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Using Environmentally Friendly Materials to Improve the Properties of the Drilling Fluid

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Abstract

This study presents a significant advancement in addressing the utilization of environmental additives to improve the properties of drilling mud. The current materials added to drilling fluids could cause a harmful effect on the environment and safety of individuals, highlighting the necessity for alternative additives. In this study, the potential use of orange peel powder (OPP) and Sidr leaf powder (SLP) as environmentally friendly additives to drilling fluid is evaluated. Laboratory tests were conducted to identify the impact of OPP and SLP on the drilling fluid properties. Different weights (1-20) % of OPP and SLP were utilized to prepare the drilling fluid. The results demonstrated that both OPP and SLP affected the rheological properties and filtration of the drilling mud. Notably, the density of the drilling fluid decreased significantly with the addition of crushed Sidr. Attributed to the composition of flavonoids and jujubogenin glycoside in the leaves, and citric acid in the orange peel. The specific weight of SLP and OPP (1.5 and 1.7 respectively) is considerably lower than that of bentonite (2.5), leading to a reduction in density. Sider leaves exhibited a high performance compared to orange peel, with the highest value of yield point, 10 min gel, pH observed at 20 gm of addition. The experimental findings demonstrate the impact of both materials, filtration, viscosity, and alkalinity, with Side leaves proving to be more in enhancing drilling fluid properties.

Keywords: Drilling fluid; environmentally friendly; Sidr leaves; orange peel.

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1- Introduction

Employment of advanced science and technology in oil industrial activities has led to environmental issues and distribution in ecological balance and cycles. These problems have far-reaching causes problems on a global scale [1]. As a result of increased consumption of chemicals, people need to produce environmentally friendly products and start using these products [2]. Eco-friendly drilling materials are products or facilities that have a lower impression on a person's health and the environment and must serve the same purpose and efficiency when compared to competing commercial products or services [3]. By using environmentally friendly products, pollution will be gradually reduced and eventually eliminated [4]. Eco-friendly products can be industrial models with the best level of energy saving. Unfortunately, many oil wells are drilled near the town and the rest of the drilling mud will be thrown away near those towns or in the soil at a hole prepared for that named pit [5]. Eco-friendly products can be defined as natural animal, plant, or wood textiles with natural biodegradability, which helps in reducing waste [6].

Ecological products are those that are produced 100% by nature and do not affect human health and the environment [7]. Ecological products are generally referred to as organic products. Many materials are used to prepare and enhance the properties of mud, for example polymers, salts, chemicals, and oil products in the oil industry, but some of those are not subject to biodegradation. If it leaks or is transferred into the environment, it will not decompose easily, which is described as a form of pollution whose effects are still clear on humans and the Earth. It has been proven that some clay additives pollute the environment, causing waste accumulation if not properly allocated. It may act as a catalyst for the growth of bacteria and insects, such as clay prepared from bentonite if left stagnant for more than a month [8]. A closer look is taken at the pollution resulting from the chemicals used in preparing drilling mud, which generates many environmental problems in oil sites. It is noted that the problem worsens over time, which requires finding alternatives [9]. A few years ago, used fluid was dumped in an open pit, polluting the natural environment and towns. This is no longer acceptable, and the drilling fluid must be disposed of in a manner where there is no pollution of the environment or towns [10]. Drilling mud is a mixture consisting of solid materials that are considered the dispersed phase, and a fluid, whether water or oil, which is considered the continuous phase. There is ongoing work to make all of these components environmentally friendly, that is, non-toxic and biodegradable in the soil [11]. Those additives include KCl, k_2SO_4, and some polymers, which are

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considered to have negative effects on the environment [12]. Therefore, the significance of discovering environmentally friendly materials has increasingly emerged, it is essential that these materials not only offer efficiency and economic factors, but also serve as excellent and acceptable alternative to chemical materials [13]. The global tendency to protect the environment from traces of chemicals and non-biodegradable additives has become prominent in the literature [14]. The consensus view seems to be the use of technologies to develop formulations to be added to drilling fluids, making them safer, more efficient, and more suitable for both humans and the environment [15]. Drilling mud can be prepared using water or oil as a base, or sometimes both. However, if the base is oil, complications may occur to workers and the environment. Therefore, castor oil is used to prepare the emulsion instead of using gas oil for the same purpose [16]. Environmental regulations call for increased use of water-based drilling mud rather than oil-based drilling mud. The reason is that the latter hurts the environment, especially in environmentally sensitive places [17].

