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COMPARATIVE PERFORMANCE ASSESSMENT OF EGG AND PERIWINKLE SHELLS IN REDUCING FLUID LOSS

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ABSTRACT

This research examines the comparative performance of eggshells and periwinkle shells as potential additives for reducing fluid loss in drilling fluids. The study focuses on assessing the effectiveness of these two natural materials in enhancing the performance of drilling muds, particularly in reducing fluid loss —a critical factor for maintaining wellbore stability and improving drilling efficiency. Both eggshells and periwinkle shells were processed into fine powders and added to the drilling fluids at different concentrations. A series of laboratory tests was conducted to measure the fluid loss control properties, including fluid loss volume, viscosity, and filtration rate, using standardized testing equipment. The results were analyzed and compared to conventional commercial fluid loss control agents like Xanthan gum (XCD). The findings show that both egg and periwinkle shells have promising fluid loss reduction capabilities, with periwinkle shells demonstrating slightly better performance in terms of lower fluid loss and greater stability across a broader range of conditions. This study highlights the potential for using these sustainable, cost-effective materials in developing environmentally friendly drilling fluids, providing an alternative to traditional synthetic and petroleum-based additives in the oil and gas industry.

Keywords: Egg shell, Fluid loss, Formation, Mud, Periwinkle, Rheology, Xanthan gum.

1.0 INTRODUCTION

Drilling oil and gas wells is a complex and demanding process vital to the global energy industry. Achieving efficient and cost-effective drilling operations is necessary to ensure the economic viability of these projects. Drilling fluids, also known as mud, are essential in the oil and gas industry, aiding the drilling process and maintaining wellbore stability. Water-based mud (WBM) is a common drilling fluid that consists of water as the continuous phase along with various additives to improve its performance. A key aspect of drilling operations is managing these fluids, which is crucial for maintaining wellbore stability, facilitating drilling, and transporting cuttings to the surface. Among available types, water-based mud (WBM) is popular due to its environmental friendliness and affordability. WBM systems are made by mixing water with various additives to create a stable drilling fluid. One major challenge in using WBM is controlling of lost circulation. Lost circulation, which occurs when drilling fluid seeps into the formation rock, can negatively impact drilling efficiency, wellbore stability, and overall costs. Excessive lost circulation can cause formation damage, differential sticking of the drillstring, and problems with well control (Bellis, 2008).

Lost circulation is a significant issue in drilling operations, potentially causing complications, such as borehole instability, differential sticking, and circulation loss. Loss of circulation happens when drilling fluid escapes into the permeable formations being drilled through. The rate of fluid loss is affected by several of factors, including formation pressure, the viscosity of the drilling fluid, and the permeability of the formation (Bellis, 2008).

To address this challenge, the oil and gas industry has created a variety of lost circulation additives, also called fluid loss control additives. These additives aim to reduce fluid loss by forming a thin, impermeable filter cake on the wellbore wall, preventing drilling fluid from invading the formation. However, there are different types of lost circulation additives on the market, and their effectiveness can vary based on the specific drilling conditions and formation features.

Various fluid loss circulation additives are used in water-based muds to reduce lost circulation. These additives create a barrier on the formation surface that stops drilling fluid from leaking into the formation. Different types of lost circulation additives are available, and their selection depends on the specific drilling conditions. Common fluid loss additives include Bentonite, Cellulose, Starch, and Synthetic polymers. Bentonite is a clay mineral that swells in water to form a gel, creating a barrier that prevents fluid loss. Starch, a natural polymer. Starch is a natural polymer that can be used to increase the viscosity of the drilling fluid. This helps to reduce the rate of fluid loss. Cellulose is another natural polymer that can be used to increase the viscosity of the drilling fluid and reduce the rate of fluid loss. There are a number of synthetic polymers that can be used as fluid loss additives. These polymers form a thin film on the surface of the formation that prevents the drilling fluid from leaking into the formation (Bellis, 2008).

The performance of fluid loss additives in water-based muds has been the subject of much research in recent years. A number of studies have shown that the performance of fluid loss additives is influenced by a number of factors, including the type of fluid loss additive, the concentration of the fluid loss additive, the composition of the water-based mud, and the drilling conditions. For example, one study found that the performance of starch as a fluid loss additive is influenced by the pH of the water-based mud. Another study by Agwu & Akpabio (2018) shows that the performance of cellulose as a fluid loss additive is influenced by the salinity of the water-based mud.

A comparative study of different fluid loss additives in WBM is necessary to evaluate their effectiveness and identify the most suitable additive for a given set of drilling conditions. Hence, this comparative study aims to address this knowledge gap by systematically evaluating and comparing the performance of various fluid loss additives in water-based mud under controlled laboratory conditions. The findings of this study are expected to provide valuable insights for the oil and gas industry, enabling more informed choices in fluid loss control during drilling operations, ultimately contributing to safer, more efficient, and environmentally responsible drilling practices.

