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Briquetting: The Solution to Agro - Waste Management

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Abstract: ***This study investigates the usefulness of Agro - wastes (rice husk, sawdust, and cow dung) as alternative fuel for household energy. Briquettes were also produced as blends in the ratio of 5: 1 with Coal Char and using starch as a binder with the aid of a compressing machine. An improved stove system was designed and fabricated to study combustion properties of these briquettes. Water Boiling Test (WBT) was carried out using the prepared briquettes and compared with firewood. Sawdust Briquettes and Firewood boiled water in 8 minutes while briquettes from other materials boiled water between 18 - 33 minutes. The chemically bound energy of the briquettes was determined by calorimetry. Good quality briquettes were produced from these abundant agro - wastes that would complement crude oil products and could be used for domestic cooking and heating besides keeping the environment clean.***

Keywords: Agro - wastes, Briquettes, Water Boiling Test (WBT), Coal Char, Starch

1. Introduction

The continuous increase in concern over environmental pollution has resulted in greater negative cost values of wastes and hence, has increased their potential as substrates for bio - derived energy [1]. Agro - wastes are biomass materials: organic carbon - based materials that react with oxygen in combustion and natural metabolic process to release heat [2].

The briquetting of agro - residues is of relatively origin in developing countries. The technique was adapted for organic wastes about 50years ago in industrial countries, having been first developed to briquette low - grade coal, but interest waned in the 60s. It has only been revived in the 80s on any significant scale in most developing countries [3]

Briquetting is one of the several densification techniques by which wood residues and other forestry products and agricultural residues are agglomerated to become denser to enable their expanded use in energy production [4]. Briquetting the wastes improve their burning characteristics and also produce fuel pieces that is similar in size and weight. At the same time, problems of dust are reduced during handling, transportation and combustion and handling and storage problems are alleviated. Briquette making exemplifies the potential of appropriate technology. It saves trees and prevents problems like soil erosion and desertification by providing an alternative to burning wood for heating and cooking [5]. It substitutes agricultural waste like hulls, husks, corn stocks, grass, leaves, food and animal garbage for a valuable resource. It improves health by providing a cleaner burning fuel. The briquettes are also designed for holding, growing, and protecting seedlings. It tackles the problem on both ends by giving a better alternative to firewood (40% more efficient, longer burning, and hotter) as well as helping with reforestation. Briquette production is well known in many manufacturing nations of the world.

As of April 1969, there were 638 plants in Japan engaged in the manufacture of sawdust briquettes Known as 'Ogalite', amounting to a production of 0.81megaton per year (MTY) [6, 7]. Aside from sawdust itself, other wood wastes as briquetting materials include bark dust, planer waste, sander dust, and chip dust, all of which are accumulated and available in powder form.

Nigeria has abundant supplies of agro - forested residues whose potentials are yet to be fully tapped for energy generation [8]

Briquettes can be made from bagasse (sugar cane waste). Surplus bagasse presents a disposal problem for many sugar factories [9]. Large acreages of land have been cultivated for cane sugar production and excess tonnes of bagasse have been produced from this cane sugar in Nigeria. This by - product of the sugar industry can be utilize to produce all the energy required for the manufacturing of sugar and other end uses such as lime - burning, brick burning and cement kiln.

Saw dust is a renewable energy source of great potential value in Nigeria. It is waste material from all types of primary and secondary wood processing [10]. Between 1983 - 1987 the average annual output of forest wood processed into log splits and plywood stood at $4.39\times10^6 m^3$/annum [10]. It is generally estimated that for every 100 metric tones of lumber produced, about 42 tonnes of saw dust are generated. Nigeria is therefore estimated to generate between 1.91×10^6 - 1.25×10^6 tonnes of saw dust annually. Presently this large quantity of saw dust is grossly under utilized and constitutes a real problem in most wood processing centers.