Additional research in this field has confirmed that most commercial chemical additives fall into the category of non-biodegradable substances, which pose many risks when leaked into the environment [18]. Amanullah et al. [19] worked on finding a formula that could be used to control filtration. This was done by modifying the starch to reduce waste to a minimum and increase the efficiency of the formula. Ayad et al. [20] studied the possibility of using cashew and mango extracts to improve the performance of drilling mud. Their results demonstrated the possibility of using the two materials to reduce the corrosion of drilling mud on the material, and they also have inhibitory properties. Tavakkoli et al. [21] Analyze the effect of adding banana peel on the properties of drilling mud. The results proved that the banana peel powder solution has alkaline properties, as it could be an acceptable substitute for caustic soda. Martel [22] demonstrated the possibility of obtaining jujube seed powder from agricultural waste and using it as a filtration control. Jujube seed powder had an acceptable effect in controlling the filtration of drilling mud whether prepared with fresh or salt water. Faraj and Abdul Hussein [23] modified the formulation of an additive to reduce filtration loss from straw and made it a substitute for artificial starch. Their new formulation had an acceptable effect of controlling filtration, as well as acceptable resistance to salt and calcium. Assi and Haiwi [24] examined the possibility of using traces of grass, sugarcane, ground pomegranate peel, corn cob, and ground soybean husk as property improvers for drilling mud. Their results proved that both soybean peel powder and pomegranate peel powder increase filtration by more than 40% because they work to increase viscosity. The use of environmentally friendly materials is part of what is called sustainable development. Sustainable development is concerned with the environmental, economic, and social dimensions. Oriented towards the optimal use of available resources to respond to the requirements of individuals to preserve both the planet and individuals together [25].

In this work, the focus was on the possibility of using both orange peel powder, which is a biodegradable food waste, and Sidr leaf powder, which is a recycled material, as additives that have a beneficial effect on the properties of the drilling fluid. The first goal of this study is to work on the probability of using sider leaves and orange peel as additives as an alternative to some commercial chemicals that are damaging to the environment and people alike. Then the second objective of this study is to add those ecological additives to enhance the performance of Iraqi calcium montmorillonite (Ca-bentonite), as one of the accessible and low-cost clay. Iraqi bentonite was obtained from Wade Bashara / Western Desert /Anbar Governorate for use as a dispersed phase, as shown in Fig. 1.

