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COMPARATIVE ANALYSES OF DENSITIES AND CALORIFIC VALUES OF WOOD AND BRIQUETTES SAMPLES PREPARED AT MODERATE PRESSURE AND AMBIENT TEMPERATURE.

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ABSTRACT : In an effort to provide an affordable firewood alternative to the rural households in Nigeria, a study was carried out to compare some properties of bio briquettes (elephant grass and spear grass) and bio-coal briquettes prepared at moderate pressure, 5MPa and ambient temperature with wood samples. It was found that elephant grass and spear grass have calorific values of 15.98MJ/kg and 16.13MJ/kg, densities of 0.319g/cm^3 and 0.367g/cm^3, durability ratings of 92.42% and 90.54% and moisture contents of 8.00% and 7.9% respectively. Comparing these properties with some wood samples, it was observed that there is a need to enhance the heating values and energy densities of the briquettes in other for them to compete favourably with firewood especially for industrial applications. Proximate analyses shows that the elephant grass and the spear grass used contained calorific values of 14.66MJ/kg and 15.12MJ/kg, moisture content of 9.26% and 10.13% and ash contents of 5.18% and 6.18% respectively.
Keywords: Briquettes, elephant grass, spear grass, firewood.

INTRODUCTION

One of the most challenging tasks facing Nigeria, just like other developing countries, is finding a means of expanding its energy services especially to the rural households and at the same time addressing the health and environmental consequences of over dependence on firewood for cooking.

The biomass resources of Nigeria can be identified as wood, forage, grasses, shrubs, animal wastes, wastes arising from agricultural, municipal, as well as industrial activities, etc. The potential for the use of biomass as energy source in Nigeria is very high because about 80% of Nigerians are rural and semi-urban dwellers and they solely depend on biomass for their energy needs. Particularly, fuel wood accounts for about 90% of the total wood demand from the forest [1] and the demand is still on the increase due to population increase and lack of alternative energy source. The result of this is a gradual depletion of the total forest cover of the country owing to the fact that the deforestation rate is higher than the afforestation efforts in the country. Aware of this situation, government had embarked on tree planting campaign at various levels but to make it succeed, there is a need to provide fuel wood alternative to the rural dwellers. Fuel wood refers to wood used as fuel. It may be available as firewood, sawdust or charcoal. Unfortunately, while pressure is high for fuel wood, most of other biomass in form of agricultural wastes or residues are burnt off during agricultural practice because too many farmers do not have the patience and the resources to control the wastes by landfill method.

By this act, not only that the biomass resource which can be processed into a useful energy source is wasted, it pollutes the environment and reduces soil fertility. Sometimes, if the burning is not controlled, it leads to bushfires thereby causing more havoc. Burning of agricultural wastes on a farmland affects soil below biodiversity, geomorphic process and volatilizes large amount of the nutrients accumulated in the soil including organic matter. Also, black carbon and other particulate matters emitted into the atmosphere during the burning is another thing to worry about. However, conversion of these wastes into fuel briquette is a good opportunity for Nigeria.

Briquetting of biomass process simply means compressing the material to increase its density and to enhance its handling characteristics. Compressing of biomass employing lignin plasticization mechanism has been widely used in many countries. This requires elevated temperature of about 160ºC to 280ºC and pressure between 4 Mpa -60Mpa [2]. Chemically, cohesion takes place between the biomass particles during the process as follows: when the biomass is compressed, the surface of the particles form absorption layers which are no longer free to move and remains in close contact by the help of Van der Waals forces and the lignin component of the biomass. Lignin liquefies at that temperature and pressure, hence acts as gluing agent (binder) in the briquette when cooled [3].

Alternatively, biomass briquette can be prepared at ambient temperature and moderate pressure by compressing the biomass using binder [4,5]. In some methods, the biomass is first carbonized before briquetting [6,7]. Common binders used for this process are starch (from various starchy roots and cereals), molasses, clay and even tree gum, etc. The biomasses used are elephant grass and spear grass. These grasses are among the common and dominating weeds found in abundance in the region especially where farming activities and recurrent fire prevents the natural vegetation from growing up to levels that can shade out weeds. Large quantities of these grasses are burnt off annually either during farming activities or by bush fire.

