CERAMIC MATERIAL DEVELOPMENT FOR CERAMIC SUSTAINABILITY: A STUDY OF NUMAN POTTERY CLAY

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Abstract
Like human beings the behavior of clay cannot be fully predicted on mire observation, unless the components of the clay and its level of purity are ascertained. The Bachama people of Numan District in Adamawa State of Nigeria have for many years been using the clay along the Gongola/Benue river valley for their breath taking traditional pottery. Due to lack of adequate scientific study of the clay, they do not know if the clay they can be used for other varieties of modern ceramics products. This paper is a report of some scientific laboratory researches conducted on the Numan pottery clay which will help in getting full information about the clay that will help in developing it for other alternative functions for modern ceramics. In order to ascertain the uses and limitations of the clay, it was subjected to chemical analysis so as to get a fair precision of the available oxide constituents. Other tests conducted include plasticity test, absorption test, workability or throwing test, thermal shock test, shrinkage test and glaze fitness test. All observations noticed in each of these tests were carefully recorded and analyzed. Conclusions were drawn based on the outcome of the tests conducted and recommendations made as to how to prepare the clay for other alternative modern ceramics. It is the view of this paper that the outcome of the research will go a long way in motivating other researchers to undertake researches on the locally available ceramic raw materials around them. It will also go a long way in drawing the interest of the ever increasing number of unemployed youths to begin to develop interest in ceramics.

Introduction

Numan is a town located around the Gongola/Benue river valley, where the major activities of the people include farming, fishing and pottery. The clay for their pottery is sourced along the river valley, and the art has been kept alive by the womenfolk. These women still produce their pots in the same manner their ancestors did many years ago. This is so partly because the colonial government how had their settlement among the Bachama in the 1880's was only interested in the agricultural products of the Bachama people and not in developing their crafts (Dada 1988). The other part is the fact that for a long time the Bachama women were not making pots for commercial purposes. The pots made though of different sizes and shapes they were only to serve the different socio-cultural functions of their local citizens.

It is therefore not amazing to note that the Bachama ethnic group, who have a long history of contact with expatriates during the colonial days and the international trading activities that went on between the Bachama and the Royal Niger Company, since 1888 the indigenes have not change any aspect of their traditional earthen ware pottery. The use of a specific three legged earthen ware pot still serve as a strong binding force in Bachama marriage, others are the pots used as water coolers, the pots used for the cooking of some special delicacies and the pots used for the storage of cereals and flour among the Bachama. One can say that the significant changes noticed among the Bachama are in the fact that majority of the people have adopted Christianity as their religion and many have become civil servants working in government and other

private organizations, while some are successful business men and women. These changes have changed the social status of many Bacharna people. As a result a good number of these people with changed status use more of modern utensils such as glass wares, stainless wares and assorted modern ceramic wares to meet up with their occurred status.

This change in status has negatively affected the traditional significance of some of the pots. It reduced some of the functions and the demand for some of the locally made traditional pots in the area. The tree legged pot which used to serve as a binding force in marriage and a few others have been turned into decorative items and placed in strategic corners in seating rooms or parlors instead of serving their original traditional functions.

The Bachama youths and school children have lost interest in the pottery art, because no efforts are made to improve on its labour extensive method of production, and no research has been made known to them as to how to improve the quality of the clay for modern ceramics. There is therefore an urgent need to undertake a careful scientific research on the abundantly available pottery clay in Numan, so as to find alternative uses for it for modern ceramics and to re-activate the desire of pottery among the youths to help reduce the ever growing rate of unemployment in the area.

The Geology of Numan Area

Numan is a District headquarters in Adamawa State, located in the valley area around the confluence of River Gongola and River Benue. These two rivers have tributaries that flow through mountainous areas that have experienced some volcanic eruptions in the past. These arc the Kerang volcanic area in Mangu Local Government of Plateau State, whose tributaries flow into river Lere, one of the major tributaries of River Gongola. The others are the rivers in Cham area of Gombe State, and the rivers in the volcanic area in Biu Borno state that flow into river Gongola. The Cameroon area where river Benue has tributaries also has areas where volcanic eruptions have once taken place in the past.

