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QUALITY ASSESSMENT OF KAOLIN CLAY FROM OZANAGOGO, UMUTU AND OTORHO, DELTA STATE, NIGERIA

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Abstract: The composition of kaolin clay collected from Ozanagogo, Umutu and Otorho in Delta State were studied for their purity, and their mineralogical composition using X-ray diffractometer and Atomic Absorption Spectrophotometer. The elemental compositions determined were CaO K_2O, MgO, Na_2O, Fe_2O_3, Al_2O_3, SiO_2 and structural water, while heamatite was a major impurity. The CaO was the major tracer and was within acceptable limits for a variety of uses. Mineralogical analysis revealed the presence of kaolinite and quartz in all CaO ranges from clay types in different amount 10.31% in Otorho to 30.21 in Ozanagogo Al_2O_3 and SiO_2 which were minor tracer element were 29.62%- 39.90% and 30-17- 42.37%. The highest being Ozanagogo clay. The kaolin quality obtained from Ozanagogo was within the limits accepted by British Industrial Standards, (BIS) and American Society for Testing Materials (ASTM) standard specification for use in manufacturing of many products

Keywords: kaolin, X-diffractometer, Quality, Mineralogy, Clay.

INTRODUCTION

Kaolin clay or china clay in soft, pure white clay but usually low in plasticity. Its chief constituent is the mineral kaolinite, a hydrous aluminium silicate, $Al_2 Si_2O_5 (OH)_4$ formed by the decomposition of aluminium silicate (Truman and Thomas, 2008). In Nigeria, it is found Delta, Kebbi, Kastina, Kano Kogi and Kwara State in its pure form, it is used in the manufacture of fine porcelain and china. Impure form is used in making pottery, stoneware, bricks, paper industry as fillers in the bulk, it is applied as white wares providing strength and plasticity in ceramics products, it improves the optical, mechanical and rheological properties of paints and it is used in pharmaceuticals for the production of human and vertinary medicine for the treatment of digestion problems (Dipa *et al*., 2002). These varying applications highlights the importance of this minerals in a developing nation like Nigeria (Mokobia, 2011). Clay can be added to the other constituents of cement during its production in order to control the setting time when mixed into paste with water or when mixed to form concrete. Other uses include surgical plaster, fertilizer, soil reclamation and effluent treatment (Ajayi and Dugba, 2004). Clay is a universal sieve. Geologist see clay materials as sediments or sedimentary rock particles with a diameter of less than 2 microns and as a group of minerals with a specific range of composition and a particular kind of crystallographic structure and contain other metals in addition to aluminium such as magnesium, sodium, calcium and iron X-ray diffraction cameras are the instruments that have finished us with modern information about clays. The industries mentioned above can make use of kaolin clay, but certain standards must be ascertained, cost of importing pure clay is high and there is need to explore local products which is cheap and readily available and environmentally friendly (Ahmadi, *et al,* 2005). This work therefore provides the basic quality of kaolin clay which would be the basis of reduction of imports and enhances economic activities for the local people.

The raw materials for these products named above especially kaolin are widely available locally. Nevertheless, some raw materials as high quality kaolin, ball clays, fire clays, for fine ceramics, porcelain and electrical insulators are imported (Ece *et al,* 2003). Kaolinite is a common phyllosilicate mineral with the formular mentioned above. It is composed of alternating layers of silicate (Si_2O_5) and gibbsite ($Al_2(OH)_4$) (Murray, 2000). Kaolin crystals are usually arranged in pseudohexagonal plates forming flaky aggregates and same chemistry as its polymorphs, halloysite, dickite and nacrite. It is formed as a result of the alteration of aluminosilicates and volcanic glasses. It usually contains different minerals as quartz. Large volume of kaolinite clays are used for cements, ceramics, bricks and porcelain as mentioned above but the greatest demand is in the paper industry to produce high quality paper (Bunde and Ishley 1991). In the Agricultural sector, it is used to help control damage in fruits and vegetables from insects, termites, fungi. In homes, it is used to manufacture ceiling boards used to protect sunburn and heat stress. In the paint manufacturing industry for instance, kaolin is used to create the effect of whiteness as well as hold every other ingredient together. The degree of whiteness of any paint, therefore, depends on the quality or grade of kaolin being used in its manufacture (Oruobu, 2004).

