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EVALUATION OF LOCALLY SOURCED BARITE, CALCITE AND HAEMATITE AS WEIGHTING MATERIALS IN NEEM OIL-BASED DRILLING FLUID

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ABSTRACT
To increase the mud density and increase drilling-fluid density, this study focuses on assessing various locally materials employed in oil-based drilling fluid formulation. Neem oil is used as a replacement for diesel in oil-based drilling fluid. The physicochemical properties of the oil analysed were the specific gravity, flash point, viscosity, pour point and pH. The values obtained are 0.9228, 172 0C, 3.6 0C and 6.1 respectively. The FTIR analysis indicates cm-1 and esters. Wyoming grade bentonite and Sabon Gari Ngalda bentonite were used in the formulation of the oil based drilling fluids. Barite, Calcite and Haematite were added at varying weight concentrations (0%, 5%, 10%, 15%, 20% and 25%) to increase the mud density. Varying oil-based drilling fluid samples designated A, B, C, D, E and F were analyzed for mud weight, plastic viscosity, yield point, , gel strength, filtration volume at 5 minutes interval, mud thickness and pH. Significant changes in Mud weight, Plastic Viscosity, Yield Point, Apparent Viscosity, Gel strength were noted to correspond to changes in the concentration of mud with variation of the weighing agents (Barite, Calcite and Haematite). The filtrate water volume increases at an interval of 5 minutes while the thickness of the cake of Haematite mud formulation has a close value of 7.97mm and 7.56mm respectively than the formulation made with Calcite and Haematite. The pH of Calcite mud formulation has the highest values of 9.1 and 8.8 than the formulation made with Barite and Haematite. Addition of locally sourced weighting materials from Nigeria (Barite, Calcite and Haematite) increased the density of the drilling fluid under the tested conditions. Thus, all the weighting materials can be used as weighing agents in drilling mud formulation.

Keywords: Neem oil; oil-based drilling fluid; weighting materials; barite; calcite; haematite; rheology.

Introduction

Depleted mature reservoirs are low pressure reservoirs with a very low value of fracture gradient. They are highly prone to common drilling problems like differential pipe sticking, excessive mud losses, wellbore collapse etc. An inter-bedded shale or cap rock if present would require a higher density drilling mud compared to the depleted reservoir. Hence, conventional Water Based Mud (WBM) cannot be used for such type of reservoirs. Engineered solutions require the use of Oil Based Mud (OBM) consisting of sized particulates of graded ground marble (CaCO3) and resilient graphite material (RGM) (Shah et al., 2010). Differential pipe sticking, excessive mud losses, wellbore collapse are encountered during drilling in depleted reservoirs (low pressure reservoir) because the pore pressure is low (Shah et al., 2010).

One important aspect of the oil and gas sector of the Nigerian economy is the drilling operation. Drilling operation is necessary for the confirmation of oil and gas beneath the earth surface and a major for this operation is the drilling fluid which is often called drilling mud (Ichenwo & Ogbonna, 2018). The use of the term "drilling fluid" is often preferred to the generic term "drilling mud" because it implies that the characteristics, features or attributes are essentially designed into fluid system rather than those that occur naturally in subsurface formations through the mixing of water and formation clays. In addition, the term "drilling fluids" relates fluids with differing composition while "drilling muds" simply mean a mixture of clay and water. Drilling mud constitutes a large proportion of oil field chemicals consumed annually (Agwu et al., 2015). in drilling mud formulation. The of the country can help to reduce the rate of importation of Barite in the oil and gas sectors. This weighting material increases the mud weight of the drilling mud which will increase drilling-fluid density; however, formation-pressure control was not established in this laboratory study.

There is a need to look inward in harnessing the local resources in providing solutions to challenges obtainable in the oil industry. This would help in reducing the importation of materials and conserving financial resources for the indigenous oil companies. The Nigerian Local Content Development Act was signed into law in 2010 with the singular purpose of encouraging the use of Nigerian local resources and content in providing benefits and solutions to the problems confronting the Nigerian oil and gas industry (Ayonmike & Okeke, 2015).

Previous works on the use of strictly Nigerian bentonite in producing drilling fluids have shown that such drilling fluids exhibit high fluid loss. This may be due to the poor quality of bentonite sourced in Nigeria. These clays in raw form exhibit poor rheological and fluid loss properties hence the need for beneficiation (Olatunde, 2012). With the rising demand for bentonite clays as oil and gas exploration shifts to deep offshore, there is a growing need to enhance the properties of local Nigerian bentonite clays to meet the American Petroleum Institute (API) standard. Also, it has been shown that Diesel oil is always used as base oil in formulating oil-based drilling fluid which is environmentally hazardous because of its high toxicity and aromatic content. Vegetable oil environmentally friendly (Agwu et al., 2015). In order to increase the mud density and increase drilling-fluid density, this study materials employed in oil-based drilling fluid formulation. To satisfy the API requirements for drilling fluid formulation, the base oil was analyzed to determine its physicochemical qualities and characterized using FTIR analysis. Drilling mud characteristics include rheological properties (plastic viscosity, yield point, apparent viscosity, and gel strength), mud weight, mud filtration characteristics, and pH test at various variations of the weighing materials. By comparing the developed oil-based drilling fluids to API standards for drilling fluid formulation, this will establish how well they might be used in drilling operations.