Apart from the environmental hazard posed by these wastes, investigations show that Millers in one timber in Enugu state Nigeria spent between N16, 000 - N24, 000 monthly to cart away the waste products from the location of the mill to designated spot where they are burnt uncontrollably. In Nigeria, the saw dust stove, using saw dust is the last resort

during periods of scarcity of domestic fuel such as kerosene and Liquefied Petroleum Gas (LPG).

Rice husk is another renewable source available in large quantity in Nigeria. In 1994, about 3.62×10^6 tonnes of rice residue were produced in Nigeria [10]. The utilization of rice husks as an energy source in Nigeria is very insignificant. In all the rice producing communities across the nation, mountains of these are seen decorating the sites constituting serious environmental problems. It is a common phenomenon all over the world where often times piles of this waste material are stacked for disposal or some are thrown and burnt on road sides to reduced its volume [10, 11]. If this waste can be converted into fuel for domestic cooking, several households can benefit, and more money saving for the country can be achieved. Studies on the pyrolysis of rice husks utilization has its greatest potential as a substitute fuel in rice milling operating and in a domestic energy use. Pyrolysis of rice husks yields combustible char, oil and gas products. The char can be briquetted and utilized as both domestic and industrial solid fuel with a heating value of 3, 930kcal/kg on a dry basis. As a smokeless fuel which is easy to transport, rice husks char can serve as replacement for firewood. It has also been noted that with some modification of the furnace, it can replace the fuel oil used in cement kilns. From an environmental point of view, rice husks char has very low Sulphur content therefore, causing no Sulphur dioxide pollution [10].

2. Materials and Methods

2.1 Materials

Sawdust was collected from sawmill industry at Muda Lawal market in Bauchi town; groundnut shell was collected from a nearby Agricultural Institution to Abubakar Tafawa Balewa University (ATBU) Bauchi, sugar cane wastes (bagasse) was collected from sugar cane processing spot in Bauchi metropolis, rice husk was collected from the rice millers at Yelwa Tudu in Bauchi town, and cassava starch was purchased from local market. A cubic steel mould was fabricated at Center for Industrial Studies (CIS) of (ATBU) Bauchi. Also with the mould was a cubic wooden block carved to fit into the mould for compression. Ele - Budenberg compressing machine of Model El: 31 - 347010 was used to compact the materials.

2.2 Methods

2.2.1 Material Preparation

Materials for the briquettes making were sorted to remove impurities or foreign bodies and reduced to smaller sizes through hammer milling. The materials were then sieved to obtained overall uniform particle size of 2000µm (2mm mesh). These materials were mixed with starch as a binder in the ratio 5: 1 and compressed in a cubic mould to a pressure of $40kN/m^2$ to form the briquettes with the aid of a compressing machine. The cubic - shaped briquettes obtained were sun - dried for one week before the commencement of the Water Boiling Test (WTB).

2.2.2 Water Boiling Tests

What is interesting concerning the energy content of a briquette is how much of the energy in the briquette that can be used. The useful energy is the energy transferred into the pot that is used while cooking. This test is performed on each briquette and on firewood for good comparison. The Water Boiling Test was used for comparing:

- The briquettes with each other
- The briquettes with firewood

2.2.3 Apparatus for water boiling test.

- A standard pot with a lid
- A pyrometer for measuring flame temperature
- A digital balance for measuring the weight of briquette, water and pot
- A stopwatch to take the time from the start to the boiling point of water
- A Thermometer for measuring the ambient and boiling water temperature.

2.3 Procedure

1.5kg of each sample of the produced briquettes was weighed and equivalent weight of firewood was also weighed for each weighed briquettes. Empty pot was weighed and filled with 3liters of water. The pot containing the water was weighed and the initial temperature of the water was estimated. The briquettes were placed inside the stove and small amount of kerosene was poured on top of the briquettes. The pot was mounted on the stove and was covered with its lid that had a hole for insertion of thermometer. The briquettes were ignited on top with a single match and the water was brought to boiling while temperatures reading were taken at 5minutes interval.

