European Journal of Sustainable Development Research
2025, 9(3), em0308
e-ISSN: 2542-4742
https://www.ejosdr.com/

MODESTUM

Research Article

OPEN ACCESS

Formulation of drilling fluids using local materials

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Citation: Eze, S. O., & Chukwu, C. J. (2025). Formulation of drilling fluids using local materials. *European Journal of Sustainable Development Research, 9*(3), em0308. https://doi.org/10.29333/ejosdr/16352

ARTICLE INFO

Received: 21 Sep. 2024

Accepted: 25 Jan. 2025

ABSTRACT

The study investigates the formulation of drilling fluids using locally sourced materials (clays) in conjunction with bentonite and non-food-based additives to address the challenges posed by the reliance on imported drilling fluid materials. The objectives were to compare the physio-chemical and rheological properties of drilling fluids made from local materials against conventional drilling fluids, develop formulations with various local additives, and enhance the viscosity of local clays to meet industry standards. A comprehensive methodology was employed, utilizing materials such as groundnut shells, eggshells, barite, and bentonite. The experimental design followed a full factorial approach, resulting in the preparation of thirty-two mud samples with varying proportions of the additives. Key properties such as mud density, pH, and viscosity were measured to evaluate the performance of the formulated drilling fluids against API standards. The results indicated that the incorporation of local additives significantly influenced the properties of the drilling mud, with pH values ranging from 8.94 to 11.22, mud density from 9.38 lb/gal to 10.17 lb/gal, and viscosity from 19.32 cP to 58.56 cP. The study highlights the potential of using local materials to enhance the performance of water-based drilling fluids, demonstrating that groundnut shell and eggshell can effectively improve key mud characteristics. The findings suggest that these locally sourced additives not only meet the required standards for drilling operations but also contribute to sustainable practices within the petroleum industry.

Keywords: drilling fluids, local materials, groundnut shell, egg shell, drilling performance, sustainable practices

INTRODUCTION

Drilling is the action of making a hole in something by boring with a drill. In oil exploration or wells, drilling involves creating a passage for the discovered hydrocarbon to be produced at the surface.. It has to do with the penetration of the earth's crust to thousands of feet where the hydrocarbons are stored in the reservoir utilizing the drilling procedure (Udoh & Okon, 2012). Up till now, from the era of cable tool rigs to the use of rotary drilling rigs, a lot of development in technology has been put forth on how best drilling operations can be carried out in the best methods that are affordable and environmentally viable (da Ponte, 2021; Teodoriu & Bello, 2021).

Drilling fluids are heterogeneous combinations of oil, water, or chemical and clay elements that enhance drilling operations (Ali et al., 2022). They are vital in effective well drilling as they have similar features that permit safe and satisfying completion of the well, such as bottomhole cleaning, managing high-pressure zones, and removal of cuttings to the surface (Njuguna et al., 2022). In Nigeria, drilling businesses commonly import bulk drilling fluid ingredients to carry out their different activities (Boyi & Amadi, 2023). This has been a big burden and major concern to the industry since some of these drilling fluid materials cannot be recycled (Boyi & Amadi, 2022). Secondly, the foreign exchange involved, and the high cost of drilling fluid ingredients also create a difficulty for the petroleum business (Antia et al., 2022).

The effectiveness of the drilling fluid to execute its major functions is based on its properties, which are formulated continually to suit the formation conditions encountered during drilling operations (Arain et al., 2022; Faisal et al., 2024). Failure of the drilling fluid to satisfy its specified purpose can prove extremely costly in terms of materials and time and may threaten the successful completion of the well and potentially result in serious difficulties such as stuck pipes, kicks, or blowouts (Basfar et al., 2023). In other words, since drilling fluid is a vital part of the drilling process, many of the difficulties experienced during the drilling of a well can be directly or indirectly related to the drilling fluids. Therefore, these fluids must be carefully selected and/or created to fulfill their role in the drilling process (DeBruijn & Whitton, 2021; Davoodi et al., 2024).

However, it is a well-known fact that clay material and other additives, such as bentonite, are added to water or oil (mainly diesel oil) to make them appropriate as a drilling fluid (Nlemedim et al., 2023). The existing use of bentonite in the drilling operations in Nigeria is above 50 thousand tons a year and all of it is imported from the USA (Igwilo et al., 2020). This tendency is projected to continue as drilling activity expands on the coasts of the Niger Delta. To this aim, the development of the Nigerian local content initiative in the oil and gas sector by the Federal Government of Nigeria has prompted the need for local substitutes for international drilling fluid ingredients. Thus, it is necessary to obtain locally available drilling fluid components and assess their varied qualities, then manufacture fluids that may be employed in the drilling process.

