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# Utilize Ground Hazelnut Shells and Willow Decoction to Improve the Effectiveness of Drilling Mud

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**ABSTRACT**

crucial to follow environmental regulations when preparing drilling mud. These regulations are becoming more important and will remain significant in the future. It's essential to use sustainable, eco-friendly materials at every stage of the oil and gas industry to uphold high standards of sustainable practices. This study investigates how adding Nano 10 Nano meter ground hazelnut shells and willow leaf water can improve lubrication and reduce friction in drilling fluid. The results show that incorporating these environmentally friendly materials also impacts other properties of the drilling fluid, including viscosity, density, filtration, and stability. The findings demonstrate that these materials reduced filtration and density, while improving stability and viscosity. When compared to conventional additives like carboxyl methyl cellulose and diesel oil, the additives used in this study showed promising efficiency, economic viability, and environmental benefits. As per the laboratory results, the Model 12 demonstrated superior performance due to its composition of 15g of Ground Hazelnut Shells, 88ml of diesel, 10g of Ben, 25 gm of Willow Decoction, and 350ml of water. The results showed that the lubrication coefficient for Model 12 was 0.89, which is the best, and the stability after 24 hours was 1%, and after 48, 72, and a week, the stability was 1.5, which is the best, as the lower the value for stability, the better the model, and this is what the above-mentioned model indicated.

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## 1. INTRODUCTION

Drilling mud, likewise identified as drilling fluid, is a thick, dense liquid mixture utilized in oil well drilling operations [1]. Its main purposes are to carry rock fragments to the surface, cool and lubricate the bit, and make available hydrostatic pressure to maintain stability in the wellbore and prevent water infiltration from water-bearing layers encountered during drilling [2]. It has been discovered that some additives used in drilling fluids can be harmful to the environment. The water that used for preparing mud should be fresh, with a salt concentration of about 10,000 parts per million (ppm), or at least 1% by weight. This water sometimes may be hard and contain magnesium or calcium salts, or it should be soft and without or free from the magnesium or calcium salts [3]. Field tests are crucial for evaluating drilling fluids to ensure they meet specified API standards. [4]. The collection of drilling fluids be contingent on their composition and proposed to use [5]. The conclusion on the type of drilling mud selected for a specific well is created on three main factors: practical recital, fee, and ecological aspect [6]. Choosing the suitable fluid for the specific circumstances is vital for effective operations. Significant amounts of toxic and non-toxic waste are generated during the extraction, refining, and transportation of oil and gas [7]. Industrial byproducts, including volatile organic compounds, nitrogen and sulfur compounds, and leaked oil, have the potential to pollute the air, water, and soil at levels that are harmful to living organisms if not managed properly [8]. Oil pollution refers to the release of gaseous, liquid, or solid elements, compounds, or mixtures originating from oil into the environment, including air, water, and soil, resulting in a change in the presence of these elements [9]. It

was found that Carboxyl Methyl Cellulose (CMC) has an effect on fish eggs if excess drilling fluid is deposited there, and it also affects the skin. Pollution of the seas and oceans with oil can lead to very dangerous disasters, some of which can be observed, counted, and controlled in the short term, while others may manifest their effects after several years, making them difficult to control [10]. The damage caused by the oil contamination touches all forms of life including humans, birds, terrestrial organisms, plants, rivers, ultimately leading to the demise and destruction of millions of marine organisms of entirely classes [11]. Assi utilized ground orange peels and ground sidr leaves to decrease the density and increase the viscosity of the drilling mud [12]. Amel and Haiwi utilized ground banana peels as an alternative to traditional clay additives to reduce filtration and enhance rheological properties [13]. Seashells were used instead of CMC and starch to reduce filtration, and they have proven effective in enhancing the clay's performance [14].
Dehghani et.al utilized an eggshell to minimize filtration, decrease shale swelling, and enhance the rheological properties of the clay [15]. However, these additives are both effective and inexpensive. This presented a challenge for researchers, as they needed to find low-cost materials that are equally effective without posing harm to the environment [16]. Xanthan is a substance that increases the viscosity of drilling fluid and reduces filtration. If its percentage exceeds 650 mg/ml, it can be fatal to fish and cause allergies during mixing [17]. A pollution-free, green environment is crucial for protecting our planet. Unfortunately, numerous obstacles, including the oil industry, particularly drilling fluids, contribute to environmental pollution [18]. The main objective of this study is to utilize ground willow leaves and hazelnut shells to enhance the properties of drilling fluid with minimal impact on the environment.