There is an ongoing interest to utilize kaolinite clays amongst others in construction industry. Special grade kaoline clay used for white cement production clinker involves clay of about 65-80% SiO_2 or sometimes less is used Al_2O_3 of 18.20% -30.10% and minor impurities (Sobolev, 2001). A recent development comprises the application of meta kaolin as an artificial pozzolanic additives for concrete. Its strength and durability of these material is improved by addition of thermally activated kaolin. This is due to the ability to improve the packing of the cement matrix as a microfiller effect, improves its morphology and the aggregate's surface. It also improves its strength and durability which is one of the component of modern architectural concrete. It is proposed that raw clays with 20-35% of kaolin can be used in pozzolanic additives to paper filler fertilizers. Ceramics which will reduce the production expenditure related to intermediate beneficiation and drying of raw materials, further more thermally activated kaolin is readily available at reduced cost.

MATERIALS AND METHODS

Materials

Kaolin clay samples were obtained from Ozanagogo in Ika South local Government Area, Umutu in Ukwani local government Area and Otorho in Ethiope East Local Government Area all of Delta State. Sampling procedures by (Nelson, 1994) and (ASTM, 1997) were adopted for this work. Sampling points of 30 meters apart were identified, excavated at 2- 3.0m depth of soil (clay) weighing about 400g. A gross sample was made by mixing the 400g obtained from the four points and a representative sample of 5g was taken for analysis.

Ozanagogo's location is latitude $6^0 8^0$- 6^0 10^1 N and longitude $6^0 6^1$ – 6^0 17^1 E in Ika South Local Government Area of Delta State. Umutu lies between longitudes 6^0 13 and 6^0 115^1 E and 05^0 50^1 and $05^0 52^0$ N and Otorho longitudes 05^0 42^1 and 05^0 45^0 E and latitudes $05^1 25^1$ and 05^0 30^1 N of the equator.

Mineralogical Analysis

X-ray diffractometer PW 1800 powder diffractometer with peak width inbuilt standard was used. Samples were air dried on a flat plastic sheet, pulverized and 2.5g were measured and mixed with sodium based coagulant and the paste sweared in a thin layer into the instrument. It cross- matched the peaks and came out with the mineral constituents using soft X SPEX version 5.62. It was carried out at National Steel Raw Material Exploration Agency in Kaduna, Nigeria.

Geometrical Analysis

2.5 g of the air dried sample was digested using concentrated hydrofluoric acid (HF), Hydrochloric acid (HCl) and perchloric acid ($HClO_4$) in ratio 3:2:1. It was cooled, filtered and made up to make. Atomic Absorption spectrophotometer spectral – 10 was used for elemental and structural water determination in accordance with Lenore et al. (2009) (ASTM, 1997). From the clays studied, the kaolin group was present in all of the clay types with OZ possessing the highest percentage of koaline (58.2%) and OT lowest (30.2%). Other groups like saponite, smectite (Montmorillorite) and chlorite were present only in OT, and chlorite in UM respectively. The sequential arrangement is as follows OZ > UM > OT.

The XRD results of the mineralogical analysis or assemblages of the samples are shown in Table 1 and Figures 1, 2 and 3 respectively. The results, of the mineralogical composition of the clays showed that the dominant minerals present were kaolin and quartz with quartz constituting about 27.5% for OZ, 34.2

for UM and 10.0% for OT. It differs from one clay deposit to another. Illite was 10.1% for OZ, 12.10 for UM and 6.20% for AM. Which are below recommend average values of 15% for china clay of high purity. The high dominance of quartz in the clays deposits clearly suggest clay of residual origin. OZ clay differs from the others UM and OT in terms of its mineralogical composition (Emofuneta, 1992). It was mainly kaolin clay 58.2% and 10.10% illite and quartz while OT has all the components present.

