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Production and Testing of Bio Char Made from Maize and Wood Waste For Domestic and Commercial Applications

IKPOTOR, O. T.[1], ***MARKSON, I. E.***[2], ***ASHIEDU, F. I.****[3]

[1,3]*Mechanical Engineering Department, Federal University of Petroleum Resources, Effurun, Nigeria*

[2]*Department of Mechanical and Aerospace Engineering, University of Uyo, Akwa Ibom State, Nigeria*

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ABSTRACT

The increased act of using fertilizers and some other soil additives over the years in the production of crops on our farm lands has created more environmental problems, ranging from air, soil and water pollution. This has however contributed to adverse climate change which has at moment a negative impact in our social and economic lives. In other to mitigate against this, Bio char which is obtained by the pyrolysis of organic matters can serve as a replacement for these fertilizers because of its eco-friendly characteristics. The method available for the production and testing of the inherent characteristics of Bio char is important and necessary for this research work. The wood shaven and the maize waste collected were processed and dried to reduce the water content of the biomass. The dried biomass was subjected to pyrolysis for one hour at a controlled temperature of 400°C. The bio char so produced was subjected to scientific test such as, water retention capacity, nitrogen content, the porosity of the biomass and its emission capacity. Results of the findings showed that saw dust has water holding capacity of 6.60ml/g, infiltration rate of 0.03cm/sec, Ph. value of 8.56, Ash content value of 0.020 and a water retention time of 60 sec. Similarly, maize cob has water holding capacity of 5.20ml/g, infiltration rate of 0.03cm/sec, Ph. value of 8.85, Ash content value of 0.012 and a water retention time of 60 sec. Only wood chip has a departure from the 60 sec. water retention to 180 seconds, which is a 300% increase. Finally, bio char which is eco-friendly has been produced. The bio char so produced can be used to improve on the soil quality for increase yield, assist in mitigating against environmental pollution problems thereby contributing to an enhanced climate change positively. It is therefore recommended that government, non-governmental agencies, philanthropist and churches be encouraged to key into this project to guarantee food security, solve the problems of flooding caused by blockage of water ways on one hand and create the much-needed employment on the other hand.

1. INTRODUCTION

Bio char has been proved to be a key component in finding solution to a number of agricultural and environmental problems. To get the most advantage from its application, environmental and social circumstances directly related to mankind should both be considered (Abiven *et al*. 2014).

*Corresponding author, e-mail:ashiedu.ifeanyi@fupre.edu.ng
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In rural areas of developing countries, biomass is generally used for cooking but not charred. Biochar production techniques at farmer scale have remained unsatisfactorily developed. An experiment developed and tested biochar production kilns for local farmers with a dimension of 50.8 cm × 38.1 cm.(MIA, et al., 2015).

According to (Kambo & Dutta, 2015),The Slow-pyrolysis of biomass for production of biochar, a stable carbon-rich solid by-product, has gained considerable attention due to its proven role and application in the areas of science and engineering. A relatively new process called hydrothermal carbonization (HTC) of biomass has shown promising results. In a study carried out by (Ilango et al, 2016) simulated human feces were charred under different conditions of maximum temperature (200–800°C), a heating rate of (2–50°C min−1), and a holding time of (0.5–6.0 h). The maximum temperature was shown to have a higher impact than the heating rate or the holding time.

Both feedstock properties and production conditions are vital for determining the yield and properties of biochar. The biochar surface area and pH were mainly affected by highest treatment temperature. (Zhaoa et al, 2013). Evaluation of Oriental beech (*Fagus orientalis* L.) was investigated with aspect of thermo-chemical conversion to get bio-char, bio-oil and gaseous. When the pyrolysis temperature amplified, the bio-char yield decreased. A high temperature and smaller particles raise the heating rate resulting in a decreased bio-char yield. The bio-char attained are carbon rich, with high heating value and comparatively pollution-free potential solid biofuel. The liquefaction yields sharply increased with increasing the temperature close to critical temperature and after that. In the pyrolysis, increases of liquid yields are noticeably sharply for all of the samples with increasing of pyrolysis temperature from 690 K to 720 K. The beechnut oil was converted to biodiesel in supercritical methanol without using catalyst. Experiments have been done in an autoclave at 493, 523 and 593 K, and with molar ratios of 1:6–1:40 of the oil to methanol. The yield of alkyl ester improved with increasing the molar ratio of oil to alcohol (Aburas et al, 2015).

