Research Paper

Preparation of Activated Carbon from Pyrolytic Conversion of *Musa paradisiaca*

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ABSTRACT

Activated carbon is a porous carbonaceous material with high adsorption capacity that can be used as adsorbent material for purification of liquids and gases. In this research work, Pyrolytic conversion of plantain stems into activated carbon was carried out. The study was aim at comparing two chemical activating agent in order to determine the most suitable one for the preparation of activated carbon from plantain stems. The activating agents used were H_2SO_4 and HNO_3. Waste plantain stems were carbonized at 500 to 750^oC and activated at 600^oC to produce activated carbon. The effect of various activating agents on percentage yield, ash content, percentage burn-off, bulk density, surface area determination, moisture content determination, fixed carbon, methylene blue number, loss on ignition, pore volume and iodine number were characterized. From the results, it was observed that H_2SO_4 at activation temperature of 600^oC gave the highest value of bulk density with an increasing impregnation ratios of 0.05, 0.1, 0.2, 0.3, 0.4 and 0.5, with the value ranging from 0.2223 to $0.2561g/cm^3$ followed by HNO_3 ranging from 0.2225 to 0.2359 g/cm^3. The values of percentage yield shows that H_2SO_4 activation was observed to have 77% as the overall best higher than HNO_3 with 76% which shows that the activation temperature at 600^oC does not favour the impregnation ratio of HNO_3 but rather favours H_2SO_4, and with HNO_3 low percentage yield resulted in high percentage burn-off at 33% to 29%. It was observed that the ash content of each of the impregnation ratios of different activating agents was high because it ranged from 33.6% to 39.4%. Similarly, the iodine number obtained showed that iodine adsorption of activated carbon prepared with H_2SO_4 with activation temperature at 600^oC is the best because the micropores content on the surface of activated carbon was the highest at the impregnated ratio of 1337.1 to 1269.1g/kg while that of HNO_3 had the lowest value though chemical activation values were better than thermal valves which shows that H_2SO_4 as activating agent was found to be the best for the preparation of activated carbon from plantain stems.

KEYWORDS: *Activated carbon, pyrolysis,* ***Musa paradisiaca,*** *agricultural waste, thermochemical decomposition.*

I. INTRODUCTION

Pyrolytic resulting from pyrolysis is thermochemical decomposition of organic material at elevated temperature in the absence of oxygen or any halogen. It involves the simultaneous change of chemical composition and physical phase, and is irreversible. The word is coined from the Greek derived elements pyro 'fire' and lysis 'separating'. Pyrolysis is a type of thermolysis, and is most commonly observed in organic materials exposed to high temperature. It is one of the processes involved in charring wood, starting at 200-300 degree Celsius [390-570°F]. It also occur in fires where solid fuels are burning or when vegetation comes into contact with lava in volcanic eruptions. In general, pyrolysis of organic substances produces gas and liquid products and leaves a solid residue richer in carbon content char, extreme pyrolysis, which leaves mostly carbon as the residue, is called carbonization. The process is used heavily in the chemical industry for example to produce charcoal, activated carbon, methanol, and other chemicals from wood, to convert ethylene dichloride into vinyl chloride, to produce coke from coal, to convert biomass into syngas and bio char, to turn waste plastics back into usable oil, or waste into safely disposable substances, and for transforming medium-weight hydrocarbons from oil into lighter ones like gasoline. These specialized uses of pyrolysis may be called various name s, such as dry distillation, destructive distillation, or cracking. Pyrolysis is also use in the creation of nanoparticles, zirconia and oxides utilizing an ultrasonic nozzle in process called ultrasonic spray pyrolysis (USP). Pyrolysis also play important role in several cooking procedures, such as baking, frying, grilling, and caramelizing. It is a tool of chemical analysis for example, in mass spectrometry and in carbon-14 dating,

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indeed, many important chemical substances, such as phosphorus and sulfuric acid, were first obtained by this process. Pyrolysis has been assumed to take place during catagenesis, the conversion of buried organic matter to fossil fuels. It is also the basis of photography in their embalming process, the ancient Egyptians used a mixture of substances, which the obtain from the pyrolysis of wood.

Plantain (musaparadisiaca) was originated in south east Asian in 500 B.C. mostly in Malaysia, plantain can be considered as the variety of banana which is generally not eaten raw due to is non-sweet flavor, plantain belong to the family of (musaceae). There are many ways to utilize the plantain, from fruits till its wastes. The fruit can be cooked, or processed becoming candy or liguor. The rotten fruit can be processed to feed poultry, pigs and other animals. The leaves can be use in wrapping food. The plantain stems contain fibre, plantain as of 2004 was grown in a total of 52 countries which were said to be world's producer of plantain, producing a total of 33million metric tons. Despite the down trend of plantain production in Nigeria between 1990 and 2004 it was still ranked fifth in the world with eight African countries name among the top ten plantain producers in the world. Plantain is grown in at least 107 countries with world's production of over 76 million metric tons with a downward trend in terms of plantain yields per hectare in Nigeria. Currently Nigeria ranks sixth and is the world's largest producer in west Africa with and annual production of about 2.4 million metric tons mostly obtained from the southern states. Despite its prominence, Nigeria does not feature among plantain exporting nation; it produces more for local consumption than export.

The production of activated carbon from plantain stem has potential economic and environmental impacts firstly, it converts unwanted low value agricultural waste to high value adsorbents secondly, activated carbons are increasingly used in water to remove organic chemicals and economic concern. Finally, it will reduce the important of activated carbon wherefore increasing our economic base as a country.

Activated carbon is an amorphous form of carbon in which the high degree density has been developed during manufacturing or treating. This high degree of porosity and associated large surface area make it and excellent adsorbent for a wide variety of heavy metals in both liquid and gaseous phases (Olatunji et al, 2017). The use of carbon dates back to ancient Egypt (1500BC) where it was employed for medicinal purpose. Later in ancient Greece, wood chars were used to treat host of alignments (Yehaskel, 1978). In 18th century, and application was found for the removal of foul odors from gangrene (Al-Omair and El- Sharkawy, 2001). Subsequently, the application of charcoal was used mainly as decolorizing agents for sugar (Sun and Xu 1997). A wide variety of agricultural by-products and agricultural waste comprising mostly cellulose matrix were tried by different workers for the removal of heavy metals from their aqueous solution. This include pine bark (Al-Asheh*et al.*, 2000), saw dust (Argun*et al.*, 2007), cotton (Ozsoy and Kumbur, 2006), fibre (James *et al.*, 2007) biomass of fungi and yeast (Kumud and Emilia, 2007), *Carica papaya* seed (Omeiza*et al.*, 2011), etc. The preparations of activated carbon from agricultural wastes is motivated by cost considerations (relatively cheaper), local generation in developing countries and effectiveness in the removal of heavy metals (Loo, 1974 and Madukasi*et al.,* 2010). This investigated the efficiency of activated carbon produced from plantain stem in the adsorption of three selected heavy metals (cadmium, copper and chromium) from their aqueous solutions under variable factors such as: agitation speed, agitation time, particle sizes, pH, initial concentration of the adsorbate and different chemical activation among others.

Nigeria is one of the West African Country that consumes plantain, the plantain stem is dumped as a waste, but this agricultural waste that is obtain from plantain stems can be used in the production of activated carbon and biofuel which can be used by industries and also for economicgrowth of any developing country. Plantain is easier to find, and is affordable in Nigeria, conversion of plantain stem into activated carbon is essential because the activated carbon that will be produces will help the economic and environment in various ways such as water purification, medicine, air filters, gas purification decaffeination, gold purification and compressed air and many other applications.

Therefore the objectives of this research work are: To prepare activated carbon from plantain stem through pyrolytic process; to characterized the activated carbon produced with different activating agents and determination of physiochemical properties of the activated carbon produced.

II.   MATERIALS AND METHODS

Materials
Equipment used: The equipment used in the experiments were: electronic weighing balance was used to weigh the plantain stems before pyrolysis, while a more sensitive (+0.001) balance (Adams AFP 360L) was for other analysis. A laboratory electrical oven, Laboratory electric muffle furnace (Type: OH85TR), locally fabricated pyrolysis reactor with thermocouple, mortar andpistol, graduated cylinder, Spectrophotometer Nitric acid, sulfuric acid, crucible, desiccator, stop watch, Funnel, Standard iodine solution, Thiosulphate solution, Starch indicator, Burette, clamped stand, polyethylene bag, distilled water, Effect of Nitric and sulfuric acid on activated carbon from the pyrolysis of plantain stem analysis was carried out at the Chemical/petrochemical laboratory, AkwaIbom State University, MkpatEnin, AkwaIbom State, Nigeria.

