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Utilizing Environmentally and Recycled Materials to Formulate Drilling Mud

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Abstract

It is important to pay attention to environmental regulations while preparing drilling mud because it has become aspects that must be taken into consideration both now and in the future. It is essential to use sustainable and environmentally friendly materials at every stage of the oil and gas industry if possible in order to ensure high standards of sustainable practices. Oil that has been used to prepare oil base mud have bad impact on soil and human at the same time. The using of flaxseed oil instead of gas oil to preparing emulsion is done in this paper. The results were encouraging, and showed the possibility of using flaxseed oil for preparing ecological emulsion. The efficacy of walnut shell powder as an emulsifying agent has been tested as a surface tension reducer and the possibility of using it to increase the stability of an oil emulsion either in reverse or direct at high temperatures (400°F). This research includes measurements of filtration, stability and rheological properties of oil emulsion under laboratory and high temperature. Sample C showed high stability less than 3% because it is a direct emulsion composed of 10% flaxseed oil and crushed walnut shells, which acted as an excellent emulsifying agent because it was composed of cellulose with a percentage of more than 40%. Sample E gave the highest viscosity values, and the reason for this is that it is a reverse emulsion consisting of 60% flax oil with a high viscosity, as it reached more than 70 centipoises at 400 degrees Fahrenheit.

Keywords: Ecological, Mud, Additives, Oil Well, Temperature.

الاستفادة من المواد الصديقة للبيئة والمعاد تدويرها لتكوين طين الحفر

الخلاصة:

من المهم الاهتمام باللوائح البيئية أثناء تحضير طين الحفر لأنها أصبحت جوانب يجب أن تؤخذ بعين الاعتبار سواء في الوقت الحاضر اومستقبلا. من الضروري استخدام مواد مستدامة وصديقة للبيئة في كل مرحلة من مراحل صناعة النفط والغاز إن أمكن ذلك من اجل ضمان معايير عالية للممارسات المستدامة. إن زيت الغازالذي تم استخدامه لتحضير الطين ذو الأساس الزيتي له تأثير سيء على التربة والإنسان في نفس الوقت. تم استخدام زيت بذور الكتان بدلا من زيت الغاز لتحضير المستحلب في هذا البحث حيث كانت النتائج مشجعة، وأظهرت إمكانية استخدام زيت بذور الكتان لتحضير المستحلب البيئي. تم اختبار فعالية

Open Access
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مسحوق قشرة الجوز كعامل استحلاب وكمخفض للتوتر السطحي وتم اختبار إمكانية استخدامه لزيادة ثبات مستحلب نفطي إما بشكل عكسي أو مباشر عند درجات حرارة عالية (400 درجة فهرنهايت). يتضمن هذا البحث قياسات الترشيح والثبات والخصائص الريولوجية للمستحلب الزيتي بدرجة حرارة المختبر ودرجات الحرارة المرتفعة. أظهرت العينة C ثباتاً عالياً حيث كانت نسبة الانفصال اقل من 3% لأنه مستحلب مباشر مكون من 10% زيت بذور الكتان وقشور الجوز المطحونة، والتي تعمل كعامل استحلاب ممتاز لأنها مكونة من السليلوز بنسبة تزيد عن 40% اما بالنسبة الى العينة E أعطت أعلى قيم للزوجة، والسبب في ذلك هو أنها عبارة عن مستحلب عكسي مكون من 60% زيت بذر الكتان ذو الزوجة العالية، حيث وصلت قيمة اللزوجة إلى حوالي 70 سنتي بواس عند حرارة 400 درجة فهرنهايت.