Materials and Methods

The major materials used in this research work are: Barite, Haematite, Calcite, Gum Arabic, Poly anionic cellulose, Wyoming grade bentonitic clay, Sabon Gari Ngalda bentonite, Neem Oil and distilled water.

1 Physicochemical Properties of the Oil-Based Fluids.

The fluids used as base fluid in the formulation of the Oil Based Mud were analyzed to determine its physicochemical properties.

a. Specific gravity: it determines the weight of base fluid. This will indicate the mud weight of the developed drilling mud.

b. Viscosity: it determines the resistance of the base fluid to flow under the influence of gravity force

c. Flash point: it shows the temperature at which the fluid begins to burn.
d. Pour point: it shows the lowest temperature at which the base fluid will be able to flow.
e. Cloud point: this is the temperature at which .
f. pH: the degree of acidity and alkalinity of the base fluid.

2 FTIR Analysis of the Base Oil

This analysis of the base Oil was to determine the functional of the base oil. FTIR analysis was carried out on the Neem oil at National Research Institute for Chemical Technology Basawa, Zaria (NARICT). The was done by means of the FTIR- 8400S Fourier transform infrared spectrophotometer.

3 XRF Analysis of the Weighing Materials (Barite, Calcite and Haematite)

X-ray Fluorescence (XRF) analysis was done to determine the elemental composition and chemical analysis of the samples. The samples were loaded into the plastic sample containers which have a thin plastic surface that allows the passage of X-ray beam into the sample. The sample holder was positioned in the pan of the x-ray equipment (model P.W 4030/45B). This equipment has 12 compartments for samples to be analyzed simultaneously. The measurement and its progress were monitored using a computer monitor.

4 Mud Preparation

The following procedure was used in the formulation of the oil-based muds respectively:

i. Using the weighing balance, the various quantities of materials as shown in Table 1 below were measured.
ii. The quantities of oil were measured using the measuring cylinder.
iii. Using the Hamilton Beach Mixer, the measured materials were thoroughly mixed until mixture was obtained.

Table 1: Mud Sample Composition (Bilal & Adamu, 2021).

Oil Sample	Neem Oil
Oil Volume	210mL
Bentonite	24.5g
Gum Arabic	2.0g
PAC	2.0g
Distilled Water	140mL

5 Determination of Mud Weight

The following procedure was used in the densities of the mud samples formulated at various (Barite, Calcite and Haematite) using the mud balance.

i. Before beginning, the calibration was checked by using the calibration mark provided on scale for fresh water i.e. 8.33 lb/gal
ii. The mud cup was cleaned out and dried, then filled to the top with the formulated mud.
iii. The lid was placed on the cup, making sure the mud overflowed to remove any bubbles that might be trapped. The cup was wiped clean.
iv. The balance was placed in its base with the knife edges on the fulcrum rest and the rider moved along the arm until the cup and arm were balanced as indicated by the bubble.
v. The mud weight was read at the edge of the rider towards the mud cup as indicated by the arrow on the rider and was recorded at variation of the weighting materials (that is 0gram, 5grams,10grams,15grams,20grams and 25grams respectively) for the formulated drilling mud.

6 Determination of Viscosity

The following procedures were used to determine the viscosity of the Formulated oil based mud using Fan viscometer.

i. The mud sample was poured into the mud cup of the fan viscometer and the rotor sleeve was immersed exactly to the fill line on the sleeve by raising the platform. The lock on the platform was tightened.
ii. The power switch located on the back panel of the viscometer was turned on.

iii. The speed knob was first rotated to the stir setting, to stir the mud for a few seconds, and it was rotated to 600RPM, waiting for the dial to reach a steady reading, the 600 RPM reading was recorded.
iv. The above process was repeated for 300RPM, 200RPM, 100RPM, 60RPM, 30RPM and 6RPM.
v. The plastic viscosity, apparent viscosity and yield point.

Plastic Viscosity (PV) = $\Theta_{600} - \Theta_{300}$
Apparent Viscosity (AV) = $\Theta_{600}/2$
Yield Point (YP) = $\Theta_{300} - PV$

7 Determination of Gel Strength

The following procedures were used to determine the gel strength of the Formulated oil based mud using Fan viscometer.

i. The speed selector knob was rotated to stir the mud sample for a few seconds, Then immediately shut off.
ii. As soon as the sleeve stopped rotating, the knob was turned to the gel reading after 10 seconds and 10 minutes respectively. The maximum dial was recorded for each case.

8 Determination of Mud Filtration Properties

The following procedures were used to determine the mud cake and mud filtrate of the Formulated oil based mud using API filter press multi-unit.

i. Each part of the 4 cells was cleaned, dried and the rubber gaskets were checked. The cell was assembled as follows: base cap, rubber gasket, screen, filter paper, rubber gasket, and cell body.
ii. A freshly stirred sample of each mud was poured into the cells respectively to within 0.5 inch (13 millimeters) to the top in order to minimize contamination of the filtrate. The top cap was checked to ensure that the rubber gasket was in place and seated all the way around and complete the assembly. The cell assembly was placed into the frame and secured with the T-screw.
iii. A clean dry graduated glass cylinder was placed under the filtrate exit tube of each cell.
iv. The regulator T-screw was turned counter-clockwise until the screw was in the right position and the diaphragm pressure was relieved. The safety bleeder valve on the regulator was put in the closed position.
v. The air hose was connected to the designated pressure source. The valve on the pressure source was opened to initiate pressurization into the air hose. The regulator was adjusted by turning the T-screw clockwise so that a pressure was applied to the cell in 30 seconds or less. The test period begins at the time of initial pressurization.
vi. At the end of 7.5 minutes the volume of filtrate collected was measured. The air flow through the pressure regulator was shut off by turning the T-screw in a counterclockwise direction. The valve on the pressure source was then closed and the relief valve was carefully opened.
vii. The assembly was then dismantled, and the mud was removed from the cup.
viii. The filter cake for each mud sample was measured using a ruler to the nearest 1/32" (0.8 mm), and the measurements were recorded.