2.0 ENVIRONMENTAL POLLUTION CAUSED BY AGRICULTURAL WASTE DISPOSAL

Agricultural waste, such as egg, periwinkle, and snail shells, is being generated from different farming processes in accumulative concentrations. Adequate utilization of agricultural waste reduces environmental problems caused by the irresponsible disposal of the waste. Seadi and Holm-Nielsen (2004) emphasized that the management of agricultural wastes is indispensable and a crucial strategy in global waste management. Again, Olabode *et al.* (2022) added that the management of huge amounts of waste from the food processing industry is a challenging problem. Waste of any kind in the environment when its concentration is in excess can become a critical factor for humans, animals, and vegetation. The nature, quantity, and type of agricultural waste generated vary from country to country. The world is besieged by the growing pressure of waste management. The amount of waste has been increasing along with an expanding population and rising human activities (The Washington Post 2017; World Bank 2018). The World Bank estimated that there were approximately 1.3 billion tons of municipal solid waste generated globally in 2012, and the volume is expected to reach 2.2 billion tons by 2025 (Hoornweg & Bhada-Tata, 2012).

2.1 Importance of Eggshell, Snail Shell, and Periwinkle Shell

Eggshell is a typical example of product-specific waste in the food processing industry with utilizable parts still present in the waste (Adeogun et al., 2018). The egg is widely utilized in the food manufacturing and food processing industries. Eggs as shown in Figure 1 are used in large quantities in products such as cakes, salads, food decorations, and fast food, wasting many tons of eggs every day. As well as leaving behind organic waste and incurring high costs for disposal. Global egg production will increase to about 90 million tons by 2030 (FAO, 2019; Ferraz et al., 2018; Muliwa et al., 2018). Researcher (Cree and Rutter, (2015) declared that about two and a half thousand tons of eggshell waste is generated worldwide every year. Most of the eggs are thrown away without any pre-treatment. Singh et al (2018) added by saying eggshells are considered useless, most of this waste is commonly disposed of in landfills without any transformation into useful materials. However, waste management is not a pleasurable task for many people and the odor added by egg biodegradation also causes air pollution. The Environmental Protection Agency has declared eggshell waste as the 15th largest food industry-produced pollutant (Dheeraj, 2021). If this waste is not disposed of properly in a specific place, it becomes a major source of environmental pollution. Thus, the growth of the fungus on the eggshell later poses a health risk. In recent years, great efforts have been made to convert egg waste into a valuable product. However, the management of this waste requires adequate strategies to consider increasing disposal costs, environmental concerns involving the risk of pathogen propagation, unpleasant odors, and the availability of disposal sites (Quina et al., 2017; Meng & Deng, 2016; Sarder et al., 2019). Moreover, according to European Union regulations, eggshell is considered hazardous waste (Quina et al, 2017; Ummartyotin & Manuspiya, 2018). Therefore, it is indispensable to find alternative ways to convert eggshells into valuable materials for further applications. The shell weighs about 11% of the total mass of the egg and consists of calcium carbonate (94%), magnesium carbonate (1%), calcium phosphate (1%), and organic matter (4%) (Wu et al., 2013, and Stadelman, 2000). In this view, the reuse of eggshell waste in numerous applications would produce both environmental and economic advantages.

Fig. 1: Diagram of Eggshell

Eggshell waste can affect the environment in several ways. Firstly, the dumping of eggshells in landfills or their disposal as waste contributes to environmental problems, including malodor, noise pollution, and resource wastage. Secondly, the production of chicken eggs leads to an increased amount of eggshell residue, which adds to the overall waste generated. However, eggshell waste can also be utilized in a beneficial manner.

Snail (Figure 2) shells which represent the discarded bio-shell waste of snails' remnants from restaurants, eateries, or snail sellers constitute a serious degree of environmental threat with little or no economic value. They are usually abandoned indiscriminately after consumption of the edible meat. Thus, effective utilization of snail shells can bring immense economic prosperity (Kolawole et al, 2017), thus, the decomposition of shells is impossible without any treatment. Kobatake and Kirihara (2019) stated that their thermal decomposition requires high temperatures of over 1000 °C, resulting in high-energy consumption and the frequent emission of greenhouse gases. The disposal and handling of waste shells can thus become a major operational and financial burden.

Fig. 2: Diagram of Snail-shell

Periwinkle or winkle (Figure 3) is a species of small edible sea snail, a marine gastropod mollusc that has gills and an operculum, and is classified within the family of Littorinidae, the periwinkles, as shown in Figure 3. This is a robust intertidal species with a dark and sometimes banded shell. It is native to the rocky shores of the northeastern Atlantic Ocean and was introduced to the northwestern Atlantic Ocean. The shell is broadly ovate, thick, and sharply pointed except when eroded (Chang et al., 2011). (Chang et al., 2011) stated the shell contains six to seven whorls with some fine threads and wrinkles; thus, the color is variable from grayish to gray-brown, often with dark spiral bands. Also, Adewuyi & Adegoke (2008) and Nwaobakata and Agwunwamba (2012) described Periwinkle as small greenish-blue marine snails with spiral conical shells and a round aperture. The width of the shell ranges from 10 to 12 mm at maturity, with an average length of 16–38 mm. Shell height can reach up to 30 mm, 43 mm, or 52 mm (Chang et al., 2011). They are found in the lagoons and mudflats of the Niger Delta region, between Calabar in the South and Badagry in the West of Nigeria. Aimikhe and Lekia (2021 further buttress the location as they are primarily found in riverine/coastal regions in countries such as Nigeria, and are widely distributed in littoral drifts and sandbanks.

