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Formulating Drilling Mud for Troubled Zone Formation Using Locally Sourced Materials

Oloro John.

Senior Lecturer

Petroleum and Gas Engineering Department

Delta State University

Abraka, Delta State

Nigeria

ABSTRACT

This paper is to formulate locally drilling mud that will be used to drill trouble zones formations successfully. Trouble zones are zones with abnormal characteristics encountered during drilling operations, such as zones of high circulation lost and zones with high formation pressure. In this paper, the zone of abnormal lost circulation was considered. For drilling to be successful drilling mud was formulated and beneficiated to lessen its filtrate into the formation and also raise its density. The outcome of this research work shows that mud formulated and beneficiated with local clay and bentonite had a decrease of filtrate volume (in percentage (%)) into the formation from 22.3 to 7.8 and 5.6 to 5 respectively. The outcome of mud density after beneficiated with 70g of barite and subjecting it to temperatures up to 80°C was still very high (12.6ppg for local clay and 13.4ppg for bentonite). Since local materials used here had close results in cumulative filtrate loss and mud density, they can make use instead of foreign materials so as to save more resources that are spent on importation.

***Keywords**: Drilling, Fluid, Additive, Filtration, Formation.*

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1. INTRODUCTION

Drilling fluids serve many purposes in a drilling process. These include, the elimination of cuttings, lubricating and cooling the drill bits, supporting the stability of the hole and preventing the inflow-outflow of fluids between well and the formation **[1]**.To formulate a drilling mud to handle trouble conditions, drilling test , drilling process and study of the formation has to be done to determine the effectiveness of the drilling mud**[2]**.

Trouble zones considered in this paper was zone of high lost circulation. For drilling to be successful, drilling mud has to be formulated and beneficiated to reduce its filtrate into the formation and also raise its density **[3]**.

2. FILTRATION PROPERTY OF DRILLING MUDS

Filtration is the process whereby of the liquid phase of the drilling mud pass through a permeable formation by differential pressure. During this process, the insoluble particles are separated from the filtrate, forming a filter cake. The knowledge of this process is very important in the design of drilling fluid formulation. Filtration across the cake depends on several properties such as initial clay content, particle or aggregate association, water retention and permeability, as well as experimental conditions (pH, etc)**[4]**. Besides, it must be friendly to the environment so that it can perform the functions in an effective way **[5]**.

2.1.Drilling Problems

In drilling operations, the following are some of drilling problems:

2.2.Wellbore Instability

Wellbore instability problems which happening as a result of exposure of shale to drilling fluid. The drilling fluids that contain nano-particles have the power to depreciate wellbore instability. The nano-particles size is less than the pore throat sizes of rocks that lead to plugging of the pore throats (Ibid). According to Suyan **[6]**.

2.3.Lost Circulation

One of the most popular drilling problems is loss circulation**[7]**. It is a partial or complete loss of the drilling fluid to the formation. Therefore; a lot of time and effort has been spent to control the loss circulation through produced additives materials or mud. The use of micro and macro particles has shown limited success. The utilization of nano-particles led to a reduced loss circulation by raising carrying capacity sufficiently to carry the cuttings efficiently and to maintain drilling fluid density and pressure over a wide range of operational conditions **[8]**.

3. METHODOLOGY

The steps followed in this research work include sourcing and preparation of local materials clay (Emede clay), Palm Ash, and Saw Dust will be clearly outlined for this work.

Mud properties to be tested for include Mud density, Filtration properties (filtrate volume and mud cake thickness) andpH.

The detail procedures for determining these mud properties will be clearly shown in subsequent sections. Point of notice is that various compositions/combination will be tested for in this work and the results will be clearly shown in subsequent pages. The mud will be subjected to increasing temperature and see the effects on the density of mud.

Standard test procedures for testing water based mud will be strictly followed as stipulated in (API Rec 13A-2 second edition).

