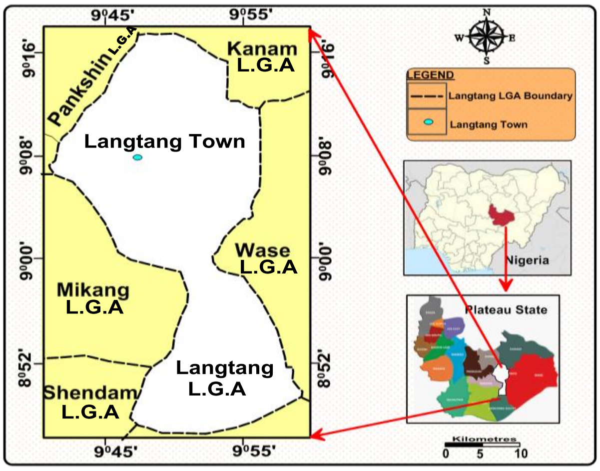

Fig. 1: Location map of the study area showing Langtang and Environs (Inset: Location of Langtang in Plateau State and Plateau State in Nigeria) (Modified from [11])

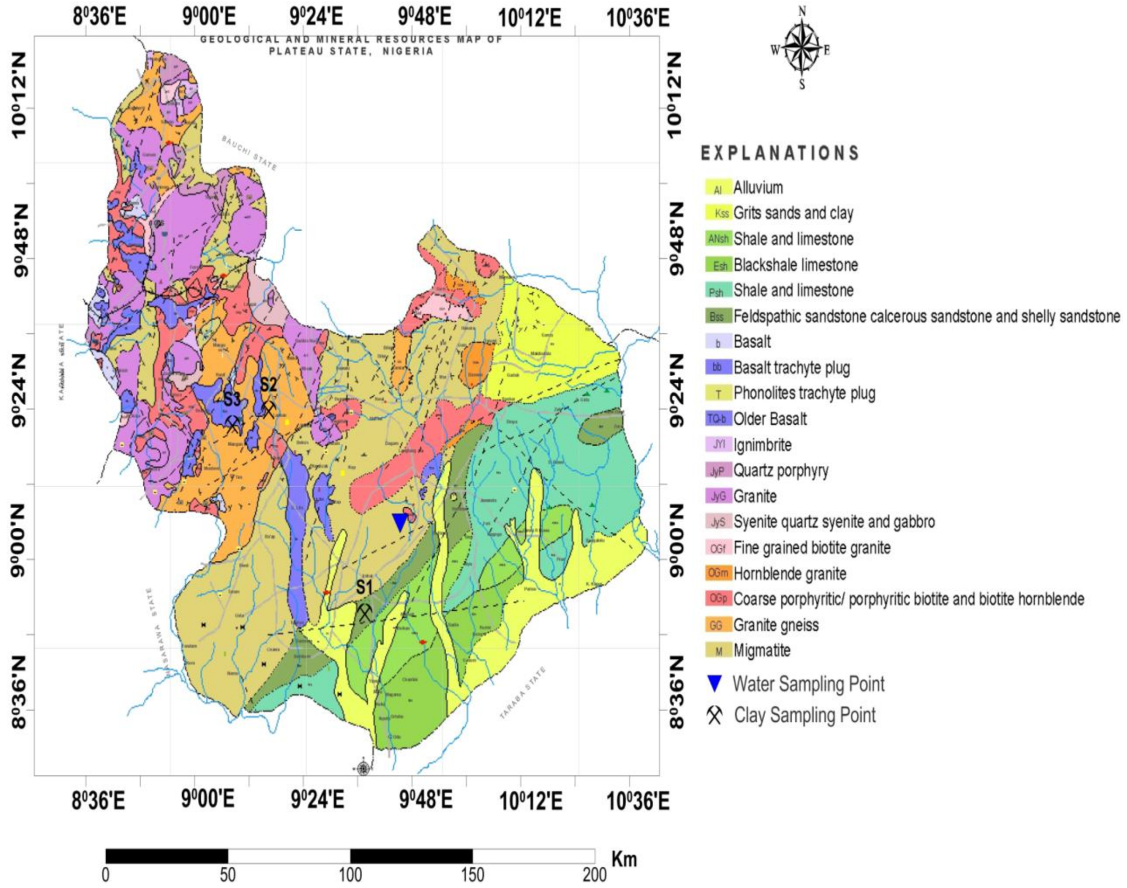

Fig. 2: Geological Map of Plateau State showing clay and water sampling points[12]

Plate II: Clay Sampling Points (A) Tunfung (NTA Kawo), Shendam LGA; (B) Pushit, Mangu LGA; (C) Mper (Kunbum), Mangu LGA.

