International Journal of Oil, Gas and Coal Engineering
2023; 11(2): 37-46
http://www.sciencepublishinggroup.com/j/ogce
doi: 10.11648/j.ogce.20231102.12
ISSN: 2376-7669 (Print); ISSN: 2376-7677 (Online)

Experimental Study on the Suitability of Local Egg Shell and Snail Shell as Additives for Drilling Mud pH Control

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To cite this article:
Onyejekwe Ifeanyichukwu Michael. Experimental Study on the Suitability of Local Egg Shell and Snail Shell as Additives for Drilling Mud pH Control. *International Journal of Oil, Gas and Coal Engineering*. Vol. 11, No. 2, 2023, pp. 37-46. doi: 10.11648/j.ogce.20231102.12

Received: January 13, 2023; **Accepted**: February 14, 2023; **Published**: April 24, 2023

Abstract: Millions of dollars associated with importation cost has and is still been spent by oil companies carrying out drilling operations in Nigeria, and this if allow to continue unchecked, does not align with the country policy of promoting local content in the oil and gas industry. This study experimentally evaluates the suitability of local eggshell and snail shell ash for use as pH control additives in water base mud by comparing it to that of conventional chemical additives (sodium hydroxide, NaoH) that served as the control experiment. The major drilling mud properties considered in this study are mud density, pH value and rheological properties, with additives concentration of 0.2g to 1.0g each. The result from the study shows that mud prepared with eggshell has a slight increase in density (8.70 – 8.75ppg) while that of snail shell was higher (8.85 – 8.90ppg). These result for the eggshell and snail shell closely compares to that of the control and satisfies the API required minimum standard specification (8.65 – 9.60pp) for drilling mud. At the same concentration, the pH values of mud prepared with eggshell responded positively, compares to that of the control and was within the API required minimum standard specification (9.5 – 12.5) while that of snail shell was seen to give low pH values but was favourable at 1.0g concentration. The result for rheological properties (viscosity and gel strength) shows an improvement with an increase in the concentration of the samples for the eggshell and snail shell. Generally, from the obtained result in this study for all the evaluated mud properties, it is concluded that with respect to API required standard specification for drilling mud, that the eggshell is the most promising and has a good potential for drilling mud purposes when beneficiated in the right amount. This study recommends that government should support and encourage purposeful research on eggshell and snail shell for use as additives in drilling mud formulation with the sole aim of supporting the local content aspiration of the nation.

Keywords: Eggshell, Snail Shell, Rheological Properties, Drilling Fluid, Local Clay

1. Introduction

Drilling fluids are complex heterogeneous fluids, consisting of several additives that were employed in drilling oil and gas wells since the early 1900. Circulation of drilling fluids is key to rotary drilling process which is the most widely used method in the oil and gas industry. It will be difficult or almost impossible to drill for oil and gas without drilling fluids and their additives. There is no doubt saying that to successfully drill a well, the properties of the drilling fluid used has to be continuously monitored and controlled during the drilling operations. In order to enhance the usage of drilling fluids, numerous additives were introduced and a simple fluid became a mixture of liquids, solids and chemicals [1]. As drilling fluids evolved, their characteristics features that determines the smoothness and success of drilling operations aids in safety, economic and satisfactory completion of a well. This is derived through the special functions performed by the drilling fluid [2, 3]. To satisfy these requirements, the mud must be compounded as to have chemical and physical properties which can be carefully control to meet the varied and changing subsurface conditions [4]. The success of the overall drilling operation is determined by the rheological properties of the drilling mud which specifies the flow behaviour of the mud and is characterized by viscosity, gel strength and yield value [5]. Additives are used in drilling fluids during formulation to achieve several purposes such as viscosity control, weighting control, rheology control, pH control and filtration control.

Owing to the increase in the prices and challenges faced with the importation of materials used in the formulation of drilling mud, the use of local waste materials as substitute for the imported materials has attracted a great deal of attention and research in the production of drilling mud in the petroleum industry. Attempts by researchers in sourcing for locally produced material as substitutes for the imported drilling fluids additives which can compare favourably well with the imported additives and satisfy the API required minimum standard specification has been reported [6, 7]. This vision if realized would save the nation from the challenge and huge amount of dollars usually spend on importation of the drilling fluids additives. The realization of this vision will be in accordance with the government wish for self-sufficiency of the oil industries and its resolve to support local content [8]. It is with this in mind that this study is been carried out. Bearing in mind the fact that this study is an effort to experimentally evaluate the suitability of local eggshell and snail shell as additives for drilling mud pH control in drilling mud production, there is need to look at previous studies done by researchers.