The people in these areas consume the edible part as seafood and dispose of the shells as waste (Festus et al., 2012). Few people utilize shells as coarse aggregate in concrete works in areas where there are neither stones nor granite. However, a large amount of these shells is still disposed of as waste and with disposal already constituting a problem in areas where they cannot find any use for it, and large deposits have accumulated in many places over the years (Festus, et al., 2012). The discarded shells are considered an environmental nuisance because of the resultant unpleasant odor and unsightly appearance in open dumpsites.

Fig. 3. Periwinkle (Littorina Littorea) Shell

3.0 MATERIALS, METHODS AND PROCEDURE

The list of materials and equipment used for simulating the bottom hole static temperature and conducting the rheological tests are shown in Table 1. These materials and equipment are listed in **Tables 2** and **Table 3**.

Table 1. List of Materials Used

Material	Function
Fresh water	Material used for mixing cement slurry
Bentonite	Additive used as rheological enhancer in drilling fluid
Soda Ash	Used to control hardness in fresh water
Caustic Soda	Used as pH enhancer
Egg/periwinkle shell	Fluid loss control additives
Barite	Used to control drilling fluid density

3.1. Formulation of Drilling Fluids

Drilling fluid systems are selected based on well objectives and requirements. Table 2 and Table 3 gives the drilling fluid systems parameters used in conducting the required experimental tests at different temperature conditions, ranging from 80°F

Table 2. Water-based drilling fluid of 2 grams of Xanthan Gum, Egg and Periwinkle shells

Additives	**Weight (g)**
Fresh water	312 ml
Bentonite	15
Soda Ash	0.5
Caustic soda	0.5
Egg/ Periwinkle shells	2
Barite	20
Total	**350**

Table 3. Water-based drilling fluid of 4 grams of Xanthan Gum, Egg and Periwinkle shells

Additives	Weight
Fresh water	310 ml
Bentonite	15
Soda Ash	0.5
Caustic soda	0.5
Egg/ Periwinkle shells	4
Barite	20
Total	**350**

3.2 Drilling Fluid Preparation Procedure

The procedure for the preparation of drilling fluid is summarized as follows. About 0.5 gram of soda ash was added to 312 and 310 ml of fresh water, respectively, and mixed homogenously for 5 minutes to remove the hardness in the fresh water. Also, 15 grams of bentonite was added to the fresh water and was stirred for 30 minutes to achieve an adequate yield effect. Similarly, 0.5 gram of caustic soda was introduced into the mixture to ensure the drilling fluid is void of acid, and thereafter 2grams and 4 grams of the egg and periwinkle shells were added, respectively, whereas 2 grams of xanthan gum was added to 312 mL of fresh water. Finally, 20 grams of barite was introduced in the various drilling fluid mixtures and allowed to mix homogenously for 60 minutes with an electric stirrer. The mud density is measured using a mud balance, and the viscosity of the mud is also measured with the aid of the Ofite Model 35 Viscometer. Dial reading of the formulated drilling fluids was recorded at 600, 300, 200, 100, 6, and 3rpm with the help of the viscometer.

3.3 Procedure for determination of drilling fluid Viscosity

Firstly, the viscometer was cleaned with water and ethanol and allowed to dry. A certain amount of formulated drilling fluid sample was put in the large bulge viscometer and pulled by pipette until the small bulge is full. The viscometer was placed vertically in the water bath at the desired temperature. Then, allowed the drilling fluid sample to flow through the capillary tube with a run time until the liquid reaches the mark shown on the viscometer, and then stopped the time when the liquid reaches the bottom mark. Repeat the experiment and record the results (take the average of the results). Repeat the experiment with other liquids and change the temperature, and calculate the viscosity.

3.3.1 Viscosity measurement using a direct-indicating viscometer

Direct-indicating viscometers are rotational-type instruments powered by means of an electronic motor. This method is used to determine the plastic viscosity (PV), the Yield point (YP), and the Gel Strength of any drilling fluid. These parameters were measured using the speed Rheometer as follows:

3.3.2 The plastic Viscosity

The mud sample was placed in the container and the rotor sleeve, and immersed until the line was scribed. The sleeve was rotating at 600 rpm, and after a few seconds, the reading was taken at the steady value. That was the reading for 600 rpm. However, the reading for 300 rpm was waited until the value became steady before the reading was taken and calculated as follows:

Plastic Viscosity, $PV\ (cP) = \theta_{600} - \theta_{300}$ (1)

Where, θ = the dial reading

The Yield points (YP) of the drilling fluid were calculated using equation

$$YP\left(\frac{Ib}{100ft^2}\right) = \theta_{300} - PV \quad (2)$$

Where $\theta =$ the dial reading

3.3.3 Determine Gel Strength of Drilling Fluid

The formulated mud was measured by using the direct-indicating viscometer and also using a shear-meter. The mud sample was placed in position as in the procedure for plastic viscosity and then stirred at high speed for 10 seconds before allowed to stand undisturbed for 10 seconds. The hand wheel was slowly and steadily turned to produce a positive dial reading. The maximum reading was then taken as the initial gel strength at 3rpm, and finally, the mud was retrieved at high speed for 10 seconds and allowed to stand undisturbed for 10 minutes.

