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EVALUATION OF INDUSTRIAL POTENTIALS OF ALLUVIAL CLAYS FROM THE CONFLUENCE OF RIVERS NIGER AND MIMI

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ABSTRACT
Physio-chemical and mineralogical studies were carried out on alluvial clay samples obtained from the confluence of River Niger and Mimi River in lokoja (Kogi state), to determine their suitability for industrial applications. Energy Dispersive X-ray Fluorescence (EDXRF) analysis of the composite sample indicated very low levels of alumina (13.76%) and silica (27.18%). The alkaline earth (CaO) and alkali (K_2O) minerals were 1.17% and 2.68% respectively. Other impurities such as TiO_2 and CuO were in traces. The % Fe_2O_3 was 5.82. X-Ray diffraction (XRD) analysis indicated laumontite as the main clay mineral phase in the composite sample with minor amounts of plancheite, Hibonite-5H, Sym; and Chlorocalcite. The unified classification of the composite sample indicates the clay sample has limited industrial potential because of the high silty organic content. However, the clay sample is suitable for making building blocks, traditional ceramic pots and insulation bricks. The clay may be beneficiated to enhance its porosity for application as an adsorbent.

Key words: Evaluation, Alluvial, Clay, Confluence, Rivers, Niger, Mimi

INTRODUCTION
Clays have become important materials in modern technology, finding applications in ceramics, refractories, paper foundry, rubber, paints, plastics, insecticides, pharmaceutical, textile and adhesives industries (Irabor, 2002; Odo & Nwajagu, 2003). Amazing variety of clays with different structures and chemical compositions have been discovered in Nigeria (Elueze *et al*., 1999; Gbadebo, 2002; Irabor, 2002; Sullayman & Ahmed, 2003). However, many clay deposits in Nigeria still remain unidentified and uncharacterised (Odo & Nwajagu, 2003; Lori *et al., 2007*). Therefore, in response to the challenges that may be posed by the demand for clay materials in Nigeria, indigenous clays with industrial potentials need to be investigated. Some workers (Akpokodje, 1992; Adeyemi, 1994; Gbadebo, 2002) have investigated geotechnical properties of clay materials in Nigeria. Adeyemi, (1994) inferred that differences in mineralogical and engineering properties of clays are often caused by pedogenic factors such as parent rocks, relief and climate. Borode *et al.,* (2000) reported the alumina content of some Nigerian clays to be low, for their use alone without blending. Obikwelu, (1987) suggested blending two or more clays from different locations helps to improve the characteristics of clay materials for industrial applications. Sources of clay deposit in Nigeria include, Ifon, Itu, Kankara, Barkinladi, Ozubulu, Ara-Ijero, Orin-Ekiti, Omibode, Ijoko, Ibamajo, Ara-Ekiti, Eha-Alumona, Isan, Ikere, Ezinachi-Okigwe, Jos, Oshiele, Enugu, Ukpor and Niger Delta (Borode *et al.,* 2000; Fasuba *et al.,* 2001; Omowumi, 2001; Irabor, 2002; Gbadebo, 2002; Igbokwe & Ogbuagu, 2003; Sullayman & Ahmed, 2003; Odo & Najagu, 2003).

Extensive studies on the alluvial clays from the confluence of Mimi and Niger rivers have not been pursued. This study is important to the development of materials database to facilitate many of the desired developments in Kogi State and Nigeria in general. The only systematic search for clay in the State was carried out in conjunction with the Jakura marble investigation and the study reported two possible sources of clay in the vicinity of Jakura (Hazell, 1956). According to this study one source occurs as beds within the cretaceous sediments and the other as alluvial deposit which was reported to be the best occurring at about 2.5km south of Lokoja at the confluence of the Mimi and Niger rivers (Hazell, 1956). The object of this study therefore, is the physiochemical and mineralogical analyses of the alluvial clay, to evaluate its industrial potentials.

