THE POTENTIALS OF SAWDUST AND RICE HUSK AS SOURCE OF ENERGY FOR ELECTRICITY GENERATION IN EBONYI SOUTH, EBONYI STATE NIGERIA

ABSTRACT

Aim: The study aims to evaluate experimentally the calorific value and the chemical composition of the sample (sawdust and rice husk).

Methodology: This study was based on an experimental analysis to determine the potential of sawdust and rice husk (a combined sample) as a source of energy generation. Samples were collected from seven different areas, considering one sawmill and two rice mills in each area. The samples collected were mixed with various mass ratios, dried in an oven, and then sieved to obtain homogeneous sizes. The samples were tested for chemical composition using ultimate and proximate analysis, while the caloric values were tested using a bomb calorimeter.

Place and duration: Ebonyi South region of Ebonyi State, Nigeria, between October 2022 and June 2023

Study design: With respect to potentiality and availability, the quantity of the combined sample generated per year was obtained from mill personnel. The data collected were carefully computed and analyzed to reflect the stated aim.

Results: The results showed that the combined sample contains 36.20 MJ/kg calorific value, 3.13% carbon, 38.31% hydrogen, 6.65% sulfur, 0.11 carbon monoxide, 45.11% oxygen, and 50.96% fixed carbon. Therefore, at 80% utilization per year, 7949.69 MWh of electricity would be generated using 10334.60 tons of the sample (sawdust and rice husk) on an average scale.

Conclusion: The study carried out has shown that the Ebonyi South region of Nigeria has the required quantity of sawdust and rice husk that can be used to generate electricity if properly harnessed. There is no doubt that the study has raised awareness about the benefits of the proper harnessing of agricultural waste to reduce the emission of dangerous gases into the environment.

Keywords: Rice husk, sawdust, calorific value, biomass, electrical energy

1. INTRODUCTION

Nigeria as a nation has been experiencing energy crisis due to its dependence on fossil fuels. Supply of fossil fuels at a subsidized rate is now an unattainable challenge for the government. This has led to an increase in their prices, which directly affected the cost of electricity consumption. Despite high electricity tariff Nigerians still experience power outage of about 14 – 20hrs or total blackout every day. Realizing this, many organizations along with the Nigerian government is working round the clock to bring renewable energy in competitive terms, in order to meet energy demand.

The Nigerian government in her efforts to end the energy crisis initiated the installation of solar energy in some communities across the country. But mainly for its inefficiency and high cost, the program is not having much success in a broader aspect.

Ebonyi south case is not different as the majority of its communities including Akanu Ibiam Federal Polytechnic have been in total blackout for more than five years. This region is an Agro-economic with the potential of producing major and minor crops in large quantities. As a result of this, a bulk of the agricultural waste is available, but not utilized. The waste can be properly utilized to meet the energy demand of the region while mitigating climate change and its impact.

Biomass energy is abundant in Ebonyi state. However, just like any other state in Nigeria, the biomass resources are mostly utilized as wood fuels for domestic purpose and in local industries. It is common knowledge that the associated harmful environmental, health and social effects with the use of traditional biomass (wood fuel and fossil fuels have enhanced the globally growing interest in the search for an alternate cleaner source of energy). Nigeria depends heavily on wood fuel as a source of fuel for most of her domestic energy needs, contributing over 50% of the primary energy supply with crude oil and hydro-power constituting the remainder [1], [2].

Biogas generation is commonly obtained through anaerobic digestion of organic waste under certain conditions. Biogas technology has been proven to be a practical and promising technology which has the potentials of generating clean energy on a large scale. The use of biomass materials to generate biogas on a large scale is yet to be available in the state. Rice husk and saw dust are the most abundant source of waste in Ebonyi south. The figure 1 shows a graphic picture of rice husk mill in Edda rice mill. These huge wastes are currently not being utilized properly in term of power generation.

Observation shows that these mills are being savage locally for cooking fuels at a very low scale. The presence of these hills of rice husk & sawdust makes solid waste deposits common in this part of the state. It is more as these waste are poorly managed. There is no waste to energy industry in the state. Also, waste management in Nigeria is mostly done in a very crude and primitive manner [3].

Figure 1. Graphic picture of rice husk mill in Edda rice mill.

The utilization of renewable energy in Ebonyi State is still done either at a very low scale or by primitive methods. Researchers have established recently the potentials of the rice husk and sawdust for generating biogas for domestic and industrial applications, and even for export if expanded on a large scale [4], [5]. Utilization of these waste for biogas production will help to reduce the over-reliance on wood fuel and fossil fuel for domestic energy needs, leading to a reduction in environmental pollution greenhouse gas emission and consequently climate change. Electric energy can be generated from rice husk (RH) & sawdust through various methods. In the case of this study, gasification method would be adopted based on its multi-benefits and most environmentally friendly. The system is so designed in such a greener way to ensure absolute zero-emission.

