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An Experimental Study To Develop An Environmentally Friendly Drilling Fluid Using Aloe Vera As An Additive

Dankwa, O. K.

Petroleum and Natural Gas engineering Department,
University of Mines and Technology (UMaT), Tarkwa

Amarfio, E. M.

Petroleum and Natural Gas engineering Department,
University of Mines and Technology (UMaT), Tarkwa

Azaglo, G. B.

Petroleum and Natural Gas engineering Department,
University of Mines and Technology (UMaT), Tarkwa

Appiah-Adjei, F. B.

Ghana National Gas Company, Atuabo, Ghana

***Abstract:** Aloe Vera contains no harmful compounds. Calcium is the dominant composite element. Most of the elements present such as silicon, potassium, chlorine and calcium are used as compounds to perform various functions in drilling fluid. This study is aimed at developing an environmentally friendly mud using Aloe Vera instead of a chemical ingredient. The experiment involves the conversion of Aloe vera plant to a dry crisp form, followed by processing to obtain a suitable powder for incorporation into the drilling fluid. An X-Ra fluorescence analysis was carried out on the aloe vera to reveal its chemical/elemental composition. Both oil-based and water-based drilling fluids were considered for this study. To examine the performance of aloe vera addition for both water-based and oil-based mud systems, complete rheological experiments of different concentrations were done. The varying concentrations of aloe vera were used to formulate five sets of drilling fluids along with the base material, bentonite. Rheological properties and other related investigations were carried out at different temperatures and assessed using standard procedures. The results were analysed to evaluate the feasibility of implementing eco-friendly drilling fluid. It was concluded that the amount of aloe vera concentration and temperature have effect on the rheological properties in both water-based and oil-based drilling muds. Elevated temperatures have thinning effect on oil-based mud making it less viscous. An increase in concentration causes a decline in yield point for both drilling fluids. This study has the potential of meeting with the oil and gas industry's growing interest in eco-friendly practices and offers a valuable contribution to the field of drilling fluid technology.*

***Keywords:** Drilling fluids, Aloe Vera, Temperature, Rheology, XRF Analysis*

I. INTRODUCTION

Drilling is the second stage of the wellbore life cycle, and drilling fluids play the most crucial role in the drilling process. The main functions of drilling fluids are cleaning the wellbore, cuttings transportation, lubricating and cooling of a drill bit, wellbore pressure control, counteract inflow of reservoir fluids, and formation of impermeable filter cake. According to (Shah et al., 2010), drilling fluids can be classified into four major categories based on their base fluid. These are Water-based drilling fluid (WBDF), Oil-based drilling fluid (OBDF), Synthetic-based drilling fluid (SBDF), and Gas-based drilling fluid (GBDF). Traditional drilling fluids, such as oil-based or synthetic-based muds, have been associated with environmental risks due to their toxicity and non-biodegradable nature. The environmental impact of conventional drilling fluids, particularly oil-based drilling fluids, has been a concern due to their potential for contamination and negative effects on ecosystems which includes toxicity and pollution, spills and leaks, and disruption of aquatic ecosystems. It is important to note that the extent of environmental impact can vary depending on factors such as the volume and concentration of drilling fluids used, drilling practices, spill prevention measures, and environmental regulations in place. However, the potential risks and environmental consequences associated with conventional drilling fluids have prompted efforts to develop and adopt more environmentally friendly alternatives, such as aloe vera-based drilling fluids, to mitigate these impacts.

According to (Hossain & Al-Majed, 2015), the toxic chemical components of drilling fluids, additives, and drilling fluid remnants with cutting waste all affect the risk of adverse health impacts. According to (Gardner, 2003), shale shaker houses, drilling floors, mud pit systems, sack rooms, laundry services, deck operations, and long-term effects following disposal are the main places where drilling fluid exposure occurs. Environmental problems extend beyond just noise, air, and water pollution. However, there could be issues with soil pollution, underground water pollution, ocean pollution, and even the collapse of ecosystems (Khodja et al., 2010). When drilling to recover hydrocarbons from geological reservoirs, drilling fluid pollution is a concern. Since the majority of drilling fluid systems are created using various chemicals and polymers, some of which are more harmful than others (Amanullah & Yu, 2005). It is unethical to pollute ecosystems whenever we exploit a natural resource for our benefit.

Depending upon the characteristics of the reservoir formation, water-based drilling fluid, oil-based drilling fluid, or synthetic-based drilling fluid needs to be used during the drilling process. None of them can meet fully all environmental considerations due to the presence of chemical compounds that are harmful to the natural ecosystem. Drilling fluid companies are still working on the development of new drilling fluid additives with lower toxicity to address new problems such as foaming, excessive torque and drag friction, corrosion, bacterial attack, and stuck drill pipes (Ayers et al., 1985). More studies have been conducted regarding biodegradable waste material as drilling fluid additives to reduce drilling waste. (Omotioma et al., 2014) studied the effect of adding cashew and mango leaves extract, which improved the mud rheological properties. (Okon et al., 2014) studied the possibility of using rice husk as an additive to control filtration properties. Their results showed that the rice husk was able to reduce fluid loss by 65% when 20 part per billion (ppb) concentration was added and compared to CMC and PAC. However, the rice husk might result in an undesirable effect on the plastic viscosity.