Several works have been done on environmentally and regionally sourced additives for drilling fluid. Burts (1997) invented a drilling fluid additive appropriate for lost circulation control containing a comminuted rice fraction in the range of concentration from about 75 to about 90% by weight; a comminuted peanut hull fraction in the range of concentration from about 3 to about 50% by weight. Carbon beads in the range of concentration from about 1 to 5% by weight to reduce friction between a borehole and drill pipe; a polyanionic cellulose type of polymer in the range of concentration from about 0.1 to about 0.5% by weight to reduce further fluid loss; and oil in the range of concentration from about 1% to about 10% by weight. Burts' patent proved the idea of employing rice products as a fluid loss additive in drilling mud, but the difficulty arose that rice is an expensive food, which inhibited further investigation into his patent (Burts, 1997).

Similarly, Anawe et al. (2014) and Okon et al. (2014) evaluated rice shell as a possible fluid loss control additive in water-based mud and compared the results with sodium carboxymethyl cellulose (CMC) and the effect of rice husk and sawdust on the properties of oil-based mud at varied temperatures, respectively. Okon et al. (2014) observed that the addition of 20 g of rice shell to 350 ml of mud (approximately 20 lb/bbl) caused a drop of 3.03% and 8.57%, respectively, when compared to CMC and PAC. From the result, it was determined that rice shell can serve as a replacement to present fluid loss control additives due to its improved performance, high resistance to water penetration and thermal stability. Adebayo et al. (2014) reported that addition of rice shell to an oil based mud raises the mud densities from 9.5 for a 5 g additive to 10.0 pounds per gallon (ppg) for a 25 g additive and increases the apparent viscosities from 55 for a 5 g additive to 115 cp for a 25 g rice shell additive. Apparent viscosity reduced with increasing temperature (55 to 37.5 from 60 oC to 1000 oC for sample B). The addition of sawdust additive to identical oil-based mud causes significantly smaller influence on density (9.60 for 5 g to 9.8 ppg for 25 g sawdust added) and viscosities. It was suggested from the obtained data that rice shell can be employed as a filter loss addition in oil-based mud. While the rheological parameters assessed following the addition of rice shell to the drilling mud promote its usage as an additive, these properties were not compared to those of a typical filtration loss control additive. However, the authors urged further investigation into the usage of rice shell as it does not match the required mud thickness; an approach to remedy this might be its combination with other local additions. This might boost the mud thickness to the desired amount (Anawe et al., 2014; Okon et al., 2014).

Hossain and Wajheeuddin (2016) offered a technique introducing grass as a sustainable, environmentally beneficial drilling fluid component. The results obtained demonstrated that grass added to the bentonite drilling fluid increased the rheological parameters such as apparent and plastic viscosities and gel strength. The filtration characteristics of the bentonite drilling fluid were also strengthened because decreased filtration losses were reported for all samples. Omotioma et al. (2015) studied the utilization of locally sourced cassava starch for the improvement of the rheological properties of water-based mud. The production method of the mud and the determination of its rheological and associated properties were carried out based on the API mud production criteria. From the examination of the trial data, water-based mud with 4% locally available cassava starch appears to be the best concentration. The cassava starch addition increases the rheological qualities of the drilling mud. While this research proved that local minerals can be employed to improve the rheological qualities of a drilling fluid. The challenge of producing drilling fluids at the expense of food also poses a serious concern.

Although rice shells and cassava starch have shown potential in improving the rheological and filtration properties of drilling fluids, their application poses economic and ethical considerations due to their relevance as food crops (Ismail et al., 2020). Existing research frequently focuses on single additions or limited comparisons to standard materials, overlooking the potential for synergistic effects. Additionally, the examination of rheological and physiochemical qualities generally lacks a thorough strategy, hampering the development of appropriate formulations. Furthermore, the economic viability and environmental impact of these local options have not been adequately examined (Awl et al., 2023).

Given this backdrop, the current work tries to solve these constraints by evaluating the usage of native clays from Lagos, Nigeria, in conjunction with bentonite and other non-food-based additives. This study presents a novel approach to the formulation of drilling fluids by utilizing locally sourced materials. The originality of this research is in its comprehensive evaluation of the physio-chemical and rheological properties of drilling fluids formulated with local materials, which has not been extensively documented in existing studies. The research addresses the critical knowledge gap concerning the synergistic effects of combining local materials with traditional additives. This study intends to produce drilling fluids that not only fulfill required viscosities and rheological qualities but also contribute to lowering the dependence on imported materials, aligning with the Nigerian local content initiative. The specific objectives are, as follows:

(1) To compare the physio-chemical and rheological properties of drilling fluids formulated with local materials to those of conventional drilling fluids. This will provide a quantitative assessment of the performance of the local alternatives.

Table 1. Apparatus used

Apparatus	Uses
Viscometer	Measuring the rheological properties of the water-based drilling mud
Sieve	Sieving the clay, grinded banana peel, and tapioca to sizes
Weighing balance	Weight measuring of materials
pH meter	Measuring the pH of the mud
Manual hand grinder	Grinding the groundnut shell and eggshell into sizes
Graduated measuring cylinder	Measuring the amount of water to be added to the clay
Spatulas or stirrers	Taking samples from their containers
Stopwatch	Measuring time during fluid loss measurement
Mud balance	Measuring the weight of mud

(2) To develop drilling fluids using a variety of local materials and additives. This will explore the potential for synergistic effects and identify optimal combinations for different drilling conditions.

