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Research Paper

Improved Filtration Loss Control of Wate-Based Mud Using Coconut Shell Nanopowder

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ABSTRACT
This work investigates the effectiveness of coconut shell nanoparticles as a filtrate control material for water-based mud for a successful drilling operation. The research employs a practical investigative methodology. The fluid loss control agent (coconut shell nanopowder) was formulated in the laboratory alongside water-based mud designed with the desired amount of filtrate control material (coconut shell). In formulating the loss circulation agent, the coconut shell was cleaned, dried, pyrolyze, and blended into powder form, then sizing distribution of the blended coconut shell was conducted. The problem of filtrate loss to permeable zones causing mud cake, drop in mud weight, and retarding the rotary movement of the drilling bit is a major challenge in drilling operations. If drilling fluid is not properly designed with the necessary additives included to mitigate this problem, might lead to a blowout, especially in unfavorable reservoir conditions such as high-pressure high-temperatureconditions, and high salt formations. In this work, the fluid loss of water-based mud was controlled using coconut shell powdered activated carbon nanoparticles. The coconut shell nanoparticle's water-based mud rheological properties and permeability plugging ability were examined in different grams (0g, 10g, 20g, 30g, and 40g). For accuracy the equipment used was all calibrated and the rheological properties of water-based mud were determined for 0g at room temperature (25^{o}c), the fluid loss was determined at time intervals (10min, 20min, 30min, & 40min) with corresponding fluid loss volume results. This procedure was repeated for samples 10g, 20g, 30g, and 40g. The result shows that the fluid loss decreased with the increase in Coconut shell nanopowder and plastic viscosity, yield point, apparent viscosity, and gel strength increases with the increase in coconut shell powder. At grams of 0g and 40g, the fluid loss was 320ml and 162ml respectively, plastic viscosity was 31cp and 109cp, the yield point was 79cp and 102cp, apparent viscosity was 70.5cp and 160cp, and gel strength was 8bl/100ft^{2}and 18bl/100ft^{2}respectively. Finally, the measured weight of filter paper increases as coconut shell nanopowder increases. At 0g and 40g of coconut shellthe weight increases from 0.43g to 0.71g respectively with the scanning electron microscopic or morphology image showing the formation of a thin filter cake and the high plugging ability of the designed filtrate control material. The pH of the mud remained constant as there were no significant changes, as thenanoparticle increases from 0g to 40g, the corresponding pH values were 7 and 7 respectively. Generally, water-based mud is preferable with the required additives to maintain the rheological properties of the mud and should always be used.
KEYWORDS: Nanoparticles, Rheological properties, Drilling fluid, Fluid loss.

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I. INTRODUCTION

The important of the drilling fluid in the petroleum industry cannot be overemphasized, and for a successful drilling operation, drilling fluid should be frequently examined to avoid some drilling disasters such as a wellkick. For drilling hazards to be avoided, drilling mud must have the desired properties suitable for any formation drilled. If the required properties are not met, nanoparticles or agents are added to the formulated mud to improve the properties.

There are two commonly used types of drilling mud; water-based mud (water is the continuous phase) and oil-based mud (oil is the continuous phase). Oil-based mud is very expensive compared to water-based mud and since the sole aim of every investment is to maximize profit, water-based mud is preferable in as much as the expected properties are attained and mud roles are not defeated. The potential of the drilling fluid to successfully perform its function is a function of the mud properties and formation encountered which varies in temperature and pressure. Since temperature and pressure increase with depth, it is very necessary to check and modify the mud properties as drilling continues and as new zones are encountered. One cannot generalize the behavior and effect of all nanoparticles on mud rheological properties due to differences in the chemical composition of the compound.Therefore, this work uses powdered coconut shellnanoparticles to improve filtration control and the effectiveness of water-based mud rheological properties.One of the primary purposes of a drilling fluid is to control fluid loss through the construction of a thin, low-permeability filter cake. The most often used viscosifier and fluid loss agent in WBDFs is Wyoming bentonite. However, problems were found in controlling the fluid's propensity to gel when bentonite was added in large amounts, leading to filtrate loss.