Several studies have been conducted to improve the rheology (Amanullah et al., 2011) and filtration-loss properties of drilling fluids. Drilling mud additives (nonpolymeric and polymeric additives) have been successfully applied in combination with bentonite to enhance mud performance under harsh drilling conditions. A study conducted by (Amanullah & Yu, 2005) indicated that these additives have the potential to better the performance of drilling muds to meet the functional requirements such as appropriate mud rheology, density, mud activity, and fluid loss. Aloe vera gel exhibits interesting rheological properties, making it a potential candidate for inclusion in drilling fluid formulations. Studies have indicated that aloe vera extracts can enhance the rheological properties of drilling fluids, including viscosity, yield point, and suspension properties (Bagum et al., 2022). Furthermore, aloe vera gel has shown promising filtration control capabilities, reduced fluid loss, and preventing formation damage during drilling operations (Ekeigwe et al., 2013). Aloe vera gel has demonstrated thixotropic behavior, which means it undergoes a reversible gel-to-fluid transition under shear stress (Dey, 2012). This property enables the drilling fluid to quickly regain its gel-like structure when the shear stress is removed, preventing the settling of solid particles and maintaining suspension stability. Improved suspension properties can help prevent the formation of a static filter cake and reduce the risk of differential sticking, enhancing wellbore stability during drilling (Dey, 2012).

A study conducted by (Fathi, 2016) assessed the environmental performance of aloe vera gel as a fluid loss additive in water-based drilling mud. The researchers evaluated the biodegradability of the drilling mud samples containing aloe vera gel using standardized biodegradation tests. The results indicated that aloe vera-based drilling fluids exhibited good biodegradability, suggesting their potential to break down naturally in the environment without causing long-term harm. Drilling fluids have several properties to be controlled and maintained to function in any drilling operation and to avoid technical and economic losses. Plastic viscosity, yield point, and gel strength are the primary rheological properties of drilling mud. Others include electrical stability, lubricity, and toxicity (Ekeigwe et al., 2013). The use of aloe vera powder and ash as an environmentally friendly additive for formulation of water-based muds was carried out by (Bagum et al., 2022). The results showed that aloe vera can be used as an additive in improving the rheological properties of water-based mud. Ultimately, the research work did not involve detailed analysis of the effect of high temperatures on rheological properties, as well as application of aloe vera as an additive in oil-based mud.

By developing environmentally friendly drilling fluids using aloe vera, it is possible to reduce the ecological footprint associated with drilling operations. This study looked into some of these fundamental characteristics that are necessary for an oil-based mud and water-based mud.

II. MATERIALS AND METHODS

The equipment used for this research work are the pulverizer; test sieve, syringe, thermo-cup, Viscometer, Measuring cylinder, beaker, spatula, electronic balance, mud balance, and constant speed mixer. The materials used also includes aloe vera, bentonite, water, diesel oil, emulsifier, lime and salt. The X-Ray Fluorescence (XRF) was also used to determine and analyse the chemical/elemental composition of the aloe vera.

The natural plant aloe vera was used in this research as a drilling fluid additive. The photograph of aloe vera is exhibited in Figure 1. Aloe Vera is collected from a local nursery for this research. The selection was done from a reputable source to ensure the purity of the gel.

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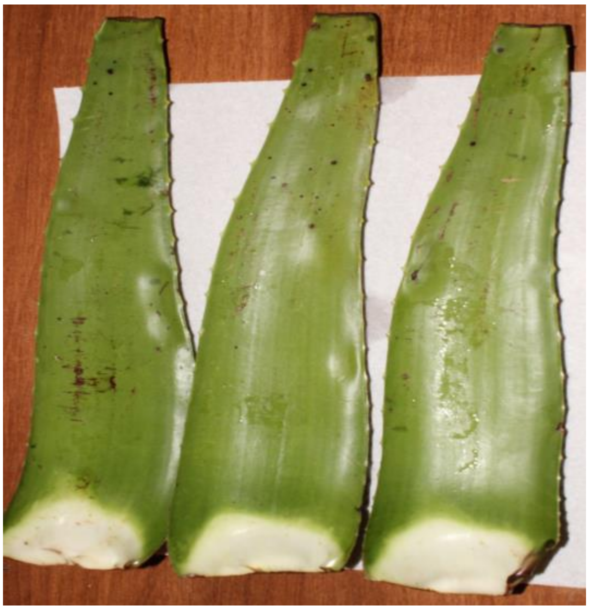

Figure 1: Aloe Vera Plant

A. SAMPLE PREPARATION

This is the first stage of the study and describes how sample was made ready for the conducting of the experiment.

B. DRYING OF THE ALOE VERA

Drying aloe vera gel in an oven is a common method used to remove the moisture content from the gel and convert it into a dry powder or flakes. The following outlined steps entails how the aloe vera sample is dried.

