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Evaluation of Local Clays from Edo and Delta State as Feedstock in Drilling Fluid Formulation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This work investigates the suitability of clay samples collected from Ogwashi-Ukwu and Oyede in Delta State as well as Ikpeshi and Afuze in Edo State for drilling mud formulation. The American Petroleum Institute (API) Standard for drilling mud formulation was adopted using 350 ml of water and 21.0 g of fresh unweathered clay samples collected at 5 ft depth from the mentioned location. The Clay Samples were processed (Weighed, dried, and sieved) and the drilling mud formulated with other additives (Carboxyl Methyl Cellulose, NaOH and Barite). The results from the four samples showed that the pH of Ikpeshi was alkaline while the other samples were acidic. When the mud was mixed with NaOH at 0.5 g, 1.0 g, 1.5 g, 2.0 g, 2.5 g and 3.0 g, the pH rose to 13 and 14 for the Ikpeshi and Ogwashi-Ukwu, while the pH values of the mud formulated with the standard clay gave 9 and increased to 13 when 3.0g of NaOH was added. The mud densities for the four mud samples formulated were within 8.40 to 8.60ppg before addition of chemical additives. After beneficiation addition with Barite, the densities of the four formulated mud rose and almost equal to that of the standard mud of 8.95 ppg at 3 g additive. The plastic viscosity of the locally formulated mud were within 1 to 2 cp before adding cmc and increased to 30cp for Ikpeshi mud, 27 cp for Ogwashi-Ukwu, 17 cp for Afuze and 18 cp for Oyede. The filtration rate for Afuze and Ikpeshi mud was 33 ml and 36 ml for 30 mins and may need additional filtration agent to be up to standard. The results have shown that the Nigeria Clay can be used with beneficiation. Therefore, the production of mud materials locally, should be encourage to reduce the cost of drilling by avoiding importation.

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Keywords: Additives; drilling mud; formulated; local clay; rheological properties.

1. INTRODUCTION

Nigeria's Economy relies largely on the proceeds from the Petroleum sector. As a result, there has been a continued increase in the use of clay; a major component of drilling mud. Research conducted over the past few years have clearly demonstrated that drilling activities in the petroleum and groundwater development industries in Nigeria have utilized, and will continue to utilize, great amounts of imported clays for drilling muds, despite the country's wealth of clay resources. Ameloko et al. [1] asserted that most local bentonite are calcium rich, while foreign bentonites are sodium bentonite.

Nweke et al., [2] reported that the raw materials used for the mud making are usually selected clays with appreciable amount of montmorillonite and are judged by their behavior in water. The raw material which meets most of these requirements for drilling is the bentonite clay. The cost of drilling mud which is formulated with clays during drilling can account for 15% of the entire drilling cost of a well (Oyeneyin, 2014). In order to reduce importation of clays for drilling mud preparation, several research has been done and still on going for suitability of Nigerian Bentonite clay as oil well drilling mud. So many of the studies have shown that Nigerian clays do not meet the American Petroleum Institute(API) Standard specification in natural forms and require beneficiation in order to meet up the standard specification. Ameloko et al. [1] showed that the rheological and flow flow properties of drilling mud formulated with Ondo State clay only improved by beneficiation with sodium carbonate, and addition of polymer (CMC). Ogofotha et al. [3] evaluated the effectiveness of local clays from the Southern region of Nigeria as substitute for convention clay in drilling mud formulation and observed that the density of locally formulated drilling mud was almost up to that of bentonite with a significant difference in the rheological properties when compared with the standard bentonite clay. Irabor et al. [4] evaluated Edeje-Irhodo clay in Jesse, Delta State as possible substitute for conventional clay in oil well water based drilling mud and concluded that the formulated drilling muds with additives were suitable for oil and gas drilling operations. Nweke et al., [2] worked on the characteristics of clays from Abakaliki Formation, Southeastern Nigeria and observed that the clays failed to satisfy the required specifications outlined for clays used as drilling mud when compared with the properties of Wyoming bentonite but can be improved with additives. Nmegbu [5] investigated clays from Egbamini (Emolga), Afam Street (Port Harcourt) and Oboboru in Rivers state and concluded that they were unsuitable for drilling mud preparation when compared to standard Bentonite. Dewu et al. [6] evaluated the bentonitic clays from Pindiga Formation in Benue Trough and concluded that the samples are Cacium -base but can be beneficiated using sodium carbonate as beneficiating agent and ion exchange procedure. Apugo-Nwosu et al. [7] worked on the suitability of Ubakala bentonitic clay for oil well drilling mud formulation and concluded that the Ubakala clay samples possess no property on their own for use as drilling mud for oil well drilling. However, when beneficiated with Na2CO3 and PAC-R or CMC; depending on the concentration of additives, much better results that satisfied American Petroleum Institute (API) specifications were derived. Okogbue and Ene [8] worked on some southeastern Nigeria natural clays and concluded that those clays possess similar properties with those of naturally active bentonitic clays from Wyoming and Texas which are used in the oil and gas industry as drilling mud. However, Mihalakis et al. [9], observed that the rheological properties of the black cotton clays improved with addition of Na_2CO_3, such that the upgraded clay can be used as multipurpose drilling mud.

According to Falode et al., [10] clays of various kinds and grades are abundant throughout Nigeria's sedimentary basins and on the basement. The Nigerian Mining Corporation established the existence of bentonitic clay reserves of over 700 million tonnes in the country, with the largest single deposit at Afuze in Edo State holding 70-80 million tonnes [7]. Despite the abundance of clay in Nigeria, drilling activities within the country has heavily dependent on the imported clay; the act drains the nation's reserves in hard currency and also unfriendly to local content policy being currently promoted for the oil industry in the country. These in turn will have negative impacts on the nation's economy since the country is largely depends on the income from oil and gas sector. Hence, the need for locally produced bentonite clays or close substitutes has become necessary and urgent. This study is primarily aimed at investigating and comparing the properties of some clay deposits from Edo and Delta state both in the Southern part of Nigeria, in order to determine whether the clay deposits meet the specifications for use as oil well drilling mud when compared with that of commercial bentonite [11,12].

2. MATERIALS AND METHODS

2.1 Materials

The materials and Apparatus used in this work includes Fresh water, Clay sample, Barite, NaOH and Carboxyl Methyl Cellulose, Grinding machine, Triple beam balance, Electric blender, Spatula, Measuring cylinder, Mud balance, Stop watch, Mechanical agitator, Mortar and Pestle/Grinder, Hammer mill, Plastic bucket, Sieves, pH paper, sand content kit, high speed multitier, Rheometer and Filter press.

