Effect and Optimization of Rheology Control Agent of Non-Damaging Drilling Fluid

Ashna Jose[1], S M Sharful Islam[2], Boggavarapu Manideep[3], Mr. Karthik M G[4], Arjun Ramesh[5], Dr. Kalpajit Hazarika[6]

[1,2]Student & Dept. of Petroleum Engineering, Presidency University, Bangalore, India
[6]Assistant Professor, Dept. of Petroleum Engineering, Presidency University, Bangalore, India

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Abstract - *Drilling mud is one of the most important things in Oil and Gas well drilling operation. The most important is to decompose that used drilling mud. Conventional drilling mud is non-biodegradable in nature and harms the environment. In this study some specific biopolymers such as XC-polymer (XCP), pregelatinized starch (PGS) has been used to make in laboratory called Non-Damaging Drilling Fluid (NDDF) which is biodegradable, environment friendly. XC-polymer generally used as a viscosifier which controls the viscosity of the mud. Pregelatinized starch (PGS) is used as fluid loss control agent. Calcium Carbonate is used as weighing and bridging material. Biocide is used to prevent the bacterial action in the drilling mud. A rigorous study has been performed on the mud properties and found their excellent role in respective purpose in the Reservoir Drilling Fluid (RDF).*

Key Words: Environment friendly, XC-polymer, PGS, NDDF, RDF

1. INTRODUCTION

Drilling fluid is an essential element of drilling operation, which is used to provide hydrostatic head, to carry out drill cuttings, to cooldown the drill bit and to act as a lubricant. There are several different types drilling fluid based on their composition and use. But the key factor which should be in mind before selection of drilling fluid is cost and its effect on environment.

The complex drilling fluid represents 15-18% of the total cost (about $ 1 million) of petroleum well drilling. (1). Our aim should be utilizing that huge amount on such types of drilling mud which is a cost efficient, environment friendly and can be decompose easily.

The non-damaging drilling fluid (NDDF) is a clay and barite free polymer mud system mostly used in a pay zone section to avoid formation damage and to keep pay zone or reservoir intact. (2)

The NDDF consist of water as a base fluid, calcium carbonate ($CaCO_3$) (specific gravity of 2.7-2.8) as weighing and bridging material instead of barite (specific gravity of 4.2-4.7). The purpose of using $CaCO_3$ in NDDF is to form a low permeable filter cake on the well bore walls and thereby minimizing the invasion of filtrate and solid to the formation. The external filter cake minimizes fluid loss and solid invasion to the formation. (3)

Sodium hydroxide is used as pH controlling agent, the ideal pH of drilling fluid should be range between 8-12. Pre-gelatinized starch is used as a fluid loss control agent, it is used to minimizing the volume of fluid loss that slips into the formation. The higher the fluid loss, the thicker formation of the mud cake and as a result drill pipe will get stuck. (4)

Xanthan gum is used as a viscosifier in NDDF. It provides viscosity, solid suspending and fluid loss control. NDDF along with biocide will improve the stability of the drilling fluid, it helps to maintain the pH of the drilling fluid and keep its basic nature. If drilling fluid turns acidic (pH<7), it can cause corrosion in the drill pipe and damage the drill pipe, the replacement of drill pipe can add extra cost to the drilling operation.

2. EXPERIMENTAL PROCEDURE

2.1. Materials Used

In this project Xanthan Gum is used as biopolymer, Sodium Hydroxide is used as pH controlling agent, Calcium Carbonate is used as Weighing and bridging material, Corn Starch is used as Fluid loss control agent and Formaldehyde is used as biocide. The chemical formula and properties of the chemicals used are tabulated in table 2.1.

