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Proximate Analyses of Selected Biomass Material

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ABSTRACT

This paper covers the determination of proximate composition of corn stover, iroko saw dust, elephant grass and mahogany bark. The selected biomass materials (corn stover, iroko saw dust, elephant grass and mahogany bark) were analyzed for their proximat concentration. The methods of analyses were as described by the American Standard for Testing and Materials. Results of proximate analysis showed moisture and ash content, fixed carbon and volatile matter content to be 0.40, 0.42, 0.86 and 1.30%; 26.60, 22.60, 14.00 and 15.35%; 69.04, 73.20, 79.24 and 79.96% and 3.96, 3.78, 5.90 and 3.39% for respectively for corn stover, iroko saw dust, elephant grass and mahogany bark. The results showed an indication that these materials are suitable for pyrolysis process because a relatively higher bio-oil yield would be expected as the case would be.

Key word: Biomass, Pyrolysis, Proximate And Analyses

INRODUCTION

Biomass is regarded as an organic matter obtained from biological organisms like herbaceous species, plants, woody, industrial and agricultural residues. Diverse biomass materials, being carbon neutral and abundantly available, mostly as residues, have been considered promising resources available to generate alternative transport fuels, heat, high valued-biochemical products and electricity (Mutsengerere *et. al.,* 2019). The International Energy Agency of 2015 reported that biomass energy accounts for approximately 14% of the global total primary energy supply. Broadly, the uses of biomass feed stocks can be classified as first and second-generation biomass. The first-generation biomass feed stocks are those from food crops like sugar cane, palm, soya bean, and corn. Their continued uses could precipitate an unhealthy competition between food and fuel supply as well as deplete the land area available for food cultivation (Agrawal *et al*., 2019). This represents a significant setback for the uses of food crop in the frontline of biofuel research such that the corn-based industry, for instance, has been adjudged to be incapable of meeting the global biofuel demand (Gan*et al.,* 2019). On the other hand, the second-generation biomass sources are those obtained from non-food crops like weeds, straws, herbs and woods (Agrawal *et al.,* 2019). One of the major demerits is that the processes of utilization are less well developed and more complex in comparison to the first-generation biomass. However, keen attention is on the second-generation biomass as they are not available as food, but rather as residues from agricultural, industrial, and even municipal activities (Agrawal *et al.,* 2019). Another significant advantage is that the use of biomass residues helps resolves the challenges of waste management, energy security, climate change, and consequently eliminate the fuel versus food debate (Sjulander and Kikas, 2020).

Pyrolysis is an endothermic process in which lignocellulosic biomass is thermally decomposed, ideally in the absence of oxygen, to produce highly heterogeneous products, namely, bio-gas, bio-char and bio-oil (Lam *et al.,* 2019). Pyrolysis, which could be either slow or fast, depending on the heating rates, occurs at controlled intermediate temperatures of 300-600°C (Zaman*et al.,* 2017;Ahorsu*et al.,* 2018). Slow pyrolysis involves low heating rates (< 10°C/min), long residence time (5-30 minutes) and it is generally applicable in the production of bio-char (Pecha and Garcia-Perez, 2020). On the other hand, fast pyrolysis is more efficient in bio-oil generation and its operating conditions include rapid heating rates (1-100°C/s), short gas and solid residence time (10-20s), and rapid vapor quenching (Safdari*et al.,* 2019). Pyrolysis is of great interest in this research due to its adaptability to a wide range of biomass, flexibility of operation, and production of a variety of products. To obtain a maximum and quality bio-oil yield, a good understanding of the reactor type in addition to its intrinsic (heat and mass) transport processes and varied reaction pathways are necessary.
The aim of this research paper is to carry out proximate analysis of selected biomass materials. The specific objectives is to determine the moisture, fixed carbon, volatile matter and ash content in corn stover, iroko sawdust, elephant grass and mahogany bark.

