International Journal of Oil, Gas and Coal Engineering
2022; 10(1): 42-49
http://www.sciencepublishinggroup.com/j/ogce
doi: 10.11648/j.ogce.20221001.14
ISSN: 2376-7669 (Print); ISSN: 2376-7677 (Online)

Characterization of Local Clay for Drilling Mud Production

Onyejekwe Ifeanyichukwu Michael*, Duru Ugochukwu Ilozuruike, Obibuike Ubanozie Julian, Odo Jude Emeka, Nnanna Okoli

Department of Petroleum Engineering, Federal University of Technology, Owerri, Nigeria

Email address:
oronst@yahoo.com (O. I. Michael)
*Corresponding author

To cite this article:
Onyejekwe Ifeanyichukwu Michael, Duru Ugochukwu Ilozuruike, Obibuike Ubanozie Julian, Odo Jude Emeka, Nnanna Okoli. Characterization of Local Clay for Drilling Mud Production.*International Journal of Oil, Gas and Coal Engineering*. Vol. 10, No. 1, 2022, pp. 42-49. doi: 10.11648/j.ogce.20221001.14

Received: January 10, 2022; **Accepted**: February 3, 2022; **Published**: February 25, 2022

Abstract: Oil companies'dealing with drilling operations in Nigeria often spends millions of dollars in importation of bentonite for its operations as a result of its importance and high demand. As a result of this, attempt to source for local substitute has been initiated, which if successful would save the nation from this huge capital flight. In this study, a sample of Umuna local clay deposit was evaluated for drilling fluid application. The viscosity and filtration loss was analyzed and it's far below that of the imported bentonite. The properties of the local clay was improved by addingmaterials such as HV-CMC, Drispac polymer and bentonite extenders to the formulated mud to enhance its viscosity and filtration loss Also the shearing speed was increased, but the used speed is limited to practical shearing speed. Theclay yield and characterization of the beneficiated samples show that the treated local clay is slightly comparable to the imported bentonite. The Calcium Exchange Capacity (CEC) result for the clay samples fall within the 70 – 150 Meq/100g. This result further suggests that the analyzed clay is of montimorillonite family, with traces of illite which is good for drilling mud production. The obtained results from this study indicates that the filtration loss and plastic viscosity for the analyzed clay samples were generally far from comparing with the imported bentonite, but through beneficiation, they were able to compare with the imported bentonite.

Keywords: Filtration Loss, Bentonite, Local Clay, Rheological Properties, Beneficiation

1. Introduction

Drilling fluid is key for maintaining well stability during rotating and non rotating time during drilling operation and clay are prime determinants of drilling fluid. The most widely used clay in the oil and gas industry is bentonite. Drilling fluid is generally described as the blood of all drilling operations. It is the most important element in any drilling operation. It is a viscous, clay laden heavy fluid designed to perform a variety of functions [1, 2]. Nigeria as a nation is reputed with substantial amount of clay deposit which its full potential has not been exploited for drilling purposes as a result of its inability in satisfying the API requirement (standard) when compared with the imported bentonite [3-8]. The demand for oil globally hasbeen on the increase and is predictable to persist in the future which then call for more drilling activities especially in Nigeria which is reputed as a major oil producer and exporting nation. The consumption rate of bentonite clay in drilling process in Nigeria is on the alarming rate with most of it imported from USA.

This high consumption rate of the imported bentonite with its attendant importation cost lead to an attempt by recent researchers in sourcing for local substitute which can compare favourably well with the imported bentonite and satisfy the API standard specification. This vision if realized would save the nation from huge amount of dollars usually spend on importation of the foreign bentonite. The realization of this vision will be in accordance with the government wish for self sufficiency of our oil industries and its resolve to support local content [3]. It is with this in mind that this study is been carried out. Bearing in mind the fact that this study is an effort to evaluate the suitability of Nigeria local clay for drilling operations, there is need to look at the previous studies done by researchers.

1.1. Literature Review

Akhirevbulu et al. [9] in their study on geology and mineralogy of clay occurrence around Kutigi Central Bida Basin, Nigeria stated that clay has a global wide spread occurrence and widely distributed in Nigeria though not always found in sufficient quantity or quality suitable for modern industrial purposes. They reported that more than 80 clay deposits can be found from all parts the country. Investigations [3, 10-13] on the existence of bentonite clay reserves in Nigeria have been carried out by various researchers. Clay is a common name for materials that become plastic and tenacious when moist, and becomes permanently hard when baked or fired. Though Velde [14] in his study on the composition and mineralogy of clay minerals stated that clay minerals were initially defined on the basis of their crystal size and as one whose particles diameter were less than $2\mu m$. This definition he said was limited by the use of the petrographic microscope as was obtained then in the 19th century. But with the recent advent of reliable x-ray diffractometer allows for distinction between the different mineral species found in the less than $2\mu m$ grain size fraction. Clays of various kinds and grades abound throughout Nigeria sedimentary basins and on the basement [10].