Table 2.1: Properties of Chemicals Used

Sl. No	Name of the Chemical	Chemical formula	Properties
1	Xanthan Gum	$C_{35}H_{49}O_{29}$ (monomer)	• Biodegradable • Control properties such as plastic viscosity yield point and gel strength • Very good shear thinning and suspension characteristics
2	Sodium Hydroxide	$NaOH$	• Increase the pH of drilling fluid • Biodegradable
3	Calcium Carbonate	$CaCO_3$	• Bridge the pore throat on the formation surface • Biodegradable
4	Corn Starch	$(C_6H_{10}O_5)_n$	• Environmental friendly and non-toxic • Control the fluid loss of the drilling mud
5	Formaldehyde	CH_2O	• Anti-bacterial • Slow down the decomposition of mud

2.2 Plan of work

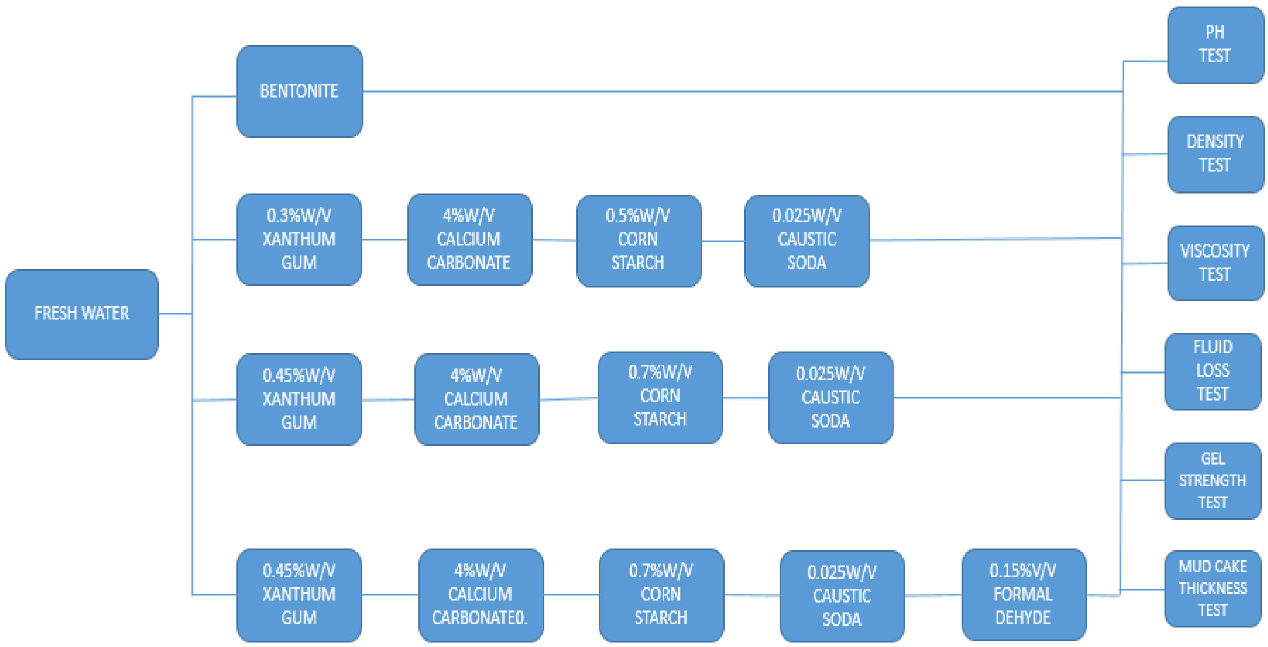

Fig 2.1: Methodology Flow Chart

The aim of our experiment is to study the changes in different rheological properties with respect to time and change in composition of chemicals used. We prepared four different types of muds, one conventional drilling mud and three non-damaging drilling muds. Then we find different rheological properties of these drilling muds using different equipment in drilling fluids and cement lab for within a span of 15 days (only once for conventional drilling mud). Within the span of 15 days we took the readings of different rheological properties seven times so that we can find how the values varies in time.

2.3 Mud Preparation

We used Remi Stirrer for the mixing of the drilling mud. Four drilling fluid samples are prepared for this study. Sample 1 is the conventional drilling fluid, where only bentonite is used. Other three samples are NDDF, where different environment friendly chemicals are used in different concentration as shown in table 2.2. In sample 4 formaldehyde is used as biocide to reduce the degradation of biopolymer.