1. Introduction:

Drilling mud is an important part of drilling operations, as these operations cannot be accomplished without it [1]. Environmental friend is a term used to deal at a level that achieves the principle of sustainable development with all components of the environment, so that we rely more on renewable energies, the use of biodegradable and recyclable materials, in addition to the safe disposal of waste, by recycling it, of all kinds, while preserving natural resources, living species, and achieving the principle of sustainability. The environmental impact of the oil industry is also extensive and scalable [2]. Large amounts of toxic and non-toxic waste are generated during the extraction, refining and transportation stages of oil and gas. Drilling fluids prepared using oil or its derivatives are fluids used in drilling oil wells. It can be used at high temperatures and in reservoirs and layers sensitive to water, and it is of two types, the first is an external oil emulsion that contains water by up to 50%, and the second is an oil based that contains a little water [3]. The wrong choice of drilling fluid can cause problems during drilling such as Non Productive Time (NPT) [4]. In some oil sites, oil or its derivatives are used to prepare drilling fluid, and as it is known, the drilling fluid is disposed of after completing the drilling process [5]. In some oil sites, environmental regulations are not applied, as the drilling fluid is disposed of either by throwing it on the soil if the drilling is on land, or it can be thrown into the sea water if the drilling is offshore [6]. Oil or its derivatives is considered one of the most dangerous sources of soil pollution and its transformation into sterile soil that is unfit for plant and animal life and for all living organisms [7]. There are a large number of harmful compounds contained in crude oil, all of which pollute the land and water environment, which are in the form of toxic organic oil pollutants or oil pollutants [8]. Toxic inorganic, which includes many dangerous compounds such as phenol compounds, cyanide compounds, sulfide compounds, toxic metal ions, dissolved and suspended matter, and hydrocarbons [9]. The spread of oil or its derivatives on the surface of the water forms a layer that prevents gas exchange and prevents sufficient light from reaching phytoplankton, which causes an imbalance in the food chain [10]. Oil and its derivatives are also distinguished by

Open Access
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their high ability to interact and spread in several forms and reach air, soil, fresh water, seas or oceans, and in many different forms that depend on many vital, physical and atmospheric factors, knowing that all these forms are very dangerous and may meet in a certain location [11]. One, more or all of the shapes and the higher the number of those shapes the more difficult it will be to get rid of it [12]. In order to keep up with environmental standards for waste disposal, the oil and gas industry is facing some challenges in technological development in order to maintain a clean and safe environment [13]. During the drilling of oil wells, a good amount of drilling fluid comes back from the well, as it is sometimes difficult to dispose of it in a safe manner and according to environmental regulations [14]. Table (1) summarizes the previous studies put forward by previous researchers in the same context as the topic of this study, which aims to encourage the use of recycled and environmentally friendly materials in the oil industry. The aim of this study is to enhance the physical and chemical properties of drilling mud emulsions using an alternative environmentally friendly recycled additive under high temperature conditions and laboratory conditions.

Table (1): The related researches.

References	Materials & Results
[15]	Their paper focused on how different chemicals can turn into environmentally destructive pollutants after providing outstanding performance in oil and gas exploration. For example, oil-based drilling fluid works excellent in deep drilling and drilling in various geological fields, but it ends up (producing) a quantity of toxic and hazardous pollutants to the environment.
[16]	Their article explained the latest drilling fluids. The main types of drilling muds, their limitations, strengths and the best limitation treatments were discussed. It also discussed the current trend as well as the future challenges of this technology. They have provided guidelines for future research focusing on encouraging the use of ecological drilling muds without environmental impact. The paper concludes that the future trend is towards promoting sustainable drilling mud.
[17]	Their results showed that the soybean husk powder reduced fluid loss up to 60% and improved yield point and gel resistance up to 330% and 640%, which gives promising results to the usability of each of the aforementioned additives as rheology modifier and leaching control agent. While other materials such as tamarind gum and henna significantly reduced the pH, which confirms their ability to be used as materials to control the pH, such as during drilling through cement.
[18]	The effect of adding potato starch as one of the environmentally friendly materials was studied on the properties of the drilling fluid. The results of

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Vol. 14, No. 3, September 2024, pp. 37-51
P- ISSN: 2220-5381
E- ISSN: 2710-1096

	the study demonstrated the possibility of using potato starch to reduce filtration and increase the viscosity of drilling mud.
[19]	They chose biodegradable herbal feed powder (GP) as filter reducer and compared it with field additives such as starch. Their results prove that GP can reduce the amount of non-decomposing waste, and have encouraging results for its use as a biodegradable drilling mud additive.
[20]	They studied the effect of adding crushed banana peels and corn cobs as one of the recycled materials on the properties of the drilling fluid. The laboratory results of their studies demonstrated the possibility of using the aforementioned materials to reduce filtration, increase the viscosity of drilling mud, and increase the gel strength of drilling fluids.
[21]	Investigated the Effect of the Temperature on the Oil-Based mud which Formulated from the Castor Seed Oil. He founded that the possibility of using castor oil to formulate oil base mud at high temperatures.

