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EVALUATION OF THE EFFECTIVENESS OF LOCAL CLAY FROM EBONYI STATE, NIGERIA AS A SUBSTITUTE FOR BENTONITE IN DRILLING FLUIDS

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ABSTRACT: *The present consumption of bentonite in the drilling operations in Nigeria alone is over 50 thousand tons per year and it is imported from abroad This trend is expected to continue as drilling activities keep increasing. The large consumption and the high importation cost of this material led to an attempt to find a local substitute. This work focuses on the possibility of utilization of local clay as a basic material for drilling fluids. This research evaluates, by means of simple but relevant laboratory tests, the properties of clay deposit from ishiagu-ivo local government area of Ebonyi state, southeastern Nigeria and compared with imported bentonite. The results were analyzed using statistical and graphical methods.Water-based mud was formulated from the local clay and the properties were determined and compared with those of imported bentonite. The results obtained showed that there were significant differences in the formulated drilling fluid's rheological properties and the pH when compared with that of imported bentonite. When beneficiated with soda ash (CO_3) and PacR at a concentration of 5.0g and 50g respectively to 350mL of the local mud, the mud pH increased from 5.65 to 10.60 while the apparent viscosity, yield point and plastic viscosity increased from 4.50, 4.00, 3.00 to 11.10, 10.00 and 7.00 respectively. With the addition of barite (BaS) (10g) to 350mL of the formulated drilling fluid, the density increased from 8.80lb/gal to 9.15lb/gal. Therefore, at considerable concentration, the ishiagu-ivo clay exhibits good rheological properties that could compete favourably with that of imported bentonite when beneficiated with soda ash (CO_3), potassium chloride and Pac R. This goes to show that a quality drilling fluid could be formulated from ishiagu-ivo clay that could meet the API specification.*

KEYWORDS: *local clay, Ebonyi State, Nigeria, Bentonite, drilling fluids*

BACKGROUND OF STUDY

Nigeria's economy is largely based on its oil resources and she is the largest oil producer in sub-Saharan Africa. In view of the fact that hydrocarbon and water beneath the ground could only be exploited through drilling wells, the petroleum industry especially has continued to make increasing use of clay which is the main constituent of drilling fluids. Research over the past several years has clearly shown that drilling activities in the petroleum and ground-water development industries in Nigeria have consumed, and are still consuming, large amounts of clays for drilling muds, all of which are imported despite the presence of large reserves of clay in Nigeria. Prior to the government's initiative to develop local content, the cost of importation of bentonite for drilling activities in Nigeria runs to millions of dollar annually which has been detrimental to the economy of the country considering that about 5 to 15% of the cost of drilling a well which ranges between $1 million to $100 million accounts for drilling fluids (Ben B., et al., 1994). Therefore, it is imperative to locally outsource these clay materials in order to

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conserve foreign exchange, create employment and to enhance Nigerian content development in the drilling component of oil and gas industry.

The use of water to cool and lubricate drill bits during drilling in early drilling practices encountered quite a number of problems traceable to the inability of water to perform certain drilling mud functions. The introduction of mud for such problems in the industry became widespread between the late 80's and early 90's with the purpose of continuously removing drill cuttings from the hole. As rotary drilling advanced, more engineering attention was needed to critically analyze mud composition and efficiency for its performance. The use of only water as drilling fluid was kicked against because of the tendency of formation damage as a result of hole instability. Early drillers encountered such problems and used muddy water to control a potentially catastrophic sand problem. They concluded with the recommendation that a fine sticky clay described as "gumbo" was a good component for drilling mud. A good mud besides been able to suspend clay materials in water for a long time should be free of sand cuttings and similar materials of specific gravity within the range of 1.05 – 1.15 (density 8.77ppg – 9.58pppg). The introduction of weighting the mud using additives and fine grains from oxide was recommended for weighting in water slurries, given a mud weight in the range of 15 – 18 ppg. The use of these materials was short lived due to its dark color and skin straining effects. Further research on this methodology led to the advancement of barium sulphate (barite) for mud weighting due to its high specific gravity, low abrasive properties and toxicity level. The discovery of Bentonite for mud preparation was later introduced to the industry, with subsequent tests showing its ability not only to suspend heavy cuttings but having comparatively good mud properties such as moderate filtration loss and good wall building properties, viscosity and gel strength . This study tends to analyze the rheological properties of clay samples retrieved from a location in southeastern, Nigeria. This sample will be subjected to certain laboratory experiments to confirm or ascertain it suitability for drilling mud formulation and results of its rheological properties will be compared to Wyoming bentonite which is a standard for mud preparation. Nigerian researchers have been actively pursuing the study of using Nigerian clay as drilling mud and finding potential markets for it in a quest to provide a substitute for foreign bentonite as a drilling fluid in the oil and gas industry in Nigeria.