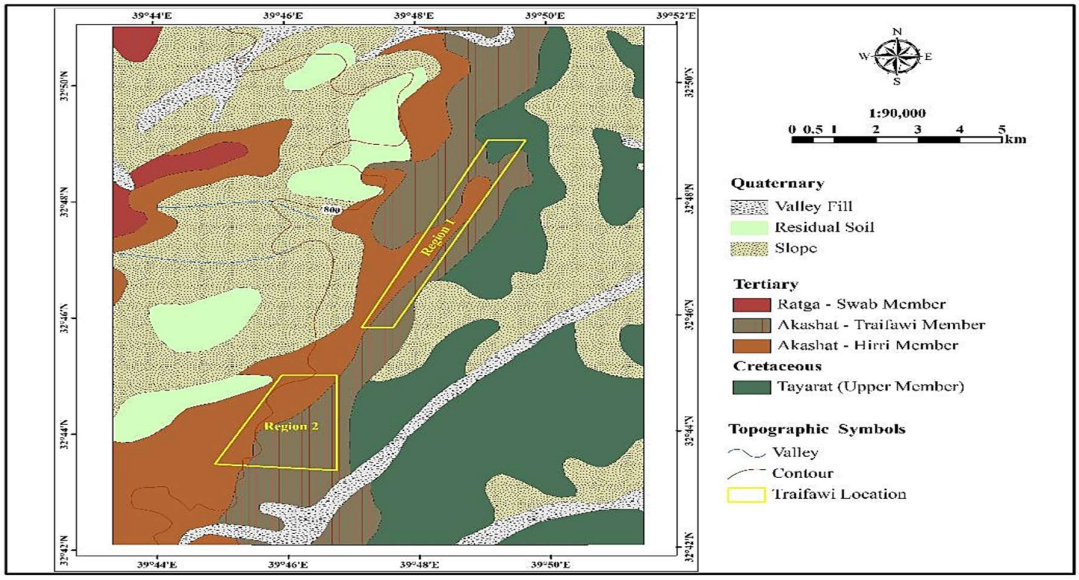

Fig. 1. Akashat Area (the Area Where Bentonite is Found) [4]

2- Materials and Method

According to the American Petroleum Institute (API), a typical 22.5g of Iraqi bentonite per 350ml of water is used for the preparation of base mud samples. The room temperature for all experiments was 20-22°C or (68-72°F). The pressure was atmospheric = 1 atm. or 1.0132 bar. Mud samples were examined and prepared according to American Petroleum Institute (API) standards. 22.5 grams of Iraqi bentonite from the Akashat area was used as in Fig. 1 with 350 cubic centimeters of water, and this was the basic model to which the materials used in the study were added. Samples were kept for 24 hours for hydration, and then measurements such as density, filtration, viscosity, and alkalinity were taken. The rest of the samples were prepared from bentonite (22.5 gm bentonite +350 cc water), with different proportions of orange peels and crushed Sidr leaves, starting from (1 gm to 20 gm). The used materials are as bellow.

2.1. Iraqi bentonite

Bentonite clay is a sort of clay initiate in nature, it is used as traditional customs and remedies in numerous cultures. The bentonite or clay montmorillonite from Trefawey claystone that was used in this research are samples taken from the Al-Anbar- Trefawey site / in the Western Desert in Iraq. Fig. 1 shows the site from which the samples of bentonite are obtained. X-ray fluorescence analysis (XRF) is done by XRF Spectrometry through SHIMADZU XRF-1800 in the German laboratory at the University of Baghdad / College of Science. The surveys for the Iraqi bentonite, orange peel, and SLP are illustrated in Table 1. The properties of the base drilling fluid are illustrated in Table 2.

2.2. Collection and preparation of the sider leaves Powder (SLP)

The beginning was by collecting the leaves of the Sidr plant from the Sidr tree (Zizyphus lotus in Iraq), avoiding the wilted and yellow leaves. After that, the leaves were exposed to the sun to dry for 2 days, and after a period of drying (2 days in winter T= 15℃ but in summer for 2 hours T= 45℃), the leaves were rubbed and cut into small pieces to speed up the drying process. After drying, the leaves are ready to be crushed into a fine powder by using a grinder, as shown in
Fig. **2** However, the process was in winter, so it must be considered that the leaves were not exposed to enough sun, where the temperature was 15 degrees Celsius. Drying may take less time in the summer. After grinding, a manual sieve was used to remove impurities and large pieces to ensure the quality of the powder. Sidr leaves powder contains flavonoids, tannins, and alkaloids. It also contains saponins such as jujubogenin glycoside, dammarane, and jujuboside.

The workflow chart of the collection and preparation of the (SLP) until using it as a powder at the experiment is shown in Fig. 3.