2. Material and Methods

2.1 Experimental work: In this research, six models of drilling mud were used, and the study was done for some tests under laboratory conditions 60 ° F and 14.7 Psi, and others with high pressure and temperature 400 °F and 500 psi. Table (2) shows the composition of the drilling muds used in the study. Also, the mixing method is very important for the success of the oil emulsion, as the continuous phase (oil in the case of reverse emulsion and water in the case of direct emulsion) is added first, then the emulsifying agent, then the dispersed phase (water in the case of reverse emulsion and oil in the case of direct emulsion). As for models A, B, C, and D, they are considered direct emulsions with an oil / water ratio = 10%. As for the models E and F, they are reverse emulsions with a ratio of water / oil =40%.

Table (2): Mud samples composition.

Drilling Fluid Constituents Measured Quantity						
Samples and materials	**A**	**B**	**C**	**D**	**E**	**F**
Gas oil	0	35	0	35	0	350
Flaxseed oil (ml.)	35	0	35	0	350	0
Water (ml)	350	350	350	350	140	140
Bentonite (g)	10	10	10	10	10	10
Crushed walnut shells(gm)	0	0	10	10	0	10
Flaxseed gel (ml.)	10	0	10	0	20	0
Caustic soda (g)	7	7	7	7	7	7
antifoaming (Silicone defoaming)(g)	5	5	5	5	5	5
CMC (g)	3	3	3	3	4	4
Spersene (g)	0	4	0	4	6	6

Open Access
Vol. 14, No. 3, September 2024, pp. 37-51
P- ISSN: 2220-5381
E- ISSN: 2710-1096

2.2 Materials: below are the materials that were used in the study:

2.2.1 Flaxseed oil soluble in water: Flax is an annual or perennial plant and belongs to the flax family. The parts used in the flax plant are the oil and seeds. The flax plant is about a meter high, has a slender stem and leaves, and its flowers are blue in color, while the seeds are brown. Flax is grown from the eastern Mediterranean to India and is also grown in Europe. it's an environmentally product which contain amount of the linoleic acid, its colorless to yellowish oil. The fuel that generated from this oil has extraordinary viscosity. The specific gravity of flaxseed oil is 0.924 @ 25^{o}C which give the possibility to mix with water. It does not contain any chemical additives that harm health and the environment, such as volatile organic compounds. It can withstand temperatures of up to 350 degrees Fahrenheit (176.67 degrees Celsius) for two hours. Because it fills pores, flaxseed oil can block pores for formations, its hydrophobic nature of hydrocarbons is also beneficial [22]. As for the flaxseed oil used in this study, it is of European origin. Flaxseed oil and gel can be prepared at home. Put two cups of water and add half a cup of flaxseeds into a pot over medium heat. Let it cook and boil while continuing to stir the mixture with a wooden spoon. Remove from heat, until a white, foamy, gel-like liquid appears and allow to cool for 20-30 minutes. Use a thin cotton cloth to extract the gel from the flaxseed mixture and store it in an airtight container, Figure (1) shows flaxseed and its oil.

2.2.2 Diesel oil: Most of the oils have been used in the preparation of emulsions, but diesel oil is the best because of its suitable properties, which are: non-fracturing, high glow point to reduce fire accidents, and an inline number greater than 155 in order to reduce damage to rubber parts, and finally a low spill point for the purpose of using it in temperatures different temperature. Its flash point is always higher than 50°C, and the specific gravity is 0,82 to 0,845 at (25 °C) [23].

2.2.3 Bentonite is an impure clay composed primarily of montmorillonite. The precautions taken while handling the substance vary according to the quantity and conditions of handling it. It is advised to protect the eyes, use gloves and a dust mask, and bentonite should be handled in a well-ventilated environment, and scattered dust should be reduced as much as possible. Bentonite has an abundance of minerals, including calcium, magnesium, silica, sodium, copper, iron, and potassium. aluminum. In addition to the presence of alkaline elements and alkaline earth elements within its internal composition, its specific gravity is 2.5 [24]. However, the used bentonite in this study is sodium bentonite and Chinese origin.