The results from the geochemical analysis showed that all the clay types contain mainly (SiO_2) and Alumina (Al_2O_3), Heamatite (Fe_2O_3) was highest in UM as found in the mineralogical assemblage. They are all high in kaolin clays. The tracer element CaO was highest in OZ (30.21%), UM (21.40%) and 10.31%) for OT. Structural water was least for Oz to show for the percentage purity of clays from Ozanagogo. The principal elements Ca and CaO were highest in OZ since kaolin clay contains SiO_2 and Al_2O_3 mainly but the presence of CaO enhances it for many industrial application (BIS, 1997). Fe_2O_3 was a major impurity which was highest in UM. Kaolin clay from OZ (30. 21%) of CaO can be used for surgical plaster of higher purity if purified (Alther *et al*, 2008).

From table 2, based on the Al_2O_3 to SiO_2 ratio, it can be expected that these kaolin clays are of high quality. From the chemical analysis, clays contain 20% of Al_2O_3 being the sublimite and all clay samples have above 20% of Al_2O_3 in agreement with Murray (2000). Low Al_2O_3 kaolin could be utilized for white cement clinkers (Subject to other composition restriction), and high Al_2O_3 content can be used for production of pozzolanic additives in addition to other purifying processes. The low values of combined water is expected from OZ since it has high kaolin content which easily absorbs water. The low level of structural water at Ozanagogo indicates the high level of purity of clay in this area (Munay, 2003).

Table 3 shows the time taken to obtain the first drop and 100ml of water described as the residence time (Manual of Practice, 1980). The higher the CaO content, the lower the residence time and the faster the setting time of clay. This depend on the mineral composition of the clay samples (Gatos, et al, 2007). The montmorinollinite clays retain water better than kaolinite clays. The lower the retention time the better the setting time of clays. It follows this order OZ > UM>OT kaolin clays are not expanding clays and do not have high swelling ability compared with the smectite clays which have high swelling ability (Umudi, 2012). UM and OT contains chlorite, saponite, smectite, illite and mixed layer. This may be responsible for the time to collect the first drop and to collect 100ml which is also known as the residence time because these groups are expanding clays with high swelling ability (John, 2002).

CONCLUSION

From the result of this study, it can be concluded that CaO which is the major tracer component in addition to SiO_2 and Al_2O_3 of kaolin clays were reasonably high and fall within acceptable limits required for many applications. The kaolin contented showed no variation with the CaO values. The higher the CaO content, the lower the SiO_2 content of kaolin clay. OZ is of a better quality in terms of the content of CaO.

It is suitable for moulding mixture in cast iron, steel fundry and insulator refractory bricks, papers, paints and fertilizers from its mineralogical investigation. Advantage of its existence, accessibility, availability, low cost and peaceful environment should be taken into consideration by governmental and non-governmental bodies, to explore this mineral for the benefit of man.

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RESULTS AND DISCUSSION

Table 1: Mineralogical Composition (%) of clays used for the studies.

Clay minerals	Ozanagogo OZ	Umutu UM	Otorho OT
Saponite	Nil	Nil	5.8
Montmorillorite	Nil	Nil	6.1
Chlorite	Nil	4.3	20.3
Illite	10.1	12.1	6.2
Mixed layer of illite and montmorinollorite	Nil	Nil	21.4
Kaolinite	58.2	43.2	30.2
Quartz	27.5	34.2	10.0
Heamatite	4.2	6.2	Nil
Total composition	100	100	100

Table 2: Mean percentage composition of oxides from geochemical analysis

% oxide	OZ	UM	OT
SiO_2	33.12	30.17	42.37
Al_2O_3	29.95	31.90	29.60
Fe_2O_3	3.89	9.89	6.61
Na_2O	1.88	0.86	1.97
MgO	2.90	1.70	1.93
K_2O	2.60	1.40	2.69
TiO_2	3.23	0.60	0.99
CaO	30.21	21.40	10.31
H_2O	1.52	2.44	3.53

