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A Comprehensive Study on the Stability of Emulsions in the Oil Industry Using Ecologically Materials

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Abstract

Sustainable products are those that offer economic, social, and environmental benefits while safeguarding public health and the environment throughout their entire lifecycle, from raw material extraction to final disposal. Since the beginning of human understanding, technologies and societal expectations have continued to evolve. Therefore, sustainable products must constantly adapt to social and environmental diversity. In this study, ground Crushed palm leaves, sider leaves, egg shells and orange peels were utilized as an emulsifying agent to enhance the stability of petroleum emulsions, whether direct or reverse. The results show that using quantities of (5-15) grams supports the stability of the emulsions, indicated by the size of the separated portion within the API. The stability of the emulsions was assessed over a period ranging from 24 hours to 7 days. Compared to Carboxyl Methyl Cellulose (CMC), ground Crushed palm leaves performed the best, especially when 15 grams were added. Additionally, ground Crushed palm leaves and sider leaves acted as a density reducer and filtration agent, and also contributed to increased viscosity and gel strength. The composition of cellulose in egg shells may serve as an alternative to carboxymethyl cellulose for increasing viscosity.

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1. Introduction

It is crucial to consider environmental regulations when preparing drilling mud, as they are important both now and in the future. Using sustainable and environmentally friendly materials at every stage of the oil and gas industry, if possible, is essential to ensure high standards of sustainable practices. The use of kerosene to prepare oil-based clay has negative effects on the soil and humans. Sustainable products may not yet measure up to competitive offerings. Therefore, competitive offerings may serve as a benchmark in terms of ecological and social performance [1]. Drilling mud is a liquid mixture of different materials used during the drilling process. In the past, only air was used to remove the pieces generated during drilling, but with the development of drilling technology, the use of drilling mud became necessary to improve the properties of the clay [2]. Drilling mud serves several purposes, such as lifting rock pieces, cooling and lubricating the drill and drilling shaft, controlling formation pressure, and supporting the well wall with mud cake [3]. The drilling mud will be circulated from the surface through a drill string and rise to the surface through the space between the outer diameter of the drill string. Mud contains 75% liquid, reactive solids, inert solids, and chemicals [4].

Drilling mud is a mixture consisting of solid materials which are considered the dispersed phase, and a fluid, whether water or oil, that is regarded as the continuous phase [5]. Emulsions are mixtures where a liquid or fluid is dispersed in another liquid or fluid that doesn't mix with it [6]. The liquid in the form of drops is called the dispersed phase or internal phase, while the phase in which the droplets are suspended is called the continuous phase or external phase. Oil-in-water mixtures (O/W) are important in the petroleum industry, being used in drilling, production, transportation, and refining [7]. Stability is crucial for efficiency and environmental sustainability, achieved by maintaining a uniform distribution of droplets and resisting phase separation [8]. Stability can be affected by factors like surfactants, composition, temperature, pressure, and mechanical forces, as well as by chemical reactions like oxidation and phase transformation [9]. Flow behavior is governed by rheological properties. Ensuring stable oil blends is vital for the industry's success [10]. Oil emulsions are formed by mixing water and oil with the help of emulsifying agents. This mixing occurs during oil production and can be caused by reservoir rocks, pumps, pipes, and surface equipment [11]. When maximum mixing occurs, it results in smaller, more stable water droplets that are dispersed in the oil [12]. Emulsifiers, especially natural ones found in the heavy fraction of crude oil, play a crucial role in this process [13]. Different crude oils contain varying amounts of emulsifiers, which can affect the stability of the emulsion [14].

Table 1 illustrates the advantages and disadvantages of emulsions [15], while table 2 summarizes the previous studies related to the studied topic. Michael and William suggest that we should make any material and product so that it is able to disintegrate when it is no longer used, and so that all the materials from which it is made are able to return to the Earth after decomposition, or be recycled infinitely as raw materials [16]. This effort aims to investigate the potential of utilizing ground Crushed palm leaves, egg shells, orange peels and sider leaves as an eco-friendly emulsifying agent to enhance the stability of petroleum emulsion.