CLAY

Clay are generally fine-grained materials, with particle size less than 0.002 mm with predominately clay minerals. Other minerals associated with clay minerals in clays may include quartz and feldspar (Grim, 1968). Clays are the most abundant class of sedimentary rocks, making up to 40% of mineral contents in these sedimentary rocks. These relatively cheap sources of colloidal materials with an average particle size of about 2 microns have the ability to exhibit the plasticity phenomenon. The alternating sheets of silica and alumina with slightly different arrangements make up the unit layers of each clay material. The geographic location, chemical and colloidal nature of the retrieved clay is also a contributory factor in determining certain properties such as its swelling capacities. Montmorilonites, illites, Kaolinites, attapulgites and sepiolites are common clay classifications with montmorilonite being the most suitable class for drilling mud preparation.

ISSN: Print 2514-9253, Online 2514-9261

BENTONITE

It is sometimes said that when drilling in a clay formation the hole been drilled makes its own mud. This is simply not true. Water and dirt does make "mud" - but that is not good drilling mud. There are many different kinds of clay and each kind has different properties. Good drilling mud is made with "bentonite" clay. Bentonite is a very special type of clay that comes from weathered volcanic ash. It is mined and processed from just a few areas; the largest commercial deposits are in Wyoming, USA. Wyoming bentonite is shipped all over the world for use by professional drillers and others. One of the special properties of bentonite is the way it quickly swells to as much as 10 times its original volume when it is completely mixed with water. When bentonite has completely swelled, it is said to be fully hydrated.

When the water condition is correct a high-quality bentonite designed for water well drilling will take at least 30 minutes of mixing through the mud pump before it is fully hydrated. If the water is too "hard" or the pH is not in the range of 8.5 to 9.5, then the bentonite will take longer to hydrate, or might not fully hydrate at all. Even if local clay seems "almost like bentonite", that clay will form a wall cake that is many times thicker than the wall cake formed by good bentonite. Thick wall cake is very hard to remove when developing the well and may remain to clog up the aquifer. The wall cake formed by high-quality bentonite is much easier to remove.

SOURCE OF LOCAL CLAY: Ebonyi is a state in Nigeria, in the south-eastern region. It is inhabited and populated primarily by Igbo, Its capital and largest city is Abakaliki. It is one of the six states created in 1996 by the Abacha government. Ebonyi was created from parts of both Enugu State and Abia State. With a land area of about 5,935 sq. km, the state lies approximately within longitude 7Â°30' and 8Â°30'E and latitude 5Â°40' and 6Â°45'N. Ebonyi State is popularly known as the 'Salt of the Nation,' apparently because of the large deposits of salt water in the state.

Figure 1.0: map of Nigeria showing Ebonyi State

Ishiagu is one of the largest villages in Ivo local government area of Ebonyi state. It is known for its pottery (clay pots), Ishiagu is a large clan community of seventeen villages varying in size in

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terms of land and population. It is one of the largest autonomous communities in ivo local government area. It is located on the plains of the south-eastern savannah belt in Nigeria.