(3) To investigate how the viscosity of the local clay can be increased using additives to meet the required standards. This will address a common challenge associated with the use of local clay as a primary component in drilling fluids. This exploration is essential for optimizing drilling fluid formulations to meet industry standards, thereby advancing the state of the art in drilling fluid technology.

RESEARCH METHODOLOGY

Materials and Apparatus

The main materials that were used to carry out this experiment were ground nut and eggshells, barite, and bentonite. The main equipment and apparatus used are summarized in **Table 1**.

Experimental Procedure

To prepare the water-based mud, 350 ml of distilled water was measured using a calibrated measuring cylinder to achieve the desired mud density, expressed in ppg. The measured water was then transferred into separate plastic containers designated for each experimental setup. The factors considered in the formulation included varying high and low values of eggshell, groundnut shell, bentonite, barite, and time. These additives were selected based on their potential to influence the physiochemical and rheological properties of the mud. The physicochemical were mixed in different proportions according to the predetermined experimental design. Each mixture was thoroughly homogenized to ensure consistent distribution of the additives throughout the fluid, preparing the samples for subsequent testing and analysis. This approach allowed for the systematic evaluation of the effects of each factor on the overall performance of the formulated drilling fluids.

Design of Experiment

To validate the experimental procedure, a design of experiment (DOE) approach was employed. DOE is a systematic method for determining the relationship between factors influencing a process and its output.

The factors considered in this study were eggshell, groundnut shell, barite, bentonite, and time. A factorial design was used, with five factors resulting in 32 sample experiments (25 = 32). The Minitab software was used to analyze mud samples. **Table 2** summarizes the low and high values for each factor used in the experiments.

Table 2. Factor levels for mud samples

Factor	Low value	High value
Egg shell (g)	2	10
Groundnut shell (g)	2	10
Bentonite (g)	15	25
Barite (g)	70	80
Time (days)	0	5
Water (ml)	350	350

Method of Analysis

Comparative analysis of the effect of groundnut shell and eggshell on pH and rheological properties

In this analysis, different proportions of groundnut shell and eggshell were added to the formulated water-based mud. The primary aim was to examine how these locally sourced additives impacted key mud properties, particularly mud density, pH, and viscosity. Mud density, an important indicator of the drilling fluid's capacity to support drilling cuttings and maintain wellbore stability, was measured across varying sample combinations. The pH levels were analyzed to assess the alkalinity or acidity of the mud, as these can influence the stability of the drilling fluid and the effectiveness of chemical additives. Rheological properties, including viscosity, were examined to determine the flow characteristics of the mud under various operational conditions, which is critical for efficient drilling operations. By comparing the performance of groundnut shell and eggshell in terms of these properties, the study sought to identify the most effective locally sourced additive for enhancing water-based mud performance.

Mud weight determination

Calibration of mud balance: Prior to conducting the mud weight measurements, the mud balance was calibrated to ensure accuracy. The procedure began with the removal of the lid from the mud balance cup, which was then filled completely with distilled water. The lid was replaced, and the exterior of the cup was wiped dry. The balance arm was placed on the base, with the knife edge resting on the fulcrum. To verify calibration, the rider on the balance arm was set to 8.33, and the level vial was checked to ensure it was centered. Once confirmed, the mud balance was considered ready for use. The water was then poured out, and the balance was dried for the subsequent mud sample testing.

Table 3. API standard numerical value requirements for drilling mud

Drilling fluid property	Numerical value requirements
Mud density (lb/gal)	9.60-10.50
pH	9.5 minimum-12.5 maximum
Viscometer dial reading at 100 rpm	10

Mud weight measurement: For the mud weight determination, the mud balance cup lid was removed, and the cup was filled with the prepared drilling mud sample. Care was taken to gently place the lid back on the cup to release any entrapped gas. The exterior of the mud cup was dried with a clean rag, and the balance arm was placed on the base, with the knife edge resting on the fulcrum. The rider was adjusted until the vial centered, at which point the mud weight reading was taken from the balance arm. This procedure was repeated for all prepared samples, with each sample measured and recorded systematically.

pH determination

The pH of the mud samples was measured using a calibrated pH meter. The electrode was first rinsed with distilled water to ensure no contamination from previous measurements, and the pH meter was adjusted to a standard reading of 7.00. The electrode was then immersed into the beaker containing the drilling mud, and the stable reading from the pH meter's digital display was recorded. After each measurement, the electrode was rinsed again with distilled water to prevent cross-contamination between samples. This procedure was repeated for all mud samples. The pH measurements were conducted twice, with a four-day interval between measurements, to assess any changes in pH over time due to potential chemical reactions occurring in the mud.