## 2.Scope of Available Data

This section outlines how established and calculated the viscosity and density of drilling mud using data from the drilling lab. The results of these calculations were then effectively converted into an Excel program. The objective of this work is to enhance the rheological properties of drilling muds by reducing the risks associated with mud filtration and improving the characteristics of thin mud cakes, while also considering other mud properties. The mud samples have been prepared as an emulsion type of drilling fluid, making it essential to calculate their stability values. Exceeding certain rheological parameters beyond desired limits can lead to complications such as stuck pipes and lost circulation [19]. This paper will detail the materials used, the techniques for mud characterization, the testing equipment for diagnostic tests as recommended by the API (API, 2012), and the experimental methodology employed [20]. Additionally, X-ray diffraction analysis was performed on the materials utilized in this laboratory work. Figure 1 illustrates the sequence of experimental steps, starting with sample preparation, proceeding to the conclusions, and concluding with several new recommendations.

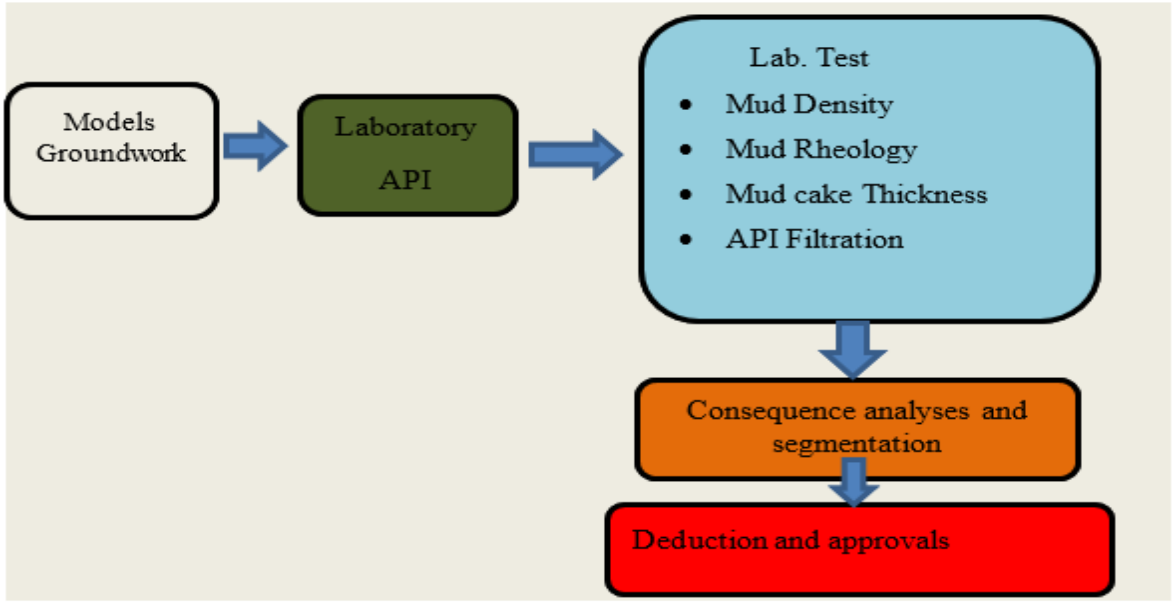


**Fig. 1 The structure of experimental work methodology**

## 2. Experimental Work:

The laboratory work was conducted at the University of Baghdad, College of Engineering. The study involved the examination of 12 laboratory models to assess the potential use of ground willow leaves and hazelnut shells in enhancing the performance of drilling mud, specifically its viscosity, density, and filtration rate, the materials used and the experimental work are depicted in figures 2. The tests were conducted in accordance with the American Petroleum Institute standards. 350 ml of water was mixed with 22.5 grams of bentonite (bent.), while 5-15 grams of other additives, and 35-88 ml of diesel were used, as illustrated in table 1. A chemical analysis of the studied materials was also conducted, and an X-ray diffraction examination was accompanied, as illustrated in table 2.

**Fig. 2 The used materials Ground Hazelnut Shells and Willow Decoction and experimental work in the laboratory.**

**Table 1. Quantities of the used samples and the volume of separated part.**

| Materials | unit | Quantities |
|---|---|---|
| Bentonite | gm | **10** |
| Water | ml. | **350** |
| Ground Hazelnut Shells | gm | **5, 10, 15,20,25** |
| Willow Decoction powder | gm | **5,10,15,20,25** |
| Diesel | ml. | **35, 88,122** |
| CMC | gm | **1,2,3** |