2.4 Instrumentation

For this experiment we used five equipments, they are remi stirrer, pH meter, mud balance, hand crank viscometer and LPLT filter press. Remi stirrer is used to mix all the additives together evenly. pH meter measures pH of the mud and mud balance measures its density. Properties like plastic viscosity, apparent viscosity, yield point and gel strength can be measured using hand crank viscometer. LPLT filter press is used to determine the fluid loss and mud cake thickness of the drilling fluid.

Table 2.2: Composition of Drilling Fluids

Components	Composition			
	Mud 1	**Mud 2**	**Mud 3**	**Mud 4**
Fresh water (liters)	1.5	5	5	5
Xanthan gum (grams)	-	15	22.5	22.5
Calcium carbonate (grams)	-	200	200	200
Corn starch (grams)	-	25	35	35
Sodium hydroxide (grams)	-	1.3	1.3	1.3
Formaldehyde (ml)	-	-	-	7.5
Bentonite (grams)	30	-	-	-

3. RESULTS AND DISCUSSION

3.1 pH

We can see that the pH of the mud 2 and mud 3 tends to decrease with the increase in time, but pH of mud 4 is almost constant. The optimum range of pH for drilling fluid is 8-12. From the above figure (Fig 3.1) we can observe that the drilling muds without formaldehyde (biocide) is falling below this range. So, these two drilling muds are not that efficient in the case of pH. The mud which contain biocide (mud 4) is having optimum pH.

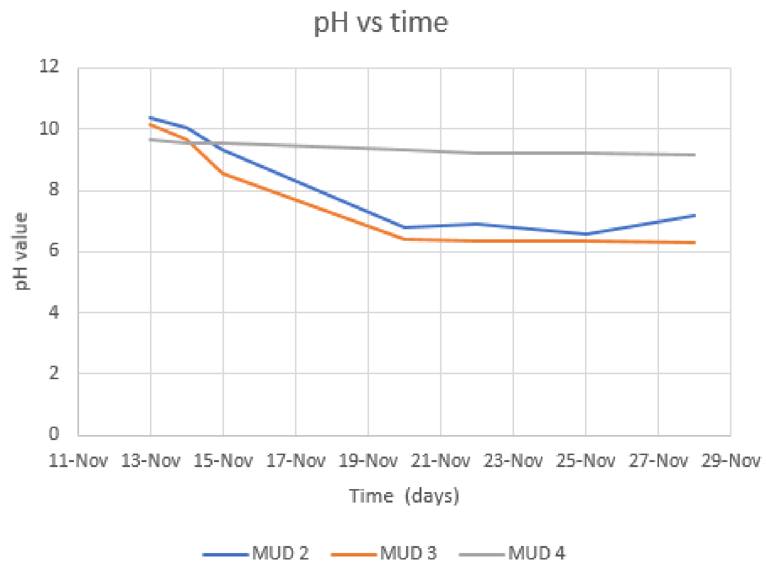

Chart 3.1: Relationship between pH Value and Time for 3 Different Muds

Table 3.1: pH Readings for NDDFs

Date	pH		
	Mud 2	Mud 3	Mud 4
13/11	10.38	10.13	9.63
14/11	10.04	9.64	9.56
15/11	9.32	8.56	9.48
20/11	6.91	6.38	9.32
22/11	6.78	6.34	9.2
25/11	6.58	6.25	9.23
28/11	6.34	6.19	9.17

3.2 Fluid Loss and Mud Cake Thickness

Table 3.2: LPLT Filter Press Readings for NDDFs

Date	Sample 2			Sample 3			Sample 4		
	15 min (ml)	30 min (ml)	Mud cake (inch)	15 min (ml)	30 min (ml)	Mud cake(inch)	15 min (ml)	30 min (ml)	Mud cake (inch)
13/11	94	125	5/32	41	60	4/32	44	62.2	4/32
14/11	98	135	4/32	43	62.5	3/32	42	64.6	4/32
15/11	90	118	4/32	25	37	3/32	40	61.6	4/32
20/11	27	44.2	3/32	16.2	26.1	2/32	42	61.2	4/32
22/11	21.8	31.6	3/32	12.4	23.1	2/32	49	60.4	4/32
25/11	13.8	22	2/32	15	22.6	1/32	42	59.9	4/32
28/11	10.3	21.1	2/32-	15.6	25.4	1/32	37	58	4/32

