International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 742-749 www.ijaem.net ISSN: 2395-5252

The Effect of Cassava Starch and Coconut Fibre on Rheological Properties and Fluid Loss Control of Water-Based Drilling Fluid

Vipene Kale Kelvin[1], K.K Dune[2]
[1] *Department of Petroleum Engineering, Faculty of Engineering, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria*
[2] *Department of Petroleum Engineering, Faculty of Engineering, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria*

Submitted: 10-03-2022 Revised: 21-03-2022 Accepted: 23-03-2022

ABSTRACT: This work explores the use of cassava starch and coconut fibre as viable replacements for poly Anionic Cellulose in the drilling fluid. They act as good fluid loss additive. Mud samples were formulated in the laboratory and properly tested to determine if these additives were practicable. Eleven samples were formulated, varying the concentrations of PAC, cassava starch and coconut fibre in each sample. Various tests were carried out on them including mud density, viscosity and filtration test (fluid loss). The cassava starch and coconut fibre were obtained from international institute for tropical agriculture (IITA), Onne in Port Harcourt, Nigeria. Barite was soaked for 24hours in distilled water and allowed to yield. After this, the drilling mud additives were introduced into the mixture one after the other and stirred using an electronic blender in order to give consistent mud properties (ensure they mix properly). The tests carried out were compared against the control sample A with respect to rheology and fluid loss. Drilling mud density of mud samples ranged between 9.5ppg to 9.86ppg which can counter formation pressure. The results showed that out of the eleven formulated mud samples, sample J was closest to the control sample. Sample J contained 1g PAC, 0.75g cassava starch and 0.25g of coconut fibre and had fluid loss volumes between 3ml and 7.2ml. The results showed that cassava starch and coconut fibre are good fluid loss additives individually, but when combined they react together to give better rheology and form a better bridging agent..

KEYWORDS: Drilling fluid, Fluid, Cassava starch, Coconut fibre, Fluid loss control and Rheological properties.

I. INTRODUCTION

Drilling fluid is one of the most important materials used in drilling operations, it is a combination of liquids, gases, solids distributed throughout a liquid or gaseous phase which is circulated around the wellbore during drilling operations (Temple, Wami, & Nmegbu, 2019). Some functions of the drilling fluid can vary with the type of well or formation, but the basic functions remain the same for most oil-well drilling operations. Two of the most important functions are controlling the formation pressure and the transport of the cuttings from the bottom of the well up to the surface. (Mortatha et al., 2020). Drilling fluids are categorized in terms of the base fluid used as well as the type of additives that it contains.

There are three main groups of drilling fluids which are gaseous, water-based and oil-based. Gaseous drilling fluids are not as commonly used as water- or oil-based fluids. (Ahmed & Ekrem 2019). The viscosity has a significant role in hole cleaning, as cuttings will settle quicker if the fluid viscosity is low. A high viscosity usually means better hole cleaning. Igwilo (2000) noted that the most relevant function of a drilling fluid is the ability to carry drill cuttings from the bit up to the annulus to the surface.

The fact that the drilling fluid is thixotropic means that when there is no circulation, the cuttings can be suspended by the gelled fluid. (Ahmadi 2008). Controlling the pressure of the formation is one of the basic functions of the drilling fluid in order to prevent the influx of formation fluid into the well. This is achieved by controlling the density of the fluid with weighting agents such as barite. (Ibrahim et al., 2016). Osei (2019) noted that adequate cuttings removal from a well while drilling is critical for cost effective drilling, as high annular cuttings build up often leads to high risk of stuck pipe, reduced rate of penetration and other impediments to standard drilling and completion. Igwilo (2000) noted that the most relevant function of a drilling fluid is the ability to carry drill cuttings from the bit up to the annulus to the surface. Starch is primarily made up of amylose and amylopectin polysaccharides which helps it to swell and aid fluid loss control. (Harry et al., 2016). Controlling the pressure of the formation is one of the basic functions of the drilling fluid in order to prevent the influx of formation fluid into the well. This is achieved by controlling the density of the fluid with weighting agents such as barite. (Ibrahim et al., 2016).