1.1 Energy generation

In order to generate the electrical energy, figure 2 shows the schematic diagram of the system which consists of a boiler from being RH & Sawdust chamber and producing superheated steam. The high-pressure steam is entered on the turbine from the boiler and low-pressure steam leaves the turbine to the condenser. The condenser is then linked to the tank, along with cooling tower to allow for energy losses. The mixture is then pumped to the boiler from the tank to complete the cycle. Thus in order to meet the energy demand using RH & Sawdust as an energy source / the process stated above should be strictly followed.

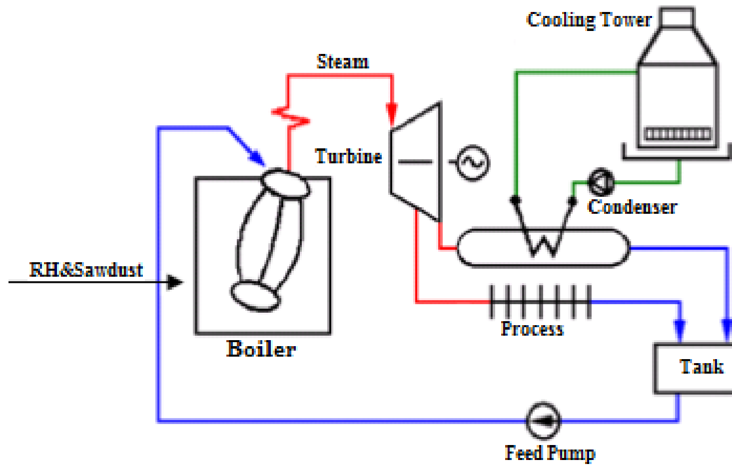

Figure 2. Schematic diagram of electrical energy generation

Njogu et al [6] noted that rice husk surrounds the paddy grain and while milling, about 78% of the weight is produced as rice, broken rice and bran, and the rest 22% of the weight of paddy is produced as a husk. Kapur et al [7] pointed out that the most important source of energy for electricity generation is rice husk. Several types of research on rice husk have been done to convert into an energy source [8, 9]. Although carbon dioxide (CO_2) is produced by combustion of biomass like rice husk, the carbon produced is absorbed by the plants by the process of photosynthesis. Hence, the combustion of biomass and biogas reduces the global warming effect since CO_2 met emission becomes zero, while combustion of conventional fossil fuels adds an extra amount of CO_2 causing global warming [10].

Direct use of rice husks as an energy source is hampered by low density and low heat value. It is thus imperative to convert it into combustible gas. Rice husks contain 75% organic volatile matter as 25% ash [11]. Rice husks can be converted thermally, biologically or chemically to other usable forms of energy like methane gas, liquid fuels (ethanol) and syngas/process gas.

Thermal gasification provides one of the most promising approaches of waste to energy conversions for rice husk. It makes use of heat in oxygen-deficient environments to transform biomass into a combustible gas. The combustible gas can be used to power internal combustion engines coupled with electricity generators for electricity generation which can be used in off-grid rural electrification in areas with huge annual biomass yield [11, 12]. In India, a rice husk power system was installed. The system operates such that sack loads of rice husk or other biomass are poured into gasifier hopper every 30 – 45mins. The biomass then burns in a restricted supply of air to produce a gas. The gas passes through different filters for cleaning, after which the gas is used as the fuel that drives the electric generator, electricity is then produced and distributed to customers, [13].

1.2 Problem statement/

An increase in population, residences, and industrial activities is directly proportional to an increase in energy demand. Constant power outages have a major impact on economic growth and human capital development. Hence, the quest to improve the economy of a nation and human development must be proportional to the increase in electricity supply. Therefore, there is a need to establish accessible and affordable electrical energy with an environmentally friendly impact. Ebonyi South is the second-highest agro-economic region in Ebonyi State, with a bulk of agricultural by-product disposal causing environmental pollution because of the burning of such residues in an open place. These residues have the potential to produce electrical energy and other social benefits if properly harnessed.

An attempt has been made by many researchers to harness agricultural by-products for different economic uses. It is important to note here that only a few researchers have considered the utilization of rice husk for power generation, with about a 75% success rate achieved. The literature reviewed showed that all the studies were carried out mostly in developed countries and some parts of African nations, excluding Nigeria. Also, there is no considerable attempt made to utilize the rice husk and sawdust combination as a potential source for electrical energy generation. Based on these findings, there is a need to carry out this kind of research considering the species and rice production capacity in Nigeria with reference to the southern region of Ebony State.