Oriji et al. [15] carried out an evaluation study on the efficiency of Nigeria local bentonite as an extender in oil well cementing with that of imported bentonite on fresh and salt water using both experimental and economic approach in analysing their results. The experimental test was basically on thickening time and ultrasonic compressive strength. They concluded from the result of their finding that the local bentonite compares favourably well to the imported bentonite and can be used interchangeably except in cases requiring high plastic viscosity and yield point. The result also indicates that the local and imported bentonite were both not fully effective in salt water cement slurry. The result from the economic analysis shows a total saving of $7509.85 cement slurry cost as the local bentonite only contributed 2% of cement slurry cost as against the 21% cement slurry cost contributed by the foreign bentonite. They also concluded that with proper management, that the local bentonite could be more efficient and cost effective means of cement slurry extender.

Nigeria has large reserves of bentonite clay deposit that if properly utilized will go a long way in supporting the oil well drilling demand in the country. This will transform into retaining the large sum of money sent overseas for importation of foreign bentonite, create employment opportunities, bring external investment and further the country's economy [16]. Studies on beneficiating our local bentonite to see if they can compare with the imported bentonite have been suggested by researchers [10, 12,]. Among the recent studies on beneficiation of Nigeriabentonites using local materials are [17, 18].

Arabi et al. [16] in their study on bentonite deposit that is of Ca-based observed from their result that there was an improvement in the rheological properties of the local clay after beneficiating with Na_2CO_3 and ion exchange as the procedure. Their obtained result compared favourably well with the commercial bentonite and standard API specification. They concluded that if the local bentonite reserve is beneficiated using Na_2CO_3 as beneficiating agent and ion exchange as beneficiating procedure, that it may even be better than the standard commercial bentonite. Udeagbara et al. [19] in their study on the possibility of utilization of local clay as basic material for drilling used simple but relevant laboratory test to determine the rheological properties of local clay deposits from Ishiagu local government area of Ebonyistate. The result from their study shows a significance difference in the rheological properties of the formulated local clay, as they were far from that of the imported bentonite. But the rheological properties of the local clay were improved and compares favourably well with that of the imported bentonite after beneficiation. They concluded from their result that the rheological properties of Ishiagu local clay can be improve and be a good substitute for the foreign imported bentonite when beneficiated with soda ash, potassium chloride and Pac R at their right concentration. Greatest percentage of bentonite used within Nigeria are imported due to the deficiency of the local clays in rheological and fluid loss properties [17] but studies has shown that imported bentonite- local clay blend in the right proportion could save Nigeria 12 to 36% of the cost of bentonite clay used to drill wells in the country [18].

Okechukwu and Okogbue (20) carried a study to see the possibilities of beneficiating Nigeria local clay to compare with the imported bentonite by their assessment of properties of clays from three geological units. The result of their analysis indicates that the local clays were of the smectite and mixed layer clay. Their findings suggested marginal performance of the local clay even after beneficiation.

1.2. Summary of Reviewed Literature

Reviewed literatures indicates that huge amount of capital has been spent on the importation of bentonite for the drilling of oil and gas despite the abundance of clay deposits of various kinds and grade distributed across Nigeria sedimentary basins and basement. Review shows that most local clay in the country fails to satisfy the API standard minimum specification requirement to compare with the imported (commercial) bentonite. This is therefore the reason why exploitation of the abundance local clays in the country to its full potential has remained a difficult excise. However, obtained results shows that if the local clays are beneficiated in their rightful proportions that it shall lead to improvement in their rheological properties.

The general conclusion from studies suggests that the rheological properties of the local clays can actually be improve after beneficiation and then be a good substitute for the foreignbentonite. This they said will translate to supporting the oil well drilling demand of the country, retaining the large sum of money sent overseas for importation of foreign bentonite, generate employment opportunities, bring external investment and improve the country's economy.

2. Materials and Methods

First, comprehensive lists of all the experiments carried out for this research were stated. Two clay samples were collected from Umuna in Okigwe Local government Area of Imo State, South East Nigeria. The collected samples were from various vertical profiles and they were oven-dried and milled. Measurements and experimentations were meticulously carried out on the collected samples. The collected samples were analysed physically, chemically and rheologically for untreated and treated mud. All the experiments for this research were carried out in the laboratory of Petroleum Engineering Department, Federal University of TechnologyOwerri, Imo State and at Project Development Institute Enugu State (PRODA), South East Nigeria.