Amanullah & Yu (2004), using corn base starches as mud viscosifier, experimentally results showed that some of the starches have better filtration control properties than that of the imported mud Starch been the second most abundant biomass found in nature. Research findings have demonstrated that calcium bentonite can easily be upgraded to sodium bentonite (Biliamino and Ibrahim, 2010). In the exploration and production phase of the petroleum industry, innovations are constantly being sought after in order to reduce the enormous costs associated with the importation of drilling fluid additives especially given the high rate of foreign exchange and the impact on the economy. The significance of this study is how we can reduce the volume of PAC used during mud formulation in favour of readily available local materials like cassava starch and coconut fibre. These properties are both rheological and mud weight properties. This research work involved the laboratory analysis, characterization of the rheological properties of water based drilling mud formulated with two local additives at different concentrations to determine its suitability in the formulation of water based drilling mud. The additives were cassava starch and coconut fibre partially replacing Polyanionic Cellulose and testing the drilling fluid density, the viscosity, the PH, yield point, gel strength and fluid loss. The experimental samples labelled B to K were compared with the control sample labelled A. Ademiluyi et al., (2011) carried out an experiment on the investigation of local polymer (cassava starches) as a substitute for imported sample in viscosity and fluid loss control of water-based drilling mud, and it was shown that imported sample had higher rheological properties compared with the local samples. It was also shown that some local starch products (with higher amylose content and high water absorption capacity) have similar or better filtration control than the imported starch. Queendarlyn and Joshua (2020) investigated the effectiveness of sweet potato and rice husk blend as a secondary viscosifier and fluid loss control agent in water-based drilling mud and found out that concentrations of sweet potato and rice blends of about 2g to 8g affected filter cake thickness and decreased fluid loss. Wami et al., (2015) carried out a study on the use of potato starch as a viscosifier and fluid loss control agent in a water-based mud and results showed the efficiency of potato starch as a viscosifier and fluid loss reducing agent. Igwe and Kinate (2015) proved the efficacy of periwinkle shell ash as a filtration loss control agent in water-based drilling mud and found out that 2g of periwinkle shell ash gave minimal filtrate volume of 6.7ml after 30 minutes of filtration. Amylose is contained in a linear polymer form and has a molecular weight in range of 100,000-500,000 mol. and amylopectin a branched polymer with a molecular weight of 1-2 million (Wing et al., 1988).

II. MATERIALS AND METHODS

In order to evaluate the effect of cassava starch and coconut fibre on the drilling mud formulation with respect to its rheological properties and fluid loss, an experimental work was carried out in the department of Petroleum Engineering laboratory. Eleven different water-based mud samples were formulated with different concentrations of drilling fluid additives, where the control sample (Sample A) PAC was kept constant at 2g while gradually replacing it with the cassava and coconut starch in subsequent samples. The cassava starch and coconut fibre were obtained from International Institute for Tropical Agriculture (IITA), Onne in Port Harcourt, Nigeria. The formulated drilling fluid parameters obtained from the experiment were used to compare with standard drilling mud formulated with Polyanionic Cellulose (PAC).

A Materials

The materials used for the experiments include the following:
Beakers, spatula, measuring cylinder, electronic weighing balance, electronic oven, sieves, oven, blender/mixer, Rheometer, mud balance, Ph paper, thermometer, stop watch and API Filter Press.

B Preparation of Starch

The starch was obtained from the international institute of tropical agriculture (IITA). The cassava was harvested and washed before removing the skin. The cassava was peeled manually using a steel knife and washed with water to remove dirt. This was grated and sieved. The different mixtures were filtered and the filtrate was allowed to settle in order to obtain the starch content. It was then decanted and sediment washed to obtain a colourless and odourless starch. The wet starch was spread on a try to allow for drying by air. This lasted for 6 hours before it was properly dried in an air oven at about 60ºC for about 3 hours. The dry matter was blended to fine particles.