**Table 2.XRF analysis for bentonite, Ground Hazelnut Shells and Willow Decoction.**

| Component % | ntonite | Ground Hazelnut Shells | Willow Decoction |
|---|---|---|---|
| **SiO2** | 49 | 5.827 | 20.66 |
| **TiO2** | 0.69 | 0.00038 | 0.00069 |
| **Al2O3** | 18 | 1.0885 | 0.0782 |
| **Fe2O3** | 9.55 | 2.01727 | 1.0001 |
| **Mn** | 0.77 | 2.00964 | 1.0001 |
| **CaO** | 4.44 | 5.31 | 2.844 |
| **MgO** | 2.33 | 2.728 | 5.2834 |
| **Na2O3** | 4.99 | 2.66 | 2.99 |
| **K2O** | .087 | 4.54 | 3.213 |
| **P2O5** | 1.88 | 1.544 | 3.3284 |
| **Cl** | 0.11 | 1.38 | 0.0615 |
| **SO3** | 0.88 | 0.06165 | 0.02558 |
| **L.O.I** | 7.29 | 0.83 | 0.08657 |
| **cellulose** | non | 38 | 49.401 |
| **Hemicellulose** | non | 32.09 | 10.06 |

## 4. Sample Preparation

In this study, twelve samples of drilling mud were prepared with different additive ratios. The materials are mixed, and the samples of drilling fluid is prepared based on the Table 4. Figure 4 illustrates XRF for the studied samples.

**Table 3:** Testers preparation of drilling fluid

| Sample | CMC gm | Diesel ml | Bentonite gm | Willow Decoction gm | Ground Hazelnut Shells gm | water ml |
|---|---|---|---|---|---|---|
| 1 | 1 | 35 | 10 | 5 | 0 | 350 |
| 2 | 2 | 35 | 10 | 10 | 0 | 350 |
| 3 | 3 | 35 | 10 | 15 | 0 | 350 |
| 4 | - | 122 | 10 | 0 | 5 | 350 |
| 5 | - | 35 | 10 | 0 | 10 | 350 |
| 6 | - | 35 | 10 | 0 | 15 | 350 |
| 7 | 5 | 88 | 10 | 0 | 20 | 350 |
| 8 | 1 | 88 | 10 | 0 | 25 | 350 |
| 9 | 2 | 122 | 10 | 10 | 20 | 350 |
| 10 | 3 | 88 | 10 | 20 | 5 | 350 |
| 11 | - | 88 | 10 | 25 | 10 | 350 |
| 12 | 3 | 122 | 10 | 25 | 25 | 350 |