2.1. Physical Analysis of Raw Clay

The under listed tests were meticulously carried out on the collected clay sample within the API standard specifications.

2.1.1. Grain Size Analysis

The aim of this test is to obtain the appropriate grain size distribution for the clay sample. The weight of sieve No $75\mu m$was measured and recorded and 100g of the samples dried in an oven were weighed using a weighing balance. The samples were introduced on the nest sieve No $75\mu m$on a sieve shaker and switched on for 20minutes after which it is disconnected. The weight of the sieve with its content was recorded.

2.1.2. Specific Gravity

The aim of this test is to obtain the ratio of the weight in air of a given volume to the weight of equal volume of distilled water. The weight of a specific gravity bottle was taken. The volume of 1000ml of distilled water was pressured out and the distilled water poured into the specific gravity bottle and weighed. Certain amount of the clay sample was measured in the balance and poured into the bottle after which both the weight of the sample and the bottle were recorded. Distilled water was poured inside to fill the bottle containing the clay sample to make up 1000ml; weight of the content was recorded.

2.1.3. Moisture Content Test

The aim here is to obtain the amount of water content present in the clay samples. 50g of samples was measured in a weighing balance and poured in a crucible, dried in an oven at constant temperature of 105℃ for 4hours. The weight of the dried samples was then measured in a weighing balance.

2.1.4. Plastic Limit

The aim of the test is to determine the water content where clay starts to exhibit plastic behaviour. In this test water was added drop by drop to 10g of the clay and the sample then rolled to 3mm diameter rod. The water content at which the clay just begins to crumble was noted and recorded.

2.1.5. Liquid Limit

The aim of this testis to determine the amount of water content where the clay sample changes from plastic to liquid. Using the casagrande method, 10g of clay was placed into the metal cup portion of the device and groove was made down its centre with a standardized tool. The cup is repeatedly dropped 10mm onto a hard rubber base during which the groove closes up gradually as a result of the impact. The number of blows for the groove to close for 13mm ($^1/_2$ $inch$) was noted and recorded. Note that the moisture content at which it takes 25 drops of the cup to cause the groove to close is defined as the liquid limit.

2.2. Untreated Mud Analysis

The aim of this test is to determine the ability of untreated mud prepared from local clay to meet the standard API specification for drilling mud prepared with bentonite. The mud for various samples are preparedby pouring 22.5g of the local clay into 350ml of distilled water and stirring for 25minutes, then mixture is allowed to stand for 16hours. This is the required measurement for a standard raw mud preparation. Figures 1and 2 shows the formulated clay samples and treated mud sample.

Figure 1. *Formulated clay samples.*

Figure 2. *Treated mud sample.*

2.2.1. Mud Density Test

The aim of this test is to determine the weight of the mud per unit volume. The instrument base was set up until it is level and a clean dry cup was filled with the mud to be weighed. The lid was placed on the cup, and seated firmly but slowly with a twisting motion allowing some mud to escape through the hole in the cap. The excess mud was wiped from the outside of the cup and arm, knife was set on the fulcrum, and the sliding weight was moved along the graduated arm until the cup and arm are balanced. The density of the mud was then read at the left hand edge of the sliding weight and reported to the nearest scale division in ib/gal.

2.2.2. Viscosity and Yield Point Determination

The aim of this test is to determine the plastic viscosity and yield point of the local clay samples. A recently agitated sample is placed in a thermo-cup and mud surface adjusted to scribed line on the rotor sleeve. Heat or cool the sample to 120°F (49°C) and stir slowly while adjusting the temperature. Record the 600RPM and 300RPM readings.

2.2.3. Gel Strength

The aim of this test is to determine the ability of the mud to suspend cuttings at static conditions and be able to release them at the surface. The sample was stirred at 600RPM for appropriately 15seconds and the gear assembly was slowly lifted to the neutral position and the motor shut off for 10seconds. The knob was flip switch to 3RPM and maximum deflection units in $^{ib}/_{100ft^2}$ were recorded as initial gel. This was repeated while allowing 10minutes, then the knob was slowly turned to 3RPM and the maximum deflection unit was read as the 10minutes gel.

2.2.4. Filtrate Loss

The aim of this test is to measure the fluid loss and filter cake characteristics of the drilling mud. The cell was filled with mud samples to within $^1/_4$ of the top and the cap checked to make sure the gasket was in place. The top cap was placed on the cell and the unit was secured with T-screw. A dried graduated cylinder was place on the filter tube. The volume of the filtrate collected from the graduated cylinder was read after 5, 10, 15, 20, 25 and 30minutes. The cake thickness on the filter paper was measured using a ruler.