Open Access
Vol. 14, No. 3, September 2024, pp. 37-51
P- ISSN: 2220-5381
E- ISSN: 2710-1096

2.2.4 Carboxyl Methyl Callous CMC: Carboxylic methyl cellulose or carboxymethyl cellulose is a cellulose derivative with carboxymethyl groups (-CH2-COOH) attached to some hydroxyl groups of the glucopyranose monomers that make up the cellulose chain. It has several uses, but in this study it was used as an emulsifying agent [25].

2.2.5 Sodium hydroxide: is a strong chemical compound with the chemical formula (NaOH). It is also known as caustic soda and is used in many industries. Its solubility in water is very high, and aqueous solutions reach large concentrations. It was used in this study for the purpose of increasing alkalinity [26].

2.2.6 Walnut shell powder: is naturally derived from walnut shell, which is natural, biodegradable and non-toxic. It is a soft abrasive compatible with anionic, non-ionic and cationic surfactants. Walnut shells have antibacterial properties and this has the benefit of preventing rotting of the drilling fluid. It has the ability to absorb oil, so it is very useful as an emulsifying agent. And preparing it is very easy, as all that needs to be done is to dry the walnut shell, grind it and use the powder. The chemical composition of Walnut shell powder is illustrated in Table (3).

Table (3): Chemical composition of Walnut shell powder

Elements	Concentration %
Nitrogen	0.10٪
Cellulose;	40-60٪
silicate	10-20٪
Toluene solubility	0.5-1.0٪
Methyl	6.50٪
Chlorine	0.10٪
Ash	1.50٪
To cut	1.00٪
Calcium	0.50٪
Magnesium	0.03٪
Copper	1.31٪
Sodium	0.02٪
Iron	0.02٪
Manganese	0.09٪
Potassium	0.03٪
Zinc	0.05٪

Open Access
Vol. 14, No. 3, September 2024, pp. 37-51
P- ISSN: 2220-5381
E- ISSN: 2710-1096

Fig. (1): The used materials: a) Crushed walnut shells, b) crushed Flaxseed and its oil

2.3 Devices:

below devices are used to achieve the experimental work at HPHT conditions (60 -400) F. However, all samples are prepared in the laboratory and kept for 24 hours for dehydration, then the required properties are measured by using:

a. Beam balance: to measure the exact mass of the used materials.
b. Mud Mixer: The Hamilton Beach Mixer to mix emulsions until me homogenous.
c. Mud Balance: to measure mud density.
d. viscometer with hot plate: is used measure the mud rheology.
e. HPHT Filter Press: to measure mud filter volume and mud cake thickness.
f. h. PH paper and PH meter: to determine the alkalinity or acidity of a mud.
g. (EP) Extreme pressure and lubricity test: to measure the lubricating quality of drilling fluid.

2.4 Theory and Calculations:

Equation from 1 to 3 are used to find the required parameters after ending the experiments.

$$\mu_p = \theta_{600} - \theta_{300} \quad \mathbf{1}$$

$$\rho = \frac{w}{v} \quad \mathbf{2}$$

$$\text{lubricity cofficient} = \frac{\text{meterreading}}{100} * \text{correctio factor} \quad \mathbf{3}$$

Where: μp: plastic viscosity cp, ρ: density ppg., w: weight of mud lb., v: volume gal

If the percentage of oil in the formula is less than 20%, the outer phase is usually water and the inner phase is oil, but if the percentage is greater than 40%, the outer phase is oil and the inner phase is water. The active substances consist of two groups: a polar group, which is the hydrophilic group, and a non-polar group, which is oil-loving. Hydrophilic-Lipophilic Balance (HLB) Used to

Open Access
Vol. 14, No. 3, September 2024, pp. 37-51

P- ISSN: 2220-5381
E- ISSN: 2710-1096

determine whether surfactants (surfactants) are hydrophilic or oleo phobic (hydrophobic). The most popular method for calculating the balance factor is the griffin method as in equation 4.

$$HLB = 20 * \frac{Mh}{M} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

M_h: is the molecular mass of the hydrophilic molecule.

M: is the molecular mass of the entire molecule.