From chart 3.21 fluid loss for mud 2 is very high in the first days because the quantity of fluid loss control agent (corn flour) is less in this mud. For mud 3 the fluid loss is maximum in first days and eventually decreasing. The mud which contain formaldehyde is having almost constant reading. The increase showing in the graph may be because of experimental error.

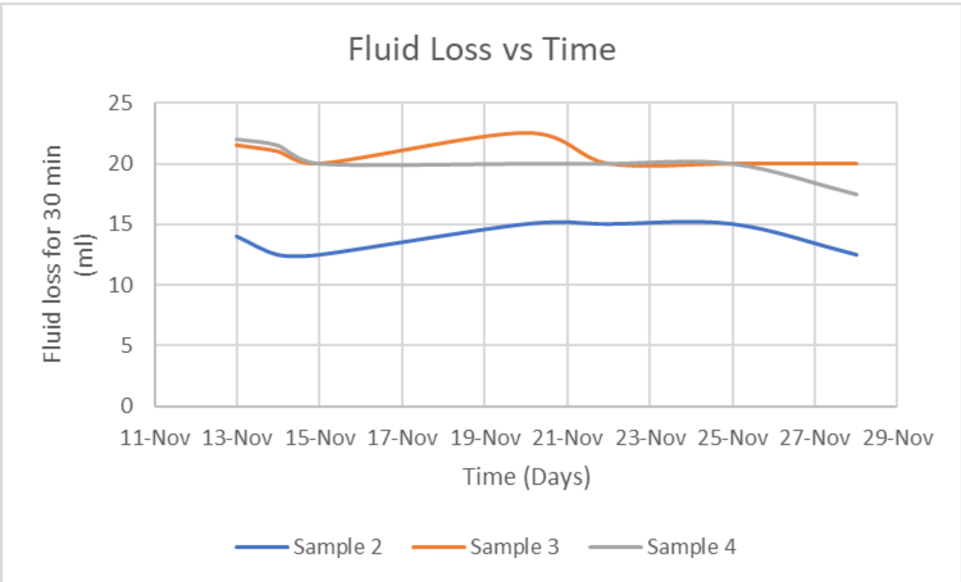

Chart 3.21: Relationship between Fluid Loss and Time for 3 Different Muds

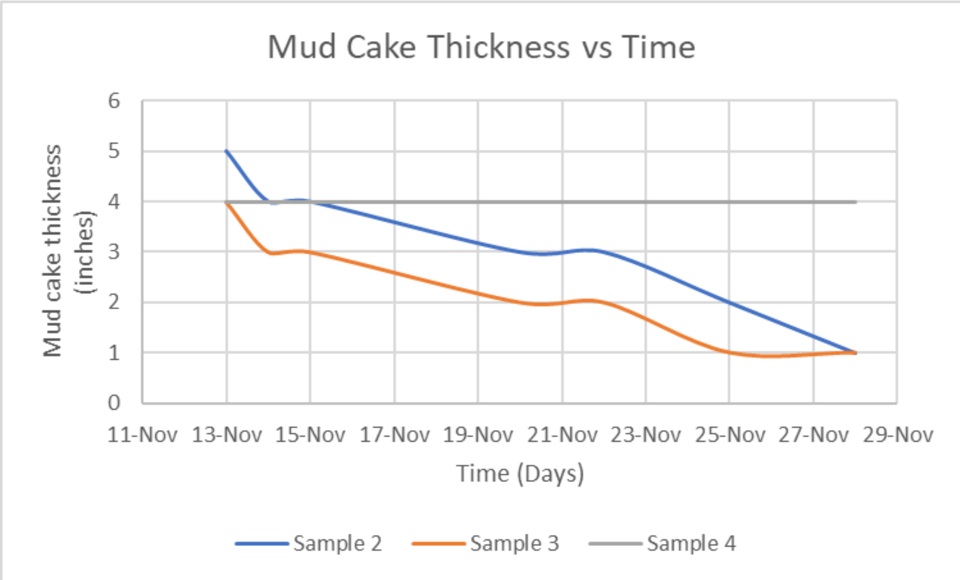

Chart 3.22: Relationship between Mud Cake Thickness and Time for 3 Different Muds

Chart 3.22 is showing the change in mud cake thickness with time. Mud cake thickness for mud 2 and mud 3 are decreasing with time. The increase in mud cake thickness of mud 2 might be instrumental error. The mud containing formaldehyde (mud 4) is not showing any change in mud cake thickness within our experimental span.

3.3 Viscosity , Yield Point and Gel Strength

We are using Xanthan gum as viscosifier in our drilling fluids. Viscosity is more for mud 3 than mud 2 because, we are using 0.45% of xanthan gum for mud 3; while 0.3% for mud 2. Formaldehyde doesn't have any influence on viscosity (chart 3.31). So, mud 3 and mud 4 doesn't have any major difference in the readings.