There are viable chemical additives used in drilling mud that have shown the desired features. However, these additives are non-biodegradable and environmentally hazardous. Therefore, there is a need to seek to identify alternate additives that are environmentally friendly, biodegradable, and sustainable, while also maintaining the properties of efficient drilling fluids such as activated carbon. Fluid loss and loss circulation are the major problems encountered while using poorly designed drilling mud in a porous formation.

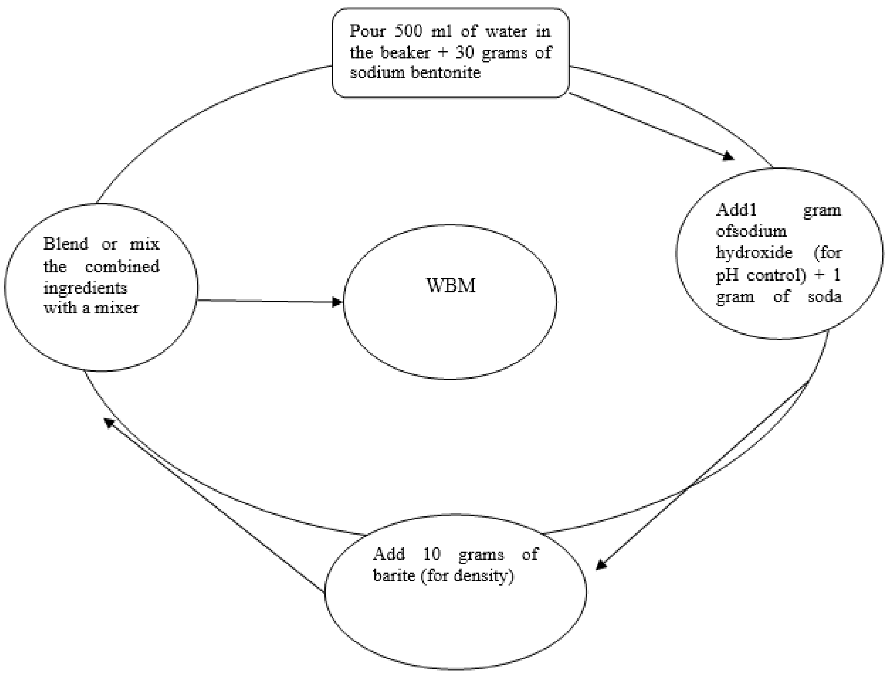
Ololade, et al., [1] in their work, concluded that an increase the in size of the nanoparticle (coconut fibre) decreases the volume of fluid loss into the formations. That is, the particle size was a major consideration in their work as it helps to plug off the fractured zones. Ololade, et al., [1] failed to consider the effect of coconut shell and the effect of its powdered form on filtrate and other water-based mud rheological properties.

The work done by Abdul et al., [2], on water-based mud using Nanoparticles (titanium oxides, aluminum oxide, and copper oxide) to study rheology from room temperature up to 250, shows that the plastic viscosity, yield point, and gel strength of the Nanowater based mud increase with the increase in nanoparticle concentration. It was also observed that an increase in nanoparticle concentration gives lower mud filtration. Therefore, this work studies the effect of coconut shell nanoparticleson the filtration loss and rheological properties of the nano water-based mud at different concentrations.