Methods
Precursor selection: The substrate is plantain stem, cultivated from local farm, peel and process at AkwaIbom State University, Nigeria.
Particle sizes separation:
The stem of plantain precursor passed through manual standard sieved size of 2.80mm. Thereafter, the sieve fraction was collected and weighed 700g for thermo-cracking process.
Carbonization Process: This is a process in which organic substance can be converted into carbon through thermo-chemical or decomposition known as pyrolysis.800g of solid plantain fibers were introduced into petri-dish and pre weighed petri-dish with the sample. The samples were dried in the oven for one hour at 100^0C, the process was. The samples were pre weighed again and the final weight were introduced into a pyrolysis reactor at initial product temperature of $30\ ^0$C, the speed of heating (regulated on the level of (T)) was maintained at every 10 minute. Around $35\ ^0$C, very intense white vapors were observed. On the walls of the two condenser, first drop of a black liquid of oily aspect of which the quantity increased as the temperature goes up was also observed. The final product temperature was at 151^0C depending on the nature of sample and a steady temperature was obtained for three consecutive time at 10-minute interval, at this point no gaseous emission was observed. The Carbonization lasted for two hours and 10 minutes, meaning that the process is a slow pyrolysis. Thereafter the charred products were transferred into desiccator and allowed to cool to room temperature. Carbonization charred material were poured into the crucible to determine the final weight.
Yield on pyrolysis (carbonization) was calculated from the weight, before carbonization (Wb) and after carbonization (Wa). The % yield is thus calculated as stated in accordance with (Yoshiyuki and Yutaka, 2003).

Yield (%) $= \frac{Wa}{Wb} \times 100$ **(1)**

Wa and Wb = weight of carbon after and weight of sample before carbonization.

Activation (step process):
After achieving the carbonized materials of plantain stem, the activation was thus carried out in chemical activation using HNO_3 and H_2SO_4 at different concentrations.
In chemical activation; concentration of activated agent (nitric acid) were prepared on the basis of 0.05M, 0.1M, 0.2M, 0.3M and neutral. The duration of impregnation ratio was maintained at 4 hours for all samples. 10g of each carbonized precursor were weighed and mixed in a separate beaker containing 30 ml of activating agents (HNO_3) and H_2SO_4. The precursor mixtures were transmitted into crucible and laid to a muffle furnace at 600^0C for one hour activated sample was then remove and put to desiccator cooled at room temperature. The activated carbon generated above were washed with distilled water to removed residual acid and washing was complete when pH value of 7 was determined, and dried in an oven at 105^0C for three hours. The final product was kept in an air tight polyethylene bag, ready for use. According to (Fapetu, 2000), the yield of activated carbon is defined as the ratio of the weight of the resultant activated carbon to that of the original precursor with both weight on a dry basis.

% yield $= \frac{Wi}{W0} \times 100$ **(2)**

Characterization of Adsorbent
Activated Carbon Yield Determination
The dried weight, Wca of each activated carbon sample was determined and the activated carbon yield (ACY) was calculated as follows;

Activated carbon yield $= \frac{Wca}{Wf} \times 100$ **(3)**

Fapetu (2000) activated carbon sample, Wf = weight of activated carbon retrieved from Where, Wca = oven dried weight of the furnace.

Percentage Burn off Determination
10g of each carbonized char were perfectly weighed and noted to be Wa and also allowed to pass through activating process step at 600^0C for one hour, thereafter the sample were weighed and noted as Wi.

% burnoff $= \frac{Wa-Wi}{Wa} \times 100$ Itodo et al., (2008). **(4)**

Bulk Density Determination
The particle bulk density was determined using Ahmedna, (1997), procedure as follows: An empty measuring cylinder was weighed and the weight noted. The cylinder was then filled with a sample of activated carbon from mango seeds and gently tamped until no more change in the level of the sample in the measuring cylinder was noticed. The volume occupied by the packed sample was recorded and noted. If Wc is the weight of empty cylinder and W is the weight of cylinder and sample, then weight of sample; Ws=W-Wc. Vs is the volume occupied by the packed sample.

Then, Bulk Density (Bd) = $\frac{Ws}{Vs}$ **(5)**

Surface Area Determination

The diameter (assuming spherical shape) of the activated carbon was obtained by passing the crushed carbon through sieve size of 2.80μm and the external surface area was calculated by the relation;

Surface area, SA = $\frac{6(cm)^3/g}{BbPd}$**(6)**

Where,
Bd = bulk density
Pd= particle size (particle diameter)

Moisture Content Determination (MC %)

Thermaldrying method was used in the determination of moisture content of the samples. 1.0g of the dried activated carbons was weighed and placed in washed, dried and weighed crucible. The crucibles were placed in an oven and dried at 105°C to constant weight for 1 hour. The percentage moisture content (MC %) was computed as follows.

(MC %) = $\frac{Wi}{Wa} \times 100$ **(7)**

Where,
Wi = Loss in weight on drying
Wa=Initial weight of sample

Determination of Ash Content (AC %)

The standard test method for ash content –ASTM D2866-94 was used.
1.0g activated carbon was taken, dried in an oven at a temperature of 105 ^{0}C for one hour.
The final weight after drying was measured and recorded as (Di = oven dry weight).
Thereafter the dried activated carbon was sent to muffle furnace and the temperature was allowed to rise until it reaches 450- 500 ^{0}C. It was removed from the muffle furnace and allowed to cool in a desiccator to room temperature and reweighed again and it weight was recorded as (Df = ash weight).
The percentage ash content was determined as thus;

(AC% $= \frac{Df}{Di} \times 100$ **(8)**

Where; Di - initial weight of sample, Df- final weight sample

Determination of Iodine Number

 Procedure of the iodine value test:
I Standardization of Iodine solution
* 10ml of 0.1M Iodine solution was taken in conical flask.
* 1 drops of Starch solution were added to it.
* The pale yellow color of Iodine Solution turned Blue.
* Titration of the formed solution was done with 0.100 M Sodium Thiosulphate till it becomes
Colorless.
* Burette reading corresponds to blank reading. (B)
II
* 0.2 g of Activated carbon was weighed very accurately.
* It was introduced into the Iodine flask which should be completely dry.
* 30ml of 0.1M Iodine solution was then added.
* The flask was shaken properly and leave for 24 hours and then filtered.
* The filtrate was collected in a dry flask and then 10g of the filtrate was titrated against
Standard Sodium thiosulphate solution using starch as indicator
Burette reading corresponds to (A)
Calculations involved in iodine adsorption number is as follows

$= \frac{B-S}{B} \times \frac{V}{W} \times M \times 126.91$ **(9)**

Where M = molarity $\left\{\frac{mol}{dm^3}\right\}$
     B = blank reading (ml)
     S = volume of thiosulphate used (ml)
      V = volume of iodine used. (ml)
      W = weight of sample used. (g/kg)

Fixed carbon
The standard test method for ash content –ASTM D2866-94 was used.
1.0g activated carbon was taken, dried in an oven at a temperature of 105 ^{0}C for one hour.
The final weight after drying was measured and recorded as (Di = oven dry weight).
Thereafter the dried activated carbon was sent to muffle furnace and the temperature was allowed to rise until it reaches 450- 500 ^{0}C. It was removed from the muffle furnace and allowed to cool in a desiccator to room temperature and reweighed again and it weight was recorded as (Df = ash weight).
The percentage ash content was determined as thus;

$$(AC\% = \frac{Di-Df}{Di} \times 100 \; Dara(1991)$$

(10) Where;

Di - initial weight of sample, Df- final weight sample

Methylene Blue Number

The Methylene blue number is defined as the maximum amount of dye adsorbed on 0.5g of adsorbent. In this method, 0.5g of activated carbon was placed in contact with 30.0ml of 1g/l L Methylene blue solution for 24 hours at room temperature followed by intermittent shaking. The solution was thereafter filtered using What man number one filter paper and an aliquot room temperature and the solution was taken for analysis. The remaining concentration of Methylene blue was analyzed using an Atomic Adsorption Spectrophotometer. The amount of Methylene blue adsorbed was calculated using the mass balance equation as follows:

$$qe = \frac{Co-Ce}{M} V \; Cleiton \; et \; al., (2011)$$

(11)

