Use of Bamboo Leaf Ash as an Additive to Aqueous Drilling Fluid and Study the Variation of Rheological and Filtration Loss PropertieS.

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Abstract - *Requisition of efficient use of imprudent by-products for the enhancement of drilling fluid is preferentially beneficial for a hassle-free and relentless drilling process. Intricately designed drilling fluids have been used in the petroleum industry having significant properties to meet many operational requirements. The conventional methods are proven to be efficient in the current scenario, but they have limited capability and may not be suitable for future drilling operations due to the increasing challenges in the petroleum industry. A need exists for a strong, stable and customizable fluid which can not only satisfy the basic functions of a drilling mud, but also make productive use of waste products for its enhancement. This paper deals with the possibility of using Bamboo Leaf Ash (BLA) as an additive in Water Based Drilling Fluid (WBDF). The main components of BLA include silica (SiO_2), aluminum (Al_2O_3) and iron oxide (Fe_2O_3). The yield percentage of silica from bamboo leaf ash is 78%. In our study we have attempted to use BLA as an additive to WBDF comparative analysis of the rheological properties of drilling fluids with different percentage of BLA has been studied. Based on the comparative study it is observed that BLA can be used as an additive to WBDF.*

Key Words: Drilling Fluid, Rheological Properties, Bamboo leaf ash …

1. INTRODUCTION

The exploration and exploitation of hydrocarbon on offshore and onshore environment suggest the use of environmentally friendly drilling mud and its additives thereby preventing any harm to the aquatic bodies and the terrestrial environment. Currently, various kinds of drilling fluid systems are used in the oil industry, among which the significant ones include, Polymer based drilling fluid system, oil-based drilling fluid system, etc. Nevertheless, most of them have some serious environmental concern, degradability issue and difficulty in the post-treatment, which bring the contradiction between clean drilling and requirements of drilling operation. Environmental regulations uplift the use of water-based drilling fluid and its application in areas where oil-based drilling fluids have previously been used due to their challenges [1]. Most of the efficient drilling fluids have high toxicity and this toxicity is limiting the use of such drilling fluids. In this scenario, the oil industry is in need of something known as eco-friendly drilling fluid, but to go with the idea of preparing the same, two things are to be considered, i.e., the efficiency of the drilling fluid and, the cost of the drilling fluid. In most of the cases we must compromise either one of these three: eco-friendly, economical, or efficiency, and in a few cases, two of them [2]. The various properties of the drilling mud are rheological properties, filtration loss properties, lubricating quality, pipe sticking tendency, thermal and bacterial inhibition, etc. Myriad additives are added for making the drilling mud most suitable for the different conditions for viscosity, mud weight, prevent mud loss, have enough gel strength and be reliable. A few additives such as calcium carbonate, starch and xanthan gum are common incorporated in the formulation of a drilling mud [3]. Xanthan Gum also used as a viscosifier which controls the rheology. Starch is a fluid loss control additive widely used in aqueous drilling fluids and has a thermal stability upto 250 °F [4]. Carboxymethyl Cellulose (CMC) is another polymer which tends to increase shear stress as its concentration in the mud increases and the fluid loss decreases. An optimum concentration is favorable in the drill mud [10]. The usage of Calcium Carbonate ($CaCO_3$) provides an ionic inhibition and hence serves as a bridging agent [5][6][7][8][9][10]. Caustic Soda, which is also known as Sodium Hydroxide (NaOH), is used in water-based mud to have a check on the pH level and does affect the salinity of the drilling mud [11]. To increase the density and for shale inhibition, Potassium Chloride (KCl) is used [12]. Mica is another Loss Circulation material. Unlike cellopane material, Mica tends to avoid absorbing large amounts of free water or oil [12]. Lube oil used to have a check on the increased torque/drag, limited displacement, increased equipment stress [13]. To provide weight to the drilling fluid, the usage of an inert, high density Barite is employed [14]. The main purpose of using weighting materials is to increase its density and thereby ensuring the borehole stability [15]. It provides the required hydrostatic pressure in the hole and has a check on the fluid loss by the formation of mud cake of the inner walls on the well [16]. Bamboos belongs to the grass family Poaceae, a flowering plant in the subfamily Bambusoideae. Its growth rate is 910 mm per day [17]. Bamboo forests covers around 12.8% of the total forest area and is found in most of the states of