METHODOLOGY

Sample Procurement and Preparation

The corn stover, elephant grass, iroko, sawdust and mahogany bark used for this research was sourced or harvested from local farms and sawmill, respectively, in Amai Community in Ukwani Local Government Area of Delta State, Nigeria After harvesting, the raw materials were transported to the

Department of Science Laboratory Technology Chemistry Laboratory followed by the preparation of the raw (biomass) materials. The raw samples were sun-dried in an open space for ten working days (8 hours per day) with an average temperature of 35 $\pm$ 2 °C. The sun-dried material with the aid of a manual crusher and hammer mill is pulverized. In order to reduce the moisture content to as low as we can the crushed materials were heated in an oven to a temperature of 105° C for 5 hours. Then the specimen was allowed to cool gradually. The process of drying was repeated to ensure further dryness. The moisture content was reduced drastically to enhance the heating value of the lignocellulose biomass. This was followed by grinding and sieving of the samples into a uniform particle size of less than 2mm to achieve perfect heat and mass. Prior to analyses, the samples were stored in Ziploc bags at ambient conditions

Determination of Proximate Analysis

This consist of the physical properties of fuels which is made up of percentages moisture content, fixed carbon, volatile matter as well as ash content.

Moisture content

The moisture content is an important property that affects the burning characteristics of biomass material. It has influence on the energy value of the fuel (Yang *et al*., 2005; Onochie *et al.,* 2017). The ASTM standard used to analyze the moisture content is ASTM E871-80. The moisture content of the samples was determined by drying at a temperature of 105°C in an oven and expressed in percentage of oven dry mass.

1. An empty moisture dish was correctly weighed and recorded.
2. 10g of the specimen was placed inside the dish and reweighed.
3. The dish with the specimen was placed in an oven of partial vacuum (less than 100mm Hg) at a temperature of 105°C for about 5 hours.
4. After which the dish was removed from the oven and gradually allowed to cool and weighed.
5. The process was repeated for an hour until we noticed a constant weight.

Calculation:

$$\% \text{ moisture} = \frac{[(\text{weight of sample before drying- weight of dry sample) X 100}]}{\text{Weight of sample before drying}}$$

Ash content

The ASTM standard used to analyze the ash content is E1755- II. The muffle furnace was used for this analysis. The ash fraction contains all the mineral elements jumbled together.

1. 5g of the prepared sample was placed in a crucible.
2. After which it was placed in an oven at 100^{o}C for 24 hours.
3. It was then removed and transferred to a muffle furnace where the temperature was increased further to 550±5^{o}C.
4. This increased temperature was maintained for another 8 hours
5. Finally, the crucible was removed from the furnace and transferred to a desiccator to cool, weighed and recorded.

Calculation:

The ash content was expressed in percentage dry basis using the expression below

$$\% \text{ ash content} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Volatile matter (VM)

The VM was obtained by difference as shown in the equation below

$$\%, VM = \frac{\text{Initial mass of the sample - Final constant mass of the sample}}{\text{Initial mass of the sample}} \times 100$$

Fixed carbon

The fixed carbon (FC) was obtained from the equation below

% FC = 100 – (% moisture content + % volatile matter + % ash content)

In obtaining the fixed carbon ASTM D3174 – 76 standard method was used. The crucible cover used in performing the volatile matter last analysis was removed after which the crucible heated over Bunsen burner to allow all the carbon to burn. The difference in weight of the residue from the previous weight is the fixed carbon.

RESULTS AND DISCUSSION

Table 1: Results of proximate analysis

SAMPLE	MOISTURE CONTENT (%)	FIXED CARBON CONTENT (%)	VOLATILE MATTER CONTENT (%)	ASH CONTENT (%)
CORN STOVER	0.40±0.2	26.60 ±0.2	69.04 ± 0.7	3.96 ± 0.2
IROKO SAWDUST	0.42±0.2	22.60 ±0.3	73.20 ± 0.2	3.78±0.1
ELEPHANT GRASS	0.86±0.4	14.00 ±0.4	79.24 ± 0.4	5.90 ±0.1
MAHOGANY BARK	1.30±0.05	15.35±0.2	79.96± 0.7	3.39 ±0.3

Table 1 showed results of proximate analysis while table 2 showed results of ultimate analysis of corn stover, iroko sawdust, elephant grass and mahogany bark.

