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PRODUCTION AND CHARACTERIZATION OF BAMBOO ACTIVATED CARBON USING DIFFERENT CHEMICAL IMPREGNATIONS FOR HEAVY METALS REMOVAL IN SURFACE WATER

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ABSTRACT

The level of heavy metals concentration in surface water is increasing due to human activities. In view of this, this study was aimed at producing and characterizing bamboo activated carbon with different chemical impregnation for the removal of heavy metals from surface water. Bamboo materials were obtained from Gidan Kwano forest in Minna, Niger State. The bamboo materials were crushed into 0.180 mm and carbonized at temperature 450 ^oC and activated using a chemical activation process. The Brunauer Emmet Teller (BET) and Langmiur method were used to determine the surface area and pore volume. The results revealed that the interaction of bamboo activated carbon with sulphuric acid (H_2SO_4) had large area than nitric acid (HNO_3). The surface area values under BET and Langmuir method for bamboo activated carbon with sulphuric acid were 825.456 and 4373.34 m^2/g while that bamboo activated carbon with nitric acid were 650.359 and 4145.78 m^2/g respectively. This study concluded impregnated bamboo activated with sulphuric acid (H_2SO_4) had large surface difference under BET and Langmuir method. Bamboo activated with sulphuric acid (H_2SO_4) was found to be the better for removing heavy metal in surface water because the percentage of heavy metal removal were 65 % (Pb), 47 % (Al) and 37 % (Cu) whereas for nutric acid, amount removed were 47% (Pb), 38 % (Al) and 32 % (Cu). The study suggests that bamboo activated carbon impregnated sulphuric acid (H_2SO_4) be produced in large scale to remove heavy metal in surface water for irrigation purposes.

1. INTRODUCTION

Water treatment issues came from heightening pollution as results of chemical compounds that are unable to be decomposed by living organisms (Ijaola *et al*., 2013). There exist different wastewaters that pollute water bodies (Koo *et al*., 2015). Recently, adsorption technology has established to be the easiest and

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effective way of treating polluted water (Koo *et al.*, 2015). Activated carbon is an absorbent developed from carbonaceous materials such bamboo, corn, sugar cane bagasse etc. It has complex pore structure, large specific surface area, good chemical stability for removing chemical compound from stream water. This is done through physical and chemical processes (Dinesh, 2011).

There are numerous type of activation carbon and these include powdered activated carbon (PAC), granular activated carbon (GAC), extruded activated carbon (EAC), impregnated carbons and polymers coated carbon. Among these type of activated carbon, this study employed powdered activated carbon because of the high surface area to volume ratio. According to Mahanim (2011), activated carbon is used for removal of hazardous substances in exhaust gases for the purification of water either for drinking or irrigation purposes and waste water treatment. It is also used in oil refineries as a support for catalysts, gas storage, dehumidification in mining and in the electronic industry (Santana et al., 2017).

Ijaola *et al.* (2013) examined the efficacy of activated carbon made from bamboo using chemical activation ($ZnCl_2$) and the study revealed that indicative pollution parameter in surface water was reduced to portability level recommended by the World Health Organisation (WHO). Ademiluyi and David-West (2012) examined the effect of chemical activation on the adsorption of heavy metals using bamboo activated carbon and their results bamboo with nitric acid has the highest metal ions adsorption. In addition, bamboo activated with HNO_3 is effective in removing metal ions from stream conveniently (Ademiluyi and David-West, 2012). Evbuomwan *et al.* (2013) assessed the effects of carbonization temperature on some physicochemical properties of bamboo based activated carbon with potassium hydroxide (KOH) activation. Their results showed that the yield decreases with increase in temperature and the specific surface area increases with increase in temperature. The study identified that no work had examined the effect of several chemical impregnation on development of bamboo activated carbon. In view of this, this study aims to produce bamboo activated carbon using different chemical impregnations for heavy metal removal in surface water.