2.2 Clay Sample Collection and Processing

Fresh unweathered representative local clay samples were collected at depth of about 5ft from Afuze and Ikpeshi in Edo State, and Oyede and Ogwahi-Ukwu in Delta State respectively. The mined bentonite was first transported to the processing plant and stockpiled. The clay was then passed through a crusher to reduce the clay pieces to less than 2.5 cm (1 in.) in size. Next, the crushed bentonite is dried using open air method. The dried material was pulverized by means of roller or hammer mills. The collected clay samples were sun-dried to remove moisture and then pounded using mortar and pestle to reduce to 12 particle size and increase the surface area. The pounded clay sample was then put in a furnace for further drying in order to remove possible moisture content. After drying, the sample was milled to get the desired particle size. A hammer mill with upper and bottom funnel serving as inlet and outlet for samples were mounted. The mill has a hammer at the center which was driven by an electric motor part of the mill. The function of the hammer was to continuously reduce the particles of the clay to obtain the desired size. Below the hammer is a sieve with mesh of size 75 μm (micrometer). After passing through the mill, the clays gotten were packaged. 21.0g of the foreign clay was measured out from Aqual Gel Bariod Nigeria clay using the triple beam balance and poured into different containers and labeled. 350 ml of distilled water was measured with measuring cylinder. The water was poured into an electrical blender which was plugged in to a power supply. The measured clay sample was added and the electric blender was turned on at a low speed for one minute. The mixture was agitated until the clay was thoroughly mixed to form a homogenous mixture. Similarly, 0.5 g, 1.0 g, 1.5 g, 2.0 g, 2.5 g and 3.0 g of additives (barite, NaOH, and sodium carboxyl methyl cellulose, the mud was formulated by addition of 21grams clay and 350 ml distilled water.

2.3 Mud Properties Determination

2.3.1 pH property

pH paper and pH indicator were used in this study to determine the mud pH. The procedures are as follow:

i. Mud sample was poured into a beaker and then stirred vigorously
ii. A pH paper was then immersed into the beaker containing the mud sample
iii. The pH paper was then removed from the beaker after about a minute or two.
iv. The color change by the pH paper was then correlated with the pH indicator which ranges from 1 to 14

2.3.2 Mud density

The procedure for mud density determination is as follows:

i. The mud balance base was placed on a flat, level surface.
ii. The clean, dry mud balance cup was filled with the mixture of mud to be tested.
iii. The cap was then rotated until it was firmly seated.
iv. Thumb was placed over hole in cap and the cap was held firmly on the cup.
v. The outside of the cup was washed or wiped and dry
vi. The balance arm was placed on a support base and balanced by moving the rider along the graduated scale until the level bubble was centered under the center line.
vii. The density (weight) of the mud shown at the left-hand edge of the rider was then read and recoded to nearest 0.1 lb/gal or ppg.

2.3.3 Mud viscosity test

Mud Viscosity Test Procedure are;

i. The mud to be tested was obtained and stirred vigorously for 10 seconds
ii. The thermal cup was filled approximately 2/3 full with mud sample
iii. The thermal cup was then placed on the viscometer stand
iv. The cup was raised and stood upright until rotary sleeve is immersed to the scribe line on sleeve
v. The meter toggle switch located on right rear side of meter was turned to a high position by pulling it forward.
vi. The sleeve was then allowed to rotate at 600-rpm and then waited for dial reading in the top front window of meter to stabilize for 10 seconds.
vii. The 600-rpm dial reading was then read and recorded
viii. The meter toggle switch located on the right rear side of the meter was turn to a low position by pulling it backward.
ix. The sleeve was then allowed to rotate at 300-rpm and then waited for dial reading in the top front window of meter to stabilize for 10 seconds
x. The 300-rpm dial reading was then read and recoded.

2.3.4 Gel strength

i. With red knob in bottom position, the flip toggle was switched to 600-rpm position (forward position) and mud sample was stirred for 10 seconds.
ii. After 10 seconds, flip toggle was switched to low (rear) position and note the maximum dial reading
iii. The maximum dial deflection is the 10-second (initial gel strength) of the mud sample was then read and recoded.
iv. The apparent viscosity (AV), plastic viscosity and yield point were then calculated and recoded using the following formula:

$$AV = \theta\ 600\ rpm/2 \quad \text{……………………(1)}$$

$$PV = \theta\ 600\ rpm - \theta\ 300\ rpm \quad \text{……………(2)}$$

$$YP = \theta\ 300\ rpm - PV \quad \text{……………………(3)}$$

Where:

AV - Apparent viscosity
PV - Plastic Viscosity
YP - Yield Point

Also, the YP/PV ratio and n factor = 3.32Log (θ 600 rpm/ θ 300 rpm) were determined and recorded.

2.3.5 Fluid loss test

The API fluid loss test is a test used to measure the filtration of mud under ambient condition. It is indicative of the tendency of the liquid phase of a drilling mud to pass into the formation.

Test Procedure is as follows;

i. The stirred mud sample was poured into the cell, the lid secured and it was ensured that all valves were in their correct positions so as to permit the application of pressure to the mud sample to be filtered.
ii. An appropriately sized, graduated cylinder was placed under the filtration tube.
iii. Using the pressure gauge as an indicator, a 700 kPa pressure was applied to the sample and timing initiated for the test.
iv. The filtrate was collected in the graduated cylinder for a period of 30 minutes.
v. The graduated cylinder was removed and the pressure on the test sample was relieved.
vi. The volume of collected fluid was reported as the fluid loss in milliliters for the period of 30 minutes.
vii. The test cell was disconnected, the mud discarded and extreme care was applied so as to save the filter paper with minimal disturbance to the filter cake. The excess mud from the filter cake was removed by light washing or lightly sliding a finger across the filter cake.
viii. The thickness of the filter cake was measured and reported in millimeters.

3. RESULTS AND DISCUSSION

3.1 Mud pH

The mud pH of the foreign clay was alkaline while the other clay samples were acidic except Ikpeshi clay which was neutral. Only mud formulated with foreign clay closely meet up the standard API Specifications while other values were low when compared with API Specification (API RP 13B-1) which is between 9.5 – 12.5 as shown in Fig. 1.

When treated or beneficiated with sodium hydroxide (NaOH) a minimum value of 9.5 was obtained. Generally, the pH of the formulated muds treated with pH control additive was progressively increased from 9.5 to 14.0 as presented in Fig. 2. These results fall within the

API specification. Results indicated that the higher the concentration of NaOH, the higher the mud pH values. It was also observed that the API specification of 9.5 – 12.5 were obtained for all the samples when they were treated with 0.5 g, 1.0 g, 1.5 g and 2.0 g of NaOH except Aqua Gel and Ikpeshi clays that were 14 when treated with 2.5 g and 3.0 g NaOH. Also Afuze, Ogwashi-Ukwu and Oyede clays were all still within API specification when beneficiated with 2.5 g and 3.0g NaOH with the exception of Ogwashi-Ukwu that was 14 when treated with 3.0g NaOH. These values indicate that formulated muds beneficiated with pH control additives will be suitable for oil and gas drilling operations when compare with foreign clay. Hence, the formulated muds treated with NaOH could be used to prevent corrosion of the drilling equipment.