Materials Used

- Local clay
- Distilled water
- Local starch
- Saw dust
- Palm ash
- Vinci Mixing machine.
- Ofite Mud balance

All the materials used in this work and how they are sourced (for local materials) are described below.

3.1.Sourcing And Preparation Of Local Clay Sourced From Emede

The local clay used for this work was sourced and prepared in the following sequence.

- Locate a swampy location (Emede in Delta State, Nigeria).
- Dig the clay deposit with the aid of a shovel to 4ft. depth to collect locally clay deposited in the location.
- Good quantity was collected and stored in a bag.
- The clay was properly soaked for 72 hours in a basin to release organic materials.
- The collected clay was placed in a room to dry naturally to complete dryness.
- The dried clay was grinded to make the clay become fine.
- The clay was sieved with a 75 micro sieve in the laboratory.
- The clay was now bagged for use.

3.2.Sourcing And Preparation Of Palm Ash

Palm ash was used as an additive for adjusting the P^H of the formulated mud, usually for raising the P^H to an alkaline.

- The palm fruit was squeezed and the shaft recovered was dried .
- The dried shaft was the burnt to complete ash
- The burnt ash was then sieved with the same sieve size (75 micron) used in sieving local clay.
- The sieved palm ash was carefully kept in a plastic container and was stored in a cool and dry place.
- The palm ash is now ready for use as an additive for mud formulation.

3.3.Preparation Of Saw Dust Partticles

Saw dust particles were used as a key additive for filtration loss to drill through an impervious zone. It was used instead of the chemicals such as Carboxyl Methyl Cellulose (CMC), PAC-L, PAC-R, (Calco) starch etc., used previously for reducing filtrate loss to loss circulation zones.

- Saw dust was gotten from the Faculty of Engineering workshop in large quantity.
- The saw dust was dried for 7 days.
- The dried saw dust was then sieved .With the same sieve size (75 micron) used was also used for sieving local clay and palm ash is illustrated in Figure1.
- The sieved saw dust was properly packaged in a polythene bag.

Local Starch: Starch is a fluid loss control agent and a viscosifier.

Local starch obtained from cassava peel was collected and dried in the sun. The starch could not pass through sieve due to its sticky nature but was ensured it is neat and a specific weight was used for experimentation.

3.4.CMC (Carboxyl Methyl Cellulose): This is a fluid loss control agent, to be investigated against the formulated mud to determine effectiveness of the local clay to reduce fluid loss control.

Barite: This will act as a weighing material.

Distilled Water: Distilled water will be used to formulate the mud.

3.5.Equipments And Materials Used

The followings were the equipment and materials used for this work are shown in Table 1. The equipment used conform to the American Petroleum Institute Recommended practices for testing oil based mud.

Table 1 Equipment used for this study

	Equipment	Manufacturer	Function
1	Mud mixer	Vinci	For mixing mud and all additives
2	Mud Balance	Ofite	To measure the density of drilling mud
3	P^H Meter	HANNA	To measure the pH of formulated mud
4	Filter Press Machine	Fann	To measure the filtration properties of mud.
5	Weighing Balance (Electronic)		To measured desired weight of clay and additives.
6	Spatula		For collecting samples from bulk containers in small quantities.
7	Syringe		For collecting specific volume of Emulsifiers
8	Measuring Cylinder (500ml)	Pyrex	Used for measuring volume of fresh water
8	Beaker (200ml)	Pyrex	For measuring volume of water and for collecting filtrate volume when filtration rate is very high especially with local clay.

Figure1. Sieve 212 (75μm)

Figure 2. Vinci Mixing machine

Figure3. Ofite Mud Balance

Figure4. Fann Filter Press Machine

Figure5. Compressor machine

Figure6. P^H Meter

3.6. LABORATORY PROCEDURE FOR FORMULATING OIL BASED MUDS

The procedures followed are as follows:

Step 1: Weigh 24.5g of local clay and bentonite separately. The essence of weighing bentonite is to compare the results of local clay with that bentonite to see how close the results of both will become.