9 pH Test

The following procedures were used to determine the pH meter.

i. The pH meter was turned on and allowed to warm up.
ii. The electrode was cleaned.
iii. The pH meter was dipped in mud and the pH was recorded.
iv. The pH meter electrode was rinsed in water
v. Repeated for other samples.

Results and Discussion

1 Physicochemical Properties of Neem Oil

Physicochemical Properties of Neem oil results in Table 2. The specific gravity value recorded corresponds to the ASTM D1250 value of 0.9680 which indicate the weight of the base fluid and can be used to formulate drilling mud with higher densities. High specific gravity was obtained and the implication of

specific gravity is felt in the amount of weighting material required in mud formulation to achieve the required mud weight standard.

The flash point shows the temperature at which the begins to burn and the value is > 66 °C according to ASTMD 93. A high flash point value was obtained which shows they can minimize fire hazards as less is expected to be formed above the drilling mud to be formulated. The lower the flash point, the easier it is to ignite the material (Anawe et al., 2018). The ASTMD 445 kinematic viscosity value obtained falls in between the range of 1.9 – 6.0 mPas which shows the resistance of base fluid to flow under the influence of gravity force and can give a better rheology. A lower kinematic viscosity is important because it allows the oil-based mud to be formulated at lower oil/water ratios and gives better rheology (lower plastic viscosity) at low mud temperature because too high viscosity increases pump pressure and limits flow properties and thus reduces penetration rates (Anawe et al., 2018).

The pour point is the lowest temperature at which a liquid will begin to flow while the cloud point is the temperature at which wax crystals begin to form in a liquid as it is cooled. The pour point shows the lowest temperature at which the base fluid will be able to flow and the value of 3.6 °C which is less than the ambient temperature was recorded. A high pour point obtained shows that the oil based mud will suffer from poor screening and excessive pressure, surges in deep water wells, or other operations that are subjected to low temperatures (Anawe et al., 2018). But with reduced temperature of −4°C which invariably means that little stresses are required to be overcome before the base mud begins to flow. Similarly, cloud point determines the storage stability. High cloud point may result in phase separation and instability while low pour point can be stored under lower temperature conditions (Anawe et al., 2018).

The degree of acidity and alkalinity can be determined by the pH value. The pH of 6.1 is to the ASTM D7946 value.

Table 2: Physicochemical Properties of Neem oil

S/No	Base oil Properties	Value	Base oil Required Properties	Test Method
1	Specific Gravity	0.9228	0.9680	ASTM D1250
2	Pour Point (°C)	3.6	< Ambient Temp.	ASTM D 97
3	Flash Point (°C)	172	> 66	ASTM D 93
4	Kinematic Viscosity @ 40°C (mm^2/s)	4.8	1.9 -6.0	ASTM D 445
5	pH	6.1	6.29	ASTM-D 7946
6	Cloud Point °C	9.0°C	-	ASTM D 2500

3.2 FTIR Analysis of Neem Oil

FTIR (Fourier Transform Infrared Spectroscopy) analysis is a common technique used to identify the functional groups present in a sample. Neem oil is a vegetable oil that is derived from the Neem tree (Azadirachta indica) and is known for its various medicinal and insecticidal properties. FTIR spectrum was used to identify the functional group of the active components based on the peak value in the region of infra-red radiation. The results of FTIR peak values and functional groups and the FTIR spectrum profile was illustrated in Figure . Around 3000-2800 cm-1: This peak is due to the C-H stretching vibrations of alkanes and indicates the presence of saturated hydrocarbons in the neem oil. Around 1750-1730 cm-1: This peak is due to the C=O stretching vibrations of esters and indicates the presence of ester functional groups in the neem oil. Around 1700-1600 cm-1: This peak is due to the C=O stretching vibrations of carboxylic acids and/or ketones, and indicates the presence of these functional groups in the neem oil. Around 1450-1370 cm-1: This peak is due to the bending vibrations of -CH2 and -CH3 groups, and indicates the presence of these groups in the neem oil. Around 1300-1000 cm-1: This peak is due to the

stretching vibrations of C-O and C-C bonds, and indicates the presence of these bonds in the neem oil. Around 900-700 cm-1: This peak is due to the bending vibrations of C-H bonds, and indicates the presence of these bonds in the neem oil. The FTIR spectrum confirmed the presence of alkane, alkene, alcohol, primary amine, esters and Nitro compound.