In these rivers minerals that are characteristic of volcanic rocks such as cristobalite, K. Feldspar, sanidine, leucite and various zeolites (anelcite, natrolite, etc flow.) (Barth 1993). Because the silic minerals from these volcanic areas are capable of floating, they are therefore transported together with some vegetation impurities through these tributaries to the Benue/Gongola river valley and settle along the flat Benue river valley around Numan. This explains the reason behind the fine grained black plastic montmorilonite soil in Numan. However, there is the need to conduct plasticity absorption, shrinkage, workability, throwing and thermal shock tests of this clay. In order to perform these tests the clay had to be prepared. Ahuwan (2011) noted that Hunkuyi traditional potters pound their clay into powder before adding water to the powder kneaded to the needed consistency. A similar method is used by the Numan traditional potters. The clay sample brought from the clay pit was dried and then pounded and sieved into fine powder so as to use the powder for the needed tests. Alkali (2009) opined that potters should be engaged in the processing of clay for a better scientific knowledge of the materials. In order to achieve this objective it was necessary to introduce the use of kaolin in the clay body. Kaolin powder was used in a biaxial blend of eleven members. Water was later added to each of the eleven members and covered over night for it to sock properly.

The next day the plasticity test was conducted on every member in the biaxial blend. Kaolin was used for the biaxial blending because Rhodes 1977 in Gukas (2012) opined that when clay is too plastic, it can be reduced by adding some more refractory elements such as kaolin in the body. The eleven members in the biaxial blend had different percentage of the Numan clay added to the kaolin as proffered by Rigger 1978 in Mathias (2013).

Each recipe in the table above was used to prepare clay bodies suitable for absorption test, throwing test, thermal shock, plasticity and shrinkage tests.

Plasticity test: As for the plasticity test, each of the clay bodies in table 1 above was rolled into a long coil, and rolled into a snail shell

like structure. Any of these bodies that did not coil properly and cracks in the process of coiling was considered as not being plastic. In the same manner any clay body which did not coil well or did not pull well during the throwing test was considered as not being plastic enough.

Thermal shock test: Two samples of works were produced form all the different clay bodies and kept to dry slowly. After drying, one set of the samples was used to test the thermal shock resistance in an open air firing. The second set was later fired in an electric kiln and fired to bisque temperature. The surviving samples from these two kinds of firing were ready to undergo glaze test (which is to be conducted in a separate paper).

Absorption test: Small balls of clay were prepared from each clay body in the biaxial and kept to dry slowly after which the weight of each ball was taken and fired to bisque temperature in an open air firing. The fired balls were then kept in a bucket filled with water for nineteen hours over night. The next morning the balls were taken out and the excess water cleaned off and weigh/ed. The difference between the bisque weight and the socked weight was calculated as the absorption rate of each clay body in the biaxial. It was weighed in the scientific digital weighing balance (Ada/20 type).

Shrinkage test: For the shrinking test, each clay body in the biaxial was rolled into a long coil measuring twelve centimeters. At leather hard stage, a straight line was drawn from one centimeter of one end of the coil to one centimeter of the other end i.e. 10cm line. Each coil was then kept to dry slowly to prevent warping or distortion. The 10cm line was used to measure the level of shrinkage of each of the bodies at dry stage and bisque stage.

Attention was paid to check if the shrinkage of any of these bodies will be above ten percent of its original length. Gukas and Datiri (2012) opined that any clay with total shrinkage which is more than ten percent is not good for industrial purposes.