C Preparation of Coconut Fibre

The coconut fibre was obtained from Chokocho community in Etche local government area of Rivers State. The coconut fibre was ground into very fine particles. The coconut fibre (coir) was dried in the sun for 7 hours. It was placed in an electronic oven for about 6 hours at a temperature of 70°C to remove any remaining moisture. It was also sieved using a 200mm sieve

D Formulation of Mud Samples

Eleven different mud samples were formulated using different concentrations of the drilling mud additives. The drilling fluid additives used for the mud formulation include: Caustic soda, Soda ash, Polyanionic Cellulose (PAC), cassava starch, coconut fibre, Xanthan gum, Potassium chloride, barite, borax and bentonite. The control sample was labelled Sample A. The experimental samples were labelled B to K. 76.8g of barite was soaked in 350ml of water for 24 hours in order for it to give good yield (swell properly and give good mud weight). The mixture was agitated (stirred) thoroughly using a mixer/blender. The other additives were introduced into the mixture and agitated at five-minute intervals one after the other until the last additive was added. The mud formulation tables are shown in the tables below.

Table 1**:** Mud Composition for Sample A (Control Sample)

Composition	**Concentration**	**Function**
Water	350ml	Base fluid
Caustic soda	0.2g	Alkalinity control
Soda Ash	0.2g	Calcium ion removal
PAC	2.0g	Fluid loss control
Xanthan gum	2.8g	Viscosifier
Potassium chloride	18g	Inhibition control
Barite	76.8g	Weighting material
Borax	2g	Preservative
Bentonite	2.8g	Viscosifier

For the experimental samples, the additives varied by different concentrations were PAC, cassava starch and coconut fibre. All other additives and their concentrations remained constant. The concentrations for PAC, cassava starch and coconut fibre in each formulated mud sample is given as follows: Sample A (2g PAC), Sample B (2g cassava starch), Sample C (2g coconut fibre), Sample D (1.5g PAC + 0.5g cassava starch), Sample E (1.5g PAC + 0.5g coconut fibre), Sample F (1g PAC + 1g cassava starch), Sample G (1g PAC + 1g coconut fibre), Sample H (1g cassava starch + 1g coconut fibre), Sample I (1g PAC + 0.5cassava starch + 0.5g coconut fibre), Sample J (1g PAC + 0.75g cassava starch + 0.25g coconut fibre), Sample K (1g PAC + 0.25g cassava starch + 0.25g coconut fibre).

E Mud Density Determination

The drilling mud density was determined using a Baroid mud balance. The instrument consists of a constant volume cup with a lever arm rider calibrated to read directly the density of the fluid in pounds per gallon (ppg). The lid was removed from the cup and completely filled with the mud to be tested. The lid was replaced and the mud that was expelled through the hole in the cup was wiped off. The balance arm was placed on the base with the knife edge resting on the fulcrum. The mud density was read directly in pounds per gallon.

F Mud Rheology Determination

Rheology is the deformation and flow behavior of a fluid. An Ofite variable speed Rheometer was used to test the rheology of the drilling fluid. A recently agitated mud sample was poured in the rheometer cup. The adjustment knob was turned to raise and lower the rotor sleeve until it was immersed in the sample to the scribed line. The sample was stirred for about 10 seconds at 600rpm until the dial was stabilized and the reading was recorded. The knob was adjusted to get the dial readings for 300rpm, 200rpm, 100rpm, 60rpm, 30rpm, 6rpm and the gel strength was also recorded.