1.1. Literature Review

Olatunde et al. [9] in their study on improving the rheological properties of drilling mud using locally based materials, formulated water base mud using bentonite, guar gum, polyaniomic cellulose (PAC) and guar Arabic. The rheological behaviour and filtration loss property of the drilling fluid was measured in line with the API recommended standard procedure. The result of their analysis indicates guar gum produces the highest gel strength, stable rheological properties with poor filtration loss while gum Arabic had unstable gel strength and good filtration loss property. Drilling operation is enhanced by the application of drilling mud which is the main component that determines the smoothness and success of that drilling operation [2, 3, 10, 11] and its selection is a function of the formation to be drilled [12, 13]. Ademiluyi et al. [6] carried out an investigative study by comparing the performance of a local polymer (cassava starch) with that of the foreign sample by testing five different cassava starches as viscosifier additives in a water base mud. The result from their study shows that the imported sample had a higher rheological property. However, the viscosity of the drilling fluid produced from the local starch was lower than that of the imported. The result also indicates that the local materials filtration control properties were better than their imported counterparts and yielded better results.

Research on the existence of bentonite clay reserves has shown the availability of more than 80 clay deposits found from all parts of the country [14]. There was a drop in the use of local additives and clays for drilling activities in the petroleum industry in Nigeria due to the introduction of foreign commercial additives and bentonite. Recent studies [7, 15, 16] on using local starch to improve the density, water retention capacity and rheological properties of water base mud has been suggested by researchers and carried out. Akinade [17] in his study on beneficiation of Nigeria local clay to see if it meets API standard specification for drilling fluid formulation, investigated on the rheological properties of local clay sample by analysing insitu properties before beneficiating with a defined concentration of potash to see if they can compare to that of imported bentonite and also satisfies the API standard specification. The obtained result shows that most of the investigated properties compares to the minimum required API standard specification for drilling mud. Mohammed and Koyejo [18] carried out a study to see the possibilities of improving the rheological properties of local mud to compare to that of the foreign bentonite using natural polymers while observing API standard of measurement throughout the experimental study. The obtained result from their study shows that increasing the concentration of the polymers enhances the mud rheological properties at ambient conditions. They concluded that a cheap organic, biodegradable non-toxic and easily available additive that is environmentally friendly has been discovered.

Okologume and Akinwumi [19] in their study did a comparative study on the rheological and thixotropic properties as well as other properties of mud prepared with local clay and mud prepared with foreign clay to see if they can compare with that of the imported bentonite and also satisfy the API required minimum standard specification for drilling mud. The formulation of the locally sourced mud as a substitute for the imported bentonite was measured in total compliance and adherence to the stipulated API standard value. The obtained result shows an improvement in the overall mud properties to compare and met the minimum required API standard specification with a defined concentration of chemical additives. They concluded that most of the parameters of the local clay sample responded positively after beneficiation and their treatment with readily available additives to improve its properties in meeting the minimum required standard specification was successful. They suggested that though significant economic opportunities existed for large scale production of local clay in the formulation of drilling mud, but that the clay must be acquired at the right depth and strata to ensure good laboratory response to treatment.

Eggshells and snail shells [20] are both waste materials from hatcheries, homes, fast food industries and market places respectively. The disposal of these waste materials contributes to environmental pollution challenges with its attendant disposal cost, availability of disposal sites, odour, flies and abrasiveness. Therefore, employing these readily available waste materials as additives in drilling mud formulation is a potential alternative to reduce the production cost of drilling mud, and if effective will be environmental friendly.

1.2. Summary of Reviewed Literature

Reviewed literatures indicates that it will be difficult or almost impossible to drill for oil and gas without drilling fluids and their additives and that additives are used in drilling fluids formulation to achieve several purposes such as viscosity control, weighting control, rheology control and filtration control. Review shows that the use of local clay and waste materials as substitute for imported bentonite and additives resulted from the challenges, high cost and capital flight associated with the importation of this foreign materials for drilling purposes and the nations policy initiative on encouraging local content in the oil and gas industry. This policy initiative of the government from reviewed literature stem from studies carried out by researchers which results suggested the abundance of clay deposits of various kinds and grades distributed across the country's length and breadth and readily available local materials such as cassava starch, potash, guar gum, polyanionics cellulose (PAC), guar Arabic, all of which can be used as additives in the formulation of drilling mud. Studies according to reviewed literatures indicate that rheological properties of drilling mud can be improved by the use of locally sourced materials. For this improvement to compare to that of the imported (foreign) bentonite and additives and also satisfy the required minimum API standard specification, is said to be sensitive and dependent on the defined concentration of the materials used in the mud formulation.

The general conclusion from studies suggests that the rheological and other properties of the locally sourced clays can actually be enhanced after beneficiation to be a good substitute for the imported bentonite and that significant economic opportunity exists for large scale production of locally sourced clay for drilling mud formulation. Reviewed literatures also indicates that beneficiating of the locally sourced clay to compare and satisfy the required API minimum standard specification, is in line with supporting the Nigeria's desire and policy in supporting local content value addition in the oil and gas industry. This they said will translate to eradicating the problem created through the importation of foreign bentonite clay and even fosters foreign exchange earnings through export of this local clays and additives and generate employment opportunities.