India. More than 50 per cent of the bamboo species appears in North East India i.e. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. Apart from these regions, there are significant traces of Bamboo leaf in the Andamans, Bastar region of Madhya Pradesh and the Western Ghats. Bamboo leaf is an agro-waste product. A typical composition of bamboo leaf ash is SiO_2: 78%, Al_2O_3: 4.96% Fe_2O_3: 2.01% CaO: 4.43% MgO: 1.02% K_2O: 3.09% P_2O_5: 0.72% TiO_2: 0.36%, LOI: 1.58% [18]. Bamboo leaf ash has a lot of application in concrete industry. B Olutoge F.A. and Oladunmoye O.M. used bamboo leaf as a supplementary cementing material. Ernesto Villar-Cociña concluded that BLA is formed by amorphous silica. In this paper, we have come up with an idea in which our objectives are equally balanced. With this approach, we use a natural organic material with bentonite and prepare a new drilling fluid which is less toxic, economical, and environment friendly. We obtain it by processing the bamboo leaf in steps including drying, grinding, heating it in a muffle furnace, removing the impurities to obtain an end product which consists of mainly silica. Bamboo leaf ash has about 75.90% of SiO_2 (Silicon Dioxide). The presence of silica provides high resistance to water penetration, thermal and fungal decomposition [19]. This property can hence help in its usage to prevent fluid loss of the drilling fluid. A comparative study between these additives is done to check for the rheological properties, filtration properties, lubricating quality, stuck pipe efficiency, thermal and bacterial inhibition, and the various rheological properties.

2. MATERIAL AND METHODOLOGY

2.1 Material used

For the experiment we have used API Grade Bentonite, industry grade Barite (SG 4.2), Carboxy Methyl Cellulose (CMC, Sigma Aldrich), Xanthan Gum (XC, Sigma Aldrich), Calcium Carbonate-Fine ($CaCO_3$, Karnataka Fine Chem.), Sodium Hydroxide (NaOH, Karnataka Fine Chem.), Potassium Chloride (KCl, Karnataka Fine Chem.), Lube Oil and Mica

2.2 Equipment used

API LPLT filter press (Fann Instrument Company): It is the most effective means of determining the filtration properties of drilling muds and cement slurries.

Lubricity tester (Fann Instrument Company): The Lubricity tester is a high-quality instrument used to measure the lubricating quality of drilling fluids.

Differential sticking tester (Model 21150 Fann Instrument Company, Houston, Texas): The Differential Sticking Tester measures the “Stuck Pipe Tendency Coefficient” of drilling fluids, and determines how effective lubricants or treatments might be with any given drilling fluid.

Fann VG meter (Fann Instrument Company): It is also known as direct-indicating viscometer or V-G meter, an instrument used to measure viscosity and gel strength of drilling mud.

Muffle Furnace: Use for combustion of raw dry bamboo leaf

2.3. Methodology

2.3.1 Preparation of BLA

Bamboo leaf was sun dried in open atmosphere for 2 to 3 days then the dry leaves were grinded and converted to powder. This powder is placed in a muffle furnace at 800°C for two hours to obtain BLA. After that the ash is passed through a sieve with mesh size 120 micron. Larger particles which were left out on the top were removed and the remaining was collected from the bottom.