II. MATERIALS AND METHOD

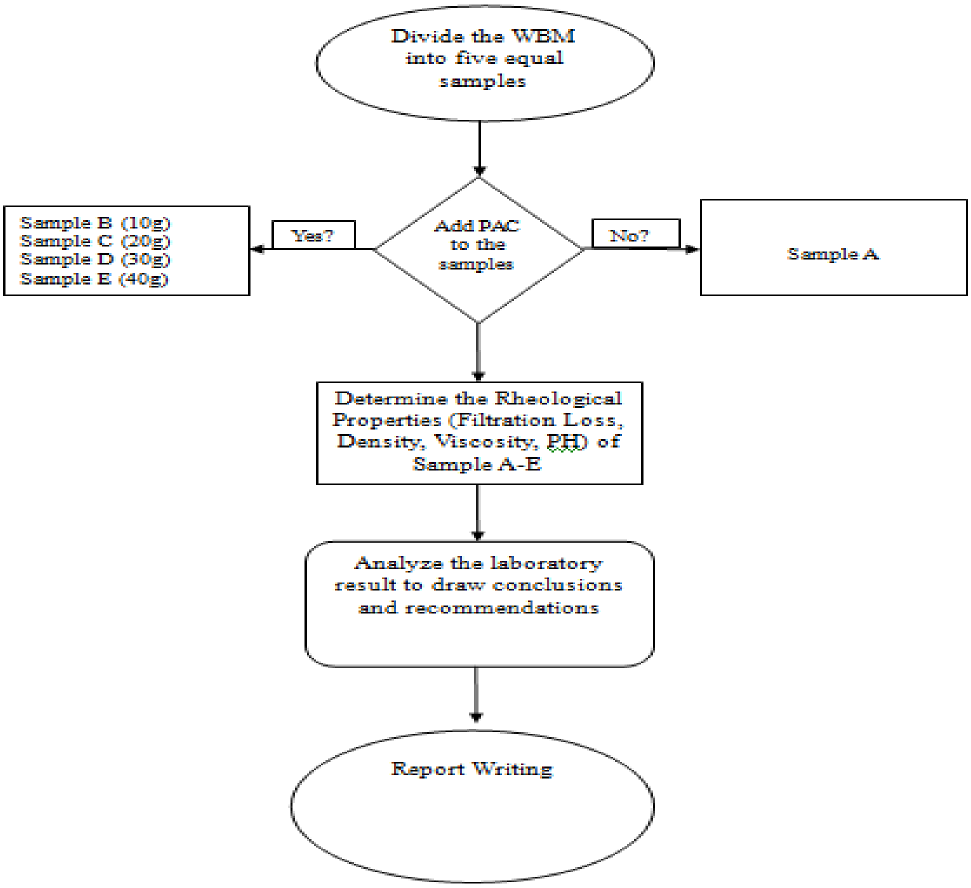
Equipment and materials used for this experiment are baroid mud balance, marsh funnel, speed rheometer, pH meter, filter press, heater, thermometer, conical flask, retort stand, tissue paper, mixer, sodium bentonite (clay), sodium hydroxide, soda ash, barite, powdered coconut shell activated carbon (charcoal).

FORMULATION OF MUD SAMPLE



NANOPARTICLE FORMULATION

EXPERIMENTAL PROCEDURES

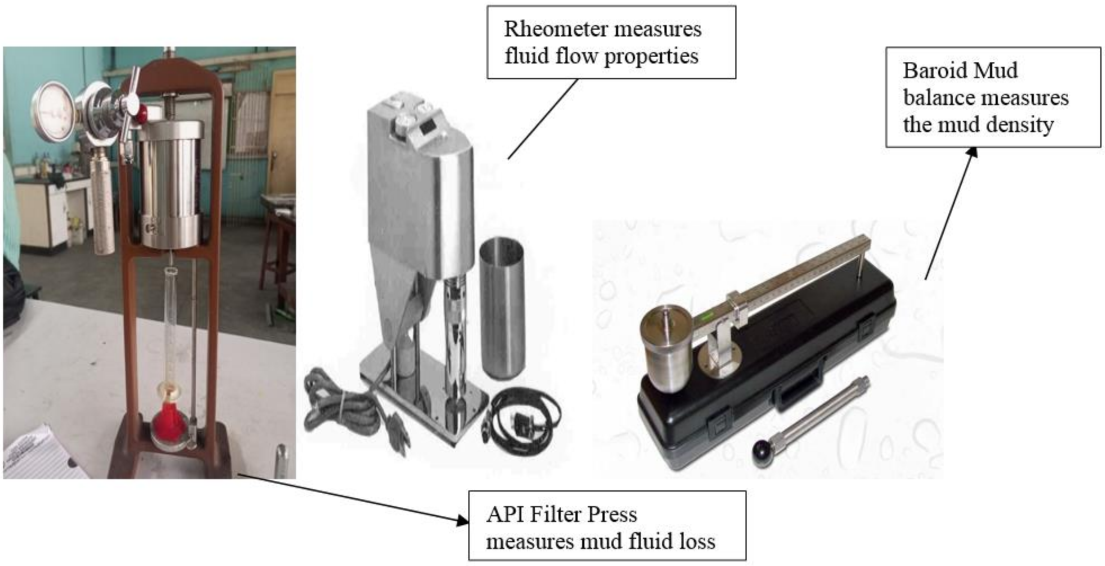


- Sample A – Formulated Mud System without Coconut Shell Nanopowder.
- Sample B - Formulated Mud System with 10 g Coconut Shell Nanopowder.
- Sample C - Formulated Mud System with 20 g Coconut Shell Nanopowder.
- Sample D - Formulated Mud System with 30 g Coconut Shell Nanopowder.
- Sample E - Formulated Mud System with 40 g Coconut Shell Nanopowder.

