International Journal of Innovative Scientific & Engineering Technologies Research 12(3):42-49, July-Sept, 2024

© SEAHI PUBLICATIONS, 2024 www.seahipublications.org ISSN: 2360-896X

Selected Engineering Properties Of Aquatic Plant-Based Briquette With Agricultural Waste As Binder

***Bazigha Bralatei Tanwei & Rotimi Moses Davies**

Department of Agricultural and Environmental Engineering
Niger Delta University, Bayelsa State, Nigeria.
***Email: ayibanoa4christ@yahoo.com. Phone: +2347039243557**

ABSTRACT

The study investigated selected engineering properties of aquatic plant-based briquette with agricultural waste as binder. The briquettes were produced using banana peels as binding agent and water lily as aquatic plants. The aquatic plant and the agro-waste were collected by hand -pick method, cleaned, sun-dried and milled to particle sizes 0.25- 4.00 mm and 0.075 mm respectively using hammer mill and Tyler sieve. The aquatic plants and binder ratios at 5%(B_1) - 50% (B_{10}) with discrepancy of 5% by weight and each feedstock was fed into a steel cylindrical die dimension 14.3cm height and 4.7cm diameter, and compressed using hydraulic press at pressure 10 MPa with dwell time of 45 second. The results showed that compressive density ranged from 604.24 kg/m^3 (B_1) to 825.68 kg/m^3 (B_{10})]. Positive correlation was observed with these parameters: relaxed density, compaction ratio, hydroscopic test. mechanical, physical and combustion characteristics of the briquettes produced improved with increased binder proportion. The study can make a valuable contribution to the field of alternative fuel sources and provide insight into the potential of water lily briquettes with banana peels as binder for a sustainable energy option

Keywords. Water lily, Banana peels, relaxed density, compaction ratio, hydroscopic test, mechanical, physical and combustion characteristics.

1.0. INTRODUCTION

Water lilies are aquatic plants that are known for their beautiful flowers and large leaves. They are commonly found in ponds, lakes, and other bodies of water. Water lilies have been used for various purposes throughout history, including as a source of food, medicine, and ornamental decoration. In recent years, researchers have been exploring the potential of water lilies as a renewable energy source (Goyal & Sharma, 2017).

One innovative way to utilize water lilies as a renewable energy source is by converting them into briquettes. Briquettes are compressed blocks of biomass that can be burned as a fuel source. By using water lilies as the main ingredient in these briquettes, we can reduce the reliance on traditional fossil fuels and help mitigate the impacts of climate change (Singh, & Singh, 2018).

The process of making water lily-based briquettes using banana peels as a binder involves several steps. First, the water lilies are harvested and dried to reduce their moisture content. The dried water lilies are then mixed with shredded banana peels and other biomass materials, such as sawdust or rice husks. The mixture is then compressed into briquettes using a briquette press or mold (Kaur, & Sharma, 2019).

Goyal & Sharma, (2017) investigation shows that water lily-based briquettes have a high calorific value, making them an effective fuel source for cooking and heating. In addition, the use of banana peels as a binder helps to improve the structural integrity of the briquettes, making them more durable and long-lasting. This makes water lily-based briquettes a viable alternative to traditional fossil fuels, such as coal and wood.

The use of water lilies and banana peels as renewable energy sources has several environmental benefits. By utilizing water lilies that are often considered as invasive species, we can help to control their growth and spread in natural water bodies. Additionally, banana peels are a common waste product that is often discarded in landfills, contributing to environmental pollution. By repurposing banana peels as a binder for briquettes, we can reduce waste and promote sustainable practices.

