International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 02 Feb 2024, pp: 247-252 www.ijaem.net ISSN: 2395-5252

Synergistic Effect of Plantain Peel Ash and Banana Peel Ash on Casing Cement Slurry

Ikechi Igwe[1], Victor Sebastian Ibanga[2], Nyelebuchi Amadichuku[3]

[1,2,3]*Petroleum Engineering Department, Faculty of Engineering, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Nigeria.*

Date of Submission: 15-02-2024 Date of Acceptance: 22-02-2024

ABSTRACT:Plantain (Musa paradisiaca) and banana (Musa sapientum) peels, which constitute about 40% of the fruits, were used to create an environmentally friendly additive for oil and gas well cement. This additive aims to enhance cement performance and reduce agricultural waste pollution. In this study, the synergistic effects of Plantain Peel Ash (PPA) and Banana Peel Ash (BPA) as casing cement slurry additives were investigated. The cement, in its slurry state, was tested for density and rheological properties, including plastic viscosity and gel strength. To assess compressive strength, 100×100×30 mm cubic specimens were created and tested after 48 hours setting time. When PPA and BPA were added at various percentages (ranging from 0% to 11.3% of PPA and 0% to 7.3% of BPA), slurry density, plastic viscosity, gel strength, and compressive strength were analyzed. Notably, slurry density increased slightly with higher PPA and BPA percentages, reaching its maximum at 6.25% for both additives. Plastic viscosity and gel strength also increased with the addition of PPA and BPA, peaking at 3% PPA and 2% BPA for plastic viscosity and 6.25% for both additives for gel strength. For compressive strength, the highest value of 246.32 psi was achieved with 5.2% PPA and 7.3% BPA, while the lowest was 238.02 psi with no PPA or BPA. Therefore, this study suggest that PPA and BPA improved various slurry properties (density, plastic viscosity, gel strength, and compressive strength) when added in lower percentages. However, an excessive PPA-to-BPA ratio resulted to a decline in these properties.

KEYWORDS: Cement, Slurry, Plantain Peel Ash, Banana Peel Ash, Slurry Properties

I. INTRODUCTION

The procedure of adding cement to the annular area between two successive casing strings or between the well-bore and casing is known as well cementing. The process of mixing and placing a cement slurry in the annular space between a sequence of casing and the open hole is known as oil well cementing. Since gas and oil wells are dug in phases, casings supported by centralizers are lowered to secure each phase. The cement-water slurry, combined to the appropriate density, is used to cement the annular area between the borehole wall and the casing.Materials called cement additives are added to cement mixtures to change or improve specific characteristics of the cement or the concrete it creates. Additives may be derived naturally or intentionally as ashes produced by the burning of coal and some crop leftovers [1].

Plantain and banana peels are waste materials generated both domestically and widely from the industrial production of these two plants. Usually, the by-products end up in streams, unmonitored areas, or trash dumps. There are very few national and international programmes that address the leftover peels from the ongoing, profitable plantain and banana industries. Consequently, this causes a significant amount of rubbish to accumulate every day, especially in Nigeria. This could be explained by our incomplete understanding of the resources contained in the discarded peels [2].

Thisresearch work presents an investigation into the suitability of plantain and banana peel ash as casing cement additive. The effect of plantain and banana peel ash on the density, rheological and compressive strength of a casing cement slurry will be investigated. These tests shall then be carried out on slurry mixes with various percentages of the ash. The percentages of the ash used in the tests shall then be applied to produce mortar cubes which would eventually be subjected to compressive strength test. Mortar cubes will also be cast with slurry produced with 0% ash content to serve as control specimen.