III. RESULTS AND DISCUSSION

A. Rheological Properties

TABLE 3: Rheology of Drilling mud samples

Sample	Θ600	Θ300	Θ200	Θ100	Θ60	Θ30	Θ6
A	157	121	105	81	67	52	30
B	74	64	56	45	40	35	25
C	76	64	54	47	40	35	25
D	135	110	94	74	61	50	32
E	132	100	95	77	66	53	40
F	114	90	80	65	54	44	29
G	112	88	78	63	52	42	27
H	65	53	45	35	33	26	19
I	102	76	65	52	50	41	26
J	120	92	85	76	65	50	28
K	108	83	72	56	51	42	27

B. Plots of Shear Stress vs Shear Rates

Fig 1: Plot of shear stress vs shear rate for sample A, B and C

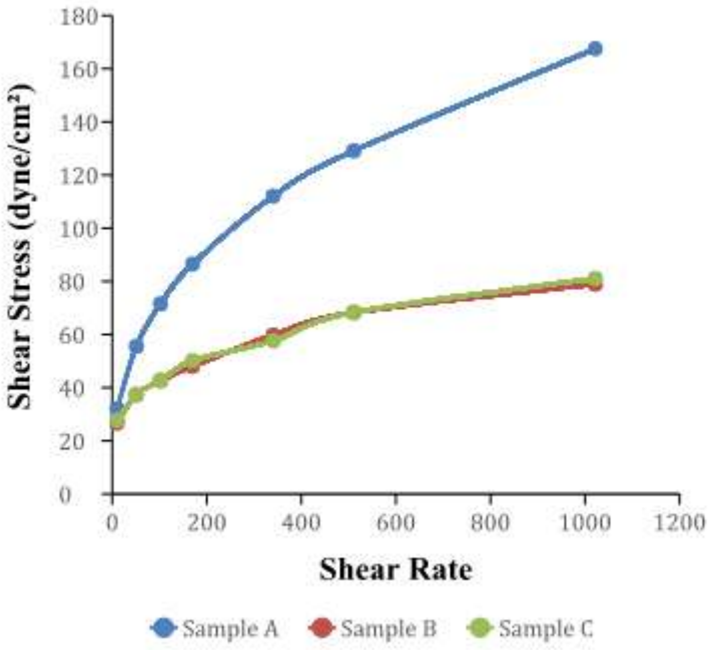

Figure 1 above shows the rheological properties for samples A, B and C. Sample A which is the control sample with 2g of PAC had the highest rheological property, exhibited better viscosity and gel strength. Sample B has 2g of cassava starch had slightly better rheology than sample C which has 2g of coconut fibre.

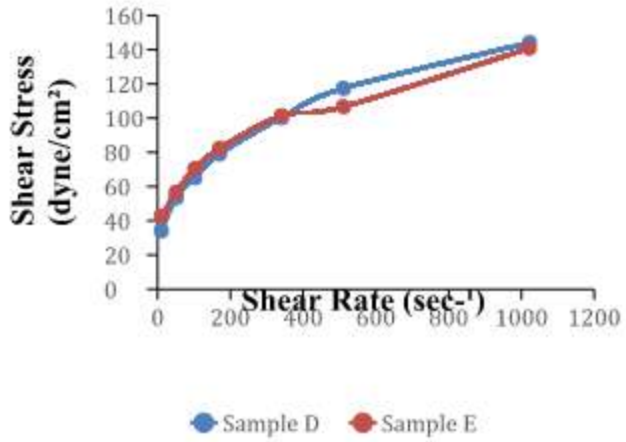

Fig 2: Plot of shear stress vs shear rate for sample D and E

Figure 2 above shows the rheological properties of sample D and E. Sample D has a concentration of 1.5g PAC and 0.5g cassava starch while sample E has a concentration of 1.5g PAC and 0.5g coconut fibre. Sample D exhibited slightly better rheology than sample E which shows that cassava starch is slightly better than coconut fibre as a fluid loss control additive