Step **2:** Measure 350ml of water and add to the local clay and begin to blend both with the Vinci Mixing machine, is shownFigure 2.

Step 3: Measure the mud density with a mud balance, is shown Figure 3and filtration properties with a filterpress machine, is shown inFigure 4.

Step 4: The above step was carried out for bentonite and its mud density and filtration properties was measured.

Step 5: 40g of barite was added to the same formulated mud and mud density and filtration properties was measured.

Step 6: 24.5g of saw dust was weighed and added to the existing sample and mud density and filtration properties was recorded.

Step 7: 24.5g of CMC high was weighed and added to the existing sample and mud density and filtration properties was recorded.

Step 8: Palm ash was added to the sample in order to study the effect of p^H change in the formulated mud. P^H value was recorded with a p^H meter.

Step 9: 5g of Sodium Hydroxide was measured and added to the formulated mud in ***step 8*** above. P^H value was recorded with a p^H meter.

Step 10: 20g of Local starch was used with the saw dust and results was also recoded.

Step 11: 75g of barite was added to the formulated mud and observe the mud density at ambient and temperature up to 80°C. Mud density was monitored at each drop of 10°C.

NB: *All the results of compositions followed in this work were carefully analyzed and presented clearly.*

3.7.Procedure For Measuring Mud Density

The test procedure was followed while testing for mud density.

1. Remove lid and fill cup to the top with sample to be tested. If air bubbles have been trapped in the mud, tap cup until they break out.
2. Replace lid and rotate until firmly seated, making sure some mud squeezes out of the vent hole.
3. Wipe mud from exterior of balance.
4. Place balance on base with knife edges on fulcrum rest.
5. Move rider until instrument is in balance, as determined by the spirit level.
6. Take the reading of the mud weight and hydrostatic pressure or gradient at edge of rider nearest fulcrum.

3.8. Procedure for Testing Filtration Properties

1. Assemble the following dry parts in this order: base cap, rubber gasket, screen, a sheet of filter paper, rubber gasket and cell. Secure the cell to the base cap.
2. Fill the cell with the sample to be tested to within ¼-in of the top. Set the unit in place in the filter press frame.
3. Check the top cap to make sure the gasket is in place. A pressure source (compressor unit) is connected to filter cell with a small rubber hose connects this unit to the filter cell, is shown in Figure 5.
4. With the regulator T-screw in its maximum outward position (close position) open the valve on the cell. Apply 100 psi pressure to the filter cell by rapidly screwing the regulator T-screw into the regulator. Timing of the test should begin now.
5. At the end of 30 minutes, close the valve close to the cell rapidly and open the safety-bleeder valve. This releases pressure on the entire system. Return the regulator T-screw to its maximum outward position.
6. Read the volume of filtrate collected in the graduated cylinder.
7. The filter cake thickness is determined after the filter cell has been disassembled. The filter paper with the cake deposited on it is removed from the base cap, and the excess mud is washed from the cake. The filter cake thickness is measured and reported as thirty-seconds of an inch.

Properties of the filter cake such as texture, hardness, flexibility, etc., will be reported.

3.9. Procedure for P^H Verification Using P^H Meter

1. Turn On instrument and standardize according to detailed directions, is shown in figure 6.
2. Wash the electrode tips under a stream of running water, or by stirring in clean water, and gently wipe dry with a piece of tissue.
3. Take away the electrode protective cap.
4. Insert or submerge the electrode and the temperature probe into the sample to be tested.
5. Stir gently and wait for the stability symbol.
6. After use, rinse the electrode with clean water, replace the electrode protective cap.

4. RESULTS AND ANALYSIS

The results obtained during the laboratory analysis for the various tests and compositions for drilling mud density, filtration properties using water based mud and P^H. These results will be analyzed to see how reduced our filtrate loss to the formation will be after subjecting the mud to local additive. Foreign materials such as Calco starch versus local starch and CMC High versus saw dust will be compared and interpreted. The behavior of these mud will also be monitored and compare with the bentonite.

