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Comparative Performance and Analysis of Fuel Briquette produced from Water Hyacinth Plant with Paraffin oil

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ABSTRACT

Water hyacinth plant popularly known as seaweed is an aquatic and problematic plant usually found floating freely on the surface of water. Research has shown that these seaweeds can be transformed into products that will provide alternative energy to the people rather than constituting environmental problems. In this study, solid briquettes were produced by blending water hyacinth plant with clay soil and waste cooking oil as binder. The goal of this study was to produce solid fuel briquettes and compare the specific fuel consumption and cooking time of the briquette produced with conventional fuel, paraffin oil. The study further looked at the quality improvement of hyacinth briquettes with blend of soil clay. This research produced solid fuel briquettes from hyacinth plant and clay blend in the ratio: 100:0, 97.5:2.5, 95:5, 92.5:7.5, 90:10, 87.5:12.5, 85:15, 82.5:17.5, 80:20, 79.5:20.5 and 75:25. This was compressed using the manually developed hydraulic press machine to effectively mold the briquettes into desired shape. The solid analysis showed that the developed bio-briquettes at the ratio 85:15 produced maximum heating values with percentage moisture content of 18.8. It was also observed that the cooking time for briquette produced using hyacinth plant was 40min/kg with SFC of 0.4kg/kg while that of paraffin was 32min/kg with SFC of 0.152kg/kg, meaning that kerosene stove cooks faster than briquette produced from hyacinth plant. However, hyacinth briquette is cost effective, available and affordable. In conclusion, the produced briquettes have lower smokiness, high maximum temperature and long burning time. Establishing a small scale water hyacinth briquetting firm is a better way of averting deforestation and creating employment to boost the confidence of young people.

Keywords: *Briquette, hyacinth, binder, cooking time, Specific Fuel Consumption (SFC).*

1. INTRODUCTION

Fossil fuel energy has been a major area of interest and source of income locally and globally in the time past. Recently, researchers have discovered alternative sources of energy to replace the existing energy source. [1,2] are of the opinion that the attention on fossil fuel would shift to alternative energy sources in the next 20 to 30 years. Engineers, scientist and researchers are so much concerned on the best possible ways to address waste issues especially on how to convert the problematic aquatic plant into useful products. As a result of high cost of kerosene and cooking gas, the poor masses cannot afford using these energy sources necessary to meet their daily domestic needs, rather they prefer to go for dry plant materials while some fetch dry wood in the bush, others fall down trees, action which has greatly resulted in deforestation. They believe these waste materials are free to source for and the process of obtaining them are stress free. Biomass have great advantage over other renewable source of energy because they are waste materials easy to source for at little or no cost. They can easily be derived from animal waste and plant materials or other forms of wastes. Materials like: hyacinth plants, groundnut shell, sugarcane waste, office papers, animal waste, plant waste, rice husk, grasses etc. are good examples of biomass materials. Using these waste materials directly is inimical to health because of the high carbon content emitted during burning. In order to improve the handling physiognomies of the biomass material, development of briquetting machines is necessary for production of solid briquettes. The briquetting process will help enhance easy movement of the products and also increase the calorific values and easy storage of the materials for effective use when necessary. [3]. The bulkiness of the biomass material as well as its low density makes it extremely uneconomical to transport and problematic for use as burners in homes [4]. One of the solution to the factors or constraints mentioned is densification of the waste materials. The quality of a briquette is usually measured or evaluated by its density [5]. If the briquette produced is well carbonized, packaged in such a way that it could be conveniently handled and transported from the point of production to demand or destination point at a reduced cost, then it will serve as alternative source of energy to kerosene, cooking gas, charcoal and pure fire wood for industrial operations, domestic cooking and for use in restaurants.

According to [6] who conducted a research on production of solid briquettes using guinea corn residue as biomass and starch mucilage as binder. The study was to investigate the physical properties and durability of bio-briquettes produced from guinea corn residue popularly known as *Sorghum bicolor*. The result of their research showed that solid briquette produced has maximum density ranging from 789 to 1372kg/m^{3}and can be safely stored for about 6months or more without deterioration. [7] conducted a study using a hybrid waste of coconut husk and white office papers in Nigeria. The result of their research showed that briquettes produced using 5% waste paper and 95% coconut husk reveal the prevalent trivial linear expansion on drying.