Where Co = Equilibrium concentration of methylene blue (1000 conc. prepared)
Ce = initial concentration of methylene blue (cy = standard curve equation = 1.4674x + 1.1876 for H_2SO_4 and 1.4426x +1.1991 for HNO_3)

M = 0.5g of activated carbon
V = volume of methylene blue used = 30ml.
The liquid phase of the extract was measured at 480 nm using spectrophotometer model: 721. The total methylene blue number in activated carbon was estimated with reference to standard
curve derived from methylene blue concentration mixed with 0.5g activated carbon using water as the blank, total methylene blue data was fitted to equation below.

$$qe = \frac{Co-Ce}{M} V$$

(12)

Loss-on-ignition
0.5 grams of activated carbon that passed through a sieve of 2.80 mm mesh was further dried at 105 ºC. The samples were subjected to calcination for 5hrs at 300 ºC (Miyazawa et al., 2000). Subsequently, the samples were weighed and the difference between the initial and final mass corresponded to the loss on ignition of activated carbon.
Loss on ignition % = Co – Ce x 100   **(13)**
Where Co = initial mass of activated carbon.
Ce = final mass of activated carbon.

Pore Volume
The sample (1 g) was collected and transferred completely into a 10 ml measuring cylinder in order to get the total volume of the sample. The sample was then poured into a beaker containing 20 ml of deionized water and boiled for 5 min. the content in the beaker was then filtered, superficially dried, and weighed. The pore volume of the sample was determined by dividing the increase in weight of the sample by the density of water (Aneke and Okafor 2005).

III.   RESULTS AND DISCUSSION
Pyrolysis Process Conversion of Plantain Stem into Char
        Figures 1- 4,shows the scattered plot, surface plot and contour plots respectively obtained from pyrolytic conversion of plantain stem into char.
        700 grams well dried plantain stem were introduced into a pyrolysis reactor at initial product temperature of 30 ^{0}C, the speed of heating (regulated on the level of (T)) was maintained at every 10 minute. Around 35 ^{0}C, very intense white vapors were observed on the walls of the two condenser, first drop of a black liquid of oily aspect of which the quantity increased as the temperature goes up was also observed. The final

product temperature was 151^0C and final product volume was at 190 ml depending on the nature of sample and this was obtained by having a steady temperature for six consecutive time at 10-minute interval, at this point no gaseous emission was observed. The Carbonization lasted for two hours, ten minute simply means that the process is a slow pyrolysis. Thereafter the charred products were transferred into desiccator and allowed to cool to room temperature. Carbonization charred material were poured into the crucible to determine the final weight. It was observed that the time of residence of sample in the reactor also influences the yield of the final material; the higher the activated carbon is maintained at the maximum temperature, the lower the yield.
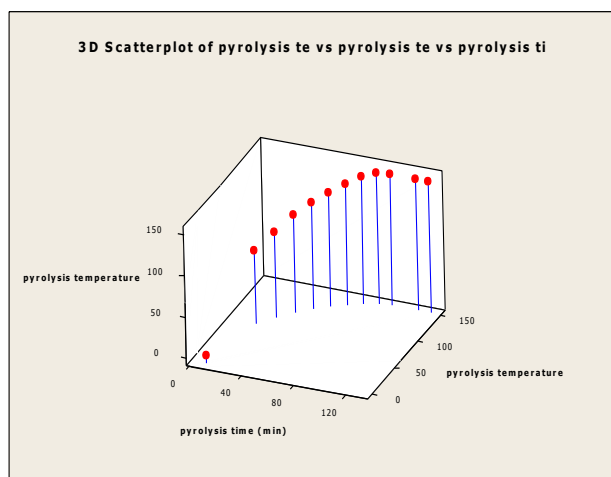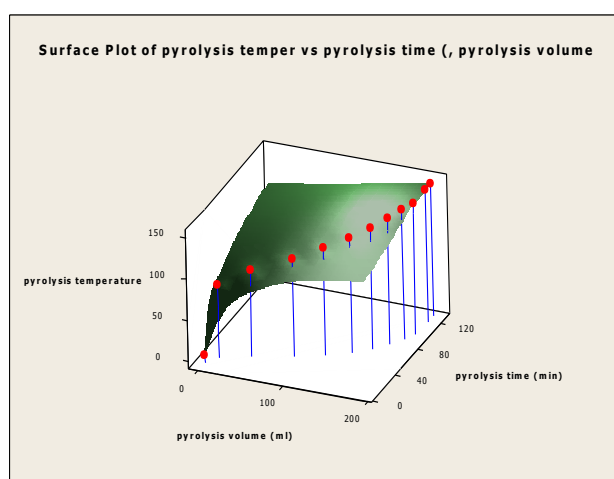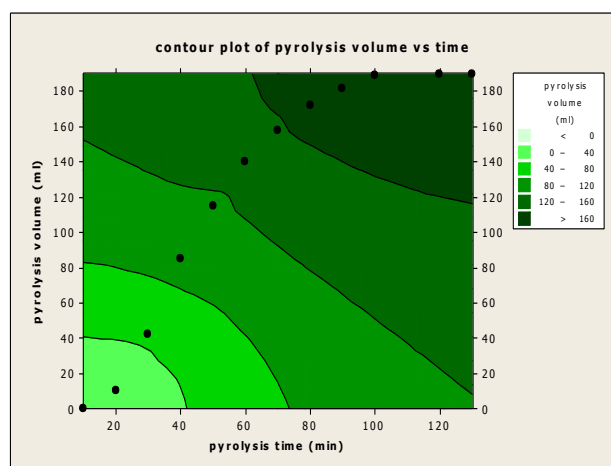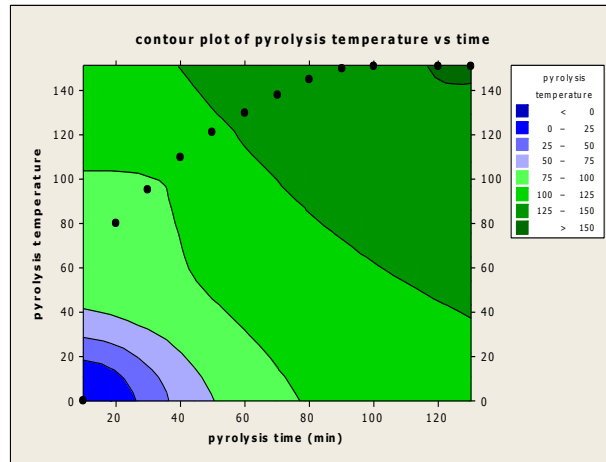
Figure 1

Figure 2

Figure 3

Figure 4

Effect of Nitric and sulfuric acid activation on the Yield of Activated Carbon from plantain stems

Figure.5 shows the results obtained from difference chemical activation agent. Generally, this data reveals that the impregnation ratio strongly influences the yield. Indeed, the higher the impregnation ratio, the higher the yield of the final material, the time of residence also influences the yield of the final material; the higher the activated carbon is maintained at the maximum temperature, the lower the yield. Chemical activation was observed to favor plantain fiber. The results obtained were compared to the reported average yield by Otaru*et al.,* (2013) and Mohammed Abedi and ZakerBahereini (2013) respectively. H_2SO_4 activation was observed to have 77% as the overall best higher than HNO_3 with 76%.

