APPLICATION OF AGRO–WASTE MATERIALS FOR IMPROVED PERFORMANCE OF WATER–BASED DRILLING FLUID

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Abstract

Bio–resources and its derivatives have distinctive potential in various industrial applications and solutions especially for captivating usage in drilling fluid formulations for the petroleum industry. Drilling fluids formulations have tremendously advanced through increasing research and development of unique additives to improve their functionalities and meet specific properties in well design operations. In this article, water–based mud formulated with powdered and ash products derived from plantain and banana peels were evaluated. The effects of varying concentrations of these additives and the blends on the performance of the mud were examined by comparison with Low Viscosity Sodium Carboxymethyl Cellulose (LV CMC) for rheology and sodium hydroxide (NaOH) for pH control. The rheology of the mud improves with increasing concentration of the powdered products in a way similar to that of LV CMC. However, powdered banana peels most effectively improved the rheology of the mud to attain 10cp plastic viscosity (PV), 13lb/100sq.ft yield point (YP), 16lb/100sq.ft and 23lb/100sq.ft gel strength at 10seconds and 10minutes respectively. Plantain peel ashes compared favourably with NaOH in controlling the pH of the mud. Further modification of the products to achieve the same properties as LV CMC is recommended in subsequent studies.

Keywords: Bio–resources, Drilling fluids, Water–Based Mud, Additives, Low Viscosity Sodium Carboxymethyl Cellulose

1. Introduction

Drilling is an important operation in oil and gas production, and drilling fluid (otherwise called drilling mud) is a critical component of rotary drilling. Drilling fluid is widely formulated as Water–Based Mud (WBM), Oil–Based Mud (OBM), and Synthetic–Based Mud (SBM), but the choice of the type of mud is based on certain factors including; the properties of the subsurface formation, cost of the mud, HSE considerations, and mud properties such as rheology, density, fluid loss, chemical composition, and solid content. In order for a mud to meet the required specifications, additives are usually added in proportions to improve its functionalities. However, most of these additives are expensive synthetic chemicals which are not sufficiently available locally, usually not readily biodegradable, and highly toxic.

The application of bioresources (as found in agro–waste materials) as Lost Circulation Materials (LCM) dates back in the history of drilling fluids[2,3]. Moreover, recent studies have recommended the products of direct conversion of agro–waste materials for alternative use in improving drilling fluid properties. Lost circulation is the condition in which the path of a drilling fluid and/or cement slurry in the annulus is short–circuit, leading to fluid loss into one or more zones in the formation[4]. A

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[2]Bruton J. R, Ivan C. D, Heinz T. J, 2001. Lost Circulation Control: Evolving Techniques and Strategies to Reduce Downhole Mud Losses. Proceedings of SPE/IADC Drilling Conference. SPE-67735-MS. https://doi.org/10.2118/67735-MS

[3]Baggini Almagro S. P, Frates C., Garand J., Meyer A. 2014. Sealing fractures: Advances in lost circulation control treatments. Oilfield Review 26(3):4-13.

[4]Nelson E. B. 1990. Well Cementing. Elsevier Science. First Edition

summary of research findings indicate that the combination of two or more different agro–waste materials is more effective as LCM than when each material is used alone[5].

Adebowale and Raji[6] examined the effects of local supplements (burnt banana and plantain peels) on the properties of drilling fluids. Similarly, Seteyeobot et al.[7] studied the performance of rice husk and plantain peels on the rheology, filtration, and stability of OBM at High Pressure High Temperature (HPHT) conditions. They observed that mud additives usually undergo thermal degradation above 107^{o}C (225^{o}F), leading to variation in the properties. Both studies showed that these locally produced additives are suitable substitutes for the imported synthetic additives. Using rice husk and saw dust as additives, Anawe et al.[8] conducted a performance evaluation on the properties of OBM at varying temperature, while Agwu et al.[9] investigated the filtration loss properties of WBM. They both observed that only higher concentration of these additive prevented fluid loss to the minimum acceptable standard recommended by API for WBM.

Onuh et al.[10] reported the fluid loss properties of WBM formulated with varying concentrations of coconut shell, corncobs and the mixture at Low Pressure Low Temperature (LPLT) conditions. They observed a lower filtrate volume for the mixture than for each additive used alone. A mixture of Guar Gum and Ginger as a viscosifier in WBM was studied by Akinwumi et al.[11]. They observed that ginger alone improved the rheology and density of the mud compared to commercially available viscosifier. Other notable agro–based materials investigated for drilling fluid applications are hay barn[12], and palm head sponge[13]. In this study, powdered and ash products derived from plantain and banana peels are employed as additives for WBM. These products and their mixture were evaluated at varying concentrations and compared to LV CMC for rheology and NaOH for pH control.