Plantain, scientifically known as Musa paradisiaca, is a significant perennial herbaceous member of the Musaceae family. Plantains have historical roots in the Southeastern Asian areas. [3]; [4] and [5]. Plantains are members of the Musa Ceae family. The genus Musa originated in the region of south-east Asia, straddling the Indian and Papuan borders [4]. Based on empirical studies, there are around 68 different plantain species in the world, which are derived from two main hybrid taxa [6]. The plantain is an herbaceous perennial that grows freely and is monopodial. It usually reaches a height of two to six meters and is composed entirely of latex [7]. 46% of the world's plantains are produced in Africa [8]. In the context of evolving agricultural techniques, plantains are grown in backyards and combined with different food crops. According to DahiruandMa'aruf[2], they are thriving in large quantities in the lowland, humid tropical areas of Congo Brazzaville, Gabon, Cameroon, Nigeria, Ghana, Côte d'Ivoire, Guinea, and Liberia. Nigeria ranked as the fifth-largest contributor globally in terms of plantain production capacity in 2011 with a notable production output of 2,722,000 metric tons [9]. Research on plantain peel ash has been studied by academics in the field of applied sciences. According to records kept by Adeyemi et al [10], the ash was produced by burning the dried peel in a porcelain crucible that was placed within a Gallenkamp muffle furnace. The temperature was gradually increased to 500°C over six hours. The samples are ground into ash, which has a distinctive graycolor. Next, they are carefully mixed using a porcelain mortar and pestle. Finally, they are sieved to guarantee consistency [11]. The study carried out by Olabanji et al [12], investigated the amount of metal present in the plantain peel ash.Most importantly, the ash was obtained by burning the dried peels. The elemental composition of plantain peel ash was analyzed by Crosby[11]and was used as a low-cost source of alkali for soap production. Plantain peel ash was also used as a substitute source for bases in acid-base titrations in chemistry practical[12]. The results of the investigation revealed that plantain peel ash had the following qualities:a bitter test, soapy to touch, turns moist red litmus paper blue, and concentrated forms is not corrosive.

The banana, a fruit of the genus Musa, is a unique fruit that comes from herbaceous plants. Musa species are found in a wide range of habitats and are useful to humans in a variety of ways. For example, they are serve as food for humans and animalsas well as used in the making offiber-materials that withstand cold temperatures and for aesthetic purposes [13]. Furthermore, according to the botanical taxonomy, bananas are categorized as belonging to the Musaceae family, with the scientific names Musa sapientum, Musacavandish, and Musa balbisiana[14]; [15]. The plant known as Musa acuminata, which is indigenous to the Malay Peninsula and its environs, is the source of all edible varieties of bananas.The mineral makeup of banana peels is mostly composed of potassium (78.10 mg/g) and manganese (76.20 mg/g). Moreover, there is iron, calcium, and sodium in amounts of 0.61 mg/g, 19.20 mg/g, and 24.30 mg/g, respectively. Though labeled as waste vegetable matter, these peels have proven useful in a variety of applications, such as lactase synthesis [16], ethanol production [17], cellulose extraction [18], water purification [19], fertilizer production [20] and incorporation into composting processes.Portland cement is the primary raw material used in cementing operations. It contains a certain percentage of clinker. This clinker's composition is obtained from the careful selection of its raw ingredients, which include clay particles (such as shale and clay) and limestone (also known as chalk), which both contribute calcium oxide and silica to the mixture. A marl, which is a combination of clay and limestone particles, may also be used on occasions. Because cement has very particular needs, such accurate grinding and obtaining a certain surface area, among other things, its manufacturing process is very complex.

Compressive strength, which measures a material's ability to withstand deformation under stress, is one of the characteristics used to evaluate the dependability of cementing. Compressive strength in a cement slurry is determined by a number of factors, including the type of raw materials (including additives), the ratios of blending that are used, the cement's structural makeup, the method and length of the curing process, and the ambient conditions [21]. A cement with good compressive strength should be able to withstand harsh environments, such as corrosive and abrasive formations, areas that are vulnerable to lost circulation, carbon (IV) oxide intrusion, and extremely high temperatures [21]. If the cement does not have sufficient compressive strength, there is a greater chance that the casing would break, which might drastically shorten the well's life. The growth of cement's compressive strength is primarily influenced by temperature, which also affects the slurry's dynamic properties, such as thickening time and fluid loss.Moreover, it is critical that the cement slurry maintain the necessary degree of flow for a prolonged period of time in order to provide easy pumping through the casing pipe column and distribution into the annular space. Cement rheology is an important factor that influences cement performance and is critical in determining how pumpable the cement slurry is. In the field of rheological analysis, a rotating viscometer is used to assess important characteristics such as apparent flow, plastic viscosity, yield point, and others.