Water lily-based briquettes using banana peels as a binder have the potential to be a valuable renewable energy source. By harnessing the natural properties of water lilies and banana peels, we can create a sustainable fuel source that is both environmentally friendly and cost-effective. This study is aimed at investigating some engineering properties of aquatic plant-based (water lily) briquette using agricultural waste like banana peels as binders

2.0 MATERIALS AND METHODS

2.1 Study Area

The study area is Yenagoa, Niger Delta, Nigeria and is located between latitudes 4^0 55" and 5^0 2" North of the equator and longitudes 6^0 15" and 6^0 25" East of the Greenwich meridian. Field work for this study involved collection of samples from Bayelsa State. Materials used for this research are; water lily, banana peels, Hydraulic press, Weighing scale, Vanier Caliper, cylindrical die, Oven dryer, furnace,

2.2 Samples Collection

Water lily and were harvested from Edepie River, located at Yenagoa Local Government Area, Yenagoa, Bayelsa State. The 35g of banana peels were collected from Mbiama market and packed into bags. A 45g fresh water lily was manually harvested and packed into bag between 2nd and 7th of August, 2022 and was transported to the Departmental Farm Power Laboratory

2.3 Preparation of briquettes

For this study, the pre-treatment processing of the briquette sample included compaction, size reduction, and drying. The raw materials were allowed to dry in the sun for five to seven days. They were then cut with knives and pulverized in a hammer mill with a sieve size of 0.750 mm. Divided into three equal portions, each aggregate was then given a binder ratio of 5–50% by weight of the residue stock to each of the divided residue rations. To improve adequate mixing before compaction, the agitation procedure was carried out in an electric mixer. Hydraulic press machines were used to perform compaction testing on the blend samples. The steel cylindrical die utilized in this investigation had dimensions of 190 mm in length and 55 mm in diameter. The die was placed in the hydraulically powered press machine and allowed to fill freely with a known quantity of weight (charge) of each sample combination before being compressed into briquettes. In order to compress the sample, the piston was moved at a speed of 30 mm per minute using a hydraulic pump. It was 10 MPa of compacted pressure.One known pressure was given to the material in the die at a time, and it was allowed to remain there for 45 seconds (the "dwell time") before being released. The briquette that resulted was then extruded. Using oven drying techniques, ASABE (2003) was used to evaluate the moisture content of the ground material both before and after compaction. After the sample's initial weight (W1) was established, it was heated to 105±3ºC for a whole day.Following removal and cooling in a desiccator, the samples were reweighed (W2). As a percentage of the material's weight, the amount of water in biomass is known as its moisture content (Zhanbin, 2003). determined using the subsequent expression,

$$\% \text{ Moisture content} = \frac{initial\ weight\ of\ the\ sample - final\ weight\ of\ the\ sample}{initial\ weight\ of\ the\ sample} \text{ x } 100$$

$$\% \text{ Moisture content} = \frac{wa - wc}{wo - wc} \text{ x } 100 \qquad 1$$

Where Wo = initial mass of briquette before drying W
= Final mass of briquette after drying

2.4. Determination of Density

Using venier calipers to measure the cylindrical briquettes' equal height (2 cm) and diameter (12 cm), the volume was calculated using nr2h.The briquette's mass to volume ratio was used to calculate its density.

$$\text{Density} = \text{g/cm}^3 \qquad 2$$

2.5. Determination of Ignition Time

The ignition time of each briquette sample was measured as the amount of time it took for it to ignite. For every sample and average time taken, the test was run twice.

2.6. Determination of Burning Time

By utilizing a stop watch and examining the mass changes noted on a mechanical balance, one can determine the burning time in minutes. The combustion of the briquettes takes time to finish.

2.7. Determination of the ash content of the raw material

The fraction of the initial briquette mass that remains incombustible after burning a certain sample of briquettes. The briquette samples weighed one gram. These are placed in a muffle furnace that is heated to 550°C, and they are kept there for about 4 hours. After that, the crucible and the contents were cooled to about 100°C in air5, brought to room temperature in desiccators, and weighed. The percentage of ash content was calculated as;

$$\text{Percentage Ash Content} = \frac{weight\ of\ ash}{inital\ weight\ of\ sample} \times 100 \qquad 3$$

$$\text{That is, \% Ash Content} = \frac{wa - wc}{wo - wc} \times 100$$

W_A =Weight of ash + can

W_c = Weight of empty can

W_o = original weight of sample can

2.8. Determination of the Volatile matter in the sample

Two grams of briquettes were baked in order to ascertain the proportion of volatile stuff. After ten minutes at 550°C in the furnace, the briquette was weighed and allowed to cool. Next, the proportion of weight loss relative to the original sample's oven-dried weight was used to express the percentage volatile matter.

