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Evaluation of Activated Carbon from Coconut Husk as Standard pH Enhancer for Drilling Mud Formulation

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ABSTRACT
In Nigeria oil and gas industry drilling operations, most of the chemicals used as pH controller are usually imported at an exorbitant price - which take a large part of the drilling/well cost and have ripple effect on the economy of the drilling companies. This study nonetheless focuses on investigating the suitability of locally sourced materials as pH enhancer in a drilling mud program. A high pH is desirable to suppress corrosion rate, hydrogen embrittlement and the solubility of Ca^{2+} and Mg^{2+} which makes up clay. In addition, the organic viscosity control additives benefit from the high pH.). In order to minimize drilling cost and maximize profit, locally made additives is being investigated to supplement the imported additives. Activated carbon from coconut husk is being envisaged for use as a pH enhancer because it is environmentally friendly in that it is degradable and has no adverse effect on the formation properties. Nevertheless, the result from the experiment conducted in this study revealed that the local additives imparted significant pH unit of 13.0 in the drilling mud when compared to the foreign addictive such as sodium hydroxide which gave 13.5. Also, from the cost/benefit analysis, the cost of formulating laboratory barrel of drilling mud using the foreign pH additive was $ 7.15, while the cost of same volume using local additive (coconut husk) was $ 6.175, the use of local additives would save a minimum of $ 0.975.
Keywords: pH, drilling cost, profit, coconut husk, drilling mud, local additives

INTRODUCTION

A drilling fluid or mud is a fluid used during drilling operations, which is circulated or pumped from the surface, down the drill string, through the bit, and back to the surface via the annulus. The term drilling fluid or mud generally applies to fluids that are used in removal of drill cuttings (rock fragments from underground geological formations from holes drilled in the earth) and maintenance of well control [11]. They provide primary well control of subsurface pressures by a combination of density and any additional pressure acting on the fluid column (annular or surface imposed). Drilling fluids are commonly known for their gel or thixotropic characteristics, in which they can go through a reversible transformation from high to low viscosity status when being subjected to shear stress force [5]. These transformations ruin the microstructure of the bit will be gradually recovered when the fluid is in resting condition [1]. Bourgoyne, et al., [3] reported that the successful and cost of a drilling process depend massively on the asset of the drilling fluid used. Azar J. and Samuel R. [1] in their work also stated that the fluid characteristics such as density and temperature are variables that need to be regularly monitored for perfect drilling conditions of the well. If these conditions are not well monitored, it can lead to numerous well problems that can be catastrophic to the production process and even loss of lives as reported by Ranney, M. [13]. A good drilling fluid must have low acid content with respect to its pH level as confirmed by Azar, J. J., et al., [2], Brondel, D., et al., [4] and Maglione, R., et al. [6]. The pH of drilling mud is a representation of the degree of acidity or alkalinity of mud as indicated by the hydrogen ion concentration [12].

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Drilling companies operating on the shores of the Niger Delta import bulk drilling fluid materials to carry out their respective operations [8]. The continual importation of these materials has been a major concern to the industry players since some of these drilling fluid materials after use results to a total waste [9]. The foreign exchange accrued from drilling fluid materials importation with the corresponding high cost of drilling fluid materials also constitute a concern for the petroleum industry [10]. With the consistent campaign for the use of "local content" in the oil industry by the Nigeria government, and the expensive nature of foreign additives, research studies are being conducted for the discovery of new and suitable "local drilling mud additive". This continual search is geared towards eradicating the concerns raised from the importation of foreign drilling mud additives. Thus, it is imperative to source for local alternative drilling fluid additives that can be used as a substitute to the imported additives in the formulation of drilling mud/fluid that can be used in drilling process. The purpose of this study is to investigate the effect of activated carbon from coconut husk as a pH enhancing additive in drilling mud/fluid formulation.

MATERIALS AND METHODS

For the purpose of this work, the materials required in this research are; coconut husk (husk), bentonite clay, caustic soda (NaOH) as reagent and distilled water. The coconut husk was sourced locally.