2. Theoretical Part

Emulsification is the presence of two liquids that do not dissolve in each other, but rather disperse one into the other. The stability of the emulsion depends on the nature of mixing and the nature of the two liquids in terms of chemical composition and viscosity. Temperature also affects the stability of emulsions. Emulsifying agents need to be present, and the mixing time must be sufficient for the dispersion of the discontinuous phase into the continuous phase.

1- Bentonite
2-CMC (Carboxymethyl cellulose).
3- Diesel.
4-Crushed palm leaves

5-Orange peel
6-Egg shell
7-sider leaves

The use of environmentally friendly materials, such as Crushed palm leaves, reflects an interest in preserving the environment and reducing the negative impacts of industrial activities. Crushed palm leave can be used in several applications as an alternative to harmful substances. It is naturally biodegradable and is often a renewable source, which reduces its harmful environmental impacts

Table 1 The advantages and disadvantages of emulsions.

Advantages of using emulsion	Disadvantages of using emulsion
1. Reducing oil loss	1. Environmental Impacts.
2. Improve oil quality	2. Cost.
3. Increasing process efficiency	3. Sedimentation and contamination problems.
4. Reduced cost and time	4. Effect on workers' health

Table 2 The previous studies related to the studied topic.

Year	Author (s)	Materials and result
2008	Shohel et.al	Their study explored how specific chemicals used in oil and gas exploration can transform into harmful pollutants. For instance, oil-based drilling fluid is efficient but generates toxic environmental byproducts.
2012	Adeley et.al	The article detailed the most recent advancements in drilling fluids, covering various types, limitations, current trends, and future challenges while providing guidelines for promoting environmentally friendly drilling muds. It concluded that the future direction is moving towards sustainable drilling mud
2018	Al-Saba et.al	The study results indicated that soybean husk powder reduced fluid loss by 60% and also improved yield point and gel resistance. This suggests that the powder has the potential to be used as a rheology modifier and leaching control agent. Additionally, other materials such as tamarind gum and henna showed significant reductions in pH, confirming their ability to control pH during drilling through cement.
2018	Assi	The study investigated the impact of adding potato starch, an environmentally friendly material, on the properties of drilling fluid. The results showed that potato starch can reduce filtration and increase viscosity, suggesting its potential use in this application.
2021	Assi and Haiwi	The researchers investigated the impact of incorporating crushed banana peels and corn cobs as recycled materials on the properties of drilling fluid. The laboratory findings from their study showed that these materials could potentially reduce filtration, elevate the viscosity of drilling mud, and enhance the gel strength of drilling fluids.

2021	Bilal et.al	Investigated the effect of temperature on oil-based mud formulated from castor seed oil. He found the possibility of using castor oil to formulate oil-based mud at high temperatures.

3. Experimental Procedure

Table 3 summarizes the materials used to prepare the clay models in this research.

Table 3 : The quantities of the used materials.

from/to		Quantities and materials						
		Water. cc	**Bent. gm.**	**Crushed palm leaves gm.**	**CMC gm**	**Diesel fuel ml.**	**Ground egg shells gm**	**Kcl gm.**
Sample No.	**1**	350	10	5	1	35	5	2
	2	350	15	10	2	35	10	2
	3	350	20	15	3	88	15	2
	4	350	25	20	4	88	20	2
	5	350	30	25	5	88	25	2

3.1. Measured properties:

Laboratory work will be conducted using the following equipment:

1-Measuring rheological properties by using viscometers 8 speeds.

2-Measuring density by using mud balance

3-Measuring mud cake thickness and filter volume by using hydraulic filter press. Figure 1 shows the used materials and apparatus.

The identification of elements and chemical compounds in a new substance is essential for study. To achieve this, we conducted an X-ray diffraction examination to identify the key compounds in ground Crushed palm leaves.X-ray fluorescence analysis (XRF) is done by XRF Instrument in the German laboratory at the University of Baghdad / College of Science. The Crushed palm leaves paper analysis is illustrated in table 3.

Fig. 1 The used materials bentonite and sider leaves and apparatus.

Figure 2 and Table 4 show the chemical composition of the materials studied, which are ground orange peels, ground sider leaves, willow, orange peel and bentonite. X-ray diffraction analysis has proven that these materials contain high percentages of cellulose, which raises viscosity and gelatinization and reduces filtration, in addition to the ground sider leaves containing saponin, which helps.to form foam and reduce density. The four tests were conducted in the German laboratory at the College of Science.

