



Application of Activated *Afzelia Africana* and *Acacia Albida* Carbon for Removal of Pollutants in Textile Wastewater

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ABSTRACT: Adsorption of contaminants in textile wastewater onto activated carbon derived from two wood species has been studied using batch-adsorption techniques. This study was carried out to examine the removal efficiency of the low-cost adsorbent (*Afzelia africana*) AFA and (*Acacia albida*) ACA for the removal of heavy metals and other organic contaminants from textile effluents. The influence of contact time and adsorbent dose kept constant on the adsorption process was also studied. Removal efficiency increased with increase in contact time. The two adsorbents had an average removal efficiency of 60% at 90mins contact time for Zn. The ACA had higher removal efficiency for chromium at all contact times than AFA except at 120mins contact time where there existed a slight difference in the removal efficiency between the two adsorbents. Removal efficiency of iron was high between 58.18- 70.52% and 72.75-75.86% for AFA and ACA carbon respectively. This showed that iron had high affinity to the adsorbents surface. It was observed that AFA exhibited highest removal efficiency for nitrate at all contact times as compared to ACA. Results indicated that the freely abundant, locally available, low-cost adsorbent derived from the two wood species could be treated as being economically viable for the removal of contaminants from textile effluents.

KEYWORDS: Adsorption, Contaminants, Environment, Effluent, Heavy Metals, Pollution

I. INTRODUCTION

The release of hazardous contaminants into the environment through industrial wastewater and related sources and their removal methods are of global concern.[1] Pollutants found in wastewater pose health hazards to both flora and fauna if their concentrations exceed the standard permissible limits.[2] Most of these waste contain suspended solids, dissolved solids, nitrate, phosphate, biochemical oxygen demand, chemical oxygen demand, phosphate, salt and heavy metals, which are nevertheless required by living organism in a small concentration.[3] However, in higher concentration, these minerals can cause critical human and environmental health problems.[4] Thus, the treatment of these contaminants and heavy metals in wastewaters before being discharging into the ecosystem is essential.[5]

Textile industries are among the industries that discharge effluents containing heavy metals and contaminants into the environment. The textile industry has been one of the main contributors to water pollution all over the world, causing more than 20% of the registered levels of water pollution in countries like Turkey, Indonesia and China (among the G20 group of countries) and also in Romania and Bulgaria (in the Eastern European area), with even more than 44% in Macedonia.[6] Dyeing is an important aspect of textile production, and during the dyeing processes, not all dyes that are applied to the fabrics are fixed on them. There is always a portion of these dyes that remains unfixed to the fabrics and gets washed out. These unfixed dyes are found to be in high concentrations in textile effluents and contribute significantly to the pollution of the wastewater. [7]

In Nigeria, Abeokuta is known for the production of Adire and Kampala, a business that provides substantial contribution to its economy in the form of income, employment and possibly foreign exchange generation. Wastewater from the industry has negatively impacted surface, shallow wells and ground water in the region as well as the freshwater bodies in the vicinity of the production site. The water pollution results in deterioration of water quality and making it harmful for human consumption. Oloyede et al. [8] reported that 'Adire' textile effluents had a deleterious effect upon the weight, blood profile, lungs, kidney, spleen and heart of mice, which could lead to many metabolic and physiological disorders. Thus, treatment of wastewater from textile industry is pertinent in order to minimize their threat to the biotic community.



Adsorption has been universally accepted by the world environmentalists for the disposal of hazardous and toxic inorganic as well as organic pollutants present in various effluents. [1] Investigation of readily available and low cost sorbent with high removal capability has been performed in various studies.[4] This present work aimed to assess the adsorptive capability of activated carbon derived from two readily abundant low density wood species on textile wastewater.

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II. MATERIALS AND METHODS

Study area description.

The study area Abeokuta 7 6'N to 7° 13'N and 3 16'E to 3° 25'E is a millennium city and the state headquarters of Ogun State, with its environ having an area coverage of about 781.16 km². [9] Tie and dye have been produced in Itoku, Abeokuta South Local Government for over a century. The clothing comes in different designs and batiks as popularly called with diverse variety of colours and these products have gained international recognition. The textile industry in Itoku is one major textile industry whose processes are not maintained at regulatory standards. Large volume of water are involved in the process and their effluents are discharged into the surrounding nearby watercourses and on land without evidence of pre-treatment. Textile wastewater was therefore sourced from this area to determine its physico-chemical parameters and the viability of activated carbon derived from two low density woods (*Azalia africana* and *Acacia albida*) in detoxifying the contaminants.

Samples preparation.