This paper presents the work on the comparative analyses of some properties of wood samples with different briquette samples prepared at moderate pressure and ambient temperature.

MATERIALS AND METHODS

Elephant grass and spear grass were collected from farmland at Emene, Enugu. Also, five different wood samples used were collected from a local timber market at Enugu. Sub-bituminous coal was sourced from Nigeria Coal Corporation Enugu, Enugu State, Nigeria.

Material Preparation

The grass samples were air-dried, pulverized with electric milling machine to pass through 4mm standard laboratory sieve. The coal sample was air-dried, ground and sieved with 1mm standard laboratory sieve and mixed with 5% of calcium hydroxide ($Ca(OH)_2$) as the desulphurizing agent. Equally, small quantity of each wood sample was air-dried and ground with a manual grinder and kept for calorific value determination while another parts was cut into cubes of dimensions 3cm by 3cm by 3cm for determination of the density.

Preparation of the briquettes

The briquettes were prepared in the laboratory of National Center for Energy Research and Developments, University of Nigeria, Nsukka using a manual hydraulic briquette machine with six cylindrical moulds of 3.9cm in diameter. Each biomass was formed into briquettes using 25% cassava starch as the binder. The pressure was maintained at 5MPa for 5 minutes for each production batch.

Again, another set of briquettes were prepared by first blending the biomass with the sub-bituminous coal in the mass ratio of 1:1 before briquetting using the same quantity of binder and at the same pressure. The choice of the quantity of binder used was based on the optimum amount for production of briquettes of best density (relaxed density), highest stability and calorific value with sawdust [8]. The briquettes were air-dried together with the prepared wood samples for 20 days before the analyses.

Sample characterisation

The briquettes and the wood samples were analyzed. The calorific values of the samples were determined using oxygen bomb calorimeter [9]. The moisture content and the ash content were determined in accordance with ASTM D-3173 Specification [10]

For the density, four briquettes from each batch were randomly picked. Their respective heights and diameters were determined at two different points using digital calipers. From the data obtained, the density after drying (relaxed density) was computed as the ratio of the measured mass to the calculated volume [8]. Equally the density of the wood samples was determined using the same method.

The durability of the briquettes was determined in accordance with the chartered index method [11]. Each briquette sample was allowed to fall from a height of 1:5m onto a metal base for four times. The fraction of the briquette retained (expressed in percentage) was used as index of the briquette breakability. To further examine the breaking strength of the briquettes, their compressive strength was determined using universal crushing machine, 781/2001/23.

Spear grass briquette

Elephant grass briquette

50% Elephant grass and 50% coal

50% Spear grass and 50% coal

RESULTS AND DISSCUSSION

The results of the analyses are shown in Table 1-3.

Table 1: The results of proximate analyses of various raw materials

Sample	Moisture content	Ash content (%)	Volatile matter (%)	Calorific value(MJ/kg)
Coal	7.64	18.27	43.44	20.64
Pennisetum purpureum	9.26	5.18	70.10	14.66
imperata cylindrica	10.13	6.18	69.10	15.12

Table 2: Results of the briquette analyses

Sample	Ash contact (%)	Moisture contact (%)	Compressive strength (N/mm^2)	Durability rating (%)
Briquette of elephant grass	4.35	8.00	3.50	92.42
Briquette of spear grass	6.09	7.90	2.00	90.54
Briquette of elephant grass blended with 50% coal	12.22	7.50	7.41	96.22
Briquette of spear grass blended with 50% coal	13.40	7.80	2.50	94.89

