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Original Research Article

Comparative Study of Mud Properties of Local and Foreign Bentonite: A Case Study of Usen Clay, Edo State, Nigeria

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ABSTRACT

This study evaluates the performance of a local mud (clay from Usen town, Edo State, Nigeria) sample for drilling operations in Nigeria. The primary objective was to investigate the mud's properties in order to ascertain its substitutability for foreign Bentonite. API RP-13B standard procedures were employed throughout the laboratory work to determine mud properties. From the results, the sand content, the yield point/plastic viscosity (Yp/PV) ratio of the clay met API standard. However, the mud needed treatment with additives in order for the mud weight, viscosity, gel strength and pH value to meet API standard. Foreign additives used for beneficiation were Q-broxine and hydroxyl ethyl cellulose. The mud weight and gel strength of the local mud met API standard when beneficiated with 5g Q-broxine and 10g hydroxyl ethyl cellulose. Local mud pH values increased when treated with 5g Q-broxine and the modification raised the mud pH to be within the API standard of 9.5 to 12.5. The viscosity of the local mud was below standard requirement of 30cp, but increased to within API standard when beneficiated with 10g hydroxyl ethyl cellulose.

1. INTRODUCTION

Drilling mud, also known as drilling fluid in Petroleum Engineering is a heavy, viscous liquid mixture that is used in oil and gas drilling operations to carry rock cuttings to the surface and also to lubricate and cool the drill bit (Darley and Gray, 2017). Bentonite is among the exportable mineral commodities in Nigeria. There is no massive pressure on production of drilling fluids using local bentonitic clay in Nigeria. There should be a reduction in importation of foreign bentonite and proper harnessing of Nigeria's solid minerals such as bentonite. This will help Nigeria to meet the indigenous demand for the country's domestic products as well as demand in the international market, thereby boosting foreign exchange reserves (Okorie, 2006).

Neff (2010) brought forward the idea of improving the weight of the mud using additives. He recommended fine-ground iron-oxide as a good weighing material for water slurries, given a mud weight in the range of 15-18 ppg. The use of this material was short-lived due to its dark colour and skin staining effects. Locally, some work has been done in the quest to determine the suitability of local clays for the production of drilling mud. Rai and Ohen (1982) carried out laboratory investigation on the suitability of clay samples from the Iguorakhi clay deposit in the old Bendel state of Nigeria, and they found out the clay has a cation exchange capacity (CEC) of between that of Kaolinite and Montmorillonite. Okorie, (2006) showed that the measured rheological properties of the Nigerian clays in their nature states were far below the API specification. He also, concluded that addition of 1g of hydroxide wasappropriate to upgrade 20g-1000g of the natural clay samples in 350ml of distilled water. In their research on Igbetic clay samples Omole and Okoye (2013) concluded that the clay samples do not possess enough during drilling operations especially during non-circulatory periods. The study by Akanaga and Okoro (2016) on the suitability of some Imo state clays for preparing drilling muds showed that the clay did not show good drilling property in their natural states of occurrence, but on chemical treatment, they can be used as drilling muds but at low temperature and pressure conditions.

Bentonite is an absorbent aluminium phyllosilicate, essentially impure clay consisting mostly montmorillonite (70 -90%). Dear e*t al.* (2018) reported the suitability of bentonite in the search for better mud making material. Subsequent tests showed that it had the ability to suspend heavy cuttings. It also had certain good mud properties which have been achieved only through chemical treatment. Some of these properties include moderate filtrate loss and good wall building properties, viscosity and gel strength.

The aim of this work was to compare mud properties of local and foreign bentonite: A case study of Usen clay, found in Edo State, Nigeria was investigated.

2. MATERIALS AND METHODS

2.1. Location and Geology of Study Area

Usen is located in Ovia South-West Local Government Area of Edo State, Nigeria. Its geographical coordinates are 6° 45' 0" North, 5° 21' 0" East. The local government headquarters is Iguobazuwa. In terms of climatic conditions, it has a mean annual rainfall of 1600 mm – 1800 mm and mean temperature of 28 – 29 ℃.