2. MATERIALS AND METHODS

The materials used for this study include bamboo (*Bambusa vulgaris*) which was obtained from Gidan Kwano Forest of Federal University of Technology Minna, Niger State. The reagents used for this study include distilled water, Nitric acid (HNO_3), sulphuric acid (H_2SO_4), Liquid nitrogen and Nitrogen gas. Furthermore, the equipment used for this study include Muffle furnace, Electronic weighing balance, Atomic absorption spectrophotometer (AAS), Cutlass, Porosimeter (ASAP 2020 model from micrometric), Oven (model number: PBS118SF and serial number: 94L234), Buhr mill and Crucibles.

2.1. Preparation of Bamboo Activated Carbon

The bamboo was reduced to 0.25 mm diameter manually using cutlasses as shown in Figure 1. These bamboo pieces were washed with distil water to remove dirt and impurities. The washed bamboo pieces were dried in oven at 105 ^oC for 24 hrs to reduce the moisture content. The sample was later crushed to 0.180 mm via buhr mill (Evbuomwan *et al.*, 2013) (Figure 2). The weight of the total sample crushed was 100 g. This sample was divided into two portions and accurately weighed 50 g each. The first sample was impregnated with 50 mL of sulphuric acid (H_2SO_4). The second sample was impregnated with 50 mL nitric acid (HNO_3) for 24 hours until the mixed sample turned into paste (Nurulain, 2007). Each impregnated sample were washed with distilled water and then filtered. The residue remaining were collected and dried in at 105 ^oC for 2 hours as described by Ademiluyi and David-West (2012) in the oven. Subsequenty, both impregnated samples were subjected to carbonization process at 450 ^oC in a muffle furnace as described by Ademiluyi and David-West (2012) (Figures 3 and 4). The carbonized samples were taken to the laboratory for characterization.

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Figure 1: Pieces of Bamboo before carbonization

Figure 2: Crushed bamboo before impregnation

Figure 3: bamboo activated carbon impregnated with nitric acid (HNO_3)

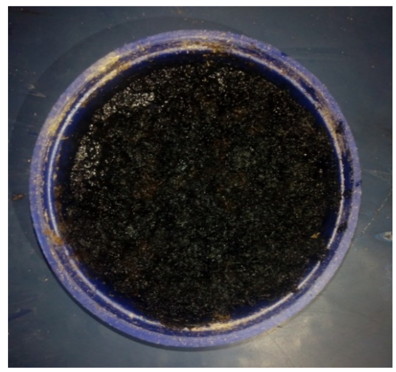

Figure 4: bamboo activated carbon impregnated with H_2SO_4

2.2. Characterization of Bamboo Activated Carbon

Bamboo activated carbon was characterized using Brunauer- Emmet- Teller theory (BET) and Langmuir method. It was used to obtain the specific surface area of the activated carbon samples. Prior to measurements, each sample was outgassed at a temperature of 523 ^oC under nitrogen flow for at least three hours. About 0.05 g of each sample was used in each adsorption experiment. This analysis was carried out at the Step-B Laboratory, Federal University of Technology Minna.

2.3. Surface Water Treatment

Surface water samples were taken from Kolo stream in Kitirin Gwari Area of Chanchaga Local Government Area. This water sample was subjected heavy metals (Lead (Pb), Aluminium (Al) and Copper (Cu) analysis using Atomic Absorption Spectrometer (AAS). Two beakers labelled A and B were used for this study. The water (100 ml) was measured and kept in the two beakers. Bamboo activated carbon with H_2SO_4 and HNO_3 (0.05 g) were dispensed in the beakers containing stream water samples for 15 minutes as described by Fu *et al.* (2012). The treated water samples were collected in a container and taken to the laboratory for heavy metal analysis using Atomic absorption spectroscopy.