3.3.4 API Fluid Loss Test

Fluid loss tests were conducted using a static filter press assembly at ambient (room) temperature and 100-psi differential pressure. After the drilling fluid was prepared, it was transferred into a filter press consisting of a cylindrical drilling fluid cell having an inside diameter of 3 inches (76.2mm) and a height of 2.5 inches (64 mm). This chamber is made of materials resistant to strongly alkaline solutions and is so fitted that a pressure medium can be conveniently admitted into, and bled from the top. The arrangement is also such that a sheet of 90 mm (3.54 in.) filter paper was placed at the bottom of the chamber just above a suitable support. The filtration area is (7.1 ± 0.1) in^2 (45.8 ± 0.6) cm^2. Below the support is a drain tube for discharging the filtrate into a graduated cylinder. Sealing is accomplished with gaskets. The entire assembly is supported by a stand. The pressure was applied with any non-hazardous fluid medium, either gas or liquid.

3.4 Procedure for API Fluid Loss Test

The procedure for the API fluid loss test is summarized as follows. Firstly, each part of the cell, particularly the screen, was cleaned and dried, and the gaskets were not distorted or worn.

Formulated drilling mud was poured into the cell to within 1cm to 1.5cm (0.4 to 0.6in) of the top to minimize CO2 contamination of the filtrate, and the assembly was completed with the filter paper in place. A dry graduated cylinder was placed under the drain tube to collect the filtrate. The relief valve was closed, and the regulators were adjusted so that a pressure of 100 psi ± 5psi (7.03 ± 0.356 kg/- cm^3) was applied within 30 seconds or less. The test period begins at the time of pressure application. At the end of 30 minutes, the volume of the filtrate was measured. The pressure regulators were shut off, and the relief valve was carefully opened. It may be desirable to use one-hour filtration tests for oil drilling fluids: the time interval is other than 30 minutes. shall be reported. Report the volume of filtrate in milliliter (to the nearest 0.1ml) as the API filtrate; also report the initial temperature in ^oC (^{o}F). The cell is removed from the frame, first making certain that all pressure has been relieved. The cell was disassembled, the mud was discarded, and extreme care was used to save the filter paper with a minimum of disturbance to the cake. Wash the filter cake on the paper with a gentle stream of water. Measure and report the thickness of the cake to the nearest milliliter. In the case of oil drilling fluids, diesel may be used in place of water for washing the cake. Clean and dry the apparatus thoroughly after each use. Although cake descriptions are subjective, such notations as hard, firm, fine, tough, soft, rubbery, etc may convey important information about cake quality.

4.0 RESULTS AND DISCUSSION

The results obtained from the experiments at different conditions on the drilling fluid are presented and discussed. The effect of fluid loss of drilling fluid added with xanthan gum, periwinkle and egg shells are also presented. The three drilling fluids at 2 grams and 4 grams were investigated; the effect of rheological properties on the drilling fluid were also studied. Furthermore, the results of pH and density are presented

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4.1 Rheological Properties of Drilling Fluid Formulated with xanthan gum, egg, and periwinkle shells

Figures 4 to 8 are results of the rheological properties of drilling fluid formulated with xanthan gum, egg and periwinkle shells temperature of 80 ^{o}F

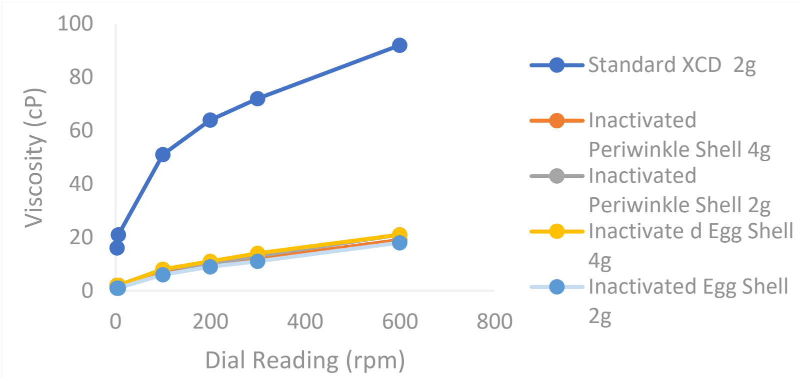

Fig. 4. Plot of viscosity as a function of dial reading of different fluid loss reducers @ 80 ^{o}F