Moisture content

Moisture content of biomass is the quantity of water existing within the biomass, expressed as a percentage of the total material's mass. Moisture content of biomass in natural conditions depends enormously on the type of biomass, ranging from less than 15% in cereals straw to more than 90% as in algae biomass. This is an important parameter when using biomass for energy since it has a marked effect on and heating value. On the other, high moisture content entails logistic issues as it increases the tendency to decompose which results in energy loss and tend to reduce energy and cost balances (Javier and Jesus, 2019)

The results of moisture content of the various biomass range of 0.40 – 1.30% with corn stover, iroko sawdust, elephant grass and mahogany bark recording 0.40, 0.42, 0.86 and 1.30% respectively. Amongst the biomass, mahogany bark recorded the highest value of 1.30% while corn stover was the lowest.

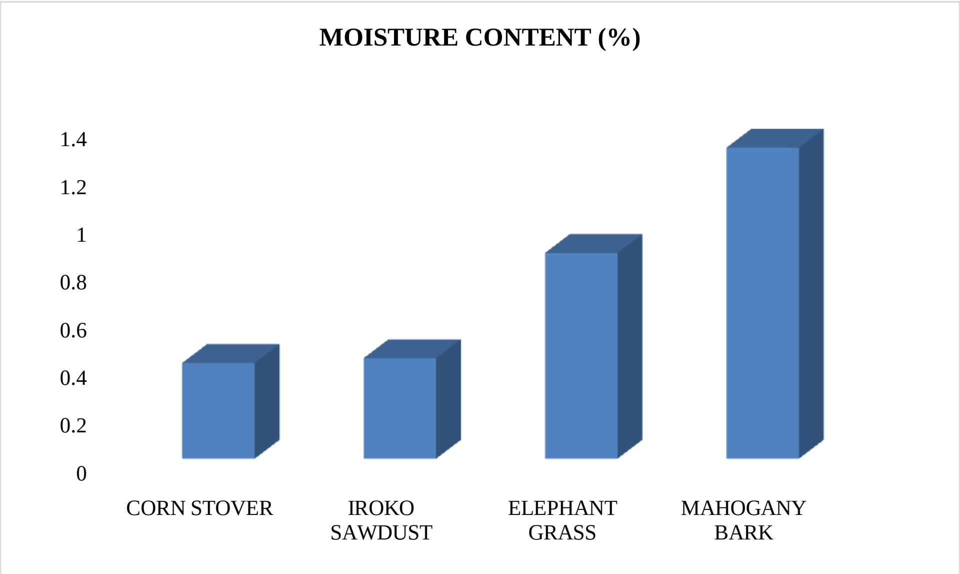

Figure 1: Moisture content of biomass

The heating value of a biomass feedstock represents the energy amount per unit mass or volume released on complete combustion. The heating value is seen in two different ways, the higher heating value (HHV) and low heating value (LHV). The HHV includes the latent heat contained in the water vapor that in practice cannot be used effectively, while the LHV excludes the heat of evaporation of the water formed from the hydrogen contained in the biomass feedstock and its moisture content. Thus, the LHV is the appropriate value to assess the energy available for subsequent use.

Fixed carbon

Fixed carbon is the solid combustible residue that remains after a sample is heated at 900 degrees Celsius for a period of 7 minutes and the volatile matter is expelled (Gianluca et. al., 2020)

The fixed carbon content of this present study was found in the range of 14.00 – 26.60%. Corn stover, iroko sawdust, elephant grass and mahogany bark recorded fixed carbon content of 26.60, 22.60, 14.00 and 15.35% respectively. Corn stover recorded the highest fixed carbon (26.60%) while elephant grass was the lowest (14.00%).