II. MATERIALS AND METHODS

The following materials and equipment will be used for this project;

1. Plantain peel ash
2. Banana peel ash
3. Class G Cement
4. Water
5. Compressive strength machine
6. Bariod mud balance
7. Fann viscometer
8. Electronic mixer

Methods

- **Drying of Peels**

The fresh plantain peels and banana peels were air dried by spreading them on a clean surface in a moisture and dust free environment to expel the moisture contained therein.

- **Burning of Peels**

The air-dried sample of the peels was carefully burnt to ashes in the open air in a dust-free atmosphere.

- **Sieving and Storage**

The ash obtained from the above process was sieved through a 75micronsieve and the material that passed through kept in an air-tight container for use in subsequent tests. This sieve has been selected such that the sieved ash obtained is at least as fine as cement particles. Hence, the material is assumed to have satisfied the fineness requirements that will qualify it to be placed on the same scale with cement.

- **Slurry Preparation**

For the preparation of slurry, the cement, water and additives were weighed with electronic balance. Water content is 37.5% of total slurry. Measured volume of water was poured into container of the mixer and then within 15 seconds, the previously weighed mass of cement and ash was added with continuous mixing while maintaining the rotational speed of the stirrer at 4000rpm. Then, the stirring is continued with the speed of 12000rpm for about 35 seconds.

- **Tests on Slurry**

Slurries containing various percentages of plantain and banana peel ash (with varying mix percentages of plantain peel ash and banana peel ash of 0:0, 3:2, 2:3, 6.25:6.25, 5.2:7.3, 11.3:1.2 %), respectively, were prepared. The prepared slurry was been subjected to density, and rheology tests, as well as compressive strength test on moulds formed by prepared slurry.

- **Slurry Density**

After cement slurry has been prepared, it was ensured that the obtained density meets the required standard of about 1380Kg/m^3 to 2280Kg/m^3 [11.5lbm/gal to 19.0lbm/gal]. The slurry density was measured with the use of a bariod mud balance.

- **Slurry Rheology**

In slurry state, rheological properties were determined. The fundamental reason to determine rheological properties is to forecast flow characteristics of cement slurry using Plastic Viscosity and Gel Strength. Dial readings at 7 speeds: 600 rpm, 300 rpm, 200 rpm, 100 rpm, 60 rpm, 30 rpm and 6 rpm were noted to calculate plastic viscosity. Plastic viscosity is calculated by subtracting the reading at 600 rpm from the reading at 300 rpm. Gel strength was also calculated at 10 seconds.

- **Compressive Strength Test**

In hardened state, compressive strength of cement was determined. The wet mix was poured into 100×100×30 mm cubic molds and kept for 48 hours to set. The cubic molds of cement were tested in universal testing machine for compressive strength.

III. RESULTS AND DISCUSSIONS

Slurry Density

Slurry density is determined by using mud balance. At concentration of PPA 6.25% and BPA 6.25% density obtained is 14.62 ppg(parts per gallon), which is higher than the rest of all concentrations used, as shown in Table 1 but it is lowest at 14.15 ppgwith PPA of 0% and BPA of 0%. Slurry density increased with increase in the concentration of both additives. Values of densities of all cement slurries obtained are between 14-17 ppgwhich falls within the API specification and recommended practice.

Table 1: Slurry Density Test Result

Weight of Cement-WOC (gr)	PPA (%)	BPA (%)	Slurry Density	
			ppg	lb/ft^3
250	0.00	0.00	14.15	105.05
245	3.00	2.00	14.45	105.60
245	2.00	3.00	14.50	105.65
237.5	6.25	6.25	14.62	105.82
237.5	5.20	7.30	14.22	105.22
237.5	11.30	1.20	14.60	105.8