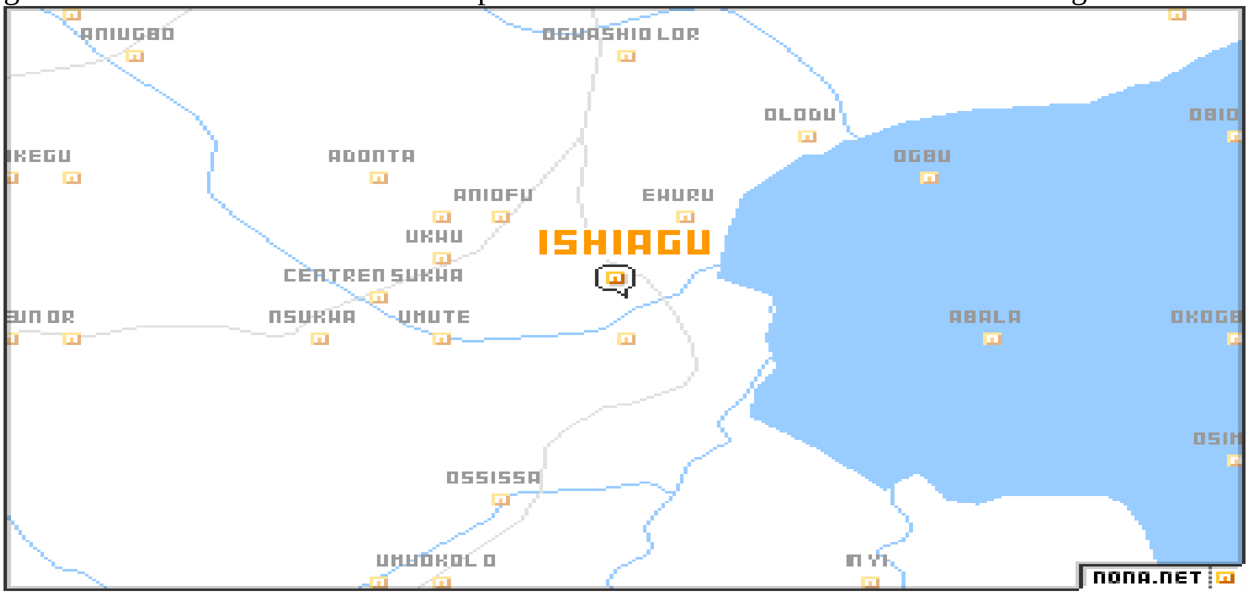

Fig 1.1, map of ishiagu-ivo

Ebonyi state has several deposits of clay, a large quantity been deposited in ivo local government area. Clay sample used in the course of this project work was gotten from ishiagu community in ivo local government area of ebonyi state, Nigeria.

MATERIALS AND METHODS

Sample Preparation:

The clay sample collected from Ishiagu was dried and crushed into very small size after which it was dissolved in water to form slurry under moderate temperature. The slurry was sieved to obtain fine particles of the clay which passed through as filtrate while sand and organic matters were deposited as residue. The filtrate was allowed to settle for about 3-5days, and then decanted to obtain a clay mud. The clay mud was dried for about 4days under sun light to obtain clay cakes, which were disaggregated and sieved to 125 microns to obtain fine clay powder. The sieved clay sample was collected in a beaker and labeled appropriately using a masking tape.

API RP-13B Standard procedures were employed throughout the laboratory work to determine rheological and fluid loss properties. All the sample muds were based on the formulation of 350ml of fluid that contains only fresh water and 25grams of clay

Mud Preparation:

The API fresh water mud containing only water and bentonite / ishiagu clay (local clay) were prepared accordingly by adding 25 g of bentonite/ishiagu clay to 350ml of water. This mud samples were named “mud A” and “mud” B respectively. The bentonite/local clay-to-water ratio was maintained constant for all subsequent mud samples used in this research work. The rheological properties of “mud A” and “mud” B were measured and recorded. Other mud samples with varying additive concentrations were prepared and their rheological properties

ISSN: Print 2514-9253, Online 2514-9261

were measured and recorded as well. All rheological properties were measured at ambient conditions (at 75°F). The mixture of the clay and water was stirred with the aid of multi- beach mixer for (3-5) minutes to obtain homogeneous mixture. The homogeneous mixture obtained was aged for 24 hours for proper hydration. After 24 hours of aging, the mud was re-stirred to re-agitate the mud for characterization.