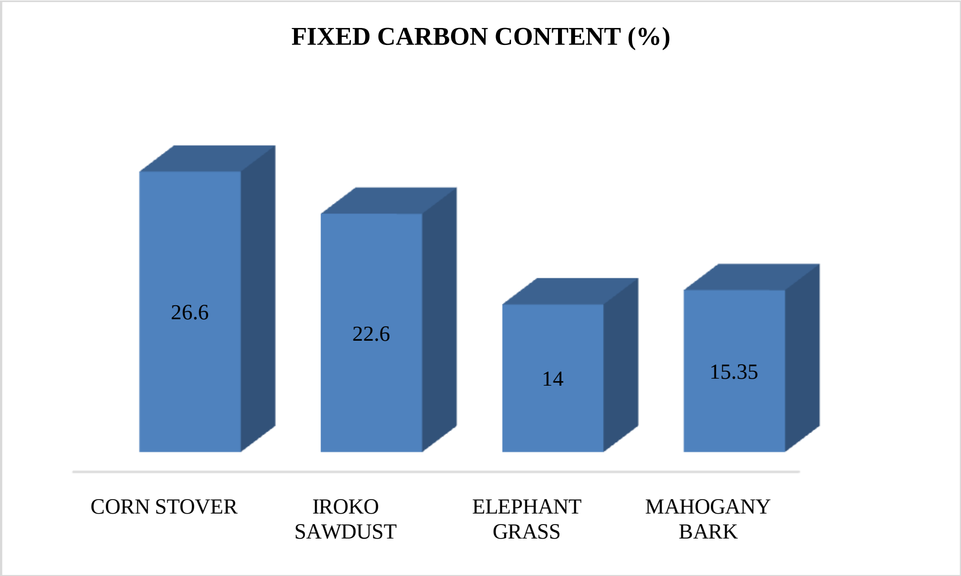

Figure 2: Fixed carbon content of biomass

The fixed carbon can influence the biological conversion of fuel. Woody biomass has a much higher fixed carbon content as compared to perennial crops. This justifies why elephant grass recorded the lowest value while corn stover which would be much in weight had the highest.

Volatile matter

The volatile matter of biomass is composed by condensable vapor and permanent gases (exclusive of water vapor) released when the biomass is heated to 925°C for few minutes. During this heating, the biomass decomposes into gases and solid matter is left out as char.

The volatile matter of this study were found to be 69.04, 73.20, 79.24 and 79.96% for corn stover, iroko sawdust, elephant grass and mahogany bark respectively.