Test results:
a. Plasticity Test:

The results of the plasticity tests revealed that S/N 1 -Was very plastic and very good for both hand built and thrown pottery on the potter's wheel. It throws to a very thin wall. S/N 2 - 3 were also good but the level of plasticity reduced slightly as the amount of Numan clay in these bodies were not as high as that in S/N I which has 100% Numan clay. S/N 8-10 although one can throw with them, the pulling appeared to be somewhat difficult as the clay gets soft very quickly. S/N 11 was difficult to pull and to be lifted off the wheel head.

b. Thermal Shock Resistance:
The pieces fired in the open air firing which lasted for just about one hour, using guinea-corn stocks and some dry grass. In this firing S/N 1 – 3 of the thrown pieces shattered into pieces just at the onset of the fire. It could not withstand sudden thermal shock. S/N 4 -5 though showed some level of resistance they developed cracks and blisters. S/N 6 - 11 serviced the shock. The more the kaolin ratio is in the body, the more the thermal resistance, This proves that the Kaolin used is more refractory than the Numan clay. It also helps in explaining why Numan traditional potters always have to add sufficient amount of grog in their clay body.

c. Throwing Test:
All the eleven bodies in the biaxial blend responded well, during the forming tests, the bodies in S/Nl-3 form easily and pull to very thin walls. They are good for anyone learning to throw on the potter's wheel. S/N 4 - 9 are good for any normal throwing. S/N 10 – 11 are difficult to lift off the wheel head they become weak very quickly during throwing and are very slippery.

The formula used is:

$$DL=\frac{WL-DL}{WL}\times\frac{100}{1} \quad \text{and} \quad FS=\frac{WL-FL}{WL}\times\frac{100}{1}$$

Where DS = Dry shrinkage
Where FS = Fired shrinkage
WL = Wet length
WL = Wet length
DL = Dry length
FL = Fired length

The result therefore, shows that Numan clay shrinks more than kaolin, while S/N 11 which

has 100 percent kaolin has the least shrinkage rate as shown in Table 2.

The formula used is:

$$A = \frac{SW - FW}{FW} \times \frac{100}{1}$$

Where A = Absorption
SW = Saturated weight
FW = Fired weight

It should be noted that the samples use varied in weight from the very beginner. However, absorption porosity exhibited a well progressive rate of absorbency of the clay pores. S/N 1 which is 100 percent Numan clay, if not because it dissolved, would have been the least, while the highest absorption body is the S/N 11 which is 100 percent kaolin.

Chemical Analysis

In order to know the actual contents of the Numan clay and that of the Kaolin used in conducting the research, samples of Numan clay and the Kuba kaolin (from Plateau State) were analyzed at the Nigeria Mining Cooperation Laboratory Jos. The results are as follows:

Numan Clay:

Silicon oxide (Sio)	56.20
Aluminum oxide ($A1_2O$)	17.61
Titanium oxide (Ti O_2)	0.10
Calcium oxide (CaO)	0.67
Magnesium oxide (MgO)	ND
Sodium oxide (Na_2O)	0.12
Potash Feldspar (K_2O)	0.10
Lost on Ignition (LOI)	14.35

This shows that Numan clay has a bulk content of silicon, which is an indication that the clay must have been sourced from an area where the primary rock mineral content is igneous rock. While the second bulk oxide is Aluminum which must have flown from the volcanic areas in Cameroon, Cham in Gombe, Biu in Borno and Kerang in Jos Plateau areas.

Kuba Kaolin

Kuba kaolin was also analyzed at the National Metallurgical Centre Jos to have the following components:

Silicon oxide (SiO_2)	48
Aluminum oxide (Al_2O_3)	37.1
Iron oxide (FeO_3)	0.57
Magnesia (MgO)	0.13
Lime (Ca0)	0.10
Soda Feldspar (Na_2O)	0.09
Potash Feldspar (K_2O)	0.93
Titanium oxide (Ti O_2)	0.77
Magnesium (MnO)	0.13
Sulphar (SO_4)	ND
Excess Water (H_2O+)	12.38

This kaolin has lesser silica content than Numan clay and more Alumina so it must be more refractory than Numan clay. This must be what has made the Kaolin to shrink more than kaolin. The other oxides are also contributory factors.