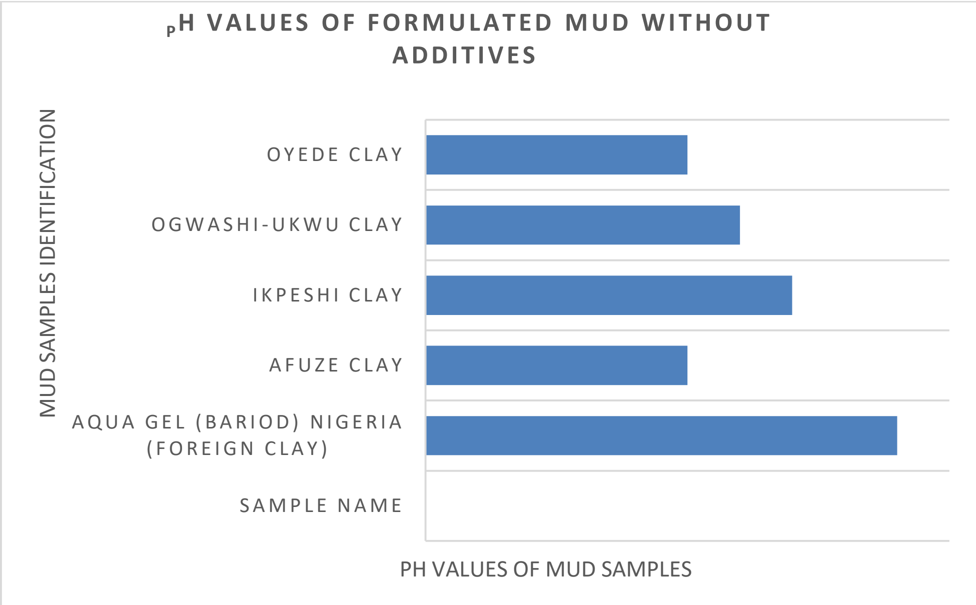

Fig. 1. pH values of formulated mud without additive

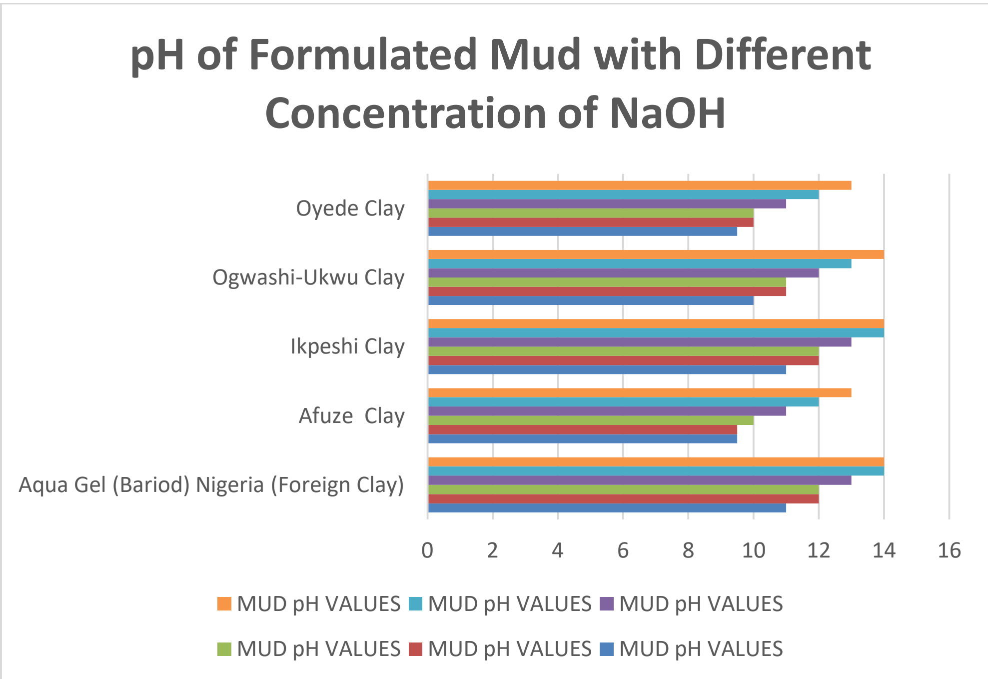

Fig. 2. pH of Mud Formulated with different concentration of NaOH Additive

3.2 Mud Density/Weight

The standard API specification for mud density is between 8.65 - 9.60 lb/gal. The mud density of all the formulated mud without additive range between 8.40 – 8.60 which was slightly less than the minimum API value. Only mud formulated with foreign clay and Ogwashi-Ukwu clay closely meet up the standard API Specifications while other values are low when compared with API Specification as seen in Fig. 3. These results reveal that the formulated local mud without additive are not suitable for oil and gas drilling operations because it will cause under balanced condition.

The results of mud density of formulated mud beneficiated with different concentration of $BaSO_4$ increased from 8.45 to 8.95 lb/gal as presented in Fig. 4. These results fall within the API specification with the exception of Afuze clay treated with 0.5 g and 1.0 g $BaSO_4$, Ikpeshi clay treated with 0.5 g $BaSO_4$, Ogwashi-Ukwu treated with 0.5 g and 1.0 g and Oyede clay beneficiated with 0.5 g, 1.0 g, 1.5 g and 2.0 g respectively. It was also observed that the higher the concentration of $BaSO_4$, the higher the mud density values. This indicates that locally formulated muds with density control additive will be suitable for oil and gas drilling operations. Hence, the formulated muds could be used to control the subsurface pressure by providing sufficient hydrostatic pressure and enhance wellbore stability when compare with foreign clay.

