Effect of Microbes on Drilling Fluid Formulation

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Abstract— *Microorganisms square measure thought of to have an effect on the properties of drilling fluids. This work self-addressed the subsequent sections: the character of Micro-organisms, microbic Mechanisms that have an effect on Drilling Fluids, Implications of microbic Contamination and Identification. This work focuses on the likelihood of utilization of microbes as basic material for lubricant. This analysis assess by means that of straightforward however relevant laboratory, the properties of the microbes cultivated from banana skin within the micro-biological laboratory and compared with commonplace drilling fluid. The results were analyzed exploitation applied mathematics and graphical ways. Water based drilling muds were developed with the microbes and characterised to work out the properties like density, rheology and pH within the laboratory and compared with those of the standard laboratory mud. Results showed enhancements in sure properties, but it verified unsuitable in different properties in comparison to straightforward drilling fluid.*

I. INTRODUCTION

The existence of natural water setting ensures, regardless of however harsh, some variety of micro-organism. These micro-organisms exists in many thousands of species and new species are bound to be discovered at the speed of over 1000 each year [1]. Natural populations will range from some hundred organisms per cubic decimetre of fluid to well in far more than a billion per cubic decimetre. Micro-organisms form a formidable force when put together capable of destroying nearly each organic existing. The role of micro-organisms is basically the reduction of complicated matter to a lot of easy kind, bringing back this energy as building blocks of life.

Drillinq fluids are perpetually exposed to giant numbers and kinds of micro-organisms although it was often thought that drilling fluids and their additives possessed low susceptability to microorganism attack. However in the wake it became clear by their terribly nature and

sophisticated organic structure, it is this evident that they are ideal environments for a range of micro-organisms.

Natural gums, carboxymethylcellulose (CMC), lignins, liqnosulphonates, tannins, and many other compounds which are added to muds are all found to be susceptible to biodegradation also synthetic polymers such as polvacrylamides are not immune to attack either [2]. The source water used to prepare the mud, wind blown dust and dirt, rain, human contact, and possibly even some of the materials which are used to prepare the mud are few means by which these micro-organisms could enter the drilling mud. Its degree of existence is then favoured by factors such as: temperature of the re-circulating mud, composition of the water used to make up new mud, chemical nature of the mud system itself, the length of time that is required to drill the hole, and type of micro-organisms which become established and time [3]. The microbes utilize xanthan gum, a common drilling mud additive. Also, drilling fluids are highly alkaline and

contain high concentrations of specific heavy mineral salts (such as BaSO4, LiBr). Thus, these drilling fluids may affect both the core microbiology and the inorganic geochemistry (e.g., pH, specific cation and anion concentrations, etc.) of interstitial water and also trace element geochemistry of igneous rock core (e.g., lithium isotopic composition). The rising demand for use of drilling fluids in the deep offshore, these shift makes for the determination of the effects of bacteria and fungi on formulated drilling mud. This work will be a guide of great relevance since it causes a great turnaround in Drilling Fluid Technology.

II. LITERATURE REVIEW

2.1 Classification of Conventional Drilling Fluids

Drilling fluids are mainly composed of a mixture that includes different liquids, gases, emulsions, and solids, some of them dispersible some not [4]. Drilling fluids are a vital component during the well construction process to reach reservoirs with different characteristics while carrying out the cuttings generated and providing a medium to stabilize the wellbore wall. Its origins can go as early as the third century BC when in China water was first used to 'softening' the underground layers to drill wells of hundreds of feet in depth [5]. Its modern history started in Spindletop Field in south Beaumont, Texas in 1901 when a kind of muddy water was used to drill through unconsolidated sands [6]. Nowadays, Industry has already understood that the correct design and application of drilling fluids depends mostly on the characteristics of the formations to drill, especially when its average cost can be about 5% to 15% of the total cost to drill a well [7] [8]. Therefore, with improvements in research, different additives have been developed and tested to enhance the drilling fluid performance in order to satisfy the requirements of each specific reservoir while reducing costs associated with non productive times.