Conclusion

From the outcome of the research so far conducted it can be concluded that Numan clay is highly plastic but because of the place from where it is sourced which is not very far from the granite or igneous rocks of the Cameroon and Cham mountains, it contains a high percentage of silica. While the fine textured minerals of the clay are due to the deposit of the fine grained volcanic materials and the vegetation materials that flowed through all the tributaries of river Gongola and river Benue to the area.

The very low thermal resistance proves that the clay on its own can only be used to produce low fired earthen ware products; however, it is such a fine clay to work with to achieve any high temperature when kaolin is adequately added. In this way the clay can be suitable for any type of modern ceramics which the youths can employ to get themselves employed.

Recommendations

It is therefore recommended that scholars be encouraged to conduct researches on the local pottery materials around them so as to help cut down on the ever growing high dependency on foreign materials, which is a major cause of the lack of interest in the pottery art among youths.

Modern working facilities that will help reduce the hard work being experienced in the processing and producing pottery wares be fabricated and given to interested youths as soft loans to start being self employed citizens. This will go a long way to reduce the rate of unemployment in the country.

Practical researches on local pottery materials should be done in conjunction with the local users; so that they will get acquainted with the methods involved in developing such materials. When this is done the local potters can also take up some researches in trying to find out how to fabricate some local working facilities that will help in easing their labour.



Plate 1: Biaxial of Numan clay/Kaolin



Plate 2: Samples of absorption, plasticity and shrinkage tests

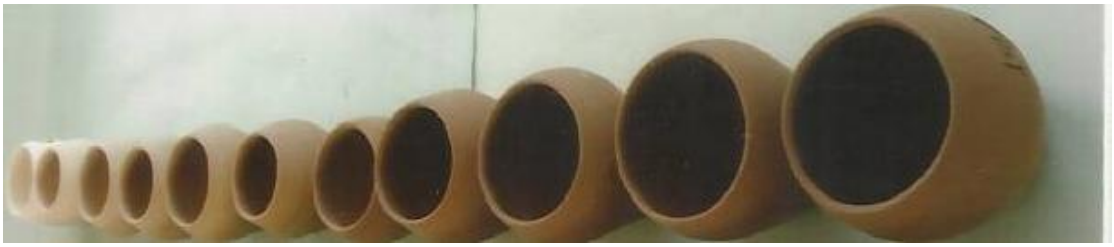

Plate 3: Thrown pieces of Numan clay and kaolin biaxial blend



Plate 4: Open air firing of the works



Plate 5: Open fired works of the biaxial



Plate 6: Survived fired works from the kiln firing

Table 1: A Biaxial Blend of Numan Clay and Kaolin

S/N	1	2	3	4	5	6	7	8	9	10	11
Numan Clay	100	90	80	70	60	50	40	30	20	10	0
Kaolin	0	10	20	30	40	50	60	70	80	90	100

Table 2: Shrinkage Test Result

S/N	Wet length (cm)	Dry length (cm)	Result %	Fired length (cm)	Result %	The total linear shrinkage result %
1	10	9.0	10	shattered	No result	No result
2	10	9.0	10	8.9	11	21
3	10	9.1	9	8.9	11	20
4	10	9.1	9	9.0	10	19
5	10	9.1	9	9.0	10	19
6	10	9.1	9	9.0	10	19
7	10	9.1	9	9.0	10	19
8	10	9.2	8	9.1	9	17
9	10	9.2	8	9.1	9	17
10	10	9.4	6	9.3	7	13
11	10	9.5	5	9.4	6	11

Table 3: Absorption Test Result

S/N	Fired weight (gr)	Saturated weight (gr)	Result %
1	Under fired	Dissolved	No result
2	61.63	64.39	4.5
3	62.19	65.28	5.0
4	57.96	60.87	5.0
5	63.78	67.19	5.4
6	62.19	66.20	6.5
7	56.21	60.08	6.7
8	62.58	67.22	7.4
9	64.41	69.20	7.4
10	63.31	68.24	7.8
11	63.51	70.18	10.5

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