Table 4.2 Data's for yield (%) of Activated Carbon from Plantain Stem

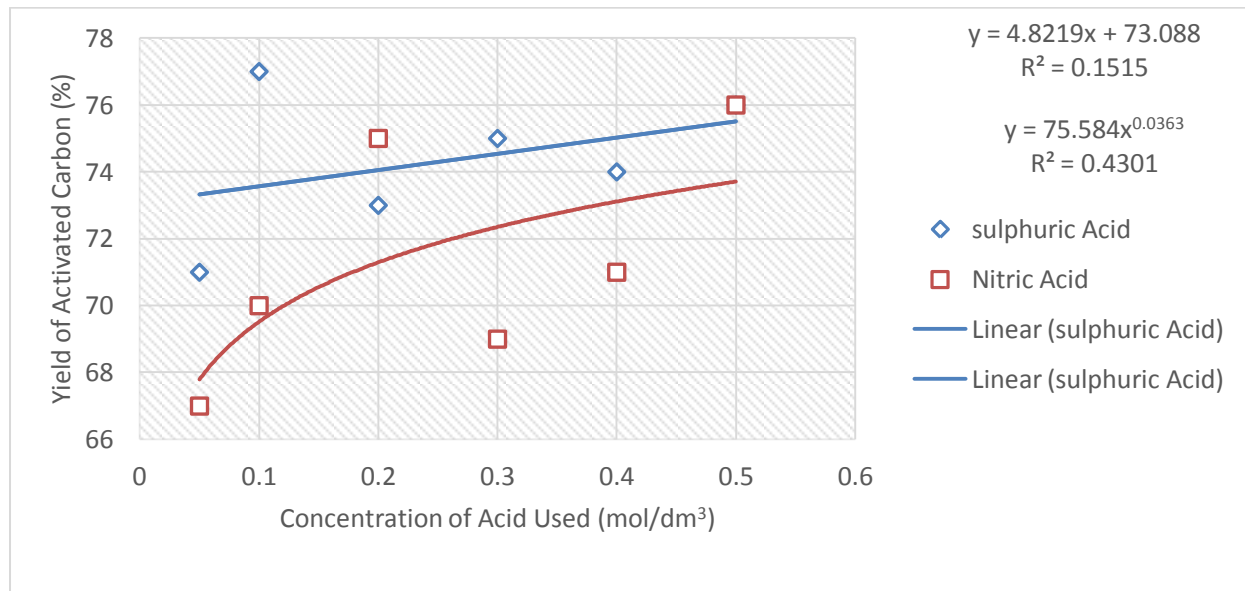| S\N	H_2SO_4	HNO_3
0.05	71	67
0.1	77	70
0.2	73	75
0.3	75	69
0.4	74	71
0.5	76	76

Figure 5: Showing the effect of Nitric and sulfuric acid activation on the Yield of Activated Carbon from plantain stems

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Effect of Nitric and sulfuric acid activation on the Percentage Burn Off of Activated Carbon from plantain stems

Figure 6, shows the percentage burnoff of carbons during activation. It was observed that activation burnoff is high with a resultant low % yield at 24 hrs activation dwell time. The expected low yield with a corresponding high burn off is more feasible for the one stage process. The results gotten from this work also give a proof that more volatiles are released from the char at longer dwell time, thereby resulting to higher burnoff with reduced yield. This corroborate the findings of (Ahmedna*et al.*, 2000). The results also investigated that burn-off was higher in HNO_3 with 33% than H_2SO_3 with 29%.

Table 4.3 Data's for percentage burnoff (%) of Activated Carbon from plantain stems

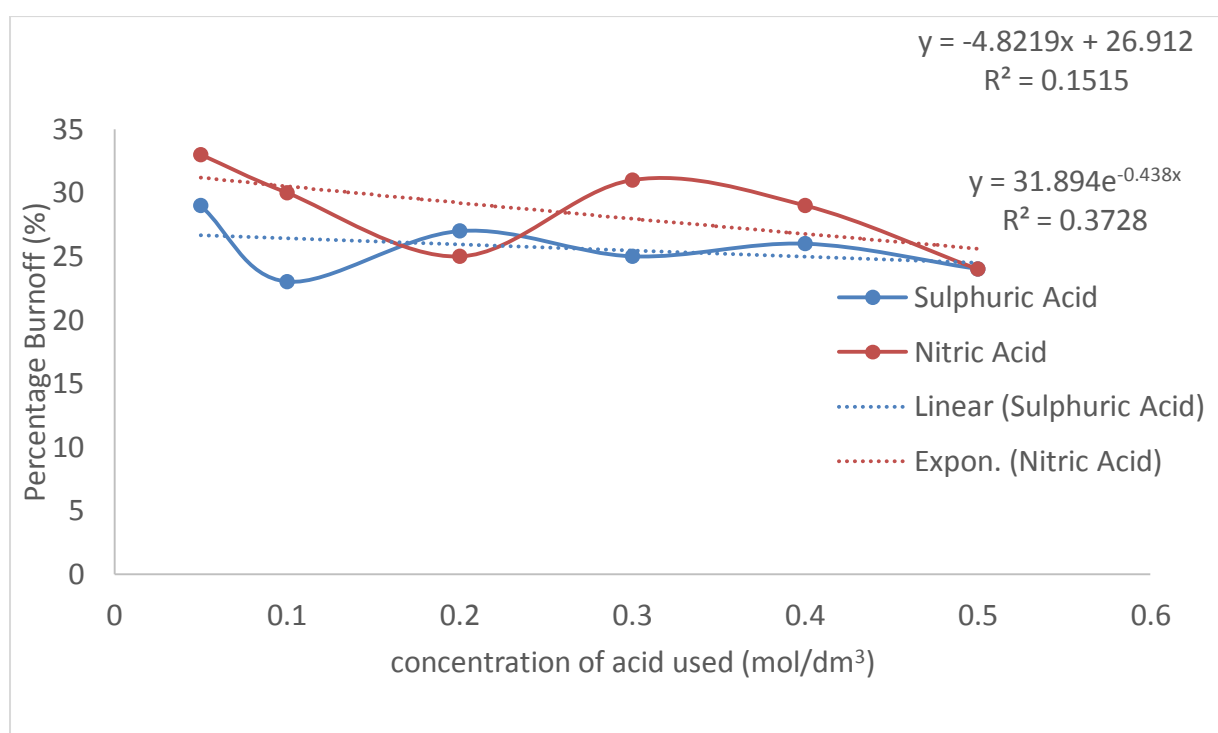| S\N	H_2SO_4	HNO_3
0.05	29	33
0.1	23	30
0.2	27	25
0.3	25	31
0.4	26	29
0.5	24	24

Figure 6. Showing the effect of Nitric and sulfuric acid activation on the percentage burn off of Activated Carbon from plantain stems

Effect of Nitric and sulfuric acid activation on the surface area of Activated Carbon from plantain stems

The surface area from the results obtained was found to be 1152 m²/g as the highest using H_2SO_4 activation and 963m²/g was reported as the highest for HNO_3 activation. In this work the inquiry carried out in the laboratory proven that H_2SO_4 generated the best surface area. The surface area obtained from this work is in conformity with (Mohammed et al., 2015). It was observed that there is variation of surface area because of different in concentration of activated agent used. The variation in surface area is as a result of chemical added. In addition to the surface area the performance of activated carbon is also influenced by surface chemistry. The different heteroatoms on the surface of activated carbon govern its chemistry. Hetero atoms such as oxygen, nitrogen and hydrogen are borne to peripheral carbon atoms and exist as organic functional groups.

Table 4.4 Data's for surface area(cm²/g) of the activated carbon from plantain stems