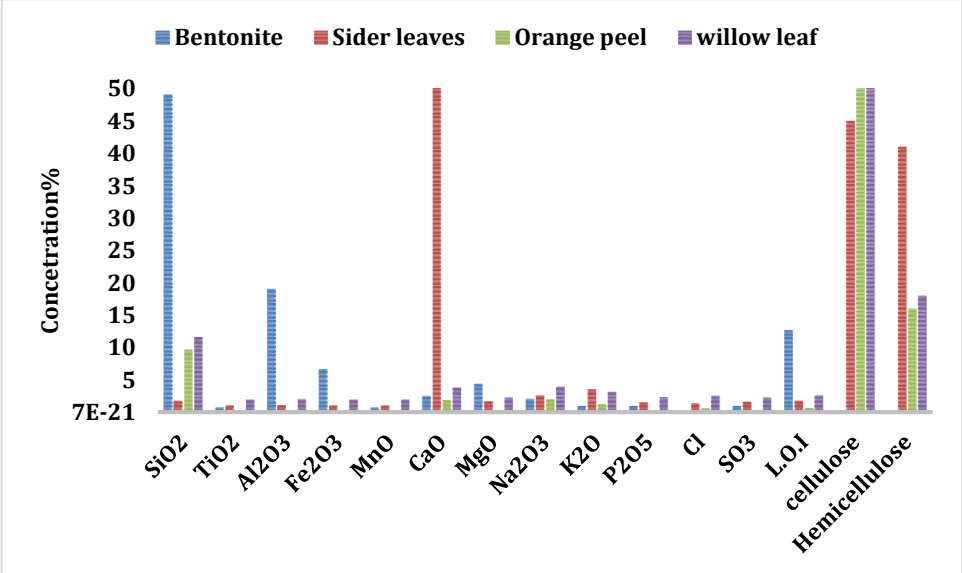

Fig.2 The XRF analysis for the studied materials.

Table 4 The XRF analysis for the studied materials and their concentrations.

Component %	Egg shell	Palm leaves	Orange peel	Sider ieaves
SiO2	49.09865	1.827	9.6698	11.66
TiO2	0.75865	1.00383	0.01049	2.00069
Al2O3	19.09865	1.0885	0.088	2.0782
Fe2O3	6.64865	1.01727	0.0099	2.0001
MnO	0.79865	1.00964	0.0099	2.0001
CaO	2.53865	50.31	1.8538	3.844
MgO	4.42865	1.728	0.2932	2.2834
Na2O3	2.08865	2.66	1.9998	3.99
K2O	0.96865	3.54	1.2228	3.213
P2O5	0.97865	1.544	0.3382	2.3284
Cl	0.20865	1.38	0.6248	2.615
SO3	0.97865	1.6165	0.2656	2.2558
L.O.I	12.68865	1.83	0.6668	2.657
cellulose	non	45	69.0198	71.01
Hemicellulose	non	41	16.0098	18

4. Results and Discussion

The composition of Crushed palm leaves, sidr leaves, orange peel and egg shell show that they are rich in calcium oxide and have significant amounts of potassium oxide and sodium oxide. This makes them useful in drilling mud formulations for changing the properties of the mud. Moreover, the presence of cellulose and hemicellulose suggests that Crushed palm leaves contain organic compounds that can affect the rheological properties of the mud, such as viscosity and gel strength. The dataset includes details about various samples containing combinations of carboxyl methylcellulose (CMC), Crushed palm leaves, and diesel. The key parameters examined are the total volume and the filtration volume over different time periods, as presented in table 5.

The addition of CMC to drilling mud generally has a slight effect on density, but the volume of diesel can influence how evenly the CMC is distributed. The addition of Crushed palm leavespaper to drilling mud affects its viscosity, and this effect can vary depending on the amount of diesel used as a base fluid as shown in figures (3-9).