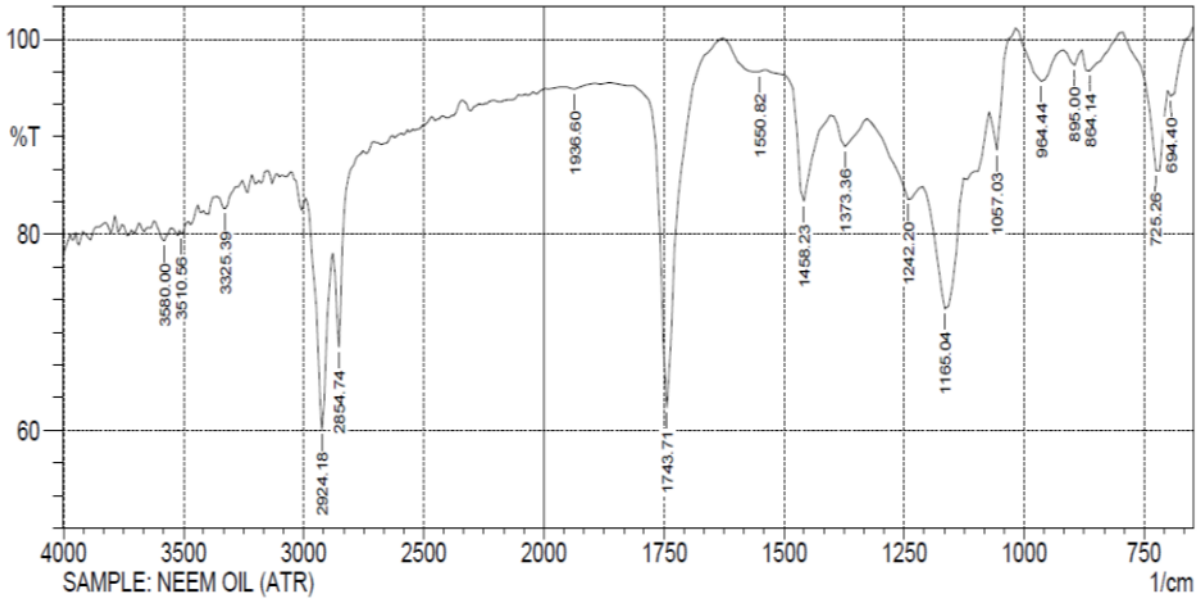


Figure 1: FTIR Result of the Neem oil

Table 3: Functional Groups of Neem Oil

S/NO	FREQUENCY	GROUPS	COMPOUND CLASS
1	3580	O-H Stretching	Alcohol
2	3510.56	O-H Stretching	Alcohol
3	3325.39	N-H Stretching	Primary Amine
4	2924.18	C-H Stretching	Alkane
5	2854.74	C-H Stretching	Alkane
6	1936.6	C=C=C Stretching	Alkene
7	1743.71	C=O Stretching	Esters
8	1550.82	N-O Stretching	Nitro compound

3 XRF Analysis

XRF analysis is a non-destructive technique that can be used to determine the elemental composition of a sample. This technique involves bombarding the sample with high-energy X-rays and measuring the emitted fluorescent X-rays to determine the elemental concentrations. The elemental compositions of the weighting materials (Barite, Calcite and Haematite) are shown in Figures 2, 3 and 4 respectively. The most abundant oxides were Fe2O3 (88 wt %) for Haematite, BaSO4 (86 wt %) for Barite and CaO (89 wt %) for Calcite. samples typically contain between 40% and 70% iron by weight, with the remaining composed of oxygen and other impurities like silica, alumina and water. It is important to note that Haematite is not found in pure form and is often mixed with other minerals, which can affect the weight percentage of Haematite in a given .

In general, a pure barite sample should contain approximately 65.7% barium oxide (BaO) and 34.3% sulfur trioxide (SO3) by weight. Pure calcite should contain approximately 40% calcium oxide (CaO) and 60% carbon dioxide (CO2) by weight. However, most naturally occurring calcite

samples will also contain small amounts of other minerals, which can affect the weight percentage of calcite in the sample.