Volatile matter =100 - *(%Fixed Carbon + %Ash Content)* 4

2.9. Determination of fixed carbon

The process by which living things transform inorganic carbon, or carbon dioxide, into organic substances is known as carbon fixation. The percentage of carbon accessible for char burning is essentially the fixed carbon of a feed. Because a sizeable portion of the fuel is also released as hydrocarbons in the volatiles, this does not match the entire quantity of carbon in the fuel (ultimate carbon). According to Moore and Johnson (1999), fixed carbon is the amount of carbon that can be burned by the main air current that is drawn through a fuel's heated bed. The percentage of char that is still present following the devitalization stage is indicated by fixed carbon. The solid, flammable residue that remains after heating a coal particle and ejecting its volatile components is called fixed carbon.

$$\text{Fixed carbon} = \frac{weight\ of\ fixed\ carbon}{initial\ weight\ of\ sample} \times 100 \qquad 5$$

2.10. Determination of Calorific (Heating) value

The energy content of a fuel is determined by its heat value or calorific value. It is a characteristic of biomass fuel that is contingent upon its molecular makeup. The calorific, or heat value, of a fuel is its most significant characteristic. The quantity of heat generated when a unit quantity of fuel is completely burned is known as the gross or high heating value. This was computed by means of the formula.

Heating value = $2326(147.6C + 144V)$ 6

Where, C is the percentage fixed carbon and V is the percentage volatile matter

3.0 Results and Discussion

3.1. Effect of Measured Parameters on Compressive Density of Briquettes

Compressive density of briquettes at the different binder proportions are presented in the figure 1. The value displayed the compressive density increased as the binder level increased proportion between (5-50%) with value is (710.34(B1) to (838.11(B10) for briquettes produced from banana peels. It was observed that the compressive density increased with increased binder ratios. This implies that the higher the binder, the higher the compressive density. The observed positive correlation between compressive density and binder ratios is in agreement with Chin and Siddiqui (2000), Engelleitner (2001), Demibas (2001) Sotannde *et al*., (2010) and Oladeji (2012).

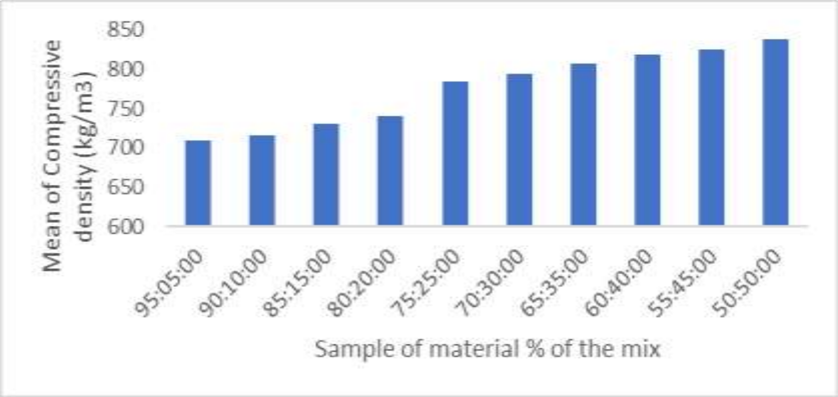

Figure 1. Compressive densities of briquettes produced from water lily at different binding ratios

3.2 Results on the Relaxed Density

The relationship between relaxed density of the water lily briquettes with the different binder ratios was shown in figure 2. It was revealed that the briquettes' loose density generated from water lily at different Binder proportion of 5% to 50% increased from [0.599g/cm3) to [0.786g/cm3) for banana peels. This implies that there’s correlation between relaxed density and the binder proportion. With a higher binder fraction, the relaxed density rose noticeably. The water lily briquettes found drop in relaxed density may be explained by the After the briquette was taken out of the die, low elastic recovery and stress relaxation procedures took place to help it reach its ultimate, stable state. The minimum strength required for handling, storing, and transporting the briquettes, as stipulated by DIN 51731 (1999), was met by all of the briquettes that were produced. Davies and Davies (2013) shown a similar pattern in terms of how different binder kinds and ratios affect relaxed density.