Plate III: Clayey pots moulded from areas with least fluoride content: (A) Shendam; (B) Pushit; (C) Mper

IV. Results

4.1 Fluoride content and pH of clay samples

The fluoride content of the clay samples is shown in Table 1. It was found that clays from Shendam, Pushit and Mper (495, 390 and 601 Ppm respectively) had low fluoride concentration. The pH of the soils ranged from 6.36 in Mper to 8.08 in Shendamand thus was slightly acidic to basic.

Table 1: Fluoride concentration and pH in clays analysed from the study area

Location	Shendam	Pushit	Mper
Sample ID	S 1	S 2	S 3
Sampling Date*	27/12/2016	28/12/2016	28/12/2016
Analysis Date*	10/03/2017	10/03/2017	10/03/2017
F^- (ppm)	495	390	601
pH	8.08	6.36	6.38
Remark	Basic	Slightly Acidic	Slightly Acidic

*Date (dd/mm/yy)

4.2 Groundwater Remediation

The physical parameters of TDS, Temperature, conductivity and pH were measured in-situ (Table 2). Measurements were also done on the 2nd, 4th, 6th and 8th days. pH ranged from 7.13 (in CAO 44) to 7.84 (in raw water sample), TDS varied from 159 to 217 (ppm), temperature ranged from 21°C in Pushit (Day 2 and 4) to 26°C in the raw water sample and Shendam sample (Day 6). Conductivity on the other hand varied from 256 (in Mper, Day 4) to399µS/cm inShendam sample (Day 2) (Table 2).

The trend of variation of the physical parameters when remediation began using clayey pots was also observed with a desire to compare with variation in fluoride content (Fig. 3).

The variation and effectiveness of the clay pots in defluoridation was observed and compared with world standards. In the water remediated using clayey pot from Shendam, fluoride concentration was reduced from 5.9 to 4.9 ppm representing a 17% reduction. That from Pushit reduced the fluoride concentration from 5.9 to 3.4 ppm representing a 42% reduction while that from Mper boasted an 80% reduction in fluoride content after eight (8) days of remediation (5.9 to 1.2 ppm) (Table 3, Fig.4).

Table 2: Physical parameters measured from raw and remediated water (measured at time of sampling)

S/N	Location	Lab No.	Sampling Date	pH	TDS (Ppm)	Temp (°C)	ConductivityµS/cm
1	Raw Water*	WAO 1	17/4/17	7.84	183	26	285
2	Shendam, Day 2	S1 2	19/4/17	7.66	197	23	399
3	Pushit, Day 2	S2 2	19/4/17	7.46	181	21	333
4	Mper, Day 2	S3 2	19/4/17	7.60	168	22	300
5	Shendam, Day 4	S1 4	21/4/17	7.13	215	23	308
6	Pushit, Day 4	S2 4	21/4/17	7.56	181	21	304
7	Mper, Day 4	S3 4	21/4/17	7.16	166	22	256
8	Shendam ,Day 6	S1 6	23/4/17	7.90	217	26	389
9	Pushit, Day 6	S2 6	23/4/17	7.69	175	24	309
10	Mper, Day 6	S3 6	23/4/17	7.36	167	23	290
11	Shendam, Day 8	S1 8	25/4/17	7.96	203	25	305
12	Pushit, Day 8	S2 8	25/4/17	7.91	159	24	299
13	Mper, Day 8	S3 8	25/4/17	7.65	160	24	258