MATERIALS AND METHODS
The study area and sampling: The area under study is delimited by latitude 7^0 and 8^0N and longitude 6^0 and 7^0E. The vegetation, cover over the basement rock and much of the sedimentary rocks is guinea savannah with the denser (gallery) forest fringing some of the rivers and the steeper slopes formed by out cropping cretaceous rocks where they immediately over lie the basement. Patches of high forest occur on the basement in the forest reserve in the southeast. The whole area is drained by the Niger-Benue river. The alluvial clay mineral deposits are along the Mimi river in Lokoja at the vicinity of Jakura. The alluvial covers a considerable area around the Niger/Benue confluence which is a continuous strip up to 4km wide along the valley of the lower Niger between Lokoja and Idah and a large area in the southeast associated with the Niger and Anambra Rivers (Hockey *et al.*, 1986). Composite samples of clay were obtained from two different locations by the method of hand dug pits from various depths across the deposit (Gbadebo, 2002).

Methods of analysis: The pH of the composite sample was measured in clay suspension using clay: salt solution at 1:2 (w/v) and clay in water mixture, while loss on ignition and linear shrinkage were determined according to the methods described by Omowumi, (2001). Firing characteristics of the samples were studied by heating the samples to 1000^0C for an hour in muffle furnace. The Atterberg limits (liquid limit (LL), plastic limit (PL) and plasticity index (PI) for the clay samples were measured using standard protocols (Casagrander's equipment).

Energy Dispersive X-ray Fluorescence (EDXRF) analysis: The samples were ground manually to powder with an agate mortar and pestle to grain size of less than 125μm. Pellets of 19mm diameter were prepared from 0.5g powder mixed with three drops of organic liquid binder (polyvinyl chloride, dissolved in toluene) and pressed at 9 x 10^4N with a hydraulic press. Measurements were performed using an annular 25 mCi ^{109}Cd as the excitation source that emits Ag-K X-rays (22.1KeV) in which case all elements with lower characteristic excitation energies were accessible for detection in the samples. The system consists of a Si(Li) detector with a resolution of 170eV for the 5.90KeV line, coupled to a computer controlled ADC-card. Quantitative analysis of the sample was carried out using a modified version of Emission- Transmission (E-T) method (Angey *et al.,* 1998; Funtua, 1999), which involves the use of pure target materials (Mo) to measure the absorption factors in the sample. The Mo target serves as a source of monochromatic X-rays, which are excited through the sample by primary radiation and then penetrate the sample on the way to the detector. In this way, the absorption factor was experimentally determined automatically and the computer program used it in the quantification of concentration of the element. The contribution to the Mo-K peak intensity by the Zr-K was subtracted for each sample. Sensitivity calibration of the system was performed using thick pure metal foils (Ti, Fe, Co, Ni, Cu, Zn, Zr, Nb, Mo, Sn, Ta, Pb) and stable chemical compounds (K_2CO_3, $CaCO_3$, Ce_2CO_3, WO_3, ThO_2 and U_3O_8). The spectra for the samples were collected for 3000s with the 109Cd source and evaluated using the AXIL-QXAS computer program (Benasconi, 1996; Benasconi *et al.*, 1996). The ^{109}Cd source was used for the determination of Fe, Ti, Ca, K and Cu. The alumina and silica content of the clay sample were determined using Neutron Activation Technique.

X-Ray Diffraction (XRD) analysis: The pulverized clay sample was prepared by creating a highly polished surface in the cavity of the sample holder of the Pw 1800 diffractometer with copper tube anode. This was introduced to the XRD equipment which scanned the sample continuously from $0^0 2\theta$ - $70^0 2\theta$ for clay bulk analysis. A generator tension of 40kv and current of 55mA were used. From the XRD traces, the clay minerals in the samples were determined by their diagnostic peaks.

RESULTS

The chemical composition of the composite alluvial clay sample indicated very low alumina (13.76 %) and silica (27.18 %) contents (Table 1). The alkaline earth mineral (CaO) and the alkali mineral (K_2O) were 1.17 % and 2.68 % respectively. The level of iron oxide (5.82 %) was high and the clay samples changed from grey to reddish brown, when heated to 1000 ^0C for one hour. The mineralogical and other physical characteristics of the clay are in Table 2. The classification of the alluvial clay sample according to the unified soil classification system is indicated on the plasticity chart (Fig. 1). The mineralogy of the clay sample is shown on the x-ray diffractogram of the sample (Fig. 2).