RESULTS AND DISCUSSION.

This work was aimed at evaluating the effectiveness of local clay obtained from Ishiagu in Ebonyi state, Nigeria to substitute for imported bentonite in drilling mud. Table 1.0 below presents the results of the mud prepared with the local clay as well as that of bentonite as control. Some of the results (from local clay mud) were found to be out of API standard compared to bentonite mud. The rheological properties (PV, YP, and gel strength, filtration loss and pH) of the local clay were all not up to the API standard when compared with the bentonite mud, maybe due to some possible experimental errors. However, the density, sand contents, marsh funnel viscosity and cake thickness of the local clay met the API specification as they were almost the same as that of bentonite control mud.

The significant differences in their rheological properties such as plastic viscosity, yield point and apparent viscosity as well as pH value of the local clay mud necessitated the beneficiation of the local clay. Beneficiation is the process where chemicals are added to low quality clay to improve its performance. The local mud was beneficiated with barite ($BaSO_4$) derived starch, soda ash (Na_2co_3) and potassium chloride (kcl) to improve the mud density, rheological properties and pH respectively.

Table 1.1 and figure 1.0 below present the effect of addition of barite ($BaSO_4$) on the local clay to enhance its density. The results obtained showed that the local clay density increased from 8.80lb/gal to 9.15lb/gal at barite ($BaSO_4$) concentration of 10g. This development implies that barite can be used as weighting material in the formulation of drilling fluid using the ishiagu-ivo local clay. The addition of barite to the local clay helped improved the density of the drilling fluid close to the API specification,

In order to improve the performance of the local clay rheology, pac R was added as a viscosifier. The result presented in Table 1.2 and figure 1.1 below showed that the formulated drilling fluid's rheological properties increased significantly with increase in the pac R. Thus, the apparent viscosity, yield point and plastic viscosity increased from 5.00cp, 4.0lb/100ft² and 4.0cp to 11.10cp, 10.0lb/100ft² and 7.0cp (about 200%) respectively. The results indicate that the local clay mud viscosity improved favourably with the addition of pac R. This significant improvement in local clay rheology with pac R can be explored commercially as the availability of pac R is abundant in Nigeria.

Table 1.2 and figures 1.2.and 1.3 present the effect of soda ash (Na_2CO_3) and potassium chloride (Kcl) on the local clay mud's properties (apparent viscosity, plastic viscosity, yield point and pH). Apparently, this table and figures indicate that an increase in the soda ash (Na_2CO_3) and

ISSN: Print 2514-9253, Online 2514-9261

potassium chloride content resulted in an increase in the properties of the local clay mud. The increase in the local clay mud properties was as a result of increase in the sodium cations (Na^{++}) content of the clay following the addition of soda ash (Na_2CO_3) and potassium chloride (kcl). This fact was illustrated more in figures 1.2 and 1.3 below. Addition of 5g of soda ash and 50g of potassium chloride to the mud formulated with the local clay from Ishiagu were able to bring the properties listed above to almost API specification (table 1.3). Figure 1.4 which is a plot of soda ash concentration against pH of the local clay indicates a remarkable improvement in the pH of the mud formulated with the local clay to API specification.

A comparison of the effect of Pac R, soda ash (Na_2CO_3) and potassium chloride (kcl) (Table 1.2 and 1.3) on the properties of the local clay mud indicates that the apparent viscosity and plastic viscosity of the local clay mud increased more when soda ash (5g) and potassium chloride (50g) were added to the mud. For the yield point, both Pac R and soda ash/potassium chloride gave the same result (10).