2.3.2 Procedure to remove BLA impurities.

The sample which is heated in the furnace at a temperature of 800°C, is later subjected to acid washing. We use 100ml of dilute Hydrochloric Acid (HCL) for this purpose. This mixture is heated at 70°C in hot air oven and left to open air for 30 minutes. The residue obtained is treated with an alkali to neutralize the acidic contaminants for which we use 100ml of sodium hydroxide (NaOH) after which it is heated to 70°C and left to open air. The product obtained by the chemical reaction is Na_2SiO_3, which is then washed with distilled water for about 4-5 times. To collect the filtrate, HCL is added drop wise till a precipitate is formed. This precipitate can be collected and heated to 90-100°C for 4 hours. The precipitate obtained after 4 hours is free from all kinds of impurities.

Figure 1 : Muffle Furnace

Figure 2 : BLA

2.3.3 Preparation of samples

For this experiment we prepare twelve samples using Hamilton Brach mixer following the American Petroleum Institute (API) standards to investigate the properties of the fluids. The composition of each sample has been mentioned in Table 1.

2.3.4 Rheological test

Fann VG meter was used to determine Apparent viscosity (AV), Plastic Viscosity (PV), Yield Point (YP) and Gel strength of the all samples. All dial readings were taken at 300 and 600 rpm. Similarly, to determine filtration loss and filter-cake thickness, API LPLT filter press was used. To determine Lubricity coefficient and Differential sticking coefficient we used EP Lubricity coefficient tester and Differential Sticking Tester.

Table 1 Composition of different samples

Materials used	Unit		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12
Bentonite	g/L		30	30	30	30	30	30	30	30	30	30	30	30
Water	mL		1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Barite	g/L		10	10	10	10	10	10	10	10	10	10	10	10
CMC	g/L		--	8	--	--	--	8	--	--	--	8	--	--
Xanthan gum	g/L		--	--	8	--	--	--	8	--	--	--	8	--
Bamboo leaf Ash	g/L		--	--	--	8	--	--	--	8	--	--	--	8
KCl	g/L		5	5	5	5	5	5	5	5	5	5	5	5
NaOH	g/L		7	7	7	7	7	7	7	7	7	7	7	7
$CaCO_3$	g/L		8	8	8	8	8	8	8	8	8	8	8	8
Mica	g/L		--	--	--	--	5	5	5	5	5	5	5	5
Lube oil	mL		--	--	--	--	--	--	--	--	8	8	8	8

3. RESULTS AND DISCUSSION

3.1 Fann VG meter results

The rheological test was performed using FANN VG meter on sample 1, 2, 3 & 4. Dial reading for each sample at 600 and 300 RPM were taken and using equation (A), (B) and (C) PV, YP and AV were determined.

$$PV = \theta_{600} - \theta_{300} \quad \text{(A)}$$

$$YP = \theta_{300} - PV \quad \text{(B)}$$

$$AV = \theta_{600}/2 \quad \text{(C)}$$

Comparison of the values are shown in the Fig 3, 4 and 5. Being a mud thickener, XG and CMC both show enhanced PV and AV value, but when we added BLA it was found that the obtained PV and AV values are in the mid-range of the values we get from both XG and CMC. It means that BLA can be used as a mud thickener because these results are comparable to XG and CMC added aqueous drilling mud (i.e., For PV 8-15 cP & for AV 25-37.5 cP). It was observed that YP values of the drilling fluid was increasing when we added XG and CMC. The YP values of BLA added drilling fluid were also obtained. It is seen that YP value of BLA added drilling fluid is comparable with the samples with XG and CMC. We know that YP is very important to lift the drill cuttings back to the surface. Hence from our study it is evident that cutting carrying capacity is increasing with the addition of BLA (Fig.5). This also reduces the annular frictional pressure drop. The YP obtained for the sample with BLA is 27 lb./100 sq.ft. In their work Bourgoyne et al., 1991, recommended that sample with YP value range 3–30 lb/100 ft^2 is most suitable for carry cuttings to the surface. In such cases frictional pressure drops in the annulus is also less. Therefore, YP values of the BLA added drilling fluid has the ability to lift the cuttings. According to Chilingarian et al., 1986, YP/PV ratio is the major factor to check whether the mud is stable or not. If the YP/AV ratio is less than the mud, it is considered to be stabilized. Whereas if the ratio is more than the mud, it is considered to be flocculated. Among all four samples (1, 2, 3 & 4), the YP/PV ratio is the least for the sample 4, i.e. the drilling mud with BLA as an additive. This indicates that the mud is stable. It has been observed from the Fig. 4 that the gel strength of the mud samples increased as we are increasing the amount of XG and CMC in it. This suggests that the mud is getting thicker. The 10 sec strength of the polymer added mud was found to be in the range of 22 to 38 lb./100 ft^2 (Table 2), and 10-min gel strength ranged from 24 to 20 lb./100 ft^2 (Table 2). It was also observed that the mud with BLA also has a significant initial and final gel strength. This gel strength value is almost comparable with the gel strength values of XG and CMC. Increasing trend in final gel strength is also observed in this case.