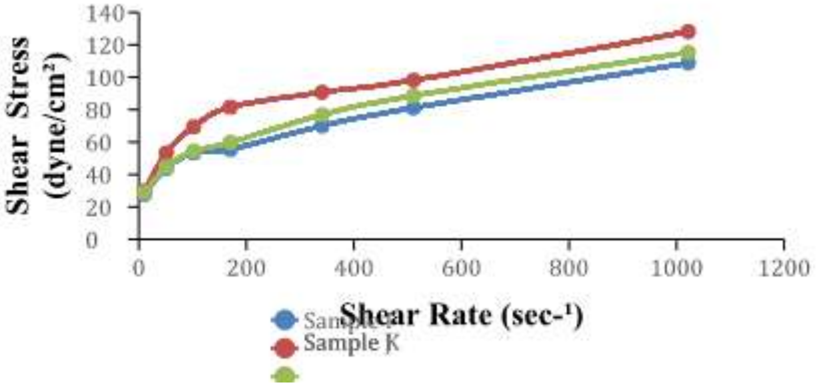

Fig 3: Plot of shear stress vs shear rate sample I, J and K

The figure above shows the rheological properties of samples I, J and K. Sample I has 1g PAC, 0.5g cassava starch and 0.75g cassava starch and 0.25 coconut fibre. Sample K has 1g PAC, 0.25g cassava and 0.75g coconut fibre. Sample J has the best rheological properties which indicates that although cassava starch and coconut fibre are both good fluid loss control additives individually, but when they combine, the form a better bridging agent.

C. Filtration Properties of Mud Samples

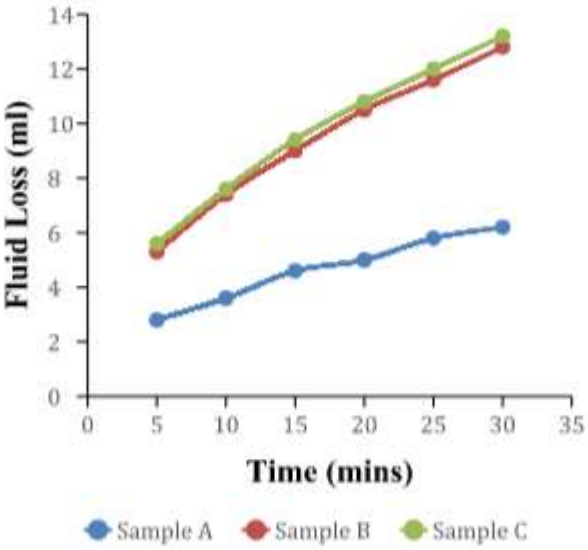

Fig 4: Plot of volume of fluid loss against time of water based mud samples

In the figure above, sample A which is the control with 2g PAC has the best fluid loss values closely followed by cassava starch of 2g with coconut fibre of 2g having the least performance.

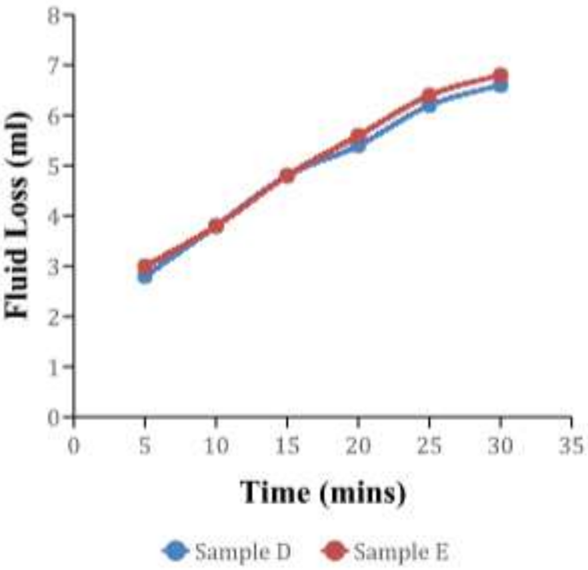

Fig 5: Plot of volume of fluid loss against time for sample D and E

For sample D the cassava starch of 0.5g mixed with 1.5g of PAC performed slightly better than 0.5g of coconut fibre mixed with 1.5g of PAC.