The filtration control mechanism of coconut shell nanopowder was probed via filter cake morphologies observation by scanning electron microscope.

Figure 1: Water-based mud sample with different grams of coconut shell nanopowder

The experimental procedures and materials used to determine each of the mud rheological properties are described below. Before each experiment is conducted, the equipment was calibrated to ensure accuracy. **Figure**1, shows samples of water-based mud slurries treated with different grams of activated coconut carbon nanoparticles.



EQUATIONS

In obtaining the laboratory data used to draw conclusions and results, the following equations were applied;

Plastic Viscosity (PV) = Reading for ϕ 600 – reading for ϕ 300 1

Yield Point (YP) = PV - θ_{300} 2

Apparent Viscosity (A.V) =$\frac{600reading}{2}$

III. FINDINGS

Table 4.1: Experimental Result for 0-40g of Powdered Coconut Nanoparticle

PAC (grams)	Density (ppg)	E.C (ms)	pH	Gel-strength (1bl/100ft^2)	Plastic viscosity (cp)	Yield point (cp)	Apparent Viscosity (cp)
0	10.7	0.17	7.0	8	31	79	70.5
10	10.9	3.2	7.0	9	24	151	99.5
20	11.1	4.2	7.0	11.9	57	108	111
30	12.7	6.3	7.0	15	99	94	146
40	14	7.4	7.0	18	109	102	160

Table 4.2: Dial result at different speeds in rpm for 0-40g of Powdered Coconut Nanoparticle

PAC (grams)	ϕ600 (rpm)	ϕ300 (rpm)	ϕ200 (rpm)	ϕ100 (rpm)	ϕ60 (rpm)	ϕ30 (rpm)	ϕ6 (rpm)
0	141	110	90	70	62	42	24
10	199	175	152	116	100	79	51
20	222	165	141	114	112	80	56
30	292	193	178	166	150	85	61
40	320	211	192	180	162	92	74

Table 4.3: Filtrate loss result at different concentrations of Powdered Coconut Nanoparticles from 0-40g

Time (Minute)	0 (gram)	10 (grams)	20 (grams)	30 (grams)	40 (grams)
0	0	0	0	0	0
10	199	175	152	116	100
20	222	165	141	114	112
30	292	193	178	166	150
40	320	211	192	180	162

Table 4.4: Weight result of Filter Paper at different concentrations of Powdered Coconut Nanoparticles from 0-40g

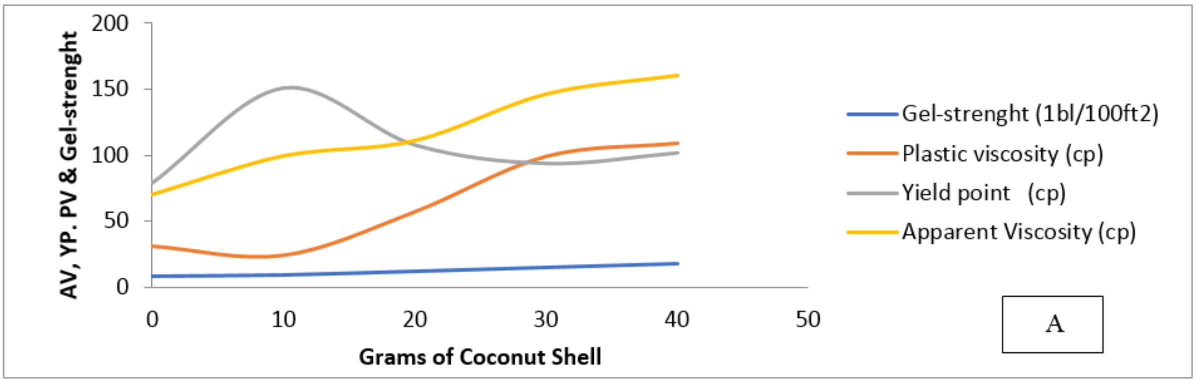
The concentration of PAC in Samples (grams)	Measured Weight of Filter Paper (grams)
0g	0.43g
10g	0.52g
20g	0.58g
30g	0.64g
40g	0.71g