Rheological properties determination

To determine the rheological properties of the mud samples, including viscosity, the samples were thoroughly shaken to ensure uniform distribution of additives and proper viscosity measurement. The mud was then poured into the sample cup of the rheometer up to the designated mark. Once placed on the rheometer's base, the sample cup was aligned with the scribe line using the black knob, and the balance plate was secured by tightening the slack. The rheometer was activated, and the mud sample was stirred at 100 revolutions per minute (rpm). The rheological readings were recorded after the sample stabilized. This process was repeated for all prepared mud samples to evaluate their flow behavior and consistency under operational conditions.

RESULTS AND DISCUSSION

API Standard Numerical Value Requirements for Drilling Mud

This study conducted a comparative analysis of groundnut shell and eggshell as additives in water-based drilling mud. Thirty-two mud samples were prepared, incorporating varying amounts of these additives, bentonite, barite, and time. The effects of the local additives on the properties of the water-based mud were compared to API standards (**Table 3**).

Table 4. Experimental table of sample materials

SO	RO	CP	B	E	G	BE	BA	T
32	1	1	1	10	10	25	80	5
18	2	1	1	10	2	15	70	5
26	3	1	1	10	2	15	80	5
22	4	1	1	10	2	25	70	5
15	5	1	1	2	10	25	80	0
11	6	1	1	2	10	15	80	0
29	7	1	1	2	2	25	80	5
12	8	1	1	10	10	15	80	0
19	9	1	1	2	10	15	70	5
21	10	1	1	2	2	25	70	5
17	11	1	1	2	2	15	70	5
25	12	1	1	2	2	15	80	5
10	13	1	1	10	2	15	80	0
14	14	1	1	10	2	25	80	0
1	15	1	1	2	2	15	70	0
6	16	1	1	10	2	25	70	0
3	17	1	1	2	10	15	70	0
13	18	1	1	2	2	25	80	0
31	19	1	1	2	10	25	80	5
20	20	1	1	10	10	15	70	5
9	21	1	1	2	2	15	80	0
27	22	1	1	2	10	15	80	5
24	23	1	1	10	10	25	70	5
8	24	1	1	10	10	25	70	0
2	25	1	1	10	2	15	70	0
5	26	1	1	2	2	25	70	0
7	27	1	1	2	10	25	70	0
30	28	1	1	10	2	25	80	5
4	29	1	1	10	10	15	70	0
16	30	1	1	10	10	25	80	0
23	31	1	1	2	10	25	70	5
28	32	1	1	10	10	15	80	5

Note. SO: StdOrder; RO: RunOrder; CP: CenterPt; B: Blocks; E: Egg (g); G: Groundnut (g); BE: Bentonite (g); BA: Barite (g); & T: Time (days)

The API standards for drilling mud specify a minimum mud density of 9.60 lb/gal and a maximum of 10.5 lb/gal. The pH must be maintained between 9.5 and 12.5. The viscometer dial reading at 100 rpm should be 10.

Sample Description

The experimental setup used for this research follows a full factorial design with five factors–eggshell, groundnut shell, bentonite, barite, and time–each applied at two levels (high and low). A total of 32 samples were formulated based on the factorial design (2^5), which effectively covers all possible combinations of the input variables. Each mud sample's pH, density, and viscosity were measured to evaluate the effect of these local additives on the properties of water-based drilling mud, as shown in **Table 4**.

From the experimental values, there is a clear indication of the variability in mud properties caused by different combinations of materials and time. The pH ranged from 8.94 to 11.22 across the samples, mud density from 9.38 lb/gal to 10.17 lb/gal, and viscosity from 19.32 cP to 58.56 cP, as seen in **Table 5**. These variations suggest a strong dependency of the drilling mud properties on the type and proportion of additives used, particularly the effects of eggshell and groundnut shell, which were incorporated to enhance specific mud characteristics in alignment with API standards. For example,

Table 5. Experimental results

SO	RO	CP	B	E	G	BE	BA	T	pH	D	V
32	1	1	1	10	10	25	80	5	8.94	10.17	65.38
18	2	1	1	10	2	15	70	5	11.14	9.87	22.37
26	3	1	1	10	2	15	80	5	10.84	9.96	41.62
22	4	1	1	10	2	25	70	5	10.65	9.94	40.72
15	5	1	1	2	10	25	80	0	9.30	9.62	52.37
11	6	1	1	2	10	15	80	0	9.81	9.48	35.09
29	7	1	1	2	2	25	80	5	10.61	9.99	43.81
12	8	1	1	10	10	15	80	0	9.62	9.62	47.03
19	9	1	1	2	10	15	70	5	11.15	9.84	22.91
21	10	1	1	2	2	25	70	5	10.94	9.88	24.43
17	11	1	1	2	2	15	70	5	11.22	9.82	20.48
25	12	1	1	2	2	15	80	5	9.90	9.89	25.18
10	13	1	1	10	2	15	80	0	10.76	9.51	33.26
14	14	1	1	10	2	25	80	0	8.96	9.63	50.04
1	15	1	1	2	2	15	70	0	11.20	9.38	19.32
6	16	1	1	10	2	25	70	0	10.93	9.49	34.46
3	17	1	1	2	10	15	70	0	11.06	9.42	20.32
13	18	1	1	2	2	25	80	0	10.43	9.52	40.35
31	19	1	1	2	10	25	80	5	10.17	10.08	58.29
20	20	1	1	10	10	15	70	5	10.93	9.90	32.11
9	21	1	1	2	2	15	80	0	10.87	9.46	22.69
27	22	1	1	2	10	15	80	5	10.78	9.91	39.71
24	23	1	1	10	10	25	70	5	10.35	10.07	50.76
8	24	1	1	10	10	25	70	0	9.30	9.60	46.44
2	25	1	1	10	2	15	70	0	11.12	9.43	22.23
5	26	1	1	2	2	25	70	0	10.83	9.45	21.00
7	27	1	1	2	10	25	70	0	10.62	9.50	34.00
30	28	1	1	10	2	25	80	5	10.57	10.08	58.29
4	29	1	1	10	10	15	70	0	10.89	9.46	29.00
16	30	1	1	10	10	25	80	0	9.13	9.70	58.56
23	31	1	1	2	10	25	70	5	10.89	9.97	38.94
28	32	1	1	10	10	15	80	5	10.01	10.08	49.53