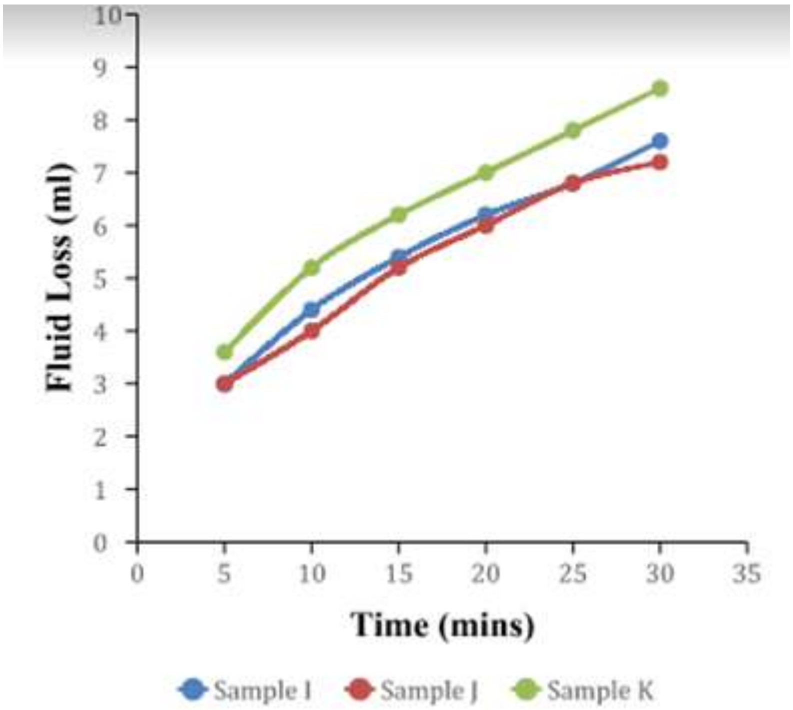

Fig 6: Plot of volume of fluid loss against time for sample I, J and K

In the figure above, sample J which had 1g PAC and a combination of 0.75g cassava starch and 0.25g coconut fibre had the least fluid loss.

D. Mud Density of Samples

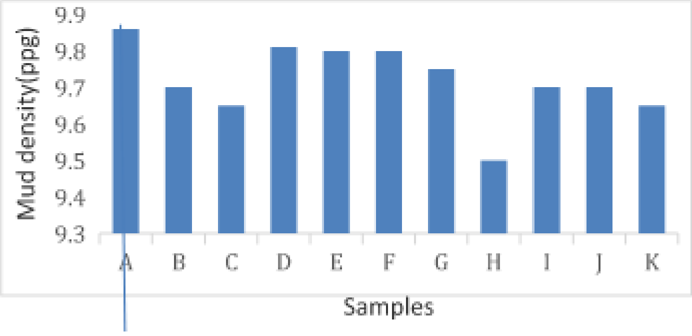

Figure 7: Effect of local materials on the density of water based mud

Generally, weighting materials are calculated and added to mud formulations to help achieve this one important property of the drilling mud. Some reservoirs require a denser drilling mud especially when faced with problems like influx of other fluids into the borehole. From figure 7 above the effect of local materials on different formulated water based mud, with sample A having the highest mud weight, this is followed by sample D with cassava starch concentration of 0.5g. Sample H had the least mud weight as it did not contain any PAC

IV. CONCLUSION

In a very dynamic and ever evolving oil and gas industry with high operating costs, the need to source for cheaper and effective local alternatives cannot be over emphasized. The local materials used for the experiments were cassava starch and coconut fibre. They are in abundance in abundance across various communities across the country especially in the South-South area where farming is done predominantly. From the research carried out, the following conclusions were made:

i) The pH range of the mud samples was between 9.0 and 9.5 which implied the mud is alkaline in nature.

ii) The cassava starch and coconut fibre had similar fluid loss values with the starch performing slightly better than the coconut fibre.

iii) The samples with cassava starch had better viscosity than samples with coconut fibre.

iv) The formulated mud samples obeyed the Bingham-Plastic rheological model.

v) The mud densities did not vary much because they all had equal volume of barite which was the weighting material.

vi) The research showed that the optimum concentration for best results was 50%, 37.5% and 12.5% for PAC, cassava starch and coconut fibre respectively.

vii) This research will help improve the local content act by promoting utilization of locally available raw materials and preserve foreign exchange.