Effects of Coconut Shell on Water-Based Mud Rheological Behaviour

It was observed that the addition of the powdered coconut shell-activated carbon particle to the water-based mud has a significant effect on the rheological behavior of the mud.

Apparent Viscosity, Yield Point, Plastic Viscosity and Gel-Strength

From Figure 4.1a and 4.1b, the result shows that an increase in coconut shellnanoparticles increases theapparent viscosity, plastic viscosity, and yield point of the mud while gel strength slightly increases with an increase in coconut shell nanopowder.



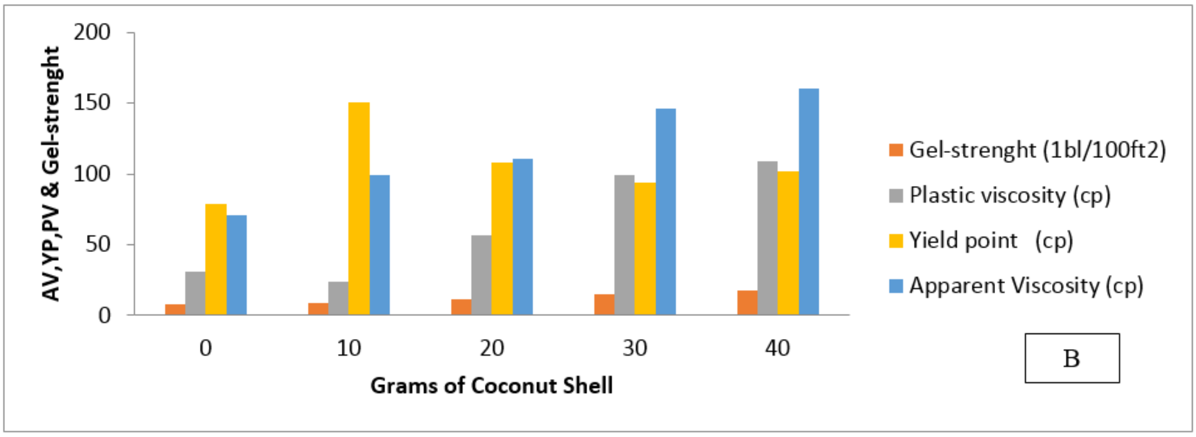
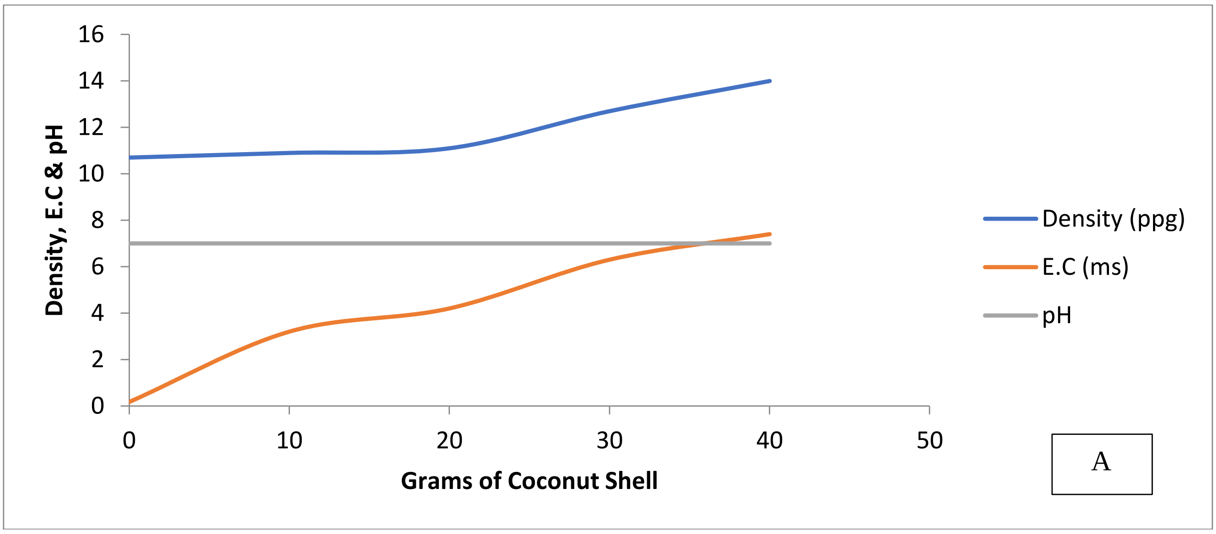