Date	600 RPM	300 RPM	PV (cP)	AV (cP)	YP (lb/100sq.ft)	Gel strength	
						Initial	Final
13/11	46	37	8	23	29	45	50
14/11	44	36	8	22	28	44	47
15/11	43	34	7	21.5	27	39	41
20/11	42	34	8	21	26	37	39
22/11	40	33	7	20	26	35	37
25/11	39	31	8	19.5	23	33	35
28/11	38	31	7	19	24	35	39

Table 3.31: Viscometer Readings for Sample 2

Date	600 RPM	300 RPM	PV (cP)	AV (cP)	YP (lb/100sq.ft)	Gel strength	
						Initial	Final
13/11	30	25	5	15	20	28	30
14/11	28	24	4	14	20	27	30
15/11	27	24	5	13.5	19	25	27
20/11	25	22	3	12.5	19	25	25
22/11	24	21	3	12	18	23	25
25/11	22	20	2	11	18	22	23
28/11	21	19	2	10.5	17	21	24

Table 3.32: Viscometer Readings for Sample 3

Table 3.33: Viscometer Readings for Sample 4

Date	600 RPM	300 RPM	PV (cP)	AV (cP)	YP (lb/100sq.ft)	Gel strength	
						Initial	Final
13/11	45	38	7	22.5	31	50	51
14/11	43	36	7	21.5	29	48	50
15/11	42	35	7	21	28	45	45
20/11	40	34	6	20	28	39	41
22/11	39	33	6	19.5	27	39	40
25/11	38	32	6	19	26	36	38
28/11	36	30	6	18	24	33	36

Formaldehyde is not influencing the value of yield point. Amount of xanthan gum used is the main cause of deviation in the values (chart 3.32).

Chart 3.33 shows that gel strength of the three muds are following almost similar pattern. Gel is not affected by the use of biocide (formaldehyde).

