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Utilization of indigenous pH control agents for drilling fluid preparation

ABSTRACT

Drilling fluid pH is an important factor in drilling and production operations. If the pH is acidic, this will cause metallic parts such as the drilling string and casings to corrode. Also, much more additives will be needed to achieve the right rheological properties. In this work, the suitability of agro waste such as oil palm fruit fibre, ripe plantain peels and unripe plantain peels as drilling fluid pH control agents was studied. The materials were gotten from local sources and subjected to drying, burning and filtration. The filtrates obtained were used to treat water based drilling mud. It was found that the oil palm fruit fibre solution raised the pH to 8, while the ripe and unripe plantain peels solutions raised the pH values to 10 respectively. Laboratory test for sodium and potassium contents on the locally prepared pH control additives showed significantly higher concentrations in the unripe plantain peel solution, thereby making it most suitable as a pH control agent compared to the others.

***Keywords**: filtration properties; mud additives; plantain, oil palm.*

1. INTRODUCTION

Drilling fluids (muds) are complex heterogeneous fluids, consisting of several additives that were employed in drilling of oil and natural gas wells since the early 1900. The original use of the drilling fluids was to remove cuttings continuously. Progress in drilling engineering demanded more sophistication from the drilling mud. In order to enhance the usage of drilling fluids, numerous additives were introduced and a simple fluid became a complicated mixture of liquids, solids and chemicals [1].

As the drilling fluids evolved, their design changed to have common characteristic features that aid in safe, economic and satisfactory completion of a well. In the light of this, the American Petroleum Institute (API) defines drilling fluid as a circulating fluid used in rotary drilling to perform any or all of the various functions required in a drilling operation [2]. These functions include:

i. Clean the rock formation beneath the bit for rock cuttings;
ii. Transport these rock cuttings to surface through annulus;
iii. Suspend cuttings in fluid if circulation stopped;
iv. Seal the formation pores by forming inflow of formation fluids into the well; etc.

The various functions of drilling fluid largely depend on the properties of the fluid itself. In some cases, the required mud properties are contradictory in the sense that fluid with moderately high viscosity is generally ideal for the removal of cuttings from the wellbore, but on the other hand has negative effect on fluid loss and removal of solid from the mud. Therefore, optimum condition is defined in the mud programme to be observed closely as the operation continues, since poor mud maintenance may have negative effect on the drilling operation [3]. Drilling fluid properties that must be closely observed are viscosity, gel strength, mud weight, mud pH, sand content etc.

The objective of this study is to investigate the suitability of agro waste such as oil palm fruit fibre and plantain peel as pH control agents for drilling

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fluids. The study focuses on the formulation of drilling fluid using indigenous pH control agents (processed oil palm fruit fibre and plantain peels) as well as determination of sodium (Na) and potassium (K) ion content in the materials [4].

Additives added to drilling fluid to modify its pH are termed pH modifiers or control agents. Common mud treating pH agents are Barium carbonate (imparts pH of 10), Baking soda (imparts pH of 8.3), Chrome lignosulfonates (imparts pH ranging from 3.4 to 4.0), Soda ash (imparts pH of 11), Slaked lime (imparts pH of 12), Caustic soda or Sodium hydroxide (imparts pH of 13), Calcium lignosulfonate (imparts pH of 7), Potassium hydroxide etc. Among all, Sodium hydroxide (NaOH) and Soda ash (NaCO3) are majorly used to precipitate calcium and act as extenders to increase clay yield [3]. Additives such as Bentonite, Altapulgatite, Carboxy-methyl-cellulose (CMC), Aqua-gel, and Drispac may be used as drilling fluid viscosifiers to improve mud viscosity. Other materials such as Egg shell and Snail shell (mud pH control agents) as well as Okra (viscosifier) etc. are also suitable drilling fluid additives.

1.1. Properties of Oil Palm Fruit Fibre and Plantain Peel

Plantain belongs to the family of Musaceaae which is one of the most important fruits in the world market. The potential application of plantain peels depend on its chemical composition. Plantain peel is rich in dietary fibre, proteins, essential amino acids, glucid ploy unsaturated fatty acids and potassium, phosphorus, iron, calcium and starch. It also contains ether, bioactive compounds and minerals.