The wood feedstock (*Azalia africana* and *Acacia albida*) were sourced and chipped into smaller pieces at Oke-Ado Sawmill in Ibadan, Oyo State, and thereafter washed with deionised water to remove waste particles adhered onto the surface. The wood samples were air-dried for moisture reduction for a period of one week. The feedstock were pyrolysed at 500°C for 2 hours in a bioreactor. The charred woods were grinded and activated with zinc chloride at ration 1:1 (w/v). To ensure proper impregnation, the samples were properly mixed manually and kept for 24 hours and subjected to temperature at 102 ±3°C for 24 hours. Thereafter, filtrates (char) were washed and dried repeatedly with distilled water to neutralize the pH, oven-dried at 120°C for 12 hours and cooled at room temperature before storage. Scanning Electron Microscope (SEM, TESCAN VEGA3: was used to examine the pore space of the sorbents.

The carbonization yield was determined using equation 1

$$\text{Percentage yield} = \frac{W_2}{W_1} \times 100 \dots\dots\dots(1)$$

W₂ = Weight of carbon produced

W₁ = Weight of raw sample

Analytical methods.

Wastewater samples used in the adsorption experiment were analysed according to APHA (1999) standard methods for water and wastewater examination. Adsorption studies was conducted by batch method on wastewater at room temperature by varying contact time. Batch experiments were carried out to determine the adsorption of contaminants onto the adsorbents in 200mL flask. Continuous mixing was provided by intermittent agitation of the samples to allow interfacial contact. The effects of various parameters on the rate of adsorption process were observed by varying contact time at an interval of 30minutes to 120minutes at room temperature. The adsorbent volume (V) was kept constant at 6g. The experiments were conducted in duplicates for each of experimental carbon to cater for possible variations. The percentage removal was calculated using equation 2

$$\text{Percentage removal} = \frac{(C_i - C_e)}{C_i} \times 100 \dots\dots\dots (2)$$

Where,

C_i (mg/L) represents initial concentration of effluents before process of adsorption

C_e (mg/L) represents residual concentration after adsorption of effluents

III. RESULTS AND DISCUSSION

Activated carbon characterization.

The carbon yields after carbonisation at a temperature of 500°C for 120minutes were 32 and 24% respectively. The result agreed with previous study carried out at the same temperature for oak tree branch (28.6%).^[10] and *Cordia millenii* (24.5%).^[11] Scanning Electron Microscope images of the two adsorbents used AFA and ACA samples showed presence of several pore spaces in the adsorbents (Figs 1a and b). This will facilitate easier trapping of impurities when used in the treatment of textile effluent. On observation, the circumference sizes of the pore spaces varied for the two adsorbents, with AFA having more pores than ACA and this is partly responsible for their differential behaviour in adsorption process. Also, the shape of the pore spaces was predominantly spherical for both samples with surface having rough structure. This structure also shows that the material will be a very good adsorbent theoretically.^[12-14]