2. Materials and Method

Ripe plantain and banana peels, distilled water, LV CMC, NaOH (≥95%, pellet, Merck), Bentonite, Barite.

2.1 Sample Preparation

[5]Agwu O. E, Akpabio J. U. 2018. Using agro-waste materials as possible filter loss control agents in drilling muds: a review. Journal of Petroleum Science and Engineering. https://doi.org/10.1016/j.petrol.2018.01.009

[6]Adebowale A., Raji J. K. 2015. Local Content Supplements as an Alternative to Imported Corrosion Control Additive for Drilling Mud Treatment (A Case Study of the Use of Burnt Plantain and Banana Peels). Proceedings of The International Academic Conference for Sub–Sahara African Transformation & Development

[7]Seteyeobot I., Uma J. A, Enaworu E. 2017. Experimental Study of the Possible use of Locally Derived Plantain Peelings and Rice Husk as Additives for Oil Based Mud at High Temperature–High Pressure Conditions. Presented at the SPE Nigeria Annual International Conference and Exhibition. SPE-189075-MS. https://doi.org/10.2118/189075-MS

[8]Anawe P. A. L, Efeovbokhan V. E, Adebayo T. A, Nwaogwugwu M. M. 2014. The Effect of Rice Husk and Sawdust on the Properties of Oil–Based Mud at Varied Temperatures. Journal of Energy Technologies and Policy

[9]Agwu O. E, Akpabio J. U, Archibong G. W. 2019. Rice husk and saw dust as filter loss control agents for water-based muds. Heliyon. https://doi.org/10.1016/j.heliyon.2019.e02059

[10]Onuh C. Y, Igwilo K. C, Anawe P. A. L, Daramola O., Ogunwomoju O. 2017. Environmentally Friendly Fluid Loss Control Agent in Water-Based Mud for Oil and Gas Drilling Operations. International Journal of Applied Engineering Research

[11]Akinwumi E. A, Okologume C. W, Akin–Taylor A. M. 2018. Improving The Rheological Properties of Drilling Mud Using Local Based Materials. American Journal of Engineering Research

[12]Biltayib B. M, Rashidi M., Balhasan S., Alothman R., Kabuli M. S. 2018. Experimental analysis on rheological and fluid loss control of water-based mud using new additives. Journal of Petroleum and Gas Engineering. https://doi.org/10.5897/JPGE2017.0279

[13]Peretomode J. P. 2018. Plantain Peels Powder, Burnt Palm Head Powder and Commercial Sodium Hydroxide as Additives for Water Based Drilling Mud. Journal of Applied Sciences and Environmental Management. https://dx.doi.org/10.4314/jasem.v22i7.1

The species of plantain and banana used were *Musa paradisiaca* and *Musa acuminata* respectively. The peels were sourced in Ibadan, Nigeria, shredded separately and washed in distilled water to remove dirt and debris. They were oven dried at 50^{o}C for 5 hours, sun dried for 10 days and finally oven dried at 70^{o}C for 1 hour. A portion of the dark–brown peels obtained was burnt into ash in a gas–powered furnace. The products were pulverized and further reduced using a 200 microns sieve. All the samples were separately packaged and stored in well labelled air tight containers.

2.2 Mud Formulation and Characterization

A total of twenty-three 9ppg WBM samples were prepared at varying concentrations of the peel powder, ash powder, powder blend and LV CMC according to Table 1. The muds are formulated and thoroughly mixed for 1 hour in a stainless steel mixer cup to form a homogenous mixture using a high–speed spindle type multi–mixer. The mud samples were kept for 17 hours for hydration.