According to a study by (Tag et al, 2016), The effect of feedstock type and pyrolysis temperature on the properties of biochar samples regarding their utilization as energy feedstock and soil amendment was investigated. For this purpose, four differing types of biomasses (vine pruning (VP), poultry litter (PL), orange pomace (OP) and seaweed (AB)) were pyrolyzed at different temperatures between 250 and 600 °C. The pyrolysis temperature of 350 °C was found as critical upper temperature within the production of biochar used as fuel. The VP and OP were seen to be more suitable than PL and AB for solid fuel production. The stable carbon contents of biochar’s produced at 500 °C and 600 °C were over than 98%. With increasing of pyrolysis temperature, plant nutrients (except K) in biochar diminish available to plants. Although the carbon exchange capacity was the very best in AB and PL biochar’s, that they had extremely high electrical conductivity values. Pyrolysis of Achnatherum splendens L. was performed under three different pyrolysis temperature (300, 500, and 700 °C) to analyze the characteristics of biochar, bio-oil, and syngas. Biochar yield declined from 48% to 24%, whereas syngas yield rose from 34% to 54% when pyrolysis temperature was increased from 300°C to 700 °C. Maximum bio-oil yield of 27% was obtained at 500 °C. The biochar was characterized for elemental composition, surface, and adsorption properties. The results showed that obtained biochar may be used as a possible soil amendment. The bio-oil and syngas co-products are evaluated within the future as bioenergy sources. Overall, the results suggest that A. splendens L. may be used as a possible feedstock for biochar and bioenergy production through pyrolytic process (Irfan, et al., 2016).

Hydrogen-rich gas production from the catalytic steam reforming of bio-oil model compounds was disbursed during a fixed bed reactor. Bio-char, which was gotten from biomass gasification process and comprised of many alkalis and alkaline earth metals (AAEM) species, was used as a catalyst. The results showed that bio-char was effectual in enhancing catalytic steam reforming of bio-oil model compounds and producing hydrogen rich gas. Acid treatment of bio-char was conducted to research the effect of inherent AAEM species on the catalytic activity of bio-char. it had been discovered that the inherent AAEM species appear to possess significant effect on the catalytic activity of bio-char especially the water-gas shift reaction under the present experimental conditions (Ma et al, 2017).

It was discovered that the economic feasibility of biochar-based bioenergy production system within the life cycle analysis system limit based on study assumptions is directly reliant on costs of pyrolysis, feedstock processing (drying, grinding and pelletization) and collection on site and the worth of total carbon offset provided by the system. Sensitivity analysis of transportation remoteness and different values of Carbon offset showed that the system is profitable in case of high biomass accessibility within 200 km and when the cost of carbon sequestration exceeds CAD $60 per tonne of equivalent carbon (CO_2) (Homagain et al, 2016). Increasing energy demands and waste managing concerns have motivated agricultural producers to contemplate the dispersed conversion of agricultural by-products for energy and value-added product (biochar) generation. "thanks to the variability of fuel properties, direct combustion of agricultural by-products with high ash contents, like rice husk, may suffer from increased fouling and slagging issues with high particulate matter (PM) emissions. Combustion of the raw pyrolysis volatiles (bio-oil and synthesis gas (syngas) mixtures) produced from pyrolysis with the inherent separation of ash within the biochar may potentially mitigate these issues". during this study, PM emissions from the combustion of the raw pyrolysis volatiles derived from the pyrolysis of rice husk were evaluated at laboratory scale by employing a combined pyrolysis and combustion facility. Pyrolysis temperatures starting from 400 °C to 800 °C were accustomed generate raw pyrolysis volatiles with differing bio-oil to syngas ratios which were then combusted at 850 °C. it had been found that bio-oil dominated the upper heating value of the raw pyrolysis volatiles produced at low pyrolysis temperatures. The burning of such raw pyrolysis volatiles with high bio-oil content substantially increased the product of PM10 and PM2.1. Linear dependence was detected between PM emissions and bio-oil fraction within the raw pyrolysis volatiles. Nevertheless, the pyrolysis-burning process, with more than 96% of the ash retained in biochar before burning, is more satisfactory than direct burning for top ash biomass as far as PM emissions are concerned (Dunnigan et al, 2018). Pyrolysis is an alternate form of renewable energy production and a potential source of greenhouse gas emissions moderation. This study examines how poplar-based biochar can be useful in Taiwan for power generation and for soil improvement and to what extent it brings economic and environmental profits. It is a primary study and focuses on the balances of different economic and environmental items. This work reports on a case study examination of the economic and greenhouse gas consequences of pyrolysis plus biochar utilization. The case study comprises using poplar grown on set-aside land in Taiwan with the biochar applied to rice fields. We inspect both fast and slow forms of pyrolysis and find how the profitability differs under different price structures. The findings show that fast pyrolysis is more profitable than slow pyrolysis under current electricity price, GHG price and crop yield as the slow pyrolysis generates comparatively less electricity but lower value product—biochar (Kung et al, 2013).

Sewage sludge (SS) has been demonstrated to be a good feedstock material for the production of biochars. However, the problem is that the total/leachable constituents of some heavy metal elements in biochar products exceed the corresponding norms. In this work, efforts were made to solve above the mentioned problem through the addition of other biomasses (rice straw (RS) and sawdust (SD)) for the co-pyrolysis with SS. The addition of RS/SD reduced the quantity of biochars, while the contents of organic matter in biochars were expressively better. In addition, the introduction of biomasses, especially the addition of Saw Dust, caused a reduction in the thermal stability, surface area, and pore volume of biochars. The total contents of heavy metals in the biochar obtained, especially their Copper, Zinc and Nickel contents, were reduced as expected (Huang et al, 2017).

blessed with abundant natural resources such as Timber and fertile soil which is fast loosing fertility to leaching and increased application of organic fertilizers.