Laboratory work has been enhanced through the integration of artificial intelligence by selecting additives that improve the coefficient of friction. This process provides optimal proportions of these additives, which helps in reducing both time and costs while also minimizing the risk of accidents, as in fig. 10 and 11. The importance of sustainable materials is indispensable. They stimulate positive change in the oil industry, help address pressing environmental issues, improve energy efficiency, and enhance worker well-being. There is no doubt about the role of drilling fluid in reducing the obstruction of pipes, whether mechanical or differential. In this paper, environmentally friendly materials was added such as ground sider leaves, orange peels, and ground palms leaves to prepare different drilling mud models that enhance their effectiveness. Table (5) shows that twelve models of drilling mud were used with different additive ratios, as shown in the first seven columns of the table. The rest of the columns in the same table show the stability values of the models and prepared emulsions for periods that ranged from 24 hours to 7 days. The first two models indicate better performance and less stability.

Table 5. laboratory results for the studies samples.

Sample	Sidr (g)	Diesel (ml)	Oran-ge peels (g)	Ben. (g)	Egg shell (ml)	Wt. (ml)	V_{total} cc	V (cc) 24 hr.	V % 24 hr.	V (cc) 48 hr.	V % 48 hr.	V (cc) 7 day	V % 7 day
1	5	35	-	10	-	350	395	0	0	0	0	0	0
2	10	35	-	10	-	350	355	0	0	0	0	0	0
3	15	35	-	10	-	350	305	0	0	1	0.3	3	0.98
4	-	35	5	10	-	350	240	14	5.8	22	9.1	16	6.67
5	-	35	10	10	-	350	240	7	2.9	18	7.5	11	4.58
6	-	35	15	10	-	350	240	6	2.5	16	6.6	9	3.75
7	5	88	-	10	-	350	50	1	2	3	6	1.50	3
8	10	88	-	10	-	350	97	0.5	0.5	1	1	2	2.06
9	15	88	-	10	-	350	50	3	6	5	10	3.50	7
10	-	88	5	10	10	350	250	1.2	0.5	10	4	15	6
11	-	88	10	10	30	350	250	0	0	8	3.2	8	3.20
12	-	88	15	10	40	350	250	0	0	6.40	2.56	7	2.80

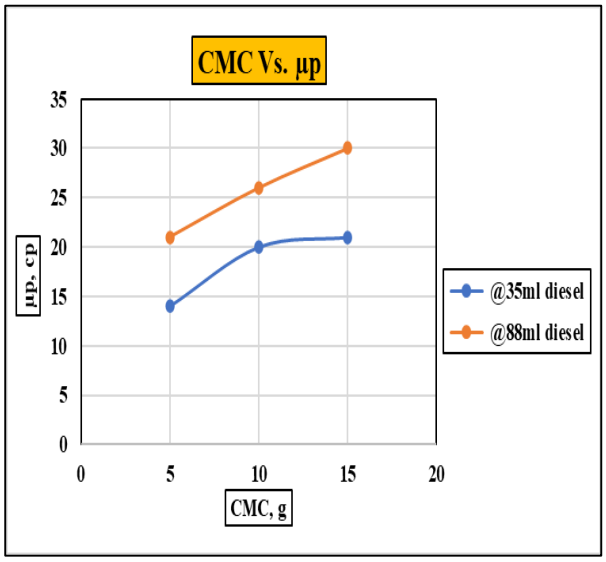

Figure 3: CMC Vs. µp Relationship.

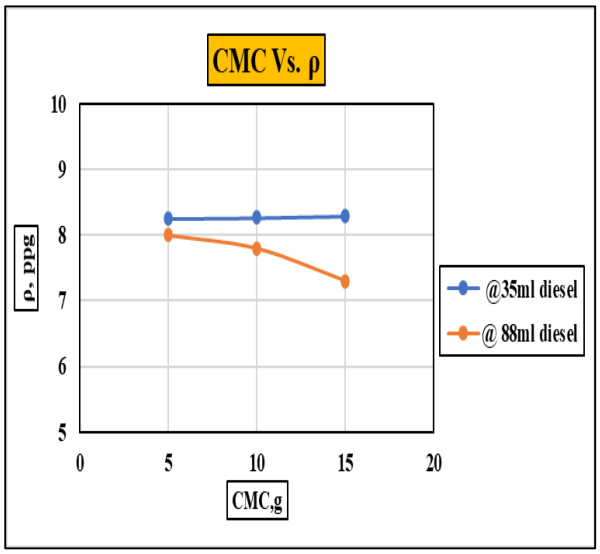

Figure 4: CMC Vs. ρ Relationship.