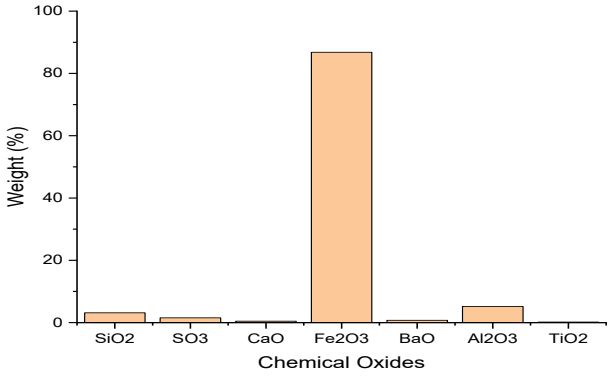


Figure 2: Chemical Compositions of the Haematite Sample Analysed by XRF

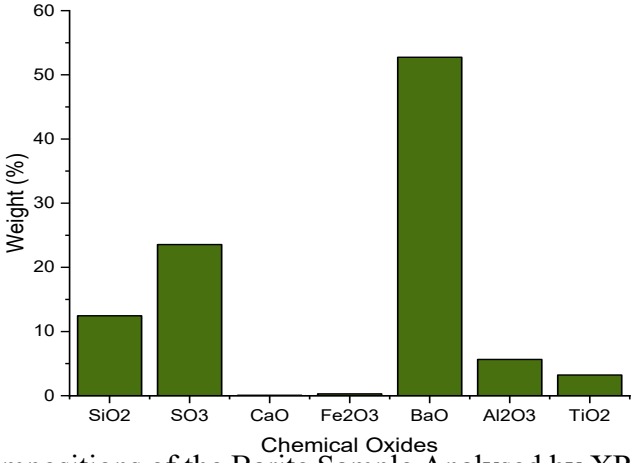


Figure 3: Chemical Compositions of the Barite Sample Analysed by XRF

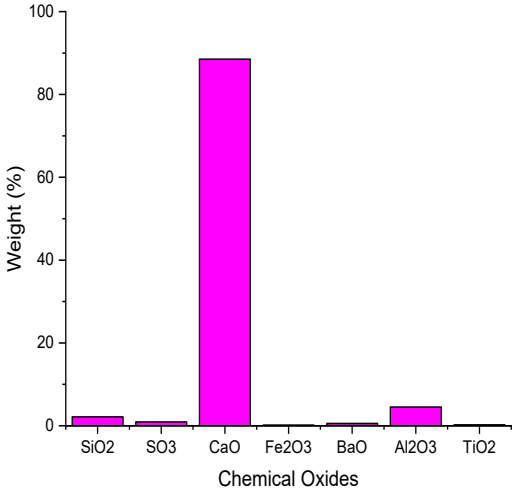


Figure 4: Chemical Compositions of the Calcite Samples Analysed by XRF

4 Mud Weight (Density)

Mud weight of drilling fluid system is very important because. Also, an increase in mud weight increases the capacity of the mud to carry drilled cuttings (Abdou et al., 2018). In Figure 5 , the mud weight of the formulated drilling muds increases as the percentage of the weighting materials (Barite, Calcite and Haematite) loading increases from 5% to 25% concentration loading. While at 20% loading increment, the formulated drilling mud has a mud weight of greater than 8.60 . This mud weight is the standard for deep well drilling operations. But for the purpose of drilling operations must have 8.60 mud weight for it to serve its purpose (Abdou et al., 2018). Also, all the mud samples with Wyoming Bentonite and Sabon Gari Ngalda Bentonite show a great similarity as the weighting materials increases the mud weight increases. materials concentration has a positive effect on the density of the mud. Generally, weighting materials added to mud formulations this one property of the drilling mud important. So therefore, it was observed that higher mud weight value of the mud samples which would help to maintain column or hydrostatic pressure and suspend cuttings in the mud leading to better clearing of the bore hole. But higher mud density will increase the possibility of drilling mud filtrate to penetrate the formation, thus causing more complication on the formation leading to excessive fluid loss (Mohamed et al., 2019). The weight of the mud to be used depends on the reservoir conditions. Some reservoirs a denser drilling fluid while others less dense fluid like in lost circulation (Falode et al., 2020). The mud weight comparison of Barite, Calcite and Haematite mud samples indicate a higher mud weight than Barite and Calcite. This can be attributed to the specific gravity of the Haematite as it is greater than that of Barite and Calcite.

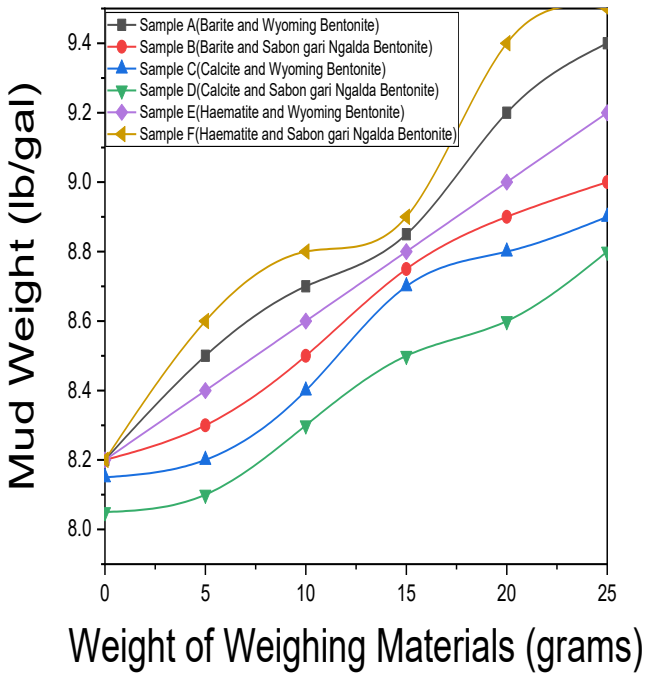


Figure 5: Response of Variation of Weight of Weighing Materials with Mud Weight.

3.5 Apparent Viscosity

Viscosity is the representation of a internal resistance to flow which defines the ratio of shear stress to shear rate. From Figure 6, the apparent viscosity increases when the concentration of the weighting materials is added to the various formulations. This would suit any drilling operations especially when high mud weight is necessary (Onojake & Chikwe, 2019). It would also perform better in terms of mud stability, cooling effect and enhancement of its ability to suspend and carry cuttings from formation to the surface (Chikwe et al., 2019).