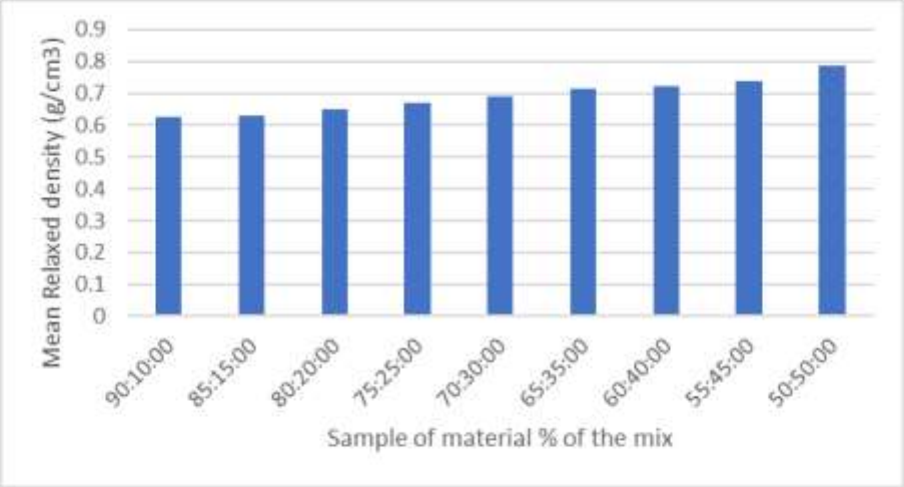

Figure 2. Relaxed Densities of briquette produced from water lily and Binder proportions

3.3 Compaction Ratio of Water Lilly and Binder Proportion

Regarding the ratio, the impact of binder varied from binder proportion ratio increases from [5.070 (B1) [7.731(B1) showing increased displacement of volume, which is advantageous for transit, storage, and packaging. It demonstrated high caliber of the briquettes. It is possible to compare the research's findings with those of other noteworthy biomass residues. The related studies on the impact of binder kinds and ratios on compaction ratio varied from 2.23 to 6.50 for briquettes made from corncob from white maize and for briquettes consisting of cassava and guinea corn starch, 3.194 to 9.730 (Demibas, 2001; Manickam and Suresh, 2011).

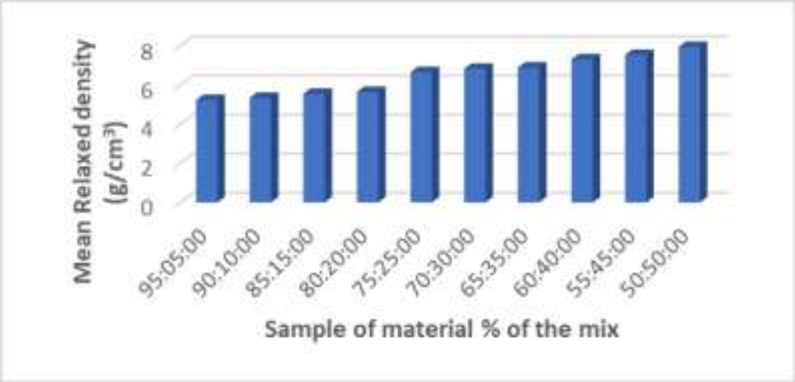

Figure 3. Compaction Ratio of briquette produced from water lily and various binder proportions

3.4 Crushing Strength of Water Lilly and Binder Ratio

The crushing strength of briquettes made from water lilies and at various binder proportions as shown in Figure 3. The relationship between the levels of binder and the crushing strength of the briquettes varied: for briquettes made from water lily, the correlation was 380 N (B1) and 685 N (B10); Crush strength, binder ratios, and binder kinds have a significant positive correlation. Increases in the binder level of petroleum pitches by 5% to 20% (by weight) resulted in improved crushing strength for sawdust, coconut, palm fiber, rice husk, and peanut shell. These findings were consistent with those of Chin and Siddiqui (2000) regarding the impact of binder ratios on the crushing strength of certain biomass.