2. Materials and Methods

First, comprehensive lists of all the equipment/raw materials and experiments for this study were stated. The egg shell and snail shell used in this study as local additives for the formulation of the drilling mud were sourced from Douglas market, Owerri, Imo State, South East Nigeria. Measurements and experimentations were meticulously carried out on the egg shell and snail shell. The mud properties monitored in this study were the effects of additives on the pH, density and on rheological properties of the formulated drilling mud. All the experiments for this study were carried out in the drilling fluid laboratory of Petroleum Engineering Department, Federal University of Technology Owerri, Imo State, South East Nigeria.

2.1. Equipment and Raw Materials

The under listed equipment and materials were used for this study with all experiments meticulously carried out within the API standard specifications.

2.1.1. Graduated Measuring Cylinder

The graduated measuring cylinder Figure 1 is used in measuring the amount of water to be used in the formulation of the drilling fluid.

Figure 1. *Measuring cylinder.*

2.1.2. Electronic Weighing Balance

This is used for dry substances; it measures the amount in grams of materials needed in the formulation of the drilling mud.

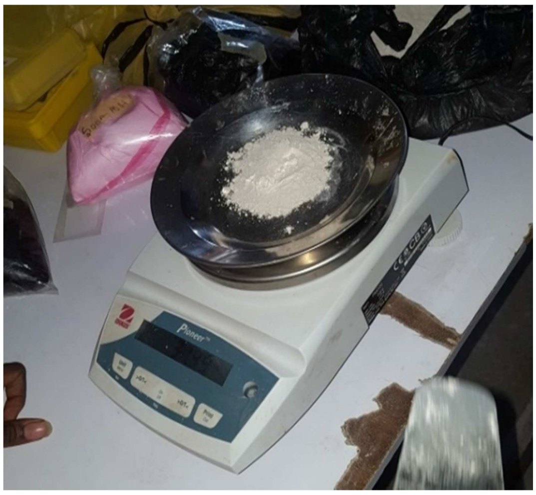

Figure 2. *Electronic measuring balance.*

2.1.3. Mud Balance

This measures the density of the formulated drilling fluid. It measures in pounds per barrel (ppb). This is necessary because the weight of the drilling fluid is an important parameter which determines whether there will be need for weighting up or further analysis. Measuring of the mud density was done at different phases when the amount of the samples was changed from 0.2g to 1.0g. The freshly prepared mud was poured into a clean, dried mud balance cup. The lid was placed on the cup and was set firmly but slowly with twisting motion. The instrument base was set up so that it was approximately levelled by moving the rider of the mud balance until it was stable. Then the reading on the mud balance scale was read and recorded properly against the mud type. Figures 3 and 4 shows the mud balance and prepared sample used for the density test respectively.

Figure 3. Mud balance.

Figure 4. *Prepared sample used for density test.*

2.1.4. Viscometer

This was used in measuring the rheological properties of the drilling fluid. It was calibrated in revolutions per minute (RPM) and the obtained results are in centipoises (cp). The OFITE 900 model viscometer was used for the measurement of rheological properties of the formulated drilling mud. The freshly prepared mud was poured into a sample cup of the viscometer, the enter button pressed and the rotor was allowed to rotate for few seconds for stabilization. The rotor speed was then immense until the mud touched the scribed line on the rotor sleeve; the mud button was pressed and the viscometer automatically carried out the measurement at θ600rpm and θ300rpm. The equipment was switched on, the speed was set to θ600rpm (high) and allowed to run until a steady reading was obtained from the dial gauge, the reading was recorded. Thereafter, the sample was stirred and left to settle, the gel strength at the end of 10seconds and 10minutes were recorded. Figure 5 shows the viscometer with a prepared mud sample for rheology test.

Figure 5. *Viscometer with a prepared mud sample for rheology test.*

2.1.5. The pH Paper

This was used in measuring the pH value of the drilling mud. The pH of the drilling fluid is important because different formation have different pH requirement, thus the pH of the drilling fluid has to be carefully monitored. The freshly prepared mud samples were re-stirred to obtain a homogenous mixture. The pH paper strips were used in measuring the pH of the various samples of the formulated mud. The mud was poured into a beaker and a pH paper strip was dipped into the sample and sufficient time was allowed to elapse (abut few seconds) for the paper to soak and change colour. The soaked paper was strip and matched with the chart on the dispenser from which the strip was taken. The pH range of the mud was read and the value recorded. The same procedure was repeated for other concentrations of the mud. Figure 6 shows the pH paper strip.

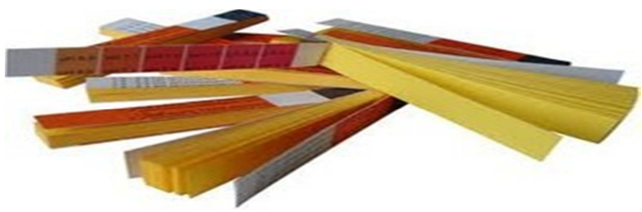

Figure 6. *pH Paper Strip.*

2.1.6. Variable Speed Mixer

A single spindle Hamilton beach commercial mixer shown in Figure 7 was utilized for preparing the mud samples. The mixer had three speeds setting with additional pulsating switch.