- ✓ Spread the aloe vera evenly onto a clean and flat surface.
- ✓ Preheat the oven to a low temperature, typically around 50-60 °C (122-140 °F). Low temperature was used to preserve the beneficial compounds and properties of the aloe vera;
- ✓ The aloe vera is considered dried when it crumbles easily into a fine powder/flakes;
- ✓ Once the aloe vera gel has dried completely, remove it from the oven and allow it to cool to room temperature; and
- ✓ The dried aloe vera was stored in an airtight zip lock bag to protect it from moisture and external contaminants.

C. GRINDING OF THE ALOE VERA INTO POWDER

In the laboratory, a pulveriser is used in the grinding of the dried aloe vera into powder to desired fineness. As the grinding process continues, the pulverized aloe vera powder is collected in a container. The fine and consistent powder that becomes suitable for further experimentation and formulation of the environmentally friendly drilling fluid

D. DRILLING FLUID FORMULATION WITH THE ALOE VERA

Formulation of the aloe vera drilling fluid is a challenging matter since correct concentration or amount of the drilling fluid is very crucial. The appropriate formula of concentration is not well known to an industry. In this research, a high amount of aloe vera additive caused separation of the drilling fluid when left for about 16 hours as compared to smaller amounts of it. Figure 2 and 3 show a high amount and a smaller amount of the aloe vera additive respectively. Hence, the formulations were kept simple with water, bentonite, and Aloe Vera (in varying concentrations) to study the effect of Aloe Vera powder for both water-based mud and oil-based mud. A simple bentonite mixture was formulated as the control experiment for comparison. Table 1, 2 and 3 show the compositions for the various drilling muds formulated.

Figure 2: Sample with Separation

Figure 3: Sample Without Separation

E. NECESSARY STEPS TO MEASURE VISCOSITY

The following procedures is used to determine viscosity with the rotary viscometer.

- ✓ After the drilling fluid is formulated and well mixed, it is poured into the Fann V-G meter cup until it reaches the engraved line on the steel cup;
- ✓ The cup is mounted onto the platform, ensuring the notch on the bottom lines up with the opening on the platform;
- ✓ Raise the platform until the fluid flows into both the holes on the top of the concentric cylinder containing the bob. This ensures the fluid enters and submerges the bob completely;
- ✓ Observe the 8 speed settings on the meter: 3 rpm, 6 rpm, 30 rpm, 60 rpm, 100rpm, 200 rpm, 300 rpm and 600 rpm.

Turn the meter on to the highest speed (stir) and let it sit for one minute;

- ✓ Start from the highest rpm (600 rpm) to the lowest rpm, and switching, back to the highest rpm for a minute in between each rpm reading;
- ✓ Starting with the highest speed, which is 600 rpm – observe the dial reading and wait until it stabilizes before taking a reading;
- ✓ Switch back to the highest rpm and take the next rpm reading. Repeat till all the rpm settings are done;
- ✓ Once the readings have been obtained, a gel strength test is to be completed. Switch the speed to 600rpm and let it mix for a minute;
- ✓ Set the switch to gel point and maintain that point for 10 minutes, then take the dial reading; and
- ✓ Analyse the data.

Mud component	**Quantity/ volume**	**Mixing order**	**Mixing Duration (min)**
Diesel oil (ml)	315	1	0.25-0.33
Emulsifier (ml)	7	2	5
Lime (g)	0.25	3	5
Water (ml) and NaCl (g)	35 and 7	4	5
Organophilic clay (g)	2	5	5
Barite (g)	55	6	15

Table 1: Preparation for Oil-based Mud Samples

Aloe Vera (g) 150 µm	Samples
0	1
0.25	2
0.50	3
0.75	4
1.00	5

Table 2: Composition for Oil-based Mud Samples

Sample	**Water (ml)**	**Bentonite (g)**	**Aloe Vera (g)**
1	350	22.5	0
2	350	22.5	0.25
3	350	22.5	0.50
4	350	22.5	0.75
5	350	22.5	1.00

Table 3: Composition and Preparation for Water-based Mud Samples

II. RESULTS AND DISCUSSION

The mud samples were tested and their dial readings were taken at different temperatures (room temperature, 45 ℃ and 65 ℃). The results are presented in (Table 4 to 15). The XRF analysis revealing several elements and their respective percentage compositions in weight is also presented in Table 16.

Quantity of Aloe Vera	**Rotation per Minute (Ib/100 ft2)**					
	3	6	100	200	300	600
	Fann VG meter Reading (Ib/100 ft2)					
0.25 g	1	1	3	4	9	12
0.50 g	1	1	2	3	4	7
0.75 g	1	1	2	2	3	6
1.00 g	1	1	1	2	3	5

Table 4: Dial Readings of WBM at 25 ℃

Quantity of Aloe Vera	**Rotation per Minute**					
	Shear Rate (1/sec)					
	5.1102	**10.2204**	**170.34**	**340.68**	**511.02**	**1022.04**
	Shear Stress/ Readings in Centipoise (cP)					
0.25 g	4.8	4.8	14.4	19.2	43.2	57.6
0.50 g	4.8	4.8	9.6	14.4	19.2	33.6
0.75 g	4.8	4.8	9.6	9.6	14.4	28.8
1.00 g	4.8	4.8	4.8	9.6	14.4	24