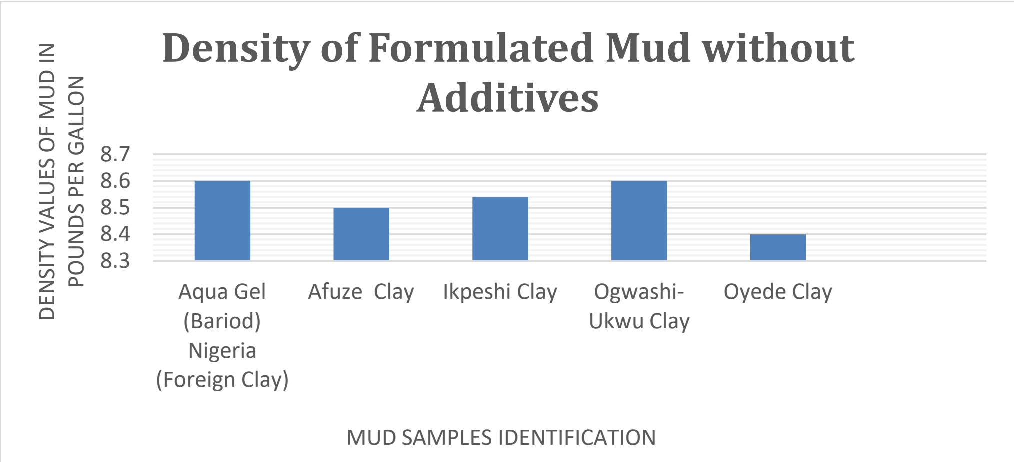

Fig. 3. Mud density of formulated mud without additives

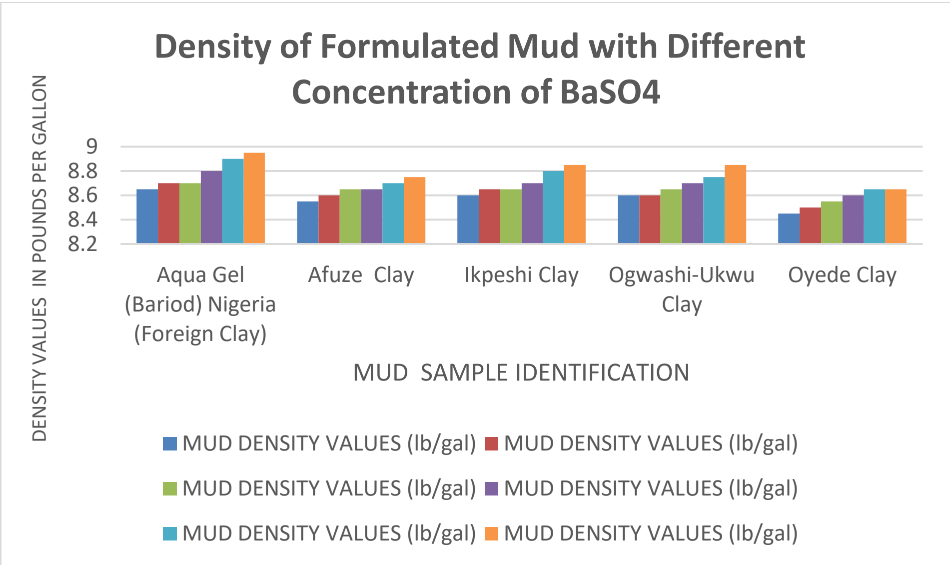

Fig. 4. Density of formulated mud with different concentrations of $BaSO_4$

3.3 Mud Viscosity

The values of viscosity readings at 300rpm and 600 rpm ranges between 1 – 3 centipoise and 2 – 5 centipoise respectively. These values were extremely low when compare with API specification with a minimum of 23 centipoises and 30 centipoises for dial readings at 300 rpm and 600 rpm respectively as seen in Fig. 5. This shows that the local clay will not be able to transport cuttings effectively unless it is improved with viscosity controlled additives. Also other parameters that depend on the mud viscosity such as plastic viscosity, apparent viscosity and yield point will be possibly low. Hence, viscosifiers such as carboxyl methyl cellulose (CMC) at 0.5 g, 1.0 g, 1.5 g, 2.0 g, 2.5 g and 3.0 g were used to beneficiate the local clays in order to have optimum mud rheological properties.

It was observed that the mud viscosity readings increased as the concentration of CMC additives was increased. Optimum mud viscosity readings that conform with API specification was obtained when the mud was formulated with Aqual Gel (Foreign clays) and treated with 1.0 g, 1.5 g, 2.0 g, 2.5 g and 3.0 g of CMC for dial readings values at 300 rpm and 600rpm which ranges from 34 – 71 centipoise and 31 – 102 centipoise respectively. However, the viscosity readings of 30 – 46 centipoise and 30 – 64 centipoise at 300 rpm and 600 rpm respectively were obtained when formulated with Afuze clay and beneficiated with CMC at 2.0 g, 2.5 g and 3.0 g respectively. Also when formulated with Ikpeshi clays and with CMC at 1.5 g, 2.0 g, 2.5 g and 3.0 g respectively, the viscosity values at 300 rpm and 600 rpm were between 31 – 68 cp and 47 – 98 cp respectively. Similarly, the viscosity readings of 26 – 57 cp and 37 – 84 cp at 300 rpm and 600 rpm respectively were obtained when formulated with Ogwashi-Ukwu clay and treated with 1.5 g, 2.0 g, 2.5 g and 3.0 g CMC. When the mud was formulated with Oyede clay and treated with 2.0 g, 2.5 g and 3.0 g CMC, the viscosity obtained met the API specification for dial readings at 300 rpm and 600 rpm and range between 29 – 45 cp and 39 – 63 cp respectively. The result also revealed that higher viscosity of the mud was obtained at 600 rpm when compared with the values obtained at 300 rpm as seen in Fig. 6.

3.4 Mud Plastic Viscosity

The results of plastic viscosity ranges between 1 – 2 centipoise. These values were relatively low when compare with API specification minimum of 7 centipoises as shown in Fig. 7. These low values confirm that Plastic Viscosity depends on the mud viscosity since it was derived by subtracting dial reading at 300 rpm from dial reading at 600 rpm.

However, when the formulated muds were treated with 0.5 g, 1.0 g, 1.5 g, 2.0 g, 2.5 g and 3.0 g CMC, there was significant improvement in the plastic viscosity values for both the foreign clay and the local clays. Though there was low Plastic Viscosity value for all the samples when treated with 0.5 g CMC. That is Aqual Gel, Afuze, Ikpeshi, Ogwashi-Ukwu and Oyede clay samples have plastic viscosity values of 5 cp, 4cp, 5 cp, 4 cp and 4 cp respectively. Similarly, the highest plastic viscosity values of 31 cp, 18 cp, 30 cp, 27 cp and 18 cp were obtained for Aqual Gel, Afuze, Ikpeshi, Ogwashi-Ukwu and Oyede clay samples respectively when beneficiated with 3.0 g CMC as shown in Fig. 8. Results shows that plastic viscosity increases with increasing concentrations of CMC.

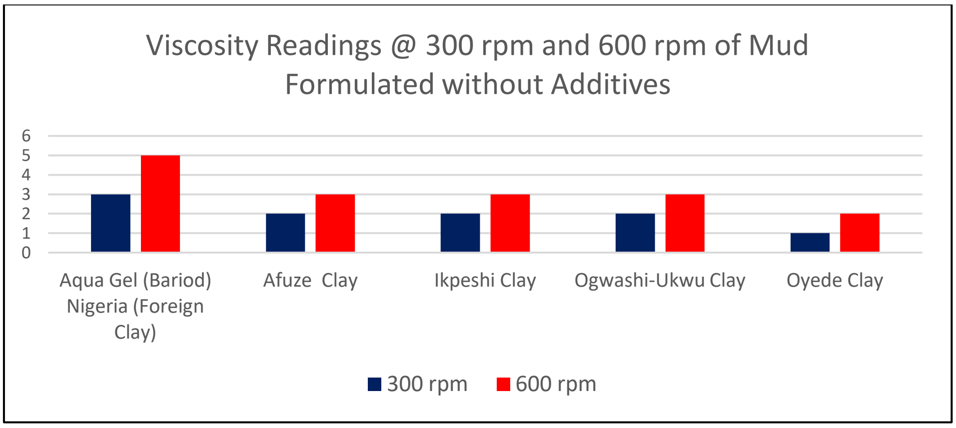

Fig. 5. Viscosity readings @ 300 rpm and 600 rpm of mud formulated without additives