2. MATERIALS AND METHODS

Samples of wood saw dust were collected from local sources in Ugbowo axis of Benin, these samples were prepared for production by drying in an electric air oven, sample drying times were not specific because they were dried according to how wet they were and the drying temperature used was between 105-135 degree Celsius. After drying a sample mass of 300 gram was measured and put in a box tray feeder with the furnace set to a specific temperature, the measured sample was put into the furnace when the temperature reaches its set limit. This was to ensure that the sample was heated at a constant temperature. After putting the sample into the furnace, the sample was heated at a constant temperature for a specific amount of time. On the elapse of the given heating time, the sample which has been turned into biochar was removed and quenched with plenty of water and left exposed to the sun for a while before being taken into the electric air oven and dried properly, the amount of time it stays in the oven also depends on the degree of wetness. When the biochar is properly dried, it was stored in a plastic container and labelled. The production was carried out on all 3 samples which were sawdust, corn cob, and wood chip at a temperature of 400 and 600 degree Celsius and for each set temperature, each of the 3 samples were heated for 1 hour, 2hours

2.1.Methods

2.1.1. Water retention Capacity Test

Before testing for water retention capacity, the biochar sample was dried to make sure there is no moisture content. It was then crushed with a wooden mortar and pestle before it was sieved with a 0.5mm^2 sieve. 5 grams of the sieved sample was measured and mixed with 50ml of clean water in a clean 100ml beaker. A mildly wet cotton wool was used to block the outlet of a funnel from the inside while a mild wet filter paper was put into the funnel. The filter paper served as the primary filter while the cotton wool served as the secondary filter. A 50ml measuring cylinder was attached to a retort stand and the funnel was put into the measuring cylinder then the mixture of water and biochar was poured into the funnel hanging on the measuring cylinder on a retort stand. The setup is left to stand for 24 hours after which the drained volume of water in the measuring cylinder was recorded and the water retention capacity of the biochar was estimated as follows.

$$\text{Water retention capacity (ml/g.day)} = \frac{\text{total volume of water(ml)} - \text{drained volume of water(ml)}}{mass\ of\ biochar(g)}$$

2.1.2. Infiltration Rate Test

Biochar sample was dried to make sure there is no moisture content. It was then crushed with a wooden mortar and pestle before it was sieved with a 0.5mm^2 sieve. A test tube was marked with a masking tape at a point 5cm from the bottom of the test tube which was measured from the inside. The already prepared biochar sample was then put inside the test tube up to the 5cm mark. As the prepared sample is being put inside the test tube, the test tube was vibrated manually by gently tapping it on a wooden surface or with the finger until there is no longer any reduction in height at the 5cm mark. The test tube is then fixed on a retort stand and a 10ml measuring cylinder is used to measure 10ml of water which was poured into the test tube of biochar and the time taken for the water to travel to the bottom of the test tube was measured using a stop watch. Hence the infiltration rate was estimated as follows.

$$\text{Infiltration rate} = \frac{distance\ travelled\ (cm)}{time\ taken\ (minutes)}$$

2.1.3. Ph Test

Biochar sample was dried to make sure there is no moisture content. It was then crushed with a wooden mortar and pestle before it was sieved with a 0.5mm^2 sieve. 5 grams of the prepared sample was measured using a digital mass scale and put in a 100ml beaker. 50ml of water was measured using a 50ml measuring cylinder and the water is poured into the beaker containing the prepared biochar sample and the mixture was stirred using a glass stirring rod. The probe of a digital pH reader was put in the thoroughly stirred mixture and the reading was taking then the value on the screen is stable.

$$pH = -\log [H^+]$$

2.1.4. Nitrate Test

Biochar sample was dried to make sure there is no moisture content. It was then crushed with a wooden mortar and pestle before it was sieved with a 0.5mm^2 sieve. 5 grams of the sieved sample was measured and mixed with 50ml of clean water in a clean 100ml beaker. A mildly wet cotton wool was used to block the outlet of a funnel from the inside while a mild wet filter paper was put into the funnel. The filter paper served as the primary filter while the cotton wool served as the secondary filter. A 50ml measuring cylinder was attached to a retort stand and the funnel was put into the measuring cylinder then the mixture of water and biochar was poured into the funnel hanging on the measuring cylinder on a retort stand for some minutes. About 10ml of the filtrate was collected in a test tube and a nitrate test strip was dipped into the filtrate and left in the filtrate for about 5 seconds, the test strip was removed and swung back and forth slightly for about 20 second. The test strip is left to dry for 15 minutes before the result was taken using the nitrate chart.

From the test strip it was discovered that there is no trace of any nitrogen compound in any of the samples tested as compared to the colour code of the strip.