3. Results and Discussion

Table 1: Proximate Analysis of the Briquette fuels.

Sample	Rice Husk Briquettes (RHB)	Groundnut Shell Briquettes (GSB)	Bagasse Briquettes (BB)	Sawdust Briquettes (SDB)
% Moisture Content	7.71	8.59	4.14	4.89
% Volatile Matter	67.92	63.33	65.66	75.23
% Ash	20.04	17.45	16.82	5.51
% Fixed Carbon	4.33	10.63	13.38	14.37
Calorific Value (cal/g)	3406.3	3882.6	3612.8	4070.4

The produced briquettes were strong after drying except for the minor cracks on the surface of most of the briquettes.

These cracks could be as a result of the applied force up and below the mould without a corresponding application at the sides during densification.

The Water Boiling Tests revealed that sawdust briquettes boiled water in 12 minutes, firewood boiled water in 15minutes. Other briquettes: bagasse, rice husks, and groundnut shells boiled water in 26, 28, 32minutes respectively. Table2 is the summary of the various temperatures and times it took each briquette and firewood to boiled 3litres of water. Figure1 also showed which briquette was fastest in boiling 3litres of water. Sawdust briquettes being fastest implied that it had better properties as fuel and groundnut shell the least as it boiled 3liters of water in 32minutes. The flame given out by groundnut shell briquettes slowed down until a steady state was attained due to poor feedback. This could be due to the difference in densities of the biomass fuels as well as the chemical composition of the fuels since rate of combustion depends on it.

It was also observed that firewood burnt with more smoke than the briquettes from all the Agro - waste materials and their flames were luminous for firewood and less luminous with intense glow for briquettes. Briquettes were also observed to maintain their shapes as they burnt compared to firewood.

Table 2: Time and Temperature of Boiling of Briquettes and Firewood. Figures in parentheses are the time it takes for boiling

Time (minutes)	SDB (^{0}C)	GSB (^{0}C)	BB (^{0}C)	RHB (^{0}C)	FW (^{0}C)
0	27	28	28	28	27
5	44	32	32	36	40
10	85	43	38	55	90
15	98	57	55	71	98
20	(12)	68	78	82	(15)
25		77	93	94	
30		83	98	98	
35		98	(26)	(28)	
40		(32)			

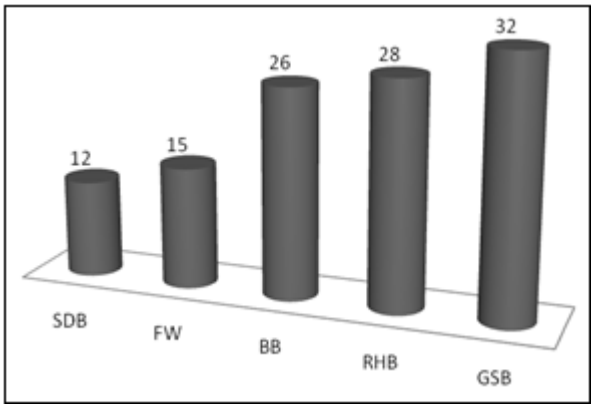

Figure 1: Plot of Time until Boiling using Briquettes and Firewood

4. Conclusion

Agro - wastes or residues can be converted to briquettes to provide process heat for a variety of end uses. Briquetting of Agro - wastes makes them cleaner and easier to transport. Conversion of wastes to briquettes is one promising strategy to curtail the dumping of agricultural wastes in many cities and rural areas, to improve energy efficiency, reduce pollution and desertification. Utilization of Agro - wastes as fuel entails replacement of firewood and hence improves the living condition of the rural women and children, who spend most of their time collecting fuel wood instead of engaging in other income generating activities or attending school. Briquettes represent an alternative source of cooking energy and viable opportunities for income generation while at the same time contribute to environmental preservation by keeping it clean.

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****Tribute to the Lead Author; of blessed memory: RIP Naron**.