Figure 4.1a-b: Effect of Coconut Shell Nanoparticle on WBM AV, YP, PV, & Gel-strength

Density, Electrical Conductivity, and pH

Figure 4.2a – 4.2b, shows the general effect of coconut shell nanopowder on the Density, Electrical Conductivity, and pH of water-based mud. It is seen that Density and Electrical Conductivity increases with an increase in coconut shell nanoparticle while the pH remains stable as there was no effect of coconut shell nanoparticle on the pH of the water-based mud.



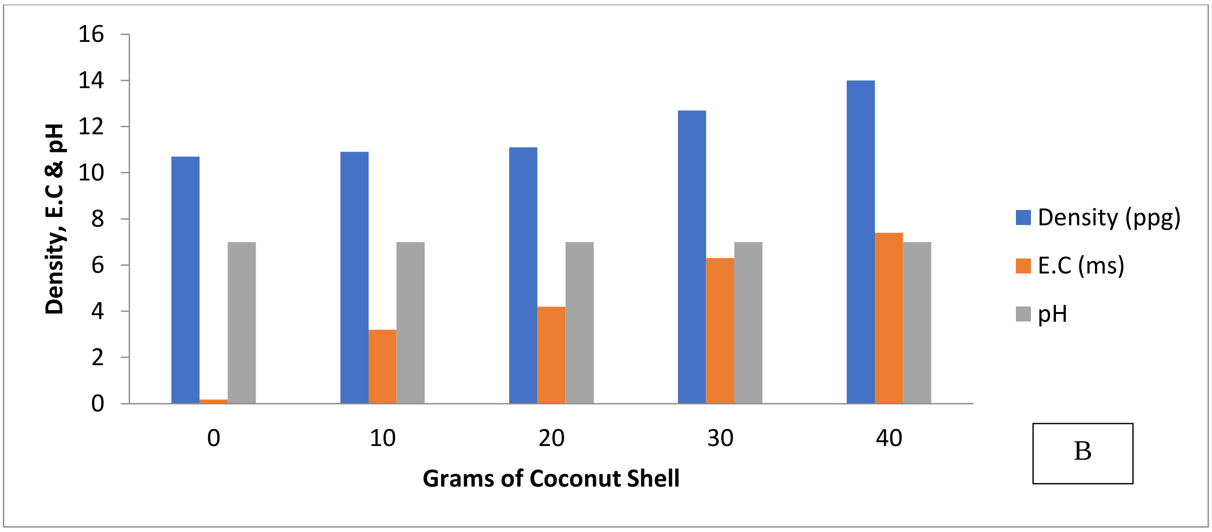
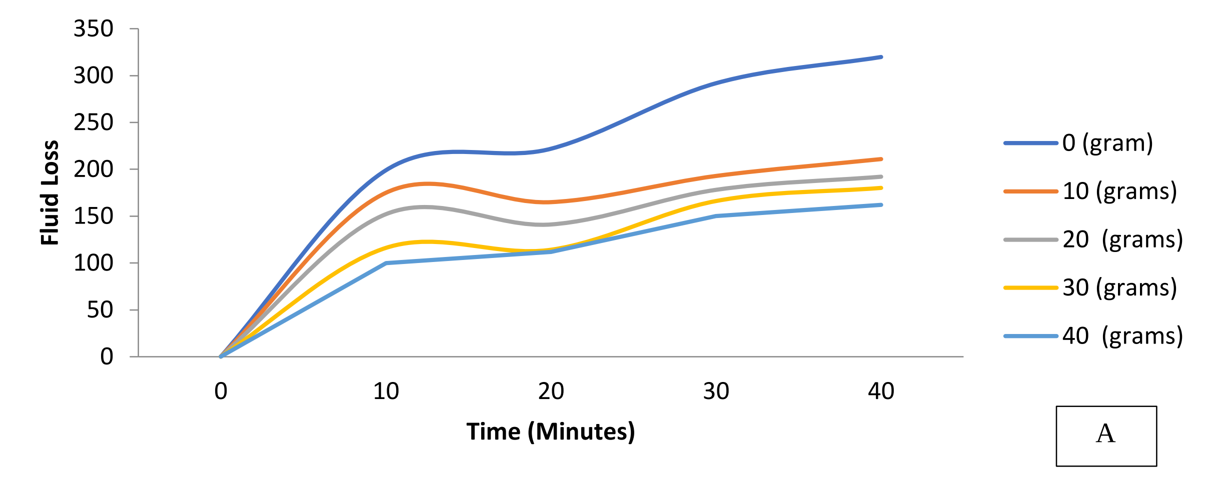