2.1.5. Ash Content Test

Raw samples of sawdust, corn cob and wood chip were oven dried to remove moist content then a specific mass was measured using a digital mass scale and recorded. The samples were put in a crucible and put in the furnace whose set temperature was 800 degree Celsius. The samples were heated in the furnace for 6hours. The crucibles were taken out of the furnace and left to cool before measuring the mass of the ash left.

$$\text{Ash content (g/g)} = \frac{mass\ of\ ash\ (grams)}{mass\ of\ raw\ sample\ before\ burning\ (grams)}$$

2.2. Material

2.2.1. Equipment and Apparatus Used for Tests

Table 1. Equipment and apparatus used for test

Apparatus	**Quantity**	**Uses**
Electric furnace (SX-5-12)	1	Used to ash samples at a high temperature.
Electric air oven.	1	Used to dry samples and eliminate moist before tests.
Retort stand.		Used to hold test tubes and measuring cylinders during tests.
Stop watch.		Used to time tests.
$0.5mm^2$ mesh size sieve.		Used to get uniform biochar grain size for testing.
Crucible tong.		Used to pick hot crucibles.
Filter paper.		Used as primary filter during the water retention capacity test.
Cotton wool.		Used as secondary filter during the water retention capacity test.
Test tube.		Used as
Mortar and pestle.		Used to crush biochar into powder form.
Nitrate test kit.		Used to measure the total nitrogen tests.
Digital pH meter.		Used to measure the pH of biochar samples.
Funnel.		Used as a housing for both primary and secondary filters during tests.
Digital mass scale.		Used to measure masses of samples during tests.
Meter rule.		Used to measure distance.
Heat resistant hand gloves.		Used to pick up hot objects when working with the furnace and oven
Crucibles.		Used as a container to ash samples in a furnace.
Glass stirring rod.		Used to properly mix biochar mixtures.
50ml, 25ml and 10ml measuring cylinder.		Used to measure specific volumes of water.
Beakers.		Used to mix biochar mixtures.

The electric furnace was chosen for the production of biochar in this research so as to achieve a constant temperature heating for a given time. It allows a specific temperature to be set and used to heat the biomass sample for a specific time frame. Though it was not designed to collect or store syngas during production because its original design was not for biochar production, but the quantity of gas produced during production was estimated using the difference between the mass before and after production of the biochar. The type of tests chosen to be carried out were due to effect of those properties to the environment especially to the soil and atmosphere. The production process looks into the factors of production such as temperature, time and quality of yield and to deduce which of the factor needs to consider first before the other.

3. RESULT AND DISCUSSION

3.1. Results Presentation

This section discusses the results gotten from the experiment carried out on the bio char production in the laboratory. The data is presented in different table sections, analyzed using charts and interpreted appropriately.

Table 2. Table of result

Label	Material sample	Mass before	Mass after	Retention time	temperature	Ash content (g/g)	Ph	Total nitrogen	Infiltration rate (cm/s)	Water holding capacity (ml/g.day)
A	Saw dust	300	140.54	60	400	0.020	8.56	0	0.03	6.60
B	Corn cob	300	64.30	60	400	0.012	8.85	0	0.03	5.20
C	Wood chip	300	96.50	60	400	0.006	7.75	0	0.08	5.40
D	Saw dust	300	113.31	120	400	0.020	8.35	0	0.13	8.40
E	Corn cob	300	91.98	120	400	0.012	8.15	0	0.05	4.40
F	Wood chip	300		120	400	0.006	8.75	0	0.03	3.80
G	Saw dust	300	53.50	180	400	0.020	8.60	0	0.06	7.00
H	Corn cob	300	50.54	180	400	0.012	8.45	0	0.05	3.20
I	Wood chip	300	120.00	180	400	0.006	8.30	0	0.03	6.40
J	Saw dust	300	96.00	60	600	0.020	8.30	0	0.10	8.20
K	Corn cob	300	73.10	60	600	0.012	8.30	0	0.01	4.60
L	Wood chip	300	79.19	60	600	0.006	8.05	0	0.01	5.20
M	Saw dust	300	69.00	120	600	0.020	8.30	0	0.03	7.20
N	Corn cob	300	65.49	120	600	0.012	8.60	0	0.03	4.20
O	Wood chip	300	73.00	120	600	0.006	8.55	0	0.02	4.80
P	Saw dust	300	70.77	180	600	0.020	8.70	0	0.09	7.20
Q	Corn cob	300	58.44	180	600	0.012	8.40	0	0.01	3.80
R	Wood chip	300	82.07	180	600	0.006	8.35	0	0.02	5.00

Table 2. represents the general experimental result gotten from the experiment. It basically measured the pH, ash content, Total nitrogen, infiltration rate and water holding capacity of

the produced biochar which was gotten by varying production data like temperature and heating time. Though the heating style was a constant temperature which was achieved by using an electric muffle furnace. The materials used were sawdust, corn cob and wood chip were sourced from the common local wastes in the vicinity of university of Ibadan. The species of wood and corn cob as not considered in material selection as the materials were a mix of species of different woods and different corn cobs. Before and after production, proper drying techniques was applied so as to get rid of moist in the material before burning and the water used for quenching after production so as to measure accurately the mass of the sample before and after heating.