The main objective is to evaluate experimentally the potentials of sawdust and rice husk as a source of energy for electricity generation in Southern region of Ebonyi State, Nigeria.

2. MATERIALS AND METHODS

The main aim of the study is to evaluate experimental the potential of sawdust and rice husk as a viable source of electrical energy considering it availability and technical analysis.

2.1 The Description of study area

Ebonyi South zone is our area of interest because it is one of the major agricultural zones with the largest number of sawmills in Ebonyi State. Ebonyi South comprises Afikpo North, Afikpo South, Ivo, Ohaozara and Onicha Local Government Areas. It is bounded to the North by Ebonyi Central, to the East by Cross River State, to the West by Enugu State and to the South by Abia State. It has an area of 1721km^{2}and a population of about 1085600persons. About 70% of its populaces are potential farmers. The climate is characterized by bimodal rainfall with peaks in July and September every year. The main crops produced are rice, yam, maize, groundnut, palm oil, sugar cane, etc. The area also has a tourist site. Apart from farming, people in the Ebonyi South also engage in other occupations like teaching, trading, and manufacturing. The agricultural predominant nature of the area contributed to its selection for the study. However, each L.G.A has sawdust and rice husk potential that could be used as fuel for power generation to overcome the shortages of electrical energy without completely relying on hydro-power. The five L.G. Areas in Ebonyi South produced more than 200,000tons of rice per year.

The areas of interest are Afikpo, Akpoha, Amaseri, Edda, Okposi, Uburu, Akaeze, Ishiagu, Onicha, Abaomega. In each of the area, one sawmill and two rice mills are selected for the study.

To achieve the stated objectives of the study, the following procedures would be followed.

- Collection of the samples (sawdust& RH) from selected Rice & saw mills within Ebonyi south.
- Drying of the samples in an oven
- Sieving the mixture to obtain homogeneous sizes.
- Mixing of the sample with various mass ratios.
- Testing for characteristics of the samples with proximate and ultimate analysis.
- Test for the caloric values of the samples using a Bomb calorimeter.
- Development of the electrical energy model

2.2 Sample availability

The sample elements considered has unique characteristics that made it possible to be used to generate energy. The quantity of the sawdust and rice husk produced per year is shown in table 1

Table 1: The quantity of the sawdust and rice husk produced per annual

Year	Sawdust in 1000(tons)	Rice husk in 1000(tons)	Total in 1000(tons)
2018	5324.4	5026.2	10350.60
2019	4525.1	5805.5	10330.60
2020	4525.1	5805.5	10330.60
2021	4525.1	5805.5	10330.60
2022	4525.1	5805.5	10330.60
Average			**10334.60**

The availability of sawdust and rice husk can be evaluated using the following models;

$P_R = P_d \times (H_P/P_d) \times (A_R\%)$ (1) [Rice husk Production]

$P_{SD} = T_p \times (SD_P/T_P) \times (A_{SD}\%)$ (2) [Sawdust Production]

where P_R = Rice husk production in tons

P_d = Paddy production

H_P/P_d = Ratio of husk to paddy

$A_R\%$ = Percentage of Rice husk availability

P_{SD} = Sawdust production in tons

T_P = Timber production

SD_P/T_P = Ratio of sawdust to timber

$A_{SD}\%$ = Percentage of sawdust availability

3. EXPERIMENTAL PROCEDURE

3.1 Determination of ash content

The residue left after burning of sample is known as ash.
It is generally composed of inorganic substances.

3.1.1 Procedure

2 gm of sample is weighed in a crucible (w1). Sample is spread with a brush. Then the crucible is kept inside a muffle furnace and the temperature is gradually raised upto 800°C. At 800°C the temperature is kept constant and the incineration of sample is completed by heating the sample for an hour at that temperature. After incineration, the crucible is allowed to cool and transferred to a desiccator. After cooling the crucible is re-weighed (W_2). Deduction of w1 (weight of the crucible) from W2 (weight of the crucible + ash) gives the amount of ash in the sample. Ash content is expressed in per cent of sample.

Ash content = $\frac{W_2 - W_1}{weight\ of\ sample} x100\%$

3.2 Determination of volatile matter

The volatile matter, sometimes called volatiles consists mainly of the gases and water and tarry vapours evolved from sample when it is heated at high temperature.