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3. RESULTS AND DISCUSSION

3.1. Characterization of Bamboo Activated Carbon

Bamboo activated carbon samples with different chemical activation were characterized by Nitrogen gas analysis at temperature 350.33 ºC. Figures 5 and 6 showed multi point BET plot for bamboo activated Carbon with with sulphuric and nitric acid. The Figures showed non-linear indicating and incorrect BET plot for both bamboo activated carbon with sulphuric and nitric acid. The bamboo activated carbon impregnated with (HNO_3) has correlation coefficient and slope values of 0.9 and 4.097 respectively. Furthermore, bamboo activated carbon impregnated with (H_2SO_4) has correlation coefficient and slope values of 0.995 and 3.029 respectively. The Figures have positive constant C. The surface area (825.456 m^2/g) for the bamboo activated carbon with sulphuric acid showing the large differences in BET area obtained in different relative pressure ranges. The surface area (4373.34 m^2/g) for the bamboo activated carbon with sulphuric acid showed larger difference in Langmuir area than that of bamboo activated carbon with nitric acid as showed in Table 1. This study revealed that the bamboo activated carbon with sulphuric acid had large surface area under BET and Langmuir method. The curves sharply increased at low relative pressure showing a high adsorptive capacity for bamboo activated carbon impregnated with sulphuric acid as described by Ademiluyi and David-West, (2012).

The Dubinn-Radushkevic Method (DR) micropore and total pore volume for bamboo activated carbon impregnated with sulphuric acid (H_2SO_4) were 0.306 cm^3/g and 0.236 cm^3/g respectively while the values for bamboo activated carbon impregnated with nitric (HNO_3) were 0.323 cm^3/g and 0.222 cm^3/g respectively as shown in Table 1. Bamboo activated carbon impregnated with sulphuric acid (H_2SO_4) was better than bamboo activated carbon impregnated with nitric (HNO_3) in terms of surface area, total pore volume and adsorption as shown in Table 1. These results agree with the work of Ademiluyi *et al.* (2012)