TABLE 1.0: Comparism of properties of local clay with foreign Bentonite clay

Properties	Sample A (bentonite mud)	Sample B (local clay mud)
Density (ppg)	9.00	8.80
pH	10.00	5.65
Sand content (%)	0.30	0.50
Marsh funnel viscosity(sec/qt+)	52.00	30.00
Filtrate volume (ml)	28.00	4.00
Cake thickness (inch)	$\frac{1}{32}$	$\frac{1}{32}$
Specific gravity	1.08	1.06
Methylene blue capacity	4.00	2.50
Bentonite equivalent (kg/m^3)	20	35.625
Plastic viscosity (cp)	8.00	3.00
Apparent viscosity (cp)	13.00	4.50
Yield point ($lb/100ft^2$)	11.00	4.00
Gel strength @10sec Gel strength @ 10min	5.00 9.00	1.00 3.00

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Table 1.1: Effect of barite on the density of the local clay mud

Local Clay mud	Sample A	Sample B	Sample C	Sample D	Sample E
Barite content(g)	2.00	4.00	6.00	8.00	10.00
Density (lb/gal)	8.70	8.80	8.92	9.05	9.15

Fig.1.0: Graph of Barite ($BaSO_4$) vs density ishiagu Mud Density

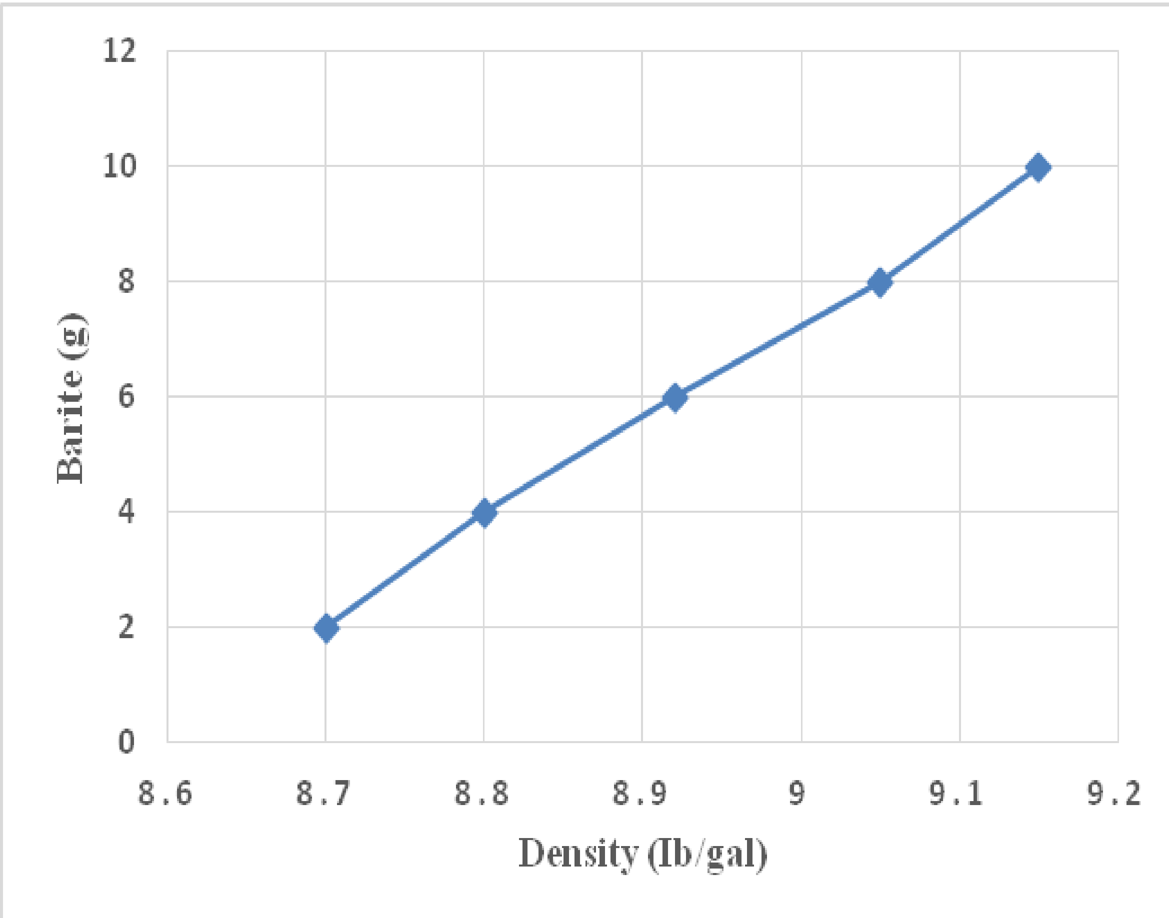


Table 1.2: Effect of PAC R on the viscosity of the local clay mud

Local Clay mud	Sample A	Sample B	Sample C	Sample D	Sample E
Pac R (g)	10.00	20.00	30.00	40.00	50.00
Apparent viscosity(cp)	5.00	6.00	8.00	9.20	11.10
Plastic viscosity(cp)	4.00	4.00	5.00	6.10	7.00
Yield point($lb/100ft^2$)	4.00	5.00	6.00	8.00	10.00

ISSN: Print 2514-9253, Online 2514-9261

Fig 1.1: Graph of pac R Vs Apparent, Plastic viscosities and yield point of local clay mud

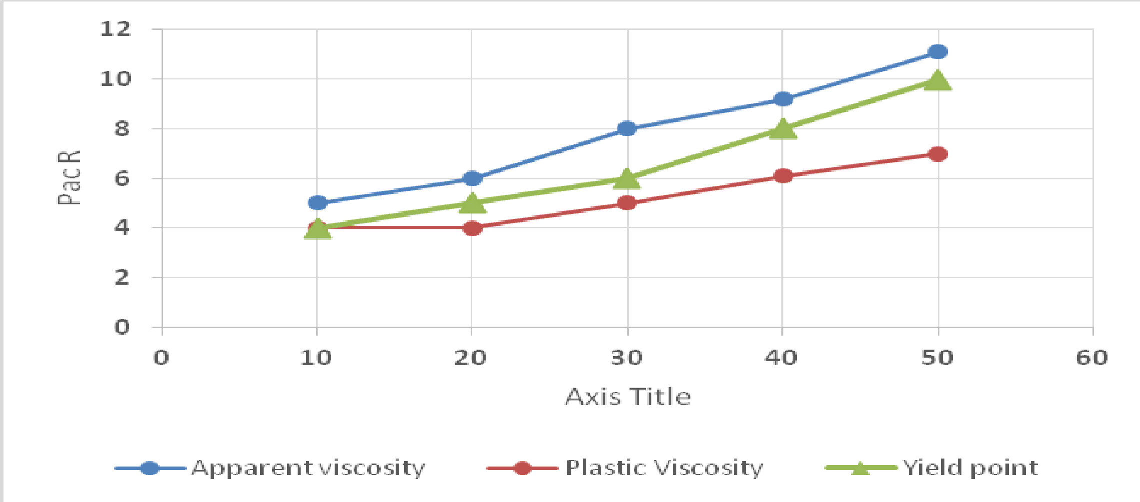


Table 1.3: Effect of soda ash and kcl on the local clay mud from ishiagu

Clay mud	Sample A	Sample B	Sample C	Sample D	Sample E
Soda ash, (Na_2CO_3) (g)	2.00	3.00	4.00	4.50	5.00
Kcl (g)	10.00	20.00	30.00	40.00	50.00
Apparent viscosity(cp)	6.50	7.05	9.00	10.50	12.40
Plastic viscosity(cp)	4.00	4.00	6.00	7.00	8.00
Yield point(lb/100ft²)	6.00	8.00	8.00	8.00	10.00
pH	8.30	9.06	9.82	10.02	10.60