2.3. Chemical Analysis of Raw Clay

The two clay samples were subjected to the following chemical analysis.

2.3.1. Percentage Oxide Content

The required reagents for this test are wet digestion solution containing 650ml of Nitric acid(NHO_3), perchloric acid ($HCLO_4$) and sulphuric acid (H_2SO_4) with addition of distilled water to the mixture. 20ml of wet digested solution was added to 1gram of sieve sample of clay and the mixture placed on the electric sand bath, and then the temperature of the sand bag was steadily regulated from 50°C to 235°C at which the digestion of the clay was expected to be completed. The solution was left to stand until the silica content has settled down. It is then filtered and dried. The elements suspected in the stabilizer were determined using UNICAM 969 atomic absorption spectrometer.

2.3.2. Cation Exchange Capacity

The aim of this test is to measure the ability of the clay to absorb cation from solution, attract positive ions and hold it on the surface of the clay particles. 1ml of mud was added to 10ml of distilled water in the Erlenmeyer flask. 15ml of 3% hydrogen peroxide and 0.5ml of distilled water was added and the content boiled for 10minutes and 50ml of distilled water was used for its dilution. Methylene blue solution was then added to the dropper. A drop of the content (dye) was placed on the filter paper to check the end point of the filtration and the dye spread as a greenish blue or tint around the spot of dyed solids. The flask was shaken for 2minutes when the blue ring or tint was detected around the spot. Another drop was placed on the filter paper and the end point was reached when the blue appeared.

3. Results Discussion

The results and discussion of the laboratory experiment carried out on two clay samples to determine if they can measure up to the standard API specification and able to compete with the imported bentonite is presented with Table 1 as reference table.

Table 1. *API Bentonite Specification 13A Section 9.*

Drilling Fluid Properties	**Numerical Value Requirement**
Moisture content	10% Max
Cation Exchange Capacity Range	70 - 130 Meq/ 100g Min
Screen analysis	4% max
Viscometer dial reading at 600rpm	30cp
Mud Density range (Ib/gal)	8.65 – 9.60
Plastic Viscosity (cp)	8-10
Yield point (Ib/100ft^2)	3 ×Plastic viscosity
YP/PV ratio	3.0 Max
Fluid Loss (H_2O)	15.0 ml Max
N-Factor (Power law index)	1 Max
Filtrate	13.5cm^3 max, <15cm^3
Ph	9.5 Min – 12.5 Max
Montimorillonite	Ion capacity 70-130
Kaolite	3 – 15
Illite	10 – 40
Chlorite	Ion capacity 10 – 40
Attapulgite	Ion capacity 10 – 35

3.1. Grain Size, Specific Gravity, P^H and Moisture Contents

The results on the investigation carried out on grain size, specific gravity, P^H and moisture content for the clay sample are shown on Table 2.

3.1.1. Grain Size

The results from Table 2 on particle size for the clay sample to determine its ability to suspend solids shows that sample one and two (S1 &S2) has 55% and 25.5% of clay respectively. This is far below the percentage of the imported bentonite. The result also shows that the sample contains sand and gravel hence the suspension capability of the clay is affected. The ability of a mud to suspend solids is a function of the colloidal particles of the clay. The high clay percentage of the imported bentonite from the result may be ascribed to pre-importation treatment resultingto the removal of the unwanted portions. Therefore, the local clay should be mined properly before usage.

Table 2. *Physical properties.*

Samples	Gravel (%)	Sand (%)	Clay (%)	Silt (%)	Moisture Content (%)	Specific gravity	P^H	Plastic limit	Liquid limit	Plasticity PI
S_1	03	12	55	30	10.94	2.67	7.80	61.60	82.00	20.40
S_2	02	11	25.50	61.50	15.12	3.12	7.60	64.10	93.00	28.90
BENTONITE	0	05	85	10	12.40	2.00	8.00	31.00	70.00	39.00

3.1.2. Specific Gravity, Ph and Moisture Contents

The results from Table 2 shows that the specific gravity for the given clay samples are close to that of the imported bentonite.

3.1.3. P^H and Moisture Contents

The results on the analysis carried out on moisture content and P^H for the given clay samples are shown on Table 2. The results show that the pH values for the given samples does not agree with that of the reference table, Table 1 and were slightly acidic compared to the imported bentonite that is alkaline, hence there is need for the local clay to be treated with basic additives such as sodium hydroxide or any other additive that is capable of reducing the acidic content of the local clay.