Table 1: Mud formulation at varying concentration of additives

Additives	Mud Samples						
	1 – 5	6 – 10	11 - 15	16 – 20	21	22	23
Water (ml)	350	350	350	350	350	350	350
Bentonite (g)	22.5	22.5	22.5	22.5	22.5	22.5	22.5
Plantain peel powder (g)	1,2,3,4,5	0	0	0	0	0	0
Banana peel powder (g)	0	1,2,3,4,5	0	0	0	0	0
Banana: Plantain peel powder (g)	0	0	1:4, 2:3, 1:1, 3:2, 4:1	0	0	0	0
LV CMC (g)	0	0	0	1,2,3,4,5	0	0	0
Plantain ash (g)	0	0	0	0	4.5	0	0
Banana ash (g)	0	0	0	0	0	4.5	0
NaOH (g)	0	0	0	0	0	0	4.5
Barite (g)							

The API recommended practice for field testing water–based drilling fluids[14] was used as a guide for the mud test experiments. A Baroid mud balance was used to measure the weight of the mud. The rheology of the mud samples were measured using the direct indicating Ofite 8–speed viscometer and calculated using the dial reading at 600RPM and 300RPM according to equation 1, 2 and 3 for apparent viscosity (cp), plastic viscosity (cp), and yield point (lb/100sqft) respectively. The pH is measure using a hand–held Ofite digital pH meter.

$$AV = \frac{\theta_{600}}{2} \quad (1)$$

$$PV = \theta_{600} - \theta_{300} \quad (2)$$

$$YP = \theta_{300} - PV \quad (3)$$

2.3 Results and Discussions

[14]API RP 13B–1, American Petroleum Institute, 2003

The viscometer dial readings at 600, 300, 6 and 3 RPM, and values of the plastic viscosity, apparent viscosity, yield point, and gel strength for the mud at varying concentrations of the additives are presented in Table 2. It is observed that the addition of the plantain and banana peel powder, and the blends generally increased the rheological properties of the mud in a similar way as LV CMC. Figure 1 to 4 graphically illustrates the effect of the additives on mud properties.

Table 2: Rheology and pH of mud samples at varying concentration of additives

Additives	Concentration (g)	Dial readings (RPM)			Rheological Properties				
		600	300	6	PV	AV	YP	Gel strength	
								10sec	10min
Banana peel powder	1	23	15	8.5	8	11.5	7	9.5	12
	2	24	16	8.5	8	12	8	11	15
	3	25	16.5	8.5	8.5	12.5	8	12	17
	4	31	22	8.5	9	15.5	13	15	21
	5	33	23	8.5	10	16.5	13	16	23
Plantain peel powder	1	22	15	9	7	11	8	9	11
	2	24	17	9.5	7	12	10	10	13
	3	25	17.5	10	7.5	12.5	10	11	15
	4	27	18.5	10	8.5	13.5	10	12	17
	5	28	19	10.5	9	14	10	13	19
Banana**:** Plantain peel powder	1:4	26	18	10.5	8	13	10	12	14
	2:3	26.5	18.5	10.5	8	13.3	10.5	14	18
	1:1	31	21.5	13	9.5	15.5	12	17	25
	3:2	33	23	13	10	16.5	13	18	26
	4:1	37	26	13	11	18.5	15	21	28.5
LV CMC	1	29.5	21	9	8.5	14.8	12.5	12.5	15
	2	32	23	9.5	9	16	14	14	19
	3	37	26	14.5	11	18.5	15	16	21
	4	46	32.5	15	13.5	23	19	18	24
	5	58.5	43	17	15.5	29.3	27.5	23	29

pH						
4.5g Ash products	Days					
	1	2	3	4	5	6
Banana peel ash	10.03	10.15	9.71	9.34	9.33	9.25
Plantain peel ash	10.21	10.32	9.78	9.50	9.40	9.33
NaOH	12.9	13.3	12.56	11.93	11.56	11.20