Table 5: Viscosity Values of WBM at 25 ℃

Quantity of Aloe Vera	**Rotation per Minute (Ib/100 ft^2)**					
	3	6	100	200	300	600
	Fann VG meter Reading (Ib/100 ft^2)					
0.25 g	2	3	4	5	6	7
0.50 g	2	2	3	4	4	6
0.75 g	1	1	2	2	3	5
1.00 g	1	1	1	2	3	4

Table 6: Dial Readings of WBM at 45 ℃

Quantity of Aloe Vera	**Rotation per Minute**					
	Shear Rate (1/sec)					
	5.1102	**10.2204**	**170.34**	**340.68**	**511.02**	**1022.04**
	Shear Stress/ Readings in Centipoise (cP)					
0.25 g	9.6	14.4	19.2	24	28.8	33.6
0.50 g	9.6	9.6	14.4	19.2	19.2	28.8
0.75 g	4.8	4.8	9.6	9.6	14.4	24
1.00 g	4.8	4.8	4.8	9.6	14.4	19.2

Table 7: Viscosity Values of WBM at 45 ℃

Quantity of Aloe Vera	**Rotation per Minute (Ib/100 ft^2)**					
	3	6	100	200	300	600
	Fann VG meter Reading (Ib/100 ft^2)					
0.25 g	1	2	4	6	8	12
0.50 g	3	3	4	5	6	8
0.75 g	1	1	2	3	3	5
1.00 g	1	1	1	2	3	4

Table 8: Dial Readings of WBM at 65 ℃

Quantity of Aloe Vera	**Rotation per Minute**					
	Shear Rate (1/sec)					
	5.1102	**10.2204**	**170.34**	**340.68**	**511.02**	**1022.04**
	Shear Stress/ Readings in Centipoise (cP)					
0.25 g	4.8	9.6	19.2	28.8	38.4	57.6
0.50 g	14.4	14.4	19.2	24	28.8	38.4
0.75 g	4.8	4.8	9.6	14.4	14.4	24
1.00 g	4.8	4.8	4.8	9.6	14.4	19.2

Table 9: Viscosity Values of WBM at 65 ℃

Quantity of Aloe Vera	**Rotation per Minute (Ib/100 ft^2)**					
	3	6	100	200	300	600
	Fann VG meter Reading (Ib/100 ft^2)					
0.25 g	1	1	3	5	8	15
0.50 g	1	1	3	5	7	13
0.75 g	1	1	3	5	9	16

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1.00 g	1	1	3	5	7	13

Table 10: Dial Readings of OBM at 25 ºC

Quantity of Aloe Vera	Rotation per Minute					
	Shear Rate (1/sec)					
	5.1102	10.2204	170.34	340.68	511.02	1022.04
	Shear Stress/ Readings in Centipoise (cP)					
0.25 g	4.8	4.8	14.4	24	38.4	72
0.50 g	4.8	4.8	14.4	24	33.6	62.4
0.75 g	4.8	4.8	14.4	24	43.2	76.8
1.00 g	4.8	4.8	14.4	24	33.6	62.4

Table 11: Computed Viscosity Values of OBM at 25 ºC

Quantity of Aloe Vera	Rotation per Minute (Ib/100 ft^2)					
	3	6	100	200	300	600
	Fann VG meter Reading (Ib/100 ft^2)					
0.25 g	3	1	2	4	7	10
0.50 g	1	1	2	4	6	10
0.75 g	2	1	2	3	6	9
1.00 g	1	1	3	4	5	8

Table 12: Dial Readings of OBM at 45 ºC

Quantity of Aloe Vera	Rotation per Minute					
	Shear Rate (1/sec)					
	5.1102	10.2204	170.34	340.68	511.02	1022.04
	Shear Stress/ Readings in Centipoise (cP)					
0.25 g	14.4	4.8	9.6	19.2	33.6	48
0.50 g	4.8	4.8	9.6	19.2	28.8	48
0.75 g	9.6	4.8	9.6	14.4	28.8	43.2
1.00 g	4.8	4.8	14.4	19.2	24	38.2

Table 13: Viscosity Values of OBM at 45 ºC

Quantity of Aloe Vera	Rotation per Minute (Ib/100 ft^2)					
	3	6	100	200	300	600
	Fann VG meter Reading (Ib/100 ft^2)					
0.25 g	1	1	2	3	4	6
0.50 g	1	1	2	2	3	5
0.75 g	1	1	1	2	4	6
1.00 g	1	1	1	2	4	7

Table 14: Dial Readings of OBM at 65 ºC

Quantity of Aloe Vera	Rotation per Minute					
	Shear Rate (1/sec)					
	5.1102	10.2204	170.34	340.68	511.02	1022.04
	Shear Stress/ Readings in Centipoise (cP)					
0.25 g	4.8	4.8	9.6	14.4	19.2	28.8
0.50 g	4.8	4.8	9.6	9.6	14.4	24
0.75 g	4.8	4.8	4.8	9.6	19.2	28.8
1.00 g	4.8	4.8	4.8	9.6	19.2	33.6