Note. SO: StdOrder; RO: RunOrder; CP: CenterPt; B: Blocks; E: Egg (g); G: Groundnut (g); BE: Bentonite (g); BA: Barite (g); T: Time (days); D: Density; & V: Viscosity

the API standard recommends a mud density range of 9.60-10.5 lb/gal and a pH range of 9.5-12.5.

pH

The pH of the mud samples ranged from 8.94 to 11.22, with an average value of approximately 10.3. The regression equation indicates that groundnut shell content had a positive (+0.53) influence on pH, while eggshell content had a slightly negative effect (-0.33). The interaction terms, as shown in **Figure 1** suggest a complex interplay between factors. These findings are consistent with the alkaline nature of groundnut shells, which contain potassium and magnesium oxides that raise pH levels when dissolved in the mud. Even so, the combination of groundnut shell and bentonite might have a slightly synergistic effect on increasing pH, while the presence of both groundnut shell and barite might have an antagonistic effect.

The pH plot also suggests that the interaction between additives is important, particularly between eggshell and groundnut shell, as seen in the significant interaction terms in the regression model (e.g., -0.011 egg groundnut). This interaction suggests that when both additives are present, their combined effect on pH is less than the sum of their individual effects, possibly due to competing reactions in the mud matrix. The API standard recommends a pH range of 9.5 to 12.5 for drilling mud. Most of the formulated mud samples fall within this range, suggesting their potential suitability from a pH standpoint.

Mud Density

Based on the experimental findings, the mud density across various formulations demonstrated both compliance and deviations from this standard, influenced by the proportion and interaction of local additives–eggshell,