Figure 7. *Variable speed mixer.*

2.2. Raw Material

The raw materials used for the formulation of the drilling mud and their functions are listed on Table 1.

Table 1. *Raw Material.*

Raw materials	Function
Water	Continuous phase /base fluid
Bentonite	Viscosity and filtration control
Caustic soda	pH modifier
Polyanionic cellulose (PAC)	Viscosifier and filtration loss control
Carboxyl methyl cellulose (CMC)	Viscosifier and filtration loss control
Eggshell	pH control agent
Snail shell	pH control agent

2.2.1. Preparation of the Eggshell and Snail Shell

The shell was soaked in warm water treated with sodium chloride (NaCl) to remove dirt and any contaminant. Thereafter, the shells were washed and dried, and then grinded in a mechanical grinding machine to obtain fine particles. The grinded materials were heated in an electric furnace at intervals of 300^0C, 600^0C and 900^0C for 3hrs 20 minutes to liberate carbon dioxide, $CO_{2,}$ and obtain quick lime which is calcium oxide, CaO. The heated materials (CaO) were inserted in a desiccator to avoid contact with the atmosphere. The resulting ash was then sieved through BS sieve (0.63mm) to obtain a fine ash (nano particles) and later stored in an air – tight container ready for use. These fine ash particles are the egg shell and snail shell used for the formulation of the mud sample of interest and when mixed with water, its reaction gives slaked lime as represented in equation 1. Figures 8, 9 and 10 show an open furnace with eggshell, the prepared eggshell and snail shell respectively.

$$CaO + H_2O \rightarrow Ca(OH)_2 \quad (1)$$

Figure 8. *Open furnace with eggshell.*

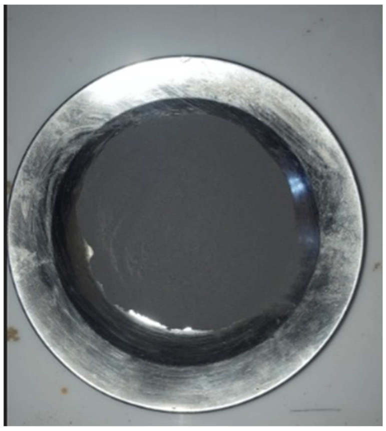

Figure 9. *Prepared eggshell.*

Figure 10. *Prepared snail shell ash.*

2.2.2. Formulation of Mud Samples

Three (3) different mud samples were formulated with varying amount of additives. The composition of mud samples is shown on Table 2 below.

Table 2. *Mud sample composition.*

S/N	Additive	Sample A Caustic Soda					Sample B Egg Shell					Sample C Snail Shell				
1	Water (ml)	350					350					350				
2	Bentonite (g)	30					30					30				
3	PAC (g)	0.2	0.4	0.6	0.8	1.0	0.2	0.4	0.6	0.8	1.0	0.2	0.4	0.6	0.8	1.0
4	CMC (g)	0.2	0.4	0.6	0.8	1.0	0.2	0.4	0.6	0.8	1.0	0.2	0.4	0.6	0.8	1.0
5	Caustic Soda (g)	0.2	0.4	0.6	0.8	1.0	-					-				
6	Egg Shell (g)	-					0.2	0.2	0.6	0.8	1.0	-				
7	Snail Shell (g)	-					-					0.2	0.4	0.6	0.8	1.0

3. Results Discussion

The results and discussion on the experimental study on the suitability of local eggshell and snail shell ash for use as pH control additives in water base mud, and to determine if they can compete with the conventional chemical additives, sodium hydroxide (NaoH) and also measure up to required minimum API standard specification is presented and discussed below.

3.1. Mud Weight, pH and Rheology of Formulated Mud

The results on the investigation carried out on mud weight, pH and rheology of mud formulated with caustic soda serving as reference Table and control experiment are shown on Table 3. Figures 11 through Figure 15 shows the comparisons of the control and proposed additives used and its effect on mud density, pH, plastic viscosity, 10 seconds gel strength, and 10 minutes gel strength respectively.

3.2. Mud Weight, pH and Rheology of Mud Formulated with Caustic Soda

The result from Table 3 shows that the mud weight of the (0.2 -1.0g) concentration of mud sample prepared with caustic soda gave a value ranging from (8.60 – 8.75ppg). The mud pH value for the same concentration was within (10 – 11). These obtained result for the mud density and pH both fell within API required minimum numerical standard specifications and are in conformity to studies by [8, 17, 19, 21] The obtained result for the viscometer dial reading @ 600rpm and 300rpm for (0.2 -1.0g) concentration of mud sample was within (33 – 58cp) and (21 -36cp) respectively. The plastic viscosity values for the same concentration fell within 12cp – 22cp. The result from Table 1 on gel strength @ 10seconds and 10 minutes indicates a slight and steady increase in gel strength with an increase in additives concentration, but with a likely decrease after attaining a maximum value as reflected for the 8.0g for the 10secs and 10minutes gel strength respectively.