REFERENCES

[1]. Ademiluyi, T., Joel, O. & Amuda, A. (2011). Investigation of local Polymer (Cassava Starches) as a Substitute for Imported Sample in Viscosity and Fluid Loss Control of Water Based drilling Mud, ARPN Journal of Engineering and Applied Sciences. 6(12)

[2]. Ahmed, A.W., & Kalkan, E. (2019). Drilling fluids, types, formation choice and environmental impact, 8, 66-71.

[3]. Amanullah, M. D., & Yu, L. (2004, September). Superior corn-based starches for oil field application. In New Director for a Diverse Planet. In: Proceedings for the 4th international conference on corns. Brisbane, Australia.

[4]. Apugo-Nwosu, T. U., Mohammed-Dabo, I. A., Ahmed, A. S., Abubakar, G., Alkali, A. S., &Ayilara, S. I. (2011). Studies on the suitability of Ubakala bentonitic clay for oil well drilling mud formulation. British Journal of Applied Science & Technology, 1(4), 152.

[5]. Biliamino, H. D. & Ibrahim, K.O (2010). Non-Metallic Mineral Endowments in Nigeria. RMRDC Technical Publication (20), 11-16.

[6]. Dewu, Abdullahi, A.S., Mark, O., Funtua, I. I. Mahatir, M.(2012). Improvement of Rheological Properties of Bentonitic Clays Using Sodium Carbonate and a SyntheticViscosifier. 2.43-52.

[7]. Harry, T.F., Joel, O.F., Ademiluyi and Oduola K. Performance Evaluation of Local Cassava Starches with imported Starch for Drilling Fluid. American Journal of Engineering Research.2016;5.

[8]. Ibrahim, D.S., Sami, N.A. & Bolasubramanian, N. (2016). Effect of barite and gas oil drilling fluid additives on the reservoir rock characteristics. Journal of Petroleum Exploration Production Technology, 7, 281-292.

[9]. Igwe, I. & Kinate, B.(2015). The use of Periwinkle Shell Ashas Filtration loss Control Agent in Water-Based Drilling Mud. International Journal of Engineering Research and General Science. Volume 3.375-381.

[10]. Igwilo, K.C. (2000). Fundamentals of Drilling Fluids Technology.Choba, Emhai Books: Port Harcourt.

[11]. Mortadha, T.A., Mohammed, A. & Ahmed. K.A. (2020). Application of nano water-based drilling fluid in improving hole cleaning. SN Applied Sciences. 2.10.1007/542452-020-2723-2.

[12]. Nwabueze, Q. & Ighalo, J.O (2020). Utilization of Sweet Potato (Ipmoe batatas) and Rice Husk (Oryza Sativa) Starch Blend as a Fluid Loss Control Agent in Water-based Drilling Mud. Petroleum and Coal. 62.1230-1241.

[13]. Osei, H. (2019). Rheological Effects of Power Law Drilling Fluids on Cuttings Transportation in Non-Vertical Wellbores. Ghana Journal of Technology , 4(1) 65-72.

[14]. Temple, E. A., Wami, E. N., &Nmegbu, G. (2019). Effect of Local Clays Substitution on Rheological Properties of Formulated Water Base Mud. International Journal of Scientific & Engineering Research, 10(3)481-489.

[15]. Wami, E., Pius, J. & Nmegbu, G. (2015). Drilling Mud Formulation using Potato Starch (Ipomoea Batatas). International Journal of Engineering Research and Applications. 5.48-54.