Drilling fluids are often classified based on their fluid phase alkalinity, dispersion, and the type of chemicals used. In the classification according to [9] drilling muds are usually classified according to their base material into liquids composed by water-based drilling fluids (WBM), and non-aqueous based drilling fluids (oil-based, OBM and synthetic-based, SBM), gas or a gas/fluid mixture (Pneumatic-based drilling fluids) However, WBMs may contain oil and OBMs may contain water [10].

OBMs generally use hydrocarbon oil as the main liquid component with other materials such as clays or colloidal asphalts added to provide the desired viscosity together with emulsifiers, polymers, and other additives including weighting agents.

Water may also be present, but in an amount not usually greater than 50 volume percent of the entire composition. If more than about 5% of water is present, the mud is often referred to as an invert emulsion, that is, water-in-oil emulsion. WBMs conventionally contain viscosifiers, fluid loss control agents, weighting agents, lubricants, emulsifiers, corrosion inhibitors, salts, and pH control agents. The water makes up the continuous phase of the mud and is usually present in any amount of at least 50 volume percent of the entire composition. Oil is also usually present in minor amounts but will typically not exceed the amount of the water so that the mud will retain its character as a water-continuous phase material. OBM and WBM have been the main conventional systems that oil & gas industry has used to drill nearly all formations.

2.2 Properties of Drilling Fluids

Rheology is the science that studies the relationship between the flow of matter and the deformation experience. In drilling operations, rheology is one of the most important characteristics to describe the drilling fluid behavior at various flow conditions. The drilling fluid rheology and analysis can have a further impact on the capabilities to increase the hole cleaning efficiency, borehole stability, and ROP if not designed properly.

Different rheological models tried to describe the behavior of the drilling fluids at dynamic conditions. When shear stress and shear rate in the drilling fluid are directly proportional the fluid behavior will be linear and can be defined as a Newtonian fluid (e.g. water, alcohols) in which its slope described a constant effective viscosity (cp). On the other hand, when the relationship does not follow the same proportion, the fluid will behave as a non-Newtonian fluid. Most drilling fluids fit the last group.

2.3 General Consideration of Filtration in Drilling Fluids

Drilling fluids are usually composed of liquid and solid phases. Filtration refers to the invasion of the liquid phase into the formation when the drilling bit exposes new formation and the drilling fluid comes in contact with it. Initially, a small volume of mud can invade the formation before the actual filtration process takes place, this volume is known as mud spurt. However, there are certain cases were the bridging materials in the drilling fluid cannot control the fluid invasion and total lost circulation is experienced [11].

Bridging agents of a certain size can plug the pores in the near-wellbore region and cause damage to the formation [12]. These bridging agents should be at least 1/3 to 1/7 of the average pore size of the formation [13]. Larger particles cannot plug the pores and the mud flow will sweep them again into the main fluid stream. Smaller

particles will tend to invade the formation creating an internal filter-cake that can generate a skin factor. The appropriate selection of the primary bridging agent will permit the particles to efficiently plug the smaller pores and eventually the other particles in the drilling fluid can be trapped forming a low-permeable seal that reduces the filtrate invasion into the formation. [14].

Filtration occurs under both dynamic and static conditions during drilling operations. Filtration under dynamic conditions occurs while the drilling fluid is circulating. Static filtration occurs during connections, trips or when the fluid is not circulating. It is logical to think that thinners and durable filter-cakes can have lower permeabilities than thicker and erodible filter-cakes. The thinner the filter-cake the less volume of filtrate that invades the formation. Nevertheless, there are some factors that affect both, the build-up of the filter-cake and the filtrate invasion [14, 15]. Some of these factors are: time and temperature, differential pressure, compressibility of the filter cake, permeability of the filter-cake, viscosity of drilling fluid and filtrate, solids composition and percentage, and particle size distribution.