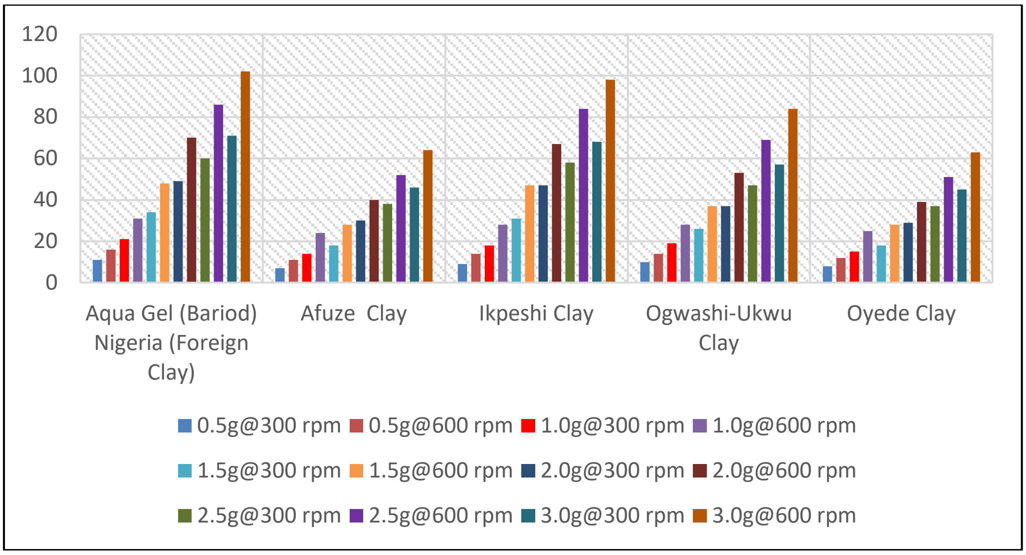

Fig. 6. Viscosity readings @ 300 rpm and 600 rpm of formulated muds with different concentration of CMC

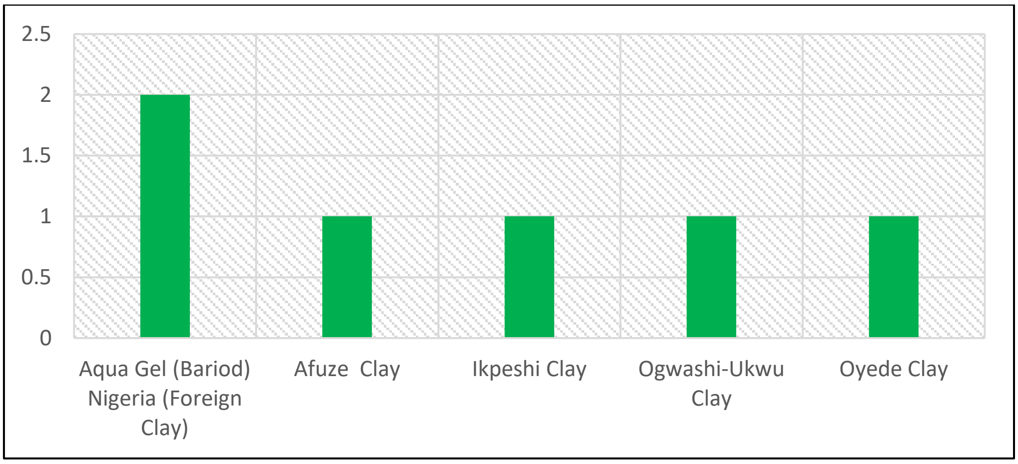

Fig. 7. Plastic viscosity of formulated mud without additives

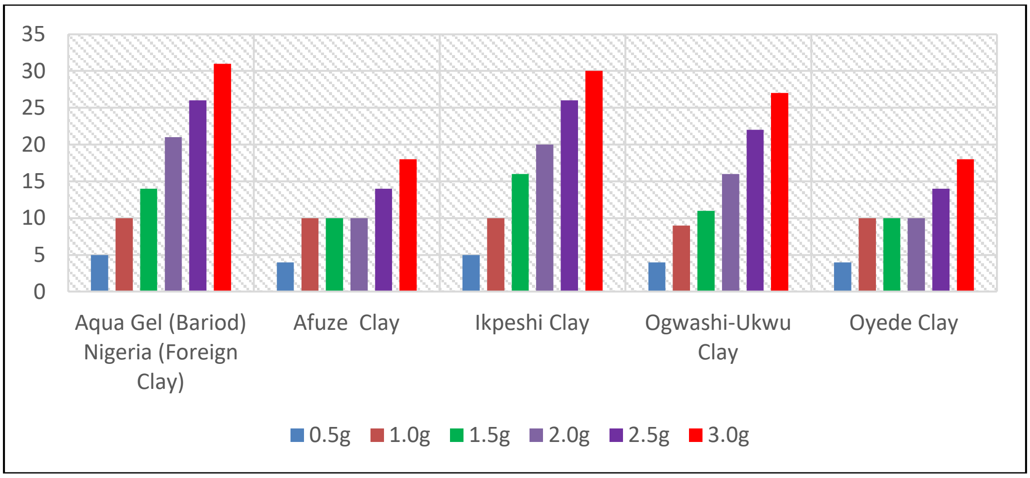

Fig. 8. Plastic viscosity values of formulated mud treated with different concentrations of CMC

3.5 Mud Yield Points

The results of yield point(YP) of mud formulated without additives is shown in Fig. 9. All the mud samples that were formulated with foreign clay and local clays have YP values that range between 0 and 1 Ib/100ft^2 with the Oyede clay having the lowest value.These values were extremely low when compare with API specification whose YP is in the range of 5 to 50 Ib/100ft^2.These values were relatively low when compare with API specification minimum of 5 Ib/100ft^2 as presented in Fig. 9.

However, when the formulated muds were treated with 0.5 g, 1.0 g, 1.5 g, 2.0g , 2.5 g and 3.0 g of CMC, there was significant improvement in the yield point values for both the formulated muds with foreign clay and the local clays. It was observed that both mud formulated with both Aqual Gel and Ogwashi-Ukwu Clay improved significantly when they were beneficiated with different concentration of CMC with both having a minimum value of 6 Ib/100ft2 at 0.5g CMC and maximum values of 40 Ib/100ft2 and 30 Ib/100ft2 at 3.0g as shown in Fig. 10. These values for both samples were within the API specification.

However, there were low YP values of 3 Ib/100ft2 and 4 Ib/100ft2 for Afuze samples when treated with 0.5 g and 1.0 g CMC and these values are below API specification while the results of other concentration were within API specification. Whereas Ikpeshi and Oyede clay samples have minimum YP value of 4 Ib/100ft^2 which was slightly below minimum API specification when treated with 0.5 g CMC and maximum values of 38 Ib/100ft^2 and 27 Ib/100ft^2 that fall within API specification when treated with 3.0 g CMC. It was observed that the YP increases with increasing concentrations of CMC as seen in Fig. 10.

3.6 Mud Gel Strength

The gel strength for all the samples range from 1 – 2 Ib/100ft^2 and 2 – 3 Ib/100ft2 for 10 seconds and 10 minutes with the foreign clay with the highest value for mud without beneficiation. These values were extremely low when compare with API specification as shown in Fig. 11.These results indicate that the formulated mud without additives will not be able to suspend drill cuttings and weighting materials during connections and other static conditions.

In order to perform the function of suspension of cuttings and weight material, the gel strength of a drilling fluid must not be allowed to be higher than necessary. Therefore 0.5 g, 1.0 g, 1.5 g, 2.0 g, 2.5 g and 3.0 g of CMC were added to the formulated muds so as to increase the gel strength. Fig. 12 shows the results of gel strength of the formulated mud with different concentrations of CMC at 10 seconds and 10 minutes respectively.