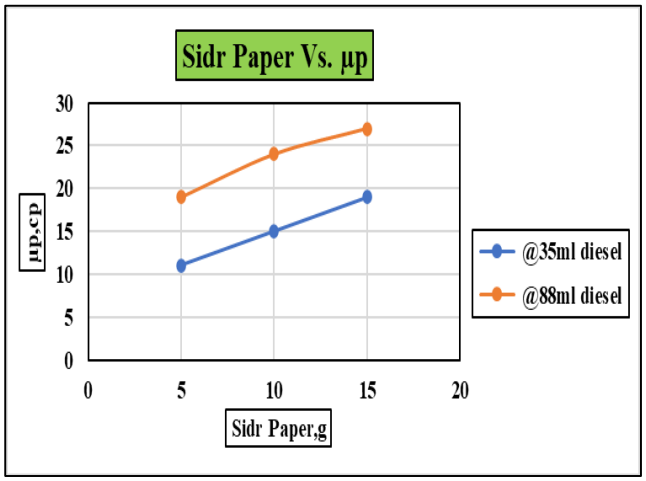

Figure 5: sider leaves Vs. ρ Relationship.

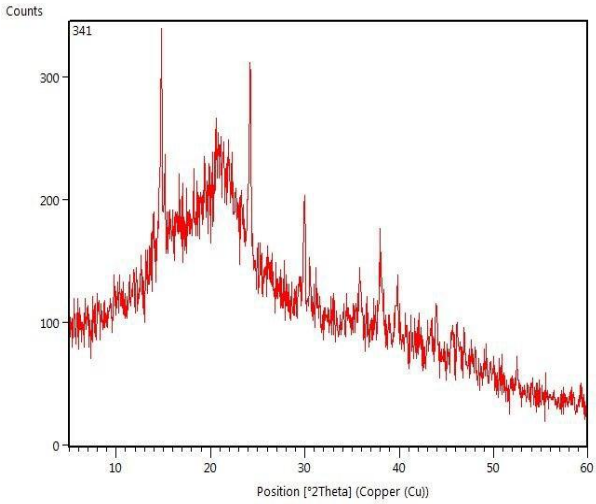

Figure 6: XRD analysis for Crushed palm leaves.

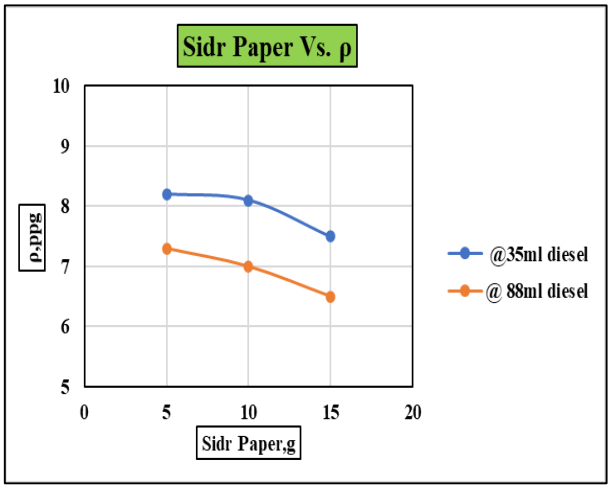

Figure 7: sider leaves Vs. ρ Relationship.

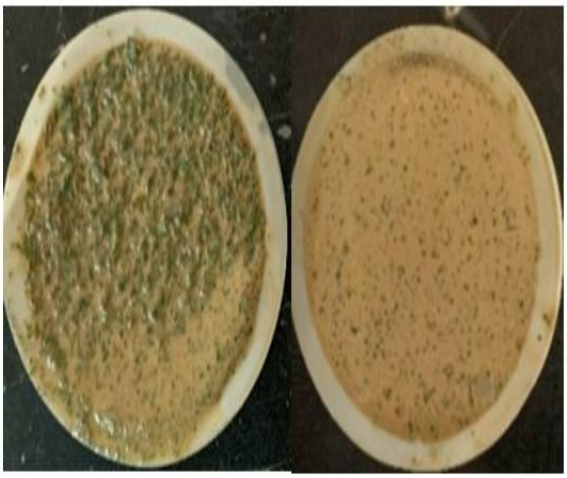

Figure 8: mud cake for Crushed palm leaves.

