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Reducing Environmental Impact of Drilling Operations through the Implementation of Organic Waste Additives for Environmental Protection

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Abstract **-** This paper aims to design a less toxic drilling fluid by testing different organic waste materials. The drilling mud is a complex fluid consisting of several additives used in the drilling process. Environmental protection is a crucial issue, and several drilling fluids and additives can have negative impacts on people, marine organisms, and plants. The selection of organic additives depends on safety concerns and the effect on the environment. The paper focuses on testing coffee residue, date seeds, and rice husks as organic additives in drilling fluids. The selection of these organic wastes was based on several factors, including cost, availability, and positive environmental impact. The properties of the mud samples, including rheology, mud filtration, and pH, were measured to determine the effect of the organic waste additives. The results showed that coffee residue can improve the lubrication properties of the fluid, and date seeds can increase the density of the fluid. Rice husks did not significantly impact the properties of the drilling fluid. The use of these organic additives can reduce the environmental impact caused by conventional additives, promoting a more sustainable and circular economy.

Keywords**:** organic additives, coffee residue, rice husks, drilling fluids and environmental impact.

1. Introduction

The drilling mud is a complex fluid that consists of a several additives, used in the drilling process. The types and quantities of the additives used depend on the employed drilling method, overbalanced drilling, or underbalanced drilling [1].

Environmental protection is an important issue when it comes to drilling operations. Several drilling fluids and additives can have negative impacts on people, marine organisms as well as plants. By designing an environmentally friendly drilling fluid, the environmental impact caused by the additives can be minimized [2].

As, an increase in concerns has risen regarding the effects that drilling fluids and its additives have on the environment. Though additives can help overcome different problems encountered during the drilling operation, they can have negative effects on the environment [3]. Some of the additives found in the drilling fluid can release hazardous vapours that may reach levels that exceed the safety exposure limit. Several additives such as lubricants, defoamers, viscofiers and corrosion inhibitors can negatively impact the environment. By dumping bentonite clay in freshwater environments can form a viscous gel, which kills the fish by trapping them in the gel and inhibiting their movement [4]. The drilling fluid additives can cause several health problems to the workers, including skin and eye irritations due to low pH drilling fluids, continuous contact with the base oil for long periods can cause drying and cracking of the skin, and respiratory problems due to toxic vapours [5].

Therefore, it is important to work towards replacing the toxic components with natural components. The selection of the drilling fluid system and the additives depends on the safety concerns and the effect on the environment. Due to the different environmental regulations, the selection of the drilling fluid additives must be carefully thought out and reconsidered. Therefore, testing organic additives and their effect on the drilling fluid properties is important to make decision about their use in the field [6].

Various researchers recommended several natural substitutes that can at least provide the same results as the usual additives [7]. The outcome of their recommendations was that the natural substitutes became important constituents in the drilling fluids [8].

The main objective of this paper is to test different organic waste materials to design a less toxic drilling fluid to minimize the impact of drilling fluid on the environment. The organic waste additives used are coffee residue, date seeds and rice husks.

2. Why coffee residue, date seeds, and rice husks

Organic waste additives, such as coffee residue, date seeds, and rice husk, have been increasingly used in various industries to reduce environmental impact and enhance sustainability. These waste materials are readily available, affordable, and renewable, making them an attractive alternative to conventional additives. In the context of drilling operations, the use of organic waste additives has been shown to improve the physical properties of drilling fluids, reduce the formation damage, and minimize the discharge of toxic wastes. Coffee residue, for instance, is a rich source of antioxidants and other organic compounds that can improve the lubricity and thermal stability of drilling fluids [9]. Date seeds, on the other hand, contain high amounts of lignocellulose, which can enhance the rheological properties of drilling fluids and reduce fluid loss [10] Rice husk, a by-product of rice milling, contains silica and other minerals that can improve the pH stability and filtration control of drilling fluids [11],[12].

The use of organic waste additives in drilling operations offers several advantages over conventional additives, including cost-effectiveness, sustainability, and environmental protection. By using waste materials as additives, drilling operators can reduce their waste disposal costs and minimize their environmental footprint. Additionally, the use of organic waste additives can contribute to the circular economy by converting waste materials into valuable resources.

3. Methodology

Preparation of Mud Samples and Measuring Properties

To start designing an environmentally friendly drilling fluid, three organic waste additives were selected, which are the coffee residue, rice husk and the date seeds. The base of the drilling fluid is 500 ml of 5% bentonite mud. A total of 14 mud samples were prepared according to Table 1.

Table 1 - mud samples

Mud Sample	Bentonite Mud	MWCR	MWDS	MWRH
Bentonite (grams)	25	25	25	25
Water (ml)	475	475	475	475
Coffee Residue (grams)	NIL	0.5, 1, 2.5, 5	NIL	NIL
Date Seeds (grams)	NIL	NIL	0.5, 1, 2.5, 5	NIL
Rice Husks (grams)	NIL	NIL	NIL	0.5, 1, 2.5, 5, 7.5

After preparing each mud sample, the properties of the mud have to be measured. These properties include the rheology, mud filtration, and pH. The rheological properties of the mud samples are measured using a viscometer to obtain the shear stress values at 600 and 300 RPM. The gel strength is also measured using the viscometer by obtaining the shear stress value at 3 RPM. The plastic viscosity and yield point are calculated using the following formulas [3]:

$$Plastic\ viscostiy\ (centipoise) = \boldsymbol{\theta}600 - \boldsymbol{\theta}300 \quad (1)$$

$$Yield\ point\ \left(\frac{lb}{100ft^2}\right) = \boldsymbol{\theta}300 - plastic\ viscosity \quad (2)$$

The filtrate loss of each mud sample is measured using the filter press. The cell body containing the mud sample is pressurized to 100 psi and the filtrate is collected after 30 minutes. After 30 minutes, the mud cake thickness can be measured by placing a caliper in the mud cake that has formed on the filter paper.