Briquettes may be produced with or without binders. The particles must bind properly during compression; otherwise, the briquettes might crumble easily. Pressure, heat, moisture, and size reduction are therefore necessary in the process of making high quality briquettes [8]. The most important fuel property is its calorific or heat value [9]. Some of the advantages derivable by converting water hyacinth to briquettes include: alternative source of income; alternative source of biomass; stress-free way of getting solid briquettes that can serve as source of energy to temperate the room during winter, power the oven, cook, iron clothes; less threat to biodiversity and easy access to the sea and reduced risk to offshore staff and maritime transport; reduce deforestation since the need to fall down trees is reduced. This is possible due the availability of water hyacinth plant popularly called the sea weed. [8,10]. Conversely, studies have been conducted with focus on development of bio-briquettes from waste materials, a good number of research work focused on agricultural waste produced globally, like: corn [11-16]; rice husk [17-25,29]; hyacinth plant or sea weed [26,27]; saw dust [28,29]; other studies have been conducted on briquettes using other agro waste materials [30-40].

2.0 MATERIALS AND METHODS

2.1. Material Preparation and production of fuel briquettes.

Water hyacinth plant, clay soil and waste cooking oil were obtained from Ogbe-ijoh river, Ugbomoro and Jemilat restaurant, Uvwie Local Government Area, Delta state, Nigeria. A local oven developed at Federal University of Petroleum Resources Effurun was used to dry the water hyacinth plant, electronic weighing balance was used to measure the weight of the produced briquettes before and after drying**.** The cut pieces of hyacinth were stored in an open environment and sun dried for few days.

2.2. Equipments

The following equipment and some others were employed in the process of carrying out the experiments: Oven, Shredder, Mixer, Sieve, Press, Bowl containers, Cutting materials, Stirrer etc.

2.3 Method

Proportions of the hyacinth plant and mixture of clay and waste oil were gathered, the materials were properly mixed and sectioned into different ratio, then weighed using the weighing balance. The content was then mixed with adequate quantity of waste cooking oil with some quantity of water and further mixed using electrically fabricated mixer. The materials were combined at mixing ratios of 100:0, 97.5:2.5, 95:5, 92.5:7.5, 90:10, 87.5:12.5, 85:15, 82.5:17.5, 80:20, 79.5:20.5 and 75:25 respectively. The mixture were manually poured into a reusable mould. In each sample, ratios were pressed using a mechanically fabricated manual hydraulic press developed in the university workshopto form briquettes and attain the desired thickness and density. It was allowed to set, harden and later dried in the sun.

Figure 1 Water Hyacinth plant sourced from Ogbe-Ijoh in Delta State

Figure 2 Crushed and Dried water hyacinth plant

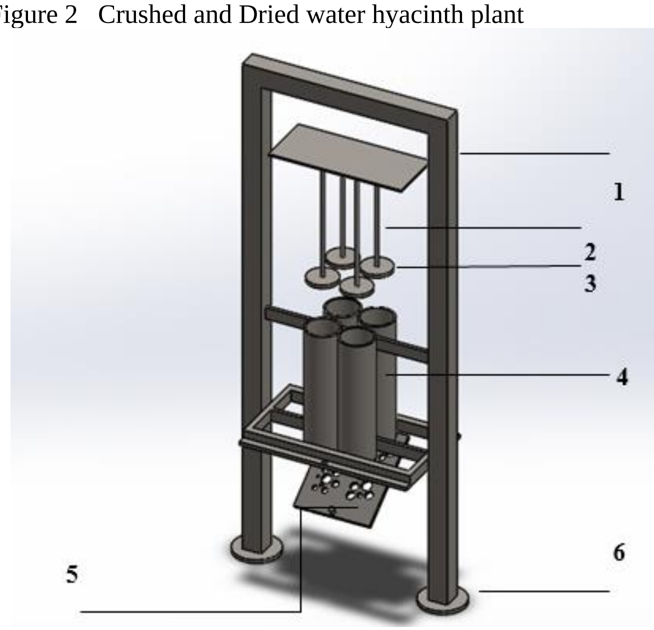

Figure 3 Exploded view of the briquetting machine: 1. Frame 2. Piston 3.Compression Plate 4. Compression Chamber 5. Base plate 6.Sprocket

Figure 4 Bio-briquettes produced from blend of hyacinth plant and clay mixed with waste oil

3.0. Thermal property analysis and thermal efficiency.

The samples were determined using moisture content (MC) analysis. All samples were weighed and properly dried in a locally made oven at a temperature of 105 ºC. Each sample was dried until the difference in mass between two successive weights separated by an interval of two hours was reduced to the bearest minimal. The moisture content of sample was calculated following equation 1, which is defined theoretically as initial weight minus final weight, divided by initial weight expressed as a percentage. The ash content (AC) was determined by subjecting the test sample to heating process at a constant temperature within a definite time interval. The ash content was calculated using substantial mass of ash deposit. The samples were all calculated following equation 2, which is defined theoretically as oven-dry weight after heating at a very high temperature divided by initial weight and expressed as a percentage. The volatile matter (VM) was determined by subjecting the test sample to heating in a closed pan and air tight system, then a calculation was made using the variance between the entire weight loss of the bio-briquette sample, and the weight loss as a result of moisture loss. The sample was calculated following equation 3, where C is the oven-dry weight after heating to further. Also, the fixed carbon (FC) content was attained by deducting the summation of moisture content, volatile matter and ash content and the result obtained is deducted from 100. The density of briquettes was also determined and this was computed by considering the ratio of mass of the briquette to that of the volume. The result is presented in Figure 5 and Table 1.