2.4   Temperature Effects on Drilling Fluids

One of the most challenging problems for drilling fluids is the temperature operational range of the chemicals use to mixed it. The temperature at the bottom of the hole increases as the well deepens, and it is important that the drilling fluid maintains acceptable rheological and filtration properties.

These properties of the mud are strongly related to the temperature effects and under downhole conditions may be very different from the ones measured at the surface leading to misinterpretations that can generate future undesirable wellbore conditions (e.g. wellbore instability, tripping difficulties). When drilling fluids are exposed to high temperatures, the portion of the fluid that is at the lower part of the wellbore becomes excessively thick, a situation that becomes worse under static conditions in which the prolonged heating may cause the drilling fluid to experiences a solidification process [16].

The effect of temperature on drilling mud can be attributed to the complicated interplay of several causes, some of which are more dominant than others. Factors such as reduction in the degree of hydration of the polymers, reduction of the viscosity of the suspending medium, increased dispersion of clay particles, and an increase in the degradation rate of additives. Since all these processes take place in the drilling fluid simultaneously as the temperature is varied, an interpretation of the observed results will only be possible in cases whereby some of the effects are predominant and as such be easily identified. One immediate effect of high temperatures is the

detrimental effect on drilling fluid rheology, which can increase cuttings settling and affect the hydraulic capabilities as well as experiencing some degree of flocculation in the drilling mud. The latter will lead to a poor quality-filter cake, thick enough to increase the risk of differential stuck pipe due to the larger contact area between the drill string and the filter cake.

On the other hand, the poor permeability condition of the filter-cake will increase the filtrate into the formation. Thermal degradation of filtrate control-additives and viscosifiers aggravate the problem previously described. As an example, at temperatures below 300 °F, starches in the drilling fluid start to experience hydrolysis and depolymerization of thinners or irreversible chemical reactions can take place leading to a complete degradation of the drilling mud [17].

Finally, the temperature should be treated as one important contaminant in drilling fluids. It is complicated to assimilated such condition, however, its detrimental effect on polymer hydration, clay flocculation, and rheological problems as described previously are a few points that support this claim. The most interesting part of all of this is that temperature has no treatment. The initial design of the drilling fluid with the appropriate chemicals is the only preventive solution to the problem.

III.   MATERIAL AND METHODS

3.1   Materials

The following materials and equipment were used for this research work includes:

MSterile cotton Q-tip-style swabs or similar swabs, Disposable latex gloves, Sterile agar plates (Petri plates filled with a bacterial food preparation, usually Luria broth mixed with agar), Sterile collection tubes filled with 20 mL of sterile water (for a back-up in case you need to re-isolate your bacteria samples), Erlenmeyer flask, bunsen burner, A black permanent marker, Proper receptacle for disposing of swabs, tubes, gloves, and plates after use, Air oven, Mortar and p, sieving mesh, spatula, electric weighting balance , Whatman 50 filter paper, measuring cylinder, Hamilton Beach Mixer, Bariod Mud balance, pH indicator strip, Beakers, Marsh Funnel, Rheometer.The chemical reagents used for this work are as follows: Distilled Water (H_2O), sugar, peptone water, lactophenol blue, Durhams tubes, alcoholic, alpha napthtol, aqueous KOH, Safranine, Barite, Caustic soda, Xanthan gum, Soda ash, Polyanionic cellulose, Potassium chloride, local clay, sodium hydroxide, and borax.

3.2.   Methodology

3.2.1.   Preparation of Microbes

The microbes were cultured prior before adding into the drilling fluid system. The microbes was in liquid form so was used as the continuous phase in the system.

3.2.2   Mud Formulation

Three mud samples were prepared which comprised of bacteria and fungi as the continuous phase, caustic soda, bentonite, soda ash material. The weighting materials are added to achieve the required density.

Sample A: Standard Water-based mud Sample B: Water-based mud with bacteria strain. Sample C: Water-based mud with fungi.

The additives, concentrations and their functions in drilling fluid are shown in the Table 1 below.