Fig. 2. Collection and Preparation of the (SLP)

Fig. 3. Workflow of Preparing of SLP

2.3. The preparation and collection of the orange peel Powder (OPP)

Raw orange peels were collected locally (1 kilo of Diyala orange, medium size, eight oranges), this quantity gave 120 gm of orange peel powder. Then, they were cut into small pieces to speed up the drying procedure and dispose of moisture quickly as referred to in Fig. 4 and Fig. 5. The pieces of orange peels were cited in the oven for an hour. After that, they were left in a dry place for 10 days at (22° C). As a last point, to ensure a complete drying progression, the orange peels were once again positioned in an oven at (40° C) till the peel was completely oxidized (5 min). When dried, the orange peels were crushed into a fine powder using a grinder and then sieved through a 200 mm sieve. Through an X-ray test, it was discovered that the orange peel contains a high percentage of calcium and potassium (they work to increase viscosity), and a small amount of zinc (helps to make gel) [21]. It contains limonene, a substance found in orange peel residue that is known as an antimicrobial agent. Orange peel contains elevated levels of flavonoids, as well as elevated levels of fiber (give stability and viscosity to the mud) and essential oil from orange peels which enhance the lubricity for orange peel [22]. So, a summary of the orange peels, they are obtained by peeling the oranges and then exposing them to the sun for two weeks or ten days. For more oxidization, place orange peels in the oven for minutes and finally ground them and sift the powder through a 200-size sieve.

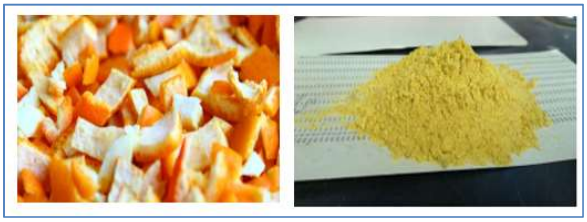

Fig. 4. Collection and Preparation of the Orange Peel

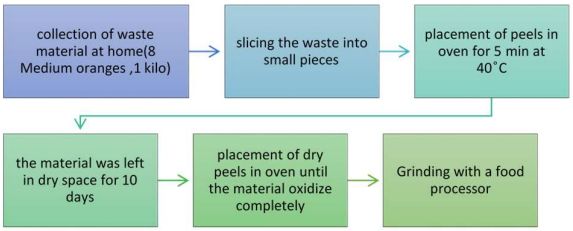

Fig. 5. Workflow of Preparing Orange Peel

Table 1. XRF Analysis for Iraqi Bentonite, Sider Leaves, and Orange Peel

Component %	Bentonite	Sider leaves	Orange peel
SiO_2	49	0.827	9.66
TiO_2	0.66	0.00383	0.00069
Al_2O_3	19	0.0885	0.0782
Fe_2O_3	6.55	0.01727	0.0001
MnO	0.7	0.00964	0.0001
CaO	2.44	4.31	1.844
MgO	4.33	0.728	0.2834
Na_2O_3	1.99	1.66	1.99
K_2O	0.87	2.54	1.213
P_2O_5	0.88	0.544	0.3284
Cl	0.11	0.38	0.615
SO_3	0.88	0.6165	0.2558
L.O.I	12.6	0.829	0.657
cellulose	non	44	69.01
Hemicellulose	non	40	16

Table 2. Properties of Base Drilling Mud (Iraqi Bentonite)

Shear rate RPM	Shear stress lb./ft^2	
600	26	
300	16	
200	14	
100	11	
60	9	
30	6	
6	5	
3	3.5	
Base mud properties		
Density	9.1	ppg.
Apparent viscosity	13	cp
plastic viscosity	10	cp
yield point	6	lb./100ft^2
10 sec gel	19.5	lb./100ft^2
10 min gel	24.5	lb./100ft^2
filter volume	10	cc
mud cake thickness	1	mm

3- Devices and Apparatus

The laboratory tests in this study were conducted at the drilling laboratory of the Department of Petroleum Engineering, University of Baghdad, using the following laboratory equipment and tools:

1. Mud Balance: to measure drilling fluid density, the density of mud is an important property because it is related to the hydrostatic pressure, and it is the first barrier against kick (well control).
2. Fan, Viscometer Model-35: for measuring rheological properties of mud. The viscosity of mud contributes of removal cutting from the annulus outside of the well (hole cleaning)
3. API Filter Tester: to measure drilling fluid filtration. Filtration is considered an important property because this property helps to make mud cake on the wall of the hole, in other words increases the stability of the well wall.
4. Electronic balance: To measure the weight of the used materials.
5. pH indicator strip and pH device: for measuring the pH of the samples. Measuring the pH of mud is a very essential test because the mud should have about 8.5 pH value at least to avoid pipe corrosion.