The burning of the peels results in ashes containing oxides of potassium and sodium, which when dissolve in water yield potassium hydroxide (KOH) and sodium hydroxide (NaOH) [5].

pH is a value representing the hydrogen ion concentration in liquid. It is used to indicate acidity or alkalinity of drilling mud. The following are the effects of pH on drilling fluid: i) Acidic mud will cause metallic drilling equipment to corrode. ii) If the pH level is too low, much more drilling additives will be needed to achieve the right properties (viscosity etc.)

1.2. Literature Review

A good number of researchers have used local additives for enhancement of drilling mud characteristics. Egun and Achandu [6] performed a study on comparative analyses of cassava starch PAC as a fluid loss control additive in water based-mud. They observed in their result that PAC and cassava have similar result and performance in the mud.

Slawomir et al. [7] used starch derivatives as the regulators in drilling mud filtration. In their result, they discovered that salt-starch drilling mud (potassium starch drilling fluid) for low filtration should comprise between 2-4% of starch component per 1m3 of drilling mud for enhanced performance. Amanullah and Yu [8] conducted research on fluid loss additives that are environmentally friendly. Their intent is to use them to protect marine ecology from harmful side effects of drilling mud. In the work the fluid loss characteristics of several starches were described. They observed that most of the starches have fluid loss characteristics that are both static and dynamic and sometimes even more superior to those of the conventional modified starch used by the mud industry. Al-Hameedi et al. [9] conducted a research using food waste products. Their result showed that potato peels powder (PPP) reduced the fluid loss, decreased the yield point and increased the plastic viscosity of drilling mud making it an alternative to the conventional fluid loss additives in drilling mud prepartation. Okon et al. [10] in their research using rice husk observed that additional of rice husk (concentration of 20 ppb) to drilling fluid reduces the drilling fluid loss by 65% when compared to 10 ppb of carboxymethyl cellulose (CMC). However they warned that too high concentration of rice husk might pose serious threat to measurement while drilling (MWD) tools. Therefore it is necessary to use calculated concentration of rice husk in the drilling fluid preparation when it is to be used. Kerunwa and Gbaranbiri [11] conducted research on use of local viscosifiers in drilling fluid. The local materials are Mucuna fagellipe (Ukpo), Brachystegia eurycoma (Achi), Afzelia africana (Akpalata) and Detarium microcarpum (Ofor). These local materials were used as a substitute for imported viscosifiers (PAC-R) used as a drilling fluid additives. Adebowale and Raji [5] researched on the use of banana peels ash (BPA) as a substitute additive for sodium hydroxide (NaOH) to pH and corrosion control. They observed in their study they observed that there is a substantial enhancement in pH due to the addition of banana peels ash. Their result of comparison of improvement equal concentration of BPA and NaOH showed an enhancement in pH by 12 and 14, respectively. In his study, Iheagwara [12] observed that banana peel displays alkaline characteristics in drilling fluid as conventional caustic soda (sodium hydroxide). Thus it can be used as pH control agent in drilling fluid formulations. Al-Hameedi et al. [13] performed an experimental study using mandarin peels powder (MPP) to improve filtration properties in drilling fluid. In their result, MPP improved the rheological properties of the drilling mud reducing the fluid loss as seepages. This highlights the possibility of using MPP in drilling fluid preparation. Igwilo and Bala [14] performed exeperiment using locally sourced additives. The locally soured additives are Detarium microcarpum (ofor), and Brachystegia eurycoma (Achi) used as a viscosifier in the formulation of water based muds. In their result, they discovered the local additives performed well as viscosifier in drilling fluid formulation.

2. MATERIALS AND METHODS

The materials required for this study include ripe and unripe plantain peels, oil palm fruit fibers, Bentonite clay as well as distilled water;

2.1. Preparation of Plantain Peel (Ripe and Unripe) as a pH Control Agent.

In view of the nutritional benefits of plantain peel at different ripening stages, this study and analysis is based on the design to compare the mineral composition of ripe and unripe plantain peel as a pH control agent used to control and adjust the degree of acidity or alkalinity of a drilling fluid (mud) to meet the recommended API standard specifications (9.5 – 12.5).

