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Removal Of Colour From Wastewater By Raffia Palm Seed Activated Carbon

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Abstract
Activated carbons were produced from raffia palm seed under varying temperatures, times and preparation procedures in order to evaluate their suitability for the removal of colour from wastewater and to determine the best preparation sequence and the optimum temperature and time of carbonization. Their efficiency on the adsorption of colour from wastewater was investigated through single stage batch adsorption studies. 200 g of raffia palm seed each was carbonized under varying temperatures of 200 ^oC, 300 ^oC, 400 ^oC, 500 ^oC, and 600^oC, and the carbonized samples were used for the removal of colour from wastewater. Similarly, the optimum carbonization time was determined by varying the carbonization times for 20 minutes, 30 minutes, 40 minutes, 50 minutes, and 60 minutes respectively at the optimum carbonization temperature. The effect of preparation sequence was evaluated by preparing the samples under different preparation procedures i.e raw seeds (powdered form), carbonization without activation, activation with $ZnCl_2$ before carbonization and carbonization before activation with $ZnCl_{2.}$ The results revealed that 300^0C was the optimum carbonization temperature removing the highest amount of colour of 87% at an optimum carbonization time of 40 minutes. The adsorbing efficiencies of the carbons prepared using the raw seeds, carbonization without activation, activation with $ZnCl_2$ before carbonization and carbonization before activation with $ZnCl_2$ with an initial colour concentration of 370 Pt- Co units were obtained as 5.68 %, 85.95 %, 100 % and 98.40 % respectively. It was concluded that the best procedure for preparation of the carbon is activation before carbonization and that raffia palm seed activated carbon can be effectively used for the removal of colour from wastewater.

Keywords: activated carbon, raffia palm seed, carbonization, time, temperature, activation

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INTRODUCTION

The discharge of dye effluents into natural streams and rivers brings about severe pollution, as dyes impart toxicity to aquatic life and colour to the water bodies. Virtually, all industries, especially the plastic, fertilizer, beverage and the oil servicing industries discharge wastewater which pollutes receiving water bodies by supplying such water bodies with excessive pollutants such as phenol, lead and phosphates. This reduces water quality thereby limiting water utilization and also endangering aquatic life. Tertiary treatment involves physico-chemical separation techniques such as carbon adsorption, flocculation/precipitation, and membranes for advanced filtration, ion exchange, dechlorination and reversed osmosis. Of the common tertiary methods, adsorption had been reported as an efficient and economic option (Mahvi, 2008; Malakootian *et al*., 2009), especially when the source of the adsorbent is economical. Adsorption currently appears as the best treatment for the removal of colour from wastewater (Chern and Wu, 2001; Gupta *et al*., 2003; Namasivayam *et al*., 2007).

Adsorption is typically used in wastewater treatment to remove toxic or recalcitrant organic pollutants (especially halogenated but also non-halogenated), and to a lesser extent, inorganic contaminants, from wastewater (Neeta and Jatinder, 2008).The adsorbent that are used today are activated alumina, powdered aluminium oxide, fly ash, activated red mud and blast furnace slag. The economic availability of these adsorbent materials is the major obstacle to their use in waste-water treatment.

Activated carbon is a form of carbon that has been processed to make it extremely porous with a very large surface area available for adsorption. It has been the appropriate low-cost technology for the treatment of wastewater (Cairncross and Feachem, 1993).

The high cost of activated carbon has stimulated interest in examining the feasibility of using cheaper raw materials. Substitute materials tested includes saw dust, coal reject, sewage slag, automobile tyres and straw. Indigenous researchers have been investigating the adsorption capacity of some local materials such as palm kernel shells (Ogedengbe *et al*., 1985, Onundi *et al.* (2010), Issabayeva *et al.*, 2008), mango seed shells (Akpen *et al.*, 2011, 2012, 2014), maize cobs

(Agunwamba *et al*., 2002a, 2002b), coconut shells (Gimba and Turoti, 2006), pumpkin shell (Okoye *et al*., 2010) and rice husks (Adebayo and Aloko, 2007) among others. Notably, these adsorbents are agricultural wastes or by-products commonly viewed as having no economic value.

However, the raffia palm seeds which are in abundance in some parts of Nigeria have not been investigated as possible precursor for the production of activated carbons for water/wastewater treatment. The use of activated carbon produced from raffia palm seed will serve dual purposes: It will provide opportunity for the utilization of raffia palm seed hitherto regarded as a waste. Also, the production of activated carbon from a locally available material will likely reduce its cost. Besides, the use of raffia palm seeds for the removal of pollutants from water will create jobs for the teeming youths in agriculture and by extension trade. The aim of this study therefore is to investigate the suitability of raffia palm seed activated carbon for the removal of colour from wastewater.