3.2. Chemical Properties

The results on the chemical analysis carried out on the given clay sample to determine their percentage oxide and cation exchange capacity are shown on Table 3. The result from table 3 shows the presence of silicate and aluminates which is primary evident for the composition of all clay types. The composition of oxide from the result of Table 3 is indicative that the clay samples arevery similar to the general montimorillonite percentage oxide fraction. The presence of some percentage magnesium oxide also suggests that the clay samples are on the family of Montimorillonite. The presence of traces of potassium oxide indicates the presence of traces of illites while that of ion oxide suggest the presence of feldspar and quartz which is not desirable for the plasticity of the clay. The Cation Exchange Capacity (CEC) result from Table 3 for the clay samples fall within the 70 – 150Meq/100g and is in agreement with that of the reference table, Table 1. This result further suggests that the analyzed clay samples are of the montimorillonite family, with traces of illite which is good for drilling mud production.

Table 3. *Chemical properties.*

Samples	Oxide (%)							Cation	
	S_1O_2	AL_2O_3	FE_2O_3	NA_2O	K_2O	CaO	MgO	Bentonite Equivalent (Ib/bbl)	CEC (Meq/100g)
S_1	84.80	10.83	0.26	0.16	0.04	0.12	0.20	7.5	75
S_2	90.20	5.86	0.20	0.28	0.04	0.57	0.34	8	80
BENTONITE	49.37	18.82	3.72	0.81	0.88	6.41	8.50	8.5	85

3.3. Rheological Properties for the Untreated Clay Samples

The result on the analysis carried out on the local clay to determine its rheological properties are presented below.

3.3.1. Mud Density and Filter Cake

The results on the investigation carried out on the clay sample to determine its filter cake and mud density are shown on table 4. The obtained result shows that the filter cake thickness for the local clays approximates to that of the importedbentonite. The result for the mud density showsthat density for sample 2 (S2) compares with that of the imported bentonite and also satisfy the AP1 standard specification. While the density for sample 1 (S1) can be approximated to that of the imported bentonite. Though, there is still need for little beneficiation for it to satisfy the AP1 standard specification according to the reference table, Table 1.

Table 4. *Mud density and Filter cake.*

Samples	Weight (Ib/gal)	Thickness (inches)
S_1	8.70	0.31
S_2	8.60	0.38
Bentonite	8.60	0.44

3.3.2. Filtration Properties of Untreated Clay Samples

The results on the analysis carried out on the given local clay samples to measure their fluid loss and determine their plastic viscosity and yield point are shown on Table 5 and 6 respectively. The results from Table 5 shows that the fluid loss values of 91.20 (S1), 99.70 (S2) were generally far from the 15.0mlmax AP1 standard specification according to Table 1, hence the need for beneficiation to compare with the imported bentonite and meet the standard API specification. The PV, YP and YP/PV result for the local clay samples on Table 6 were far from comparing with AP1 standard specification according to Table 1, hence the need for beneficiation by adding some cheap materials to the prepared mud to enhance its viscosity and filtration loss. However, the PV at 600 RPM, YP and YP/PV value equally did not meet the AP1 standard specification.

Table 5. *Fluid loss.*

Time (min)	0	5	10	15	20	25	30
S_1	0.00	39.00	53.00	65.70	73.00	82.50	91.20
S_2	0.00	45.00	60.00	73.90	87.00	95.00	99.70
Bentonite	0.00	40.00	58.00	72.00	80.00	88.00	96.40

Table 6. *PV and YP for the untreated clay samples.*

RPM	600	300	200	100	6	3	PV	YP
S_1	5	4	3	3	3	2	1	3
S_2	6	4	4	3	3	2	2	2
Bentonite	25	19	17	15	10	10	6	13