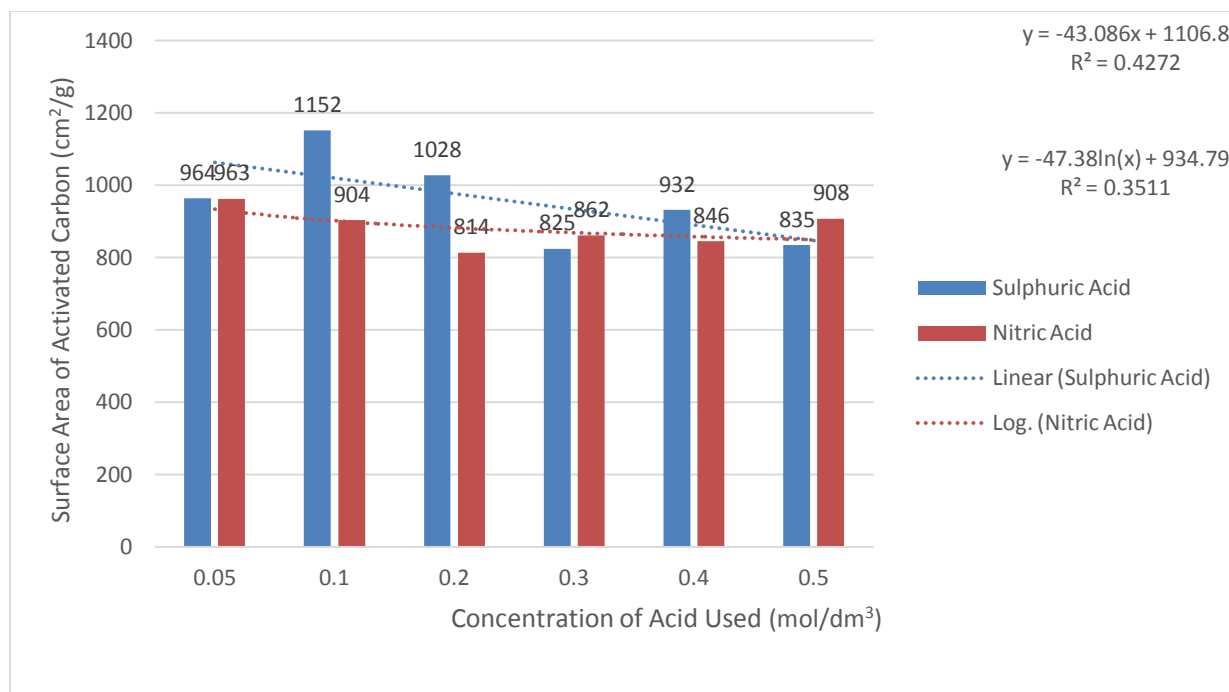| S\N	H₂SO₄	HNO₃
0.05	964	963
0.1	1152	904
0.2	1028	814
0.3	825	862
0.4	932	846
0.5	835	908

Figure 4.4. Showing the effect of Nitric and sulfuric acid activation on the surface area of Activated Carbon from plantain stem

Effect of Nitric and sulfuric acid activation on the moisture content of Activated Carbon from plantain fibers.

The moisture content in this work from the graph above was found to fall between 17-30%.

Moisture content, according to Olatunji et al., (2011) has a relationship with porosity (α) of a given carbon. Adsorbent with high moisture content is expected to swell less, thus retarding pore size expansion for adsorbate uptake.

Table 4.5 Data's for moisture content(%) of the Activated Carbon from plantain stems

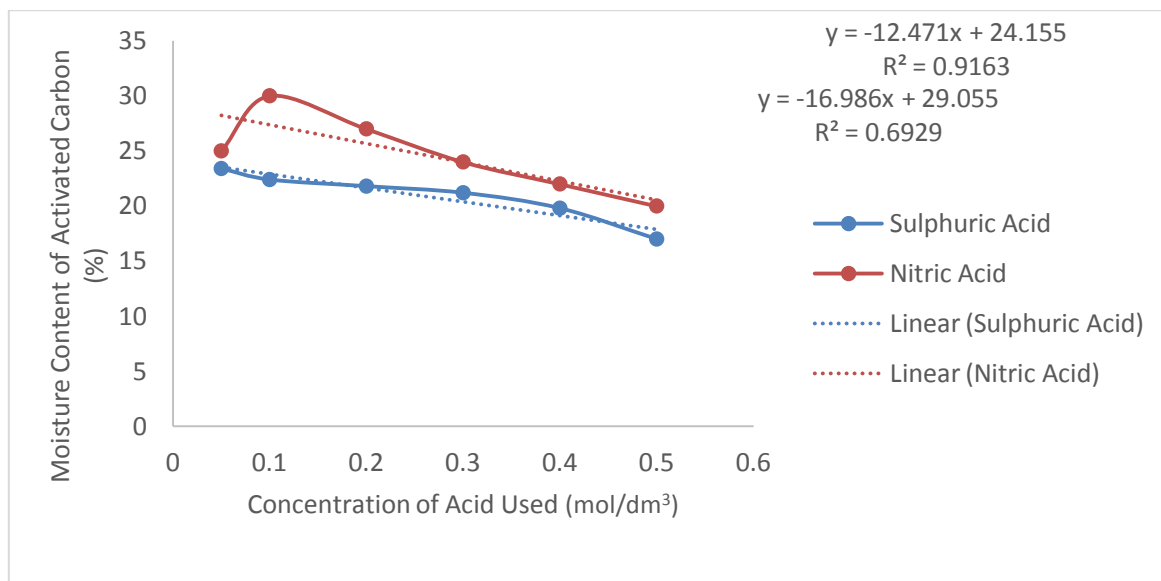| S\N	H₂SO₄	HNO₃
0.05	23.4	25
0.1	22.4	30
0.2	21.4	27
0.3	21.2	24
0.4	19.8	22
0.5	17	20

Figure 4.5. Showing the effect of Nitric and sulfuric acid activation on the moisture content of Activated Carbon from plantain stems

Effect of Nitric and sulfuric acid activation on the ash content of Activated Carbon from plantain stem.

Figure 4.6 below shows exact amount of carbon that has turned into ash during activation in furnace at 500^0c for one hour. Ash is a measure of inorganic impurities in the carbons (Bansode*et al.*, 2003). The ash content in this research was found to be 66.8% using H_2SO_4 activated agent which is in range of most ash content of agricultural waste.

Table 4.6 Data's for ash content of the activated carbon from plantain stems

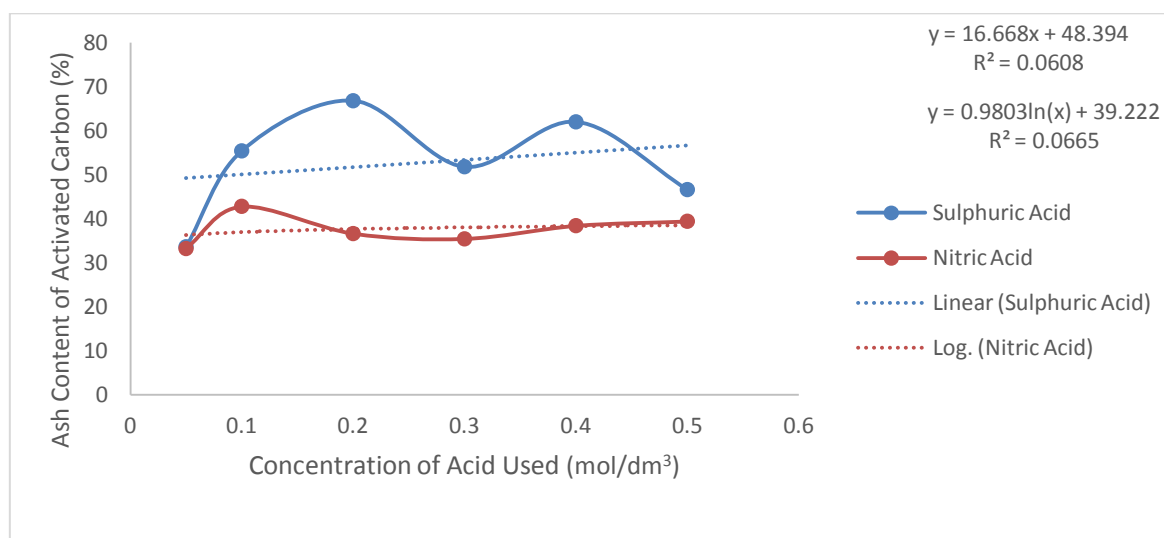| S\N	H_2SO_4	HNO_3
0.05	33.6	33.2
0.1	55.4	42.8
0.2	66.8	36.6
0.3	51.8	35.4
0.4	62	38.4
0.5	46.6	39.4

Figure 4.6. Showing the effect of Nitric and sulfuric acid activation on the ash content of Activated Carbon from plantain stems

Effect of Nitric and sulfuric acid activation on the fixed content of Activated Carbon from plantain stems.

Figure 4.7 shows the amount of carbon that has remained after volatile, ash and moisture content has been removed. Fixed Carbon content is the residual amount of carbon present in the sample. The results

obtained from H_2SO_4 activation agent shows that fixed carbon content is 66.8%. This is in concord with the findings of Malik et al., (2006) who reported that most of the carbon composition of A.C falls within 33-66.8%. It was observed that fixed carbon is high with a resultant low ash content.