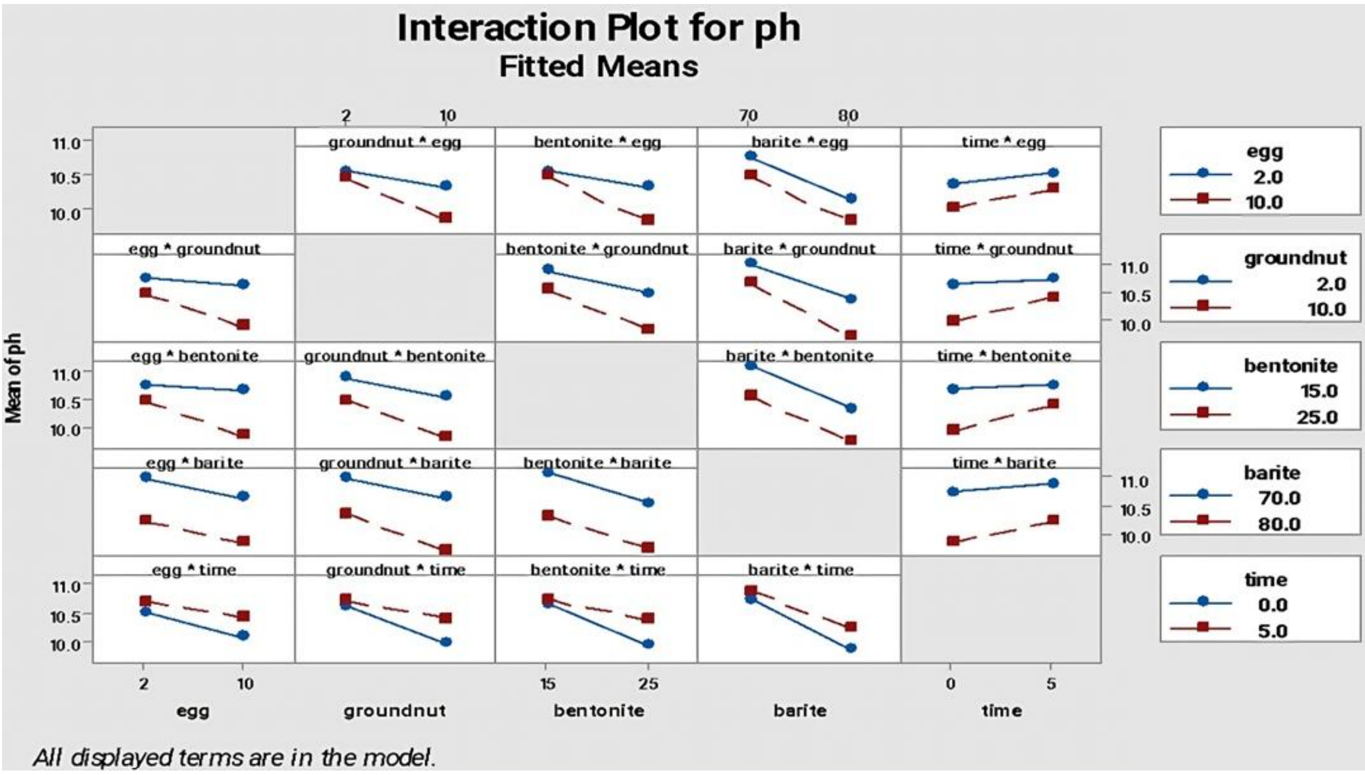

Figure 1. pH interaction plot (Source: Authors' own elaboration)

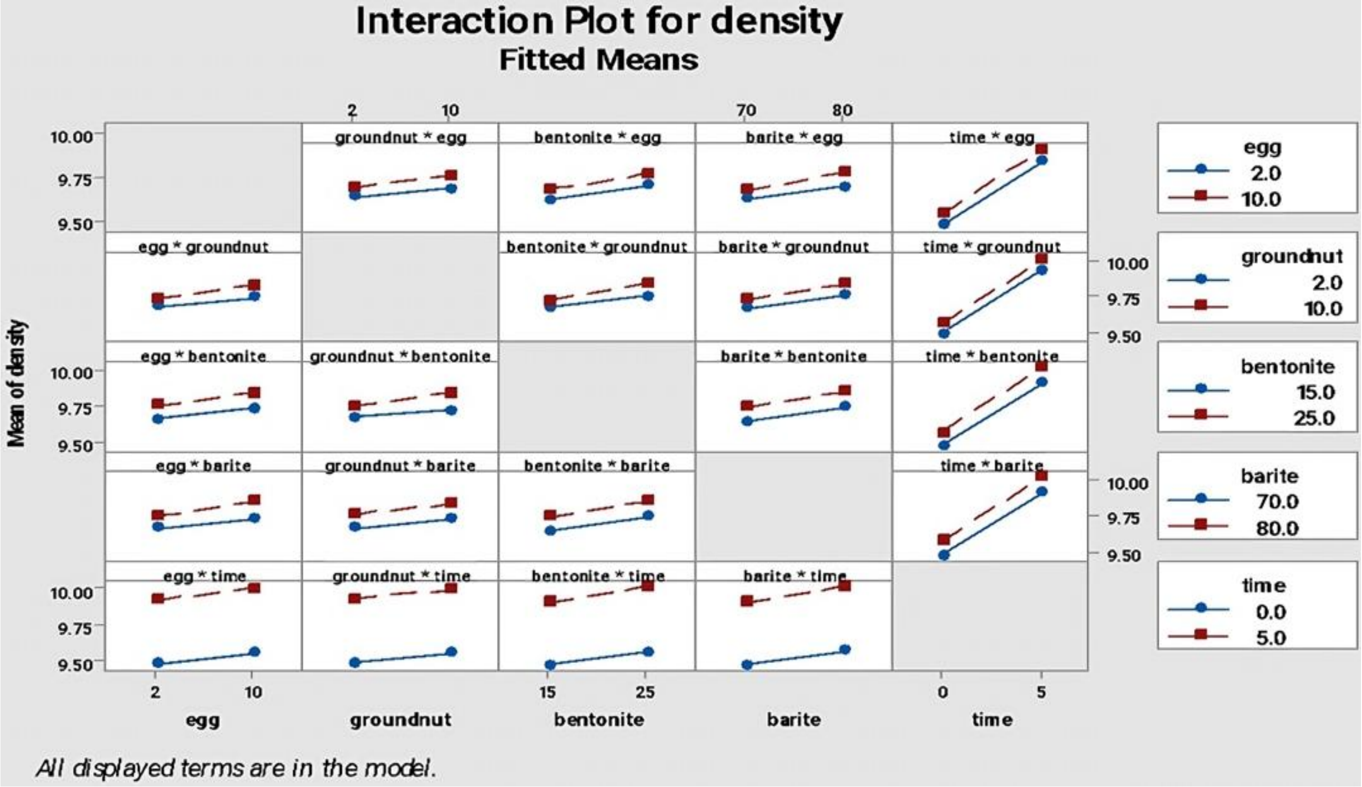

Figure 2. Density interaction plot (Source: Authors' own elaboration)

groundnut shell, bentonite, and barite–as well as the time factor. The mud density values obtained largely fall within the API standard range, with some exceptions. The regression equation for mud density indicates that while the individual effects of groundnut shells and eggshells on density are minimal, their interaction with other factors plays a significant role. Notably, the interaction between groundnut shell and bentonite has a positive effect on increasing density, as seen in **Figure 2**.