Figure 4.2a-b: Effect of Coconut shell Nanoparticle on WBM Density, E.C, & mud pH

Mud Fluid Loss

The experimental result shown in figure 4.3a – 4.3b, describes the effect of coconut shell nanopowder on water-based mud. From the figure below, it is seen that increase in coconut shell nanopowder decreases the mud fluid loss in a porous formation. From figure 4.3a – 4.3b, the fluid loss at 0 grams of coconut shell nanopowder (Sample A) is 320ml against 162ml for 40 grams of coconut shell nanopowder (Sample D) added to the water-based mud.



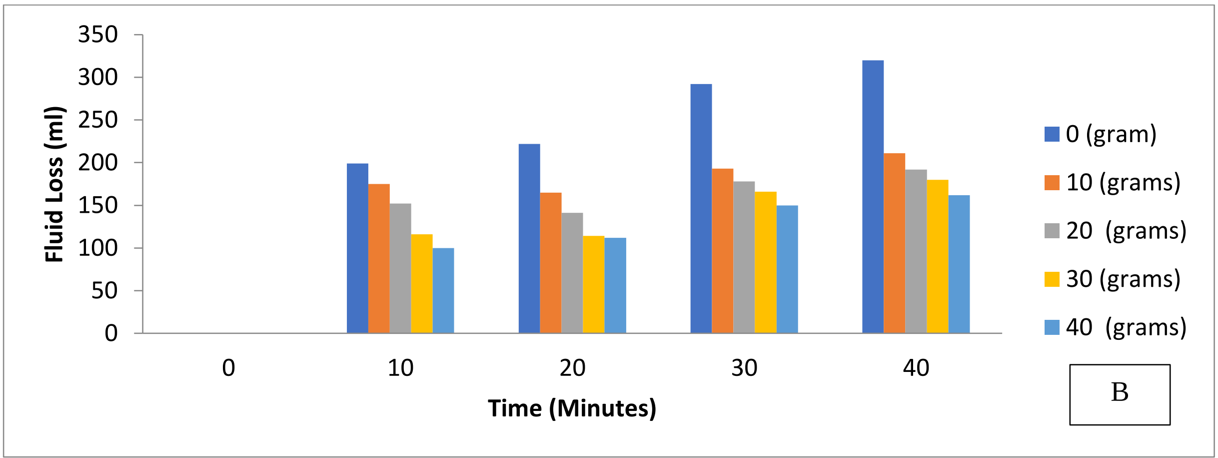


Figure 4.3a-b: Effect of Coconut shell Nanoperticle on WBM Fluid Loss

Weight of Filter Paper

After each sample filtrate test, the weight of the filter paper was measured to determine the effect of the nanoparticle on its weight at different concentrations. The experimental result shown in figure 4.4 indicates that as the concentration of the nanoparticle increases the filter paper thickness and weight increase.

