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BRIQUETTES MAKING FROM HOUSEHOLD WASTES AND BANANA FIBER AS AN ALTERNATIVE ENERGY FOR COOKING (CASE STUDY: NGOMA DISTRICT, RWANDA)

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ABSTRACT

This research focuses on developing and evaluating the performance of low cost, low technology banana fiber and household waste based fuel briquettes as an alternative to the common use of wood fuels (charcoal and firewood) for domestic cooking applications in Ngoma district. The ever-rising high price of kerosene and cooking gas influence Ngoma district's populations to use firewood and charcoal as cooking fuel, though the use of trees on making charcoals has been a major factor that contributes to the climate change. Thousands of tons of trees have been cut in Ngoma district and the trend is still going on, despite the efforts made by the government to stop people from this long rooted behavior of cutting trees for charcoal making. Banana plantation in Ngoma district occupies 80% of agriculture activities and around 65% of all arable land in the District is occupied by banana plantation. Banana is by far the dominant food crop in Ngoma district in terms of value of production consumption and socio-economic value, it is the most grown crop in Ngoma district on 23,000 hectares, though is the most consumed food across the district however after being pick up banana fiber still unused on the other hand banana fiber can be used as another source of making charcoal without causing hazards in the environment. In Ngoma district household waste are collected in Kibungo landfill and waste is composted in mixed fields mainly food residues from sweet potatoes, banana and cassava are habitually generated in a huge amount but most of waste are not recycled which causes environmental problems. Banana fiber and household wastes can save the district from becoming dry by being used in briquettes production, the mixer of household waste and banana fiber collected are sun dried and then mixed with water and the natural binders which include; sweet potato stems sap, banana stem pulp and cassava flour has been added to the mixer and finally by hands they are compressed into the mold to get proper briquette shapes. During this research, both desktop reviews of earlier studies and laboratory investigations of the developed food residue based fuel briquettes have been considered. Carbonized sweet potato, banana peels, cassava peelings (household waste) and banana fiber were mixed in different proportions with either sweet potato or banana stem pulp (1 or 2kgs) and later densified using a hand operated molder to develop the food residue based briquettes. The drop test method was used to determine the resilience of the produced briquettes to disintegrating forces in particular during transportation and storage. Given the amount of wastes from individual households and the amount of banana pseudo stems generated annually in Ngoma district and the amount of heating value these contain, fuel briquettes produced can be an alternative for the use of charcoal and firewood which will aid in securing a low cost, low medium technology in cooking applications.

KEYWORDS: Briquettes, banana fiber, household wastes, natural binders.

INTRODUCTION

Wood is a primary source of fuel in Rwanda. The prevalence of this wood-fueled cooking and heating is causing major environmental problems, such as deforestation and pollution. Briquettes made from banana fiber and household waste can be alternative energy sources of the use of fuel wood in cooking application.

Banana is among the major commodities in Rwanda used both as cash and food crop. The banana crop was introduced in 1971 in Rwanda and at the moment Rwanda is among the highest consumption of bananas in the Eastern Africa Region and ranks 2nd in banana consumption about 144 kg person per year after Uganda with 223 kg per person per year. The bananas are grown on165 000 ha and occupy 23% of arable land in the country.

Banana has carried major importance to Rwanda’s dietary for a long time now. It is one of highly consumed staple crops in the country by its multipurpose uses in culinary and wine brewing; Currently, there are more than 60 banana varieties in farers’ fields, and 117 in RAB field collection, the commonly grown varieties being; Injagi, FHIA 17 and FHIA 25, Gros

Michel, and Poyo. Others are Mpologoma, Icyerwa, Poyo, Kamaramasenge, Barabeshya, Nkazikamwa, and Intokatoke.

Rwanda Agriculture and Animal Resources Development Board (RAB) estimates that there are about 1.4 million smallholder banana growers out of about 8 million people who rely on agriculture in the country concentrated mainly in five major banana farming districts, namely; Ngoma, Kirehe, Gatsibo, Kayonza and Rwamagana.

The proportions of banana types are: 45% beer type; 45% cooking type; and 10% dessert type. Banana production in Rwanda averages at about 2.5 million metric tons per year. The crop is grown on about 165,000 ha and occupies 23% of all arable land in the country (Seasonal Agricultural Survey reports (SAS), NISR). Banana plantation in Ngoma district occupies 80% of agriculture activities and around 65% of all arable land in District is occupied by banana plantation.

Figure 1.1: Banana plantation in Rukira sector (Ngoma district).

In Ngoma district household waste are collected in Kibungo landfill and waste is composted in mixed fields mainly food residues from sweet potatoes, banana and cassava are habitually generated in a huge amount but most of waste are not recycled which causes environmental problems.

Energy is regarded a key prerequisite for the development of the national economy and essential to the development of industries and businesses, as well as to the delivery of high-quality services from social institutions such as health facilities, schools and administrative, the transformation and use of energy must pursue the objective of a sustainable, competitive and secure energy supply.