3.2 API Filter Press results

API filtration loss test was performed to measure the filtration loss and the mud cake thickness of the drilling fluid. The results obtained are shown in the Table 3. From the Fig. 6 and Fig. 7 and from the results it is distinct that fluid loss decreased with the addition of polymers such as XG and CMC. The filtrate loss obtained after addition of XG and CMC were 24 & 27 mL respectively. Whereas after addition of BLA the obtained filtrate loss is 24 mL. Similarly, the mud cake thickness of mud with BLA is also comparable with the mud cake obtained from XG and CMC added drilling fluid (Table 3). Based on the filtration loss and cake thickness results, it was observed that BLA can be added in the drilling fluid system and its filtration loss behavior is almost identical with XG and CMC.

3.3 EP Lubricity Tester results

Lubricity is one of the major properties of an aqueous drilling fluid. Lubricating property of drilling fluid reduce the friction in the downhole equipment and, the wear and tear of drill string. In Lubricity coefficient test, 150 in-pounds of force is applied between two hardened steel surfaces, a block, and a ring rotating at 60 RPM. Lubricity coefficient for different samples (Sample 9, 10, 11 & 12) are shown in Table 4. It is observed that sample with BLS shows a comparable result with mud with XG and CMC (Fig 8). In fact, compared to other samples we have better lubricating property of mud when we add BLA in the drilling system. With this, it can be concluded that lubricating property of drilling fluid can be enhanced by adding BLA.

3.4 Differential Sticking Tester

Differential sticking typically occurs in the downhole where there is higher pressure differential between wellbore and the formation. In such cases drill string assembly gets stuck in the mud cake. The sticking force is a product of the Pressure differential and the contact area. Table 5 shows the differential sticking coefficient of different samples. It is also observed that among all four samples (Sample 9, 10, 11 & 12) mud sample with BLA has the least tendency to stick (Fig. 9). Hence, it can be concluded that BLA can be solution for possible differential sticking problem in the downhole condition.

4. CONCLUSION

From the study we can conclude that bamboo leaf ash has a significant effect on the properties of the drilling mud. The following is the conclusion of our study:

a) Based on the study it can be concluded that addition of BLA in drilling fluid has a significant effect in the PV and AV.

b) The cutting transport properties of the drilling fluid also enhances upon addition of BLA in the drilling fluid

c) Gel strength property is enhanced, especially as there is improvement in the final gel strength over initial gel strength, which is an indication of mud stabilization.

d) There is a significant reduction in the filtration loss for the mud having BLA as an additive. The results are almost comparable with XG and CMC.

e) Lubricating property of the drilling fluid is enhanced with the addition of BLA in the drilling fluid system.

f) Sticking tendency is also reduced for the drilling fluid with BLA as an additive

g) After careful observation of all the properties it can be concluded that BLA can be used in Drilling fluid as a mud thickener to improve rheological and filtration loss properties of drilling fluid.