From the data it was obvious that, there was absence of any nitrogenous compound present in the bio char after production which means it doesn't add any nitrogen to the soil or wherever it is applied. The pH of all the samples of bio char were slightly basic and can have effect in soil pH depending on the original pH of the soil. The ash content affects the yield of biochar directly, the higher the ash content, the greater the bio char yield.

The water-holding capacity of bio char is determined by a number of factors, including the type of organic material used to make the bio char, the temperature and retention time of the pyrolysis process, and the post-processing of the bio char. In general, biochar with a high porosity and a large surface area will have a higher water-holding capacity, because it will be able to absorb more water into its pores. Additionally, the addition of certain chemicals, such as alkaline solutions, can increase the water-holding capacity of bio char by modifying its surface chemistry and making it more hydrophilic. Overall, the water-holding capacity of bio char can be affected by a number of factors, and can be optimized by carefully controlling the production process and post-processing treatments.

The temperature at which biochar is produced can vary depending on the specific process used to make it. In general, biochar is produced using pyrolysis, which is a process that involves heating organic material in the absence of oxygen. This can be done at a variety of temperatures, but the most commonly used temperature range is between 300 and 700 degrees Celsius. The exact temperature will depend on the type of biochar being produced and the specific characteristics that are desired in the final product.

The infiltration rate of soil refers to the rate at which water can enter and move through the soil. The addition of biochar to soil can affect the infiltration rate in several ways. First, biochar can improve the physical structure of the soil, making it more porous and allowing water to more easily enter and move through the soil. Second, biochar can also improve the chemical properties of the soil, making it more alkaline and increasing its ability to hold onto water. As a result, the addition of biochar to soil can generally improve the infiltration rate, allowing water to move more quickly through the soil and reducing the risk of surface runoff and erosion.

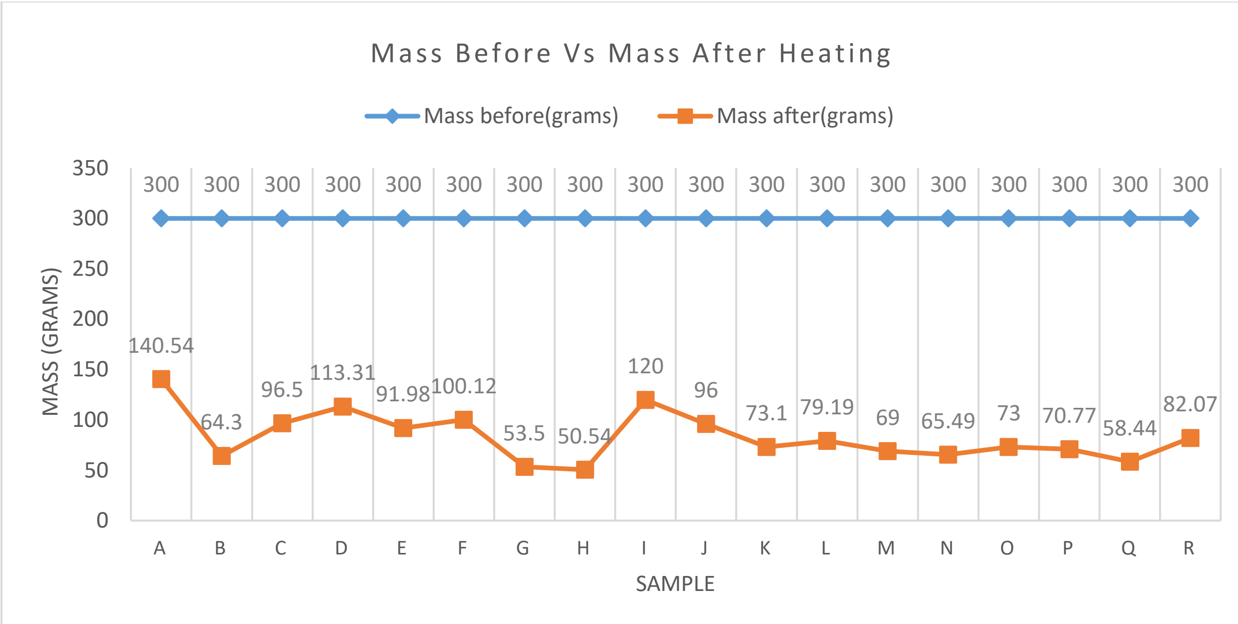

Fig.1. A chart showing the mass before and after pyrolysis of all samples

The figure 1, shows a graph of mass before and after heating which shows a direct relationship between the mass of biochar produced and the mass of (syngas and syn-oil) produced during sample production. The temperature of production vs the amount of syngas and syn-oil produced shows that at higher temperature more of syngas and syn-oil is produced. The heating time also has a significant effect on the quantity of syngas and syn-oil produced as seen in the figure below.