4- Results and Discussion

various drilling fluids cause environmental problems because of the presence of quantities of chemicals in the drilling fluids that pollute the environment, they must first be disposed of in one way or another so that the environment is preserved and the least possible damage to it. Environmental considerations have led to an increased interest in using water-based mud instead of oil-based mud because of the higher toxicity of the latter, particularly in environmentally sensitive sites. Many conventional chemical materials are non-biodegradable and pose significant risks if released into the environment. Those extras include but are not limited to; KCl, NaCl, some polymers, fluid loss control, etc., as they have multiple undesirable environmental impacts. The need has become urgent for novel ecological additives that can aid in enhancing the properties of the drilling fluid and recover its efficiency with the least impact on the environment. Global concerns to protect the environment from the deadly impact of non-biodegradable chemicals still exist today. These concerns are driving the industries toward drilling mud improvement technologies to progress safer and more ecologically formulations. Different proportions of orange peel and Sidr leaf powder were added to the baseline drilling fluid, which consisted of 22.5 gm of bentonite and 350 cc of water, where the rheological properties were examined. using a Fann viscometer, density using mud balancing, and using filtering Baroid filter pressure plus pH check with a pH meter. The results showed that the addition of crushed Sidr leaves leads to a significant reduction in density. Similarly, orange peels affected the density of drilling mud, as it also led to a decrease in its density at low addition rates, while the addition at high rates greater than 10 gm led to an increase in the density of the mud, as shown in Fig. 6. The reason behind this is that the leaves of the Sidr plant contain saponins of the type: jujubogenin

glycoside, dammarane, and jujuboside, which can make foam. There is a specific range for the clay balance, i.e., an upper and lower limit for density values. In some experiments, clay containing 5, 10, and 20 grams of Sidr leaf powder and the density value was outside the range specified for the scale (less than the minimum balance value), so it was not possible to measure the density. To solve this problem, a different method was used to calculate the density of mud by using a beaker and the density law as in Eq. 1. Plastic viscosity, yield point, and apparent viscosity were calculated by using Eq. 3, and Eq. 4.

$$\rho = \frac{w}{v} \quad (1)$$

Where: ρ: density ppg., w: weight of mud lb., v: volume gal.

$$\mu_p = \theta_{600} - \theta_{300} \quad (2)$$

$$yp = 2 * \theta_{300} - \theta_{600} \quad (3)$$

$$\mu a = \theta_{600} / 2 \quad (4)$$

Where: µp: plastic viscosity, cp. yb: yield point lb./100ft^2. µa: apparent viscosity, cp.