Table 3: Results of Percolation studies

Clay sample	Time to obtain	Time to obtain
	First drop of water $1h^{-1}$	100ml of water $1h^{-1}$
OZ	3.1 (2hrs. 01min)	2hrs 51 mins (2.2)
UM	2.2 (2hrs 55min)	3hrs 49 min (1.6)
OT	1.7 (3. 48min)	4hrs 34 mins (1.3)

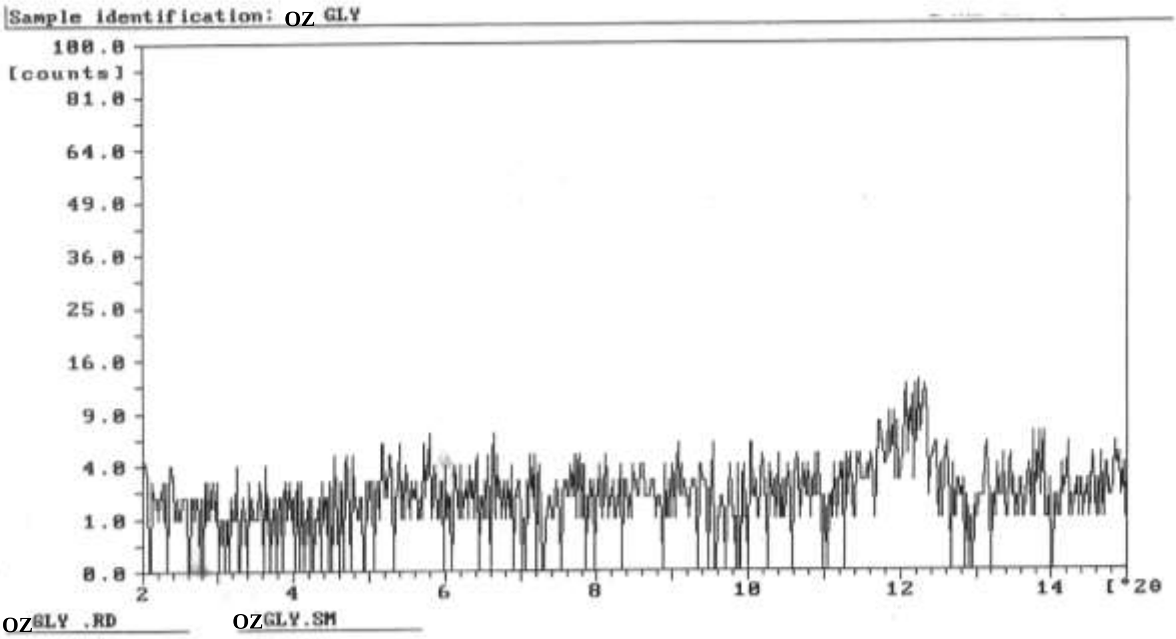

Fig. 1: Diffractogram of Clays for OT

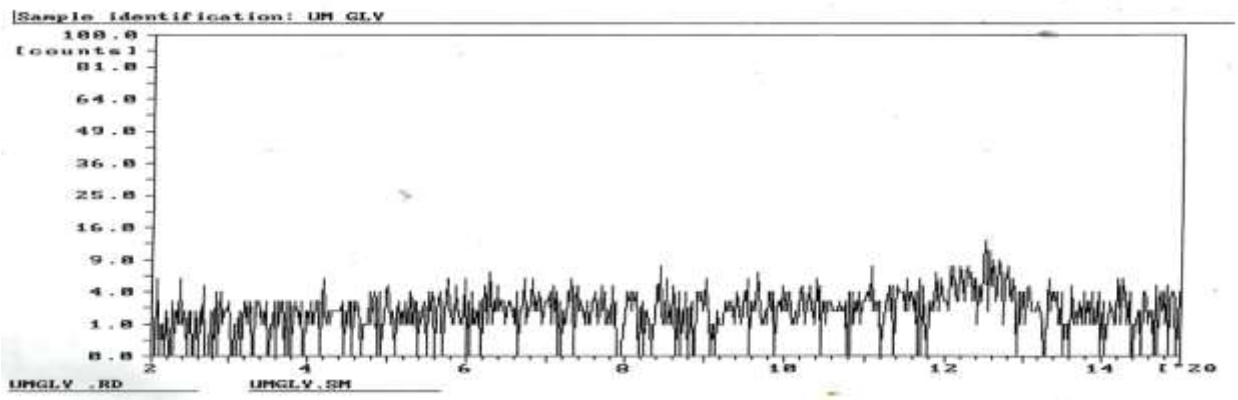

Fig. 2: Diffractogram of Clays for UM

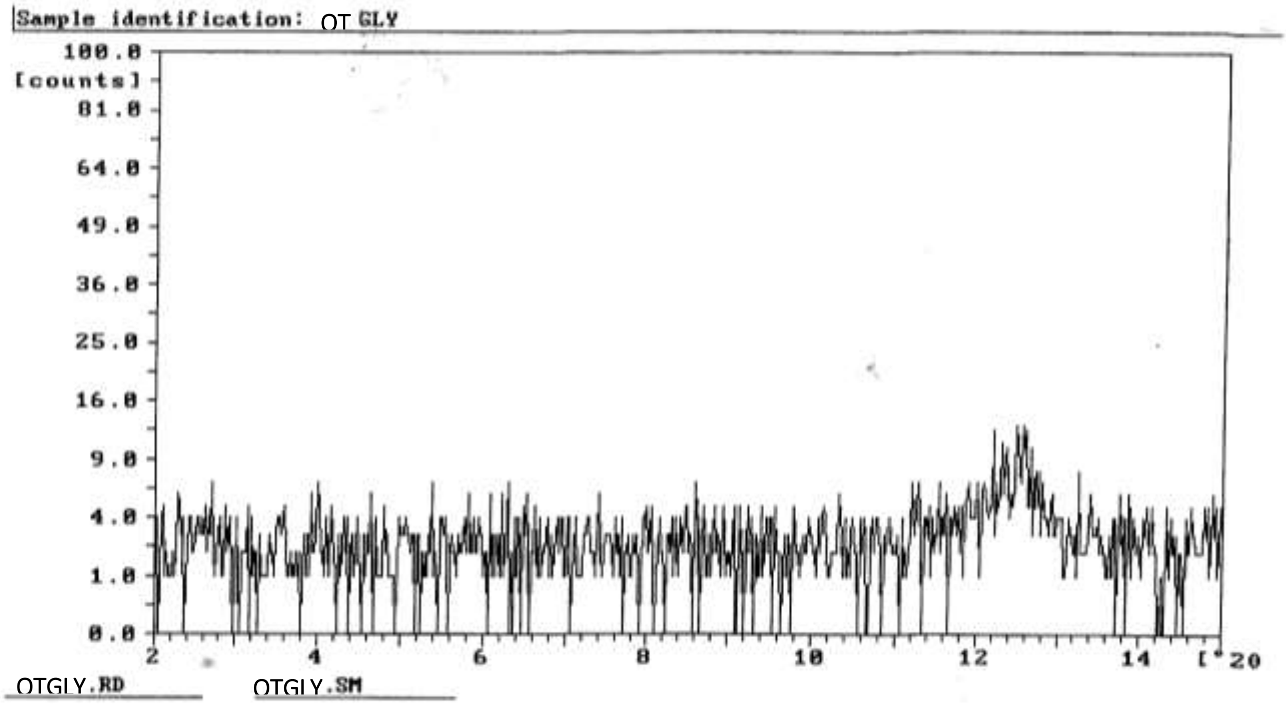

Fig. 3: Diffractogram of Clays for OT

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