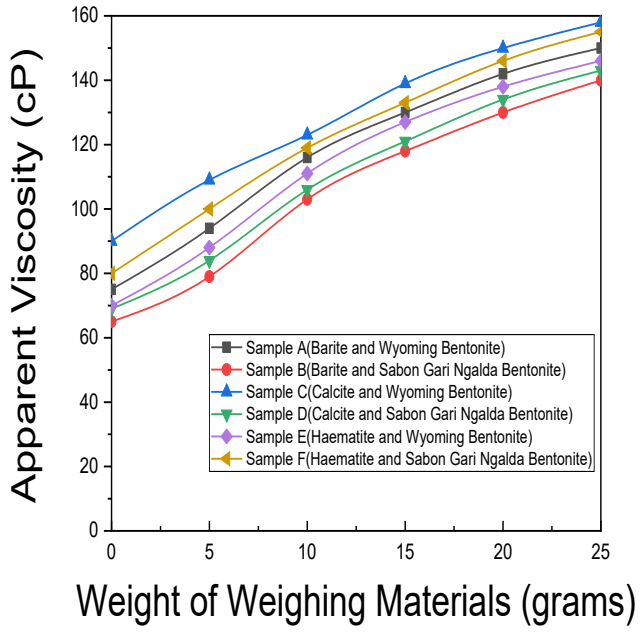


Figure 6: Response of Apparent Viscosity with Variation of Weight of Weighing Materials.

6 Plastic Viscosity

Plastic viscosity is the resistance to flow caused by mechanical friction resulting from solids concentration, size and shapes of solids as well as viscosity of the fluid phase and also, an indicator of shear rate viscosities. It gives a good understanding about the expected behavior of the mud at the bit (Ichenwo & Ogbonna, 2018). On addition of weighting materials to the formulations a close correlation was observed which results . An increase in the Plastic viscosity is not the best way of increasing the hole cleaning ability of the mud. But the rapid rise in pressure drops down the drilling string can be caused by the plastic viscosity increase. This would reduce the available flow rate and offset any increase in lifting ability (Mohamed et al., 2019). A lower Plastic viscosity indicates that the mud is capable of drilling rapidly because of the low viscosity of mud existing at the bit. The plastic viscosity is one of the major parameters that enable the transporting capacity of the mud, suspension of weighting materials as well as pressure surges at the reservoir through pressure in the annulus (Julius et al., 2015). So therefore, drilling fluids with high plastic viscosity will exert so much pressure on the annulus in which solid content reduction can be achieved by dilution to lower the plastic viscosity (Delikesheva et al., 2020). Plastic viscosity increases as the percentage volume of solid increases. It also increases at constant percentage volume of solid at decreasing particle size of the fluid; this is because decreased particle size increases surface area

which in turn increases the frictional drag of the fluid (Onojake & Chikwe, 2019). The Plastic viscosity of a mud is by theory the lowest viscosity a mud can have as such it is the effective viscosity as the shear rate approaches infinity (Olatunde & Usman, 2011). The shear rate of drilling mud is at its maximum as it passes through the bit nozzles. The Plastic viscosity is therefore approximately the mud's viscosity at the nozzles (Onojake & Chikwe, 2019).

The American Association of Drilling Engineers (AADE) specifies a Plastic viscosity in the range of 15 to 30 2 for oil based muds (Adachi et al., 2004). The result shown in Figure 7, the Plastic viscosity of the formulated drilling mud that is Samples A, B, C, D, E and F respectively are within the specification at 0% to 15% concentration while from 15% to 25% concentration is off specification.

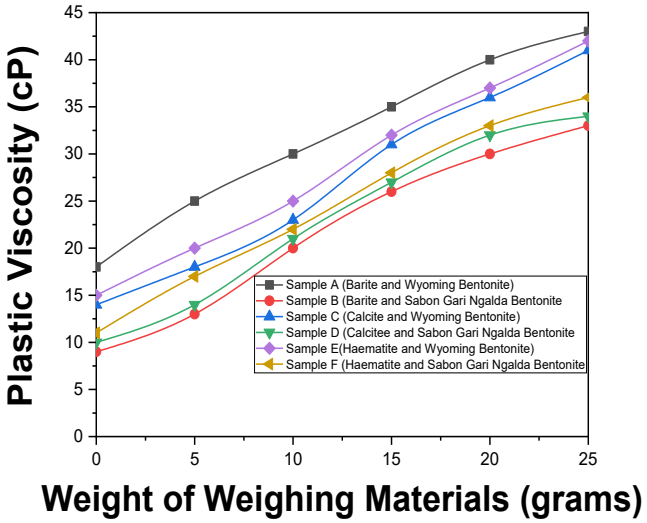


Figure 7: Response of Plastic Viscosity with Variation of Weight

7 Yield Point

Yield point is the initial resistance to flow caused by electrochemical forces between the particles. It is also dependent upon the surface properties of the mud solids and volume concentrations of the solids. Yield point could be used to evaluate the ability of a mud to lift cuttings out of the annulus (Abdou et al., 2018). From the result in Figure 8, the yield point at 0% of weighting materials (Barite, Calcite and Haematite) concentration gave the least yield point. This implies that the concentration increases the yield point of the fluid.