***Initial values before treatment**

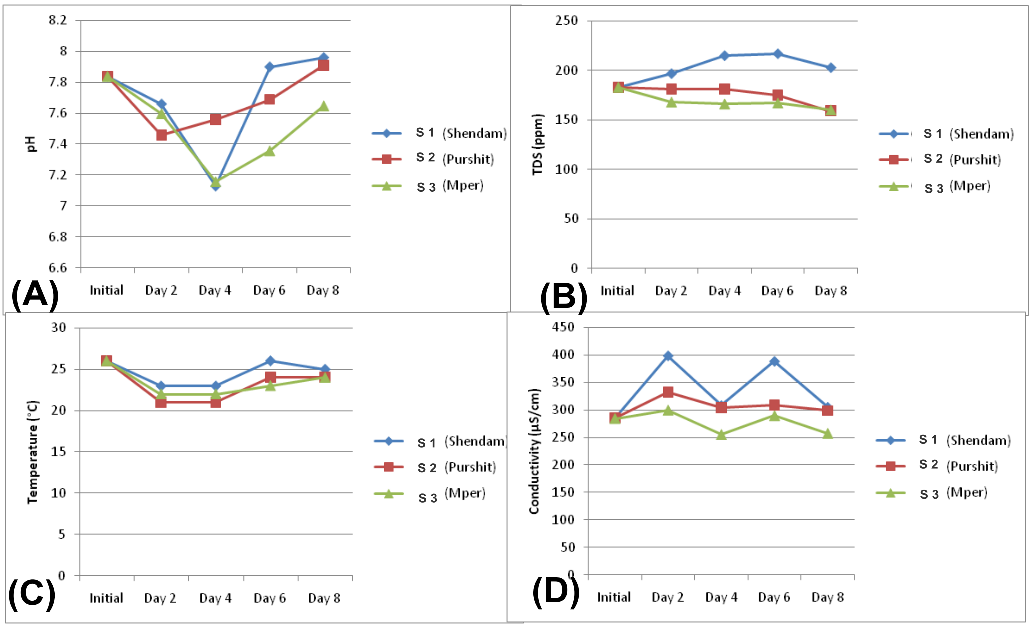

Fig. 3: Variation of physical parameters with days of clayey pot treatment: (A) pH; (B) TDS; (C) Temperature; (D) Conductivity

Table 3: Variation in fluoride content of water after remediation with clay pots (Sampled (27-28)/2/2017, Analysed 02/6/2017)

Locality	Lab No	Initial (F^-, ppm)	Day 2 (F^-, ppm)	Day 4 (F^-, ppm)	Day 6 (F^-, ppm)	Day 8 (F^-, ppm)
Shendam	S 1	5.9	5	4.8	4.8	4.9
Pushit	S 2	5.9	4.1	3.7	3.6	3.4
Mper	S 3	5.9	2.8	2.2	1.5	1.2

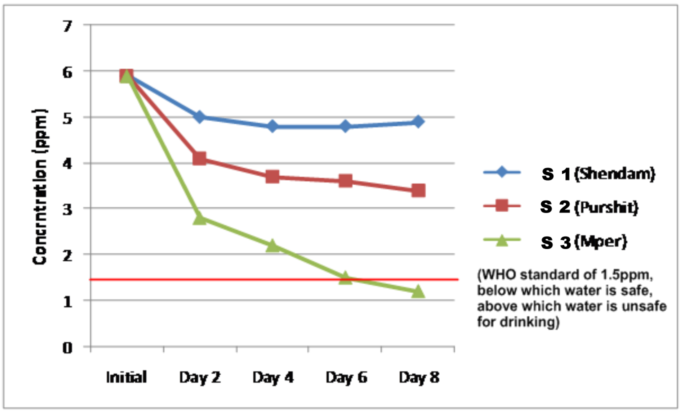

Figure 4: Plot showing variation in fluoride content of water on remediation with clay pots

V. Discussions

The results obtained fromthe clayey pots sourced locally indicate itcan be used in remediation of high fluoride in groundwater as has been proven in other countries[13,14,15,16,17,18,19,20,21,22,23,24,25,26].

The choice of which clay in the environs of the Langtang area is best for fluoride remediation has shown that remediation clays from Pushit and Mper display better remediation/ fluoride adsorption ability. Comparison of trends of fluoride content with time and other physical parameters like TDS, temperature, pH and conductivity with time show high positive correlation between fluoride, TDS and conductivity (Table 4). However, pH which has been severally related to fluoride content [27,28,16,17,29,30,20,31,22,32,33,25] was found to be weak as correlation between fluoride content and pH was found to be 0.3761 (Table 4).

Table 4: Correlation matrix showing relationship between fluoride and physical parameters

	pH	*TDS (Ppm)*	*Temp (°C)*	*Conductivity µS/cm*	*F-*
PH	1				
TDS (Ppm)	0.087086	1			
Temp (°C)	0.659593	0.328259	1		
Conductivity µS/cm	0.366676	0.664973	0.256544	1	
F-	0.376108	0.741313	0.386774	0.747157	1

VI. Conclusion And Recommendations

From the foregoing, it can be concluded that the clays from Mperhas the highestdefluoridation efficiency as it reduced fluoride content to within [4] limits for save drinking water after six (6) days. Thus, the clayey pot from Mper is recommended for use in defluoridation of groundwater around Langtang area which known for endemic occurrence of fluorosis. Additionally, research into the mechanisms of fluoride adsorption by the clays in the area is advocated.

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