Nigerian Research Journal of Engineering and Environmental Sciences 8(2) 2023 pp. 580-585
p ISSN: 2635-3342; e ISSN: 2635-3350

Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

Original Research Article

Scanning Electron Microscopic Analysis of Changes in Dry Bamboo Adsorbent after Use for the Treatment of Paint Wastewater

***Achadu, M.A. and Ndubuisi, F.A.**

Department of Chemical Engineering, University of Port Harcourt, Rivers State, Nigeria.
*abahmikeking@gmail.com

http://doi.org/10.5281/zenodo.10442828

ARTICLE INFORMATION

Article history:
Received 01 Dec. 2023
Revised 22 Dec. 2023
Accepted 23 Dec. 2023
Available online 30 Dec. 2023

Keywords:
Moso phyllostachysedulis
SEM
Paint wastewater
Adsorption
Atomic concentration
Weight concentration

ABSTRACT

The study focused on the evaluation of the changes in dry bamboo adsorbent after use for the treatment of paint wastewater. The dry bamboo adsorbent was produced by first carbonizing dry bamboo at a temperature of 800 ^oC, activated at the same temperature in the absence of air and in the presence potassium hydroxide and thereafter washed with hydrochloric acid until a pH value of 6.88 was achieved. It was later subjected to drying at 12 ^oC in an oven for 24 h. The produced activated carbon was used as an adsorbent to treat paint manufacturing wastewater. The produced, activated and used adsorbent were subjected to an imaging scan using scanning electron microscopic (SEM). The result showed that the application of the activated carbon, a good non-polar adsorbent with micro-pores and surface areas was effective for the removal of impurities from paint based waste water. The SEM images also showed the pores of the activated carbonized material and deposits of impurities on the surface areas and pores of the used activated samples. The concentration of some elements found in the activated carbons increased after usage implying adsorption of some of inorganic pollutants present in the paint wastewater. Hence, activated carbons from dry bamboo, an economical and readily available resource can be used as adsorbent for the adsorption of pollutants from waste water.

1. INTRODUCTION

Bamboo (*Moso phyllostachysedulis*) is described as an eco-friendly and renewable plant based raw materials resource whose growth is rapid and thrives on little land requiring no fertilizers or insecticides. Similar to woods (hard or soft). Bamboo is characterized by long and semi-long fibers with high percentage of fines, density and storage degradation resistance than other fibers due to the presence of culms and internodes

(Lewis and Carol, 2008). Wang and Shen (1987) reported that bamboo is indigenous to China and Taiwan with global spread while Lewis and Carol, (2008) noted that the plant grows to about 28 m in height and multiplies by both asexual and sexual reproduction methods. It has also been reported to possess the capacity to adsorb twice the measure of contaminants as other plants source and also produces about 30% more oxygen (Philips et al., 2015). The natural antibacterial properties of bamboo trees are added advantage for their application in water and waste water treatment.

The application of activated carbon is a classical procedure for removing impurities from wastewater or gas. It serves as a filtering medium acceptable in a wide range of applications such as water purification and gas filtration. This is due to its potency to remove contaminants (Md et al, 2020). Activated carbon is characterized with super physicochemical properties such as large surface area, pore volume, chemical structure and surface morphology. It is also described as a group of carbonaceous adsorbents (Gurten et al., 2012).

In the production of activated carbon, carbonaceous raw materials that are usually considered as waste are selected and examples are coconut shell waste, bamboo waste from building site, palm kernel shell and other agricultural wastes. The process of production includes firstly carbonizing in the absence of air and activated either physically or chemically for improved properties, efficiency and effectiveness (Sujiono et al., 2022).