The model indicates that both eggshell and groundnut shell reduce the overall mud density, with eggshell having a slightly greater effect. Interestingly, barite, typically used as a weighting agent, shows a relatively small negative coefficient (-0.00841), indicating a minimal direct effect on density within the concentration range explored. Time, however, exerts a positive effect, suggesting that the duration for which the mud is left to age or mix contributes to a slight increase in density.

The interaction terms in the regression model, such as egg *groundnut (-0.00039) and bentonite barite* (0.000762), although small, indicate the presence of synergies or counteracting forces between different additives that further modulate density. For instance, the positive interaction between bentonite and barite suggests that while individually they may not significantly affect density, their combined presence strengthens the mud's structural integrity and density. It can be said, however, that formulations with higher quantities of barite led to increased mud density.

Upon analysis, most of the mud density values fall within the API standard range (9.60-10.5 lb/gal). However, deviations were observed in certain formulations, particularly those with lower concentrations of barite and higher concentrations of ground nut and eggshell. The reduction in density attributed to these local additives is significant, as both groundnut shell and eggshell are less dense compared to conventional materials like barite or bentonite. The slight reduction in density observed in samples with higher proportions of eggshell and groundnut shell can be attributed to their intrinsic material properties. Eggshell, largely composed of calcium carbonate, is not as dense as barite, a conventional weighting agent used to increase the specific gravity of drilling fluids. Similarly, groundnut shell contains lightweight fibrous components, which also contribute to the observed reduction in density.

Despite these findings, the positive interaction terms between additives suggest that a judicious combination of these local materials with bentonite and barite can mitigate the density reduction. For instance, while barite alone showed a minimal influence on density in this factorial design, its interaction with bentonite appears to slightly enhance mud density, as indicated by the positive interaction coefficient (0.000762). This suggests that barite and bentonite work synergistically to form a more cohesive mud structure that compensates for the lower density of the local additives.

Viscosity

The viscosity of the mud samples exhibited the highest degree of variation among the measured properties. Samples with a higher proportion of bentonite showed increased viscosity, with a peak value of 58.56 cP. This is expected, as bentonite is a known viscosities, which helps increase the fluid's resistance to flow. Additionally, the regression analysis revealed that groundnut shell, when combined with higher amounts of bentonite, also positively influenced viscosity, as indicated by a positive interaction term (+0.0173 groundnut bentonite), as shown in **Figure 3**.