2.2. Sample collection and preparation

The clay sample used for this work was collected at the appropriate depth of about 4 feet. The local clay was collected by the use of a spade to till the soil at the bank of the Ada River, in Usen, Edo state. The experiment was carried out in two phases:

- Phase1: Formulation of local clay mud and foreign bentonite mud without additives
- Phase2: Formulation of local and foreign bentonite mud containing Q- Broxine and Hydroxyl Ethyl Cellulose

The clay sample was dried at temperature of 60 ºC by spreading out in a steel tray in a drying oven. The dried clay sample was then pounded in a mortal and sieved to obtained fine powdered clay particles of 250 microns size. The sieved clay sample was collected in a beaker and labeled. Samples of the sieved clay, 17.5g, 21.0g and 24.5g were weighed using a spatula into separate mixer cups with the help of weighing balance and labeled appropriately. Distilled water (350 ml) was then added to the clay samples. The mixture

of the clay and water was stirred with the aid of multi-beach mixer for 2 minutes to obtain a homogeneous mixture.

2.3. Determination of Drilling Mud Properties

API RP-13B standard procedures (API practices 13B section 5) were employed throughout the laboratory work to determine mud properties. All the mud samples were based on the formulation of 350 ml of fluid that contains only fresh water.

2.3.1. Determination of rheological properties

This was done to obtain the rheological properties of the mud such as viscosity at 600 rpm and 300 rpm, 10 minutes and 10 seconds gel strength, plastic viscosity and yield stress. The equipment used was an OFITE 900 Model viscometer.

2.3.2. pH determination

To determine the pH of the mud, the following were followed; the freshly prepared mud was re-stirred to obtain homogeneous mixture. About one-inch strip of the ph-hydrion dispenser paper was removed and placed gently on the surface of the mud and sufficient time was allowed to elapsed (about few seconds) for the paper to soak up filtrate and change color. The soaked paper strip was matched with chart on the dispenser from which the strip was taken. The pH range of the mud was read and the value recorded.

2.3.3. Determination of mud weight

The mud density test was conducted in order to determine the weight per unit volume of the mud. Mud density must be great enough to provide sufficient hydrostatic heat to prevent influx of formation fluids, but not so great to cause loss of circulation, damage to the drilled formation, or reduce the rate of penetration (ROP). This test was done to determine whether the prepared local mud samples possessed API minimum weight for oil well drilling. The procedures used to determine the weight of the prepared mud were:

- The instrument base was set up so that it was approximately leveled.
- The freshly prepared mud was poured into a clean, dried mud balance cup and covered with the lid.
- The reading of the mud balance scale was taken and recorded properly against the mud type.
- The mud cup was then emptied, washed, dried and kept for future use.

2.3.4. Determination of sand content

The Baroid sand content tube was used to carry out this experiment. API RP-13B standard procedures (API practices 13B section 5) were applied in carrying out this experiment.

2.3.5. API standard tests and analysis values of drilling mud

The American Petroleum Institute (API) standard specification is very important for drilling mud and these specifications are for all the montmorillonite clay family as contained in API practices 13A section 5 as presented in Table 1.

Table 1: API standard numerical value requirement for drilling fluids (API practices 13A section 5)

Drilling Fluid Property	Numerical value requirement
Mud density (lb/gal)	8.65-9.60
Viscometer dial reading @600rpm	30cp
Plastic viscosity (cp)	8 – 10
Yield point (Ib/100ft2)	3 x plastic viscosity
Fluid loss (Water)	15.0ml maximum
pH level	9.5min – 12.5max
Sand content	(1 - 2) % maximum
Screen analysis	4 (maximum)
Moisture content	10% (maximum)
Ca 2+ (ppm)	2.50 (maximum)
Marsh funnel viscosity	52 – 56 sec/q+
Mud yield (bbi/ton)	91 (maximum)
API filtrate (ml)	30 (minimum)
Montmorillonite	70 – 130
Vermiculite	100 – 200
Illite	10 – 40
Kadinite	3 – 15
Chlorite	10 – 40
Marsh funnel viscosity for water	26 sec/q+ ± 0
N-Factor (power law index)	1 (maximum)
Yp/Pv ratio	3.0 (maximum)

