

## THE SUITABILITY OF EGG SHELL AND SNAIL SHELL WASTE FOR PH AND MUD WEIGHT ENHANCEMENT OF WATER BASED DRILLING MUD

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### Abstract

In this study, the effect of two food waste materials, egg shell, and snail shell as local environmentally-friendly additives, on the pH and mud weight of water based mud was evaluated. The water based mud samples were formulated using bentonite, barite, distilled water with egg shell and snail shell in varying weight proportions. Mud weight and pH measurements were taken at 25°C. The results showed that egg shell and snail shell increased the pH value by 8.4% and 29.9% respectively due to the addition of 30g of each additive. The pH value was however increased by 54.9% when 15g of each additive in equal amounts was added to the mud. Correspondingly, the mud weight was increased by 12.6% and 8.4% due to the addition of 30g of egg shell and snail shell respectively. The mud weight was however increased by 28.9% when 15g of each additive in equal amounts was added to the mud. It was concluded that the combination of a snail shell and egg shell has a high potential for pH enhancement with a reduced potential for the mud weight increase. Snail shell is more effective as a pH enhancer while egg shell is more effective in increasing mud weight.

**Keywords:** Water based mud; pH enhancer; local additives; egg shell; snail shell; weighting agent.

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## 1. Introduction

There are a plethora of additives for drilling fluids. These drilling mud additives are chemicals added to drilling mud in order to change the mud properties and composition. However, many efforts have been devoted to drilling mud formulation mainly to enhance the quality and function of drilling muds, as well as to comply with the more stringent laws on environmental pollution or marine contamination. Some are used for pH control-that is, for chemical-reaction control (inhibit or enhance) and drill-string-corrosion mitigation [1-2]. While synthetic additives are currently in use, several researchers have investigated the use of natural products as additives to these chemicals.

The potential of cocoa pods, plantain peels, rice husks, and groundnut shells as corrosion inhibitors was investigated. Cocoa pod extracts exhibited high corrosion inhibition potential when compared to the synthetic KOH. Cocoa pod extract was also found to be more stable thermally and very effective in filtration loss reduction at high temperatures. However, it showed a thinning tendency with the mud requiring additional viscosifier to improve its rheology [3]. An experimental investigation into the use of burnt plantain and banana peels in water based drilling local mud as corrosion control additives revealed that though plantain peels were more effective than banana peels for increasing the pH both local additives increased mud pH to between 9.5 to 12.5 which compared suitably to imported sodium hydroxide [4].

Properties of mud formulated with variable concentrations of cellulose processed from corn cob were compared with that of a standard mud formulated from Polyanionic Cellulose (PAC). The results showed that the pH, mud density, specific gravity of the mud formulated from corn cob cellulose are higher than that of the standard mud, but rheology of the prepared mud was lower than that of the standard mud. The results show that cellulose processed from corn

cob can significantly reduce fluid loss in a water based drilling mud, suggesting cellulose as a good fluid loss control agent [5]. Grass added to the bentonite drilling fluid improved the rheological properties such as apparent and plastic viscosities and gel strength. The filtration characteristics of the bentonite drilling fluid were also enhanced because lower filtration losses were observed for all samples. However, the test carried out on the pH indicated that the addition of grass decreased the pH of the drilling fluid [6].

The aim of this paper is to investigate the suitability of egg shell and snail shell as local additives to enhance and improve the pH and density of water based mud, as both materials are biodegradable and easily accessible.

### 1.1. The composition of food waste additives

The main component of snail shell includes more than 95% calcium carbonate in the form of aragonite ( $\text{CaCO}_3$ ), a small number of shells hormone (organic matter and trace elements) and trace amounts of K, Na, Zn, Sr, Fe, Mg but with no trace of sulfur [7]. The pH value of snail shell in solution is 8.84, which shows that its solution is alkaline, which may result from the presence of Calcium carbonate and protein as some of the composition of the shell [8].

The microstructure of the egg shell powder reveals that the powder consists of porous irregular shaped powder. The Energy-dispersive X-ray spectroscopy of egg shell particles reveals that the particles contain Ca, Si, O, C. These elements confirm that, the egg shell powder consists of calcium carbonate in the form of calcite ( $\text{CaCO}_3$ ), tilleyite ( $\text{Ca}_5\text{Si}_2\text{O}_7(\text{CO}_3)_2$ ), etc. [9]. The composition of hen eggshell has been reported to be 94 to 96 kg calcium carbonate, 1 kg magnesium carbonate, and 1 kg calcium phosphate per 100 kg eggshell with a minor amount of organic matter [10]

## 2. Experimental section

### 2.1. Materials

The influence of snail shell powder and egg shell powder on pH and mud weight of water based drilling mud was investigated.

#### 2.1.1. Egg shell (ES) powder

Egg shell was extracted from boiled eggs. After the extraction, it was then broken into smaller sizes to provide a large surface area for effective drying. The egg shell was naturally dried under the sun for about 2 days because it has low water content. It was then grinded, using a manual grinder and pulverized using 250mm spaced sieve and then transferred into a clean petri-dish for storage.