Paint production processes generates a lot of wastes especially liquid waste that often discharged into empty lands or surface water bodies. Generally, the waste water from the paint industry, usually small scale with small amount of waste water have really not been looked into by regulatory bodies, may be because of the sizes of the industry notwithstanding they produced a lot of wastewater. Paint waste water are also generated from equipment cleaning and residual paint sludge (a product of distillation of waste solvents) (Nick, 2018). The paint sludge contains solvents and residual toxic metals such as mercury, lead, chromium, etc (Aniyikaiye *et al*., 2019) while the cleaning operations contributes considerable part of the waste-water generated in the industry and are highly alkaline in nature. Generally, the waste water from the paint manufacturing industries are mostly alkaline, containing oil and grease with high biochemical oxygen demand (BOD) as well as total suspended solids (cloudy high turbidity). The BOD and COD values give a gross measure of organics in the wastes (Tati et al., 2015; Edokpayi et al., 2015). The organic and inorganic compounds used in the manufacturing operations are classified as toxic and hazardous. Chromium, copper, lead, zinc, ethyl benzene, di-(2-ethylhexyl) phthalate, tetrachloroethylene and toluene may be in high concentrations (Aniyikaiye *et al*., 2019). Treatment of this wastewater prior disposal to the land or natural water bodies are highly essential to avoid depletion biodiversity and damage to the eco system in general and its regulatory requirements. Treating paint wastewater with activated carbon locally produced from dry bamboo could be effective and productive in purifying this effluent especially at low cost. This study therefore seeks to evaluate the functionality of adsorbent produced from dry bamboo before and after used for treating paint waste water using SEM analysis.

2. MATERIALS AND METHODS

2.1. Materials

The materials used for this study was dry bamboo waste. The apparatus/equipment employed in the investigation include Beaker, conical flask, oven, horizontal alumina tube, desiccator and scanning electron microscope (SEM) set up while the reagents used were KOH, HCl and distil water.

2.2. Production of Activated Carbon using dry Bamboo Waste

The dry bamboo waste was collected from a construction site in Port Harcourt metropolis, Rivers State, Nigeria. A mass of 1000 g of the sample was measured and placed in a horizontal alumina tube and carbonized in a furnace at 800 °C, maintained at this temperature for three (3) hours. After carbonization, it was immediately placed in a desiccator to avoid contact with oxygen until is cooled and ready for the next process. Fifty grams of carbonized sample was mixed with 150 g of KOH pellets and poured into a foil and then subjected to activated heat treatment under N_2 flow at 800 ºC for one hour in a cylindrical furnace were conducted it was then allowed to cool for the carbonized sample. After cooling the resulting mixtures were crushed and washed with 1.0M solution of HCL, followed by addition of hot distilled water until pH 6.88 was achieved to eliminate activating agent residues and other inorganic species formed during the process. The prepared activated carbon was oven-dried at 120 °C for 24 h, sieved to obtain the particle size (0.5 mm to 1.0 mm), and stored in a desiccator for preservation until required for analysis. The yield was defined as the final weight of product after the processing stages of carbonization, activation, washing and drying.

2.3. Scanning Electron Microscope Analysis

Morphological investigations of the composite particles were carried out with SEM Quanta FEG 450 (FEI) with EDS analysis (APOLLO X - EDAX). 0.5g Samples were coated with Au/Pd film and the SEM images were obtained using a secondary electron detector. Point chemical analysis was performed in 2 independently selected particles. This was carried out on the samples before and after activation. SEM powder sample of the dry bamboo was prepared by separating individual particles. This was carried by breaking apart agglomerates to ensure accurate downstream analysis of particle properties before commencement of the analysis.

2.4. Treatment of Paint Wastewater

Two open end columns of 50 ml with a sieve at the bottom end was used for the adsorption and filtration process in treating the raw wastewater with the produced activated carbon. The columns were packed with the produced activated carbon while the other end of the column was covered with a sieve of 0.18 mm size. The wastewater is then poured into the column from the top, passing through the packed activated carbon and coming out as droplets into the recipient vessel with a filter paper. Figure 1 shows an illustration of the treatment scheme.