Table 15: Viscosity Values of OBM at 65 ºC

Aloe Vera			
SN	Element	Weight (%)	Eeror Margin
1	Potassium (K)	1.096	0.008
2	Calcium (Ca)	4.324	0.013
3	Sulphur (S)	0.148	0.007
4	Iron (Fe)	0.083	0.001
5	Manganese (Mn)	0.063	0.002
6	Copper (Cu)	0.027	0
7	Titanium (Ti)	<LOD	0.001
8	Zinc (Zn)	0.018	0
9	Cadmium (Cd)	<LOD	0.001
10	Molybdenum (Mo)	0.001	0
11	Rubidium (Rb)	0.003	0
12	Zirconium (Zr)	0.001	0
13	Antimony (Sb)	<LOD	0
14	Strontium (Sr)	0.016	0
15	Silver (Ag)	<LOD	0
16	Palladium (Pd)	0.001	0
17	Tin (Sn)	0.002	0
18	Chromium (Cr)	<LOD	0
19	Tellurium (Te)	<LOD	0
20	Uranium (U)	0	0
21	Thorium (Th)	<LOD	0
22	Arsenic (As)	<LOD	0
23	Gold (Au)	<LOD	0
24	Barium (Ba)	<LOD	0
25	Cobalt (Co)	<LOD	0
26	Cesium (Cs)	<LOD	0
27	Mercury (Hg)	<LOD	0
28	Nickel (Ni)	<LOD	0
29	Lead (Pb)	0	0
30	Scandium (Sc)	0.017	0
31	Selenium (Se)	<LOD	0
32	Vanadium (V)	<LOD	0
33	Tungsten (W)	<LOD	0
LOD - Limit of detection			

Table 16: XRF Analysis of Aloe Vera

III. DISCUSSIONS

The graphs for the shear stress against shear rate were plotted for the mud samples at different temperatures. The Rheogram for all temperatures for both water-based and oil-based mud are represented in Figures 4 to 9. All graphs in Figures 4 to 9 exhibit a non-Newtonian flow model. It is observed that the water-based mud sample with 0.25 g of Aloe vera has higher shear stress to shear rate values in Figures 4 and 6 as opposed to Figure 5 as the mud sample with no Aloe vera recorded the highest value. This substantial increase in Figure 4 and 6 could be as the additive likely played a role in enhancing the fluid's viscosity at this temperature. It might have introduced molecular interactions that caused these changes.

For aloe vera in oil-based mud all the samples had varying shear stress to shear rate at different temperatures. Elevated temperatures had thinning effect on the mud samples as the samples became less viscous or more fluid when subjected to shear stress or increased shear rate.

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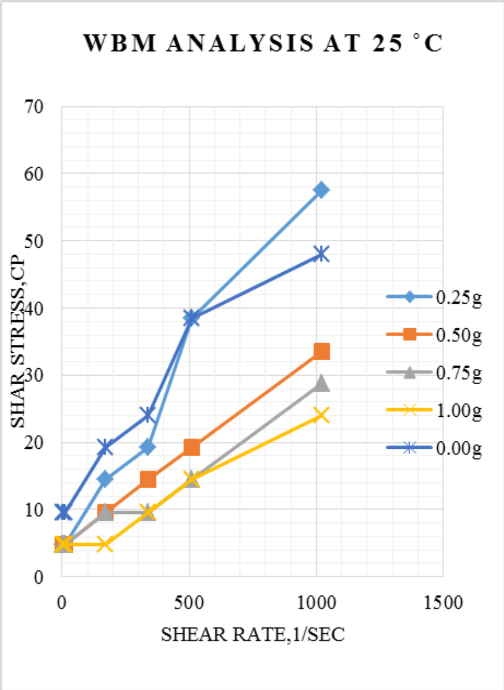