Biomass is one of the sources for energy production with the greatest growth potential in the coming years and can be easily obtained from agricultural production, which generates large amounts of waste.

Biomass accounts for 85% of all energy consumed. The subsector covers bio-products. Bio-products are fuels developed from biological materials, split into those that are wood-based, such as wood and charcoal, and biogas, which are derived from waste matter. Biomass is largely consumed for cooking, with wood used by rural households and charcoal by urban households.

The biomass subsector is being informed by the development of the Biomass Energy Strategy. This analyses supply and demand of biomass and sets out a strategy to reduce reliance on wood and charcoal.

Under the National strategy for transformation, the sector objective is to halve the number of households using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass through promotion of most energy efficient technologies.

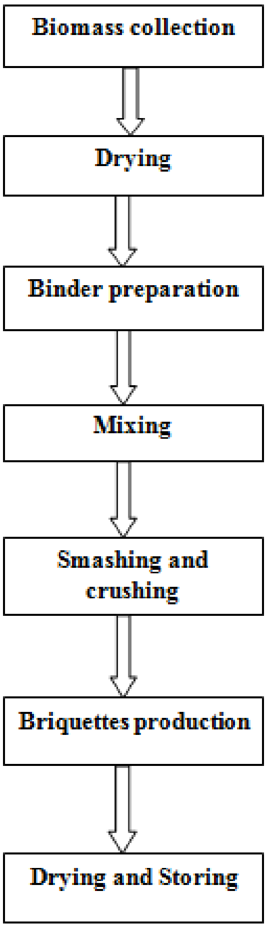
About 95% of households rely either on firewood (about 82%) or charcoal (about 13%) as main sources of energy for cooking. However, firewood is three times more likely to be used in rural areas (about 93%) than in urban areas (about 31%), while charcoal is 21 times more likely to be used in urban areas (about 63%) than in rural areas (about 3%). To alleviate the intense consumption of biomass energy, the Government of Rwanda (GoR) is promoting the installation of energy-saving stoves in households. However, only 35% of private households currently have these energy-saving stoves.

The use of agricultural and agro-industrial wastes as biomass fuel for power generation is being increasingly studied and could be an alternative solution to the problems related to them. These wastes can be availed as briquettes and pellets for use in combustion and gasification processes in power generation; in the briquetting process, particles of solid materials are pressed to form blocks with defined shape and dimensions. Briquettes produced from this waste at low cost are an excellent source to produce cheap energy following an environmentally correct way and they are, in many cases, ideal for replacing fossil fuels in use today, with significant economic and environmental advantages.

MATERIALS AND DISCUSSION

The trial to produce briquettes from household waste and banana was carried out by using direct extrusion or high pressure briquette production.

The following steps have been carried out in order to produce a low cost, low technology food residue based fuel briquettes in domestic cooking applications.



Feedstock/Raw Material Preparation

3.1 Biomass collection

Firstly, biomass was collected, Household wastes was collected from Ngoma landfill in Kibungo sector, banana fiber also was collected from SHE a company which fabricate pads from banana fiber and the natural binder has been also collected to carry out the experiment for briquette making.

Figure 3.1: Fresh Household waste.

3.2 Drying biomass

Household wastes are dried by solar ray to reduce its moisture content and it takes about two to three days for those wastes to be dried, the experiment was 10kgs of fresh wastes and it gives around 6 Kgs of dry wastes.

Figure 3.2: Sun dried household waste.

After drying, the selection of dried materials was done before crashing dried wastes into small particles; in order to separate them with metals and other unwanted materials. By hand dried wastes were separated from metals and other unwanted scraps, and for removing very small metals magnetic has been used.

3.3 Briquetting trial

The material was tested if it could make a good briquette by soaking it in water, and a handful of wet material was grabbed and pressed into the hands. The material formed into a ball which retained its shape and did not fall apart and this demonstrated that this type of material can form a good solid briquette when mixed with a binder that increases the binding capacity of the mixture

3.4 Binder preparation

Briquette binder plays a key role in the process of briquette production. The quality and performance of briquette also depend on the quality of briquette binder. Different types of briquette need different briquette binder. Binder used in briquetting process can be divided into inorganic binder, organic binder and compound binder.

A binder as it is used for strengthening the briquettes; the carbonized char powder can be mixed with different binders such as commercial starch, rice powder, rice starch (rice boiled water) and other cost effective materials like clay soil and mixed in different proportions and shaped with the help of briquetting machine. (www.researchgate.net)

For this experiment natural binders which include; - sweet potato stems sap, banana stem pulp and cassava flour has been used.

Figure 3.4: Sweet potato stems, Banana stem and Cassava flour.

3.5 Mixing preparation and smashing the dried wastes into powder

Prepared wastes and the binder prepared were mixed thoroughly until a homogenous mixture was obtained and water was added to give an insert that can agglomerate.