Equipment and Apparatus Used

Mud mixer, 500 ml measuring cylinder, beaker, spatula, weighing balance, set of bowls etc.

Preparation of the Mud Sample

1. The clay samples - high concentration (24.5g of clay) mud, medium concentration (21.0g of clay) mud and low concentration (17g of clay) mud were prepared accordingly with the addition of 350ml of water.
2. The mixture of the clay and water was stirred with the aid of multi-beach mixer for 2-5 minutes to obtain homogeneous mixture, the expected 1 spud mud.

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Fig. 1: Agitation Process of Water Base mud using Mud Mixer

Preparation of Molar Concentration Solution from Coconut Husk

1. Collection of coconut husk from source (Ughelli, Delta State, Nigeria).
2. The husk was sun dried in the open field for 7 days.
3. The dried husks were burnt in a gas kiln and weighed using an electronic weighing balance as recommended by [7].
4. 10g of the coconut husk was dissolved in 100ml of distilled water and sieved with filter paper to obtain a molar solution.
5. Sample A was treated with caustic soda, Sample B treated with coconut husk while Sample C was treated with bentonite. The samples are shown Fig. 2.

Fig. 2: Molar solution Prepared for the analysis

Laboratory Test

A. Measuring pH of drilling fluids

1. To the first mud sample, 1.0 mol. molar concentration of caustic soda was added into the controlled volume of 0.5, 1.0, 1.5 up to 7.0ml. The pH was determined by dipping a pH paper strips which is removed and compared the standard color change readings and were recorded at different intervals.
2. The same procedure was repeated for the second sample except that 2mol molar concentration of caustic soda was used.
3. To the third sample, burnt coconut husk filtrate was added at a controlled volume of 0.5, 1.0, 1.5 up to 7.0ml and the pH was also measured as stated above.
4. The mud density was measured using a mud balance.

B. Determination of Rheological properties

Experiments were performed in this study to obtain the following rheological properties of the mud: viscosity, plastic viscosity, gel strength and yield point.

RESULTS AND DISCUSSIONS

pH of blank mud = 9.5
pH of Burnt coconut husk (BCF) filtrate = 13.0
Mud Temperature = 27°C

Table 1: Results of the pH of Molar Concentration of Burnt Coconut Husk in water.

VOLUME (ml)	**2.0 mol. molar concentration of NaOH (caustic soda) in 350 ml of water**	**pH of Molar Concentration of Burnt Coconut Husk (BCF) + 350ml of water.**
0.5	7.5	7.3
1.0	8.0	7.5
1.5	8.5	8.0
2.0	9.0	8.0
2.5	9.0	8.0
3.0	9.5	8.5
3.5	10.0	9.0
4.0	10.5	9.5
4.5	11.0	10.0
5.0	11.5	11.0
5.5	12.0	11.5
6.0	12.8	12.0
6.5	13.5	12.0
7.0	13.5	12.2

Table 2: Results of the pH of Molar Concentration of NaOH + Drilling Mud and Molar Solution of Burnt Coconut Husk in Drilling Mud

VOLUME (ml)	2.0 mol molar concentration of NaOH (caustic soda) + Drilling Mud, SAMPLE A	pH of Molar Concentration of Burnt Coconut Husk (BCF) filtrate + Drilling Mud, SAMPLE B
0.5	11	10.0
1.0	11	10.3
1.5	12	10.5
2.0	12	10.5
2.5	12.5	11.0
3.0	12.5	11.0
3.5	12.5	11.5
4.0	13.0	12.0
4.5	13.5	12.5
5.0	13.5	12.5
5.5	13.5	13.0
6.0	13.8	13.0
6.5	13.8	13.2
7.0	13.8	13.5

Table 3: Result of Final Rheological Properties of drilling mud samples

Type of Mud	Viscosity Reading		Gel Strength		Rheological Properties			Mud Weight (ppg)
	600rpm	300rpm	10esc	10mins.	Plastic Viscosity	Apparent Viscosity	Yield Point	
Sample A	40	30	25	33	10	20	20	8.65
Sample B	41	30	18	25	11	21.5	19	8.67