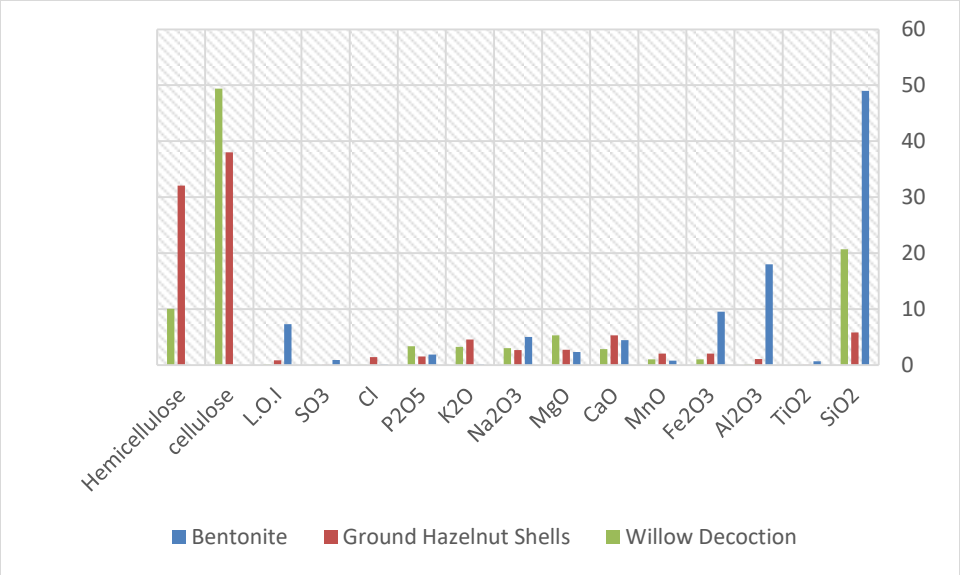


**Figure 4:** The XRF analysis for the studied materials.

## 5.Results and Discussions:

The use of drilling fluids is continually increasing, so it is important for workers to adhere to environmental regulations. This research focuses on using environmentally friendly materials to prepare emulsified drilling fluids that are safe for the environment. Figure 3 shows a decrease in the value of the lubrication coefficient with an increase in the percentage of ground willow leaf and ground hazelnut shells because they contain cellulose in high proportions. Figure 4 illustrates the impact of clay composition on stability rates. Model 12 showed the lowest value, attributed to its high percentage of willow leaf solution, meeting API standards. In Figure 5a, the stability rate is shown to be affected by clay composition, while Figure 5b illustrates the impact of clay composition on clay density. Model 12 yielded the lowest value due to its high percentage of willow leaf solution and gas oil, which contributed to the reduction. Figure 6 illustrates the impact of additives on viscosity and lubricity. Both gas oil and ground hazelnut shells effectively increased viscosity, with Model 12 serving as a clear example. Figure 7 illustrates the instability of emulsion 10 and the good stability of emulsion 12. This difference can be attributed to the absence of environmentally friendly additives in emulsion 10, while emulsion 12 contains these additives, which act as strong emulsifying agents. Figure 8 illustrates the X-ray diffraction analysis of ground hazelnut shells, revealing high silicon content, similar in performance to carboxyl methylcellulose. X-ray diffraction analysis revealed that hazelnut shells contain high levels of calcium, a bridging material that inhibits shale swelling, as well as a percentage of potassium, which raises the pH of drilling fluids. Ground hazelnut shells contain silicon, which increases viscosity and reduces filtration, in addition to sodium, considered a bridging material. Figure 9 illustrates how the willow leaf solution, containing flavonoids, causes foaming, leading to a reduction in drilling mud density. The stability of the twelve models was illustrated in Figures 10 and 11. It was observed that model number 12 exhibited the highest level of

stability over 24, 48, and 72 hours, as well as a full week after being left stagnant. This can be attributed to its high percentage of willow solution, which reduces surface tension and enhances the stability of the emulsion.