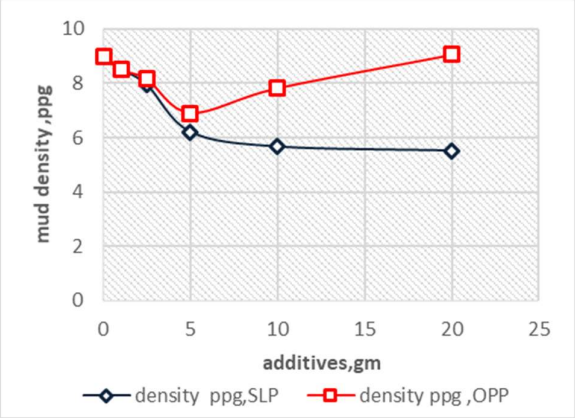

Fig. 6. The Effect of SLP and OPP on Mud Density

Fig. 7 refers to the effect of adding sidr leaves and orange peels on the viscosity of drilling mud. The addition of both materials contributed to an increase in the viscosity of the clay, but the orange peel had the greatest effect. This is because orange peels contain essential oils, fiber, and a percentage of cellulose. As for Sidr leaves, they contain saponins, which are a class of chemical compounds. They are semi-alkaline substances that reduce the surface tension of aqueous liquids and lather well. In addition, Sidr leaves contain flavonoids, which are a group of organic compounds that are soluble in water. Fig. 8 shows the effect of adding crushed orange peel and Sidr leaves on the size of the drilling mud filtrate and its comparison with the most famous filter reducer, carboxymethyl cellulose CMC. Where all the materials reduced the filtration volume of the drilling mud, but the CMC was the best and the reason is due to the ability of the materials used to absorb water and thus increase hydration and viscosity and reduce filtration. Table 3 shows the remaining laboratory results obtained. Where it is clear about the pH, the effect of Sidr paper is almost non-existent. As for orange peels, adding them leads to a decrease in the pH value, and this is due to being rich in citric acid, as citric acid is known as a weak organic acid. The addition of both materials led to a rise in the gel resistance value because both materials can gelatinize and form gelatinous structures over time, this is because both materials contain cellulose. It is an organic material and the most plentiful biopolymer in the world. It is a complex polysaccharide or carbohydrate involving thousands to hundreds of glucose molecules. Also, for yield point, apparent viscosity, and drilling mud cake thickness, both materials contributed to a noticeable increase in them. The reason for this is that both substances contain hemicellulose (also recognized as polyose), which is one of several heteropolymers (matrix polysaccharides), for instance, arabinoxylan, found laterally with cellulose in virtually all terrestrial plant cell walls.

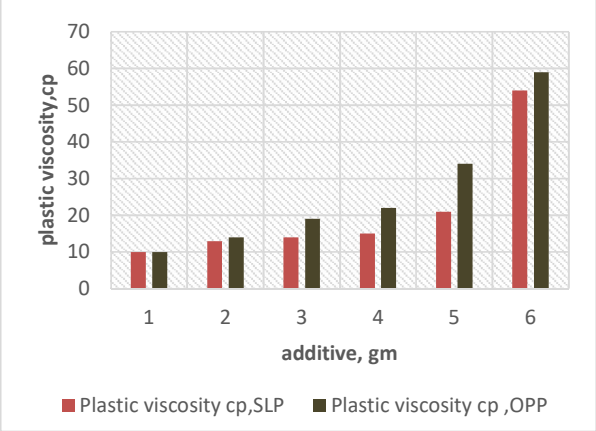

Fig. 7. The Effect of SLP and OPP on Drilling Fluid Viscosity

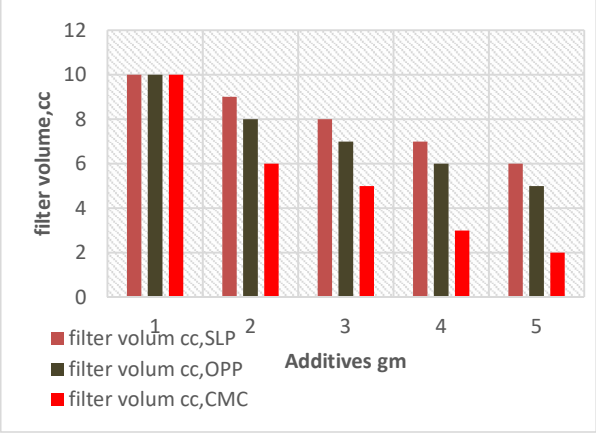

Fig. 8. The Effect of SLP and OPP on Mud Viscosity

Table 3. Laboratory Results

property	0 g	1g SLP	2.5g SLP	5g SLP	10g SLP	20g SLP
pH	9.1	9.2	9.21	9.22	9.22	9.25
10 sec Gel	19.5	9	12	17	24	36
10 min Gel	24.5	11	14	18	29	39
Apparent viscosity	13	16	19	24.5	35.5	54.5
Yield point	6	18	19	19.5	29	61
Mud cake thickness, mm	1	0.9	0.5	0.9	1.5	2.25
Property	**0 g**	**1g OPP**	**2.5g OPP**	**5g OPP**	**10g OPP**	**20g OPP**
pH	9.1	8.72	8.06	8.059	7.91	6.66
10 sec Gel	19.5	13	9	12	22	22
10 min Gel	24.5	14	11	14	25	30
Apparent viscosity	13	15	19.5	22	39	55
Yield point	6	14	16	21	25	39.5
Mud cake thickness, mm	1	0.7	0.6	1.1	1.2	1.5