Table 3. *Mud weight and rheology of mud formulated with caustic soda..*

Quantity (g)	Density (ppg)	pH	Rheological Properties				
			Viscosity (cp)		Plastic Viscosity (cp)	Gel Strength (ib/100ft^2)	
			300 RPM	600 RPM	(600- 300) RPM	10 secs	10 mins
0.2	8.75	10	21	33	12	7	8
0.4	8.70	10	28	44	16	8	8
0.6	8.70	10	27	42	15	9	10
0.8	8.60	10.5	26	40	14	10	10
1.0	8.70	11	36	58	22	10	9

3.3. Mud Weight, pH and Rheology of Mud Formulated with Eggshell

The result on mud weight, pH and rheology of mud formulated with eggshell is summarized on Table 4 while Figures 11 through Figure 15 shows the comparisons of the control and proposed additives used and its effects on pH, mud density, 10seconds gel strength, 10 minutes gel strength and plastic viscosity. The result from Table 4 for the 0.2g to 1.0g concentration eggshell formulated mud shows that mud density (8.70 to 8.75), pH (9.0 to 9.5), viscosity @ 300rpm (21 to 51cp), @ 600rpm (34 to 76cp), plastic viscosity (13 to 26cp), 10seconds (8 to 10 ib/100ft^2) and 10minutes (8 to 12 ib/100ft^2) were generally very close to and compares to the control result. However, exceptional cases are the observed sharp differential at 0.8g for viscosity at 300rpm and 600rpm respectively.

The obtained result for mud density compares favourably well with the control result of Table 3 and Figure 11 respectively, satisfy the API required standard specification for drilling mud and are a confirmation to studies by [8, 17, 18, 19, 21, 22]. The relative constant value observed for the mud density after beneficiation is suggestive of low concentration mud. The results from Table 4 and Figure 12 show that pH value has remain relatively constant at (9.5) for varied quantities of additives and therefore compares favourably well with the pH values for the control except for the 0.4g with pH value (9.0) which are slightly lower than the minimum required numerical value for API standard specification. Though pH value for foreign bentonite in the range of (8.5 -10.0) exist [23]. The obtained result generally compares with that of the control and satisfies the stipulated API standard specification for pH values according to the researches [8, 17, 19, 21]. The rheological properties for the eggshell formulated mud for the 0.2 to 1.0g were monitored and the result presented on Table 4 while

Figures 13, 14 and 15 presents their comparisons with that of the control result. The plastic viscosity (PV) was generally very close to that of the control as shown on Table 3 and Figure 13 respectively. However, exceptional cases are the plastic viscosity values with sharp differentials at 0.8g and 1.0g with numerical error percentage value of 78.57% and 18.18% respectively. The PV results obtained satisfy the API standard numerical range value specification for drilling grade bentonite [24]. From Table 4 also, the viscometer reading at 300rpm (21 to 51cp) and 600rpm (34 to 76cp) range compares with that of the control result and meets the API minimum numerical value standard specifications according to Akinade and Ogolo et al., which states that a minimum viscosity requirement for any clay that will be used for drilling operations, must be able to yield a viscosity 23cp at 300rpm and 30cp at 600rpm [17, 25]. Though, 0.2g concentration for the 300rpm is slightly below the minimum API specification. The obtained result for the 10seconds (8 to 10 ib/100ft^2) and 10minutes (8 to 12 ib/100ft^2) gel strength approximates to that of the control result for the 0.2g to 1.0g additive concentration and this is clearly shown on Table 4 and Figures 14 and 15 respectively. This obtained results for the 10 seconds and 10 minutes gel strength are a confirmation to studies by Udeagbara et al., Queendarlyn and Joshua [22, 24].

Table 4. *Mud weight, pH and rheology of mud formulated with egg shell.*

Quantity (g)	Density (ppg)	pH	Rheological Properties				
			Viscosity		Plastic Viscosity (cp)	Gel Strength	
			300 RPM	600 RPM	(600- 300) RPM	10 secs	10 mins
0.2	8.80	9.5	21	34	13	9	8
0.4	8.85	9.0	28	44	16	8	9
0.6	8.70	9.5	35	52	17	10	12
0.8	8.75	9.5	51	76	25	9	10
1.0	8.80	9.5	42	68	26	10	11