Smashing the dried wastes into powder was done by the dried wastes mixed with water and put into compressing machine.

Figure 3.5: Mixed dried waste.

3.6 Compressing and Extrusion processes

The biomass mixture was hand fed into the molder (mould of 6cm in diameter by 9cm in height was made from mild steel by milling to the required diameter and properly polished to achieve smooth internal surfaces. In the mould, the briquette mixture was in contact with a piston-like compressive metal with a plunger that was 12cm long. The force that was applied to compact and densified the produced briquettes was that of a human arm.

The briquettes were removed from the mould by using the long lever arm to jack up the briquettes, after the hydraulic jack had been released. The briquettes were dried again at this time, for about two sunny days, so that the raw starch will cure and also to reduce the moisture content. They were then removed from sun dried and stored.

RESULTS AND DISCUSSION

Physical Properties

Physical properties of the raw material and developed briquettes was evaluated in the below experiments.

4.1. Evaluating the briquette properties

Proximate analysis was applied when evaluating the produced briquettes.

The purpose of the proximate analysis is to indicate the percentage by weight of the Fixed Carbon (FC), Volatile matter (VM), Ash and Moisture Content in the briquettes.

i) Measurement of Moisture content

Moisture content is important to charcoal quality.

The following procedure was used to determine the moisture content.

1. The ceramic weighing dishes were pre-dried by placing then in a drying oven at 105 ± 3^0C for four hours. The pre-dried dish was then weighed to the nearest 0.1mg, this weight was recorded.
2. An approximate amount from the briquette sample was then weighed out to the nearest 0.1mg into the weighing dish.
3. The briquette sample was then placed in a conventional oven at 105 ± 3^0C for a minimum of four hours. The sample was then removed from the oven to cool to room temperature in desiccators. The dish containing the oven dried sample was weighed and the weight recorded.
4. The sample was placed back into the conventional oven at 105 ± 3^0C and dried to constant weight. Constant weight is defined as ± 0.1 percent change in weight percent solids upon one hour of re-heating the sample. The weight was then recorded.

CALCULATIONS

$$\%\text{Total solids} = \left\{\frac{\text{Weight of dry pan and dry sample - Weight of dry pan}}{\text{Weight of sample as received}}\right\} x100$$

$$\%\ \text{Moisture} = (100 - \%\text{Total solids})$$

ii) Measurement of Volatile Matter

The following procedure was used to determine the volatile matter:

- The weight of the container was determined
- The weight of the container and the briquette was determined.
- The briquette was put in the oven and heated to 700 ^{0}C and then held for 4 hours.
- The briquette was then removed and weighed.

The volatile matter content was calculated from the following expression:

$$\%\text{Volatile matter} = \left[100 - 100\,x\left(\frac{\text{Weight of container and fuel after heating - Weight of container}}{\text{Weight of briquette alone}}\right)\right]$$

iii) Measurement of calorific value

The calorific or heating value is an important indicator of the quality of the pressed fuel briquettes. It measures the energy content of the briquettes. It is defined as the amount of heat evolved when a pressed fuel briquette is completely burnt and the combustion products are cooled. And the Gross Calorific Value, shortened as GCV, refers to the calorific value with the condensation of water in the latent heat, also known as higher heating value. Whereas during combustion, the heat of condensation of the water contained in the fuel and formed during combustion will become unavailable because the vaporization of the water. And then, the useful heating value is gained after the heat of condensation of the water being subtracted from the gross calorific value, which is referred as the Net Heating Value or lower heating value.

Figure 3.6: Produced briquettes.

CONCLUSIONS

In this study, household wastes and banana fiber which treated as unwanted waste in Ngoma district was densified into briquettes by using natural binder namely cassava flour, banana stem and sweet potato stem pulp at room temperature using a molder which is compressed by the strength of a human arm.

Most of rural areas in Rwanda food residues from homes are simply put to waste; especially in Ngoma district there no appropriate strategy of collecting household waste and do recycling for environmental purpose and for fighting against cooking energy crisis.

Given the amount of wastes from individual households and the amount of banana pseudo stems generated in Ngoma district annually and the amount of heating value these contain, a shift from the use of charcoal and firewood use to fuel briquettes made from household wastes and banana fiber will aid in securing a low cost, low medium technology in cooking applications.

Since the quality of any fuel briquette depends on its ability to provide sufficient heat at the necessary time, to ignite easily without any danger, generate less ash as this will constitute nuisance during cooking, the research results prove that developed briquettes from those used biomass materials can be used as alternative cooking fuel.

Generally, the briquettes produced has the average heating value ranged from 13.6 – 25.7 MJ/kg and had good durability characteristics in terms of drop strength (44.1%-80.9%) and particle density (281.6kg/m3 - 426.3 kg/m3).

Briquetting process is good technology not only for environment protection but also for cooking applications.

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