Table 4: Readings of the Rheological properties of Mud containing Burnt Coconut Husk

Volume (ml)	Viscosity Readings		Rheological Properties		
	300 rpm	600 rpm	Plastic Viscosity	Apparent Viscosity	Yield Point
0.5	31	41	10	20.5	21
1.0	31	41	10	20.5	21
1.5	31	41	10	20.5	21
2.0	31	41	10	20.5	21
2.5	30	41	11	20.5	19
3.0	30	40	10	20	20
3.5	30	40	10	20	20
4.0	30	40	10	20	20
4.5	29	39	9	19.5	21
5.0	29	39	10	19.5	19
5.5	29	39	10	19.5	19
6.0	29	38	9	19	20
6.5	28	38	10	19	18
7.0	28	38	10	18	18

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Table 5: Results of the mud parameters obtained at the experiment.

Mud parameters	Mud Compositions	
	SAMPLE A	SAMPLE B
Mud Weight(ppg)	8.7 = 1.040g/cm3	9.2 = 1.1g/cm3
Marsh Viscosity(seconds)	37	37
Plastic Viscosity (cp)	6	7
Apparent Viscosity	11	13.5
Yield Point (Ib/100ft2)	10	13
Gel Strength (Ib/100ft2)	10s =8 10min=18	10sec=17 10min=32
Gel Strength, Shearometer (Ib/100ft2)	10sec=4.7 10min=5.7	10sec=8.2 10min=5.3
pH	8.5	8.5