Table 4.7 Data's for fixed content of activated carbon from plantain stems

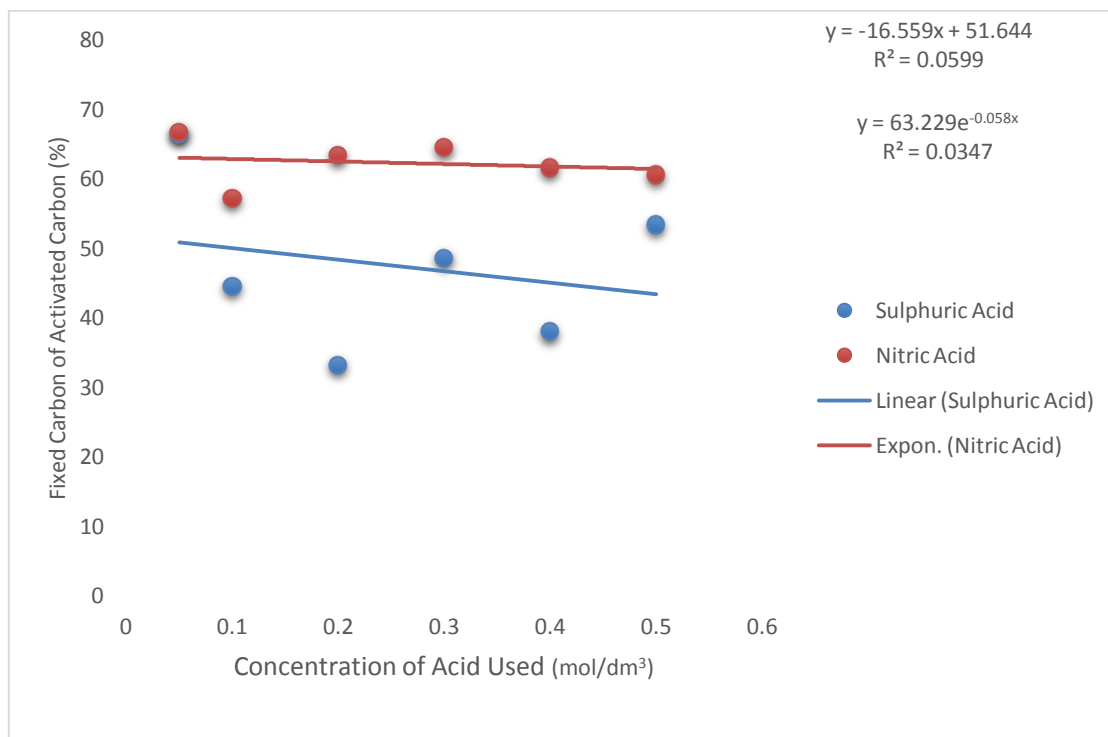| S\N	H_2SO_4	HNO_3
0.05	66.4	66.8
0.1	44.6	57.2
0.2	33.2	63.4
0.3	48.6	64.6
0.4	38	61.6
0.5	53.4	60.6

Figure 4.7. Showing the effect of Nitric and sulfuric acid activation on the fixed content of Activated Carbon from plantain stems

Effect of Nitric and sulfuric acid activation on the bulk density of Activated Carbon from plantain stems.

Figure 4.8 Bulk density shows the fiber content of the adsorbent from different activated carbon. It was observed that 0.2M concentration of HNO_3 gave the highest bulk density. The density of a generated activated carbon plays a great role on adsorbate uptake. Generally, higher density carbons hold more adsorbate per unit volume (Jibril, *et al.*, 2007). According to Itodo*et al.,* (2008) bulk density has impact on adsorbate-retention level by any adsorbent. An adsorbent with bulk density need not be regenerated frequently because it can hold more adsorbate per unit weight. With difference in activation agents used, the results are in line with (0.165g/cm^3) commercial bulk density of activated carbon.

Table 4.8 Data's for bulk density (g/cm^3) of activated carbon from plantain stems

S\N	H_2SO_4	HNO_3
0.05	0.2223	0.2225
0.1	0.1860	0.2363
0.2	0.2083	0.2619
0.3	0.2597	0.2484
0.4	0.2297	0.2532
0.5	0.2561	0.2359

$$y = 0.114x + 0.1976$$
$$R^2 = 0.4972$$

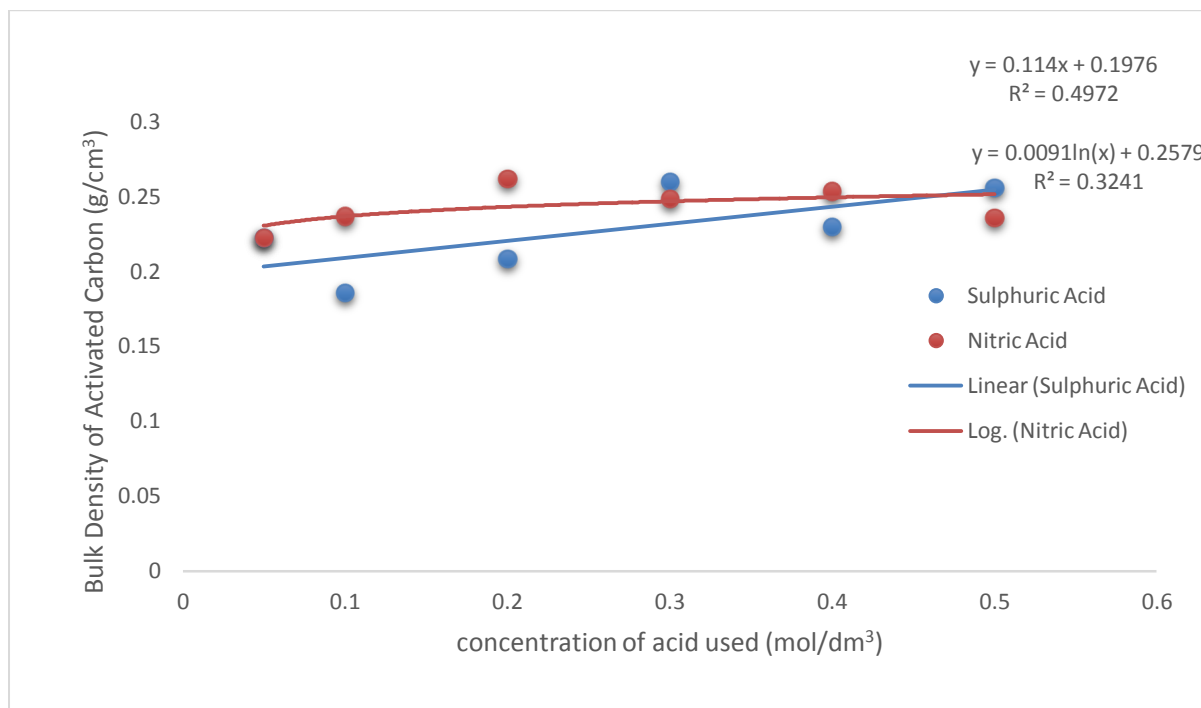$$y = 0.0091\ln(x) + 0.2579$$
$$R^2 = 0.3241$$

Figure 4.8. Showing the effect of Nitric and sulfuric acid activation on the bulk density of Activated Carbon from plantain stems

Effect of Nitric and sulfuric acid activation on the Iodine number of Activated Carbon from plantain stems.

Figure 4.9 Shows effect of Nitric acid activation on the iodine number of different activated carbon from plantain stem. Iodine number for commercial adsorbent range from 300 to 1200g/kg and above is good. In the other words the results of adsorptive property obtained indicates that plantain stems is a very good source of raw material for the production of activated carbon of high efficiency. Iodine number of this work is within the range of Malik *et al.,* 2005. It was observed that there was much effect on all the concentrations. From experimental results obtained it was observed that H_2SO_4 activation attained the highest iodine number.