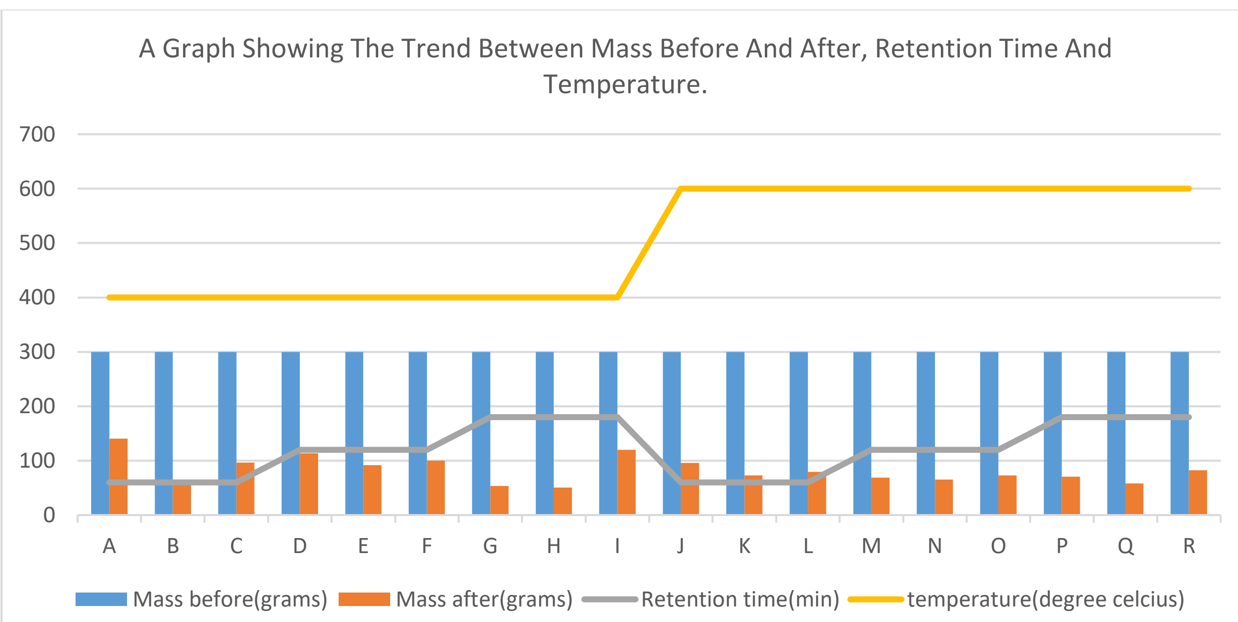

Fig. 2. A chart showing the retention time with corresponding temperature, mass before and after of all samples

Table 2. also shows that the infiltration rate and water holding capacity tends to be higher that of corn cob and wood chip. The water holding capacity property shows the quantity of water that the biochar can hold per unit mass over a period of time and it is an important attribute in the field of agriculture. While the infiltration rate shows the rate at which water travels in the biochar sample.

The retention time of a biochar sample refers to the amount of time that the biochar is held at a specific temperature during the pyrolysis process. The retention time can have an effect on the properties of the biochar, such as its porosity, surface area, and ash content. In general, longer retention times can lead to a higher degree of pyrolysis and a greater degree of charring, which can result in biochar with a higher carbon content and a lower ash content. However, longer retention times can also lead to the production of undesirable byproducts, such as tar and other organic compounds, which can affect the quality of the biochar. Therefore, the optimal retention time for a given biochar sample will depend on the specific properties that are desired in the final product (openai, n.d.)

3.1.1 Experimental result of sawdust sample

Table 3. Sawdust experimental result

label	Material sample	Mass before	Mass after	Retention time	temperature	Ash content	Ph	Total nitrogen	Infiltration rate	Water holding capacity
A	Saw dust	300	140.54	60	400	0.02	8.56	0	0.03	6.60
D	Saw dust	300	113.31	120	400	0.02	8.35	0	0.13	8.40
G	Saw dust	300	53.50	180	400	0.02	8.60	0	0.06	7.00
J	Saw dust	300	96.00	60	600	0.02	8.30	0	0.10	8.20
M	Saw dust	300	69.00	120	600	0.02	8.30	0	0.03	7.20
P	Saw dust	300	70.77	180	600	0.02	8.70	0	0.09	7.20

Table 3. is an extract from table 4 containing data for just the production of biochar from sawdust. With the pH value within the same range of slightly basic and an irregular pattern in infiltration rate and an average water retention capacity of 7.4 ml/g.day. No nitrogen compound was present and the ash content was 0.02g/g.