$$MC\ (\%) = \frac{Initial\ weight - final\ weight}{initial\ weight} \times 100 \qquad 1$$

$$AC\ (\%) = \frac{oven\ dry\ weight\ after\ heating}{initial\ weight} \times 100 \qquad 2$$

$$\mathrm{VM}(\%) = \frac{\text{final weight} - \text{oven dry weight after heating}}{\text{final weight}} \times 100 \qquad 3$$

$$\mathrm{FC}\ (\%) = 100 - (\%\mathrm{MC} + \mathrm{VM} + \mathrm{AC}) \qquad 4$$

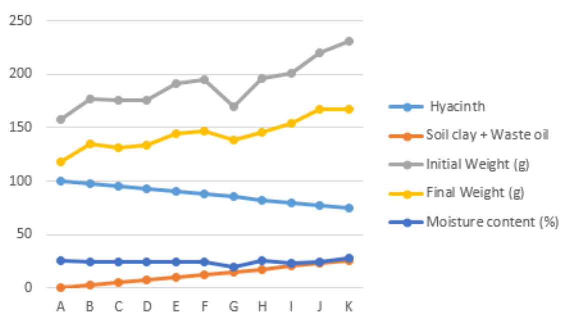

Figure 5. Physical and fuel characteristics of briquette fuel of different composition

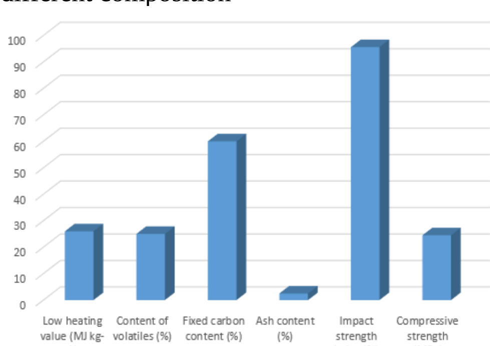

Figure 6 Thermal Properties of Solid Fuel Briquettes

4. RESULTS AND DISCUSSION

The results showed that the thermal properties of the samples were improved as shown in Figures 5 and 6. Controlled cooking test was conducted for samples of briquette produced from hyacinth plant with that of Kerosene stove in order to test the strength of the solid bio-briquette produced. The specific fuel consumption and cooking time were computed. For the controlled cooking Test, initial mass of the fuel was noted and measured, then the mass of empty pot was also measured. The same quantity of food items (unripe plantain) and volume of water was used during the experiments. The cooking briquette stove developed in the workshop was ignited. The aluminum cooking pot with already known volume of water and unripe plantain was positioned on the glowing fuel. After some minutes the item on fire was observed, as soon as it was properly done, the mass and the time taken to achieve a softened and ready to eat plantain was noted and recorded. Also, the mass of the solid fuel remaining after cooking was also noted and recorded. The same process was conducted using kerosene stove to boil unripe plantain of same volume of water. This was done to reveal, test and compare the general performance of a non-conventional but renewable energy source (hyacinth solid briquette) with conventional (paraffin or kerosene) fuel under the same cooking condition. See Table 1 for data collected during the cooking process with stove powered by WHB and Kerosene. Figure 7 shows the graphical analysis of consumption for hyacinth briquette and kerosene controlled cooking

Table 1. Data collected during consumption of Hyacinth briquette and Kerosene controlled Cooking

	Hyacinth briquette	**Conventional fuel (Kerosene)**
Mass of empty Pot, Mp (kg)	0.612	0.612
Mass of empty pot with cooked unripe plantain Mpc (kg)	0.812	0.812
Moisture content value of fuel assumed to be zero i.e. 100% dryness (X)	0	0
Mass of charcoal left Mc, (kg)	Negligible (Mc = 0)	Negligible (Mc = 0)
Initial Mass of fuel before burning M_{f0}, (kg)	0.318	0.433
Final mass of fuel burnt M_{f1}, (kg)	0.218	0.395
Initial time before cooking t_0, (Min)	18	21
Final time after cooking t1, (min)	8	13
Cooking time t, for 1kg of unripe plantain (min/kg)	40 (calculated)	32 (calculated)