Table 4.9 Data's for iodine number (g/kg) of activated carbon from plantain stems

S\N	H_2SO_4	HNO_3
0.05	1337.1	1155.7
0.1	1133.1	1246.44
0.2	1178.5	1269.1
0.3	1155.8	1087.8
0.4	1291.8	1201.1
0.5	1269.1	1042.5

$y = 73.293x + 1208.6$
$R^2 = 0.0238$

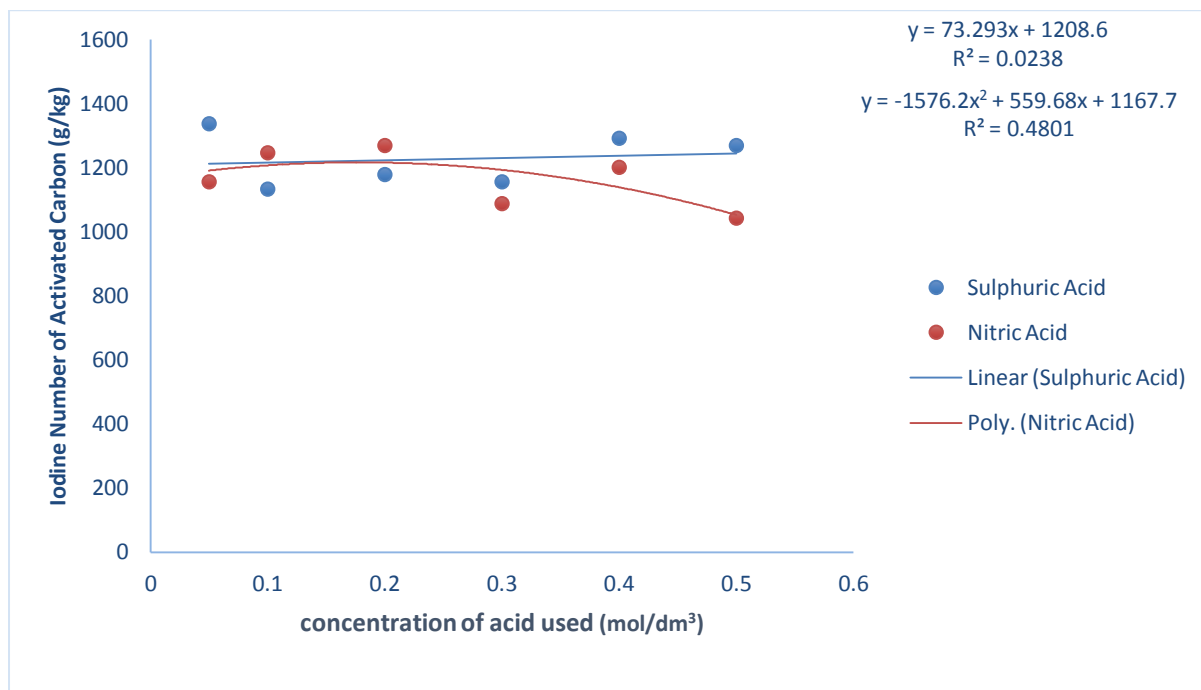$y = -1576.2x^2 + 559.68x + 1167.7$
$R^2 = 0.4801$

Figure 4.9. Showing the effect of Nitric and sulfuric acid activation on the Iodine number of Activated Carbon from plantain stems

Effect of Nitric and sulfuric acid activation on the methylene blue number of Activated Carbon from plantain stems

Figure 4.10 shows that the Methylene blue number is correlated with ability of activated carbon to absorb color and high molecular weight substance. It was observed for the sample that color reduction was proportional to the quantity of activated carbon used. For instance, using 0.5g of the activated carbon on the methylene blue concentration, the color was reduced to light blue from the original deep blue color. The observed increase in color reduction with the quantity of activated carbon is probably due to the availability of more adsorption sites until saturation point is attained. This could also be as a result of an increase in the collision frequency between the molecules of the coloring matter and the activated carbon. It was observed that 0.05 concentration of H_2SO_4 has the best methylene blue number of 59.8713.

Table 4.10 Data's for methylene blue number (g/kg) of activated carbon from plantain stems

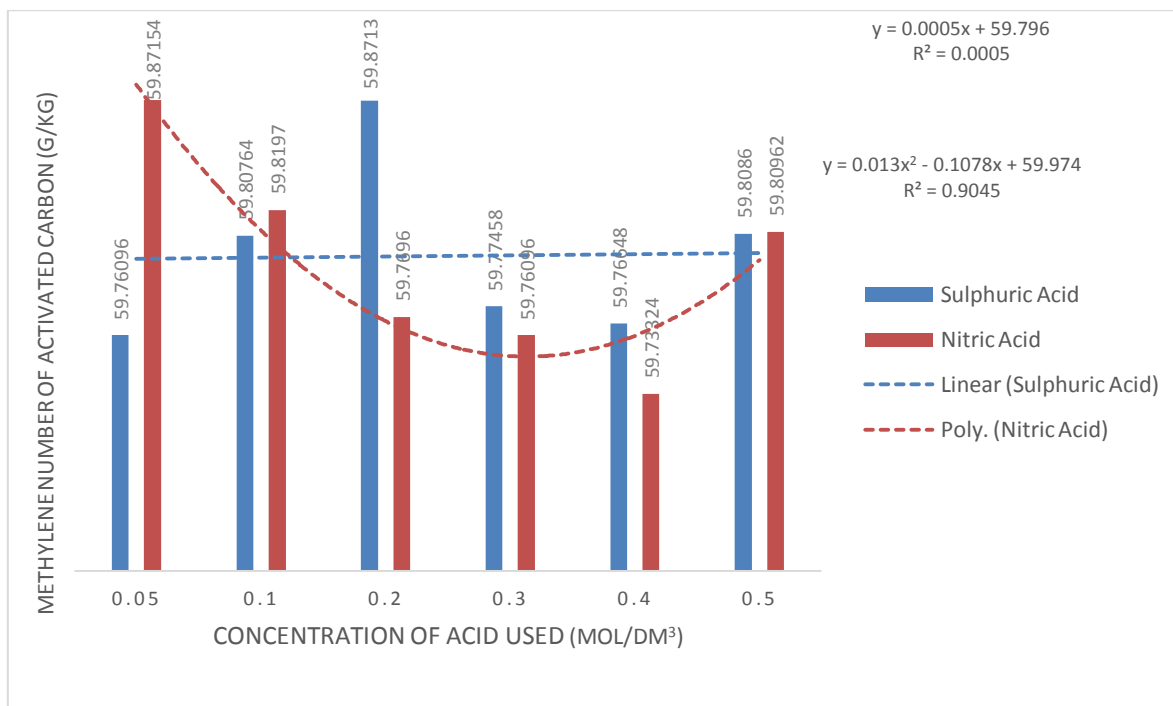| S\N	H_2SO_4	HNO_3
0.05	59.760	59.871
0.1	59.807	59.819
0.2	59.871	59.769
0.3	59.774	59.760
0.4	59.764	59.733
0.5	59.000	59.807

Figure 4.10. Showing the effect of Nitric and sulfuric acid activation on the methylene blue number of Activated Carbon from plantain stems.

Effect of Nitric and sulfuric acid activation on the percentage loss on ignition of Activated Carbon from plantain stems.

Figure 4.10Shows the percentage loss on ignition of activated carbons during activation. It was observed that at 300 $^{o}_{C}$ for 5 hours volatile substances of activated carbon escaped and the mass ceases to change.

Table 4.11 Data's for percentage loss on ignition (%) of activated carbon from plantain stems