Fig. 1.2: Graph of Soda Ash against Apparent, Plastic viscosities and yield point of local clay mud

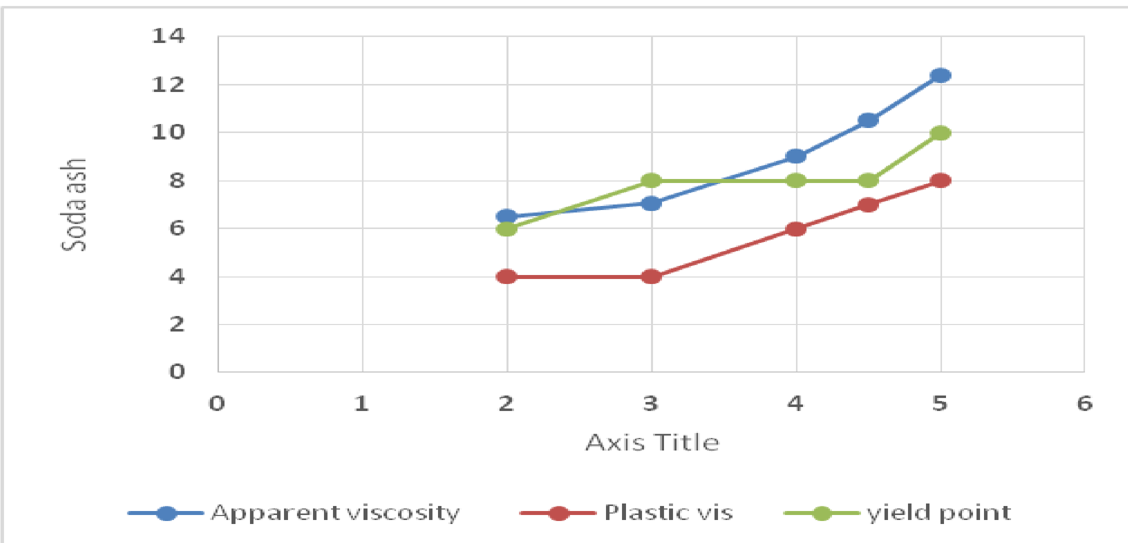


Fig. 1.3: Graph of Kcl Vs Apparent, Plastic viscosities and yield point of local clay mud