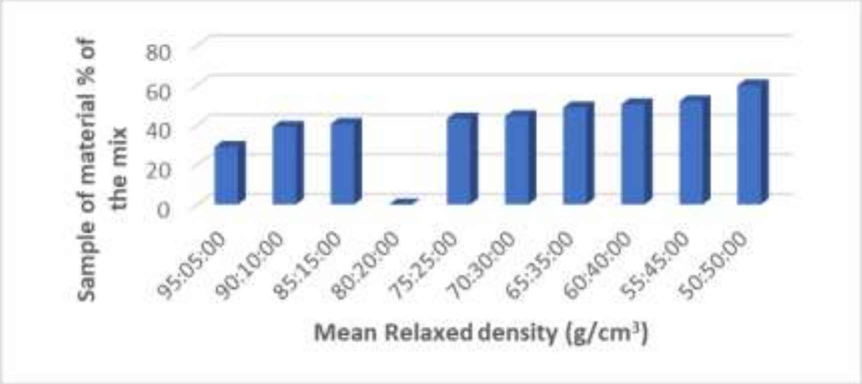

Figure 3. Crushing strength of briquette produced from water lilly and binders

3.5 Handling durability index

The Figure 4 presented showed the durability index of briquettes at different binder proportions. The durability index of briquette increased with increased binder proportions. Physical metrics like density and durability index were established as the most reliable markers of additive quality for briquette quality control. Consequently, it may be said that briquette durability ratings increase with the amount of binder present.

The durability and binder ratio were positively correlated according to Hussain *et al.,* (2002), Adus and Egbe (2024), Tariebi and Davies (2024), and Olorunnisola (2007), among other densification variables, the compaction pressure, binder types, and binder ratio are examples of densification variables that significantly affect the durability rating of briquettes.

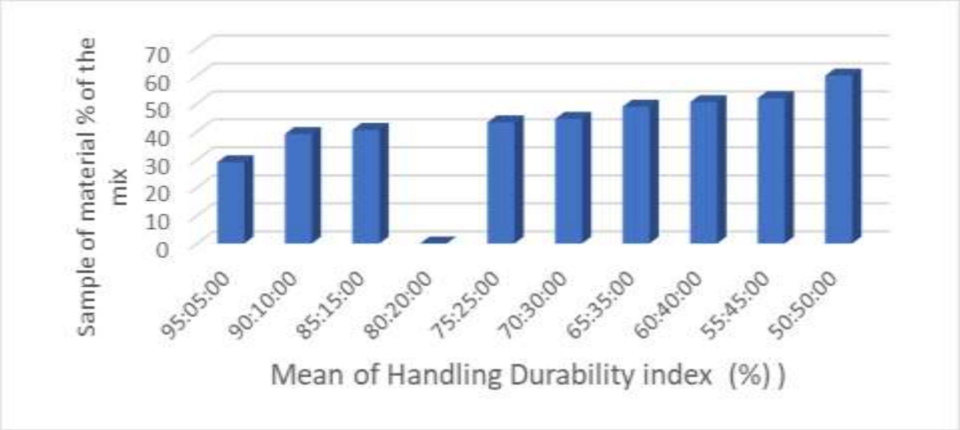

Figure 4. Handling durability index of briquette produced from water lily and binders

3.6. Hydroscopic Properties

After testing the hydroscopic properties of the briquettes by immersion of the sample in water, different characteristics are found depending on the proportion of the binder proportions. The analysis of increased in water resistant with increased in binder applied from 5% to 50% for briquettes produced from water lily. In the figure 5 showed the impact of binder proportion on the briquettes' ability to absorb water when submerged in it.