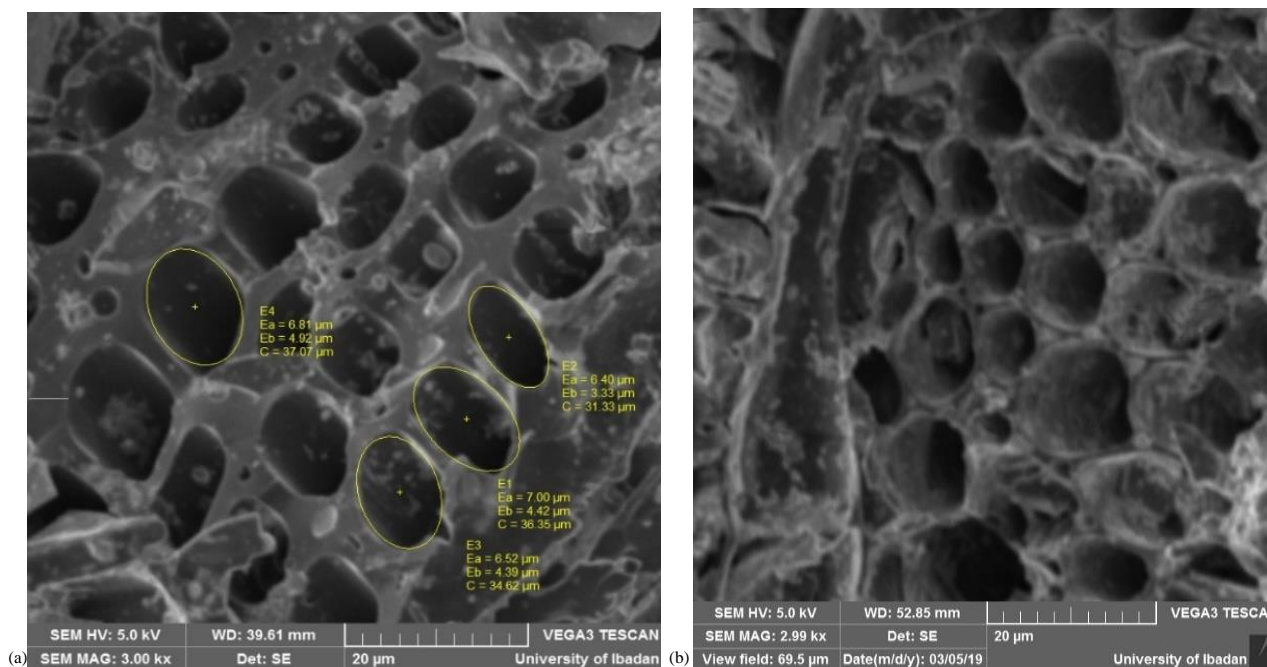


Fig. 1. Electron micrograph of adsorbent: a- Alcacia albida carbon b- Afzelia africana carbon

Removal efficiency of heavy metal.

The removal efficiency of all the heavy metals treated increased with contact time. From Figure 2, there was rapid uptake of 74% percentage removal efficiency for Manganese (Mn) at 30mins contact time using ACA carbon whereas percentage removal of Mn using AFA carbon was low (between 30.7-48.4%), showing that ACA is more effective in removing Mn, the finding is in agreement with the result of locust beans husk^[15] and *Cordia millenii* Carbon and *Gmelina arborea* Carbon.^[14]

The AFA has the highest removal efficiency (59.72-77.78%) for Cadmium from at all contact time. The two adsorbents had removal efficiency of over 60% at 90mins contact time for Zinc. ACA has higher removal efficiency for chromium at all contact time than AFA except at 120mins contact time where there exists a slight difference in the removal efficiency between the two adsorbents. Removal efficiency was high in iron between 58.18- 70.52% and 72.75-75.86% for AFA and ACA carbon respectively. This shows that iron has high mobility to the adsorbents surface.

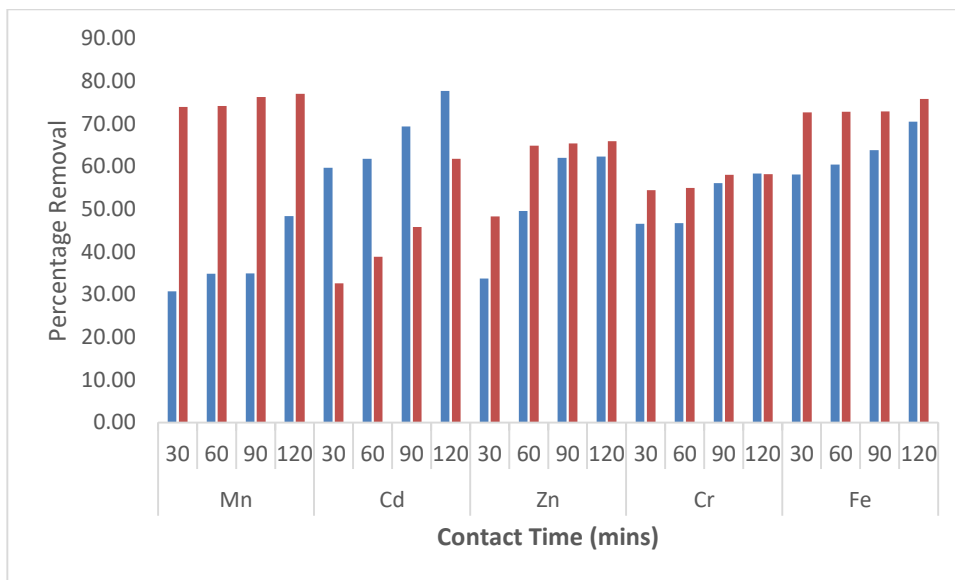


Fig. 2. Graph of decontamination level (in percent) using the two adsorbents

Decontamination of organic pollutants.

Figures 3 and 4 show the effect of different contact time of AFA and ACA carbon on the percentage removal of sulphate, nitrate and phosphate. The percentage removal increased from 22.4- 31.08% for sulphate, 69.42- 75.83% for nitrate, 48.85- 55.19% for phosphate for AFA carbon and that of ACA carbon increased from 14.32- 29.73% for sulphate, 53.72- 57.64% for nitrate and 24.78- 37.75% for phosphate respectively. It was observed that AFA exhibited highest removal efficiency for nitrate at all contact time as compared to ACA. Similar result was obtained for phosphate which can be attributed to strong interaction between AFA adsorbents and the contaminants (nitrate and phosphate). The result also showed that sulphate requires higher contact time and dosage of adsorbent for its removal by adsorption process. This is in conformity with the result obtained by de Caprariis et al. [16]. Both carbon show less affinity for sulphate. The result of the treatment showed that the diminution of the contaminants increased with increasing contact time and the trend at which each of the adsorbents adsorbed the contaminants is as a function of their microstructure.