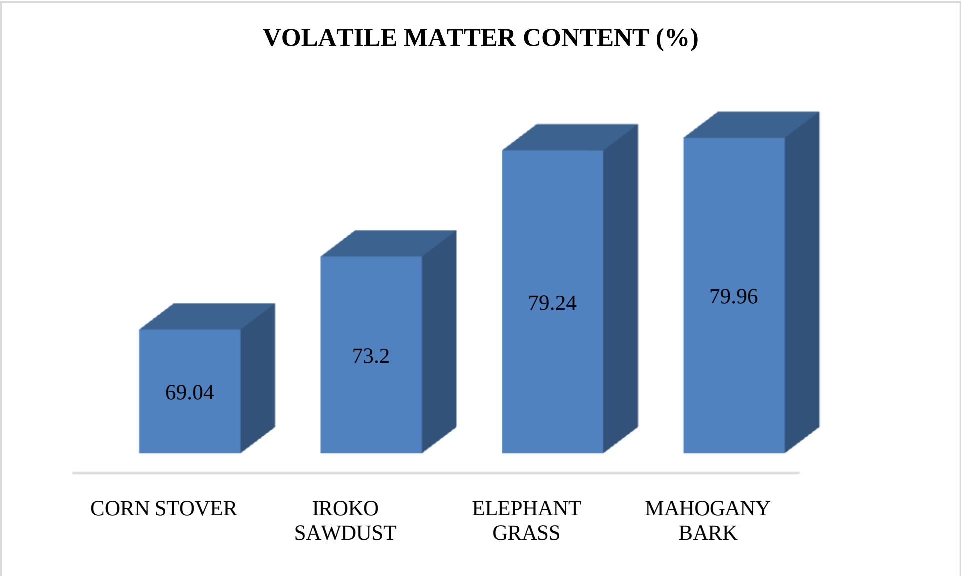

Figure 3: Volatile matter content of biomass

It is worthy to state that the presence of volatile matter in biomass influences fuel reactivity, it has been observed that an increase in the volatile matter content of the biomass sample causes, as a general tendency, an increase in the peak temperature. The peak temperature is the point on the burning profile at which the rate of weight loss due to combustion is maximum. The burning profile peak temperature is usually taken as a measure of the reactivity of the sample (Haykırı-Açma, 2003). The volatile matter content is also an important parameter for evaluating anaerobic digestion for biogas production (Cai et. al., 2027).

Ash

Ash is generally considered to be the residue remaining after the material has been incinerated. It therefore has no energy value and, being made up of the inorganic elements in the biomass, is of no direct value in hydrolysis technologies.

The ash contents of this study for corn stover, iroko sawdust, elephant grass and mahogany bark are 3.96, 3.78, 5.90 and 3.39% respectively

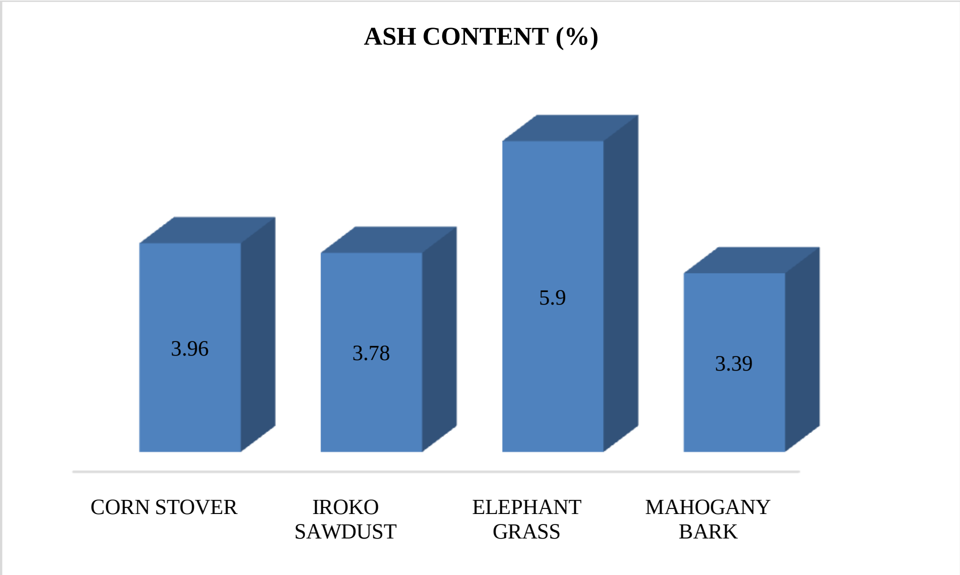

Figure 4: Ash content of biomass

The primary components of biomass ash are oxides of silica, aluminium, iron, calcium, magnesium, titanium, sodium and potassium. For example, knowing

the exact composition of the ashes of a biomass aids in predicting both its tendency to form deposits in the boiler components and the composition of the char produced during pyrolysis and gasification processes, which in turn also influence the combustion rate. The percentage and composition varies according to the type of biomass (Gianluca et. al., 2020).

CONCLUSION

Biomass is regarded as an organic matter obtained from biological organisms like herbaceous species, plants, woody, industrial and agricultural residues. Diverse biomass materials, being carbon neutral and abundantly available, mostly as residues, have been considered promising resources available to generate alternative transport fuels, heat, high valued-biochemical products and electricity.

These materials are therefore recommended as a good material for biomass which would also be suitable for the production of bio-oil

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