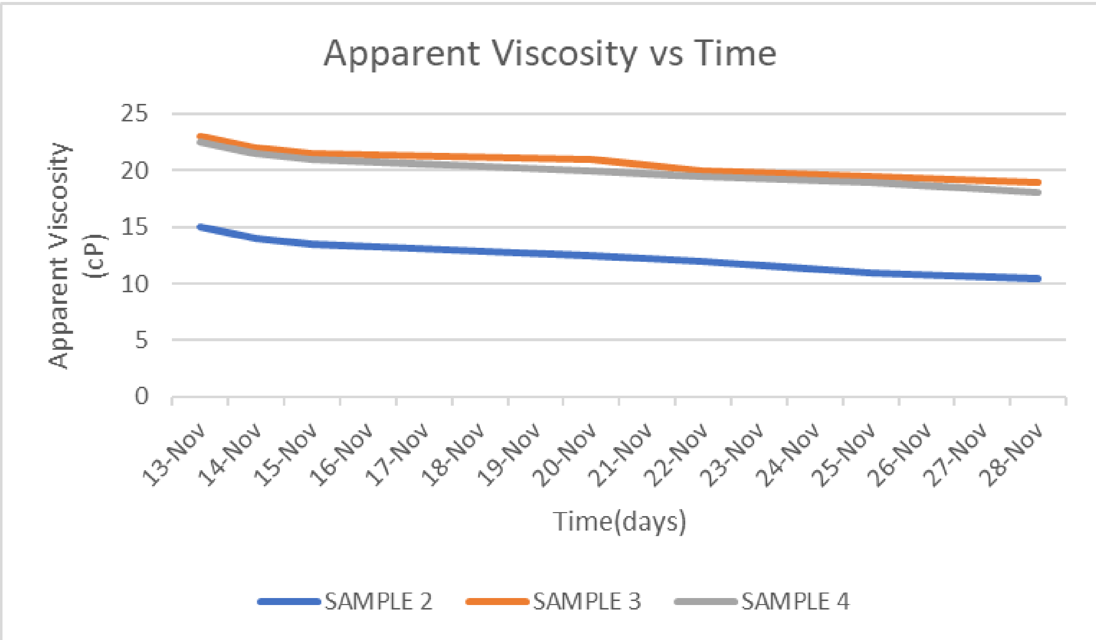

Chart 3.31: Relationship between Apparent Viscosity and Time for 3 Different Muds

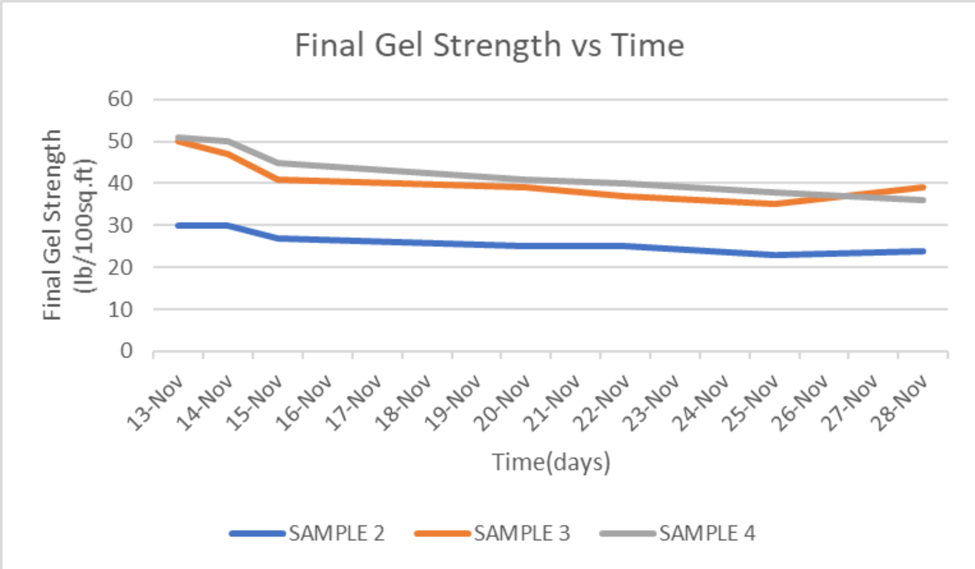

Chart 3.32: Relationship between Final Gel Strength and Time for 3 Different Muds