3.3.3. Improving the Rheology of the Local Clay Samples

The results obtained for filtration loss, PV, YP and YP/PV from the addition of 2g of PACR, increase in shearing speed, addition of DRISPAC and HV – CMC are shown on Tables 7, 8, 9 and 10 respectively while Figures 3 to 6 shows the improved viscosity, filtration loss, untreated and treated rheology for the clay samples. The obtained result from the addition of 2g of PACR to the prepared local clay sample on Table 7 shows a great improvement on the PV, YP and YP/PV values. The obtained results are a confirmation to studies by [16, 19]. The API standard specifications according to Table 1 for 600rpm, 300rpm and plastic viscosity were all satisfied. The result from Table 7 also illustrates that the effect of beneficiating the prepared local clay with 2g of PacR is more on YP value. The result as obtained for filtration loss and viscosity by increasing the shear speed from 6000rpm to 15000rpm is as presented on Table 8. Increasing the shear speed from 6000rpm to 15000rpm improved the filtration loss and viscosity of the local clay samples with close to 200% increase in viscosity and approximately 37% reduction in filtration loss. However, these improvements did not compare well with the API standard specification according to Table 1. The result obtained when DRISPAC is added to the prepared local samples is shown on Table 9. The addition of DRISPAC to the prepared local clay samples reduces the filtration loss @ 30mins of 91.20 (S1) and 91.70 (S2) to 10.50. This reduction in filtration loss @ 30mins is also an improvement on the 40.0 value obtained from increasing the shearing speed from 6000rpm t0 15000rpm. The obtained result though did not satisfy the API standard specification, however there is an improvement. The addition of DRISPAC also increases the plastic viscosity values of the local sample to 13.60cp. However, this improvement in viscosity did not also satisfy the API standard specification. The result obtained when HV-CMC was added to the prepared local clay samples is as shown on Table 10. The result from Table 10 shows that filtration loss for the local clay samples was reduced from 91.20 (S1) and 99.70 (S2) to 10.0. However, this obtained result of 10.00 for filtration loss @30 mins still did not meet the API standard specification. The reduction in filtration loss at 30 mins obtained is also better than the filtration loss value of 40.0 obtained when the shearing speed was increased from 6000rpm to 15000rpm. The addition of HV-CMC to the local clay sample causes an increase in viscosity to almost double at a concentration of 6gm/L of mud, though this concentration is relatively high. At a concentration of 1gm/L, there was a sharp reduction in filtration loss from 50 to just 20. The improvement in viscosity from Table 10 is also better than the 13.60cp results obtained when DRISPAC is added and 11.70cp when shearing speed was increased from 6000rpm to 15000rpm. Thus the viscosity improvement as a result of addition of HV-CMC is close to meeting the API standard specification. Figure 3shows that the local clay sample after enhancement compared with that of imported bentonite. Similarly, from Figure 4, it can be observed that the local clay filtration loss after enhancement compared favourably well with that of the imported bentonite.

Table 7. *Rheology of improved clay samples with 2g PacR.*

RPM	600	300	200	100	6	3	PV	YP
S_1+(L)	38	30	25	16	13	9	8	22
S_2+(L)	43	34	29	20	15	9	9	25

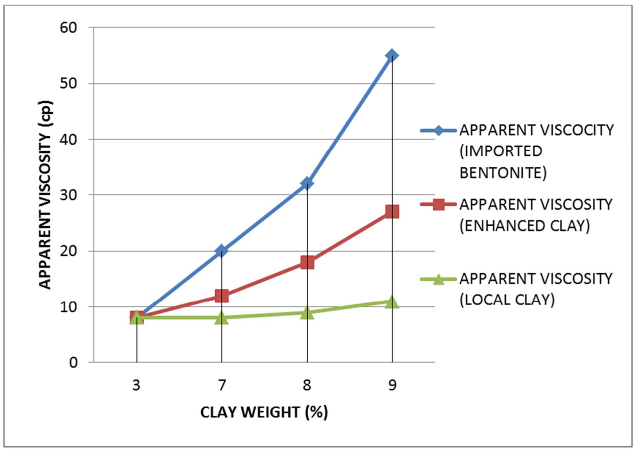

Figure 3. *Improved local clay viscosity versus Imported Bentonite.*

Table 8. *Increased shearing speed.*

RPM	6000	8000	12000	15000
Filtration loss @ 30mins	60	50	47	40
Viscosity (cp)	4.90	6.00	9.00	11.70