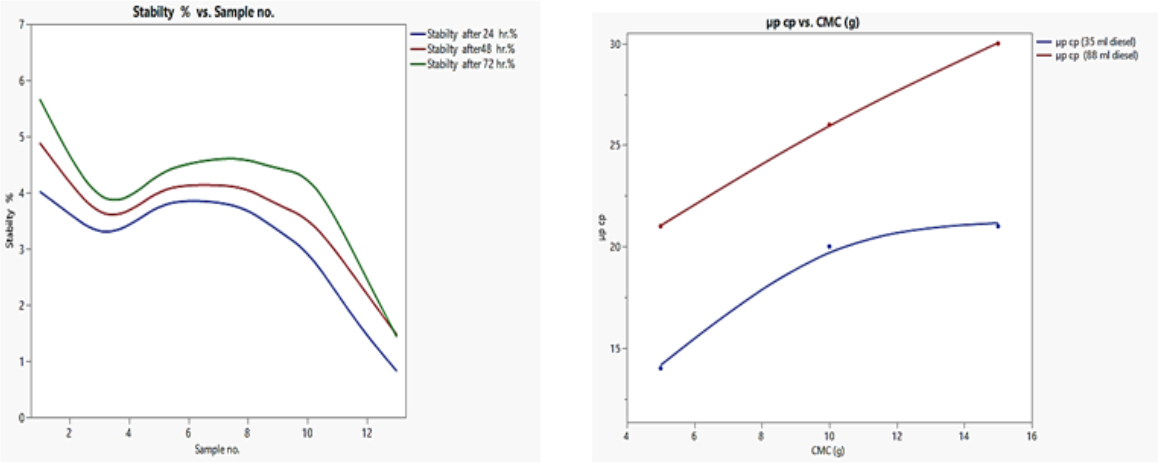


**Fig.5 The effect of sample composition on stability and density**

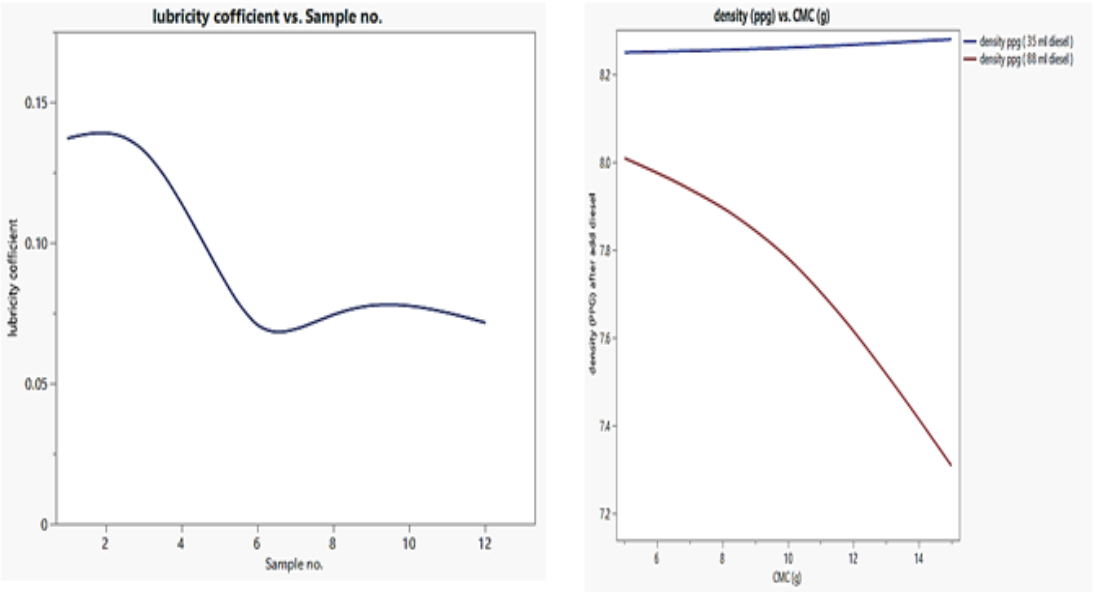


**Fig.6 The effect of sample composition on stability and viscosity**

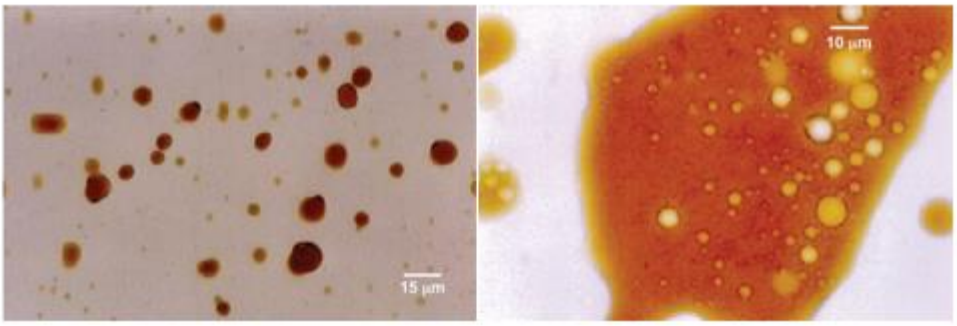


**Fig. 7 stability sample 10 on right and 12 on left (w/o) Emulsion**

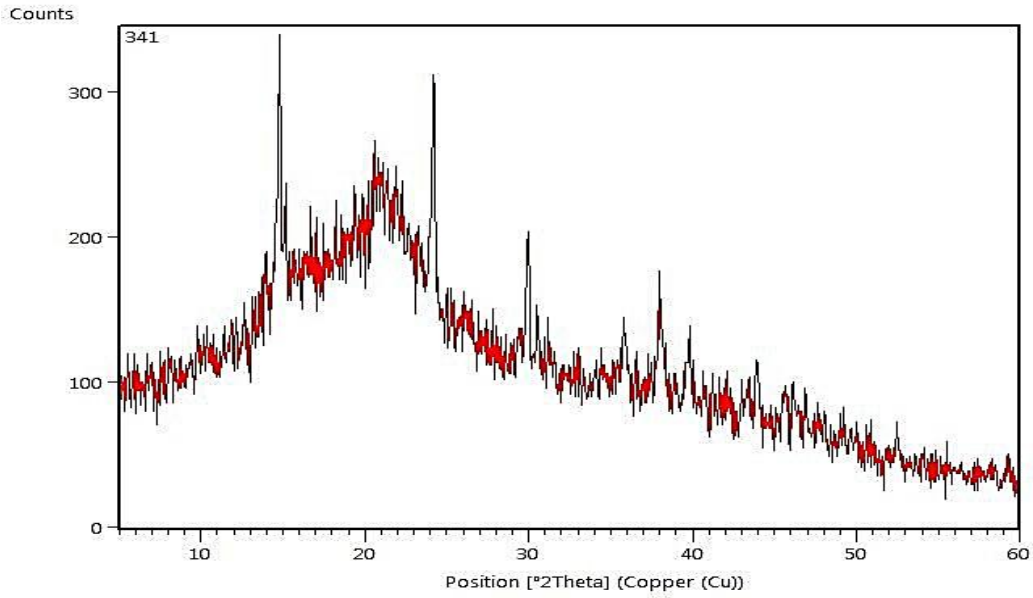


**Fig. 8 XRF analysis for Ground Hazelnut Shells**

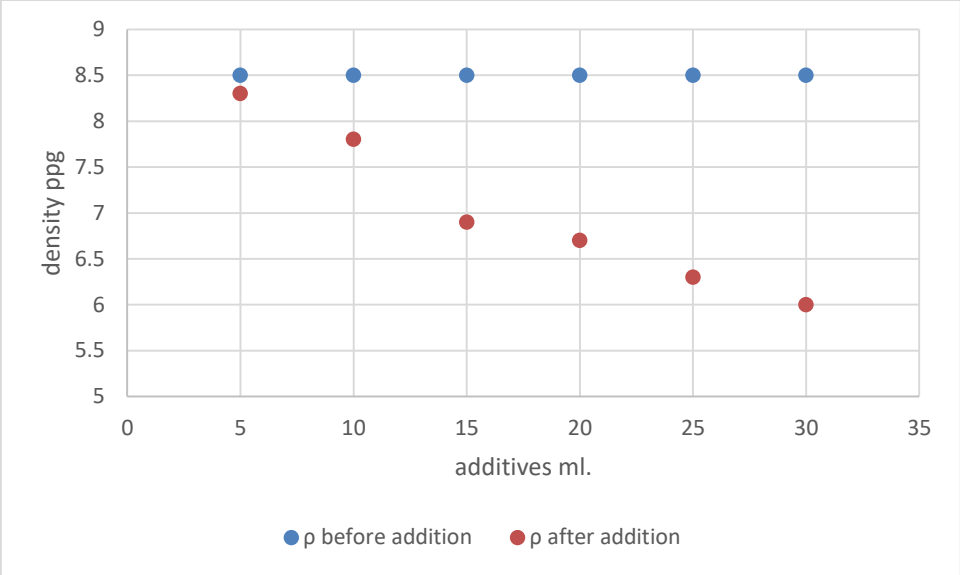


**Fig.9 Effect of Willow Decoction on density.**

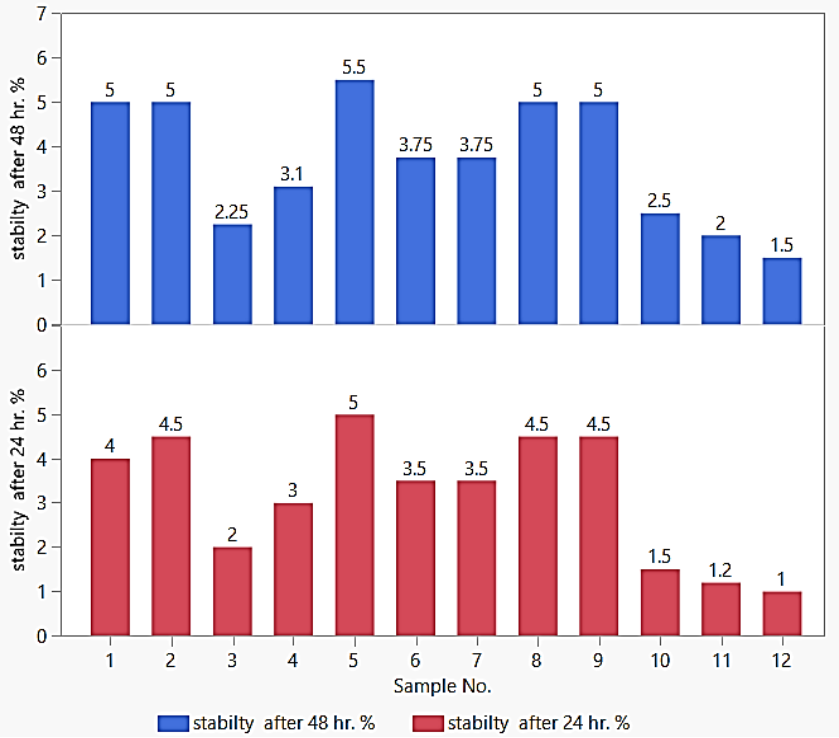


**Fig.10 Effect of Willow Decoction on stability for 24 and 48 hr.**

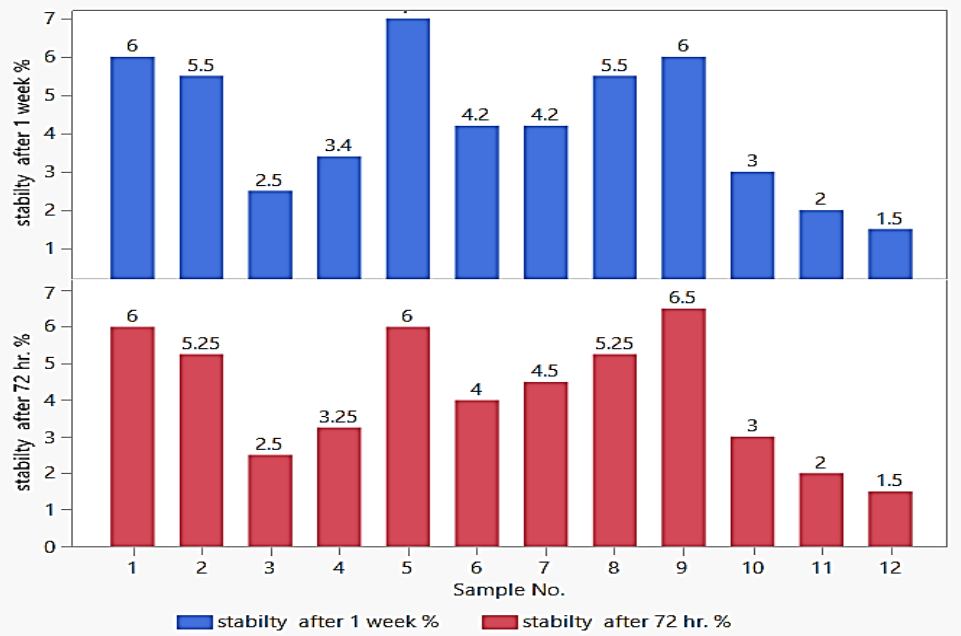


**Fig.11 Effect of Willow Decoction on stability after 72 hr. and one week.**

## 6. Gathering Experimental Work and Machine Learning:

A factorial design method has been successfully employed in this study to develop a model to predict the optimal concentration of additives. Factorial design (FD) is a method that monitors the Interactions of multiple