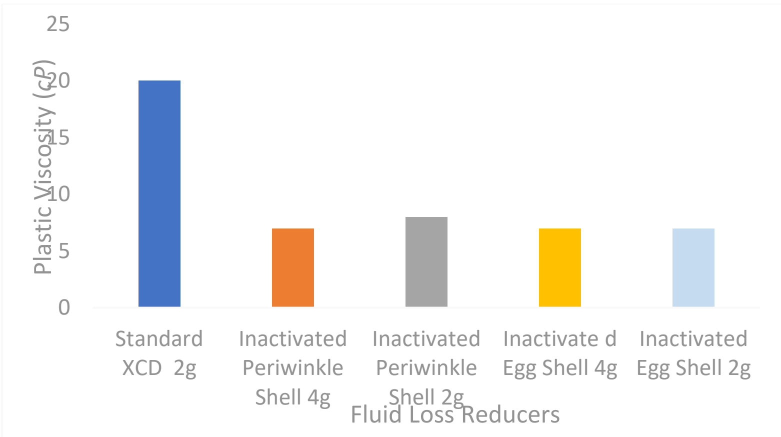

Fig. 5. Plot of Plastic viscosity against different fluid loss reducers

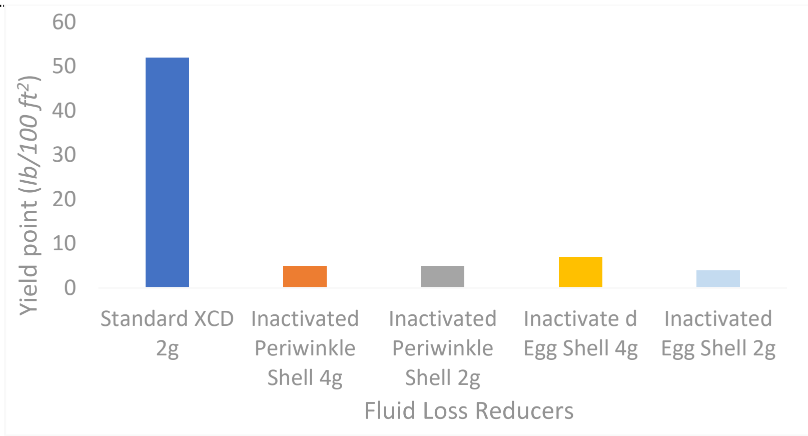

Fig. 6. Plot of Yield Point against different fluid loss reducers

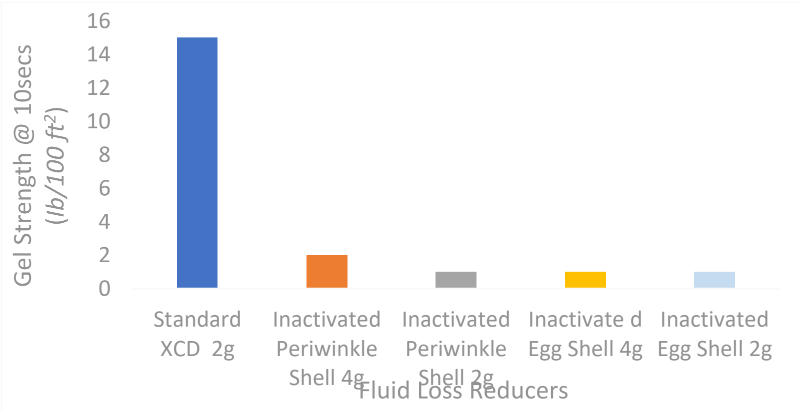

Fig. 7. Plot of Gel Strength at 10secs against different fluid loss reducers

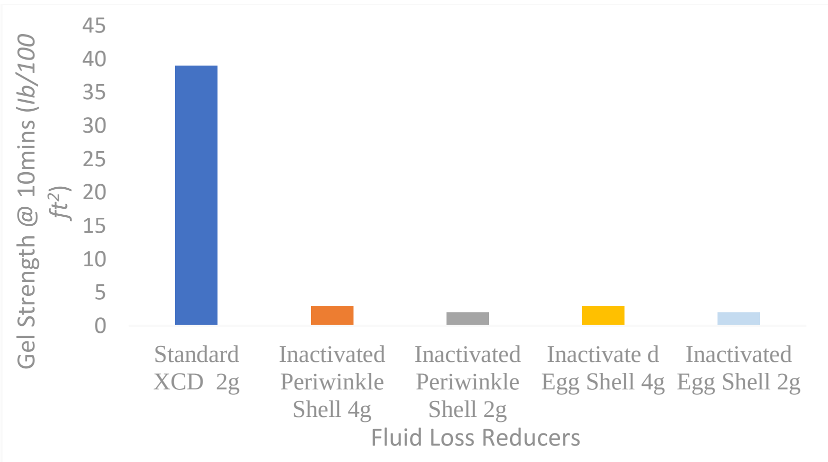

Fig. 8. Graph of Gel Strength at10mins vs different fluid loss reducers

In **Figure 4**, It is observed that standard XCD had the highest viscosity at all shear rates (having a viscosity value of 72 at 300rpm//min) followed by eggshell (viscosity value of 14 at 300rpm/min) and non-activated periwinkle shell (viscosity value of 13 at 300rpm/min). This suggests that XCD may provide better suspension and hole-cleaning capabilities. Besides, it could also lead to higher pumping pressures and potential formation damage if not properly controlled. Standard XCD had significantly higher gel strengths (25 and 39, respectively) at both 10 seconds and 10 minutes, as shown in Figures 4 to **8**, indicating a stronger ability to hold cuttings in suspension when circulation is stopped. This is also important for preventing settling of solids during tripping operations or when drilling is paused. The shell-based additives had much lower gel strengths, suggesting they might be less effective in preventing cuttings settling.

4.2 Results of pH of drilling fluid formulated with Xanthan gum, Egg, and Periwinkle shells

Figure 9 present result of the pH of drilling fluid formulated with xanthan gum, egg and periwinkle shells temperature of 80 ^{o}F

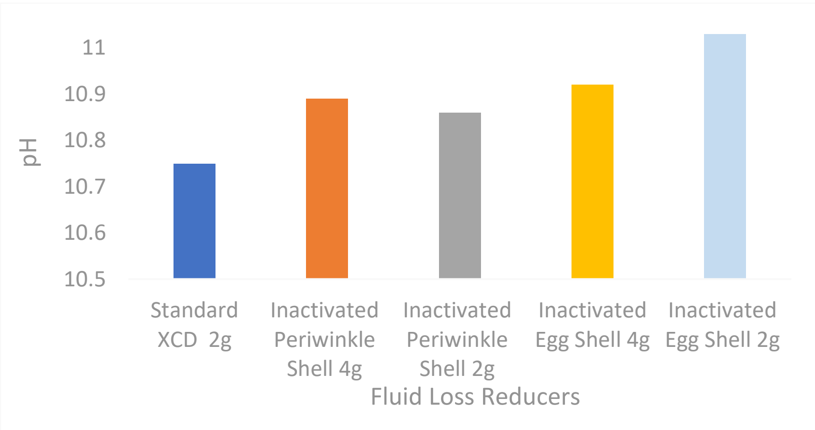

Fig. 9. Graph of Concentration (pH) vs Different Fluid Loss Reducers