5- Conclusions

The development of multifunctional drilling fluids with enhanced properties utilizing environmentally friendly additives shows promising potential. This paper describes the preparation of a novel drilling fluid utilizing crushed Sidr leaves and orange peel powder as additives to enhance rheological properties and reduce filtration of Iraqi bentonite. The study aimed to evaluate the effect of these additives on the drilling fluid across different percentages ranging from 1-20 gm. Results demonstrate that both materials can be effectively used as additives, causing reduced fluid density, and improved rheological properties, particularly with the addition of orange peels at 20 gm with significantly increased velocity. However, adding crushed orange peels led to a decrease in pH, which is undesirable during drilling. Sidr leaves showed negligible effects on pH but demonstrated improved gel strength indicating that these additives are feasible alternatives for some polymers. Additionally, the orange powder was observed to decrease filtration and alkalinity, presenting an economic substitute for traditional materials such as industrial starch and CMC. These findings propose the possible benefit of Sidr leaves and orange peels in improving drilling fluids properties and solving economic and environmental consequences in drilling operations.

Nomenclatures

SLP: sider leaves Powder
OPP: orange peel Powder
μp: Plastic viscosity
Yp: Yield point
Cp: Centipoise.
pH: the concentration of hydrogen ions (H+) in a liquid

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استخدام مواد صديقة للبيئة لتحسين خصائص مائع الحفر

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الخلاصة

يقدم هذا البحث وصفاً لتحضير سائل حفر جديد عن طريق إضافة أوراق السدر المسحوقة وقشور البرتقال إلى سوائل الحفر كمضافات لتحسين خصائص مائع الحفر. مواد الحفر الصديقة للبيئة هي منتجات أو خدمات لها تأثير أقل على صحة الإنسان والبيئة عند مقارنتها بالمنتجات أو الخدمات المنافسة التي تخدم نفس الغرض. ولذا فإن هذا البحث يقدم مسألتين، أحدهما أنه يسبب أقل قدر ممكن من الضرر البيئي والآخر هو أنه مقياس مقارن حيث يوجد عدد قليل جدًا من المواد الصديقة للبيئة تمامًا. الهدف من هذه المبادرة الجديدة هو التحرك نحو عمليات الحفر المستدامة، مع تقليل الضرر الذي يلحق بالبشر أو البيئة. من أجل تحقيق هدفنا في عمليات الحفر الصديقة للبيئة وعدم إطلاق أي ملوثات، تم استخدام أوراق السدر وقشور البرتقال المطحونه بنسب وزن مختلفة (١-٢٠)٪ لإعداد سائل حفر يمكن استخدامه في عمليات حفر الآبار. كان لأوراق السدر وقشر البرتقال تأثير على الخواص الريولوجية وترشيح طين الحفر. كان التأثير ملحوظاعلى الكثافة وخاصة أوراق السدر المطحونة حيث انخفضت الكثافة بشكل ملحوظ بعد إضافة المواد المذكورة أعلاه وتم الحصول على أعلى قيمة لمقومة الجل عند وزن (٢٠ جرام) من مسحوق السدر (٣٩ رطل / ١٠٠ قدم ٢)، بينما أعطى مسحوق البرتقال أقل قيمة للكثافة عند ٢٠ جرام حيث كانت القيمة ٦,٦ رطل / جزء. بالنسبة لمسحوق البرتقال كانت نسبة التحسن في قيمة مقاومة الجل حوالي ٢٠٪ من (٢٤,٥ إلى ٣٠) رطل / ١٠٠ قدم ٢ عند وزن ٢٠ جرام من الإضافة وأخيرا استخدام طرق مستدامة وصديقة للبيئة في كل مرحلة من مراحل صناعة النفط مهم جدا، وذلك بهدف التعامل معها على مستوى عالٍ من الممارسات المستدامة.

الكلمات الدالة: سائل الحفر، صديق للبيئة، أوراق السدر، قشر البرتقال.