3.4. Mud Weight, pH and Rheology of Mud Formulated with Snail Shell

The results from Table 5 and Figure11 show that mud density value from Table 5 ranges from (8.85 -8.90ppg) and this moderately compares to the control result as indicated on Figure 11. The obtained mud density result for the snail shell additives for the 0.2g to 1.0g concentration satisfy the required API numerical value (8.65 – 9.60ppg) standard specification and are a confirmation to studies by [8, 17-19, 21, 25]. The pH result from Table 5 show that the pH value is relatively constant (9.0) for the 0.2g to 0.8g snail shell concentration except for the 1.0g with a pH value of 9.5. The obtained pH result generally did not compare to the control result and also fell short of the API numerical value (9.5 – 12.5) specification according to [8, 17-19, 21], except for the 1.0g concentration that just satisfy the API minimum required standard specification of pH value of 9.5. Figure 12 presents the comparisons of the pH obtained result with that of the control. The result on the rheological properties for the snail shell formulated mud for the 0.2g to 1.0g concentration are shown on Table 5 while Figure 13 to Figure 15 presents the comparisons for the control and the proposed additives used and its effect on PV, 10seconds and 10minutes gel strength respectively. From Table 5, a sharp increase on viscosity values at 300rpm and 600rpm respectively for the 0.4g to 1.0g additives concentration was observed. This increase in viscosity value was more on the snail shell when compared to that of the control result and that of the eggshell. This shows that the local snail shell increased the viscosity of the mud. The obtained result shows that it just the 0.4g to 1.0g and 0.2g to 1.0g additives concentration that satisfy the viscosity values at 300rpm and 600rpm according to Okologume and Akinade, and that the 23cp minimum requirement for viscosity at 300rpm was slightly below for the 0.2g concentration [19].

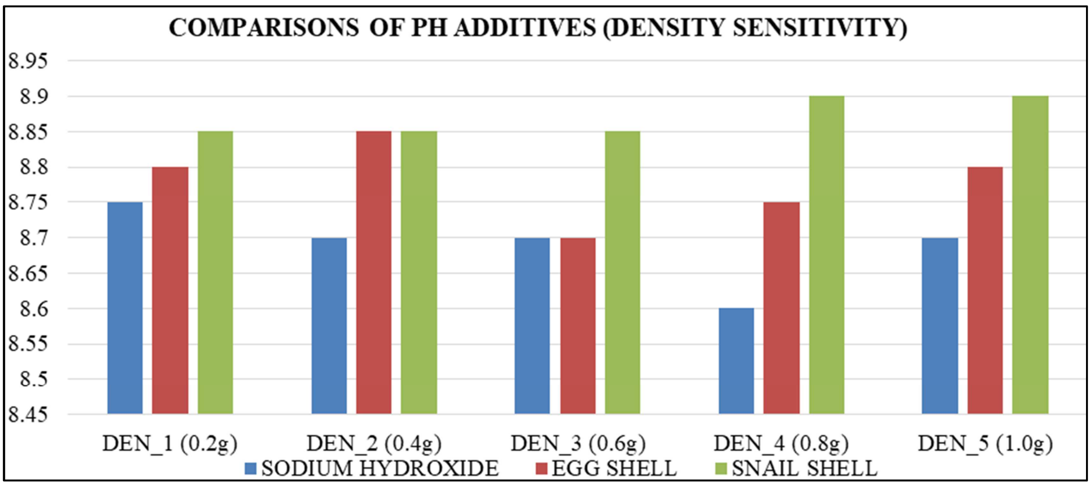

Figure 11. *Comparison of the control and proposed additives used and its effect on mud density.*

The obtained result for the plastic viscosity (10 – 21cp) as presented on Table 5 are not in good agreement with the API numerical value specification of 8cp minimum and 10cp maximum according to studies [8, 17, 18, 21]. Though obtained results compares to the API standard range of numerical values specification for drilling grade bentonite according to A. N. Queendarlyn and O. I. Joshua [24].

The results from Table 5, Figures 14 and 15 shows the gel strength for the 10seconds, 10minutes and the comparisons of the control and proposed additives used and its effect on 10seconds and 10minutes gel strength respectively. From Table 5, the 10 seconds and 10 minutes gel strength values ranges from (13 to 16 ib/100ft^2) as against the (7 to 10 ib/100ft^2) values obtained for the control result.

Table 5. *Mud weight, pH and rheology of mud formulated with snail shell.*

Quantity (g)	Density (ppg)	pH	Rheological Properties				
			Viscosity		Plastic Viscosity (cp)	Gel Strength	
			300 RPM	600 RPM	(600- 300) RPM	10 secs	10 mins
0.2	8.85	9.0	21	32	11	13	13
0.4	8.85	9.0	35	54	19	13	14
0.6	8.85	9.0	45	66	21	14	15
0.8	8.90	9.0	54	68	14	15	16
1.0	8.90	9.5	78	88	10	16	16