To determine it, 2 gm of sample is taken in a silica crucible with a porous silica cover. The weight of the silica crucible and sample is w_1. The cover is used to avoid oxidation. The sample is then heated for 7 minutes at a constant temperature of 825°C inside a furnace. After heating the crucible is cooled and transferred to a desiccator. After few minutes the silica crucible is re-weighed (W_2). The difference between w_1 and w_2 gives the amount of apparent volatile matter in the sample. The actual volatile matter is obtained after deducting the moisture content of the sample. Volatile matter content is expressed in per cent of sample

Apparent volatile matter = $\frac{W_2 - W_1}{weight\ of\ sample} x100\%$

Actual volatile mater = Apparent volatile matter – moisture content

3.3 Fixed carbon

The fixed carbon represents the carbon content in a sample that has not combined with any other element (in a free state).l. The amount of fixed carbon is computed by subtracting the sum of the percentage of moisture, volatile matter and ash from hundred.

Fixed carbon% = 100 - (moisture% + ash% + volatile matter %)

3.4 Moisture Content (AOAC 1990)

Procedure

A petri-dish was washed and dried in the oven

- Approximately 1-2g of the sample was weighed into petri dish
- The weight of the petri dish and sample was noted before drying
- The petridish and sample were put in the oven and heated at 105^0c for 2hr the result noted and heated another 1hr until a steady result is obtained and the weight was noted
- The drying procedure was continued until a constant weight was obtained

% moisture content = $\frac{W_1 - W_2}{weight\ of\ sample} x100$

Where w_1 = weight of petridish and sample before drying

W_2 weigh of petridish and sample after drying.

3.5 Hardness

Carbon hardness was determined according to ASTM (2002) method. This involves measuring 2 g of carbon sample in a standard sieve no 40. The sieve was shaken for 1h using mechanical shaker (Millano Italia-type) at 160 strokes per minutes with four steel balls (6.0 mm diameter each) inside the sieve. The amount of activated carbon retained in the sieve after 1h was expressed in percent.

3.6 Bulk Density

Bulk density was determined according to the method of Okaka and Potter (1976). Five-gram quantity of each activated carbon was weighed in a graduated glass cylinder and tap until a constant volume is noted. The density was calculated in g/cm^3 .

4. RESULTS AND DISCUSSION

It was observed that one mound of paddy (45kg) produces 9.20kg of husk, while 100kg of timber produces 20.71kg of sawdust; therefore, 0.20 and 0.21 represent the respective technical ratios. Since sawdust and rice husk cannot be utilized by the mills, the availability factor was taken to be 100%.

4.1 Technical analysis

The energy potential of sawdust and rice husk is a function of three major factors, which include; calorific value, chemical characteristics, and conversion technique. Table 2 shows the ultimate analysis and calorific value of the combined sample.

Table 2: The Ultimate analysis and calorific value

Parameters	% Composition
Carbon monoxide	0.113
Carbondioxide	2.713
Carbon	3.130
Sulphur	6.646
Methanol	19.376
Methane	29.61
Hydrogen	38.306
Phenol	41.266
Oxygen	45.133
Calorific value	36.20MJ/kg

Table 3 shows the proximate analysis and fixed carbon of the combined sample

Parameters	% Composition
Ash	8.957
Moisture	19.026
Volatile	21.060
Hardness	13.907
Fixed carbon	50.957

Table 1 showed that there were huge quantities of sawdust and rice husk available, which can be used as sources of energy generation instead of as waste.

Table 2 shows that the energy produced depends on the calorific value and ultimate analysis of the combined sample. The combined sample contains 50.96% fixed carbon, and carbon and hydrogen contributed 30.44% of the total composition during combustion.

The calorific value of the sample was 36.20 MJ/kg, which is enough to produce steam for power generation. For this to be possible, steam turbine technology is recommended.

Table 3 showed that the proximate analysis contained a high concentration of fixed carbon, followed by volatiles, moisture, hardness, and ash, respectively.

Abedin et al. [14] reported that a steam turbine power plant consumed 1.3kg per kWh of electricity using rice husk as a source of energy. Considering this technical conversion factor, it is possible to generate 7949.69 MWh of electricity from 10334.60 tons of the combined sample per year.

5. CONCLUSION

The study carried out has shown that the Ebonyi South region of Nigeria has the required quantity of sawdust and rice husk that can be used to generate electricity if properly harnessed. With an average of 10334.60 tons of the combined sample (sawdust and rice husk) per year, 7949.69 MWh of electricity could be generated, and 80% utilization of the sample was achieved. There is no doubt that the study has raised awareness about the benefits of the proper harnessing of agricultural waste to reduce the emission of dangerous gases into the environment.

However, the following recommendations were made:

- The government should encourage the conversion of waste into wealth.
- The government should invest in the establishment of FBC technology because it is more economical and environmentally friendly.

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