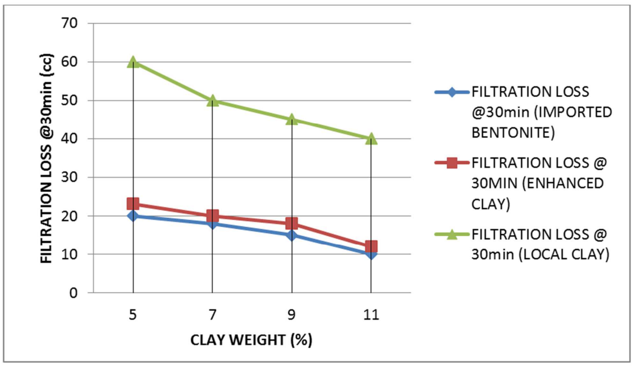

Figure 4. *Improved local clay filtration loss versus Imported Bentonite.*

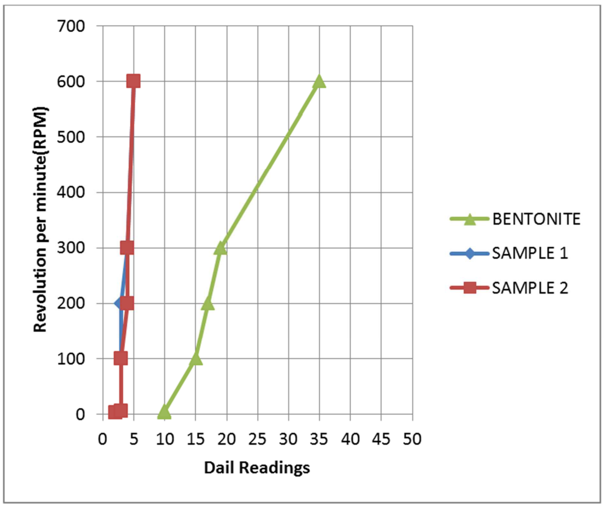

Figure 5. *Rheology of untreated clay samples.*

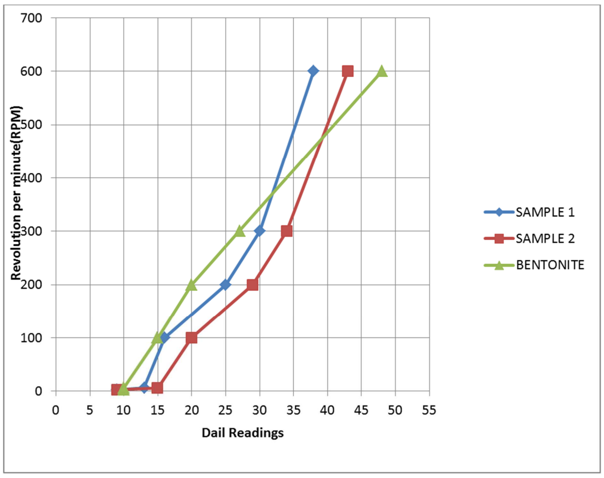

Figure 6. *Rheology of treated clay samples.*

Table 9. *Addition of DRISPAC (PolyanionicCellulose Polymer).*

Conc. (gm/L)	0	0.5	1	1.5	2
Filtration loss @ 30mins	50	20	15	13	10.50
Viscosity (cp)	6	6.9	7.8	9.6	13.60

Table 10. *Addition of HV-CMC (Sodium Carboxymethyl Cellulose).*

Conc. (gm/L)	0	1	2	4	6
Filtration loss @ 30mins	50	20	16	13	10
Viscosity (cp)	6	6.4	7	8.3	11.2

4. Conclusion and Recommendation

4.1. Conclusion

The chemical analysis result obtained under the characterization of local clay for drilling mud production showed that the clay deposits in Umuna, Onuimo Local Government Area of Imo state belong to the Monitmorillonite clay family and has the propensity for slightly swelling due to its calcium content. Moreso, the analysed clay cannot perform well as a drilling mud without beneficiation because of its relatively weak rheological and filtration properties. The general result obtained from physical analysis of the local clay samples shows that they compare fairly well with this imported bentonite on the grain size analysis, moisture content, specificgravity and P^H values. The clay content of 55% for sample 1 and 25.5%for sample 2 as against the 85% for the imported bentonite issuggestive that the high clay content of the imported bentonite is dueto pre-importation treatment resulting in the removal of all unwanted portion. The P^H of 7.80 for sample 1 and 7.60 for sample 2 (S2) as against the 8.00 for the imported bentonite, suggest that the local clay sample is slightly acidic and should be treated with basic additives such as NaoH that is capable of reducing the acidic content. The Atterberglimitresults as obtained are far from that of imported bentonite. From the result obtained in this study, it is concluded that with greater improvement through the addition of salt extenders (soda ash), at a concentration of 5% and by adding cheap polymers such as DRISPAC at a very low concentration of 0.5%, that the local clay can be compared to that of imported bentonite. This will translateto huge financial savings to the oil companies and the country at large.

4.2. Recommendation

Based on reviewed literatures and results obtained from this study, it is recommended that the Nigerian government should support research in all parts of the country with better record of clay sediments. The research should be done with a more precise and sophisticated equipment for better result. Also indigenous companies who have interest in local bentonite production should be assisted in shopping for credible technical partners and also assisted financially.

References

[1] C. W. Davies. "The swelling of bentonite and its control."Ind Eng. Chem., vol. 19, pp. 1350-1352, 1927.

[2] H. C. Darly& R. G. "George. Composition and properties of drilling and completion fluids." 5th edn. Gulf Publishing Company, Houston, 1988.

[3] R. O. Afolabi., O. D. Orodu., & V. E. Efeovbokhan. "Applied clay science properties and application of Nigerian bentonite clay deposits for drilling mud formulation: recent advances and future prospects."ApplClay Sci., vol. 143, pp. 39-49, 2017.

[4] B. B. Dewu., S. A. Arabi., M. O. Oladipo., I. I. Funtua., I. A. Moammed-Dabo., & A. M. Muhammad. "Improvement of rheological properties of bentonitic clays using sodium carbonate and a synthetic viscosifier."Int Arch ApplSci Technology, vol. 2 (2), pp. 43-52, 2011.