Slurry Rheology

Plastic viscosity is determined using Rotational viscometer by taking dial readings at 7 speeds: 600, 300, 200, 100, 60, 30, and 6 rpm, respectively. Plastic viscosity is maximum at 69 cp with PPA of 3% and BPA of 2% as well as PPA of 2% and BPA of 3%. Conversely, it is minimum at 39 cp with slurry sample having PPA of 5.2% and BPA of 7.3% as shown in Table 2. The values of plastic viscosity of all cement samples are below 100 cp, which according to Abbas et al [22] is favourable to retain cement slurry being pumpable. Minimum Gel strength is 13 lb/100 ft^2 with slurry having 0% PPA 0% BPA and maximum gel strength of 23 lb/100 ft^{2}is obtained with slurries having 6.25% PPA and6.25% BPA, and 5.2% PPA and7.3% BPA at 10 seconds and 10 minutes, respectively, as shown in Table 2.

Compressive Strength

The sample with 5.2% PPA and 7.3% BPA showed the highest value of compressive strength (246.32 psi) after 48hours. The sample with 11.3% PPA and 1.2% BPA showed lowest value of compressive strength of (235.30psi) as presented in Tables 3.

Table 2:Slurry Rheological Test Result

Weight of Cement-WOC (gr)	PPA (%)	BPA (%)	Plastic Viscosity (cp)	Gel Strength (lb/100ft^2)
250	0.00	0.00	42	13
245	3.00	2.00	69	18
245	2.00	3.00	69	22
237.5	6.25	6.25	48	23
237.5	5.20	7.30	58	23
237.5	11.30	1.20	39	15

Table 3:Compressive Strength Test Result

Weight of Cement-WOC (gr)	PPA (%)	BPA (%)	Compressive Strength – 48 hrs (psi)
250	0.00	0.00	238.02
245	3.00	2.00	240.56
245	2.00	3.00	242.26
237.5	6.25	6.25	244.46
237.5	5.20	7.30	246.32
237.5	11.30	1.20	235.30

IV. CONCLUSIONS

This research work has been carried out to examine the synergetic effect of plantain peel ash(PPA) and banana peel ash(BPA) in oil and gas well casing cementing as an additive to enhance density, compressive strength and other rheological properties. The results suggest that cement slurry mixed with PPA and BPA has better properties than base slurry and hence, the following conclusions:

1. The addition of both PPA and BPA to the casing cement slurry resulted in a slight increase in density compared to the control sample. Slurry density increased slightly with increasing amount

of PPA and BPA. Maximum density value of 14.62 ppg was obtained with equal percentages of PPA and BPA.

2. The plastic viscosity of the cement slurry also increased with increase in PPA and BPA percentages. This indicates that these additives can make the slurry more viscous, which can be advantageous in some wellbore construction scenarios.

3. The gel strength of the slurry increased as percentages of PPA and BPA were increased, which can be beneficial for preventing fluid loss and maintaining wellbore stability during drilling and cementing operations.

4. At 48 hours, the compressive strength of the cement slurry increased with the addition of both PPA and BPA. This suggests that these additives had a positive impact on the strength of the slurry. Optimum results of compressive strength was obtained with 5.2% PPA and 7.3% BPA.

5. There appears to be an optimal ratio of PPA to BPA in the slurry where all the properties (density, plastic viscosity, gel strength, and compressive strength) are maximized. However, once this optimal ratio is exceeded, there was a noticeable decrease in these properties. This indicates that there's a balance to be struck in the formulation of the cement slurry, as a considerable increase in the percentage of PPA to BPA resulted in a decline of all the properties.

6. The results highlight the importance of selecting the right ratio of PPA to BPA for a specific application. Depending on the desired outcome, whether it's to enhance density, viscosity, gel strength, or compressive strength, the proportion of these additives should be carefully considered.

REFERENCES

[1]. Neville A.M. (2015). Properties of Cement Pearson Education Limited Edinburgh Gate, Harlow, England, 147-160.

[2]. Dahiru, Ali Ahmad, Ma'aruf, Ado (2016). Investigation into the Use of Plantain Peels Ash as an Admixture in Concrete. International Journal of Engineering Science and Computing, 6(5), 5377-5380.

[3]. International Institute of Tropical Agriculture (IITA), 1997.

[4]. Inusa, L. (2007). Investigation into admixture properties of plantain peels as (a case study of setting time of cement). B.Eng. Project, Civil Engineering Department, Bayero University Kano, Nigeria.