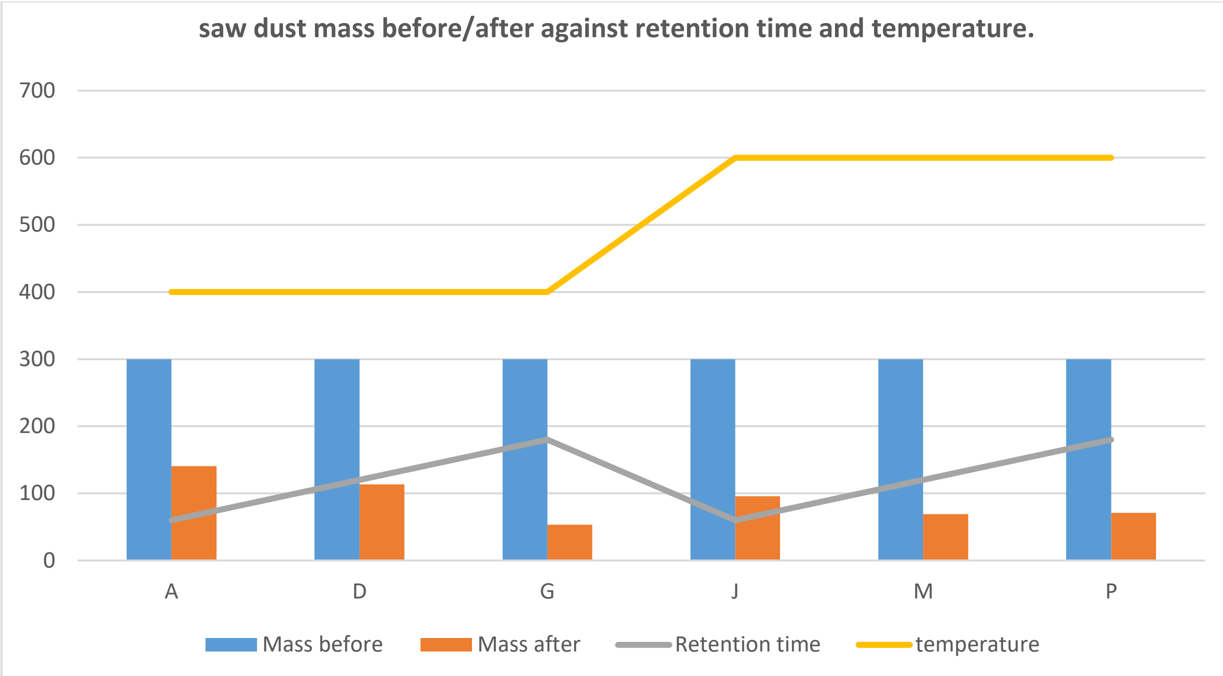

Fig.3. A chart showing the retention time with corresponding temperature, mass before and after of sawdust samples

Figure 3 shows the relationship between heating temperature, retention time and masses before and after heating. From the graph it shows that higher temperature and retention time gives lesser yields in the conversion of sawdust to biochar and a higher yield in bio fuels.

3.1.2. Experimental result of corn samples

Table 4. Corn cob experimental result

label	Material sample	Mass before	Mass after	Retention time	temperature	Ash content	Ph	Total nitrogen	Infiltration rate	Water holding capacity
B	Corn cob	300	64.30	60	400	0.012	8.85	0	0.03	5.20
E	Corn cob	300	91.98	120	400	0.012	8.15	0	0.05	4.40
H	Corn cob	300	50.54	180	400	0.012	8.45	0	0.05	3.20
K	Corn cob	300	73.10	60	600	0.012	8.30	0	0.01	4.60
N	Corn cob	300	65.49	120	600	0.012	8.60	0	0.03	4.20
Q	Corn cob	300	58.44	180	600	0.012	8.40	0	0.01	3.80

Table 4 is an extract from the containing data for just the production of biochar from corn cob. With the pH value within the same range of slightly basic and an irregular pattern in infiltration rate which ranges from 0.01-0.05 cm/s and an average water retention capacity of 4.23 ml/g.day. No nitrogen compound was present and the ash content was 0.012g/g.