S\N	H_2SO_4	HNO_3
0.05	34.9	21.3
0.1	36.8	30.4
0.2	37.1	32.1
0.3	41.2	47.6
0.4	36.7	31.6
0.5	31.5	33

$y = -4.8219x + 37.612$
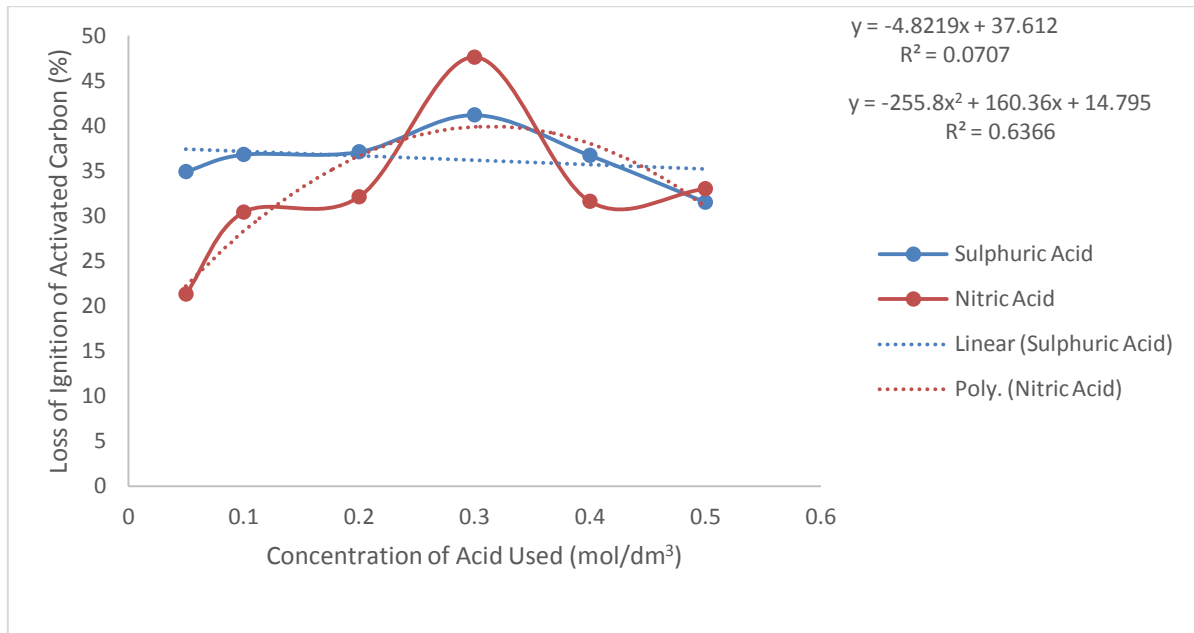$R^2 = 0.0707$

$y = -255.8x^2 + 160.36x + 14.795$
$R^2 = 0.6366$

Figure 4.11. Showing the effect of Nitric and sulfuric acid activation on the percentage loss ignition of Activated Carbon from plantain stem.

Effect of Nitric and sulfuric acid activation on the pore volume of Activated Carbon from plantain stems.

Figure 4.12. Shows the pore volume of activated carbons during activation. The total volume of very small openings in a bed of adsorbent particles was observed. The results obtained shows rapid access of absorption during activation of carbon particles. The results obtained were compared with those of (Hameed et al., 2006, Ademiluyi et al., 2008 and Inyang et al., 2010).

Table 4.12 Data's for pore volume (g/ml) of activated carbon from plantain stems

S\N	H_2SO_4	HNO_3
0.05	0.75	0.52
0.1	1.13	0.82
0.2	1.04	1.03
0.3	0.6	0.84
0.4	1.64	0.61
0.5	0.82	1.16

$y = 0.0411x + 0.8527$
$R^2 = 0.0434$
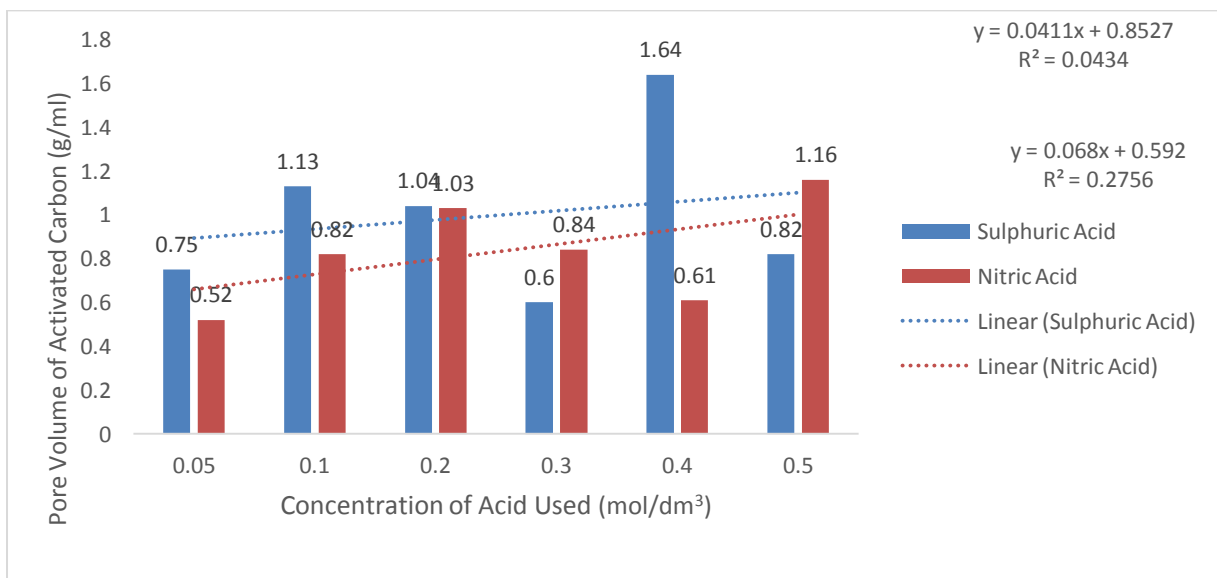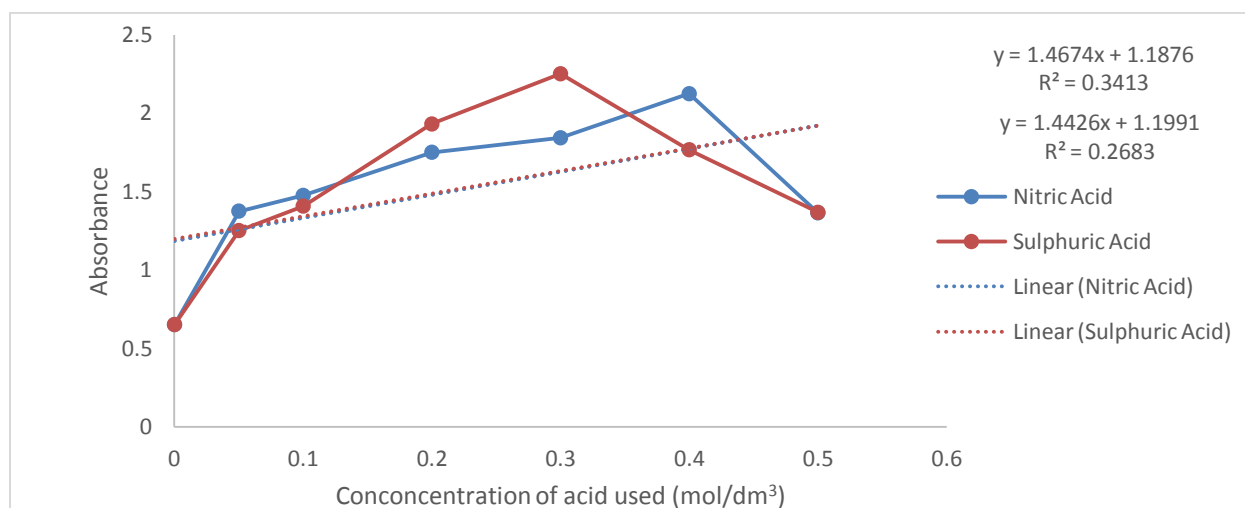
$y = 0.068x + 0.592$
$R^2 = 0.2756$

Figure 4.12. Showing the effect of Nitric and sulfuric acid activation on the pore volume of Activated Carbon from plantain stems.

Table 4.13 Data's for standard curve derived from methylene blue concentration

S/N	H_2SO_4	HON_3
0.0	0.653	0.653
0.05	1.252	1.376
0.1	1.408	1.476
0.2	1.931	1.751
0.3	2.251	1.843
0.4	1.767	2.124
0.5	1.368	1.365

Figure 4.13 Shows standard curve derived from methylene blue concentration

IV. CONCLUSION

From the experimental observation of the research work, result and analysis can be inferred that the plantain stem sample use as activated carbon have these:

It is cheap, good alternative source for activated carbon production and the one step activated method of preparation with suitable activating agent and agitation time can be employed.

The adsorption process is highly dependent on particle size, activating agents, adsorbent dosage, agitation speed, pH and initial concentration.

The adsorption capacity of activated carbon prepared from plantain stem with both acid and base activators have comparable strength adsorption rate which is not higher than commercial activated carbon.

V. RECOMMENDATION

Ability of the adsorbent to be employed in the treatment of water dispensed for public consumption should be investigated. Solid phase adsorption of gas should be examine. Use of other activating agent like KOH, HCL among others. Study the adsorption process using zinc, lead and copper.

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