From **Figure 9**, It is seen that all additives increased the pH of the water-based drilling fluid compared to the standard XCD (pH 10.75), while non-activated egg shell had a pH of 11.03 and periwinkle had a pH of 10.89. Non-activated egg shell (at 2gram concentration) had the highest pH increase (11.03), while Xanthan gum had the smallest increase. It is noted that higher pH values indicate increased alkalinity, which can impact the stability of the drilling fluid and affect corrosion rates **(Figure 9)**.

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4.3 Results of Fluid loss of Drilling Fluid Formulated with xanthan gum, egg, and periwinkle shells

Figure 10 explored the potential of eggshells and non-activated periwinkle shells as sustainable alternatives to Xanthan gum, a conventional fluid loss reducer used in water-based drilling fluids. From **Figure 10**, it is observed that eggshell, particularly at 4g concentration, exhibited performance (API fluid loss value of 9cc/30min) comparable to Xanthan gum (API fluid loss value of 9.7cc/30min) in reducing fluid loss. Non-activated periwinkle shell showed mixed results, with 4g concentration (API fluid loss value of 11.5cc/30min) performing better than the 2g concentration (API fluid loss value of 13cc/30min). However, this suggests that eggshell may be a promising alternative to Xanthan gum for reducing fluid loss, depending on the desired performance level. These results suggest the potential of eggshell as a viable substitute for Xanthan gum.

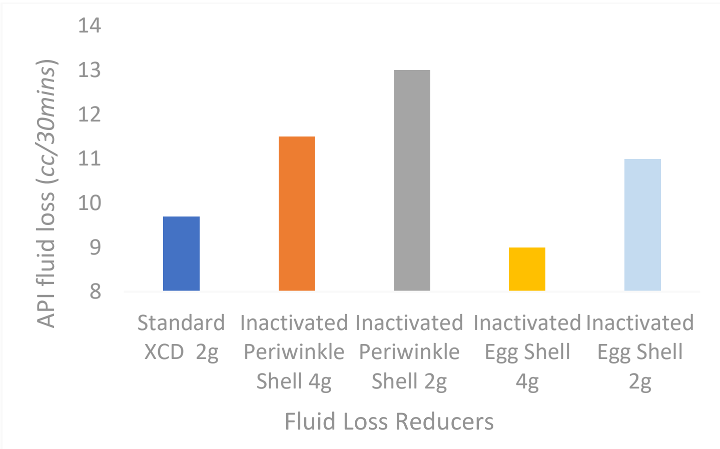

Fig. 10. Graph of API fluid loss vs different fluid loss reduces

Non-activated periwinkle shells at both concentrations had the lowest mud weight (8.80 ppg). While these differences are relatively small, they could affect wellbore pressure control and drilling efficiency. Higher mud weight can help maintain pressure in deeper wells, but it may also increase the pumping power needed and impact formation stability. One concern with shell-based additives is their lower gel strength compared to Xanthan gum, which could lead to increased settling of cuttings when drilling is paused. However, this might also reduce the risk of formation damage, especially in sensitive formations.