#### 2.1.2. Snail shell (SS) powder

Snail shells were obtained from de-shelled cooked snails. The snail species is *Archachatina marginata*. The shells were dried naturally under the sun for about 3 days because snail shell has high water content compared to the egg shell. The snail shell was then grinded using a manual grinder after which it was pulverized using 250mm spaced sieve. The pulverized sample was transferred into a petri-dish container for storage.

#### 2.1.3. Drilling mud

Non-inhibitive water based mud was prepared (the composition of the control mud sample is shown in Table 1).

Table 1. Composition of control mud sample

Constituents	Concentration	Function
De-ionized Water	350 ml	Base fluid
Barite	90 grams	Weighting agent
API Bentonite	25 grams	Viscosifier

## 2.2. Methods

### 2.2.1. Mud balance

A pressurized mud balance was used to determine the mud weight of each sample. The mud balance was calibrated using distilled water. The balanced cup was cleaned, dried and filled to the brim with the mud sample to be measured. The lid was placed on the cup as some mud flowed out of the hole on the lid to ensure that there was no trapped air in the cup. The cup and lid were wiped to dry off any mud on the surface in order to obtain accurate measurement as the knife edge was placed on the fulcrum and the rider adjusted until the cup content and the rider was at equilibrium. The density of the mud sample was read on the calibrated arm of the mud balance.

### 2.2.2. pH Meter

The pH meter was calibrated using deionized (distilled) water and the mud sample to be measured was poured into a glass beaker. The pH meter probe was immersed in the mud sample and at steady pH value indicated on the meter. This was recorded as the pH value of the mud sample.

## 2.3. Procedure

Nineteen water based mud samples were prepared to have varying masses of egg shell and snail shell in addition to the constituents given in Table 1. The first sample (Sample A) is the control mud without the local additives. Samples B to G have egg shell concentration ranging from 5g to 30g with the concentration increasing by 5g across samples. Samples H to M have snail shell concentration ranging from 5g to 30g with the concentration increasing by 5g across samples. Both egg shell and snail shell were blended into samples N to S in equal amounts ranging from 2.5g to 15g of each local additive. The corresponding pH and mud density for each were measured using mud balance and pH meter respectively. The effect of the local additives on the properties of the water based drilling mud was compared to that of the standard API values.

## 3. Results and discussion

### 3.1. The effect of the local additives on mud weight

The mud weight of the control mud sample before the addition of either egg shell or snail shell was 9.50 ppg. Figure 1 shows the effect of the local additives on mud weight. On addition of 5 g of each local additive to different samples of the control mud, snail shell increased the mud weight by about 0.63% while egg shell increased the mud weight by 1.89%, with egg shell having the more obvious effect on the mud weight of the drilling fluid. With the addition of 10 g of each local additive to different samples of the control mud, the mud weight of egg shell gave 9.73 ppg which is an increase of 2.42% due to the egg shell, and that of snail shell gave 9.64 ppg which is an increase of 1.47%.

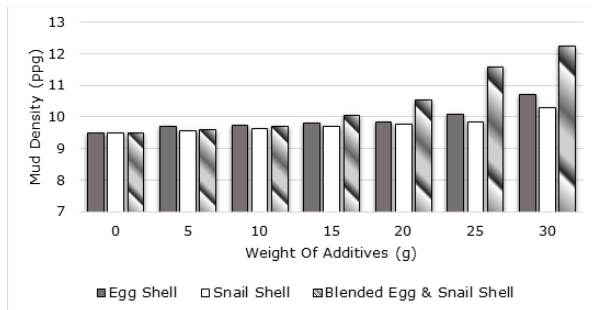


Figure 1. Effect of additives (individual and combined) on mud density

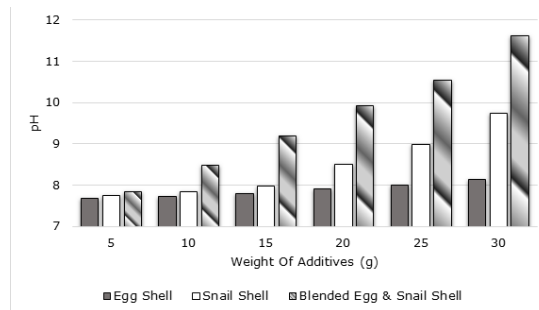


Figure 2 Effect of additives (individual and combined) on pH of mud samples

The mud weight was increased by 12.6% and 8.4% due to the addition of 30 g of egg shell and snail shell respectively to separate control mud samples.