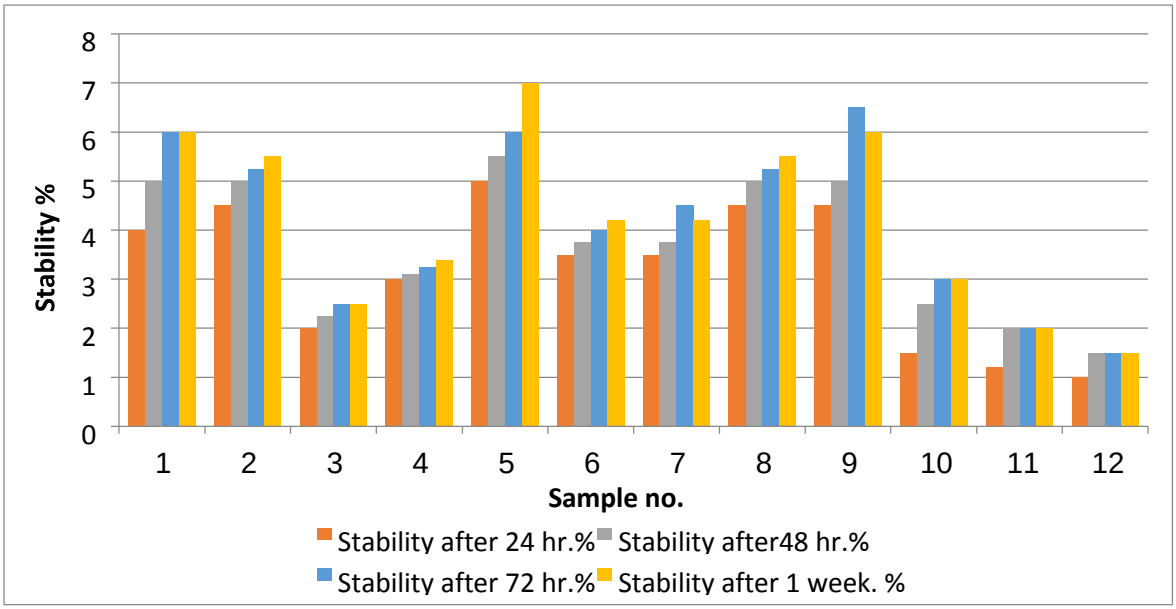

Fig.9 Stability samples for different time

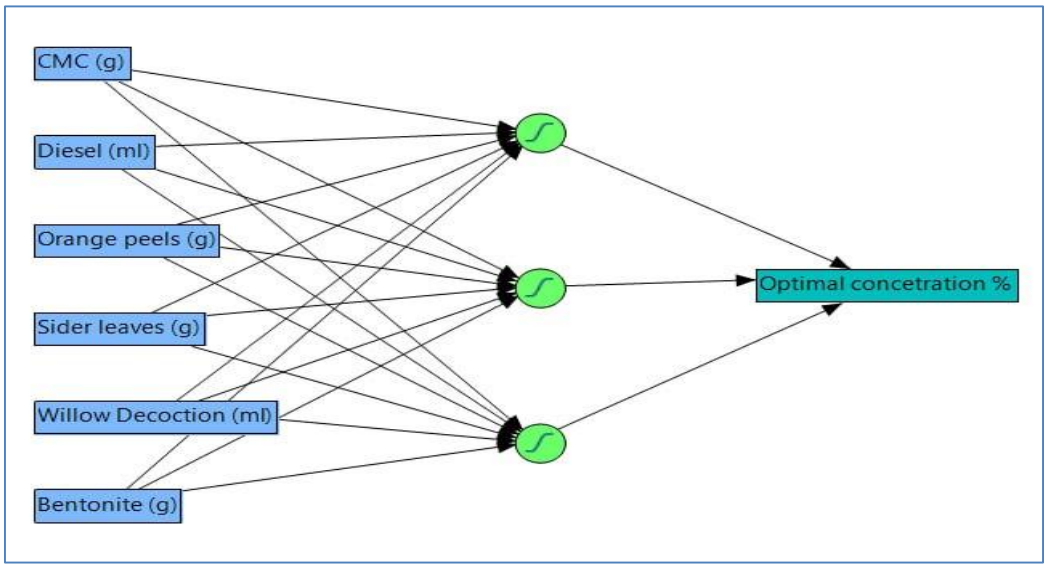

Fig. 10 The neural network analyzes the impact of various additions on the optimal ratios .