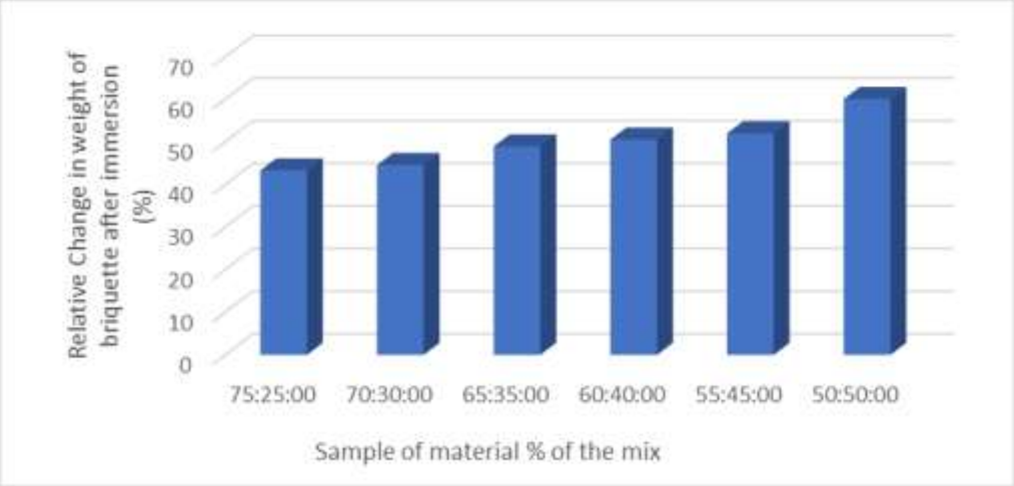

Figure 5 Hydroscopic properties of briquette produced from water lilly and binders

3.7 Combustion Properties

From figure 6 the Afterglow had an increasing value from 342.001s to 368.70s. With binder, the volatile matter increased, addition with the lowest value of 55.106% at 5% binder ratio and highest value of 72.410% at 50% binder ratio. Ash content reduced significantly with an increased binder ratio. Fixed carbon reduced in value from binder addition and later had an increase at 40% and 50% with value of 16.687% and 16.515% respectively. The heating value increased with binder proportions at 26.890Mj/kg at 5% as its lowest value and 29.943Mj/kg at 50% as its highest value. Based on the findings, the fixed carbon varies, demonstrating that the kind and quantity of binder affect the combustion properties of briquette in different ways (Olorunnisola, 2007).

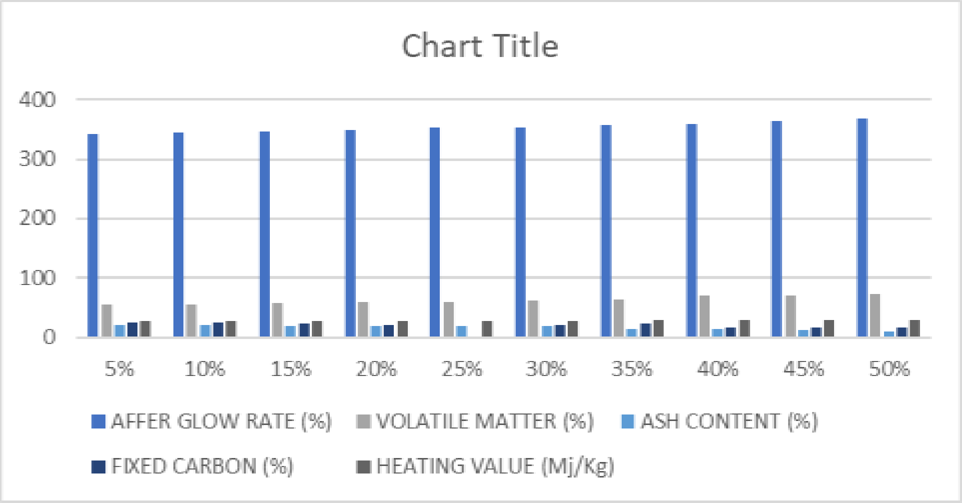

Figure 6 Combustion Properties of Water lily and Banana Peels at varying binder proportions