Figure 4: Rheogram of the WBM at 25 ºC

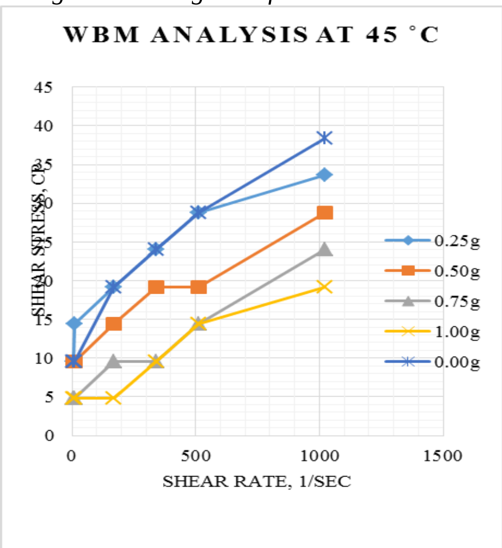

Figure 5: Rheogram of the WBM at 45 °C

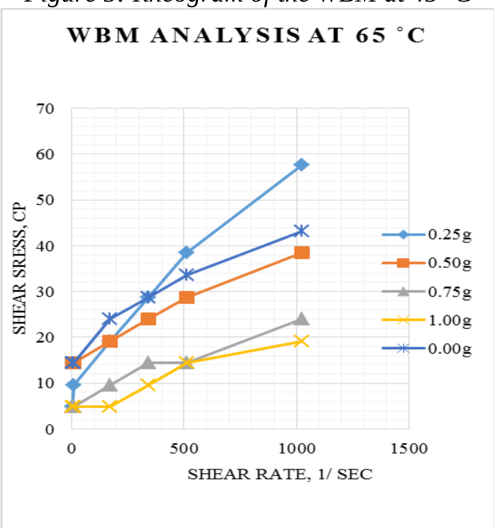

Figure 6: Rheogram of the WBM at 65 °C

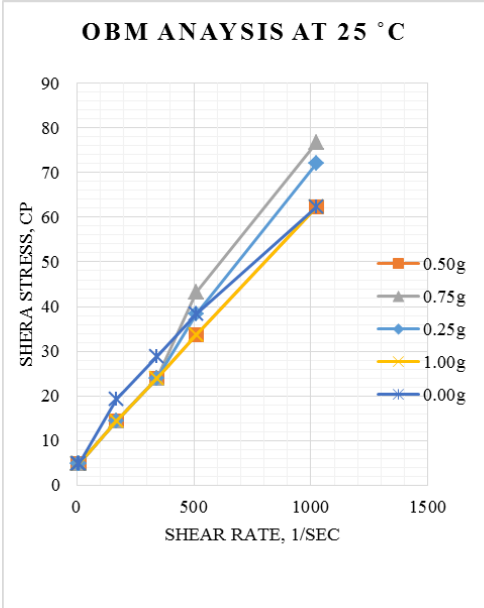

Figure 7: Rheogram of the OBM at 25 ºC

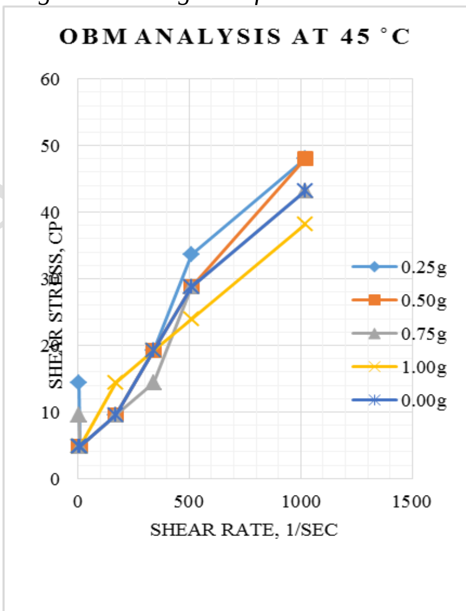

Figure 8: Rheogram of the OBM at 45 °C

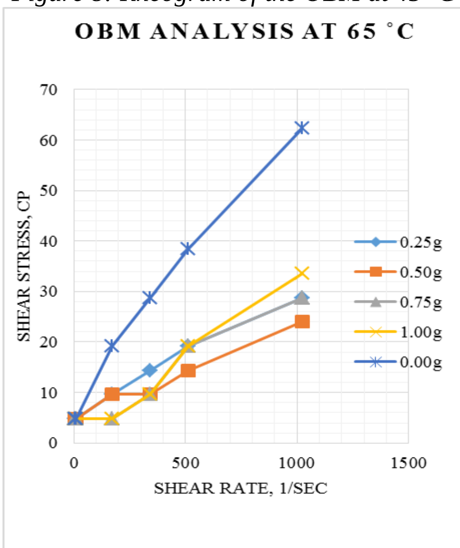

Figure 9: Rheogram of the OBM at 65 ºC

a. PLASTIC VISCOSITY (PV)

Plastic viscosity is the measure of the resistance of flow of the drilling fluid as a result of mechanical friction. This is important in the control of drilling fluid mud solids. As more solids enter into the mud, the mud gets more viscous and PV increases which may be undesirable as more power is needed to circulate the mud. For water-based mud samples, a constant PV was observed for concentrations from 0.25 g to 0.75 g at room temperature and a constant PV for concentrations from 0.50 g to 0.75 g for PV values at 45ºC. This implies that these concentrations are effective in maintaining a consistent viscosity under those specific thermal conditions.

For aloe vera in oil-based mud it is observed that an increase in temperature causes a decrease in plastic viscosity and shows similar trends for all samples except 0.75 g of aloe vera which showed a consistent PV value as temperature increased. The oil-based mud samples tend to exhibit shear-thinning behaviour as temperature is increased and the fluids become less viscous as shear stress increases. However, the PV values of the oil samples compared favourable well with API PV value of 65 CP.