The resulting HLB value is represented on a scale from 0-20, where the value (0) represents a completely oleo phobic material, while the value (20) represents a completely hydrophilic material, and the HLB value indicates the properties of the surfactant. Walnut shell powder was used as an emulsifying agent. In this case, ground nut shells work to reduce surface tension, allowing the possibility of making tiny droplets of oil into a quantity of water, or vice versa. Whereas, if the crushed walnut shells were not present, the two liquids would not have mixed, because the surface tension forces of each of the two liquids are greater than the cohesion forces of one of them with the other. Figure (2) shows the effect of emulsifying and mixing on giving stability and homogeneity of the emulsion.

Fig. (2): Effect of emulsifying agent and mixing on emulsion stability

3. Results and Discussion:

The operations associated with the activities of the oil industry in Iraq, whether related to the production of crude oil or sequestration gas, or the production of oil derivatives in refineries, has left clear negative effects on the Iraqi environment through Pollution of air, water and soil due to the backwardness of this industry and its lack of interest in environmental requirements. The Iraqi environment has suffered greatly as a result of oil and gas operations, which has led to significant pollution of environmental elements different types (water, air and soil), through drilling oil wells,

Open Access
Vol. 14, No. 3, September 2024, pp. 37-51
P- ISSN: 2220-5381
E- ISSN: 2710-1096

whether exploratory or productive, and the resulting Water, mud, acids and various chemicals that can leak or mix with the elements of the environment, causing It has pollution, as many liquid materials or solid materials are added during the drilling process. And perform these additions. This leads to contamination of groundwater in particular, surface water and lands adjacent to the excavation area. Figure (3) shows the effect of time on the stability of the emulsion. The stability of the emulsions was examined over several periods ranging from one day to a week. It was found that the relationship was inverse, but sample C showed high stability. Whereas, Emulsifier C is a direct emulsion composed of flaxseed oil by 10% and crushed walnut shells, which worked as an excellent emulsifying agent because it is composed of cellulous, which act as an emulsifying agent. Figure (4) shows the lubrication ability of the emulsion models used in the study, where the F model showed the lowest lubrication factor, which means high lubrication ability. The reason behind this is due to being a reverse emulsion consisting of 60% of gas oil. It should be noted that the lubricating property of drilling fluids is desirable and important to reduce drilling speed and reduce friction and differential sticking. Figure (5) shows the measurement of the density of the emulsions, as model F gave the lowest density value of 6.2 ppg. This is because it is composed of 60% gas oil and 10 gm crushed walnut shells, which act as density reducers, as their specific weight is 0.82 and 1.5 respectively. Figure (6) shows the effect of temperature on the viscosity of the emulsions, where sample E showed the highest values of viscosity. The reason behind this is that it is a reverse emulsion consisting of 60% flax oil with high viscosity. Table (4) shows the results of filtration for different temperatures and the PH values for the tested mud samples. By increasing temperatures, the filter volume decrease which is desirable features through drilling.

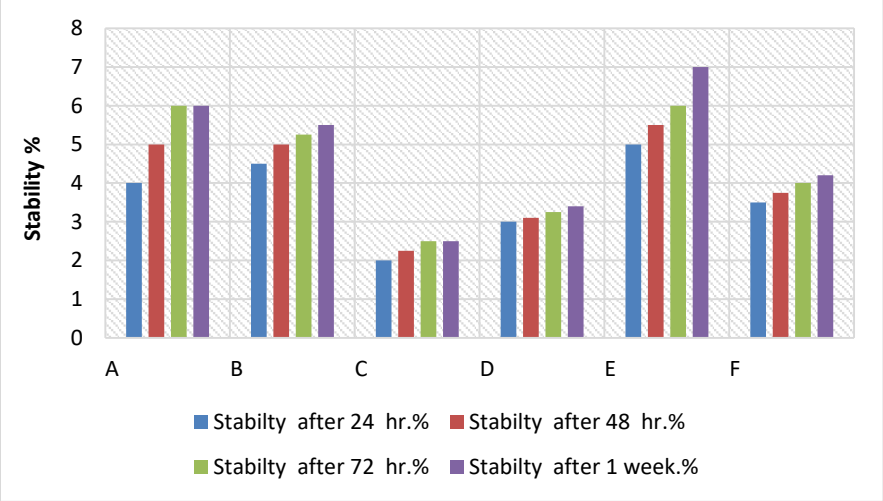

Fig. (3): Stability of mud samples at different times.