The pH of each mud sample is measured by using a pH meter. The electrode is placed in the mud sample until the value is stabilized. The pH is then read and recorded from the pH meter.

4. Results and Discussions

4.1. Coffee Residue

The results obtained from the coffee residue additive can be found in Table 2. It can be seen that by increasing the concentration, the plastic viscosity and the yield point are also increasing. The gel strength is the highest at the 5 grams concentration. The pH values indicate that the drilling fluids are alkaline. The values for the mud cake thickness and the filtrate loss are almost consistent for each concentration.

The best concentration is the 5 grams because it has the highest plastic viscosity and the highest gel strength, which can help in hole cleaning and allows the suspension of the cuttings when the circulation is stopped, respectively, while still having a mud thickness of less than 1/16 inches.

Table 2 - Properties of drilling fluid with coffee residue

Additive 1: Coffee Residue (500 ml of 5% Bentonite Mud)										
Concentration (grams)	θ600	θ300	PV (cp)	YP (lb/100 ft2)	Gel Strength		Mud Cake Thickness (mm)	Filtrate (ml)		pH
					10 seconds	10 minutes		7.5 minutes	30 minutes	
0.5	17	14	3	11	9	20	1.27	15	30	9.42
1	16	12	4	8	7	21	1.397	15	30	9.33
2.5	20	16	4	12	12	21	0.68	14	28	9.32
5	22	17	5	12	17	23	1.1	15.5	31	8.88

4.2. Date Seeds

The results obtained from the date seeds additive, which can be found in Table 4, show that the mud cake thickness and filtrate loss decrease when the concentration of the date seeds increases. The pH values indicate that the drilling fluids are alkaline. The date seed concentration of 5 grams did not result in any values for the plastic viscosity and the yield point. When the viscometer was switched on to θ600 and θ300, the viscometer did no provide any readings. Date seeds are usually used for sealing fractured formations. The date seeds are crushed into different diameters according to the size of the fracture. It can also be seen from Table 3 that the plastic viscosity and yield point values are almost the same for the different concentrations.

Table 3 - Properties of drilling fluid with date seeds

Additive 2: Date Seeds (500 ml of 5% Bentonite Mud)										
Concentration (grams)	θ600	θ300	PV (cp)	YP (lb/100 ft^2)	Gel Strength		Mud Cake Thickness (mm)	Filtrate (ml)		pH
					10 seconds	10 minutes		7.5 minutes	30 minutes	
0.5	18	12	6	6	6	9	2.286	23.6	47.2	9.35
1	18	12	6	6	5	8	1.27	25	50	9.54
2.5	20	15	5	10	8	19	0.3556	22	44	9.2
5	-	-	-	-	-	-	0.762	20	40	8.83

4.3. Rice Husks

The results obtained from the rice husk additives found in Table 5, indicate that the plastic viscosity increases when the concentration increases. However, the yield point decreases when the concentration increases. The filtrate loss increases when the concentration of the rice husk increases. Therefore, to reduce the filtrate loss while drilling, it is better to select a drilling fluid with a low rice husk concentration. In general, the pH of the drilling fluid is 9, which is a good indicator that the drilling fluid is not acidic and would not cause corrosion.

Table 4 - Properties of drilling fluid with rice husks

Additive 3: Rice Husks (500 ml of 5% Bentonite Mud)										
Concentration (grams)	θ600	θ300	PV (cp)	YP (lb/100 ft^2)	Gel Strength		Mud Cake Thickness (mm)	Filtrate (ml)		pH
					10 seconds	10 minutes		7.5 minutes	30 minutes	
0.5	40	36	4	32	24	32	8.22	8.5	17	9.15
1	39	34	5	29	22	37	6.1	7.1	14.2	9.2
2.5	21	17	4	13	9	13	1.016	5	10	9.4
5	21	17	4	13	11	25	0.6858	11.5	23	9.2
7.5	31	21	10	11	18	25	1.27	13	26	9.9

5. Conclusion

In conclusion, environmental protection is an important issue in the oil and gas drilling industry. There are many environmental concerns when it comes to the drilling fluid additives, such as barite as it can harm the marine organisms. By designing environmentally friendly drilling fluids, the environmental impacts can be reduced. For example, coffee residue is an organic waste matter that exists in bulk due to the high consumption of coffee. By adding it to a water-based drilling fluid, it can reduce the filtrate lost by acting as a filtrate control additive. This can in turn reduce the environmental impacts.

It was found that the coffee residue and rice husk could provide an excellent performance as viscofiers and provide an efficient gel strength that helps in suspending drilling cuttings. When the concentration of rice husk exceeds the limit of 5 grams as per laboratory results, it would show an increase in filtration loss, which is not a desirable condition in drilling operations. Furthermore, dates seeds exhibited an inversely proportional relationship between the concentration and the mud filtrate loss, as it showed a decrease in fluid loss when the concentration is increased.

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