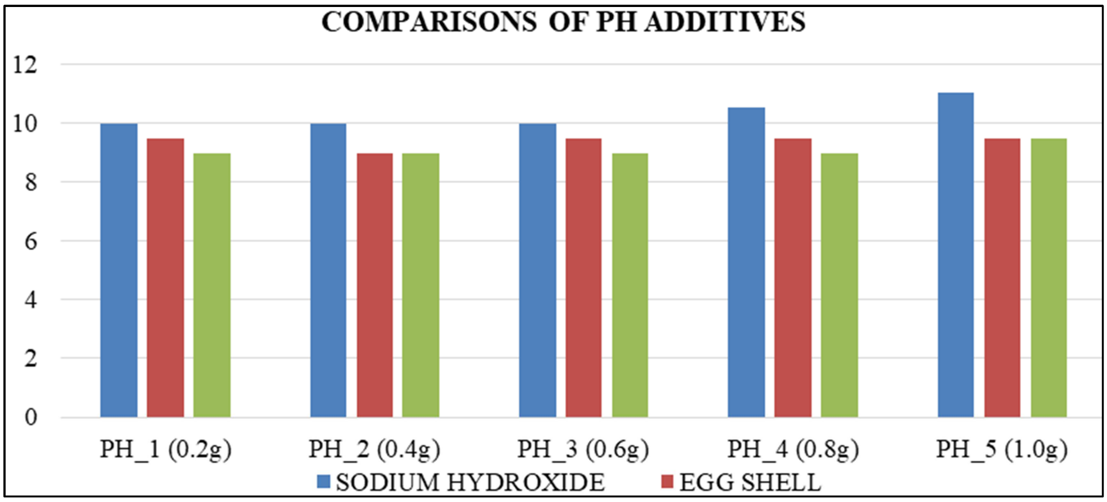

Figure 12. *Comparison of the control and proposed additives used and its effect on P^H.*

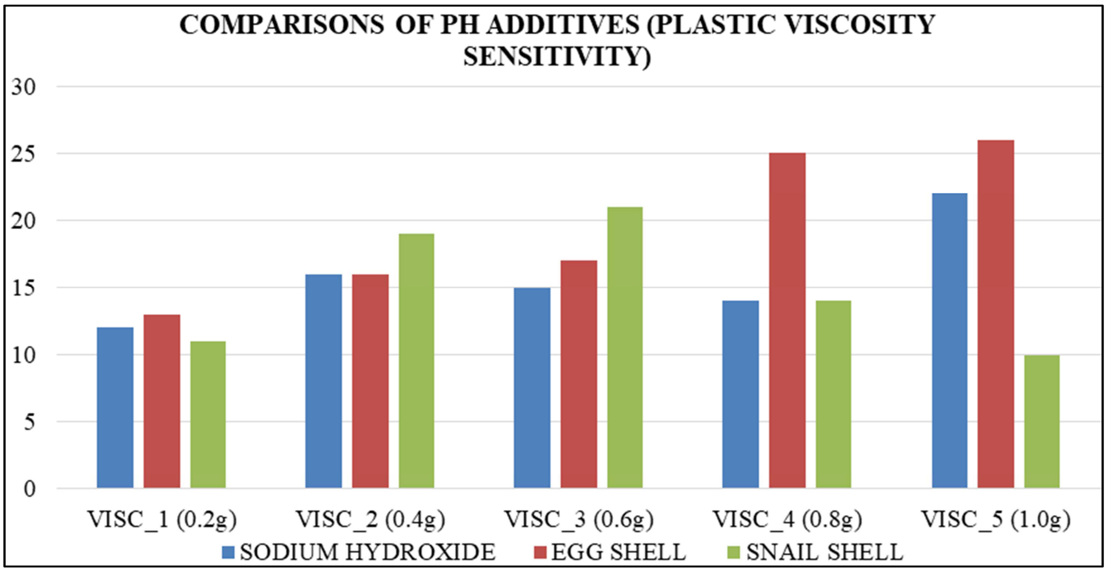

Figure 13. *Comparison of the control and proposed additives used and its effect on plastic viscosity.*