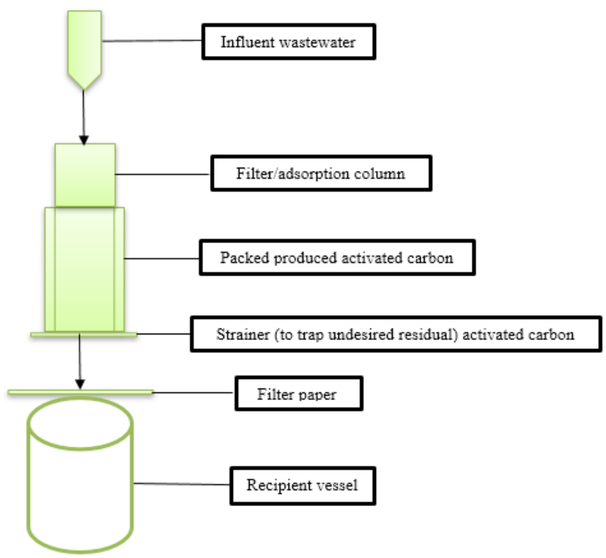

Figure 1: Waste water treatment via adsorption

3. RESULTS AND DISCUSSION

The dry bamboo based activated carbon was produced and characterized using Scanning Electron Microscope (SEM). Image of the surface morphology and pore structures of the produced, carbonized, activated and used activated carbon were obtained and are presented in Figures 2 - 4. Table 1 showed the weight concentration of the elements contained in the carbonized samples, activated carbonized and used activated carbon from the SEM analysis.

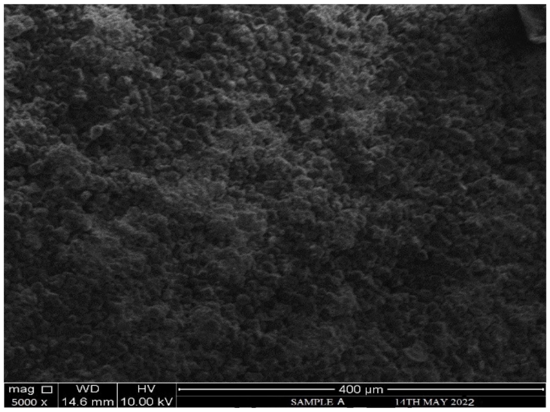

Figure 2: SEM photograph of transverse section of carbonized dry bamboo

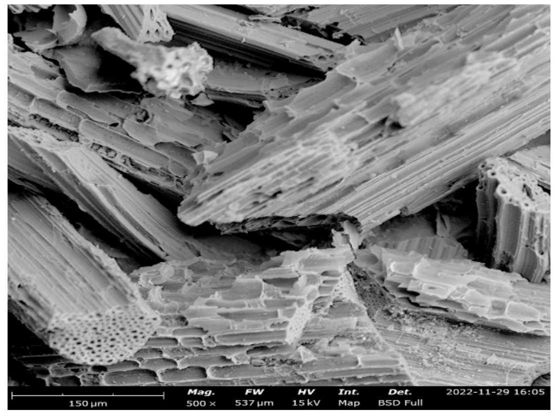

Figure 3: SEM photograph of transverse section of activated dry bamboo

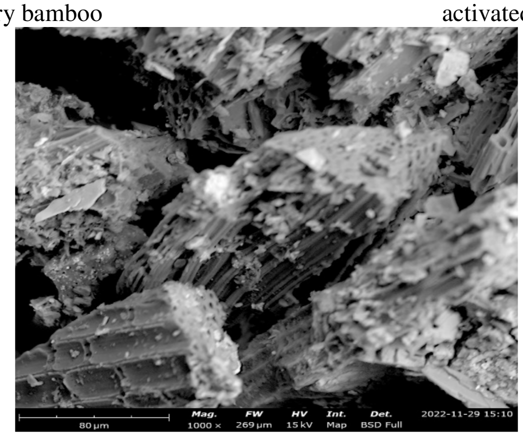

Figure 4: SEM photographic transverse section of used activated dry bamboo

The SEM photograph of the transverse section of carbonized dry bamboo (Figure 2) showed a blurred sky-like cloud of irregularly arranged particles while that of activated material (Figure 3) showed an enlarged surface areas as evidence in the halved hollowed curvature which allows more contacts with the waste water and the interactions provided results in the separation of the contaminants through adsorption mechanism from the waste liquid streams (Akpan et al., 2022). Again, Figure 4 showed the SEM picture of the used activated dry bamboo. The photograph showed adsorbed components on the surface of the adsorbent. These adsorbed components are evidenced on the enlarged surface as seeds. The result of the SEM analysis showed that after activation with KOH, a clear porosity and pore structure of the sample were visible and after usage, the deposits of the pollutants were evident on the pores of the used adsorbent.