Also, the values of the yield point for the formulated drilling mud increases rapidly as the weighting materials (Barite, Calcite and Haematite) loading increases from 5% to 25% and become constant at a further 5% increment. At further loading increment, the yield point values may be steady or reduce or increase. High yield point was obtained which implies a non-Newtonian fluid; one that carries cuttings better and would help to increase the hole capacity than a fluid of similar density but lower yield point (Ichenwo & Ogbonna, 2018). Excessively high yield point can lead to high pressure losses while the drilling mud is being circulated. Yield point can be lowered by adding deflocculant and by adding flocculant.

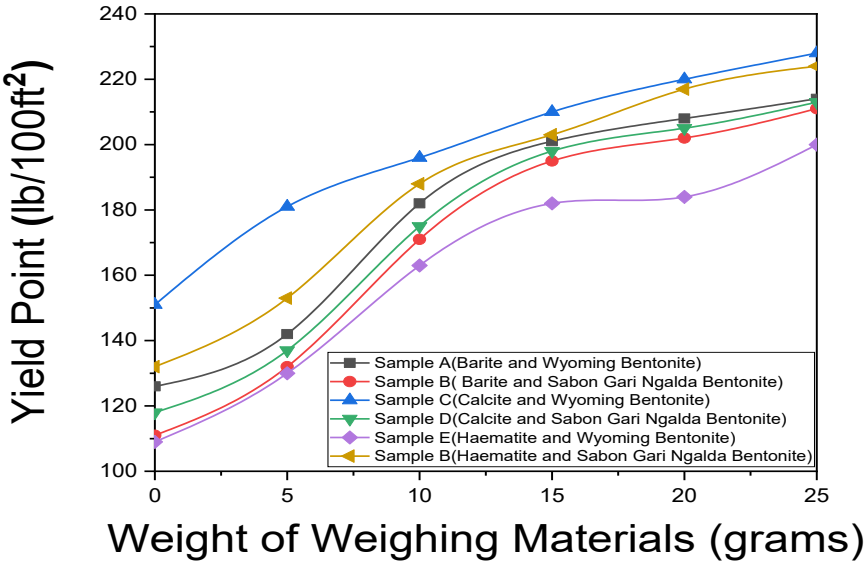


Figure 8: Response of Yield Point with Variation of Weight of Weighing Materials.

Filtration Properties

1 Filtrate Loss

Filtration rate is often the most important property of a drilling fluid, particularly when drilling permeable formations where the hydrostatic pressure the formation pressure (Agwu et al., 2015). All the formulated drilling mud increase as the time is been varying up to 30 minute. This implies that proper control of the filtration can prevent or minimize wall sticking and drag in some areas, improve borehole stability (Chikwe et al., 2019). Figure 9 shows the results of the mud filtration test of the various mud samples. For the formulation made with Wyoming bentonite, sample A had the highest mud filtrate while with that of Sabon Gari Ngalda bentonite sample D had the highest. Some problems encountered a result of excessive filtration volumes include: formation damage due to filtration and solid invasions, Damaged zone too deep to be by perforation, Damaged may be precipitation of insoluble compounds, changes in wettability and changes in relative permeability of oil and swelling of in-situ clays. Formation evaluation difficulties are caused by excessive filtrate invasion, poor transmission of electrical properties through thick cake and potential mechanical problems and retrieving logging tools (Chikwe et al., 2019).

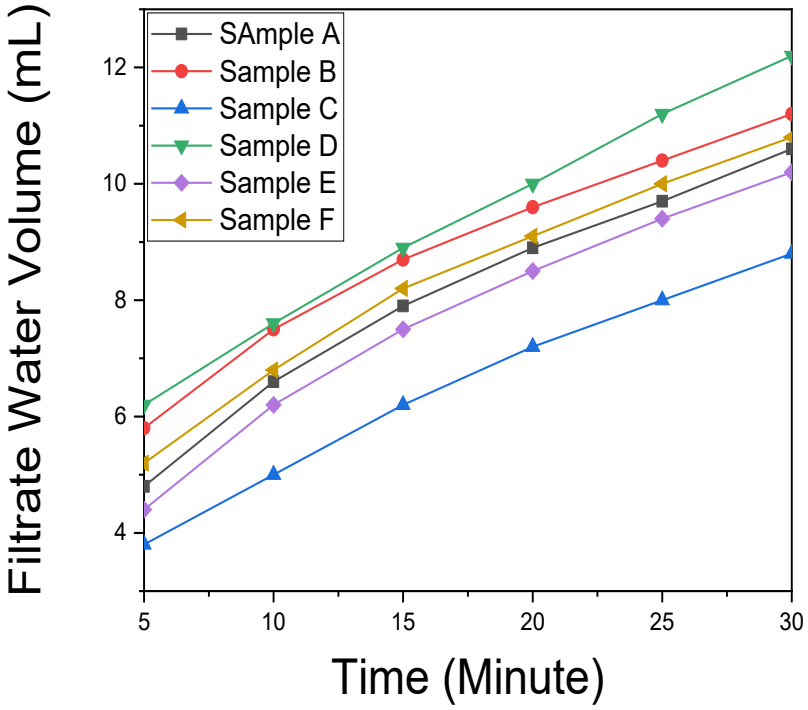


Figure 9: Filtrate Water Volume with Time for Formulated Drilling Mud.