2.4. Beneficiation of Drilling Mud

Beneficiation is the treatment of the prepared drilling mud with enhancers to improve the fluid properties for enhanced performance. In this study, foreign additives (Hydroxyl Ethyl Cellulose and Q-Broxine) were used for the beneficiation of the sample, to achieve improvement of mud weight, rheological properties (i.e. viscosity and gel strength) and pH. A mass (10g) of Hydroxyl Ethyl Cellulose and 5g of Q-Broxine was added to each of the mud samples at the various concentrations. The mixtures were stirred for 2 minutes to obtain a homogenous mixture.

3. RESULTS AND DISCUSSION

From the preliminary experimental work, the results for the 17.5g, 21.0g and 24.5g concentrations were basically the same, hence, only 24.5g concentration served as basis for the experiment. From Figure 1, the mud weight of the local mud was 8.50lb/gal before beneficiation took place. This was short of API minimum numerical value standard (8.65lb/gal). The mud weight of the foreign mud was 8.70lb/gal. The mud weight of the local mud was 8.70lb/gal after beneficiation with foreign additives. This was within API numerical value standard (8.65lb/gal -9.6 lb/gal). This conformed to the report by Omole and Okoye (2013).

From Figure 2, the pH of the local mud was 6.0 before beneficiation. This showed that the local mud was a little bit acidic and fell short of API minimum numerical value standard (i.e. 9.5). The pH of the foreign mud was 10.0. The pH of the local mud was 11.0 after beneficiation with 5g Q-Broxine. This showed that the beneficiated local mud was within API numerical value standard (i.e. 9.5 -12.5). This result is in-line with what Akanaga and Okoro (2016) reported. From Figure 3, the viscosity of the local mud at 600rpm was 6.0cp before beneficiation. This is low compared to the 30cp API minimum numerical value standard for drilling mud. The viscosity of the foreign mud at 600rpm was 42.0cp. The viscosity of the local mud at 600rpm after beneficiation with 10g Hydroxyl Ethyl Cellulose was 35.0 cp and this met the API numerical value standard (30.0 cp min.) for drilling mud. This was comparable to what Rai and Ohen (1982) obtained. From Figure 4, the sand content of the local mud was 0.3% before beneficiation. This was within API

standard requirement (0%-2%). Also, the sand content of the foreign mud was 0.1%. The sand content of the local mud was 0.3% after beneficiation with both additives. This was comparable with the observations of Abdulkadir et. al. (2013). From Figure 5, the gel strength at 10sec of the local mud was 0.7lb/100ft² before beneficiation. The gel strength at 10sec of the foreign mud was 0.7lb/100ft². The gel strength at 10sec of the local mud sample was 0.5lb/100ft² after beneficiation with 5g Q-Broxine and 10g Hydroxyl Ethyl Cellulose. This conformed to what Neff (2010) observed. From Figure 6, the Yp/PV ratio of the local mud was 0.0 before beneficiation and the Yp/PV ratio of foreign mud was 1.5. The Yp/PV ratio of the local mud was 1.2 after beneficiation. This was comparable with the observations of Rai and Ohen (1982).

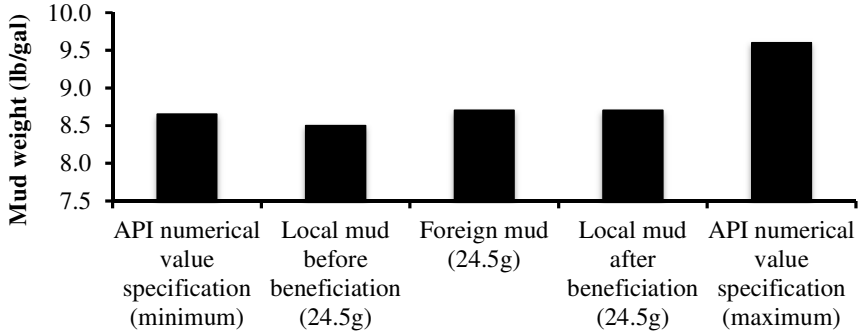

Figure 1: Comparison of different mud samples weight (lb/gal) with API numerical value specification