Nanomaterials (NMs) are materials with structural components smaller than 1 µm (1000 nm) in at least one dimension. These include nanoparticles (NPs) with structures on the nanoscale in at least two dimensions (EPA, 2008; Luoma, 2008). NMs can be classified by their source into: (a)

Natural (b) Incidental (c) Engineered

Based on product material, they are classified as: (a) Carbon-based (b) Metal-based (c) Dendrimers (d) Composites (Lv *et al.*, 2012). NMs are developed in various forms such as nanowires, nanotubes, films, particles, quantum dots, and colloids (Edelstein and Cammaratra, 1998; Lubick and Betts, 2008). They possess extraordinary properties including (a) Large surface area (b) Quantum effects (c) Electrochemical and magnetic properties (d) Highly active surface bonds (e) Other size-dependent. These properties make nanomaterials more reactive and sensitive to environmental contaminants than conventional technologies or their macro-scale counterparts (Keiner, 2008), enabling their use in technologies like nanoremediation. The processes involved in nanoremediation include oxidation, reduction, and sorption.

Mechanisms of Nanoparticles; Nanoparticles have been used to remediate contaminated soil under various conditions for many years. Their presence can decrease soil pH, organic carbon, dehydrogenase enzyme activity, microbial biomass transformation rate, soil bacteria populations, and fungal colony numbers, leading to reduced soil microbial diversity (Huang *et al.*, 2022). Due to their magnetic properties, nanoparticles often aggregate, forming larger particles, which decreases their mobility and reactivity in the soil (Vu & Mulligan, 2022). Their high solvent affinity and large specific surface area allow nanoparticles to easily interact with oil compounds, enhancing their solubility and resulting in a high removal rate. The interaction between nanoparticles and other substances depends greatly on their type, amount, and properties. The main treatment mechanisms employed by nanoparticles include adsorption (e.g., nZVI, carbon nanotubes), oxidation (e.g manganese nanoparticles, cobalt nanoparticles), and photocatalysis (e.g., bismuth nanocomposite, BiPO4-based photocatalysts). Oil pollutants can be adsorbed onto the surface of nanoparticles through π–π interactions and van der Waals forces (Wang *et al.*, 2014). However, the tendency of nanoparticles to aggregate, which reduces their surface area and active sites, is a significant disadvantage that can lower treatment efficiency.

In the oxidation method, oil pollutants are converted into less toxic or non-toxic compounds such as CO_2 and H_2O through Fenton-like reactions. This process involves the degradation of oil pollutants by reactive oxygen species (ROS), which are generated by the reaction of iron oxides with H_2O_2 , UV light, or ultrasound. ROS, such as hydroxyl radicals (HO·) and hydroperoxyl radicals (HO_2), degrade oil pollutants to produce final products like CO_2 and H_2O (Hou *et al.*, 2016). The reactions are as follows:

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^{-} + HO \quad (1)$$

$$Fe^{3+} + H_2O_2 \rightarrow Fe\,(OOH)^{2+} + H^{+} \quad (2)$$

$$Fe\,(OOH)^{2+} \rightarrow Fe^{2+} + HO_2 \quad (3)$$

$$H_2O_2 + HO^{\cdot} \rightarrow HO_2^{\cdot} + H_2O \quad (4)$$

$$Fe^{3+} + HO_2 \cdot \rightarrow Fe^{2+} + H^+ + O_2 \quad (5)$$

$$ROS + \text{oil pollutants} \rightarrow CO_2 + H_2O$$

5.0 CONCLUSIONS

The experimental evaluation of Egg and Periwinkle shells in fluid loss reduction was conducted and assessed. The study examined the viability of two readily available shell powders, eggshell and non-activated periwinkle shell, as sustainable alternatives to xanthan gum for reducing fluid loss in water-based drilling fluids. However, from the analysis of the results, it can be concluded that:

- Eggshell proved t be a strong alternative, showing similar fluid loss control to Xanthan gum at 4g concentration. This indicates its potential as an eco-friendly and cost-effective substitute in certain drilling applications.
- Periwinkle shell showed the highest API fluid loss at 2 2-gram concentration. This indicates that the periwinkle shell does not act as a fluid loss reducer in water-based mud.
- While both shells had lower mud weight than Xanthan gum (both at 2 gram concentration), which can be a desirable trait in certain situations, their significantly lower viscosity and gel strength compared to Xanthan gum raise concerns about hole cleaning and cuttings suspension.