Generally, it was observed that the mud gel strength values increased as the concentration of CMC is increased. Although, the gel strength of Aqual Gel clay at 10 seconds and 10 minutes increases optimally to 20 lb/100ft^2 and 30 lb/100ft^2 respectively when treated with 0.5 g CMC then decreases drastically to 3 lb/100ft^2

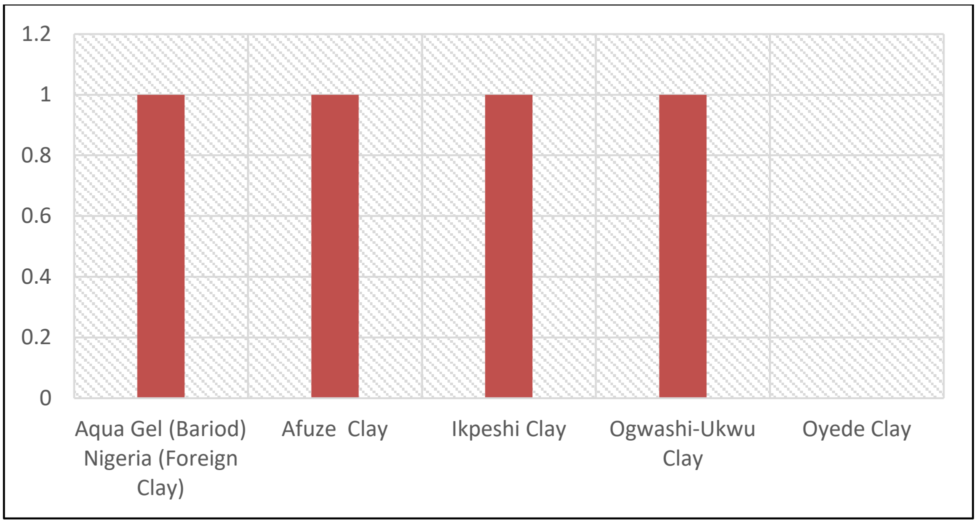

Fig. 9. Yield point of formulated muds without additives

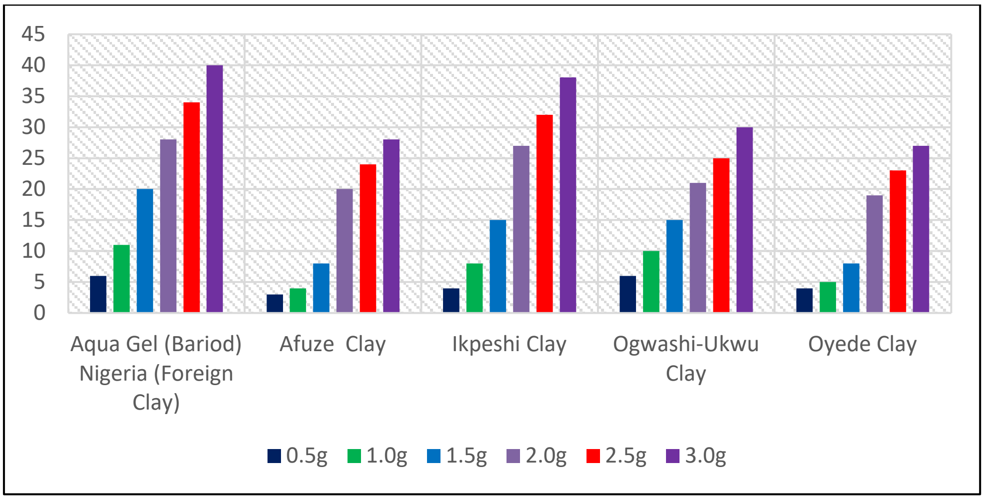

Fig. 10. Yield point values of formulated mud treated with different concentrations of CMC

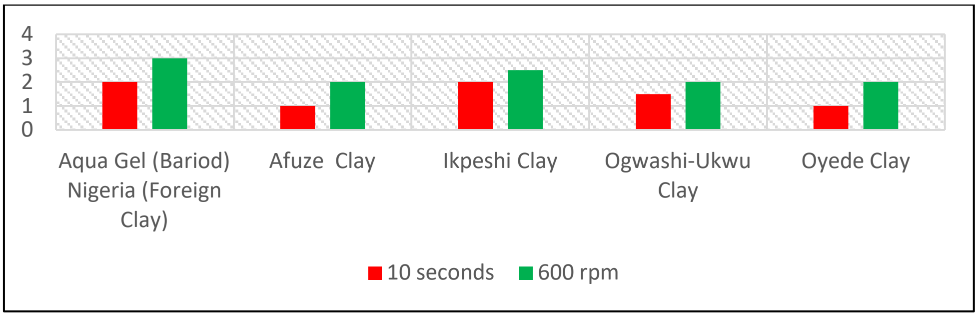

Fig. 11. Gel strength of formulated muds at 10 seconds and 10 minutes without additives

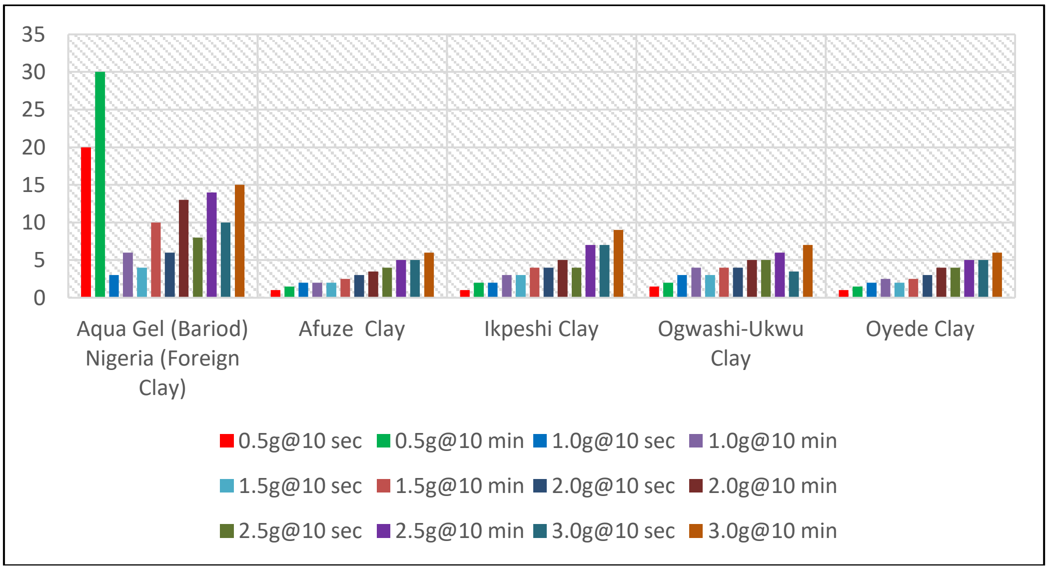

Fig. 12. Gel strength at 10 seconds and 10 minutes of formulated muds with different concentration of CMC

and 6 lb/100ft^2 when treated with 1.0g CMC and increases progressively until 10 lb/100ft^2 and 15 lb/100ft^2 for 10 seconds and 10 minutes respectively when treated with 3.0 g CMC. The gel strengths of Afuze, Ikpeshi, Ogwashi-ukwu and Oyede at 10 seconds increase slightly from