The results for various mud properties (mud density, filtration properties and P^H) tested are presented here. Results of filtration properties before and after beneficiation are presented below:

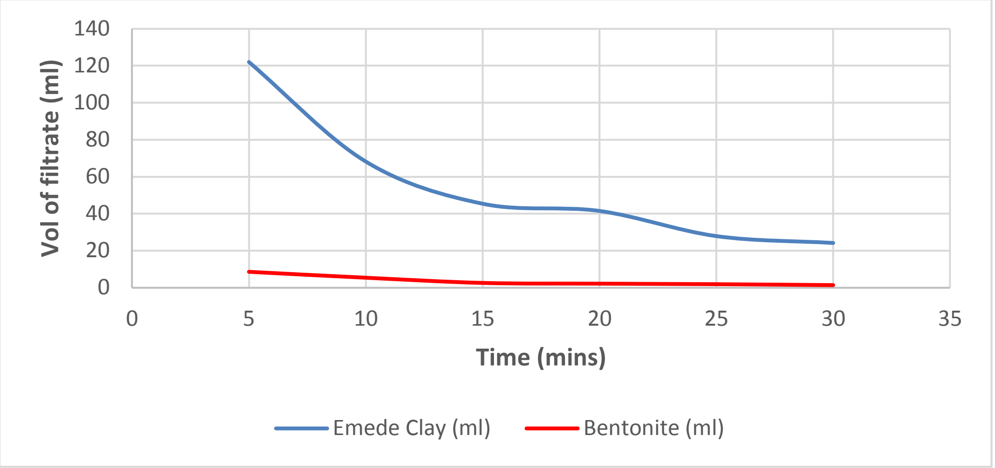

Figure 7: Graph showing filtrate loss recorded without additives

(From the graph in figure 7, the volume of filtrate loss was high in the early time (up to 122ml & 8.6ml for Emede clay &Bentonite respectively) was reduced to 24.4ml & 1.4ml after 30 minutes). Cumulative filtrate volume loss was 287.72ml & 22.1ml for Emede clay and Bentonite.)

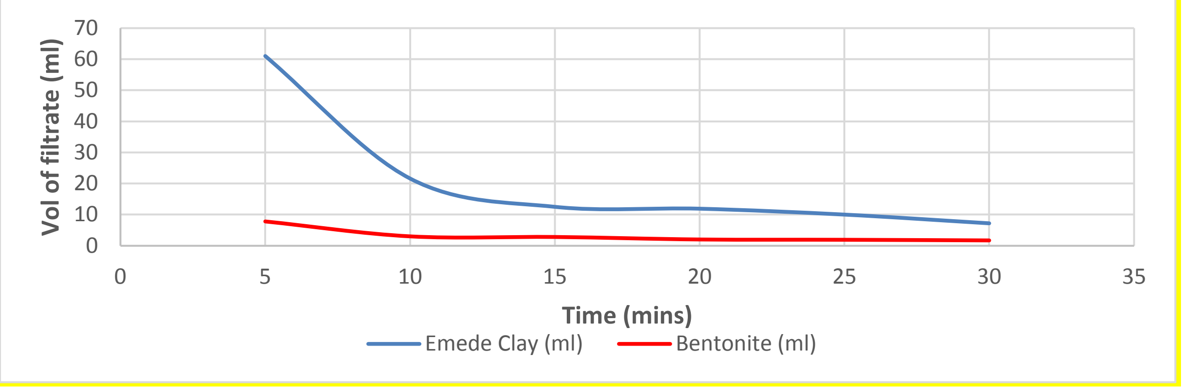

Figure 8: Graph showing filtrate loss with the addition of 40g Barite

(From the graph in figure 8, the volume of filtrate loss was high in the early time (up to 61ml & 7.8ml for Emede clay &Bentonite respectively) was reduced to 7.2ml & 1.7ml after 30 minutes). Cumulative filtrate volume loss was 124.2ml & 19.2ml for Emede clay and Bentonite).