CONCLUSION AND RECOMENDATION

This study was conducted in order to examined selected engineering properties of aquatic plant-based briquette with agricultural waste as binder at different binder proportions. Environmentally friendly practices have been noted in the utilization of water lily briquettes. For the generation of fuel for both home and industrial applications, water lily briquettes are an excellent option. Some physical, mechanical and combustion properties of the water lily briquettes were investigated, the result shows that the compressive density increased with increased binder ratios, the relaxed density of the briquettes produced from water lily at different binder proportion of 5% to 50% increased from [0.599g/cm3) to [0.786g/cm3) for banana peels this implies that there's correlation between relaxed density and the binder proportion. With a higher binder fraction, the relaxed density rose noticeably. The durability index of briquette increased with increased binder proportions. Physical metrics like density and durability index were determined to be the most accurate measures of the additive quality for briquette quality control. Consequently, it may be said that briquette durability ratings increase with the amount of binder present. The analysis of increased in water resistant with increased in binder applied from 5% to 50% for briquettes produced from water lily. The combustion properties increased as the binding ratio increases. Economic of briquettes making can compete favorably with other traditional fuel. The produced water Lilly briquettes are healthy, environmentally friendly and economical. Water lily briquettes is an alternative source of energy which will reduce the use of fossil fuel and deforestation and the emission of carbon gases to the atmosphere, so it contributes to the environmental management.

REFERENCES

Abhon Adus and Egbe Ebiyeritei Wisdom, (2024).Creating Fuel Briquettes From Discarded Coconut Shells And Peanut Shells As Renewable Energy Sources , *Rivers State University Journal of Biology & Applied Sciences*: Vol. 4 No. 1 (2024): RSUJBAS

American Society of Agricultural and Biological Engineering (ASABE). 2003. Cubes, pellet and crumbles definitions and methods for determining density, durability and moisture content. St. Joseph, MI, America.

Chin, O. C. & Siddiqui, K. M. (2000). Characteristics of some biomass briquettes prepared under modest die pressures. *Biomass and Bioenergy*, 18, 223–228.

Davies RM., Davies OA. (2013). Physical and combustion characteristics of briquettes made from water hyacinth and phytoplankton as binder. *Journal of Renewable Energy*, Volume 2013, Article ID 429230, 5.

Demibas A. (2001). Yield of hydrogen –rich gaseous products via pyrolysis from selected biomass samples. *Fuel*, 80, 1885- 1891.

Goyal, P., & Sharma, P. (2017). Biomass briquetting: technology and practices. TERI Press.

Husain, Z., Zainac, Z. & Abdullah, Z. (2002). Briquetting of Palm Fibre and Shell from the Processing of Palm Nuts to Palm Oil. *Biomass and Bioenergy*, 22, 505-509.

Kaur, A., & Sharma, P. (2019). Banana peel as a binder in biomass briquetting: a review. *International Journal of Renewable Energy Research*, 9(1), 1-8.

Manickam I., Suresh SR. (201)1. Effect of moisture content and particle size on bulk density, Porosity, Particle density and coefficient of friction of coir pith. *Int. Journal of Engineering Science and Tech*, 4, 2596-2602.

Oladeji, J.T. (2012). Conversion of Agricultural Wastes into Biomass Briquettes. *IJAAAR*. 5(2), 116-123.

Olorunnisola AO. (2001). Briquetting Rattan Furniture Waste For Domestic and Agro- Industrial Fuel Applications. *Nigeria Journal of Renewable Energy*, 2:130-135.

Olorunnisola, A.O. (2007). Production of fuel Briquettes from Waste Paper and Coconut Husk Admixtures. *Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 06 066. Vol. 1X*.

Singh, R., & Singh, S. (2018). Water lily as a potential biomass feedstock for bioenergy production. *Renewable and Sustainable Energy Reviews*, 82, 2940-2951.

Sotannde, OA Oluyege AO., and Aba G.B. (2010). Physical and Combustion of charcoal briquettes from neem wood residues, *Int. Agrophysics*, 24, 189-194.

Tariebi Karikarisei and Davies Rotimi Moses. (2024). Some Handling Properties of Cassava Peels Bonded Water Hyacinth Briquettes. *International Journal of Innovative mathematics, Statistics and Energy Policies* 12(2): 72-80 April-June, 2024.