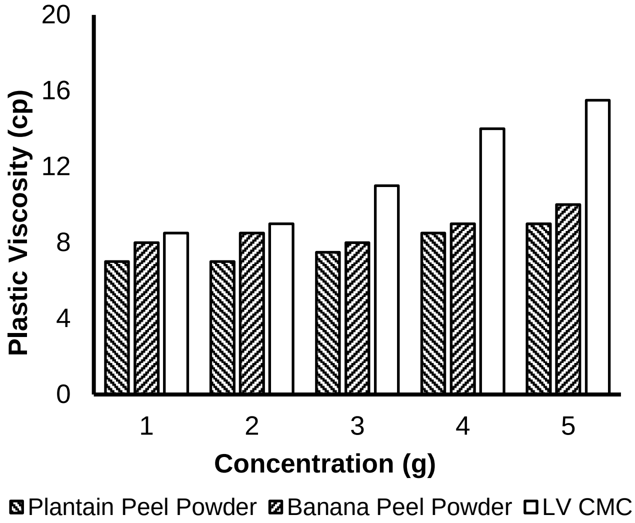

Figure 1: Effect of additive concentrations on plastic viscosity

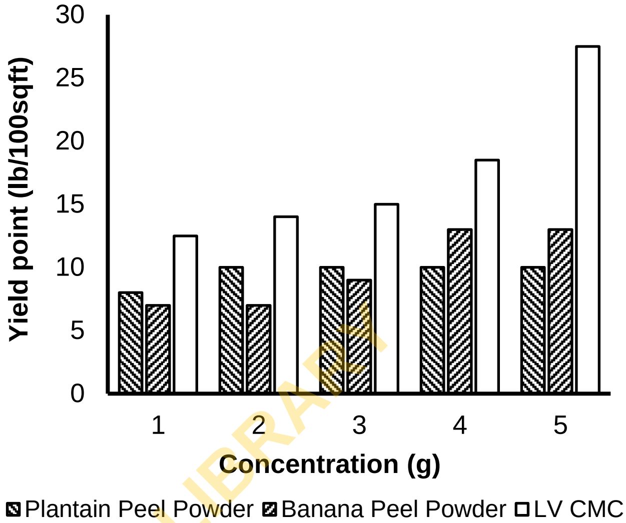

Figure 2: Effect of additive concentrations on yield point

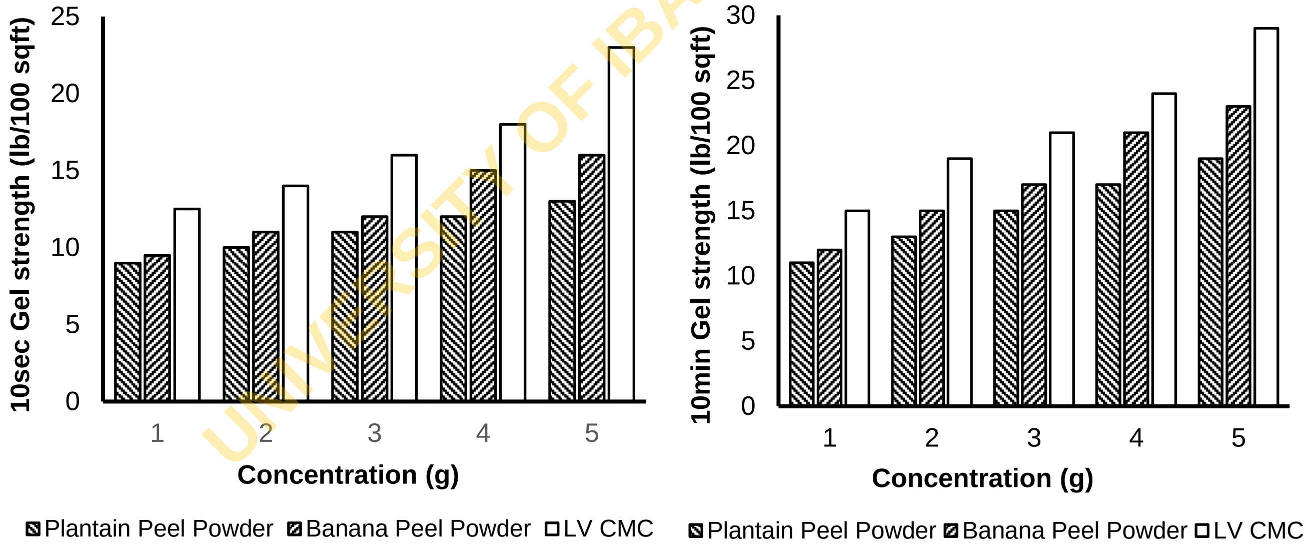

Figure 3: Effect of additive concentrations on gel strength

An examination of the mud performance at each concentration of additives shows that banana peel powder is effective in increasing the rheology of the mud than plantain peel powder. This is also evident in the properties of the mud containing the blend of additives where the rheology increases with increasing concentration of banana peel powder. With the addition of 1.0g banana peel powder, the PV is 8cp, AV is 11.5cp and YP is 7.0lb/100sqft compared to 7cp, 8cp, and 11lb/100sqft respectively for plantain peel powder. This trend remains with increasing amount of the additives up to 5g where banana peel powder increased the PV and YP to 10cp and 13lb/100sqft respectively as against 9cp and 10lb/100sqft for plantain peel powder. Plastic viscosity is a measure of the resistance to flow caused by mechanical friction, and this depend on the presence of uniform fine particles and solid content of the mud[15]. However, plastic viscosity should be kept as low as practical in all cases because a low plastic viscosity result in greater energy at the bit, greater flow in the annulus for hole cleaning, as well as less wear and tear on the equipment and low fuel usage[16]. The concentration of the additives does not have a direct effect on the yield point of mud formulated with plantain peel powder as the value remains constant at 10lb/100sqft for all concentrations between 2g and 5g. This value indicates the shear thinning characteristics of the mud and the ability to transport drilled cuttings through the annulus. The additives generally improved the gel strength of the mud which indicate the ability to suspend weighting materials and carry drilled cuttings effectively.