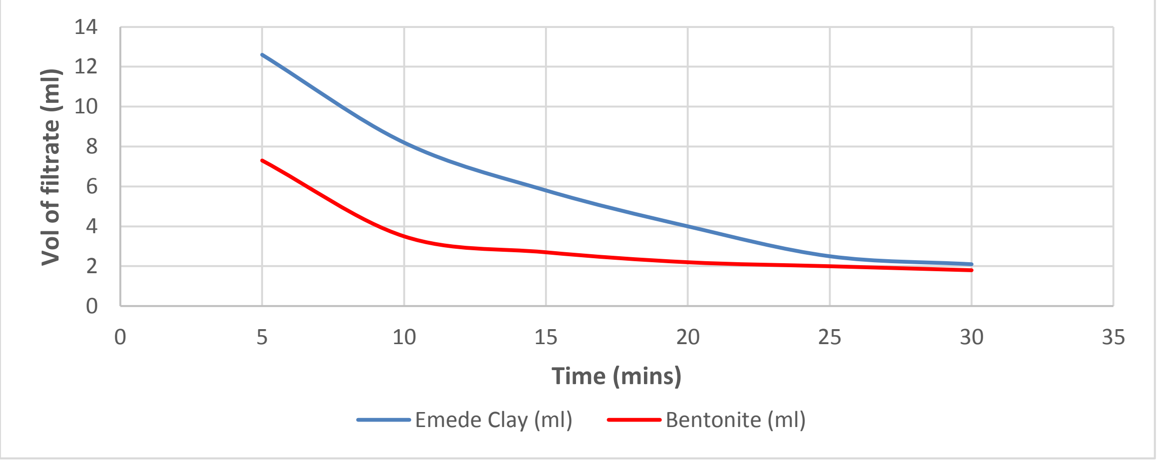

Figure 9: Graph showing filtrate loss with the addition of 40g barite and 24.5g of sawdust

(From the graph in figure 9, the volume of filtrate loss was high in the early time (up to 12.6ml & 7.3ml for Emede clay &Bentonite respectively) was reduced to 2.1ml & 1.8ml after 30 minutes). Cumulative filtrate volume loss was 10.1ml & 19.1ml for Emede clay and Bentonite).

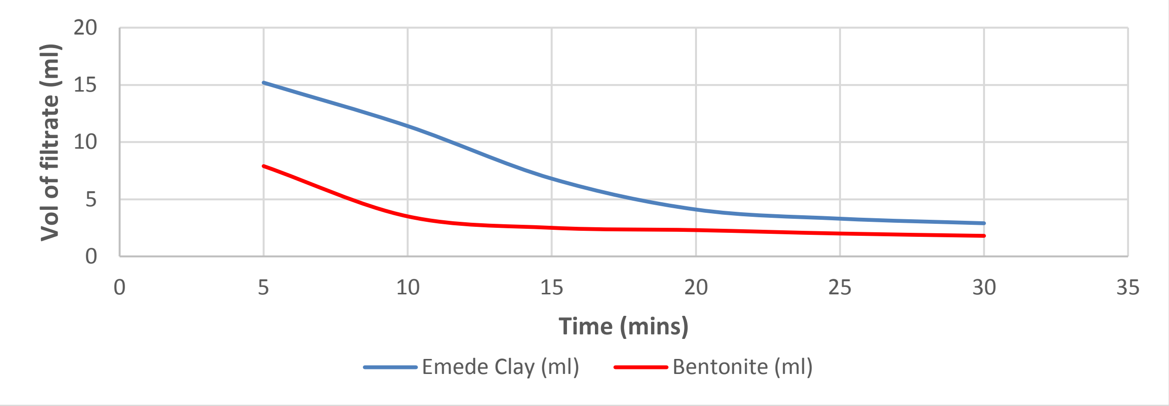

Figure 10: Graph showing filtrate loss with the addition of only Saw dust

(From the graph in figure 10, the volume of filtrate loss was high in the early time (up to 15.2ml & 7.9ml for Emede clay &Bentonite respectively) was reduced to 2.9ml & 1.8ml after 30 minutes). Cumulative filtrate volume loss was 43.7ml & 20.0ml for Emede clay and Bentonite).