Both local materials (egg shell and snail shell) were combined in weight proportions with the control mud which contains 350ml of de-ionized water, 90 g of barite and 25 g of bentonite. With the addition of 2.5 g of egg shell and 2.5 g of a snail shell, the mud weight increased by 1.05%. With the addition of 5 g of each local material combined in the mud, the mud weight increased by 2.1%. As shown in Figure 1, the effect of the combined local additives on mud weight is less than the individual effect of egg shell at 5 g and 10 g weight proportion. However, on the addition of 7.5 g of each local material combined in the mud which gives a total weight of 15 g, the weight increased by 5.8% as compared to 3.16% and 2.2% due to the addition of 15 g of egg shell and snail shell respectively. The effect of combining both egg shell and snail shell increases with increasing weight proportion in the water based drilling mud, as shown in Figure 1. The mud weight increased by 28.9% due to the addition of 15 g of both egg shell and snail shell (total local additive weight of 30 g) while the weight by 12.6% and 8.4% due to the addition of 30 g of egg shell and snail shell respectively.

A statistical correlation for mud weight estimation was developed from the mud weight measurements obtained from the addition of egg shell powder and snail shell powder to water based drilling mud.

$$MW = 9.46 + 0.020547SS + 0.001254ES^2 + 0.009679(ES)(SS) \quad (1)$$

The correlation has  $R^2 = 0.969$  (Adjusted  $R^2 = 0.963$  and Standard error of 0.139853). The correlation is a non-linear regression equation with a significant two-way interaction term (ES)(SS). The correlation is applicable for less than 30 g of the local additive; egg shell, snail shell or combined additives.

### 3.2. The effect of the local additives on the pH

The pH is defined as the negative log of the activity of the hydrogen ion in an aqueous solution. Solutions with less pH less than 7 are said to be acidic, and solutions with a pH greater than 7 are basic or alkaline. It was expected that both egg shell and snail shell would significantly enhance the pH of drilling mud because of their high calcium content. The pH measurements taken are shown in Figure 2.

The incremental additions of egg shell gave a minimal change in pH of mud while additions of snail shell enhanced pH value. Figure 2 shows that as the mud weight increased the pH value also increased due to the additional additives added to the drilling mud. It can be clearly observed that snail shell is a better pH enhancer than an egg shell. The combination of both local material (i.e. egg shell and snail shell) further enhanced the pH values of the drilling mud.

The initial pH value of the control mud sample was 7.65. As shown in Figure 2, the pH increased by 1.31% to 29.9% due to the additional of 5 g to 30 g of snail shell respectively. The addition of 5 g of egg shell increased the pH by only 0.52% while the pH increased by 8.4% on the addition of 30 g of the egg shell to the control mud. Significant pH enhancement was observed with both egg shell, and snail shell was added to the control mud. With the addition of 2.5 g of egg shell and 2.5 g of a snail shell, the pH increased by 2.61%. On the addition of 15 g of each local material combined in the mud which gives a total weight of 30 g, the pH was increased by 54.9%.

A statistical correlation for pH estimation was also developed from the pH measurements obtained by the addition of egg shell powder and snail shell powder to water based drilling mud.

$$pH = 7.7035 + 0.01259ES + 0.002131SS^2 + 0.001538(ES)(SS) \quad (2)$$

The correlation has  $R^2 = 0.977$  (Adjusted  $R^2 = 0.973$  and Standard error of 0.175104). From the measurements, pH strongly correlates with both the square of the snail shell weight and with the two-way interaction term (ES)(SS). However, pH correlates weakly with the egg shell added. The correlation is also applicable for less than 30 g of the local additive; egg shell, snail shell or combined additives.

Drilling fluids perform better in pH range between 9.5 and 12.5 for water-base mud. If the pH of the mud is low, below 7.0, it becomes acidic and can corrode the drilling equipment and also pollute the environment [11]. The results gave an average pH value between 7.69 and 12.25 which is within the stipulated API standard of 9.5 – 12.5.

This results confirm that snail shell is effective as a pH enhancer. It measures up to caustic soda in its pH enhancing quality, and the incremental addition of the additives increase the pH of the mud. Furthermore, the combination of egg shell and snail shell can be used for pH enhancement.

#### 4. Conclusions

Egg shell powder has a higher potential to enhance water based drilling mud weight as compared to snail shell powder. Snail shell powder is effective in enhancing the pH of water based drilling mud. The effect of snail shell compared favourably to sodium hydroxide the widely used pH enhancer in the drilling industry. Egg shell minimally enhanced the pH as compared to a snail shell.

The effect of combined egg shell and snail shell blended into the drilling mud for enhancing drilling mud is not significant below 7.5 g/350 mL. However, above this threshold, the combined additive is more effective than egg shell in enhancing the mud weight.

Egg shell and snail shell blended into water based drilling mud are recommended for enhancing the pH. Similar pilot studies can be guided by the statistical correlations for mud weight and pH using egg shell and snail shell independently in combination.

#### Recommendation

Based on these results and conclusions of the experimental research study, the following recommendations are suggested for future work:

- The effect of egg shell and snail shell on the rheology of water based mud is imperative.
- The potential of egg shell for mud weight enhancement should be investigated without barite as the weighting agent and compared to industrial calcium carbonate.

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