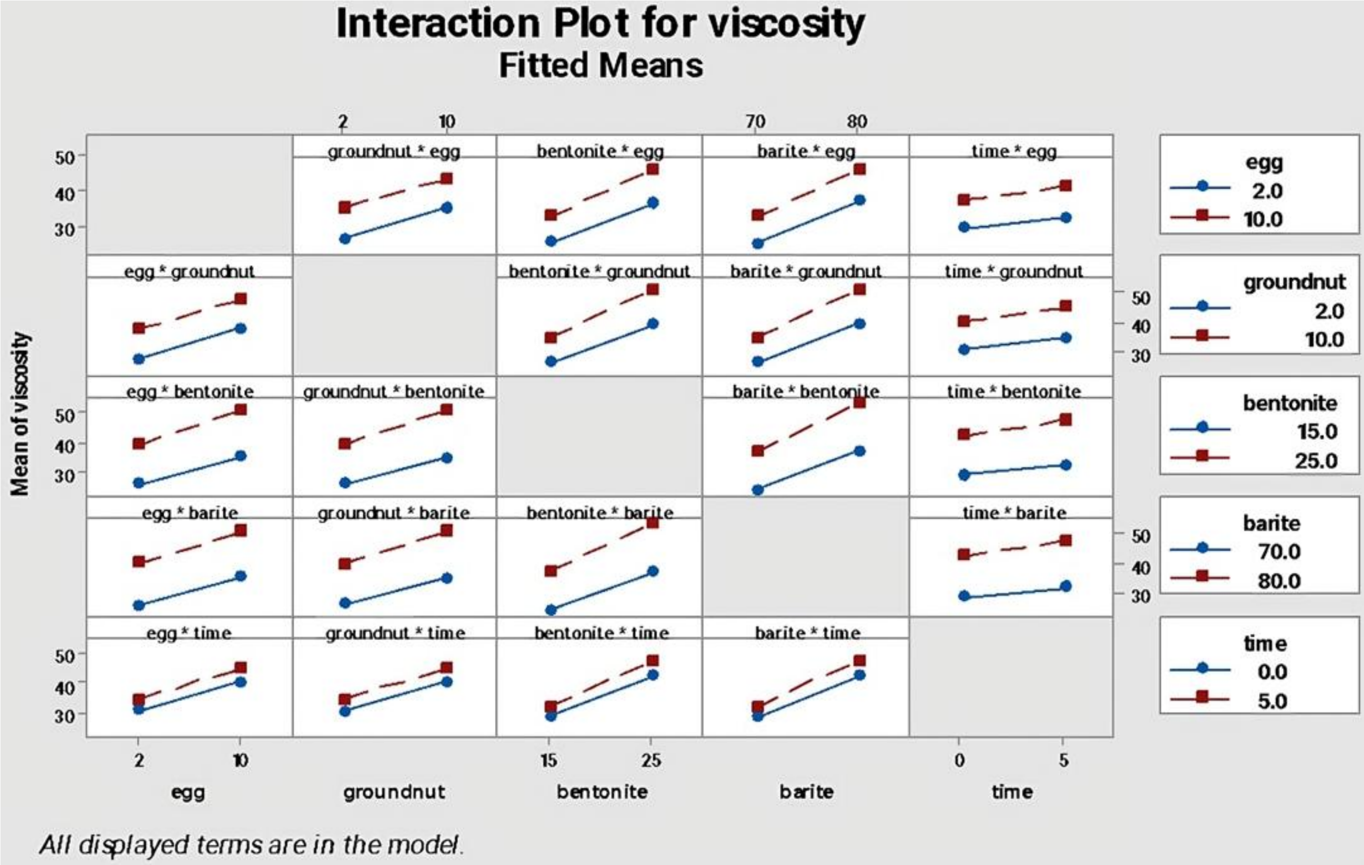

Figure 3. Viscosity interaction plot (Source: Authors' own elaboration)

From the result, the viscosity for an eggshell of 10 g, groundnut shell of 10 g, bentonite of 25 g, barite of 80g and time of 5 days gave a viscosity of 65.38. When the values were inputed into the model, a viscosity of 63.62, which is very close. We can infer that any values between the high and low values of the factors would give us the viscosity when we experiment. The interaction plot for viscosity shows that the presence of groundnut shell enhances the effect of bentonite on viscosity, likely due to the fibrous nature of groundnut shell, which can increase the solid content of the mud and contribute to a more structured network. This interaction results in better suspension stability, which is crucial in preventing cuttings from settling during drilling.

Interaction Between Factors

The regression equation highlights the presence of interaction terms, suggesting that the effects of groundnut shell and eggshell content on mud properties are not solely independent but influenced by their combined presence and interaction with other factors like bentonite, barite, and time. The inclusion of eggshells and groundnut shell as local materials provides an environmentally friendly and cost-effective alternative to conventional drilling mud additives. Eggshell, despite its slight reduction in pH, plays a significant role in stabilizing mud properties by providing calcium carbonate, which helps in maintaining an adequate mud weight. Groundnut shell, on the other hand, not only raises the pH but also enhances viscosity through its interaction with bentonite.

However, the interaction between these local materials introduces complexity in predicting the mud's behavior, particularly in terms of pH and viscosity. The regression model captures some of these interactions, but further studies could focus on optimizing the proportions of these additives to achieve the desired properties more consistently.

CONCLUSION

Drilling fluids used in the drilling industry are very important as they possess several functions that bring about successful and effective drilling campaigns. The behavior of drilling fluids under time factor is extremely important for drilling deep wells as pH of drilling mud tends to change and cause problems; thus, proper investigation on the proper use of additives is paramount so as to find additives to make drilling fluid withstand time. In this research work, an investigation was carried out on the individual and combined effect of eggshell and groundnut shell on the pH, density, and viscosity of barite and bentonite. In this research work, the experimental results demonstrate that using groundnut shell and eggshell as local additives can effectively modify the properties of water-based drilling mud, aligning with API standards in most cases. The effect of the individual and combined effect of eggshell and groundnut shell on the mud density, pH, and viscosity at 100 rpm was compared with that of the conventional additive used in the drilling industry. The experimental research has shown that both eggshells and groundnut shells serve as effective additives in drilling fluids, enhancing critical properties such as pH, viscosity, and density. The study demonstrated that eggshells had a marginally greater influence on the pH and viscosity of the drilling fluids compared to groundnut shells. While the individual effects of these local materials on density were minimal, their interactions with conventional weighting agents like barite and bentonite demonstrated potential for optimizing drilling fluid formulations. The research highlights that the right combinations of these local additives can help achieve desired drilling fluid properties that meet or exceed API standards. The experimental results also showed significant variability in drilling mud properties depending on the proportions of the additives used, with pH ranging from 8.94 to 11.22, mud density between 9.38 lb/gal and 10.17 lb/gal, and viscosity ranging from 19.32 cP to 58.56 cP. Based on the findings, it is recommended that further analysis be carried out on the shelf-life of the indigenous additive from combined eggshell and groundnut shell to properly certain the maximum time this product can be stored and still maintain an accepted quality and also to enhance their properties and overall efficiency.

Author contributions: Both authors have involved in all stages of this study while preparing the final version. Both authors agree with the results and conclusions.

Funding: No funding source is reported for this study.

Ethical statement: The authors stated that the study did not require approval from an ethics committee. It does not contain any studies with human or animal subjects performed by any of the authors.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from corresponding author.

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