TABLE 1. CHEMICAL COMPOSITION OF THE ALLUVIAL CLAY SAMPLE

Oxides	% Composition	% Error
Al_2O_3	13.76	-
SiO_2	27.18	-
Fe_2O_3	5.82	0.07
TiO_2	0.71	0.10
CaO	1.17	LOD
K_2O	2.68	0.56
CuO	0.02	LOD

LOD: Limit of detection.

TABLE 2. MINERALOGICAL COMPOSITION AND PHYSICAL PROPERTIES OF THE ALLUVIAL CLAY SAMPLE

Sample	Atterberg limits (%)			Linear shrinkage (%)	Firing at 1000°C for 1 hour	Minerals	PH		Loss on ignition (%)
	Liquid Limit	Plastic limit	Plasticity index				$CaCl_2$	H_2O	
A	58.00	34.00	24.00	12.00	Sample Changed from grey to reddish brown	Laumontite, plancheite, Hibonite 5H, Syn chlorocalcite	8.17	8.20	11.90
B	57.00	38.00	19.00	11.00					
A+B	59.20	39.20	20.00	12.14					

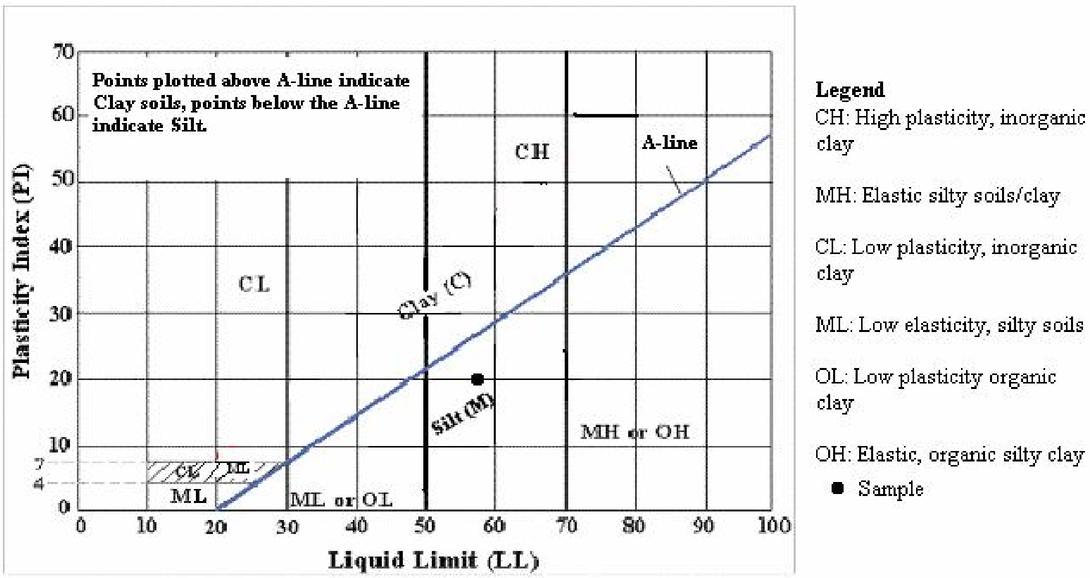

FIG. 1. PLASTICITY CHART FOR UNIFIED SOIL CLASSIFICATION SYSTEM SHOWING THE LOCATION OF CLAY SAMPLE

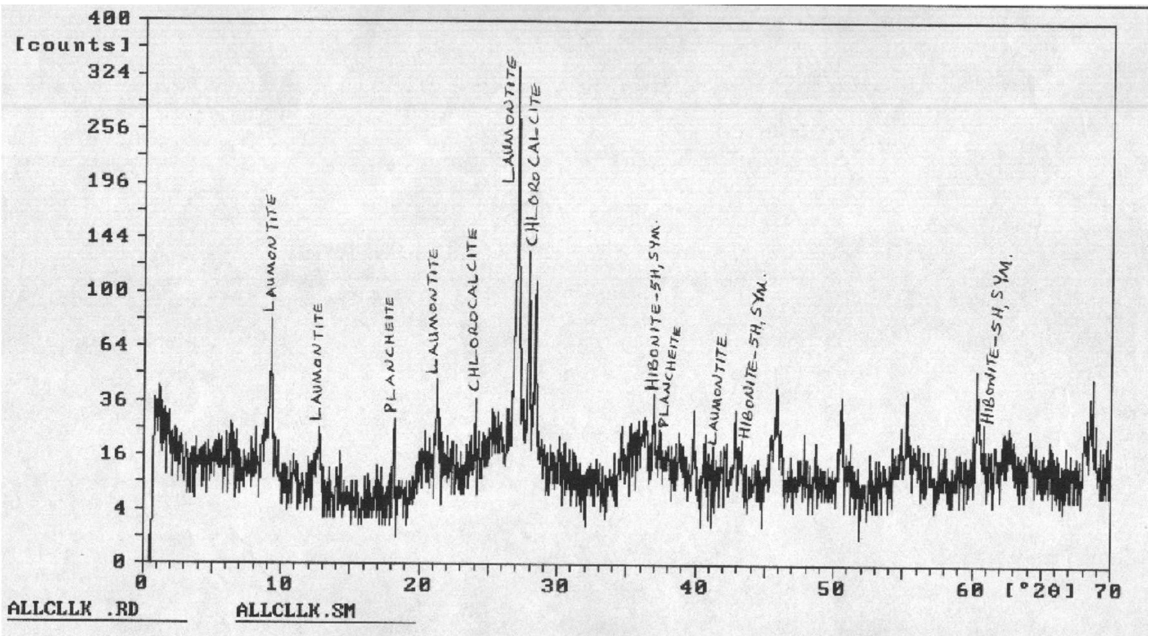

FIG. 2. X-RAY DIFFRACTOGRAM OF THE ALLUVIAL CLAY SAMPLE

DISCUSSION

The change in colour of the studied clay samples from grey to reddish brown upon firing at 1000 ^{0}C for 1hr suggests the presence of high level of iron (5.82 wt%) and organic matter. The high average liquid limit value of 57.5 wt% indicates a sample with a high water retention capacity. Atterberg plasticity index (API) of 20wt% shows that the sample is plastic over a wide range of moisture content. This also corroborate the high alkali content of 3.85 wt% in the sample. The plot of the values of the liquid limit (LL) versus the Atterberg plasticity index (API) on the Cassgrande's plasticity chart (Fig.1), describes the alluvial clay sample as an inorganic silty-clay of high compressibility and plasticity. The high plasticity index reveals the clay's potential for great volume change characteristics. The silt content makes the sample material unsuitable for wide ceramic applications.