Procedure

i. Both ripe and unripe plantain peels of sufficient quantities were obtained and dried using an oven for up to 16 hours at 105^{o}C so as to remove their moisture contents.
ii. Placed separately in an electric furnace, the ripe and unripe plantain peels were burnt at 300oC for 40 minutes and 30 minutes respectively to remove their oil contents.
iii. After allowing the burnt plantain peels to cool, they were crushed to small particles/samples, using mortar and pestle.
iv. The crushed ripe plantain peels as well as the unripe plantain peel samples were thus placed in separate containers for storage.
v. Using a 500 ml measuring cylinder, 350 ml of distilled water was measured twice and poured into two separate containers (350 ml for each container).
vi. Using a weighting balance, 35g and 18.1g of the crushed ripe and unripe plantain samples was measured respectively and added to the container containing 350 ml of distilled water separately.
vii. The samples were thoroughly stirred for 5 minutes to obtain homogenous mixture of the ripe plantain peel sample and water as well as the unripe plantain peel sample and water solutions respectively.
viii. Each sample containers were labeled and allowed to rest undisturbed for 24 hours. The container carrying ripe plantain peel sample mixed with water was labeled SAMPLE A while the other SAMPLE B.
ix. Using filter papers and laboratory funnel, each sample was filtered into laboratory glassware containers and labeled accordingly.
x. Sample A filtrate produced a purple liquid and the container labeled SAMPLE A1.
xi. Step (ix) was repeated for Sample B whose filtrate also produced a colored purple liquid and the container labeled SAMPLE B1.

2.2. Preparation of Oil Palm Fruit Fibre as a pH Control Additive.

Palm fruit fiber is a lignocelluloses fiber. Palm fruit is used worldwide in approximately 800 different ways. It is used to produce jam, jelly, cake etc. which generate a huge amount of fiber as wastage. The prime objective of this study is to explore the potential use of palm fruit fibre and its compositions as a pH control agent when formulating a drilling mud for drilling operations in the oil and gas industries.

Procedure:

i. Oil palm fruit fibres were obtained in sufficient quantity and washed with detergent and water.
ii. The fibres were sun-dried to remove water content.
iii. Next, the fibres were burnt in an electric furnace for 50 minutes at 280^{o}C.
iv. After cooling, the fibres were crushed to small particles using mortar and pestle.
v. The crushed fibres were thereafter poured into a container.
vi. Using a 500 ml measuring cylinder, 500 ml of distilled water was measured and poured into an empty glassware sample container.
vii. 50g of the fibre samples was weighed using an electronic balance and added to the container carrying 500 ml of distilled water.
viii. The sample was thoroughly stirred for 5 minutes to obtain proper mixture.
ix. Afterwards, the sample container was labeled SAMPLE C and allowed to rest undisturbed for 24 hours.

x. Next the filter paper was placed around the interior of a laboratory funnel and the lower end placed inside an empty sample container.

xi. Sample C was then shaken again and poured through the filter paper into the empty container. The yellowish liquid was covered and the container labeled SAMPLE C1.

Figure 1. Dried Oil Palm Fruit Fibre.

Slika 1. Uzorak osušenih vlakana ploda uljane palme

Figure 1 is a sample of dried oil palm fruit fibre. It was properly dried prior to use for experiment.

2.3. Determination Of The pH Of Local Additives (Ripe Plantain Peels, Unripe Plantain Peels and Oil Palm Fruit Fibre).

The determination of the pH content of the local additive use in this study is done to determine its degree of acidity or alkalinity which is employed to achieve the main purpose and objective of the experiment and its suitability in drilling mud for comparison with the standard API practices.

Procedure

i) Each sample of the local additives was agitated and pH paper was inserted into them.

ii) The pH papers were removed after a few seconds and compared to the scales on the pH indicator chart. The results in each case were recorded.

2.4. Sodium And Potassium Contents Of Additives Samples (Ripe Plantain Peels, Unripe Plantain Peels And Oil Palm Fruit Fibre).

The pH of a drilling fluid formulation containing bentonite clays usually never falls below a value of 8.5 unless acidic material are added to these based fluids. Except for some drilling fluid systems which maybe viscosified with certain water-soluble polymers, the pH of these formulations is usually raised above pH 8.5 with alkalinity control agents, such as sodium or potassium hydroxide (caustic soda or caustic potash), or calcium hydroxide (lime).However, it is of utmost importance that sodium and potassium contents in the pH control additive samples must be determined and recorded.

For the prepared mud to be beneficiated it has to be aged and this aging will enable the mixture to hydrate properly and form homogeneous mixture, ready for characterization. Beneficiation is the treatment of the prepared drilling mud with enhancers such as pH agent raiser to improve the fluid properties for enhanced performance. The blending of the additives (beneficiation) can be achieved by mixing the drilling mud sample with the additives in right proportion to enhance the properties of the mud (i.e. the blend plus water).