5. AUTHOR AFFILIATION

With the help of this paper we are trying to find a solution for one of the biggest problems faced in the oil industry, i.e. the lack of an eco-friendly water-based drilling fluid. In this paper we have introduced a new water-based drilling fluid with the help of a natural additive in form of bamboo leaf ash with which we have also solved the economic part of drilling fluid additive. We think this water-based drilling mud can be very widely used in the drilling process because of its economical, efficiency and eco-friendly advantage over other drilling fluids which are currently used.

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NOMENCLATURE:

AV: Apparent viscosity (cP)

PV: Plastic viscosity (cP)

YP: Yield point (lb./100ft^2)

θ: Bob dial reading

XG: Xanthan Gum

CMC: Carboxy Methyl Cellulose, cP: centipoise

Table 2. Values obtained from Fann VG meter

SAMPLE	PV (cP)	YP (lb./100 sq. ft.)	AV (cP)	Initial Gel Strength (lb./100 sq. ft.)	Final Gel Strength (lb./100 sq. ft.)	YP/PV ration	pH
Sample 1	6.00	3.00	7.50	3.00	1.00	0.50	7.40
Sample 2	8.00	34.00	25.00	22.00	24.00	4.25	8.65

Sample 3	15.00	45.00	37.50	38.00	40.00	4.25	8.44
Sample 4	13.00	27.00	26.50	33.00	35.00	3.89	8.00

Table 3. Values obtained from API Filter Press

API Filter Press

SAMPLE	Mud Filtrate (mL)	Mud Cake thickness (1/32")
Sample 5	50	2
Sample 6	27	4
Sample 7	24	5
Sample 8	24	4

Table 4. Values obtained from EP Lubricity Tester

EP Lubricity tester				
SAMPLE	Average Reading	Correction factor	Meter Reading	Lubricity Coefficient
Sample 9	22	1.55	21	0.32
Sample 10	24	1.42	28	0.40
Sample 11	27	1.26	33	0.42
Sample 12	29	1.17	37	0.43

Table 5. Values obtained from Differential Sticking Test apparatus

Differential Sticking Tester		
SAMPLE	Torque reading	Sticking Coefficient
Sample 9	150	0.1500
Sample 10	141	0.1410
Sample 11	137	0.1370
Sample 12	126	0.1260

GRAPHS:

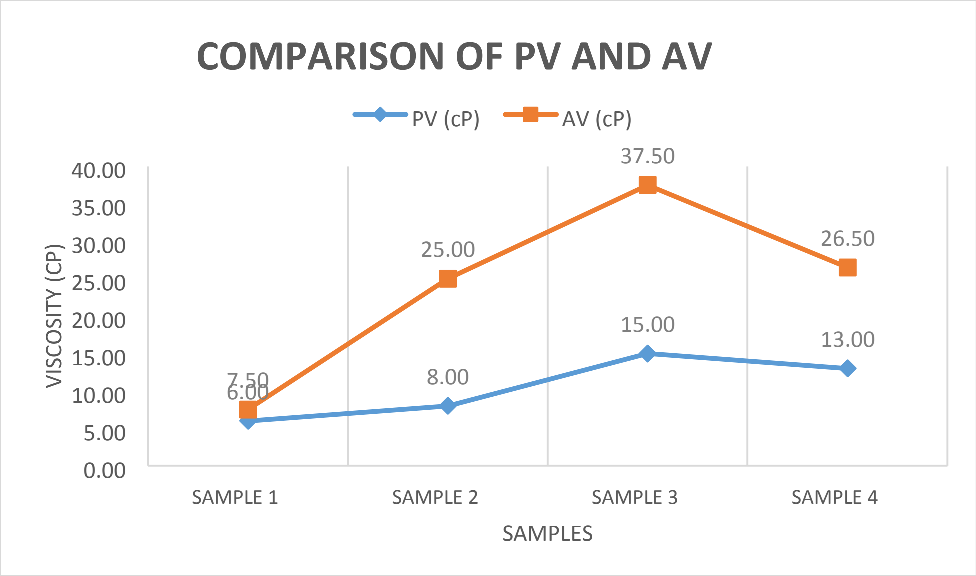

Chart 1: Comparison of PV and AV

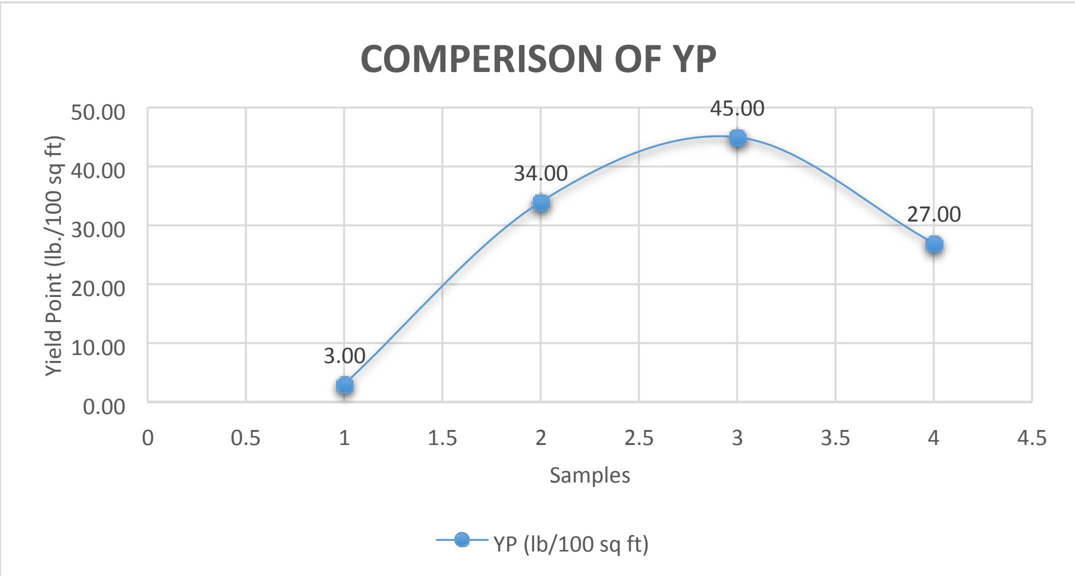

Chart 2: Comparison of YP

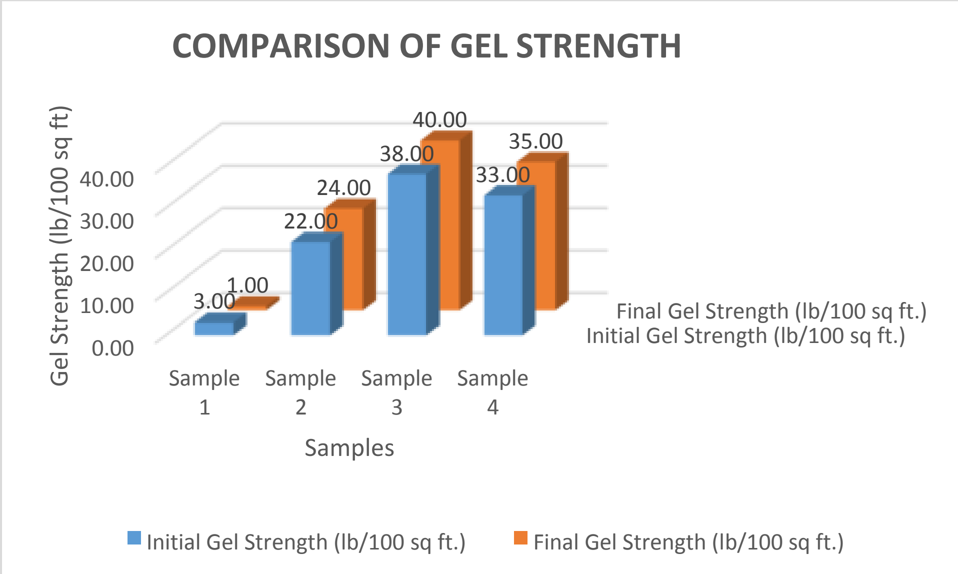

Chart 3: Comparison of Gel Strength