1 – 5 lb/100ft^2, 1 – 7 lb/100ft^2, 1.5 - 6 lb/100ft^2 and 1 – 5 lb/100ft^2 respectively when beneficiated with 0.5g – 3.0g CMC. Whereas their gel strength at 10 minutes also increase slightly from 1.5 – 6 lb/100ft^2, 2 – 9 lb/100ft2, 2 - 7 lb/100ft^2 and 1.5 – 6 lb/100ft^2 when beneficiated with 0.5 g – 3.0 g CMC. These results indicate that the formulated mud with foreign clay treated with CMC have sufficient gel strength to suspend drill cuttings and weighting materials during connections and other static conditions than the formulated muds with local clays.

3.7 Mud Flow Behavior Index (N Factor)

Fig. 13 shows the flow index behavior results of formulated muds without additives. The flow behavior index indicates the degree of non-Newtonian characteristics of the fluid. The n factor of all the samples range from 0.58 – 1.0 with the Oyede clay with the highest value and classified as Newtonian fluid while others are non-Newtonian pseudo plastic fluids. These values are within the API specification which stipulated a maximum of 1 for flow index behavior as seen in Fig. 13. These values reveal that both the foreign clay and the local clay have the ability to facilitate hole cleaning.

Similarly, when the formulated muds were beneficiated with 0.5g, 1.0g, 1.5g, 2.0g, 2.5g and 3.0g CMC, the values obtained were all within API specification with 0.78 and 0.41 being the maximum and minimum values obtained from Afuze clay when treated with 2.5g and 1.5g CMC as seen in Fig. 14. The values of Aqual Gel, Ikpheshi, Ogwashi-Ukwu and Oyede clays range from 0.50 – 0.56 obtained at 1.5 g and 1.0 g CMC, 0.51 – 0.64 obtained at 2.0g and 0.50/1.0g CMC, 0.49 – 0.60 obtained at 3.0 g and 0.5 g and 0.43 – 0.74 obtained at 2.0g and 1.0g CMC as shown in Fig. 14. These results also indicate that the local clay have the capacity to facilitate hole cleaning and are non-Newtonian pseudo plastics fluids since their values are greater than 0 but less than 1.

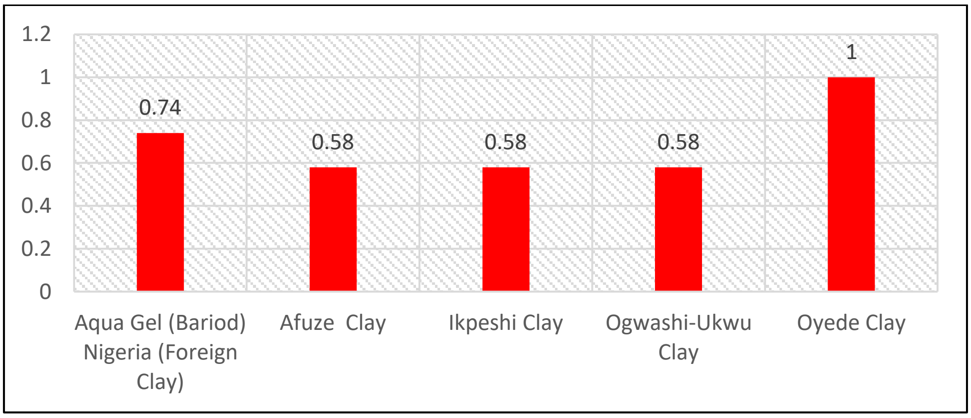

Fig. 13. Flow behavior index of formulated muds without additives

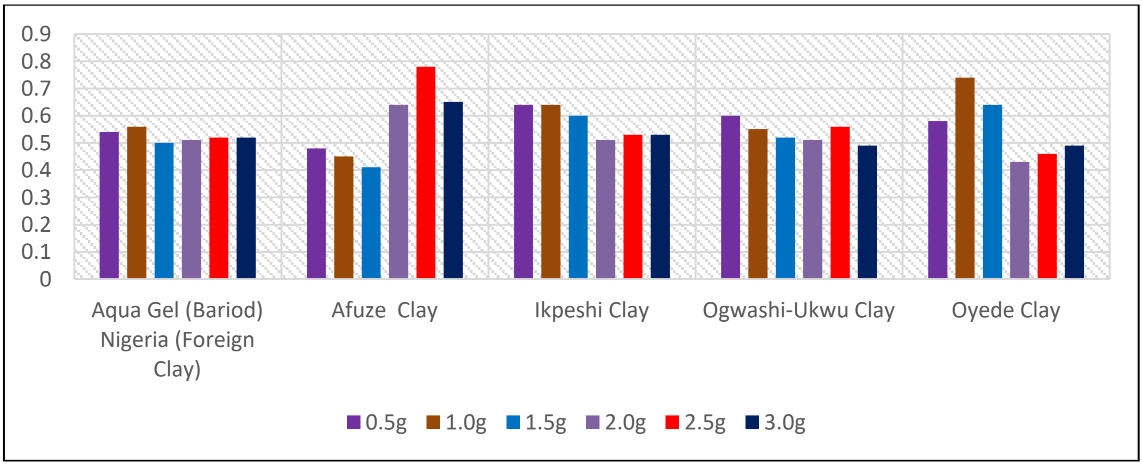

Fig. 14. Flow behavior index of formulated mud treated with different concentrations of CMC

3.8 Mud Yield Point /Plastic Viscosity Ratio

The result of YP/PV ratio of formulated muds without additives is presented in Fig. 15. The API specification for YP/PV ratio is 3 (maximum). The YP/PV ratio of all the samples range between 0 and 1 with the Oyede clay having the lowest value and followed by Aqua Gel clay with YP/PV ratio of 0.5. These values are within the API specification as shown in Fig. 15. These values indicate that both the foreign clay and Oyede clay will exhibit lower flow performance, lower ability of hole cleaning and lower rate of penetration when compared with other Afuze, Ikpeshi and Ogwashi-Ukwu clay sample.

Similarly, there was better improvement when the formulated muds were beneficiated with 0.5 g, 1.0 g, 1.5 g, 2.0 g, 2.5 g and 3.0 g CMC. The results obtained were all within API specification where the highest and lowest values obtained are 2.0 and 0.4 from Afuze clay when treated with 1.5 g and 2.5 g CMC respectively. The values of Aqual Gel, Ikpheshi, Ogwashi-Ukwu and Oyede clays range from 1.1 – 1.4 obtained at 1.0 g and 1.5 g CMC, 0.8 – 1.4 obtained at 0.5/1.0 g and 2.0 g CMC, 1.1 – 1.5 obtained at 0.5/1.0/2.5 g and 3.0 g and 0.5 – 1.9 obtained at 1.0g and 2.0g CMC as seen in Fig. 16.