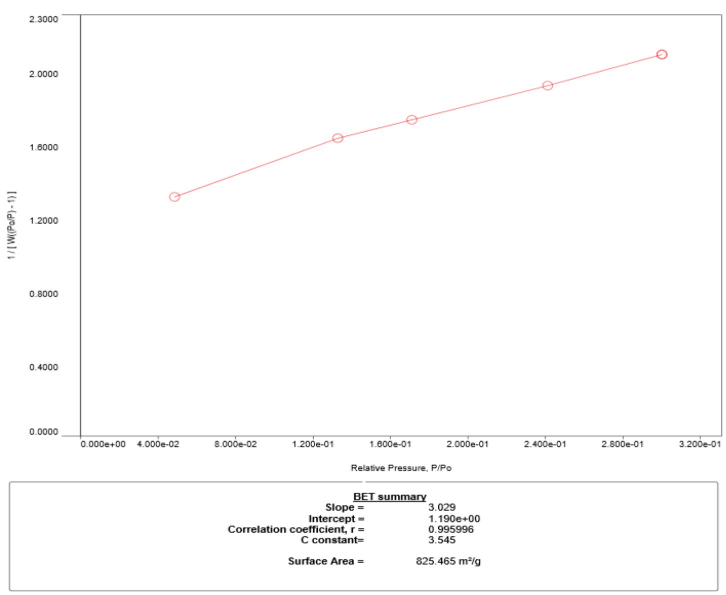

Figure 5: Multi Point BET plot for bamboo activated carbon with with H_2SO_4

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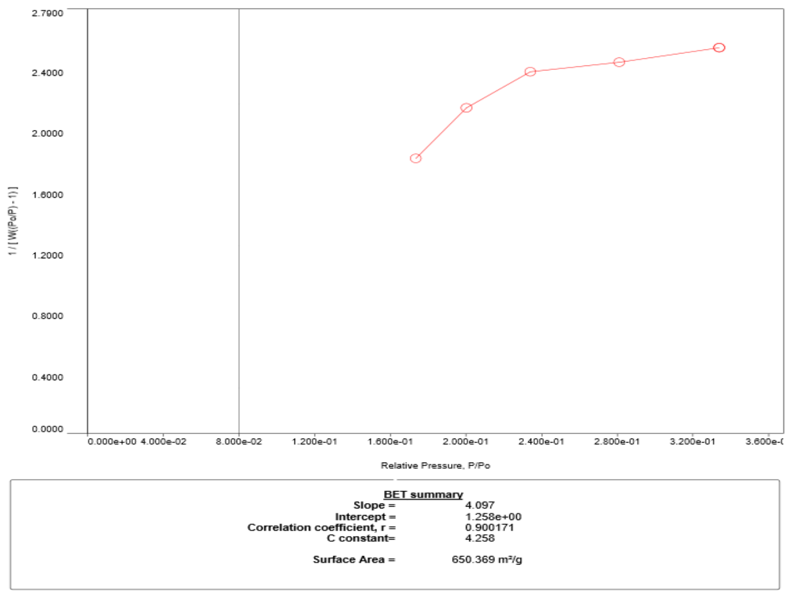

Figure 6: Multi Point BET plot for bamboo activated carbon with HNO_3

Table 1: Characterization of Bamboo Activated Carbon (BAC)

Characteristics	Impregnated with H_2SO_4	Impregnated with HNO_3
BET surfaces area (m^2/g)	825.456	650.359
Langmuir area (m^2/g)	4373.34	4145.78
DR micropore volume DR (cm^3/g)	0.306	0.323
Total pore volume (P/Po=0.99) (cm^3/g)	0.236	0.222
Average pore diameter (A)	6.077	7.195
Dubinin-Astakhov (DA) Pore diameter (A)	2.92	2.86

3.2. Surface Water Treatment using Bamboo Activated Carbon (BAC)

Table 2 shows the concentration of the heavy metals in surface water such as Lead (Pb), Aluminium (Al) and Copper (Cu) in surface water. Bamboo activated carbon impregnated with H_2SO_4 reduced the level of Pb, Al and Cu from 0.85, 1.23 and 3.52 to 0.30, 0.65 and 2.21 respectively. On the other hand, bamboo activated carbon impregnated with HNO_3 reduced the levels to 0.45, 0.76 and 2.37 respectively. The percentage of heavy metals removed using bamboo activated carbon with sulphuric acid from the stream water sample were 65 % (Pb), 47 % (AL) and 37 % (Cu) whereas nutric acid removed 47% (Pb), 38 % (AL) and 32 % (Cu). This implies that both bamboo activated carbon impregnated with H_2SO_4 was effective in removing heavy metals in surface water than bamboo activated carbon with HNO_3 because of the higher surface area and total pore volume as showed in Table 1. Furthermore, bamboo activated carbon impregnated with sulphuric acid (H_2SO_4) was found to be the best in absoption, surface area and total pore volume. These results disagree with the work of Ademiluyi and David-West (2012)

Table 2: Surface water treatment using Bamboo Activated Carbon (BAC) with different chemical impregnation

Parameters	Lead (mg/L)	Aluminum (mg/L)	Copper (mg/L)
Surface water	0.85	1.23	3.52
BAC impregnated with HNO_3	0.45	0.76	2.37
BAC impregnated with H_2SO_4	0.30	0.65	2.21

4. CONCLUSION

Bamboo activated carbon for the removal of heavy metals from surface water was produced using different chemical activation. The study revealed that the surface area values under BET and Langmuir method for bamboo activated carbon with sulphuric acid were 825.456 and 4373.34 m^2/g while that of nitric acid were 650.359 and 4145.78 m^2/g respectively. The study revealed that bamboo activated carbon impregnated with sulphuric acid (H_2SO_4) was found to be the best in absoption, surface area and total pore volume. The study concluded that bamboo activated with sulphuric acid had large surface area and it was efficient in removing heavy metals in surface water than nitric acid. This study concluded that impregnated bamboo activated with sulphuric acid (H_2SO_4) was found to be the best.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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