The very low alumina (13.76 wt%) and silica (27.18 wt%) contents compared with refractory standards (25-45 wt% alumina and 55-75 wt%- silica), coupled with the high levels of iron and organic matter make the clay sample very unsuitable as a refractory material. However, the clay sample is suitable for making building blocks, traditional ceramic pots and insulation bricks.

The combined alkali contents of 3.85 wt% fall within the limit of the recommended 2-5wt% (Chesti, 1994). Other impurities such as TiO_2 and CuO occur as traces and within acceptable limits. The loss on ignition (11.90wt %) fall within the limits (6-18wt %) (Chesti, 1994) for clay materials. The average linear shrinkage of 11.17wt % is considered high and unsuitable for ceramic fabrications because this property measures the capacity of the material to hold finishing or dimensional tolerances.

The clay sample may not be suitable for bleaching oils because of the presence of Ca and K in addition to its associated high pH (8.17) in salt solution. This observation places the clay sample among the unleached clay with natural disposition to high retention of K and Ca.

The X-ray diffraction (XRD) analysis of the clay sample revealed Laumontite as the main mineral phase in association with other clay minerals such as plancheite, Hibonite- 5H, Sym and Chlorocalcite (Fig.2).

CONCLUSION

The geotechnical property and mineralogy of the alluvial clay sample from the study area indicated only a few of the characteristics required for industrial utilization. The unified classification of the sample infers that the clay sample has limited industrial potential because of the silt and organic contents. However, the clay sample may be used for making building blocks, traditional ceramic pots and insulation bricks. The clay may be beneficiated to enhance its porosity for application as an adsorbent.

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