3.9 Fluid Loss for Afuze and Ipkeshi Mud

The fluid loss test for the Afuze formulated mud indicates that the mud had a fluid loss of 33 ml for a period of 30 minutes and a filter cake thickness of 6mm as presented in Fig. 17. For the Ikpeshi mud, the filter loss volume gotten for the period of 30 minutes was 36ml a slightly higher value than the Afuze mud as shown in Fig. 18. The fluid loss is the volume of the drilling mud that passes into the formation through the filter cake formed during drilling. The lower the fluid loss, the more suitable the drilling mud and vice versa.

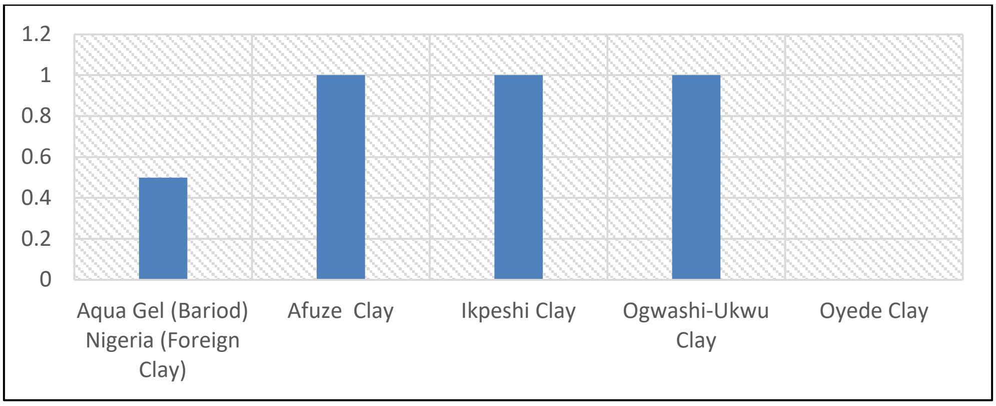

Fig. 15. Flow behavior index of formulated muds without additives

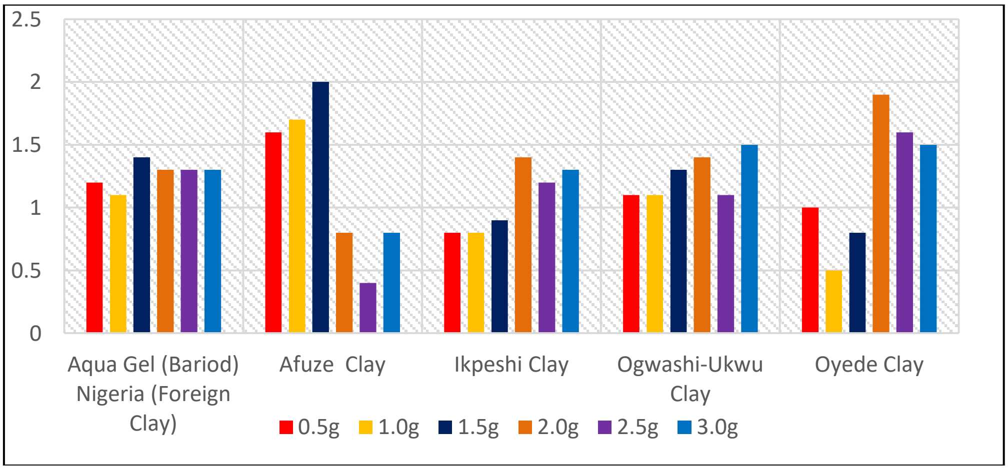

Fig. 16. YP/PV Ratio of Formulated Mud Treated with Different Concentrations of CMC

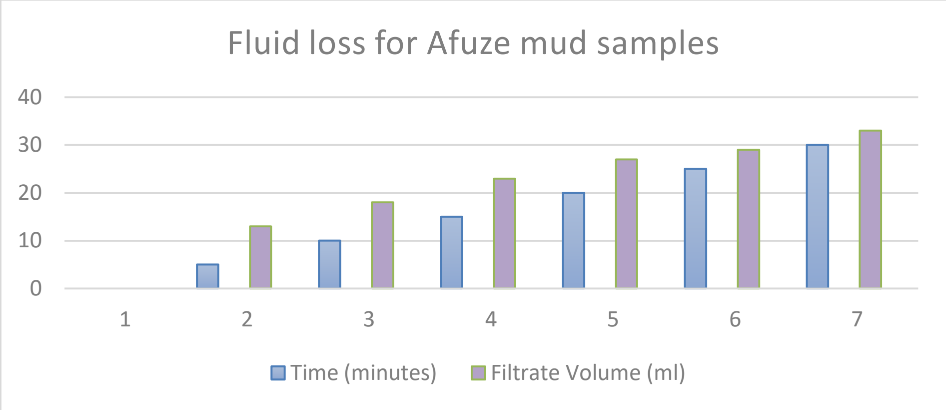

Fig. 17. Fluid loss for afuze mud samples

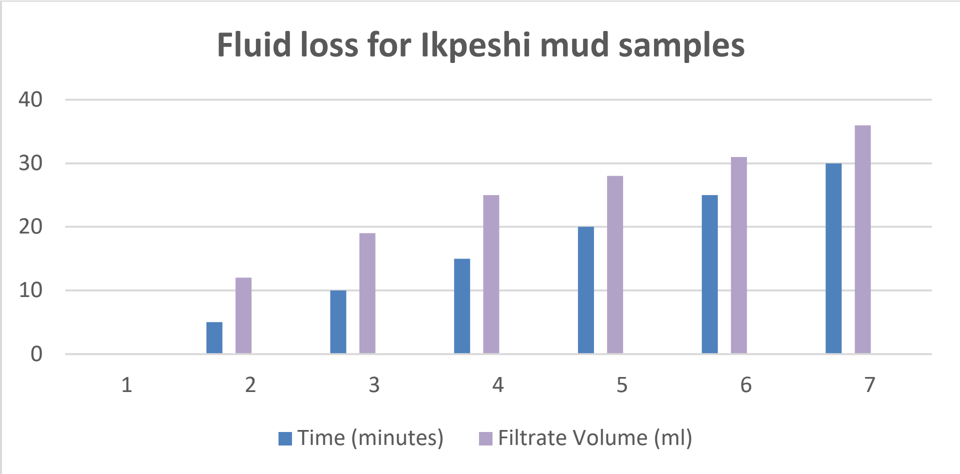

Fig. 18. Fluid loss for ikpeshi mud samples

4. CONCLUSION

This work evaluated the suitability of local clays from Edo and Delta State in Niger Delta for drilling mud Formulation Some Mud properties were investigated before and after the addition of chemical additives and the following conclusion were drawn:

i. The mud pH values were all acidic but when NaOH was added their pH values increased
ii. The Mud density increased when chemical additives were increased.
iii. The mud rheology increased when CMC was added.
iv. The filtration test was below standard, however no filter loss additives was used for this work and so further work should be done in this regards.
v. Conclusively, the Edo and Delta State clay can be used with the addition of chemical additves so as to increase the values of their mud properties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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