Table 3: Results of the briquette analyses

Sample	Trade name?botanical/ name	Calorific value (MJ/kg)	Density ($glcm^3$)
Briquette of elephant grass (EB)	Elephant grass briquette	15.98	0.319
Briquette of spear grass(SB)	Spear grass briquette	16.13	0.367
Briquette of elephant grass blended with 50% coal (EB_2)	Briquette of elephant grass with 50% coal	18.53	0.490
Briquette of spear grass blended with 50% coal (SB_2)	Briquette of spear grass with 50% coal	18.09	0.449
Silk cotton (SC)	Ceiba pentandra	16.93	0.209
White afara(WA)	Terminalia superba	18.22	0.481
Iroko (IR)	Chlorophora exelsa	18.56	0.679
Gmelina (GM)	Gmelina Arborea	18.60	0.500
Danta mahogany (DM)	Kahya ivorensis/ senegalensis/gradiflora	18.24	0.682

The results show that the calorific values of spear grass and elephant grass briquettes were 16.13MJ/kg and 15.98MJ/kg respectively.

Considering the calorific values of the plant materials before briquetting, it was shown that there is an increase in the calorific value after conversion of the wastes into briquettes. The spear grass and elephant grass had calorific values of 15.12 MJ/kg and 14.66 MJ/kg respectively before briquetting. This increase is partly attributed to the slight difference in the moisture content of the materials; as at the time of the analyses, elephant grass and spear grass had moisture content of 10.13% and 9.26% respectively while their briquettes had moisture contents of 8.00% and 7.9% respectively. Also, the cassava starch as a binder has been reported to have the ability of increasing the calorific value of briquettes [8]. Comparing the heating values of the briquettes with those of selected wood samples, Table 3 shows that their calorific values were relatively lower than those of the wood samples. However, the heating value of the briquettes can be enhanced by blending the wastes with some quantity of desulfurized coal before briquetting especially when the briquettes are to be used for industrial application. Elephant grass blended with coal has calorific value of 18.53MJ/kg which is higher than the calorific value of silk cotton wood, mahogany and white Ofara.

Furthermore, the density of elephant grass briquette was 0.319g/cm^3 and that of spear grass briquette was 0.367g/cm^3. However, these values are less than the densities of the wood samples except silk cotton wood. Though, the briquetting process increased the density of the bulky materials; improved the handling characteristics, but the density was relatively low. This is because of fibrous and the natural springiness of the biomass. After the compression, the materials tend to expand as the pressure is released which negatively affects the density of the briquettes. This observation is a common experience in briquetting biomass using this method [8].

In order to overcome this springiness, high temperature and much more pressure are needed. This entails additional energy and stronger materials to fabricate such briquette machine that can withstand the wear and tear of the operating forces. However, the wide spread use of such briquette process in the rural communities of Nigeria may be restricted by the high cost of machinery and production cost.

Low density biomass briquettes usually have low energy density. Cooking with such briquette in a briquette stove requires frequent tending to the fire i.e. re-feeding the stove with the briquette especially for a cooking that requires a long simmering phase because of its relatively low mass to volume ratio. This may pose unnecessary inconveniences to the users. However, the low energy density of the briquettes is equally enhanced by adding some quantity of coal to the wastes. Elephant grass and spear grass blended with coal in the mass ratio of 1:1 have density of 0.449g/cm^3 and 0.490g/cm^3 respectively which are very close to those of wood samples. Besides, co-combustion of coal and biomass has been reported to be favorable in terms of thermal efficiency and pollutant reduction [12-13].

From the results of compressive strength and durability rating in Table 1, spear grass briquette has compressive strength of 2.00N/mm^2 and durability rating of 90.54% while that of elephant grass briquettes are 3.50N/mm^2 and 92.42% respectively. These results shows that the briquettes produced from this wastes at pressure of 5Mpa using 25% cassava starch as the binder is stable enough to be stored and transported safely without much breakages. The results also revealed that blending the wastes with coal further improved the strength of the briquettes.

Conclusion

The results of the study show that elephant grass and spear grass cleared during farmland preparation or construction work can be economically processed into a good fuel briquette for domestic cooking. Though at moderate pressure and ambient temperature, the resultant briquettes are of lower density and heating value compared to some wood sample, but these properties can be fortified by adding some quantity of desulfurized coal before briquetting.

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