Table 1: Sample A, B, and Standard (Std)

S/No.	Additives	Composition	Property
1	Base fluid	350ml	Based fluid
2	Potassium Chloride	18.0g	Inhibition control
3	Borax	4.0g	Preservative
4	Xanthan gum	2.8g	Viscosifier
5	Polyanionic cellulose	2.0g	Filtration control
6	Barite	76.8g	Weighting agent
7	Soda ash	0.2g	Calcium ion remover
8	Caustic Soda	0.2g	Alkalinity control
9	Bentonite	2.8g	

3.2.2.1 Procedure

The following steps were taken for formulation of the mud samples (Std, A and B);

1. 76.8grams of barite was dissolved in 350ml of water and property mixed using electric mixer for a time period of 10 minutes

2. The resultant mixture was left for 24 hours for proper yielding.

3. The 350ml of barite solution was placed in the electric mixer.

4. Agitation was done with the correct measurement of each material additive added at 3minutes interval.

5. After about 1hour agitation, the resultant mud was used for different mud testing.

6. This procedure was repeated for the conventional mud where distilled water was replaced with bacteria and fungi culture respectively.

3.2.3   Mud weight determination

i. The lid of the mud balance was taken off and the cup was filled with the already prepared mud from the samples and carefully positioned on a mud balance.

ii. The balance arm was placed on the vase, with the knife edge resting on the fulcrum of the mud balance.

iii. The rider was moved until the graduated arm was leveled as indicated by the level vial on the beam.

iv. The mud weight was read at the edge of the rider.

v. Wight of mud samples were recorded in lb/gal.

Fig.1: Mud balance instrument Missouri S&T.

3.2.4   Rheology of Drilling Fluids

Rheology is the science that studies the relationship between the flow of matter and the deformation experience. In drilling operations, rheology is one of the most important characteristics to describe the drilling fluid behavior at various flow conditions. The drilling fluid rheology and analysis can have rheology and gel strength test. Rheological characteristics and drilling fluid gel strength properties provide vital information about the drilling fluid capacity to transport cuttings and also to suspend the same cuttings in the fluid column at static conditions. To determine the rheology behavior and gel strength of the drilling fluids under this research

100 an OFITE Viscometer model 800 was used (Figure 3.2). This viscometer has 8 different

speeds 3, 6, 30, 60, 100, 200, 300, and 600 RPM.

Figure 2. 8-speed OFITE viscometer. Missouri S & T.

From the dial values collected for each shear rate, three values were obtained Plastic

viscosity (PV), yield point (YP) and the gel strengths, which was measured at 3 different

periods of time (10 sec, 10 min, and 30 min). The procedure followed to measure the

rheology (PV, YP) and gel strength is described below:

1. The test cup was filled with the desired drilling fluid up to the scribed line.

2. The leg lock nut was loosed and the cup containing the drilling fluid was raised to the viscometer assembly until the scribed line indicated in the rotor sleeve.

3. Once in position, the leg lock nut was tightening to secure the mud cup in place.

4. The viscometer was then started at 600 RPM until a steady value was reached in the indicator dial. The value was a record and the same procedure was repeated with the other 7 speeds recording the value for each shear rate.

5. For the gel strength measurements, the drilling fluid was stirred at 600 RPM for 10 seconds. The viscometer was then stopped and kept undisturbed for 10 seconds, the viscometer was then initiated at 3 RPM and the maximum value reached in the dial was recorded as initial gel strength. The value was recorded in pascals and lb/100ft2.

6. The 10 min and 30 min gel strength were measured repeating the step 4. The drilling fluid was stirred for 10 seconds at 600 RPM then was stopped and the fluid was undisturbed for the period of time needed. Then the viscometer was then started at 3 RPM and the maximum values in the dial reading were recorded. The tests were performed at 28 °C.