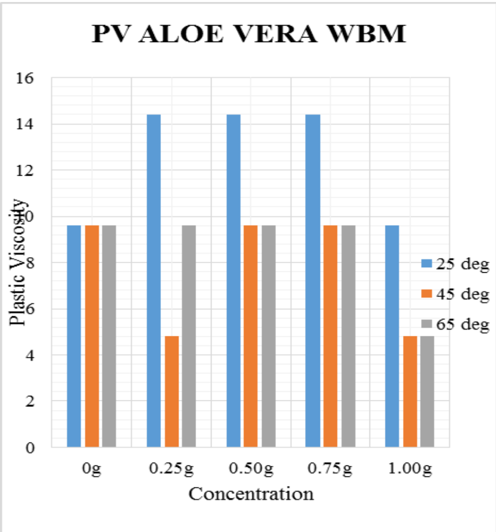

Figure 10: Plastic Viscosity of the WBM at Different Temperatures

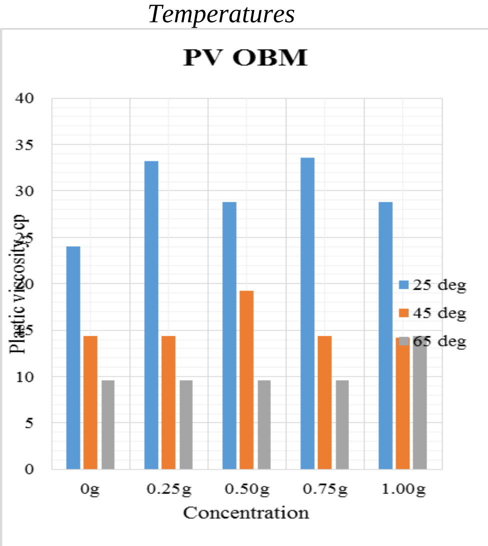

Figure 11: Plastic Viscosity of the WBM at Different Temperatures

b. YIELD POINT (YP)

Yield point is used to evaluate the ability of a mud to lift cuttings out of the wellbore annulus. The higher the YP, the higher the ability for the drilling fluid to carry cuttings better than a fluid of similar density but lower YP. An increase in the aloe vera concentration from 0.50 g to 1.00 g caused a decline in YP values for both water-based mud and oil-based mud as shown in Figure 12 to 13. Temperature also affected the yield point. The decrease in yield point may be as a result of aloe vera breaking the attractive forces between the clay in the mud and the mud as a whole. Generally, the formulated oil-based mud samples could not achieve a suitable YP value compared to API YP (15 - 45 Ib/100 ft^2) except for 0.25 g of Aloe vera at room temperature and 45 degrees Celsius which was in the API range as shown in Figure 12 and 13.

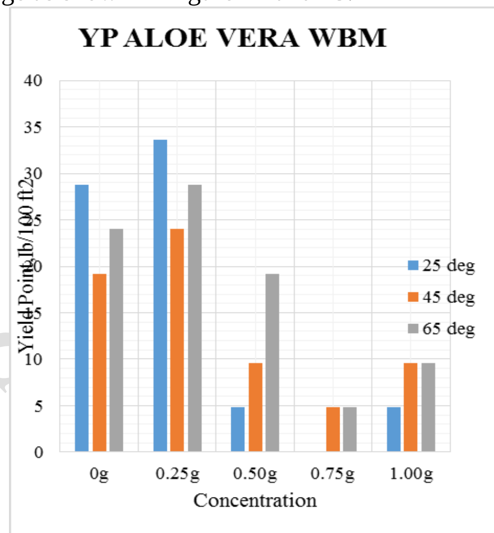

Figure 12: Yield Point of the WBM at Different Temperatures

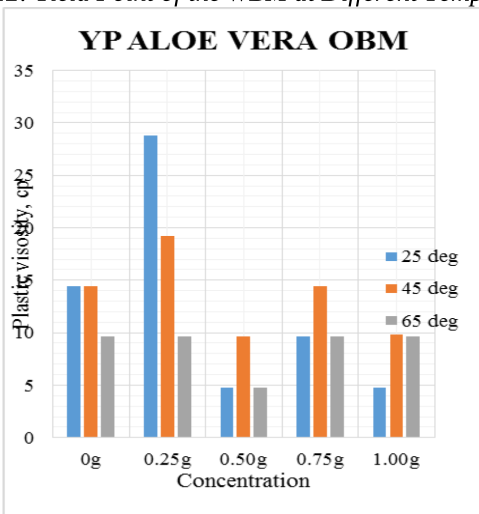

Figure 13: Yield Point of the OBM at Different Temperatures

c. GEL STRENGTH

The Gel strength is a function of the inter-particle forces. An initial 10-second gel and 10-minute gel strength measurement give an indication of the amount of gelation that will occur after circulation ceased and mud remains static. The more the mud gels during shutdown periods, the more pump

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pressure will be required to initiate circulation again**.** In Figure 15, it is observed that after 10-seconds, all the samples had varying gel strengths except the 0.50 g and 0.75 g of aloe vera concentration which exhibited an increase in gel strength as temperature increased and a decrease in gel as temperature decreased respectively. This might be that as temperature increased in 0.50 g of aloe vera the strength of attractive forces in the drilling fluid increased unlike the 0.75 g of aloe vera which saw a decrease in strength of the attractive forces in the mud. In Figure 16, it is observed that as temperature increases the gel strength of the mud also increases but shows a decline in gelation as concentration increases. This could be that an increase in concentration of aloe vera additive affects the gelation of the mud after 10-minutes.