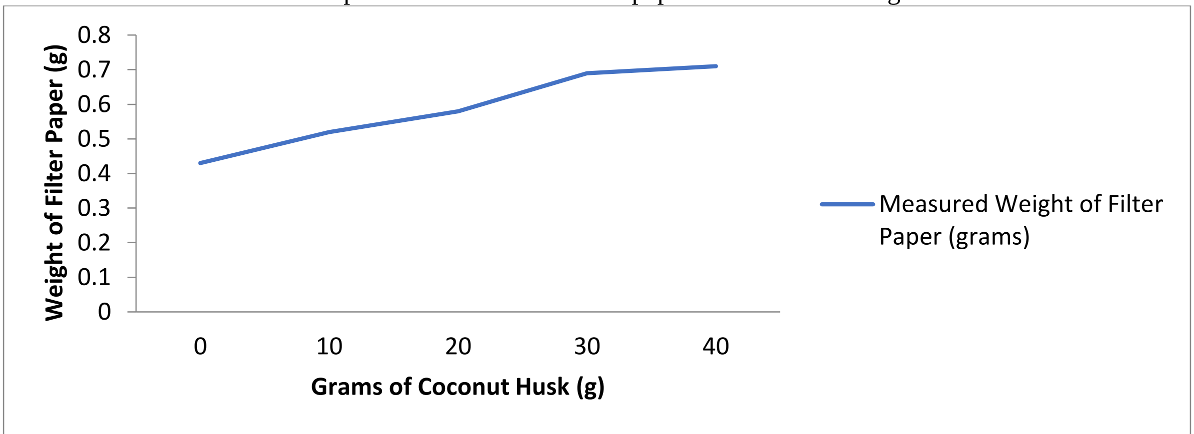


Figure 4.4: Effect of Coconut Husk on the Weight of Filter Paper

Result Analysis of Scanning Electron Microscope

SEM was used to view the morphology of the filter cake of base fluid (Sample A) and sample E as shown in Fig. 4.5a. and Fig. 4.5b,which showed an accumulation of coconut shell nanopowder in the filter cake indicating internal packing which supports the low permeability of sample E.

This type of internal packing is absent for the base fluid filter cake as shown in Fig. 4.5a. The texture of the filter cake from Fig. 4.5b is different from Fig. 4.5a which is an indication of a better dispersion of additives to give a rigid filter cake.

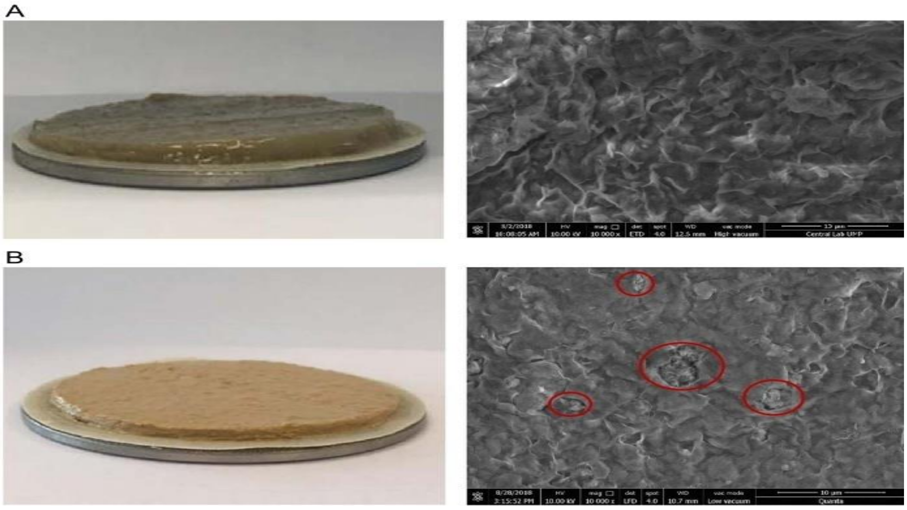


Figure 4.5: Scanning Electron Microscope (SEM) of Nano-water based mud filter cake

IV. CONCLUSIONS

- This experimental study showed the pore-blocking ability of Coconut Shell Nanopowder in filter cake under HPHT conditions.
- Coconut Shell Nanopowder occupied the micropores of the filter cake, contributing to the formation of a filter cake with sufficiently low permeability.
- Nanomaterials are good potential additives in drilling fluid to improve the thermal and physical-mechanical properties of the mud systems.

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