Rheology calculations: The plastic viscosity (PV), represents the resistance of the fluid to flow due to the internal mechanical conditions (Solids) inside the system. That resistance is most commonly affected by the solid concentration, size and shape and their relationship with the viscosity of the fluid phase in the system. It was calculated subtracting the 300 RPM dial reading from the 600 RPM,

$$PV = \theta 600 - \theta 300 \qquad (1)$$

The yield point (YP) is based on the electrochemical interaction between the additives and the other solids present in the mud system while drilling (solids, clays). Also, gives an idea about the drilling fluid ability to carry or transport the drill cuttings to the surface. YP was calculated by subtracting the PV value from the 300 RPM dial reading,

$$YP = \theta 300 - PV \qquad (2)$$

IV. RESULTS AND DISCUSSION

A comparison of contaminated mud properties by bacteria and fungi in this paper with standard laboratory mud is presented in Table 1. The significant differences in their rheological properties such as plastic viscosity, yield point and apparent viscosity as well as density and pH value necessitate monitoring of these organisms.

Figure 1 notably presents the difference in their rheological properties using shear rate versus shear stress plot. The relationship between shear rate and shear stress for a fluid defines how that fluid flows [5].

Table 2: Mud weight , Specific Gravity and pH from experiment

Sample		A	B	C
Mud Weight	Ppg	9.40	9.85	6.95
	Ib/ft^3	70.90	74	52
pH		7	8	9
Specific Gravity		1.13	1.18	0.84

The discrepancy in the shear stress versus shear rate plot between the infested mud and the standard laboratory mud is greatly attributed to the relative presence of these microbes, as the feed on the mud additives.

Sample A, B and C represents Standard mud, Mud formulated with bacteria and mud formulated with fungi respectively.

A comparison of the rheological properties of the three mud in (Table 2) indicates that the microbes improved favourably the rheological properties. Our only fear would be when it gets in contact with the formation

Table 3 Rheological Parameters

	A	B	C
Plastic Viscosity(cp)	14	40	9
Yield Point(Ib/100ft^2)	44	95	66
Apparent viscosity(cp)	36	87.5	42
Gel(10 secs)	4	13	10

Table 4: Rheological results for Mud sample A

RPM(Speed)	RPM readings	Shear Rate (Sec^{-1})	Shear stress (Pa)
600	72	1022	36.54
300	58	511	29.44
200	50	340	25.38
100	38	170	19.29
60	30	102.18	15.23
30	23	51.09	11.67
6	12	10.22	6.09

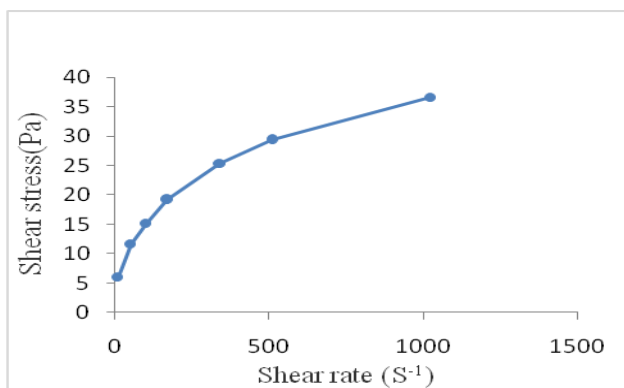YP: 36Ib/ft^3, AV: 36cp, Pv: 14Ib/100ft^2