According to [42], the specific fuel consumption, S.F.C for a controlled cooking test was computed from the data using the equation below:

$$S.F.C = \frac{\text{Mass of Consumed Fuel}}{\text{Total mass of cooked food}}$$

$$S.F.C = \frac{(M_{fo} - M_{f1})(1-x) - 1.5mc}{M_{pc} - M_p}$$

Also according to [42], the time spent in cooking per kg; T for a controlled cooking Test was computed from the data using the equation below:

$$t = \frac{\text{Total time spent in cooking}}{\text{Total mass of cooked food}}$$

$$t = \frac{t_0 - t_1}{M_{pc} - M_p}$$

For briquette produced, the specific fuel consumptions are calculated thus:

$$S.F.C_{(B)} = \frac{(M_{f0} - M_{f1})(1-x) - 1.5M_c}{M_{pc} - M_p}$$

$$S.F.C_{(B)} = \frac{(0.318 - 0.218)(1-0) - 1.5(0)}{0.862 - 0.612}$$

$$S.F.C_{(B)} = \frac{(0.1)(1) - 0}{0.250}$$

$$S.F.C_{(B)} = \frac{0.1}{0.250}$$

S.F.C(B) = 0.4kg/kg

For kerosene, the specific fuel was obtained through this:

$$S.F.C_{(k)} = \frac{(M_{f0} - M_{f1})(1-x) - 1.5M_c}{M_{pc} - M_p}$$

$$S.F.C_{(k)} = \frac{(0.433 - 0.395)(1-0) - 1.5(0)}{0.862 - 0.612}$$

$$S.F.C_{(k)} = \frac{(0.038)(1) - 0}{0.250}$$

S.F.C(k) = 0.152kg/kg

The cooking time per kg was also calculated using briquettes and kerosene.

Using developed hyacinth briquette for cooking,

$$t_{(B)} = \frac{t_1 - t_0}{m_{pc} - m_p}$$

$$t_{(B)} = \frac{18 - 8}{0.862 - 0.612}$$

$$t_{(B)} = 40\,\text{min}/\,kg$$

Using kerosene for cooking

$$t_{(K)} = \frac{t_1 - t_0}{m_{pc} - m_p}$$

$$t_{(K)} = \frac{21 - 13}{0.862 - 0.612}$$

$$t_{(K)} = 32\,\text{min}/\,kg$$

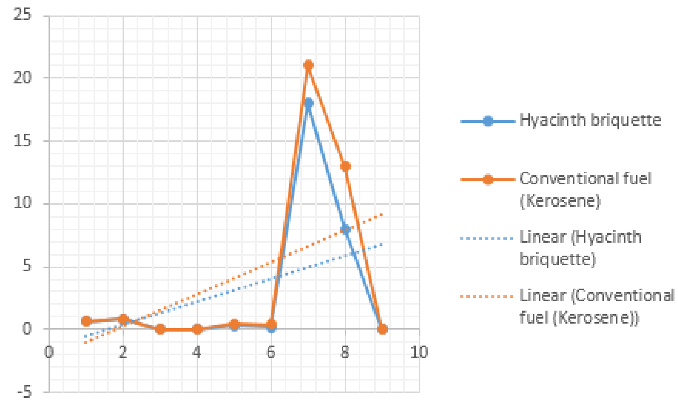

Figure 7. Graph Showing Consumption of Hyacinth briquette and Kerosene controlled Cooking

5. CONCLUSION

The research has demonstrated the possibility of waste conversion to wealth. Moisture content of the hyacinth fuel briquettes was found in the range of 0-18.8 % wb. The lowest moisture content (MC) is 0.8 % wb at ratio 85:15. The low MC is due to the removal of moisture from hyacinth plant as a result of compression during the briquetting process. The ash content decreases as the ratio of clay increases to a minimum of 2.5 % at 85:15 wt.% caused by decrease in the quantity of the water hyacinth blend. This is because sea weeds contain fiber which is not available in clay. The volatile matter of the developed fuel briquettes was found in the range of 76.05 - 90.05%. The volatile matter increases in line with the decreasing moisture content of the samples. Conversely, the highest heating values were recorded as 26.5 MJ/kg. The properties of the developed briquettes were satisfactory. Controlled cooking test was conducted for samples of briquette produced from hyacinth plant with that of Kerosene stove to further test the quality of the solid briquette produced. The analysis of the research showed that bio-briquettes has higher specific fuel consumption (SFC) and cooking time per kg compared with kerosene. This signifies that all things being equal, kerosene would cook faster than the water hyacinth fuel briquette. Though water hyacinth briquette has advantage over kerosene in terms of cost, affordability and availability.

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