The raffia palm is a genus of twenty species of palms native to tropical regions of Africa, especially Madagascar. They grow up to 16 m tall and are remarkable for their compound pinnate leaves, the longest in the plant kingdom, The plants are either monocarpic, flowering once and then dying after the seeds are mature, or hapaxanthic, with individual stems dying after fruiting but the root system remaining alive and sending up new stems. Raffia palm are commonly used in areas of textiles and construction. In their local environments, they are used for ropes, sticks and supporting beams, and various roof coverings are made out of its fibrous branches and leaves. It is commonly found in abundance in the southern part of Nigeria especially the fresh water lowland zones. It is equally valued in societies such as the Igbos and Ibibio/Annang of the south eastern Nigeria and the Yorubas of south western Nigeria. It is identified with a local name, *Ichor* in Benue state of Nigeria. Due to the abundance of raffia palm in Nigeria, it is reasonable to investigate the possibility of producing activated carbon from the seeds.

MATERIALS AND METHODS

Sample Collection and Preparation

The raffia palm fruits were collected from Agan in Makurdi Local Government Area of Benue State. The inner seeds were removed from the husks and air-dried and broken into smaller particle sizes ranging from 1-3 cm. The chemical composition of raffia palm seed was determined (See Table 1).

Determination of Optimum Carbonization Temperature/ Time of Raffia Palm Seed

The carbonization was done in a muffle furnace (model SXL) in accordance with the method described by (Gimba and Turoti, 2008). 200 g each of raffia palm seed (without activation) was carbonized in the muffle furnace. The optimum carbonization temperature of raffia palm seed (RPS) was determined by varying the carbonization temperatures of 200, 300, 400, 500, and 600^{o}C respectively at a constant time of 30 minutes. To determine the optimum time of carbonization of RPS, 200 g each was carbonized at carbonization times of 20, 30, 40, 50, and 60 minutes at a constant temperature of 300^{0}C (optimum). At the end of each carbonization period, the produced carbons were applied to waste water to remove colour. The carbonization temperature/time of the sample that removed the highest amount of colour was taken as the optimum carbonization temperature/time of raffia palm seed.

Activation of Raffia Palm Seed

Zinc Chloride ($ZnCl_2$) was used for chemical activation. The activation was done by dissolving 100 g of anhydrous Zinc chloride in 400 ml of distilled water. After which 200 g of RPS was added to the solution of the activating agent. The mixture was poured into an autoclave and heated for 30 minutes. At the expiration of the heating period, it was allowed to cool. The supernatant liquid was discarded leaving the activated raffia palm seed which was then air-dried. The air-dried activated carbons were carbonized at 300^{0}C for 40 minutes as described above and allowed to cool in a dessicator.

Simulation of Wastewater

The wastewater to be treated was prepared artificially by dissolving 1ml of methylene blue in 100 ml of distilled water.

Colour Determination

A direct reading spectrophotometer (DR/2000) from HACH Company was used for the determination of the concentration of colour in the wastewater.

The amount of colour adsorbed by the produced carbons was calculated using Equation 1:

$$\frac{(C_i - C_f)}{C_f} \times 100\% \qquad 1$$

Where;

C_i - C_f = the amount of colour adsorbed, C_i = initial concentration of colour and C_f = final concentration of colour.

RESULTS AND DISCUSIONS

Chemical Composition of Raffia Palm Seed

The results of the chemical composition of raffia palm seed are as given in Table 1 below. The results show that RPS has high carbon content (39%) which implies that it is a good material for production of activated carbon because it can give high carbon yield.

Table 1: The Chemical Composition of Raffia Palm Seed.

Element	Composition (%)
Carbon	39
Oxygen	4.21
Hydrogen	0.172
Sulphur	0.03
Nitrogen	3.703

Optimum Carbonization Temperature of Raffia Palm Seed

The results of the amount of colour removed from wastewater as a function of carbonization temperatures of 200, 300, 400, 500, and 600^{O}C are presented in Fig.1. The Figure shows that the adsorbing capacity of the carbonized samples increased with increase in carbonization temperatures up to 300^{0}C, after which the capacity begins to decrease with further increase in temperature. The carbonization temperature of the sample that removed the highest amount of colour was 300^{O}C (87%), and it was therefore, taken as the optimum temperature for carbonization of raffia palm seed.