The results obtained from SEM of the produced carbonaceous and activated adsorbent showed their surface morphology and pore structures as well as their atomic and weight concentration of the elements contained therein. Table 1 detailed the values and changes in the atomic and weight concentrations of the elements contained in the carbonized samples, activated and used activated dry bamboo from the SEM analysis.

The atomic concentrations of the various elemental compositions of the materials (dry bamboo) changes with activation and usage are as presented in Table 1. Chlorine, phosphorus, titanus, aluminum and nitrogen increase after activation and usage for paint waste water treatment while calcium and silicon reduced in value after activation and usage. This increment could be attributed the presence of some of the substances in the activation agent as well as the loosing effect of increase in temperature (Krouk and Kiba, 2020). There was reduction in atomic concentrations of oxygen, magnesium and Yttrium after activation and a rise in value after usage. However, the atomic concentrations after usage were equal to the original values before activation. Sodium and sulphur increased in concentration after activation but reduced after usage with the final values same with values recorded before activation. On the other hand, the atomic concentration of Iron increased with activation and reduced after usage. The final atomic concentration of Iron after usage was greater that the values noted before activation. The atomic concentrations of potassium and carbon contents reduced after activation and increased after usage. The values of the two elements after usage were less than the values reported before activation.

Table 1: Chemical characteristics of dry bamboo samples

Element name	Carbonized		Activated		Used activated carbon	
	Atomic conc.	Weight conc.	Atomic conc.	Weight conc.	Atomic conc.	Weight conc.
Potassium	19.36	28.88	10.98	25.89	14.36	28.32
Chlorine	2.17	23.23	12.89	20.54	15.17	23.22
Carbon	40.68	18.64	40.59	16.29	45.68	18.64
Calcium	4.17	6.37	1.15	6.74	1.00	6.19
Iron	2.10	4.48	3.45	3.00	2.16	4.38
Sulfur	2.98	3.65	3.32	6.94	2.98	3.65
Yttrium	0.89	3.03	0.79	9.94	0.89	3.22
Silicon	17.21	2.37	12.09	1.83	2,21	2.30
Magnesium	1.94	1.80	1.60	1.20	1.94	1.80
Sodium	1.60	1.40	1.80	1.13	1.60	1.40
Phosphorus	1.16	1.37	1.23	1.10	1.34	1.37
Titanium	0.74	1.35	0.82	1.23	0.94	1.37
Oxygen	2.16	1.32	2.05	2.10	2.16	2.00
Aluminum	1.22	1.25	5.34	1.14	5.65	1.25
Nitrogen	1.62	0.87	1.90	0.93	1.92	0.87

Generally, the concentration of inorganic matters increased after usage which implied that the paint wastewater contained some of these inorganic matters (Ahmed, 2016; Nair et al., 2021)). For instance, potassium and chlorine were of high concentration probably because potassium hydroxide (KOH) was used to activate the adsorbent and hydrochloric acid was used in washing the adsorbent after activation to achieve a pH close to neutral respectively. Carbon concentration was equally high due to the carbonaceous nature of dry bamboo adsorbent with lignin, hemicellulose and cellulose contents.

The weight concentration of the dry bamboo sample (carbonated, activated and used) are also detailed in Table 1 alongside atomic concentration. The result showed variation in the elemental contents in the materials. Potassium, Iron and silicon's weight concentrations reduced after activated but increased after application for waste water treatment. The results for the three elements showed that the values after usage were less than the concentration recorded before activation. The values recorded for Cl, C, Mg, Na, P and Al showed that the values reduced with activation and increased after usage. The final values were however equal to the values reported before activation. There was increase in the weight concentrations of oxygen and Yttrium after activation and a reduction in value after usage. However, the values after usage were greater than the original value before activation. The weight concentration of sulphur and nitrogen increased and reduced after activation and after usage respectively. However, the final weight concentrations were equal to the initial value before activation for both elements. Again, for calcium and titanium, the weight concentrations increased after activation and reduced after usage and reduced after activation and increased after usage respectively.