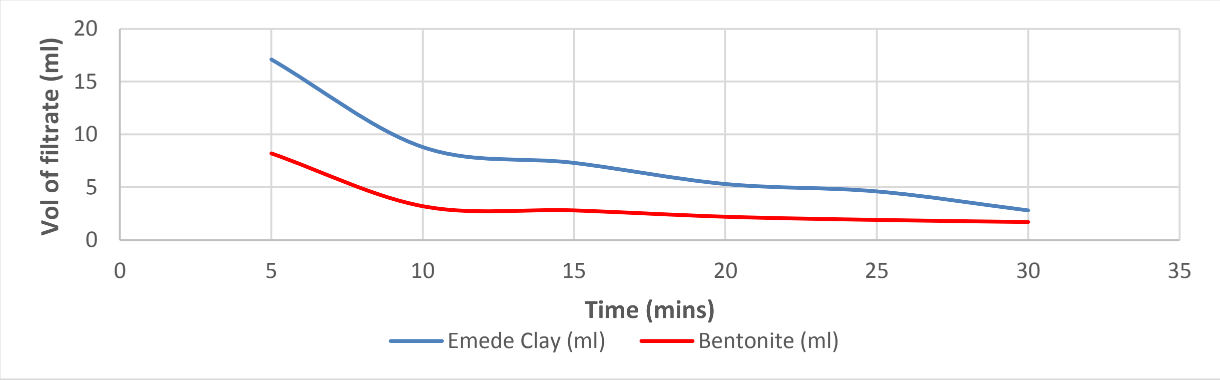

Figure 11: Graph showing filtrate loss with the addition of Saw dust (30g) and Barite (50g)

(From the graph in figure 11, the volume of filtrate loss was high in the early time (up to 17.1ml & 8.2ml for Emede clay &Bentonite respectively) was reduced to 2.8ml & 1.7ml after 30 minutes). Cumulative filtrate volume loss was 45.9ml & 20.0ml for Emede clay and Bentonite).

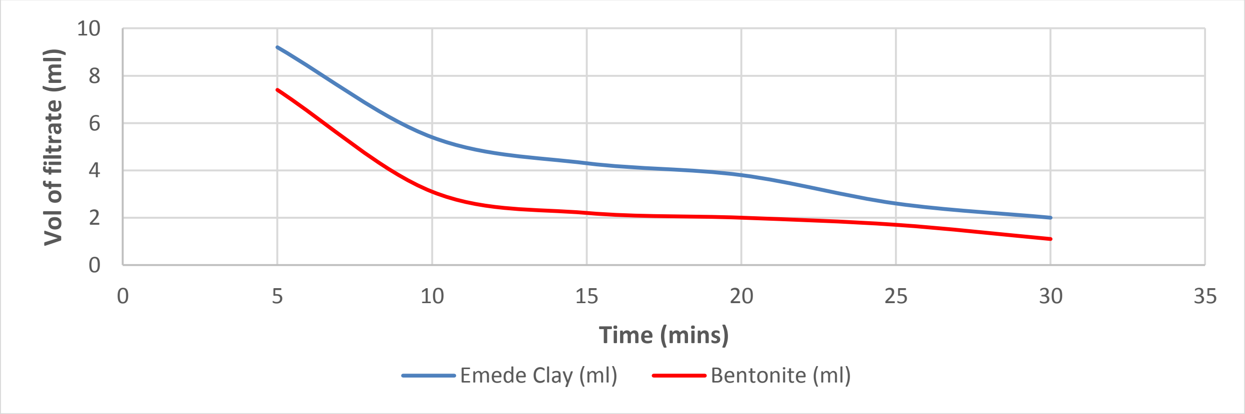

Figure 12: Graph showing filtrate loss with the addition of Saw dust (24.5g) and Local Starch (10g)