ISSN: Print 2514-9253, Online 2514-9261

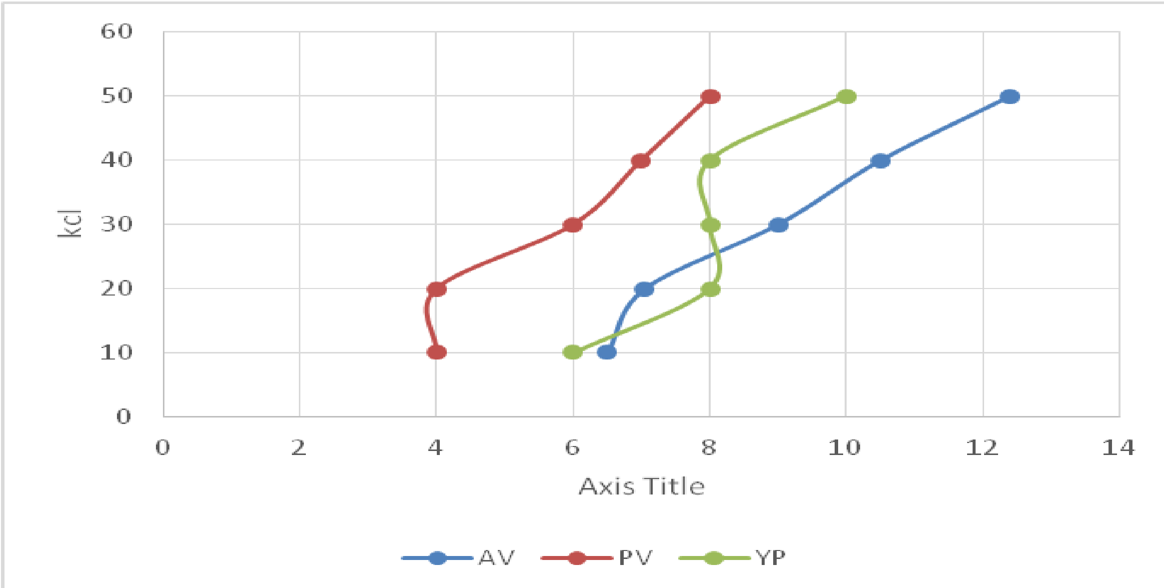
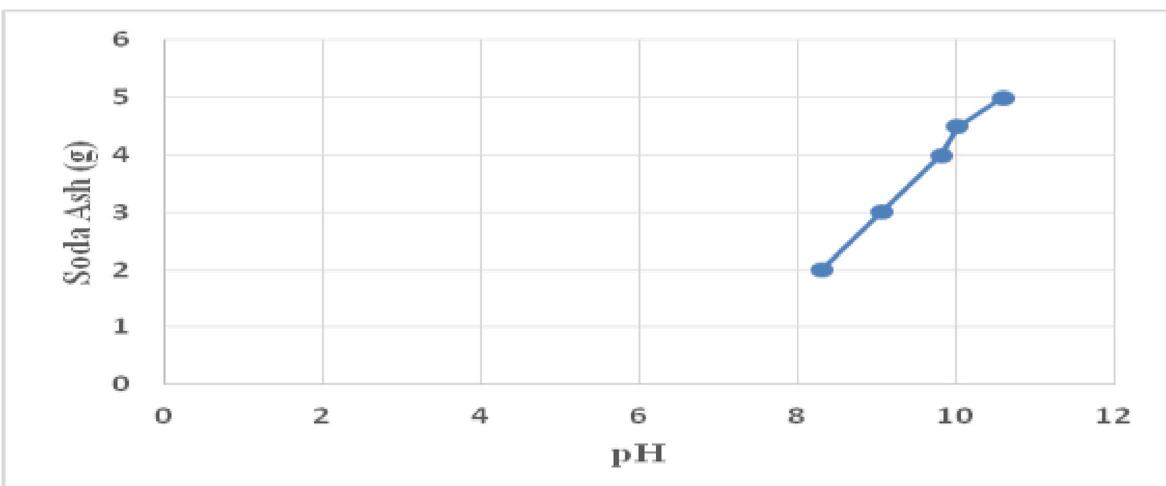


Fig. 1.4: Graph of Soda Ash (Na_2CO_3) against pH of the local clay Mud



CONCLUSION

One of the factors affecting the rate of ion exchange in clay is the relative concentration of sodium cations (Al-Homadhi, 2007). The introduction of soda ash (Na_2CO_3) and potassium chloride (kcl) improved the properties of the local clay as some of the sodium cations (Na^{++}) occupied the surface area. Thus, the higher sodium ion concentration increases the attraction of clay and water (Falode et al., 2006). The addition of soda ash (Na_2CO_3) and

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potassium chloride (kcl) to the local clay mud increased the formulated drilling fluid's pH as well as the rheological properties. The local clay mud pH increased from an initial value of 8.30 to 10.60 at a concentration of 5.0g of soda ash (Na_2CO_3) and 50g of potassium chloride (kcl). This increase in pH value created an alkaline medium in the local clay mud that enhanced the solubility of the pac R (viscosifier) which resulted in increase in the rheological properties of the local clay mud. Therefore, it was observed that the physio-chemical properties of drilling mud made with ishiagu clay improved to the API specification with the added additives mentioned above.

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