Open Access
Vol. 14, No. 3, September 2024, pp. 37-51

P- ISSN: 2220-5381
E- ISSN: 2710-1096

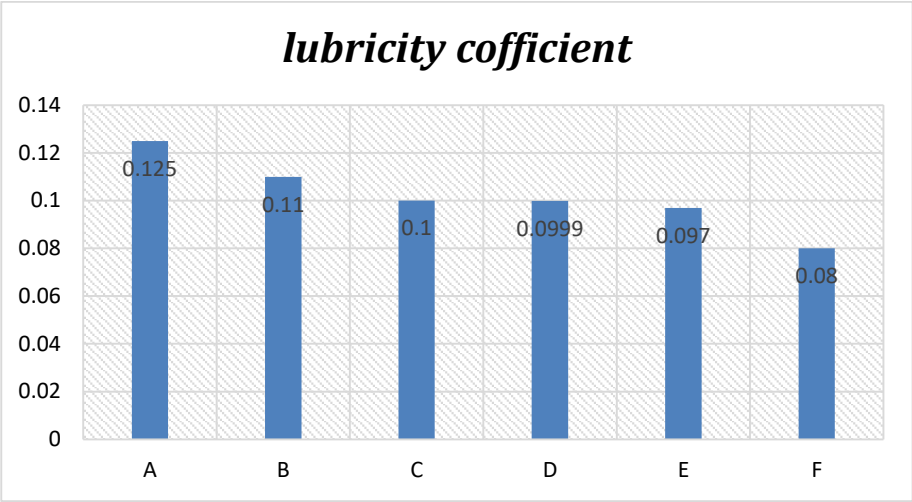

Fig. (4): Lubricity coefficient for mud samples

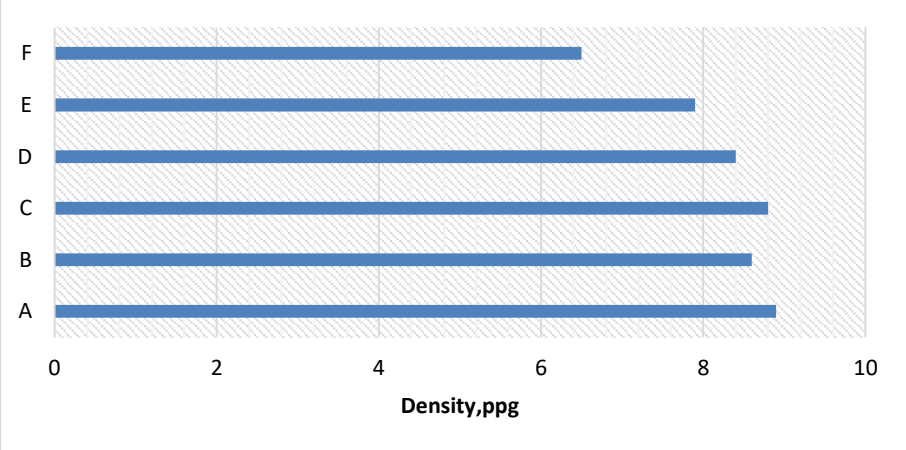

Fig. (5): Density of the studied samples

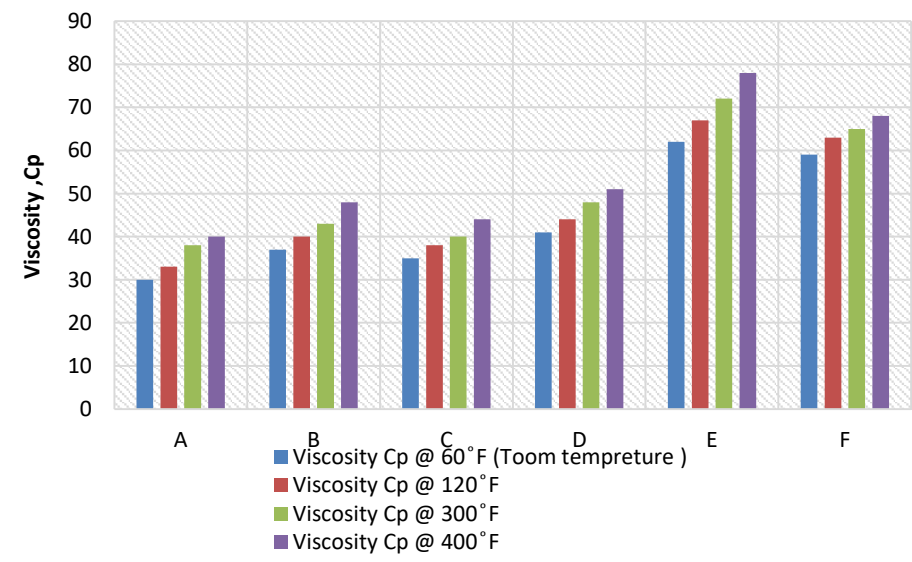

Fig. (6): Viscosity for the studied samples at different temperatures.

Open Access
Vol. 14, No. 3, September 2024, pp. 37-51
P- ISSN: 2220-5381
E- ISSN: 2710-1096

Table (4): The other laboratory results.

Samples	A	B	C	D	E	F
Filter volume cc @ 120 °F	7.5	6	7	7.1	5.8	5.1
Filter volume cc@ 300 °F	7	5.8	6.7	6.6	5.2	4.7
Filter volume cc@ 400 °F	6.8	5.2	6.3	5.7	4.8	4.4
pH of samples at 60 °F	8.8	8.87	9	9.1	8.88	9.2

4. Economic Aspect:

The economic feasibility study is defined as a scientific tool used to rationalize new investment decisions or to evaluate previously made decisions. Or make a comparison between the available alternatives on technical and financial grounds and in light of specific data. It relates to the project location, operating costs, operating capacities, revenues, and the type of technology used. Regarding this research, all materials used in the study are available and not harmful to the environment. The economic aspect of the study may be represented by the effects of drilling fluids prepared from petroleum derivatives on the environment compared to their environmentally friendly counterparts. Pollution is the addition of any harmful substances or elements to the environment, such as volatile substances and toxic particles, as a result of human activity in a way that can affect the quality of life and human well-being and cause damage to vital materials and ecosystems. The price of a metric ton of ground walnut shells is approximately 200$. The price of a kilogram of flax seeds is approximately 6$. As for flaxseed oil, the price of one liter is 2$. The price of one liter of gas oil is approximately 1,000 Iraqi dinars. The topics of the environment and environmental studies have received the attention of specialists and public opinion in the last decade and have had an impact. The arrival of drilling fluid prepared from petroleum derivatives (oil