3. RESULTS

This section presents various tables of results obtained from the experimental procedures as given in the preceding section. It also provides discussions on the behavioral trends of the properties determined on the tested samples.

3.1 Sodium and Potassium Contents of the Local Additives:

The findings obtained after test for sodium and potassium on the local additives is shown in Table1.

Table 1. Sodium and potassium test

Tabela 1. Test natrijum i kalijum

S/N	Parameters (Mg/L)	Oil Palm Fruit Fibre Solution	Ripe Plantain Solution	Unripe Plantain Solution
1	Potassium (K)	1.59	45.72	176.1215
2	Sodium (Na)	32.84	191.18	525.6188

Table 1 gives the results for sodium and potassium tests. The results from table 1 show that oil palm fruit fibre contained the least concentrations of potassium (K) and sodium (Na), followed by the ripe plantain peels additive. The unripe plantain peels (additive) contained a significantly higher amount of potassium (K) and sodium (Na) respectively, as compared to the other additives. This means that the unripe plantain peel will be better serve as a pH control agent than the others (Ripe plantain peels and palm fruit fiber).

3.2. Prepared Local Additives Mixed With Water and Spud Mud

Figure 2 is the plot for pH values realized at various volume of water for the samples considered. The results plotted were obtained by adding each of the local additives (Plantain peels and oil palm fruit fibre) to water showed variations in their potency. In this case, only ripe plantain peels and unripe plantain peels additives proved viable with ripe plantain peel mixed with distilled water attaining a pH value of 9, while unripe plantain peels (additive) mixed with distilled water reached pH value of 10.

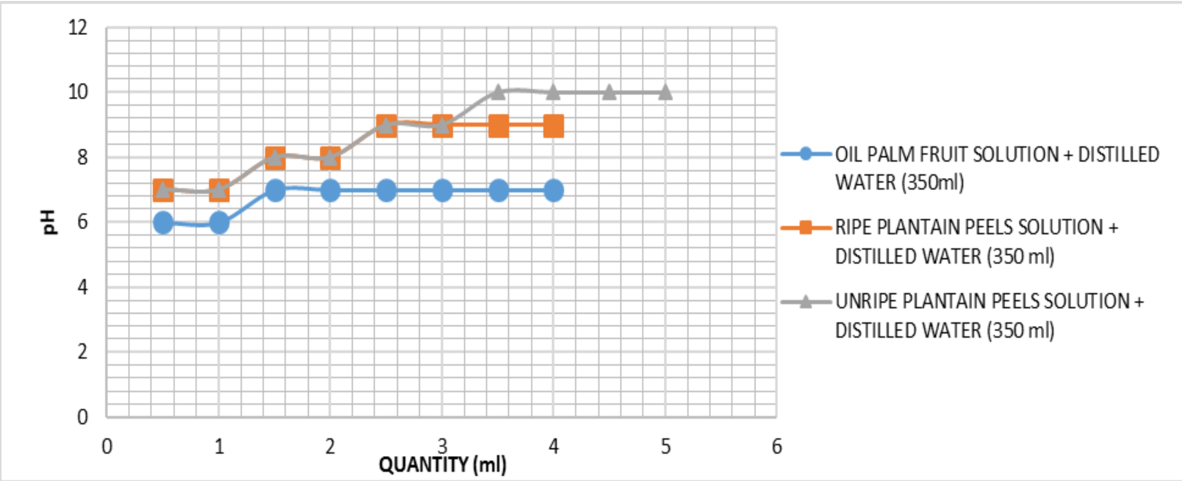

Figure 2. pH Vs Quantity, ml (Distilled Water)

Slika 2. pH u odnosu na količinu, ml (Destilovana voda)

3.3. Prepared Local Additives Mixed With Water and Spud Mud

De-emulsification performance was evaluated from a chemical and mechanical standpoint.

As can be observed from figure 3, the formulated drilling mud attained a pH value of 10 when 2.0 ml of unripe plantain peel filtrate (additive) was added. At that same quantity of 2.0 ml, the ripe plantain peel filtrate (additive) caused the mud to attain a pH value of 9. However, 2.0 ml of the oil palm fruit fibre filtrate (additive) added to formulated mud (1 laboratory barrel) resulted in a pH value of 8. This value was constant even after further addition of the additive. Moreover, both the unripe plantain and ripe plantain filtrates (additive) attained a maximum pH value of 10 which falls in the range of recommended API 13A standard specifications (9.5 – 12.5) as shown in table 2 below.