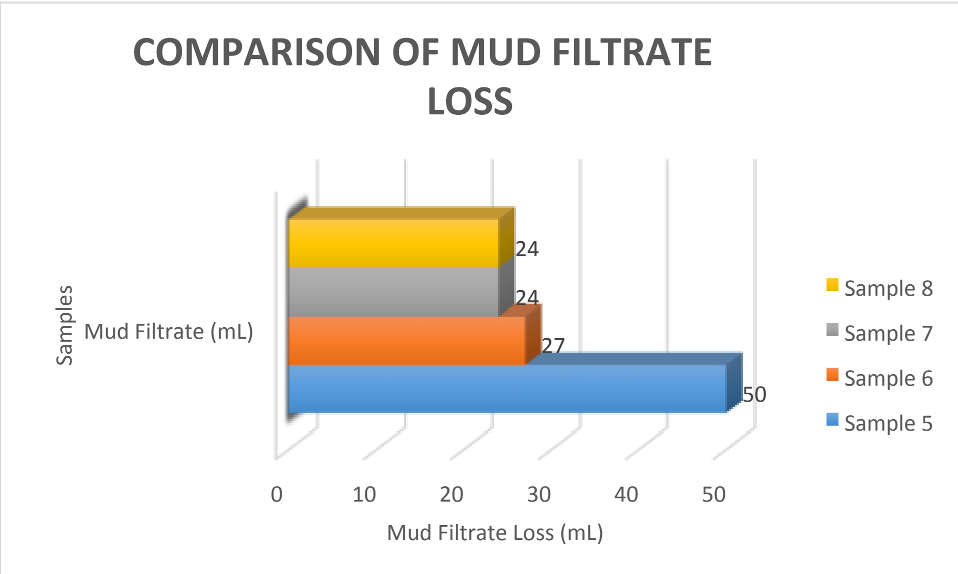

Chart 4: Comparison of Mud Filtrate loss

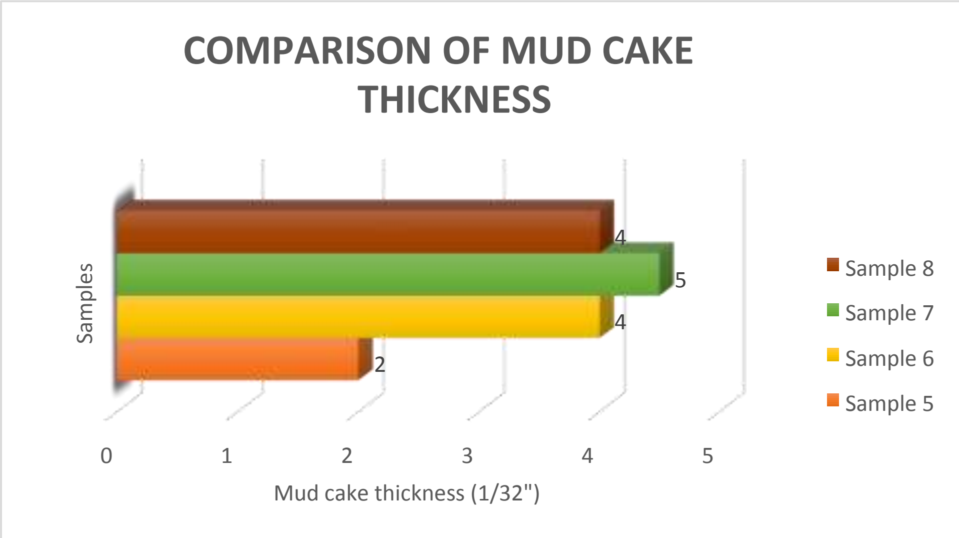

Chart 5: Comparison of Mud cake thickness