[5]. Ogidi I.A., Wariboko C. and A. Alamene (2018). Appraisal of Some Chemical Elements of Plantain (Musa Paradisiaca) Cultivars in Bayelsa State, Nigeria. European journal of agriculture and forestry research 6(4), 1-31.

[6]. FAO, 2013: Food and Agriculture Organization of the United Nations. Crop yield [online], available: http://Faostat.fao.org/site/567/DesktopDefault.aspx? 10-567 anchor[accessed 16th August 2022].

[7]. Oluwaseun, A. Adetayo and OlatunjiJubril (2019). Effect of Ripe and Unripe Plantain Peel Ash on Concrete Workability and Compressive Strength. FUOYE Journal of Engineering and Technology, 4(1), 145-148

[8]. Muhhammad K.R. (2005). Investigation into chemical composition of plantain. M.Science Thesis, Chemistry Department, Bayero University Kano, Nigeria.

[9]. FAO, 2012: Commodity data,country rankings [online], available: http://mongabay.com/commodities/data/category/production/1-crop/489-plantain/51-production+%29 [accessed 17th August 2022].

[10]. Adeyemi, O.S., Aiyelaagbe I.O. and Akyeampong E. (2010). Plantain (Musa Spp.) cultivation in Nigeria: A Review of its Production, Marketing, and Research in the Last Two Decades. Ressearchgate.

[11]. Crosby, N.T. (1997). Determination of metals in foods. A review. Analyst 102 (1213), 225-268.

[12]. Olabanji, O.I., Oluyemi, E.A. and Ajayi, O.S. (2012). Metal analyses of ash derived alkalis from 16512-16518.

[13]. Igboegwu E.N. (2013). Plantain Peel: an alternative source for some imported bases in acid-base titrations in Chemistry Practicals. Journal of Research in Pure and Applied Sciences 2(1), 93-99.

[14]. ICJRT (2021): International Journal of Creative Research Thought, 9(1): Utilization of Banana Peel Powder on Concrete, 14-16.

[15]. Nelson, S.C., Randy, P., & Angela, U.K. (2006). Musa Species (Banana and Plantain). Species profiles for Pacific Island Agroforestry. https://www.researchgate.net/publication/267362931_Musa_species_banana_and_plantain.

[16]. Sasha, A.A., Diaz-Carrillo, A.J., Florez-Lopez, E., and Tovar, D.G. (2021). Recovery of banana wastes – loss from production and processing: A contribution to circular economy. MDPI Journal Molecules, 26(17), Article 5282

[17]. Franck, C., Frederique, O., Andres, G., Navarroie, F., & Patrick, l. (2016). Phylogenic origin of limes and lemons revealed by cytoplasmic and nuclear markers. Annals of Botany, 117(4), 565-583
[18]. Ogidi, I.A., Wariboko, C., and Alamene A. (2017). Investiogation of Some nutritiona properties of plantain (Musa Paradisiaca) cultivars in Bayelsa State, Nigeria. European Journal of Food Science and Technology: 5(3), 15-35.
[19]. Hai-Yan Sun, Li Juanhua, Pingjuanzhao Ming Peng (2011). Banana Peel: Novel substrates for cellulose production under solid state fermentation. African Journal of Biotechnology, 10(7), 1788.
[20]. Daud, Z., Awang, H., Kassim, S.S.M., Hatta, M.Z. M., &Airpin, A.M. (2014c). Comparison of pineapple leaf and cassava peel by chemical properties and morphology characterization. Advanced Materials Research, 974, 384-388.
[21]. V. Vivekanand, P. Dwivedi, N. Pareek, R. P. Singh (2011). Banana Peel: Potential substrates for laccase production by Aspergillus Fumigatus VKJ2.45 in solid state fermentation. Applied Biochemistry and Biotechnology, 165(1), 204-220.
[22]. Abbas, G., Irawan, S., Kumar, S., Memon, K. R., Khalwar, S. A. (2014). Characteristics of oil well cement slurry using hydroxyl propylmethylcellulose. Journal of Applied Science, 14, 1154-1160.