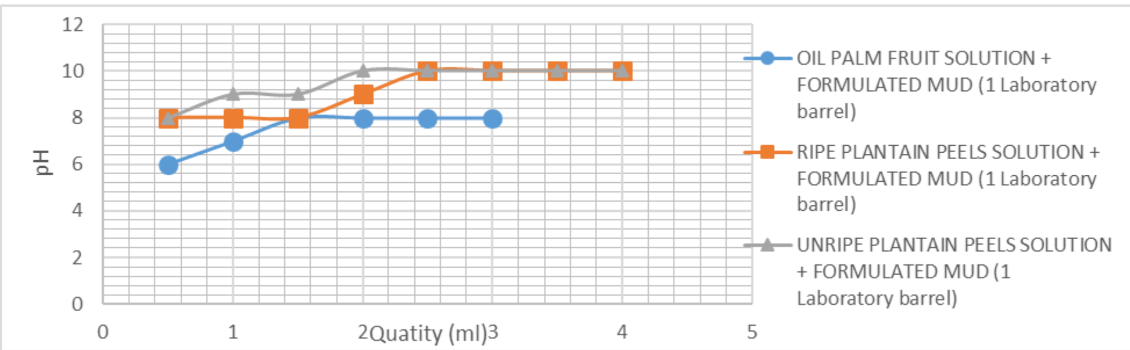

Figure 3. pH Vs Quantity, ml (Formulated Mud)

Slika 3. pH u odnosu na količinu, ml (formulisano blato)

Table 2. Standard API Recommended Values

Tabela 2. Standardne preporučene vrednosti za API

Requirement	Numerical Values
pH level	9.5 minimum – 12.5 maximum
Viscometer dial reading (at 600 rpm)	30cp minimum
Plastic viscosity (cP)	8cp – 10cp
Yield Point (lbs./100ft^2)	3 x Plastic viscosity minimum
Density (lbs./gal)	1.5kg/liter – 1.15kg/liter
Field loss (ml)	15ml/30minutes
YP/PV ratio	3.0 maximum
Moisture content	10% maximum
Sand content	(1 – 2)% maximum

Table 2 gives the standard API recommended values applicable to various parametres.

4. DISCUSSION OF RESULTS

The results obtained when the oil palm fruit fibre (used as a pH control agent) was added to the prepared water based drilling mud shows it does not meet the standard pH value as recommended by API. The proposed pH additive also contained low concentrations of sodium and potassium whose hydroxides are key to achieving standard pH values.

The result obtained when ripe and unripe plantain peels (used as pH control agents) were added to the formulated spud mud suggests that they meet the accepted pH standard as recommended by API. The ripe plantain peels additive attained a maximum pH value of 10 when added to the formulated mud. The unripe peel used as pH control additive also reached a similar value. However, sodium and potassium contents were much higher in the unripe plantain additive in its pure state compared to the ripe plantain. Thus lesser quantity of the unripe plantain peels as mud pH control agent would be required to increase mud pH compared to the ripe plantain peels

5. CONCLUSION AND RECOMMENDATION

The results obtained when the oil palm fruit fibre (used as a pH control agent) was added to the prepared water based drilling mud shows it does not meet the standard pH value as recommended by API. The proposed pH additive also contained low concentrations of sodium and potassium whose hydroxides are key to achieving standard pH values. The result obtained when ripe and unripe plantain peels (used as pH control agents) were added to the formulated spud mud suggests that they meet the accepted pH standard as recommended by API. The ripe plantain peels additive attained a maximum pH value of 10 when added to the formulated mud. The unripe peel used as pH control additive also reached a similar value. However, sodium and potassium contents were much higher in the unripe plantain additive in its pure state compared to the ripe plantain. Thus lesser quantity of the unripe plantain peels as mud pH control agent would be required to increase mud pH compared to the ripe plantain peels.

Based on the data from the analysis and practical carried out, it is recommended that ripe and unripe plantain peels should be judiciously used as substitute to foreign/imported mud pH control agent. Also, further research should be carried out to discover other local materials that could potentially be used as mud pH control agents.

6. REFERENCES

[1] D.Moore, R.C. Reynolds (1997) X-Ray Diffraction and the Identification and Analysis of Clay Minerals, 2nd ed.: Oxford University Press, New York Oxford University Press, New York.