(From the graph in figure 12, the volume of filtrate loss was high in the early time (up to 9.2ml & 7.4ml for Emede clay &Bentonite respectively) was reduced to 2.0ml & 1.1ml after 30 minutes). Cumulative filtrate volume loss was 27.3ml & 17.5ml for Emede clay and Bentonite).

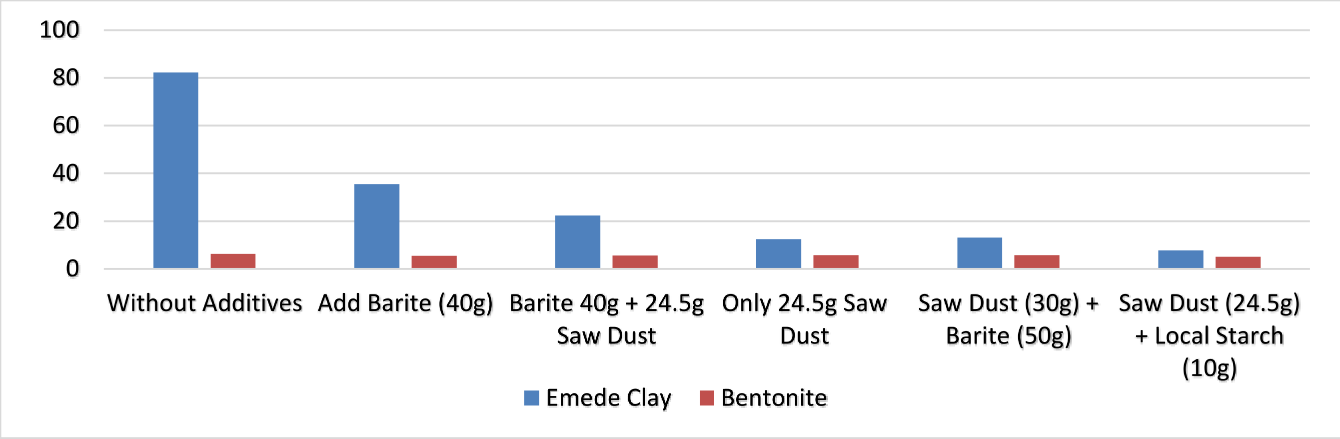

Figure 13: % Fluid loss before and after beneficiation for Emede Clay and Bentonite

(From the plots in figure 13 above, there was a reduction in filtrate volume lost to the formation from all the compositions, the best being recorded with mud beneficiated with saw dust and local starch).

This research work which is based on formulating drilling mud to drill trouble zones (lost circulation and over pressure zones) using local materials. Various compositions have been formulated for this purpose and results presented above.

For filtration property experimented above, results show that fluid loss to formation was reduced from 22.3% to 7.8% when subjected to only local materials (additives) while fluid lost with drilling mud formulated with bentonite subjected to the same materials (additives) was reduced from 5.6% to 5%. With these results, local additives can be used successfully with bentonite and local clay sourced from Emede clay is very successful in terms of fluid loss to the formation.

70g of barite produces very high mud density for both Emede clay and Bentonite. Temperature affects the density of liquids but at high temperatures of 80°C, mud densities still attain 12.6ppg for local clay while 13.4ppg for bentonite.

5. CONCLUSION

Based on the results presented in this research work, it shows that the local materials sourced, prepared and formulated for this work though could not match bentonite, they can be very successful for oil/gas well drilling in zones highly prone to lost circulation. This is due to the small percentages of fluid lost to the formation as simulated with the Fann filter press machine. Also from the result mud properties can be improved with the addition of adequate additives.

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