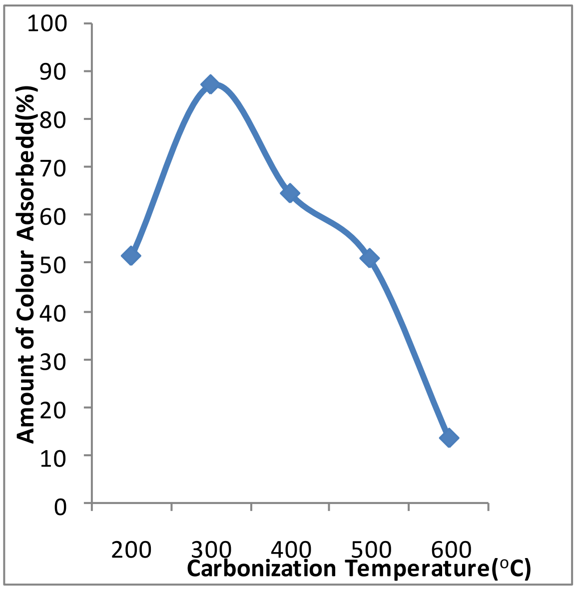

Fig. 1 Colour Adsorbed as a Function of Carbonization Temperature of Raffia Palm Seed.

The percentage removal of colour from wastewater at various carbonization periods is depicted in Fig. 2. The carbonization times of 20 minutes, 30 minutes, 40 minutes, 50 minutes and 60 minutes gave removal efficiencies of; 59.3 %, 84.8 %, 100 %, 100 % and 97.7 % respectively. Within the experimental conditions investigated, carbonization times of 40 and 50 minutes gave the highest removal efficiency of 100 %. The shorter time of 40 minutes was taken as the optimum carbonization time of raffia palm seed.

Effect of Preparation Sequence on Colour Removal

The essence of varying the preparation method of the activated carbons was to determine the best preparation sequence under which the carbons perform best (in terms of percentage removal). From the results shown in Table 2, the lowest amount of colour of 5.68% was removed by the raw sample (powdered form); while the carbons produced using other procedures achieved high colour removal efficiencies. The carbon produced by activation before carbonization adsorbed the highest amount of colour of 100%. Hence, the optimum preparation procedure for preparation of activated carbon from RPS is activation before carbonization.

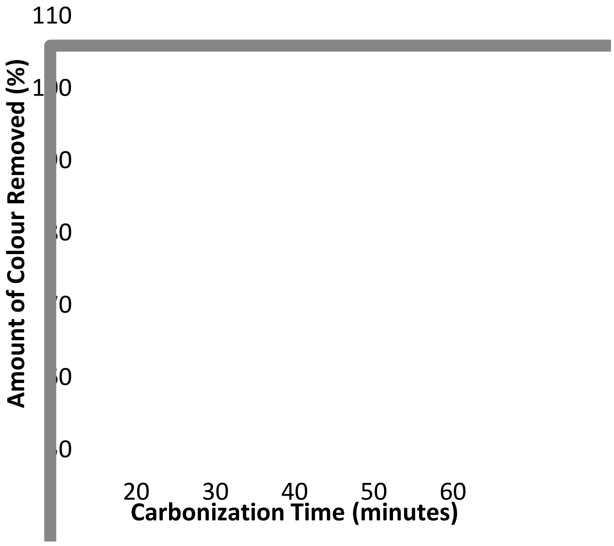

Fig. 2 Colour Adsorbed as a Function of Carbonization Time of Raffia Palm Seed.

Optimum Carbonization Time of Raffia Palm Seed

Table 2: Effect of Preparation Procedure on the Removal of Colour from Wastewater

Preparation Procedure	**Initial Conc. (Pt-co. unit)**	**Final Conc. (Pt-co. unit)**	**Colour Adsorbed (Pt-co. unit)**	**Colour Adsorbed (%)**
Powdered Raffia Palm Seed (raw)	370	349	21	5.68
Activation before Carbonization	370	0	370	100
Activation after Carbonization	370	6	364	98.40
Carbonization without Activation	370	52	318	85.95

CONCLUSIONS AND RECOMMENDATION

Activated carbons were produced from raffia palm seed under varying temperatures, times and preparation procedures in order to evaluate their suitability for the removal of colour from wastewater and to determine the best preparation sequence and the optimum temperature and time of carbonization of the seeds. The efficiencies of the carbons on the adsorption of colour from wastewater were investigated through single stage batch adsorption studies.

The results obtained revealed carbonization temperature and time of 300^0C and 40 minutes respectively. Also, the optimum preparation procedure for raffia palm seed is activation before carbonization, given the highest amount of colour adsorbed by the activated carbon sample produced by activation before carbonization. Based on the results of this study, it was concluded that the optimum carbonization temperature and time of raffia palm seed is 300^0C and 40 minutes respectively. Also, raffia palm seed based activated carbon performs best when activated before carbonization. However, simulated wastewater was adopted in this study, which could not account for the effect of interference in live wastewater streams; hence, the need for further studies using live wastewater. The efficiency of the produced carbons for the adsorption of other pollutants from water should also be investigated.

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