For 10-seconds and 10 minutes gel strengths for the oil-based mud, API recommends a range of 3 – 20 Ib/100 ft2 and 8 – 30 Ib/100 ft2 respectively. Generally, the mud samples exhibited good gel strengths for both 10-seconds and 10 minutes as they recorded low gel strength build-ups.

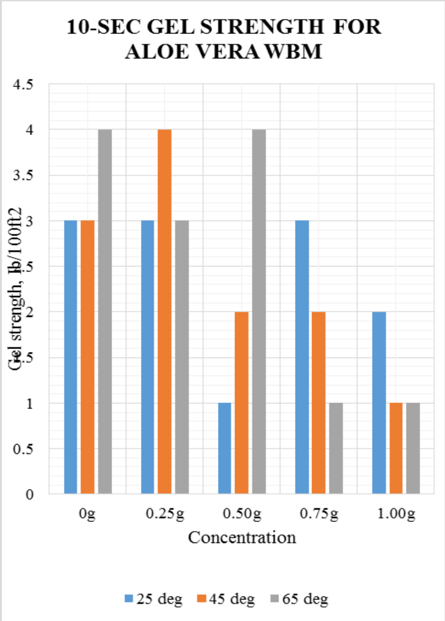

Figure 14: 10-seconds Gel Strength of the WBM at Different temperatures

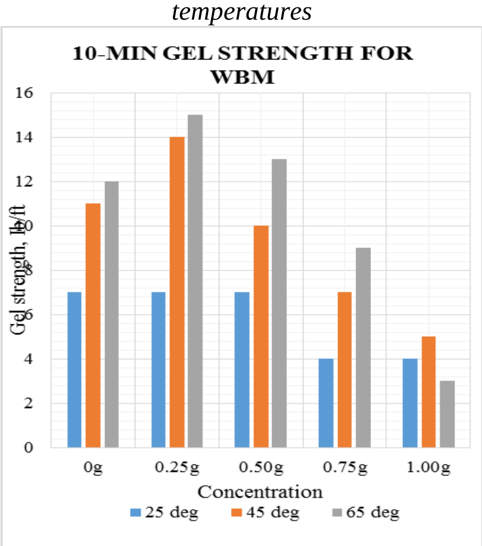

Figure 15: 10-minutes Gel Strength of the WBM at Different Temperatures

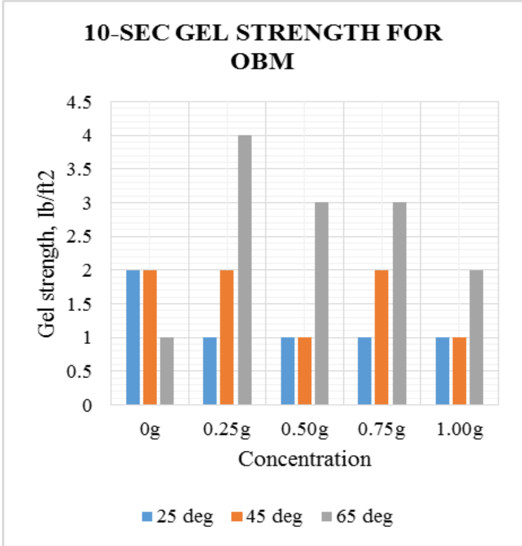

Figure 16: 10-seconds Gel Strength of the OBM at Different Temperatures

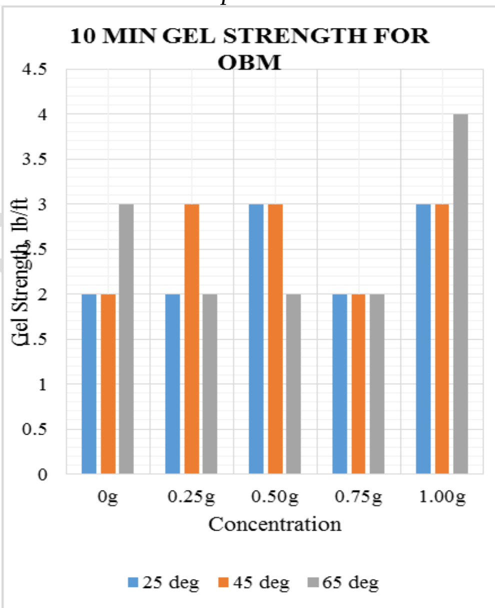

Figure 17: 10-minutes Gel Strength of the OBM at Different Temperatures

IV. CONCLUSION

Generally, aloe vera as an additive in oil-based mud samples performed better as compared to the water-based mud. Temperature and amount of additive concentration played a vital role in the drilling mud as elevated temperatures have thinning effect on oil-based mud but could be normalised by addition of viscosity additives and increase in concentration causes a decline in yield point for both drilling fluids. Aloe vera has the tendency to improve rheological properties in drilling fluids based on the results. The 0.25 g of aloe vera concentration in both drilling muds showed a significant effect on rheological properties as it exhibited a higher yield point, gel strength and plastic viscosity values at varying temperatures.

On the XRF analysis of the chemical/elemental composition of aloe vera, Calcium is the dominant element as reported in most literature works and the next being Potassium. Several other elements were in smaller quantities while some were below the limit of being detected by the machine.

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