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References

[1] Bellis, J. M. (2008). Drilling fluids. In Petroleum production handbook: Reservoir engineering and surface operations (pp. 427-458). Burlington, MA: Elsevier

[2] Agwu, C. E., & Akpabio, J. U. (2018). Locally sourced materials as fluid loss control additives in water-based drilling fluids: A review. Petroleum Science and Technology, 36(19), 1810-1818.

[3] Olabode E. O., William. S. and Temitope, E. (2022): “Construction Waste Management in Nigeria Using the 3R Principle of the Circular Economy. Circular Economy and Waste Valorisation (pp.177-195). DOI: 10.1007/978-3-031-04725-1_8

[4] Seadi, T. A. and Holm-Nielsen, J. B (2004): “Agricultural wastes,” in Waste Management Series, I. Twardowska and J. L. William, Eds., Elsevier, 2004.

[6] Food and Agriculture Organization of the United Nations (2019): Statistics Division (FAOSTAT) Production: Livestock Primary: Eggs Primary, 2014, http://www.fao.org.

[7] Ferraz, E., Gamelas, J. A. F., Coroado, J., Monteiro, C. & Rocha, F. Eggshell waste to produce building lime: calcium oxide reactivity, industrial, environmental and economic implications. Mater. Struct. 51, 115, https://doi.org/10.1617/s11527-018-1243-7 (2018).

[8] Muliwa, A. M., Leswifi, T. Y. & Onyango, M. S. Performance evaluation of eggshell waste material for remediation of acid mine drainage from coal dump leachate. Miner. Eng. 122,241–250, https://doi.org/10.1016/j.mineng.2018.04.009 (2018).

[9] Cree, D. & Rutter, A. Sustainable bio-inspired limestone eggshell powder for potential industrialized applications. ACS Sustain. Chem. Eng. 3, 941–949, https://doi.org/10.1021/acssuschemeng.5b00035 (2015).

[10] Singh, V. K., Chevli, M. H., Tauseef, S. M. & Siddiqui, N. A. Treatment of effluent from pharmaceutical industry using calcium oxide obtained from eggshells. In: Siddiqui, N., Tauseef, S., Bansal, K. (eds.) Advances in Health and Environment Safety, pp. 327–343. Springer, Singapore (2018).

[11] Quina, M. J., Soares, M. A. R. & Quinta-Ferreira, R. Applications of industrial eggshell as a valuable anthropogenic resource. Resour. Conserv. Recycl. 123, 176–186, https://doi.org/10.1016/j.resconrec.2016.09.027 (2017).

[12] Sarder, M. R., Hafiz, N. A. & Alamgir, M. Study on the effective reuse of eggshells as a resource recovery from municipal solid waste. In: Ghosh, S. (ed.) Waste Management and Resource Efficiency, pp. 71–79. Springer, Singapore (2019).

[13] Ummartyotin, S. & Manuspiya, H. A critical review of eggshell waste: An effective source of hydroxyapatite as photocatalyst. J. Met. Mat. Miner. 28, 124–135, https://doi.org/10.14456/jmmm.2018.17 (2018).

[14] Kolawole, M.Y., Aweda, J.O., and Abdulkareem, S. (2017). Archachatina Marginata bio-shells as reinforcement materials in metal matrix composites. International Journal of Automotive and Mechanical Engineering. 14(1), pp 4068 – 4079

[15] Kobatake, H.; Kirihara, S. (2019): “Lowering the Incineration Temperature of Fishery Waste to Optimize the Thermal Decomposition of Shells and Spines”. Fish. Sci. 2019, 85, 573–579. [Google Scholar] [CrossRef].

[16] Adewuyi, A. P. and Adegoke T. (2008): “Exploratory Study of Periwinkle Shells as Coarse Aggregates in Concrete Work”. RPN Journal of Engineering and Applied Science (ISSN 1819-6608)

[17] Nwaobakata C., Agwunwamba J. Influence of periwinkle shells ash as filler in hot mix asphalt. Int. J. Sci. Res. 2012; 3:2319–7064.

[18] Aimikhe V.J., Lekia G.B. An Overview of the Applications of Periwinkle (Tympanotonus fuscatus) Shells. Curr. J. Appl. Sci. Technol. 2021; 40:31–58. Doi: 10.9734/cjast/2021/v40i1831442.

[19] Dahunsi B.I.O. Properties of Periwinkle-Granite Concretes. J. Civ. Eng. 2003; 8:27–35. Doi: 10.4314/jce.v8i1.18993.

[20] Chang A. L., Blakeslee A. M. H., Miller A. W. & Ruiz G. M. (2011). "Establishment Failure in Biological Invasions: A Case History of Littorina littorea in California, USA". PLoS ONE 6(1): e16035. doi:10.1371/journal.pone.0016035.

[21] Festus A. O., Oriyomi M. O. and Olatunji S. O. (2012). Assessment of the Suitability of Periwinkle Shell Ash (PSA) as Partial Replacement for Ordinary Portland Cement (OPC) in Concrete”IJRRAS 10 (3) www.Arpapress.com/volumes/vol10 issue3/ijrras_10_3_08.pdf