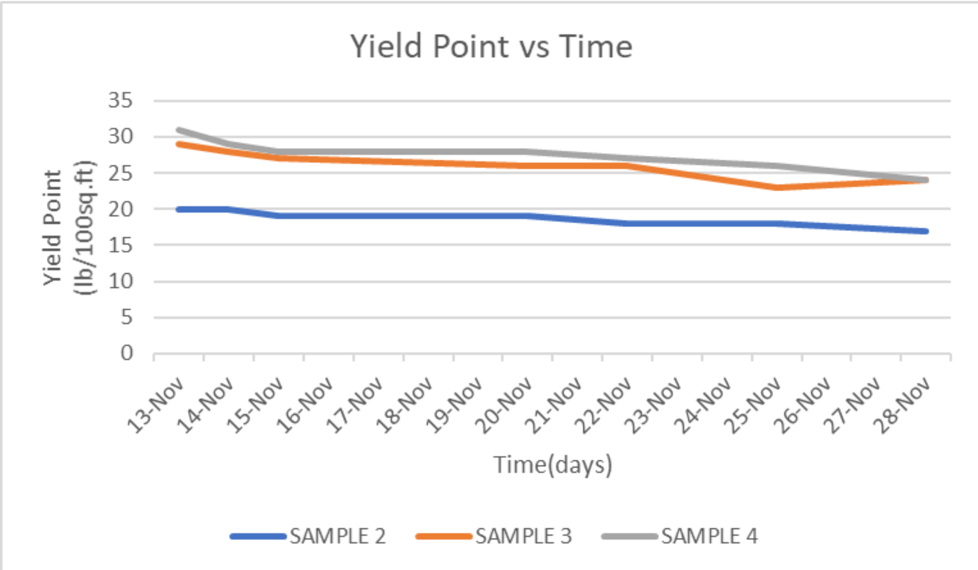

Chart 3.33: Relationship between Yield Point and Time for 3 Different Muds

3.4 Specific Gravity

Specific Gravity of the mud 4 is not showing any change with time. So that it is confirmed that the formaldehyde has some effect in specific gravity (figure 3.7). For mud 2 and mud 3 specific gravity is varying with time.

Table 3.4: Density Readings for NDDFs

Date	Sample 2				Sample 3				Sample 4			
	Sp gr	ppg	Lb/ft³	Psi/ft	Sp gr	ppg	Lb/ft³	Psi/ft	Sp gr	Ppg	Lb/ft³	Psi/ft
13/11	1.04	8.6	64	450	1.04	8.7	65	450	1.03	8.6	64	450
14/11	1.03	8.6	64	450	1.03	8.6	64	450	1.03	8.6	64	450
15/11	1.02	8.5	64	440	1.03	8.6	64	450	1.03	8.6	64	450
20/11	1.03	8.6	64	440	1.03	8.6	64	440	1.04	8.6	65	450
22/11	1.02	8.5	64	440	1.02	8.5	64	440	1.04	8.7	65	450
25/11	1.03	8.6	64	440	1.03	8.6	64	440	1.03	8.6	64	440
28/11	1.02	8.5	64	440	1.02	8.5	64	440	1.03	8.6	64	440

4. CONCLUSION

Non-Damaging Drilling Fluid (NDDF) is a clay and barite free environmental friendly polymer mud. We can dispose this mud anywhere because the components of this mud are degradable and environmental friendly. According to our study it is clear that the NDDF is giving almost same or better rheological properties as the conventional drilling fluid. So, we can get the all the properties of conventional drilling mud by varying the composition of components of non-damaging drilling fluid. We can use biocides like formaldehyde to limit the bacterial action on the mud, so that the deviation in rheological properties will be reduced. The NDDF with biocide can be used for a large span of time, while conventional drilling fluids can use only once because its components will decompose faster. According to our studies we can say that the non-damaging drilling fluids are efficient, environmental friendly, cost effective and easily decomposable. Use of this mud can save our earth from a huge pollution.

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Nomenclature

AV Apparent Viscosity
LPLT Low Pressure Low Temperature
LWD Logging While Drilling
NDDF Non-Damaging Drilling Fluid
OBM Oil Based Mud
PAC Polyanionic Cellulose
PGS Pregelatinized Starch
PV Plastic Viscosity
RDF Reservoir Drilling Fluid
WBM Water Based Mud
XCP XC-Polymer
YP Yield Point

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