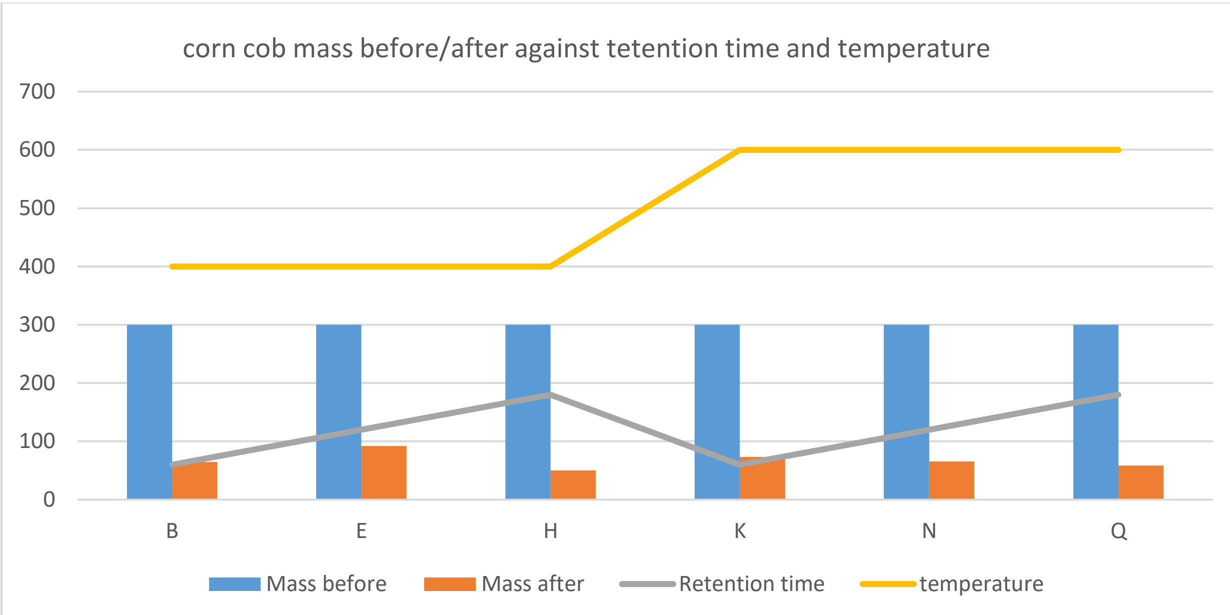

Fig. 5. A chart showing the retention time with corresponding temperature, mass before and after of corn cob samples

Figure 5 shows the relationship between heating temperature, retention time and masses before and after heating for corn cob. From the graph it shows that higher temperature and retention time gives lesser yields in the conversion of sawdust to biochar and a higher yield in bio fuels.

4.1.3 Experimental result of wood chip samples

Table 5 is an extract from table 4 containing data for just the production of biochar from wood chip. With the pH value within the same range of slightly basic and an irregular pattern in infiltration rate which ranges from 0.01-0.08 cm/s and an average water retention capacity of 5.10 ml/g.day. No nitrogen compound was present and the ash content was 0.006g/g.

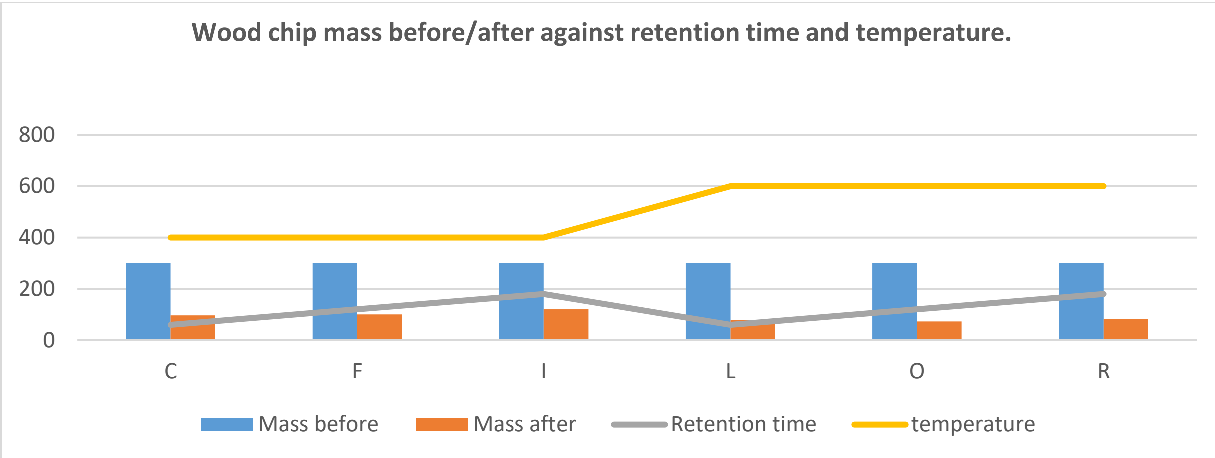

Fig. 6 A chart showing the retention time with corresponding temperature, mass before and after of wood chip samples.

Figure 6 shows the relationship between heating temperature, retention time and masses before and after heating for wood chip. From the graph it shows that higher temperature and retention time gives lesser yields in the conversion of sawdust to biochar and a higher yield in bio fuels.

4. DISCUSSIONS AND CONCLUSION

The benefits derived from the use of bio char produced from waste are enormous, it ranges from improvement from soil fertility, increase in crop yields, better drainage and water retention capacity. Others are, it helps to reduce soil acidity. Bio char application assist greatly in carbon sequestration. During Pyrolysis, less carbon is emitted into the atmosphere as compared to the burning of biomass. When applied directly to the soil for agricultural purposes, carbon conponents are sinked into the soil further, thereby reducing the volume of carbon present in the atmosphere, this again help in balancing the effects of climate change.

As a result of the molecular arrangements of bio char, bio char has a moderate porosity. This property assists in increasing the water retention capacity of the soil. This increased water retention capacity gives room to increased production of crops and vegetables which ultimately leads to increased productivity. In addition to all these qualities, the bio char so produced has the capacity and ability to reduce the emission of greenhouse gases. Bio char is very stable, it can stay in the soil for a considerable length of time, and this ultimately has a way of depleting the emission of the greenhouse gas effect.

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