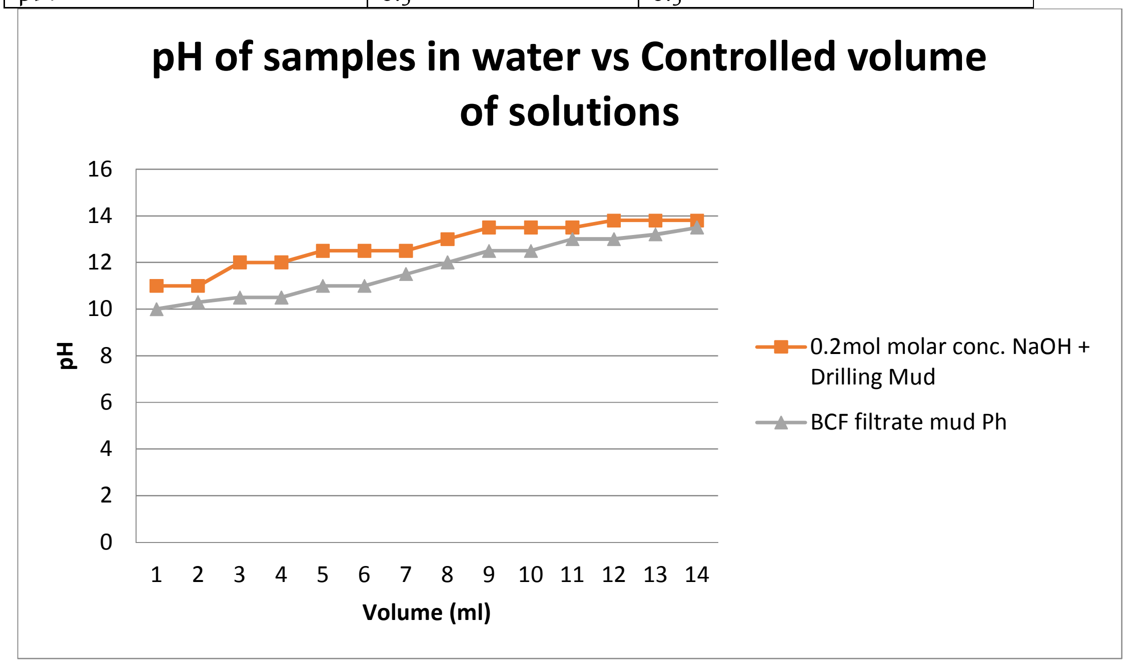

Fig. 3: A chart showing the pH of burnt coconut husk filtrates in water

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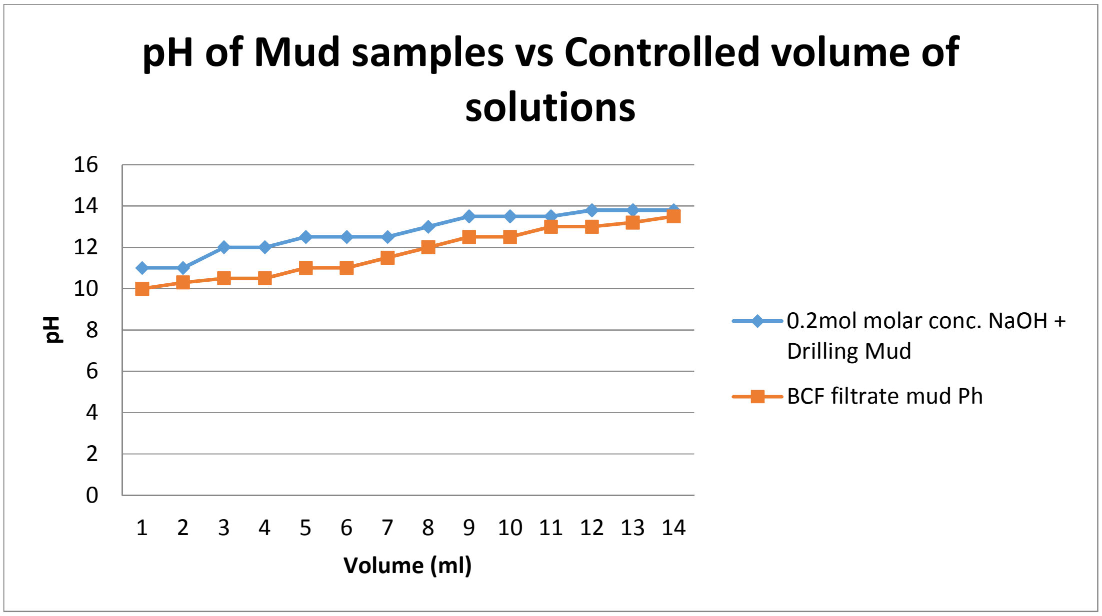

Fig. 4: A chart showing the comparison of pH of Sodium hydroxide (NaOH) with Burnt Coconut Husk filtrates in drilling mud.

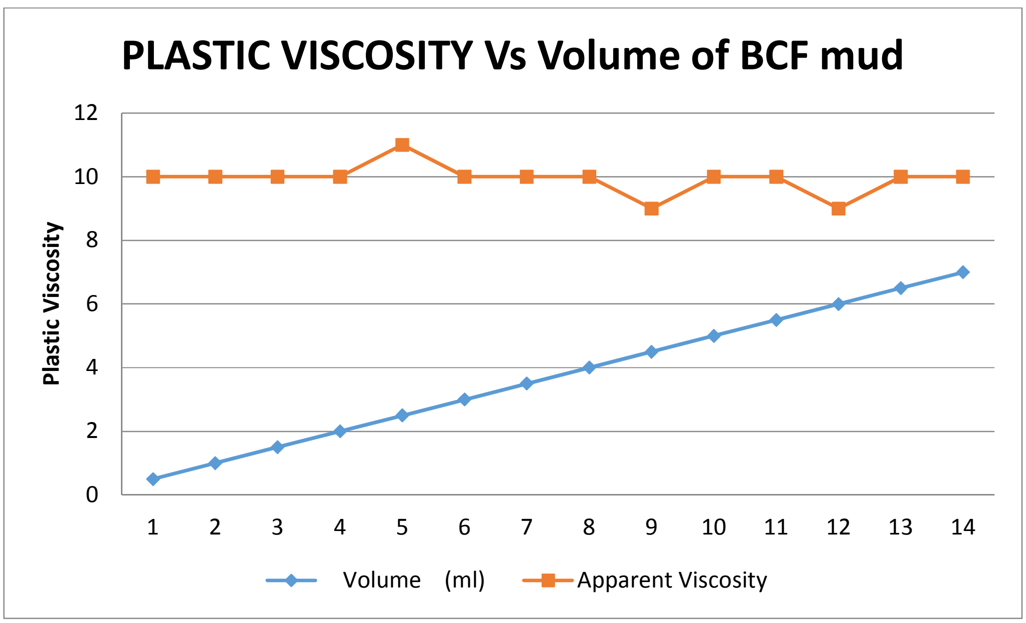

Fig. 5: A chart showing comparison between plastic viscosities of Burnt Coconut Husk Mud