4. CONCLUSION

The article showcased the effect of changes in dry bamboo adsorbent employed for the treatment of paint wastewater using SEM analysis. The study established the level of inorganic matter that was adsorbed in using the activated carbon to treat paint wastewater. Wastewater from paint making industry pollutes the environment especially water bodies due to presence of pollutants like lead, mercury, chromium, copper, etc that are harmful to human and environment. Application of activated carbon, a good non-polar adsorbent with micro-pores and large surface areas demonstrated effectiveness in the removal of impurities from paint waste water. The SEM photograph showed the pores of the activated carbonized material and deposits of impurities on the surface areas and pores of the used activated samples. The concentration of some of the elements found in the activated carbons increased after usage which implied adsorption of some of the inorganic pollutants present in the paint wastewater. Hence, activated carbons from dry bamboo which is very economical and readily available can be used as packing materials for the adsorption of pollutants for waste water.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Achadu, M. A. and Akpan, E.I (2022). Treatment and characterization of wastewater from tissue paper making industry using bamboo as raw material. *Sustainability in Environment*, 7(1), pp. 85 -101

Ahmed, M.J. (2016). Preparation of activated carbons from date (Phoenix dactylifera L.) palm stones and application for wastewater treatments: Review. *Process Safety and Environment Protection*., 102, pp. 168–182.

Akpan, I. E. Achadu M. A and. Chukwuma F. O (2022): Evaluation of Discharged Untreated Wastewater from Pulping and Bleaching Operations in a Bamboo Based Tissue Paper Making Plant in Nigeria. *Research and Analysis Journals*, 5(01), pp. 7 -15

Aniyikaiye, E. T., Oluseyi, T., Odiyo, O, J., and Edokpayi, N. J (2019). Physico-Chemical Analysis of Wastewater Discharge from Selected Paint Industries in Lagos, Nigeria. *International Journal of Environmental Research and Public Health.* 16 (7) pp. 1235 -1344

Edokpayi, J. N., Odiyo, J. O., Msagati, T. A., and Potgieter, N. (2015). Temporal variations in physicochemical and microbiological characteristics of Mvudi River, South Africa. *International Journal of Environmental Research and Public Health*, 12 (4), pp. 4128-4140.

Gurten, I. I., Ozmak, M., Yagmur, E. and Aktas. Z. (2012). Preparation and characterisation of activated carbon from waste tea using K_2CO_3. *Biomass Bioenergy, 37*, pp 73–81.

Krouk, G and Kiba, T (2020). Nitrogen and Phosphorus interactions in plants: from agronomic to physiological and molecular insights. *Current opinion in plant biology*, 57, pp. 104 -109

Lewis, D. and Carol, A. M. (2008). "Farming Bamboo". Lulu.com. pp. 155-165.

Md, S. R., Cheong, S. Y., Shammya, A. and Abul, A. (2020). Preparation of activated carbon from biomass and its' applications in water and gas purification, a review. *Arab Journal of Basic and Applied Sciences*, 27(1), pp. 208-238,.

Nair, K.S., Manu, B. and Azhoni, A. (2021). Sustainable treatment of paint industry wastewater: Current techniques and challenges. *Journal of Environmental Management*, 296, pp. 1131- 1141.

Philips, R. B., Naithani, V., Chang H. M., and Jameel, H (2015). Technical/economic analysis of bamboo fiber in pulp and paper manufacture – Part 2. Economics potential for bamboo utilization in an uncoated free sheet mill. In: TAPPI PEERS. TAPPI press, Atlanta

Sujiono, E.H, Mulyati, Z., Zharvan, V., Humairah, N.A and Zabrian, D. (2022). Fabrication and characterization of coconut shell activated carbon using variation chemical activation for wastewater treatment application. *Results in Chemistry*, 4, pp. 102 – 1012.