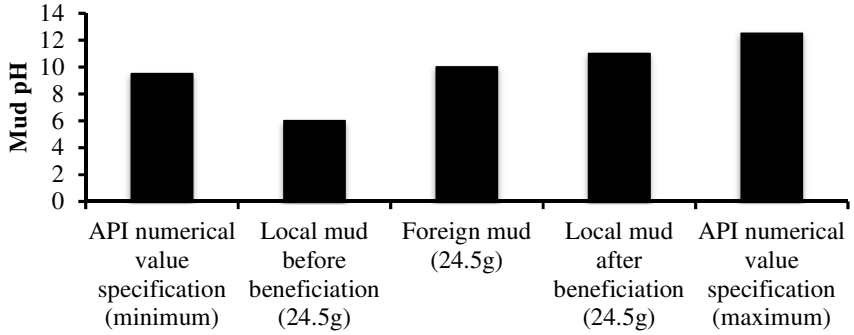

Figure 2: Comparison of different mud samples pH with API numerical value specification

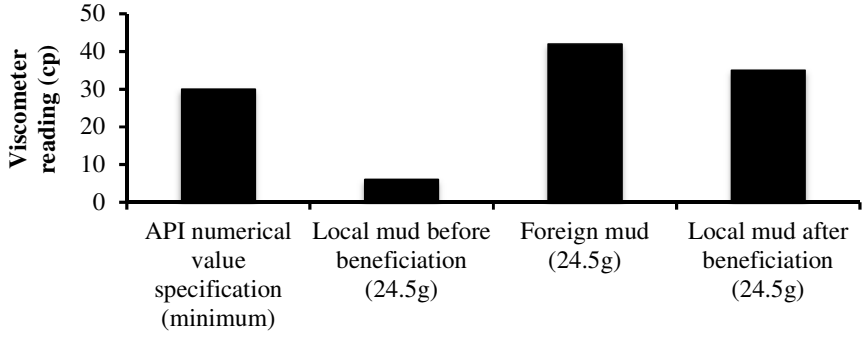

Figure 3: Comparison of different mud samples viscometer reading @600rpm with API numerical value specification

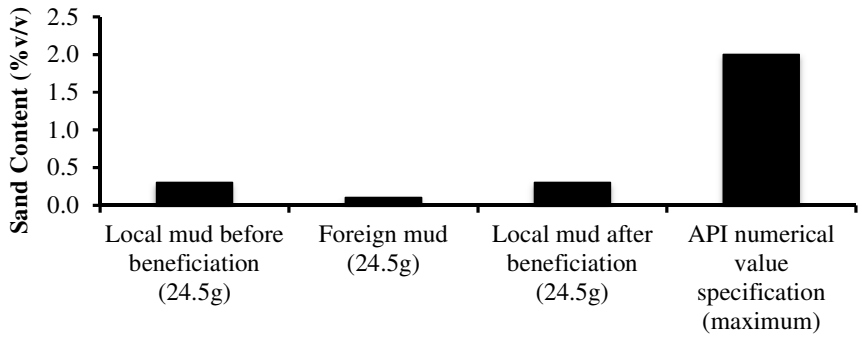

Figure 4: Comparison of different mud samples sand content % volume with API numerical value specification