[5] O. E. Agwu., A. N. Okon., & O. I. Akpanika. "Activation of local bentonitic clays for use as viscosifiers in water-based drilling fluids."J. Sci Res Rep, vol. 12 (2), pp. 1-11, 2016.

[6] A. S. Arabi., B. B. M. Dewu., M. O. A. Oladipo., & I. I. Funtua. "Mineralogy and rheology of raw activated turoniantoconiacian clays from Benue trough, northern Nigeria."Egyptian Journal of. Petroleum, vol. 27 (1), pp. 1-14, 2017.

[7] O. A. Arinkoola., T. O. Salawudeen., K. K. Salam., M. O. Jimoh., G. O. Abidemi., & Z. M. Atitebi. "Optimization of water-based drilling fluid produced using 9 modified Nigerian bentonite and natural biopolymers: reduced experiment and response surface methodology."*Iran J. ChemEng,* vol. 16, 39-53, 2019.

[8] O. Omole., S. Malomo., & S. Akande. "The suitability of Nigeria black soil clays as drilling mud clays."Appl Clay Sci, vol. 4, 357-372, 1989.

[9] O. E. Akhirevbulu., C. V. O. Amadasun., M. I. Ogunbajo., & O. Ujuanbi. "The geology and mineralogy of clay occurrences around kutigi central bida basin, Nigeria." *Ethiopian Journal of Environmental Studies and Management,* vol. 3 (3), pp. 49-56, 2010.

[10] O. A. Falode., O. A. Ehinola., & P. C. Nebeife. "Evaluation of local clay as oil well drilling fluids in Nigeria."Appl Clay Sci., vol. 39, pp. 19-27, 2007.

[11] T. U. Apugo-Nwosu., I. A. Mohammed-Dabo., A. S. Ahmed., G. Abubakar., A. S. Alkali., & S. I. Ayilara. "Studies on the suitability of ubakalabentonite clay for oil well drilling mud formulation."Br J ApplSciTechnol, vol. 1 (4), pp. 152-171, 2011.

[12] O. Omole., J. O. Adeleye., O. Falode., S. Malomo., & O. A. Oyedeji. "Investigation into the rheological and filtration properties of drilling mud formulated with clays from Northern Nigeria." *J Petrol Gas Eng.,* vol. 4 (1), pp. 1-13, 2013.

[13] O. E. Agwu., A. N. Okon., &F. D. Udoh. "A review of Nigerian bentonitic clays as drilling mud."In: SPE presented at SPE annual technical conference and exhibition, Nigeria, 2015.

[14] B. Velde. "Composition and mineralogy of clay mineral. In: B. Velde., Ed., origin and mineralogy of clays: clays and the environment." Springer, verlag, pp. 8-29, 1995.

[15] A. B. Oriji., F. S. Lawal& Z. Bala. "Evaluating the efficiency of Nigerian local bentonite as an extender in oil well cementation."Chem. Process Engrg. Res., vol. 28, pp. 78-88, 2014.

[16] S. A. Arabi., A. A. Ibrahim., M. A. Muhammad., M. Y. Kwaya& S. Mustapha. "Comparative evaluation of rheological properties of standard commercial bentonite and a locally beneficiatedbentonitic clay from a marine deposit in upper Benue basin, Nigeria."*British Journal of Applied Science and Technology,* vol. 1 (4), pp. 211-221, 2011.

[17] K. C. Igwilo., N. Uwaezuoke., N. Okoli., F. T. Obasi& E. E. Okoro. "Beneficiation of Nigerian bentonite using local materials."*Journal of Petroleum Exploration and Production Technology,* vol. 10, pp. 3399-3407, 2020.

[18] O. Ogolo., A. Arinkoola., S. Osisanya., F. Egede., & T. J. Chior. "Rheological impact and economic implications of partial to total substitutions of imported bentonite clay for oil and gas drilling operations in Nigeria." Journal of Petroleum Exploration and Production Technology, vol. 11, pp. 233-242, 2021.

[19] S. G. Udeagbara., S. O. Ogiriki., F. Afolabi., & E. J. Bodunde. "Evaluation of the effectiveness of local clay from Ebonyi state, Nigeria as a substitute for bentonite in drilling fluids." *International Journal of Petroleum and Gas Engineering Research,* vol. 3 (1), pp. 1-10, 2019.

[20] P. A. Okechukwu and C. O. Okogbue. "Characterization of some clays from Nigeria for their use in drilling mud."AppliedClay Science, vol. 116-117 (11), pp. 158-166, 2015.