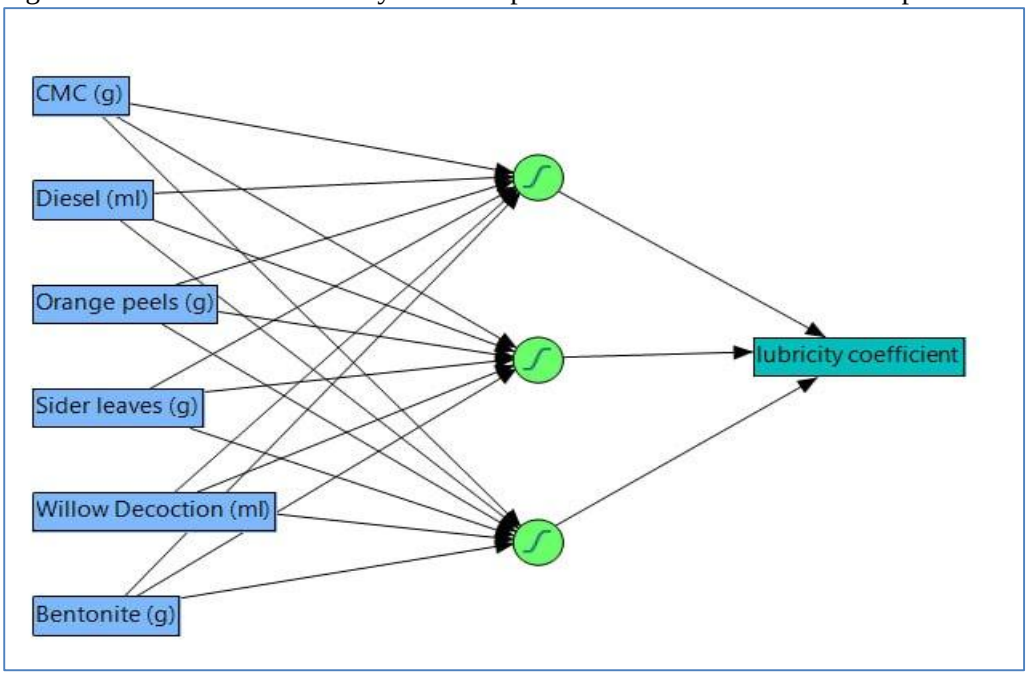

Fig. 11 Neural network analyzing the impact of the lubrication factor on drilling mud.

5.Conclusions

Adding orange peels, crushed palm leaves paper, sidr leaves, egg shell to drilling mud enhances its ability to suspend drill cuttings and stabilize the wellbore through different mechanisms, significantly influencing viscosity and density. Orange peel significantly increases drilling mud viscosity due to its high-molecular-weight polymer structure, forming a gel-like network. This effect becomes more pronounced with higher volumes of diesel, resulting in thicker mud. The impact of CMC on mud density is minimal but may result in slight increases. Ensuring proper mixing is crucial to prevent clumping and achieve uniform density distribution. Crushed palm leaves paper increases drilling mud viscosity by forming a fibrous network in the fluid. Viscosity rises significantly with higher Crushed palm leaves paper concentration and diesel volumes. The effect of sidr leaves paper on mud density generally decreases with a lower volume of diesel. The egg shell in diesel leads to higher filtration rates over time compared to CMC. The total volume remains consistent for Crushed palm leaves

paper samples, whereas it varies more with CMC. This indicates that Crushed palm leaves paper may be more effective in enhancing filtration in these mixtures. Laboratory work has proven the possibility of using environmentally friendly materials, namely sidr paper, which increases lubrication and reduces density. Ground willow leaf gives stability to the emulsion because it contains a percentage of cellulose, which enables it to increase stability and reduce differential hardness.

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