factors which accommodate the effect of both main and interaction effects. Laboratory work has been integrated with artificial intelligence by selecting additives that contribute to enhancing the value of the optimal concentration, reducing the occurrence of stickiness, and giving us the optimal. Equations (1and 2) along with Figure 12 show the dynamic model that has been developed using ANNs. Figure 13 shows the effect of additives on filter volume for the studied models.

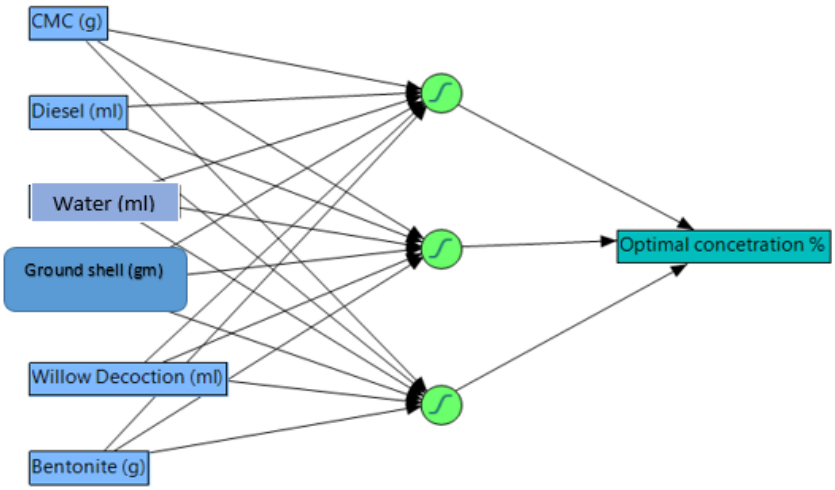


**Fig. 12 the neural network with optimal additives concentration.**

$$factorial\ design\ = \sum_{i=1}^{N}\left[w_{2_i} * \left(\frac{2}{1+e^{-2(X)}} - 1\right)\right] + b_2 \quad (1)$$

$$X = w_{1_{i,1}} * CMC + w_{1_{i,2}} * WL + w_{1_{i,3}} * GS + w_{1_{i,4}} * D + w_{1_{i,5}} * DE + w_{1_{i,6}} * PV + w_{1_{i,7}} * Yp + w_{1_{i,8}} * GL + w_{1_{i,9}} * W + b_{1_i} \quad (2)$$

Sensitivity analysis is a powerful technique for identifying the cause-and-effect relationships between a network's inputs and outputs. This method effectively measures the relative importance of various inputs within a neural model. It clearly shows how changes in any input directly impact the model's output. Identifying the best combination of variables linked to optimal incidents is vital given the many factors at play in the drilling process. We have employed sensitivity analysis methods on the input data to safeguard model integrity, honing in on the overarching trends of each parameter associated with stuck pipe events. Logistic regression analysis serves as a powerful tool for understanding relationships among variables, enabling us to predict outcomes based on one or more influencing factors. By inputting operational parameters into JMP statistical software, we can accurately gauge how input parameters affect network outputs through regression coefficients. Moreover, the insights from Table 4 reveal the critical variables examined in the sensitivity analysis, emphasizing their significance in improving drilling safety and efficiency.