Figure 4 show that both plantain and banana peel ash followed similar trend as NaOH in increasing the pH of the mud sample with time. The pH of the additives fall within the range required of drilling fluids (pH of 10 to 11.5), and this indicate the ability for corrosion control. A sharp increase in pH value on day 2 for all samples is due to hydration of the muds, and this become stable once the mud is completely hydrated as obtained on day 4 to 6.

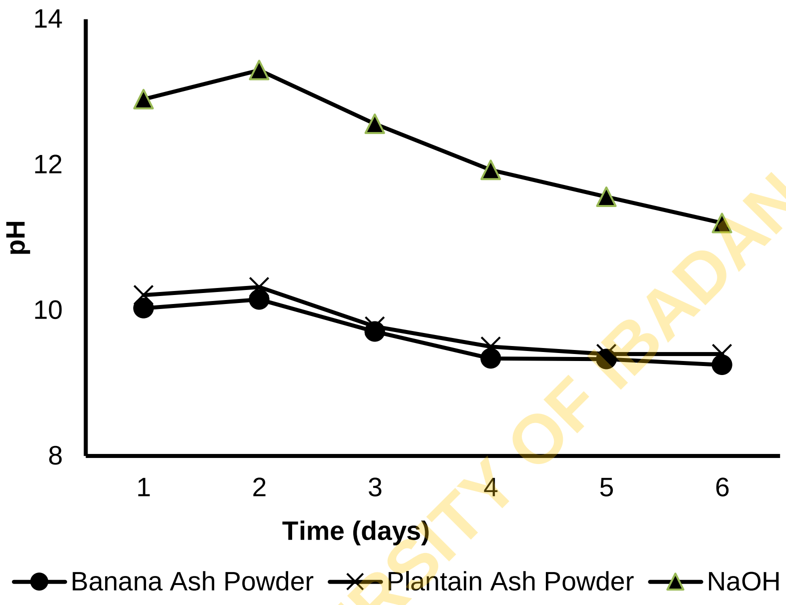

Figure 4: Variation of pH with time

3. Conclusion and Recommendations

This work studied the effects of the products of plantain and banana peels on the rheology and pH of WBM and compared it with the commercial LV CMC and NaOH additives. The locally derived additives performed effectively and achieved similar increasing trend in mud rheology and pH as the commercial additives. Moreover, banana peel powder is more effective in rheology than pH, and this is reflected in the properties of mud formulated with blends of the additives where the rheology improves with increasing concentration of banana peel powder. At higher concentrations, the local additives will compare favourably as the commercial additives, but this might increase the mud weight than necessary. A blend of the additives results in a blend of properties. Therefore, further investigation on blending the additives and determination of the effect of the additives on mud weight, thermal stability and filtration properties is recommended. This will aid in subsequent

[15] Skalle P. 2008. Drilling Fluid Engineering. Ventus Publishing ApS

[16] Amoco Production Drilling Fluid Manual. 2001. Palmer Publishers, Los Angeles. (96–101)

refinement of the additives to compete favourably with commercial additives for improved performance in mud formulation without compromising the industry specific standards.

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Nomenclature

cp	Centipoise
lb	Pound
sq	Square
ft	Feet
API	American Petroleum Institute
^{O}C	Degree Celsius
ppg	Pound per gallon
mL	Milliliter
g	Gram
θ	Viscometer Dial reading
RPM	Revolution Per Minute
AV	Apparent Viscosity
PV	Plastic Viscosity
YP	Yield Point
sec	Second
min	Minute