2 Mud Cake Thickness

Filtrate with high volumes are associated with thick filter cake, this is as a result of deposition of clay particles on the walls of the hole during filtrate loss to the formation (Fadairo et al., 2012). Figure 10 shows the mud cake thickness of the formulated drilling muds in which the formulation made with Wyoming bentonite containing the weighting materials (Barite, Calcite and Haematite) has higher thickness of mud cake with formulation done with Ngalda bentonite. So the higher the filter volume, the thicker the filter cake and the less efficient the drilling mud. Some of the problems caused by excessive thickness includes: tight spots in the hole that cause drag, increase in surges and swabbing due to annular clearance, Differential sticking of the drill string due to increased contact area and rapid development of sticking forces caused by higher filtration rate (Chikwe et al., 2019). The effect of thicker filter cake is that a thick mud cake reduces the effective diameter of the drilled wellbore thereby increasing the area of contact between the drill pipe and the cake leading to increased risk of pipe sticking (Shah et al., 2010).

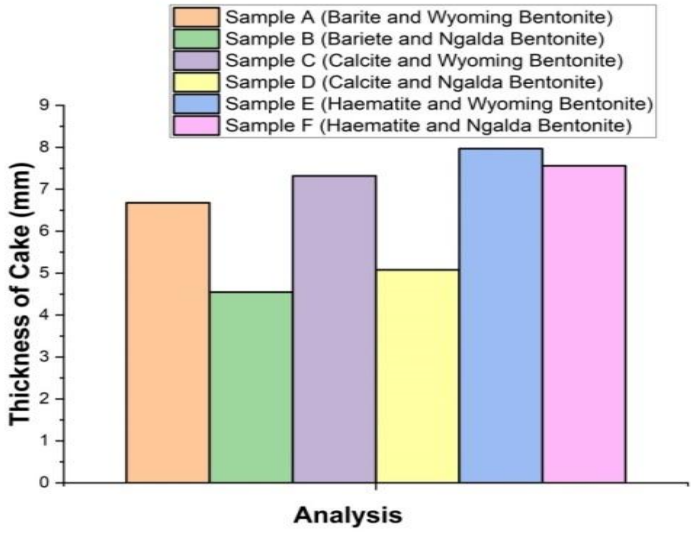


Figure 10: Mud Cake Thickness of Formulated Drilling mud.

9 pH Determination

Drilling muds are greater than 7. Bentonite is least affected by pH if it is between the range 7 to 9.5 but viscosity is affected by pH. For minimizing shale problems, a pH of 8.5 to 9.5 appears to give the best hole stability and control over mud properties. So therefore, a pH should be controlled within the range appropriate to the selected mud system (Bourgoyne & Chenevert, 1986). Figure 11, shows the value of the pH of the formulated drilling muds. pH of 9.1 and 8.8 values. This shows better results since their pH values within the range. The other mud samples have a pH of less than 6.4 which does not meet with specification. So therefore mud samples C and D better results because their pH values fall within the range. The corrosion of metal is increased if in contact with an acidic fluid. So therefore, high pH would be desirable to protect (Bourgoyne & Chenevert, 1986).

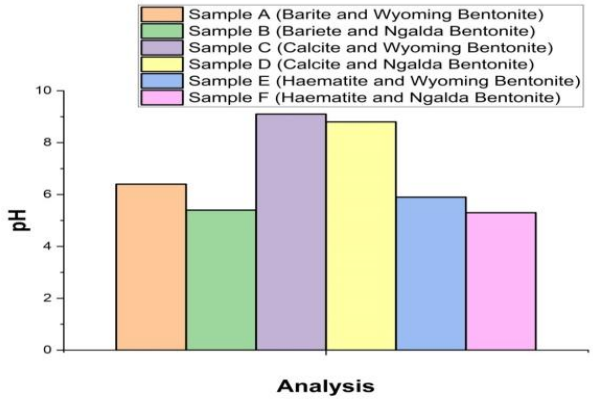


Figure 11: pH Measurement of Formulated Drilling mud.

The available manuscript does not contain measured specific gravity or particle-size distributions for the weighting materials, complete gel-strength data, replicate measurements/statistical analysis, or an unambiguous definition of sample designations A–F. The filtration-test duration is also reported inconsistently in different sections. These items should be checked against laboratory records before submission. No missing experimental values have been fabricated in this revision.

Conclusion

The study concluded that the characterized Neem oil revealed the Specific Gravity, Pour Point, kinematic viscosity, pH, flash and cloud points were; 0.9228, respectively. The FTIR spectrum confirmed the presence of alkane, alkene, alcohol, primary amine, esters and Nitro compound. From the XRF analysis, the most abundant oxides in the weighting materials are Barium (BaO, 52.73wt %) and (SO3, 23.55wt %) for Barite, iron (Fe2O3, 86.80wt %) for Haematite and calcium (CaO, 88.52wt %) for Calcite. Formulation with Haematite gave a when used at the same concentration as Calcite and Barite. Addition of locally sourced weighting materials from Nigeria (Barite, Calcite and Haematite) increases the density of the drilling mud. Thus, all the materials may be used as weighing agents in drilling mud formulation. The filtrate water volume increases at an interval of 5 minutes while the thickness of the cake of Haematite mud formulation has a close value of 7.97mm and 7.56mm respectively than the formulation made with Calcite and Haematite. The pH mud formulation has the highest values of 9.1 and 8.8 containing Wyoming and Ngalda Bentonites than the formulation made with Barite and Haematite.

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