[2] S.A.Dhiman (2012) Rheological properties and corrosion characteristics of drilling mud additives, Halifax. Retrieved from www.enggpedia.com

[3] O.M.Okorie, U.S.Offia (2011) Basic Petroleum Production Technology, COEWA Publishers, Warri, 1st Edition, p. 215-265.

[4] T.R.Nickdel (2007) Laboratory Investigation of Rheological Properties of Water Based Drilling Muds, Petroleum University of Technology, Ahwaz, Iran.

[5] A.Adebowale, J.Raji (2015) Local content supplements as an alternative to imported corrosion control additives for drilling mud treatment (a case study of the use of burnt plantain and banana peels). In: Proceedings of the international academic conference for sub-Sahara African transformation and development, vol 3.

[6] I.L.Egun, M.A.Achandu (2013) Comparative Performance of Cassava Starch to PAC as Fluid Loss Control Agent in Water Base Drilling Mud, Discovery, 3(9), 1-4.

[7] R.K.Slawomir, B.Zbigniew, U.Malgorzata (2009) Study on the application of starch derivatives as the regulators of potassium drilling fluids filtration, Chemistry and Chemical Technology, 3(3), 1-2.

[8] M.Amanullah, L.Yu (2005) Environmentally Friendly Fluid Loss Additives to Protect the Marine Environment from the Detrimental Effect of Mud

Additives, Journal of Petroleum Science Engineering, 48, 199-208.

[9] A.T.Al-Hameedi, H.Alkinani, S.Dunn-Norman, N.Alashwak, A.F.Alshammari, M.M.Alkhamis, M.T.Alsaba (2019) Environmental friendly drilling fluid additives: can food waste products be used as thinners and fuid loss control agents for drilling fluid? Society of Petroleum Engineers.

[10] A.N.Okon, F.D.Udoh, P.G.Bassey (2014) Evaluation of rice husk as fluid loss control additive in water-based drilling mud. Society of Petroleum Engineers.

[11] A.Kerunwa, B.A.Gbaranbiri (2018) Evaluation of local viscosifiers as an alternative to conventional Pac-R. Adv Pet Explor Dev, 15(1), 1–8.

[12] O.Iheagwara (2015) Comparative analysis of the use of banana peels and NaOH in pH control in Nigerian clays. J Niger Assoc Math Phys, 30, 197–202.

[13] A.T.Al-Hameedi, H.Alkinani, S.Dunn-Norman, H.W.Albazzaz, M.Alkhamis (2019a) Insights into eco-friendly and conventional drilling additives: applications, cost analysis, health, safety, and environmental considerations. Society of Petroleum Engineers.

[14] K.C.Igwilo, P.A.Anawe, S.T.Okolie, I.Uzorchukwu, O.Charles (2016) Evaluation of the fluid loss property of Annona muricata and Carica papaya. Open J Yangtze Gas Oil, 2, 144–150.

IZVOD

KORIŠĆENJE AUTOHTONIH SREDSTAVA ZA KONTROLU pH VREDNOSTI ZA PRIPREMU TEČNOSTI ZA BUŠENJE

Vrednost pH tečnosti za bušenje je važan faktor u operacijama bušenja i proizvodnje. Ako je pH kiseo, to će uzrokovati korodiranje metalnih delova kao što su bušaća kolona i kućišta. Takođe, biće potrebno mnogo više aditiva da bi se postigla prava reološka svojstva. U ovom radu je proučavana podobnost agro otpada kao što su voćna vlakna uljane palme, kore zrele i nezrele kore platana kao sredstva za kontrolu pH tečnosti za bušenje. Materijali su dobijeni iz lokalnih izvora i podvrgnuti sušenju, spaljivanju i filtriranju. Dobijeni filtrati su korišćeni za tretiranje isplake za bušenje na bazi vode. Utvrđeno je da rastvor voćnih vlakana uljane palme podiže pH na 8, dok rastvori kore zrele i nezrele kore platana podižu pH vrednosti na 10. Laboratorijski test na sadržaj natrijuma i kalijuma na lokalno pripremljenim aditivima za kontrolu pH pokazao je značajno veće koncentracije u rastvoru kore nezrele bokvice, što ga čini najpogodnijim kao sredstvo za kontrolu pH u poređenju sa ostalima.

Ključne reči: *svojstva filtracije; aditivi za blato; plantain, uljane palme.*

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