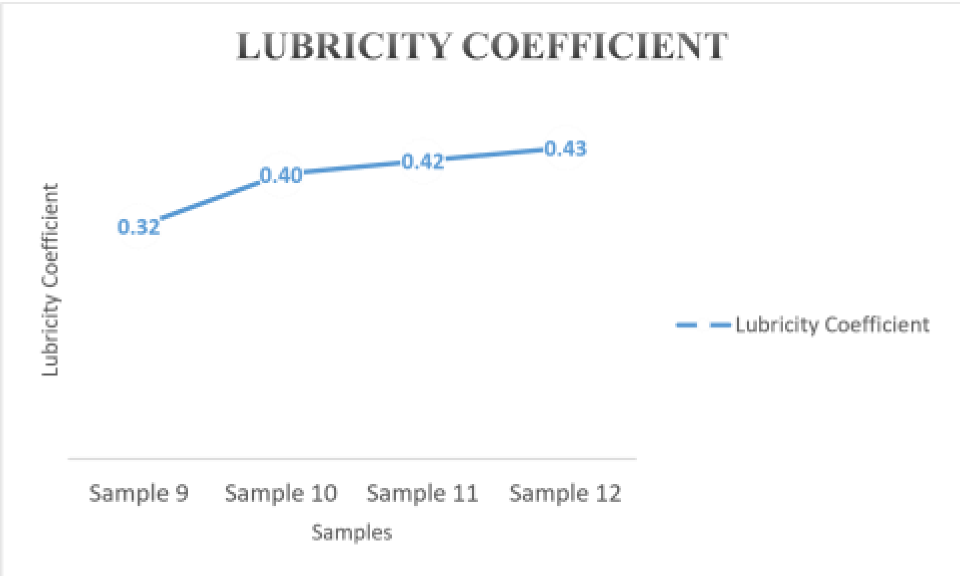

Chart 6: Comparison of Lubricity coefficient

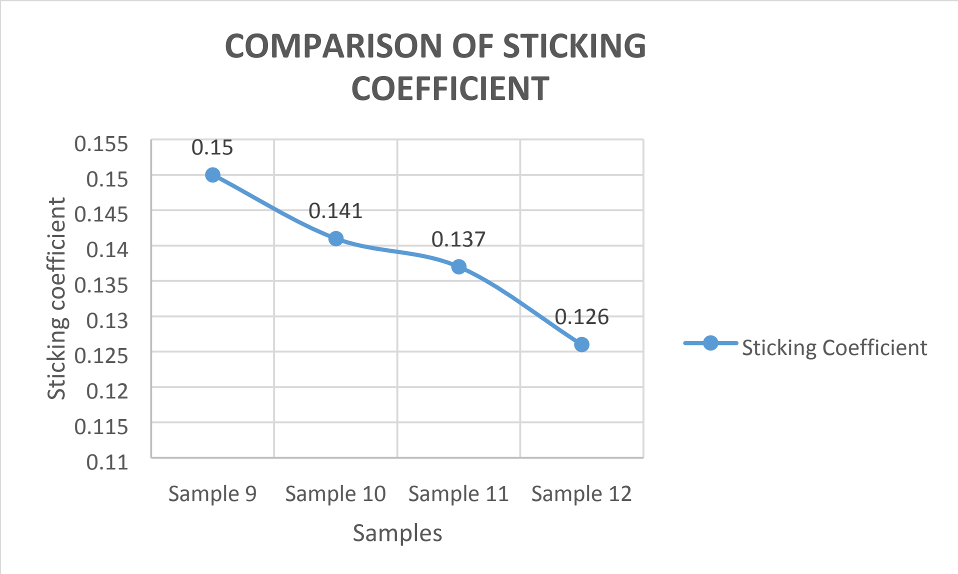

Chart 7: Comparison of Sticking coefficient

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