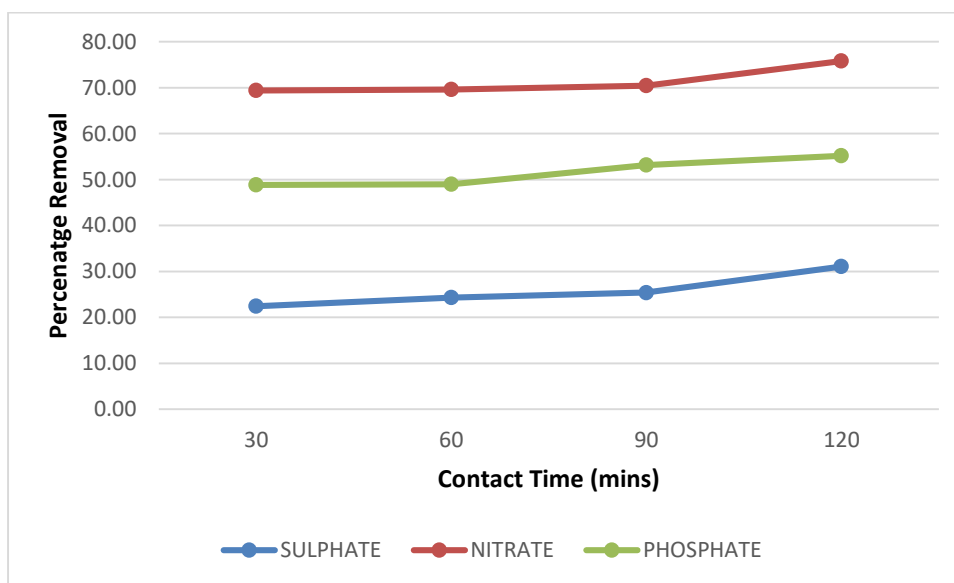


Fig. 3. Effect of AFA on percentage removal of sulphate, nitrate and phosphate

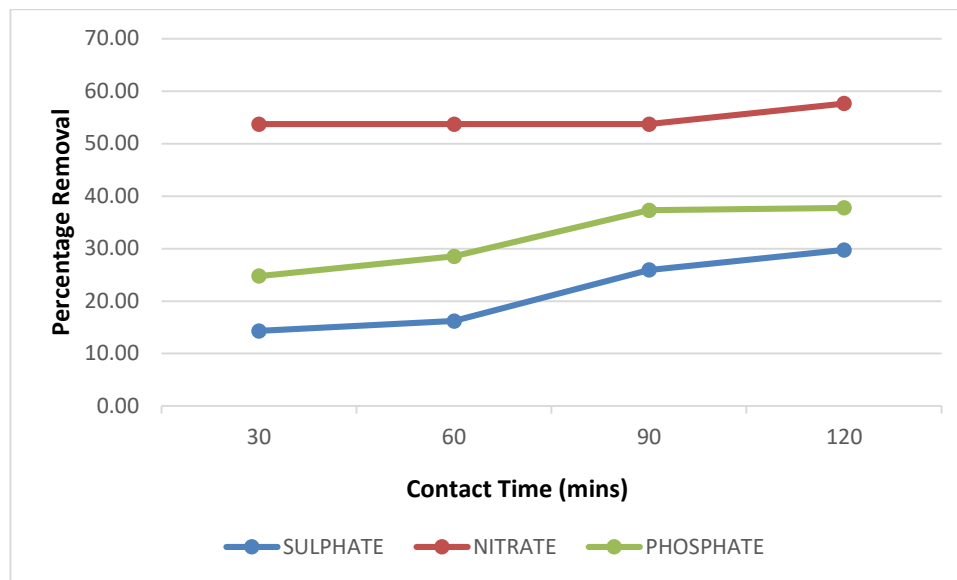


Fig. 4. Effect of ACA on percentage removal of sulphate, nitrate and phosphate

IV. CONCLUSION

Activated carbons produced from low density woods (*Azelia africana* and *Acacia albida*) were tested on the adsorption of textile wastewater. The study revealed that contact time and pore space of the adsorbents influenced the removal of the contaminants from the wastewater. The ACA was more effective in removal of heavy metal except for cadmium as compared to AFA, on the other hand, AFA performed better in removal of inorganic pollutants in textile wastewater. Among all the heavy metal studied, iron showed high mobility to the surface for the two adsorbents. The activated carbons derived from the two-wood species were able to reduce the contaminants in the textile wastewater and proved to be effective in reducing the parameters below specified limit set by WHO for discharge of industrial wastewater onto land and surface water bodies.

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