Table (4): Model Sensitivity variables

| ·ce | og Worth | Percentage % | Value |
|---|---|---|---|
| el (ml) | 2.002 | | 30100 |
| r (gm) | 5.600 | | 40003 |
| ow Decoction (gm) | 11.561 | | 90001 |
| (Nm) | 13.260 | | 80055 |
| nd Hazelnut Shells | 18.696 | | 70005 |
| ation (ml) | 15.512 | | 60000 |
| cp) | 33.076 | | 50002 |
| lb/100 ft$^2$) | 10.249 | | 0.0400 |
| g/100 ft$^2$) | 21.486 | | 04 |
| ity | 26.914 | | 05 |

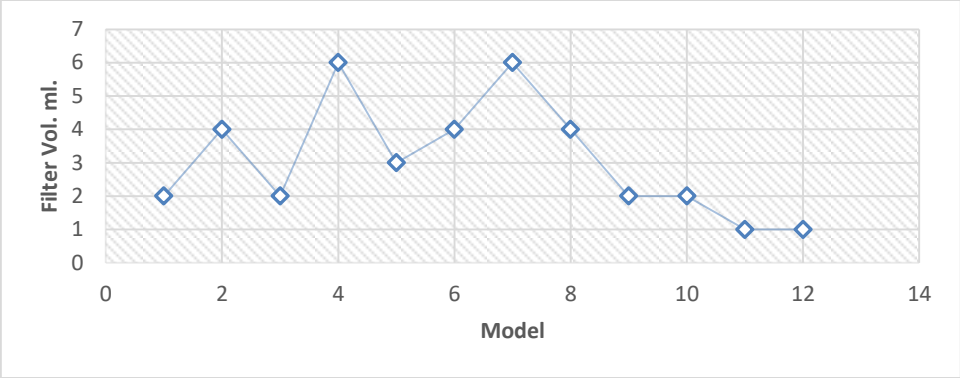


**Fig 13 Filter volume of the studied model**

## Conclusions:

Adding willow leaves and ground hazelnut shells to drilling mud significantly impacts its viscosity and density, enhancing its ability to suspend drill bits and stabilize the wellbore through different mechanisms. Laboratory studies have demonstrated that using environmentally friendly materials, specifically ground hazelnut shells, enhances lubrication and reduces density. Additionally, ground willow leaves contribute to the stability of the emulsion due to their cellulose content, which helps improve stability and decrease differential hardness. The combination of willow leaves and ground hazelnut shells can enhance the viscosity, stability, and lubricating properties of drilling mud. This is because the fibrous components form a network within the fluid. The use of higher concentrations of diesel results in a significant increase in viscosity due to the higher concentration of willow leaves. Additionally, the density of the clay generally decreases as the volume of diesel decreases. Adding willow leaf to diesel leads to a greater decrease in filtration over time compared to CMC. The total size is also more consistent with the willow leaf samples, whereas it varies more with the CMC. This suggests that willow leaf may be more effective in enhancing filtration in these mixtures. The impact of CMC on mud density is minor but can result in slight increases. Proper mixing is crucial to prevent clumping and ensure even density distribution. CMC significantly increases drilling mud viscosity due to its high-molecular-weight polymer structure, which forms a gel-like network. This effect is more pronounced with higher volumes of diesel, resulting in thicker mud.

### Recommendations:

Conduct a study on a larger number of drilling mud samples, focusing primarily on water-based formulations, and compare their performance with the emulsions previously studied. Additionally, perform an economic analysis to compare the environmentally friendly materials researched with the conventional chemical materials currently in use in the field. It is recommended to provide available real-time data to display the results on a log viewer, as predicting the potential of the studied factors can be very effective during drilling.

## Nomenclatures:

CMC: Carboxyl Methyl Cellulose

PPM: Parts Per Million

PV: Plastic Viscosity

XRF:X-ray diffraction analysis

ppg: Pound per Gallon

API: American Petroleum Institute

g: Gram

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**Assist prof.Dr. Amel Habeeb Assi**: I obtained bachelor's degree from the University of Baghdad, College of Engineering, Department of Petroleum Engineering in 2008. I obtained a master's degree from the University of Baghdad, College of Engineering, Department of Petroleum Engineering in 2015. I obtained a doctorate degree from the University of Baghdad, College of Engineering, Department of Petroleum Engineering in 2021.I have had 29 research papers in the field of oil well drilling engineering published in peer-reviewed scientific journals. I have also participated in numerous scientific conferences, including the Abu Dhabi conference in 2019, the Maysan College conference in 2022, and the University of Technology and Oil Research and Development Center conference in 2023.I have reviewed numerous research papers for peer-reviewed journals, supervised many graduation projects, and contributed to research aimed at minimizing the detrimental impact of the oil industry on the environment at the College of Engineering Exhibition at the University of Baghdad.