emulsion) into the soil, causing pollution, shrinking agricultural areas, and decreasing crop production. The degree of oil pollution depends on the degree of pollution and the extent of the impact or negative effects of this oil on the environment to the greatest extent possible, which requires making great efforts and knowing how to remove those effects, especially from the soil. Topics and studies that address environmental issues to consider the problem of pollution as one of the most urgent environmental issues. Which began to take environmental, economic and social dimensions. Since ground walnut shells are composed of cellulose, they are biodegradable, as are flax seeds, as they do no harm to the environment, unlike emulsified drilling fluids (prepared from petroleum derivatives). This type of liquid requires additional costs for treatment and reducing

Open Access
Vol. 14, No. 3, September 2024, pp. 37-51
P- ISSN: 2220-5381
E- ISSN: 2710-1096

environmental pollution. According to a study in America, pollution emanating from oil and gas operations in Colorado will cause more than 13$ billion in damage between 2020 and 2030.

5. Conclusions:

One of the most important results of this study is the possibility of using flaxseed oil to prepare an oil emulsion. Where it showed high stability and high stability as well, but it needs continuous mixing because its viscosity is high. And one of the most important conclusions of this study is the possibility of using crushed walnut shells as an emulsifying agent, because it is a material that reduces surface tension and contains high levels of cellulose, reaching more than 50%. Cellulose is a filler, thickener, stabilizes emulsions, is biodegradable, and is a renewable resource. Compounds derived from cellulose tend to be non-toxic. As Flaxseed gel, it is considered one of the materials that increase the viscosity and lubrication of the drilling fluid because it contains high levels of flavonoids and potassium. At high temperatures (300-400)$^{\circ}$F, the viscosity and volume of the filtrate decreased as a result of the evaporation of part of the continuous phase.

Open Access
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