Fig. 3: Plot of shear stress against shear rate for sample A

Table 5: Rheological results for Mud sample B

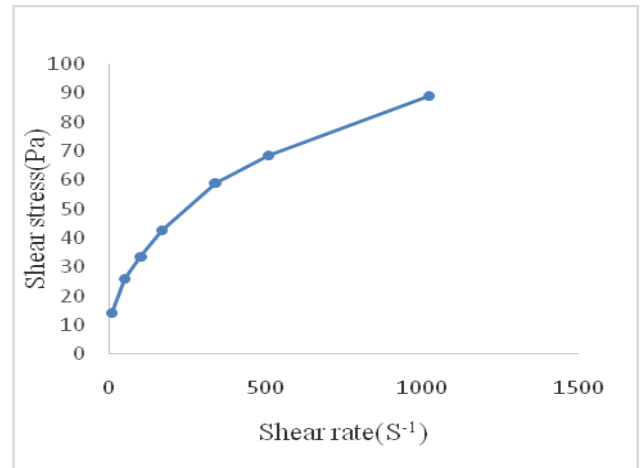| RPM(Speed)	RPM readings	Shear Rate (Sec^{-1})	Shear stress (Pa)
600	175	1022	88.8
300	135	511	68.5
200	116	340	58.87
100	84	170	42.63
60	66	102.18	33.5
30	51	51.09	25.88
6	28	10.22	14.21

YP: 95Ib/ft^3, AV: 87.5cp, Pv: 40Ib/100ft^2

Fig 4: Plot of Shear Stress V Shear rate for sample B

Table 6: Rheological results for Mud sample C

RPM(Speed)	RPM readings	Shear Rate (Sec^{-1})	Shear stress (Pa)
600	84	1022	42.63
300	75	511	38.06
200	53	340	26.90
100	40	170	20.30
60	37	102.18	18.78
30	24	51.09	12.18
6	11	10.22	5.58

YP: 66Ib/ft^3, AV:42cp, Pv: 9Ib/100ft^2

Thus, the apparent viscosity, yield point and plastic viscosity for sample B increased from 36 cp, 44Ib/100ft2 and 14cp to 87.5cp, 95Ib/100ft2 and 40cp while sample C increased to 42cp, 66Ib/100ft2 but the plastic viscosity reduced to 9cp respectively.
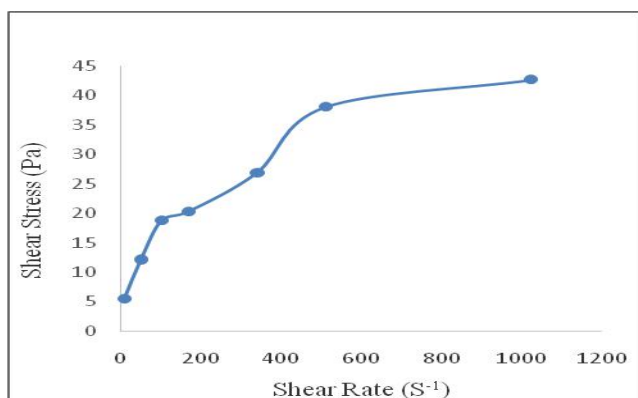
Fig. 5: Plot of Shear Stress (Pa) vs Shear Rate (S⁻¹)

The pH value of both samples was within range acceptable by standard as the stated in Table 2. This increase in pH value was created by an alkaline medium in the bacteria and fungi respectively. A comparison of the effect of Bacteria and Fungi (Table 2)

Worthy of mention is the fact that controlling the formation pressure during drilling operation with drilling fluid is a direct function of the mud density. From Table 2 the results obtained show that the density of Sample B was 9.85Ib/gal outweighing the standard 9.40lb/gal, meanwhile Sample C reduced to 6.95 making it unfit in terms of use as a weighting material.

V.   CONCLUSIONS

The microbes at its natural concentration have the required rheological properties to be used as oil well drilling fluid. However, as weighting material, there was a significant improvement in the drilling mud which was formulated from the bacteria over mud formulated from fungi. From the results obtained, it was observed that the rheological properties increased drastically as the apparent viscosity, yield point and plastic viscosity of the sample B increased by more than 11% for sample B and decrease by about 75% for sample C. Also, the pH increased by about 14% and 28% respectively. In this connection, it can be concluded that, at considerable concentration, the exhibits good rheological properties that would compare favourably with those of standard drilling mud from the laboratory.

It is recommended that further research be carried out on the microbes to determine its filtrate loss at different thermodynamic conditions as well as evaluate its presence for filtration control to improve the performance of this clay in order to make it competitive.

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