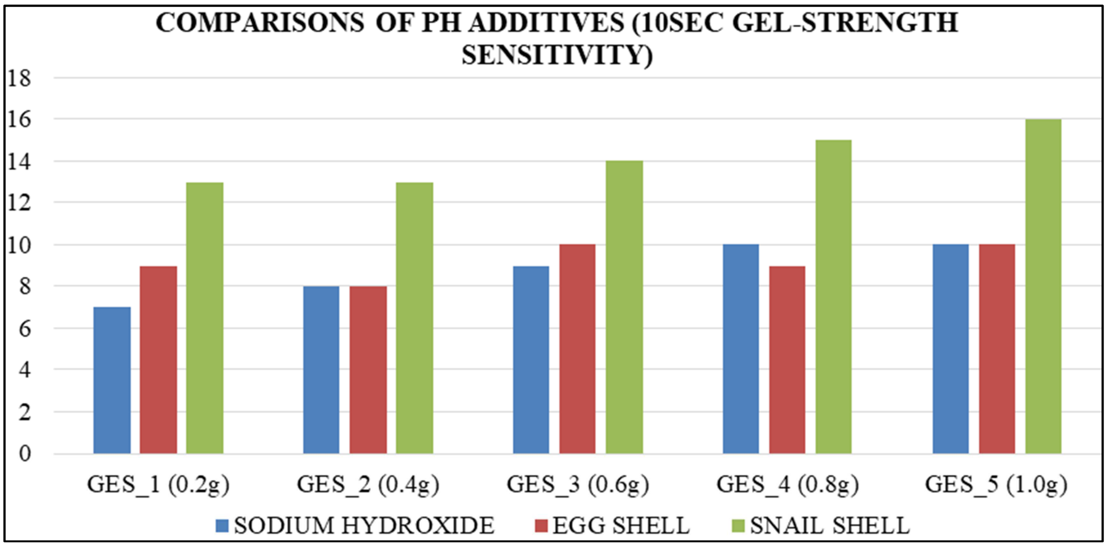

Figure 14. *Comparison of the control and proposed additives used and its effect on 10seconds gel strength.*

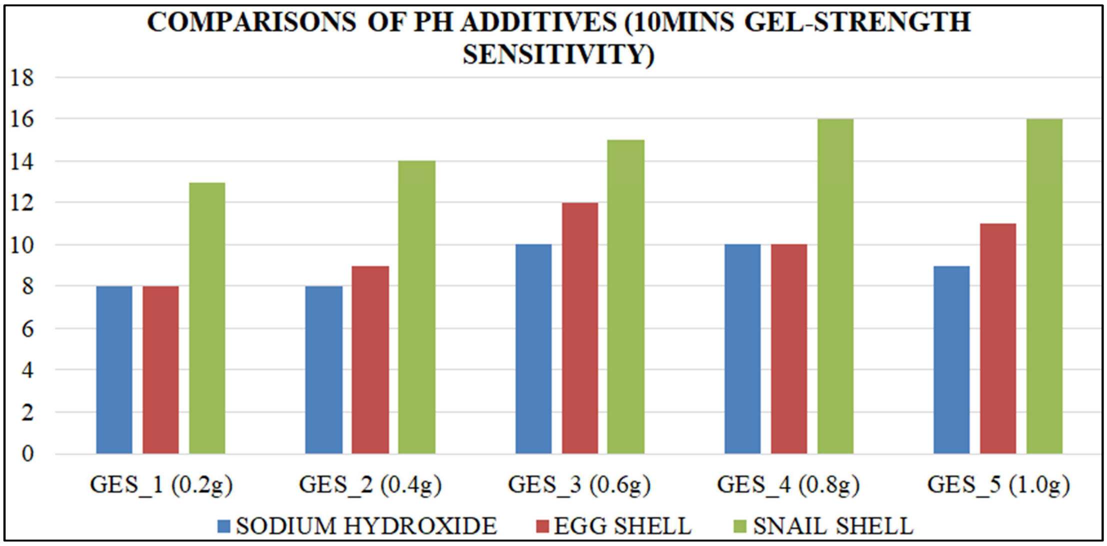

Figure 15. *Comparison of the control and proposed additives used and its effect on 10minutes gel strength.*

4. Conclusion and Recommendation

4.1. Conclusion

The results obtained under experimental study on the suitability of local eggshell and snail shell as additives for drilling mud pH control shows that beneficiation of drilling mud samples with eggshell and snail shell influences the density, pH and rheological properties of the formulated mud. The result for the caustic soda (control experiment) for mud density (8.60 - 8.75ppg) and pH (10 – 11) for all the given additives concentration fell within the API minimum numerical value specification for drilling mud. Its rheological properties were equally close to API minimum standard specification, though the plastic viscosity value (12 – 33cp) is somehow outside the API standard specification. The result obtained shows that the mud density for the eggshell and snail shell closely and moderately compares to that of the control and are in close agreement to that of the API requirement (8.65 – 9.60ppg) standard minimum specification for drilling mud. The results for the pH value for the eggshell closely compares to that of the control and are in close agreement to that of the API required minimum standard specification. While that of the snail shell did not compare to that of the control and also fail to meet the API required minimum standard specification except for the 1.0g additive concentration with a pH value of 9.5.

From the results obtained in this study, it is concluded that with respect to API required value standard specification of mud pH (9.5 -12.5) and control of pH value of (10 -11), that the eggshell is the most promising and have shown it suitability as pH control additive compared to the snail shell. Also, the concentration of mud additives is vital to control the rheological properties of drilling mud. Significant changes in the viscosity and gel strength were noted to correspond to changes in the concentration of the eggshell and snail shell used in the formulation of the water base mud.

4.2. Recommendation

Based on reviewed literatures and results obtained from this study, it is recommended that the Nigerian government should support and encourage purposeful research as it relates to eggshell and snail shell. The eggshell and snail shell used in this study is readily available in its raw form and in commercial quantities; this will make it easy for use and would also improve their export value.

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