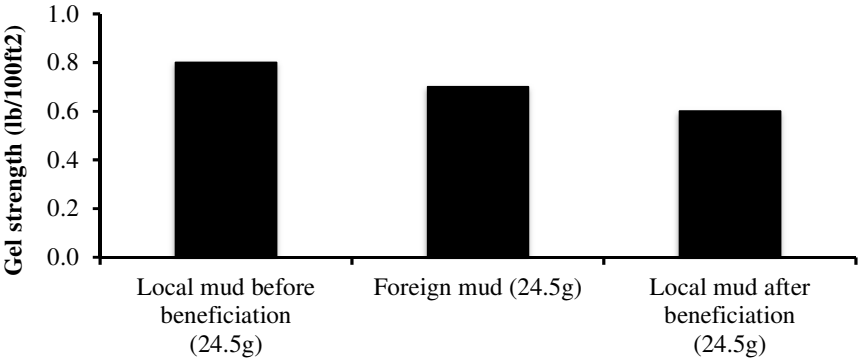

Figure 5: Comparison of different mud samples gel strength (lb/100 ft^2) with API numerical value specification

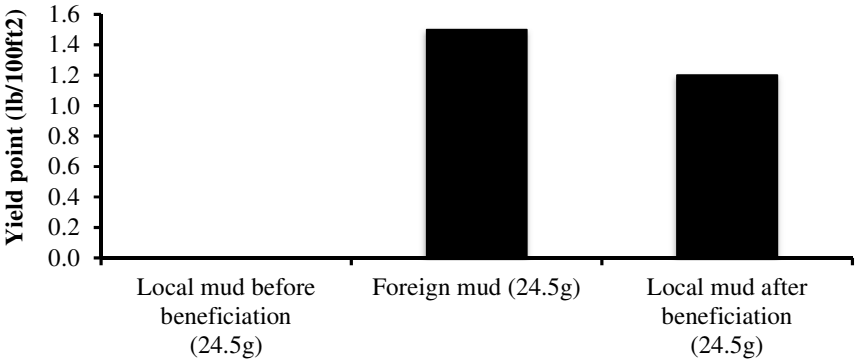

Figure 6: Comparison of different mud samples yield point (lb/100 ft^2) with API numerical value specification

4. CONCLUSION

The sand content and Yp/PV ratio of the local clay mud met the minimum required API specification. Mud weight, viscosities, gel strength and pH of the local mud didn't meet up with API standard. The local clay samples showed desired results when beneficiated with foreign additives (5g Q-broxine and 10g hydroxyl ethyl cellulose) and met API standard. Therefore, local clay muds could be used as a substitute for foreign bentonite mud in drilling operations.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Abdulkadir, L.A., Osawemwenze O, Adogbo G.M, (2013). Rheological and Filtration Properties of Kaolinite Based Drilling Mud. *International Journal of Scientific and Engineering Research*-4(7), pp. 2214-2220

Akanaga, R.C. and Okoro, F.I. (2016). Improving rheological and filtration properties of drillingmuds with addition of Chemicals.7thInstitute of Geology and Mineral Exploration, (IGME), The NationalCongress on Mechanics, Lagos, Nigeria

Darley, H.C.H. and Gray, G.R. (2017). Composition and Properties of Drilling Fluid and Completion Fluids, 2 Ed, Penn well publishing company, California

Dear, W.A., Howie, R.A. andZussaman, J. (2016). *Review on Introduction to Rock-forming Mineral*. ELBS/Longman Essex England, pp.252–269

Neff, J.M. (2015). Composition, Environmental Fates, and Biological Effect of Water Based Drilling Muds and Cuttings Discharged to the Marine Environment: A Synthesis and Annotated Bibliography; Prepared for Petroleum Environmental Research Forum and API, Duxbury, MA. p.73,

Okorie, M. (2006). Formulation of Drilling Mud with Local Materials. *Petroleum Training Journal*, 3(2), pp. 92-111

Omole, O. and Okoye, A. (2013). Investigation into the Rheological and Filtration Properties of Drilling Mud Formulated with Clays from Northern Nigeria. *Journal of Petroleum and Gas Engineering*, 1(4) p. 144.

Rai, A. A. and Ohen, I.P (1982). Laboratory Investigation on the Suitability of Clay Samples From the Iguorakhi Clay Deposit in the Old Bendel State of Nigeria. *Petroleum Training Journal*, 2(1), pp. 22-65.