Cost/Benefit Justification

This section gives a comparative analysis of the tested local additives and foreign additives to justify its economic prospects since the pH impartation is appreciable.

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A. For Local Additives (Coconut Husk)

During the experiment, coconut husk was extracted from three coconut fruit which cost two hundred Naira (₦ 200.00). The coconut extract yielded 10grams of caustic soda (NaOH) from which 1.5grams gave the desired pH unit for one laboratory barrel of drilling mud.

1 gram = 0.0022

Thus, 1.5 gram = 1.5 x 0.0022 lb

= 0.0033 lb

If 10 grams cost ₦ 200.00 then 1.5 grams will cost N 15

₦ 15 = $ 0.075

B. Drilling Mud Economics

The economic analysis performed for Fresh Water Dispersed Drilling Fluid and Fresh Water Dispersed Drilling Fluid using Burnt Coconut husk are presented in Table 4.5 and Table 4.6 respectively.

Table 5: Fresh Water Dispersed Drilling Fluid

Component	Volume pounds (lbs)	Cost Unit ($)	Cost Components ($)
Bentonite	25.0	0.07	1.75
Chrome Lignosulfonate	6.0	0.50	3.00
Lignite	4.0	0.30	1.20
Caustic Soda (NaOH)	4.0	0.40	1.60
Water	1.0 bbl	-	-
Total cost (1 bbl)			**7.15**

Table 6: Fresh Water Dispersed Drilling Fluid using Burnt Coconut husk

Component	Volume pounds (lbs)	Cost Unit ($)	Cost Components ($)
Bentonite	25.0	0.07	1.75
Chrome Lignosulfonate	6.0	0.50	3.00
Lignite	4.0	0.30	1.20
Local Additives	3.0	0.075	0.225
Water	1.0 bbl	-	-
Total cost (1 bbl)			**6.175**

DISCUSSION

From Fig. 1, it was observed that the pH of water which was 7.0 was increased with the addition of 2.0 molar concentration of NaOH to 13.5. Moreover, further addition of the solution did not have any effect on the pH. Also, Fig. 2, showed that the local material (i.e. the burnt coconut husk) increased the pH of the drilling mud from 9.5 to 13.0. However, when foreign standard sodium hydroxide was used as mud pH modifier, the mud pH increased from 9.5 to 13.8. Nevertheless, it was also established from Table 4.0 and Table 4.1 that the mud pH increased significantly from 11.0 to 13.5 on addition of varying volume of 0.2mol of NaOH as compared with the pH of the mud which increased significantly from 10.0 to 12.5 in the case of the burnt coconut husk. Nonetheless, from the Table 2 and Fig. 4, it was established that there was no significant change in plastic viscosity of the drilling mud samples containing burnt coconut husk solution. Also, from the economic analysis, the cost of formulating laboratory barrel of drilling mud using the foreign pH additive was $ 7.15, while the cost of same volume using local additive (coconut husk) was $ 6.175, the use of local additives would save a minimum of $ 0.975.

CONCLUSION

From the result analysis, it was established that the local additives (coconut husk) had great effect on the mud pH significantly. The burnt coconut husk imparted a pH of 13.0. This pH value is comparable to the standard imported foreign pH additives like Sodium Hydroxide (NaOH) that imparted 13.8. It can be concluded that the foreign additives such as Sodium Hydroxide (NaOH) imparted 0.8 pH unit more than the local burnt coconut husk. From the economic justification, the use of these local additives would save a minimum of $ 0.975 per barrel of drilling mud formulated.

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