COLOR REMOVAL USING ARECANUT PEELS AS AN ADSORBENT

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ABSTRACT

The present work aims at finding out the effectiveness of color removal using arecanut peels as an activated carbon. Commercial activated carbon is costly and uneconomical. This has necessitated the development of cheaper carbonaceous materials. Although various materials are used in the production of activated carbons abundant availability and low cost of agricultural by-products make them good source of raw materials for activated carbon. The arecanut peels activated carbon was prepared in the laboratory by carbonization followed by activation. The batch adsorption studies were carried on the simulated samples prepared using malachite green dye in the laboratory under varied conditions like contact time, pH, dosage of adsorbent and various concentrations of adsorbate. Form the batch study, it was found that the arecanut peels activated carbon dosage of 0.5g/l is optimum as it removes 91.8% of the dye at pH 10 for a contact time of 35 minutes for dye concentration of 5mg/l. The sorption data follow Langmuir model as well as Freundlich model. Results in this study indicated that powdered arecanut peels activated carbons was an attractive candidate for removing dyes from dye wastewater.

Key Words : Arecanut peels, Adsorption, Batch study, Color removal, Sorption

INTRODUCTION

Out of many contaminants present in wastewater, such as acids, bases, toxic organic and inorganic dissolved solids and color, colors are considered the most undesirable and are mainly caused by dyes1. The textile industry, a major consumer of water for several of its wet processing operations also a major producer of effluent wastewater containing dyes. Dyes though present in only small amounts are highly detectable and there are capable of causing serious problems to an aesthetic nature in the receiving water bodies. Discharge of dye bearing wastewater into natural streams has created significant concern, of impart toxicity, visibility and also presence of carcinogenic have been reported2. Therefore safe and effective treatment of color containing wastewater is always a challenging task for the industries.

Color acquired by water body through the discharge of effluents reduces the penetration of sunlight and consequent reduction in photosynthetic activities and primary production3. Also causes oxygen depletion, emission of foul odor, reducing
reaeration capacity and inhibits the growth of desirable aquatic biota.

Due to low biodegradability of color causing pollutants, physico-chemical methods have been commonly adopted for treatment of color bearing wastewater. Other conventional methods for treating wastewater containing dyes are chemical oxidation, radiation, ion exchange, reverse osmosis and adsorption. The process of adsorption as an edge over the other methods due to its sludge free clean operation and completely remove dyes, even for the diluting solution.

Most of the conventional adsorption systems use activated carbon, which is expensive and necessitates regeneration and the problem of the disposal of concentrated sludge. Therefore the potential exists for more economical and equally effective materials for dye removal by adsorption. As the cost for activated carbon is high there is continuing search for adsorbent which are cost effective and can be produced locally from waste materials, like agricultural waste. The alternative materials which have undergone research are lignite, wood, flyash, coal, bottom ash, clay, coconut shell.

Activated carbons have been indigenously prepared by the various raw materials like bagasse, straw, fruit nuts, shells, hulls, agricultural byproducts. Although various materials are used in the production of commercial activated carbons, abundant availability and low cost of agricultural byproducts make them good candidature and source of raw materials for activated carbon.

A number of biological processes for removal of dyes from effluents have been explored. Adsorptive components comprise of natural content such as municipal solid waste and agricultural waste which acts as bioadsorbents. However the use of agro wastes residues for the adsorption of dyes has been highlighted as an effective and cheap alternative for dye removal. These dye absorbed agro wastes were previously burnt for power generation, but the potential exists for them to be fermented to produce high protein content cattle feed. Solid state fermentation of the dye-adsorb waste will degrade the dyes and simultaneously enrich the nutritional value of the waste.

An adsorption isotherm is a graphical representation showing the relationship between the amount adsorbed by a unit weight of adsorbent and the amount of adsorbate remaining in a test medium at equilibrium. The adsorption capacity of any adsorbent may be determined by the use of an adsorption isotherms.

In the present investigation, the application of arecanut peels as an low cost adsorbent has been reported to be viable for removing dyes from aqueous solution. The effect of various parameters such as initial concentration, dosage, contact time and pH has been studied.

**MATERIAL AND METHODS**

Preparation of adsorbent: Areca nut peels activated carbon was prepared by treating 4 parts of the banana stem with 3 parts of concentrated sulfuric acid and keeping it in the hot air oven with the temperature being maintained in the range of 85°C - 100°C for a period of 24 hours. The carbonized material was washed well to remove excess acid and dried at 101°C. The dried material was subjected to thermal activation in the muffle furnace at 600°C for 30 minutes.

Preparation of adsorbate: Stock solution was prepared by dissolving appropriate quantity (1mg/L) of malachite green dye, a coloring reagent in distilled water. The stock solution was diluted as required to obtain a standard solution. The same was used throughout the experiment.
Specification of dye used:
Dye – Malachite green
Color – Bluish green
Type – Basic dye
Chemical formula – $C_{23}H_{24}CLN_2$
Molecular weight – 364.9
Wave length ($\lambda$) – 616nm

The adsorption experiments were carried out in a batch process by using aqueous solution of malachite green in the concentration range 1-6 mg/l, the other variable parameters were adsorbent dose (0.25-0.75 gm/l), contact time (0 - 60 minutes) and pH of the medium (2 – 10). The concentration was determined with the help of carefully prepared calibration curve with standard malachite green dye solution.

RESULTS AND DISCUSSION

The results of the present study reveal that the adsorbent prepared from the arecanut peels remove the dye selected for the investigation efficiently and effectively.

Effect of initial concentration of Dye
Concentration of malachite green dye was varied from 1 to 6 mg/L for a dosage of 0.5gm of adsorbent. It has been observed that there is a considerable decrease in percentage removal as the concentration of dye increases. The maximum removal efficiency was obtained at 5mg/L of adsorbate. It is shown in Fig. 1.

Effect of dosage of adsorbent
Dosage of adsorbent was varied from 0.25 to 0.75gm. It has been observed that there is a considerable decrease in percentage removal as the dosage of adsorbent increases. The maximum removal efficiency was obtained at 5gm of adsorbent. It is as shown in Fig. 2.

![Fig. 1 : Effect of Dye concentration for the removal of dye](image-url)
Effect of time

Color adsorption by arecanut peels carbon as a function of stirring time at different concentrations. The effect of contact time with 0.5gm of adsorbent dose in 5mg/l of dye solution were investigated, the color removal increases with increase in time. However contact time required to reach the equilibrium is 35minutes. At equilibrium the color removal was 92%. The results are as shown in Fig. 3.

Fig. 2 : Removal of dye as a function of adsorbent dosage

Fig. 3 : Effect of contact time for the removal of dye.
Effect of pH

The effect of pH on removal process at 0.5gm of arecanut peels activated carbon is shown in Figure 4. The maximum removal efficiency was obtained at pH 10.

Adsorption Isotherms

For assessing the efficiency of the absorbent for dye removal Freundlich and Langmuir isotherms are considered. The Freundlich isotherms represented by the following equation

\[
\log q_e = \log k + \frac{1}{n} \log C_e
\]  

(1)

Where \( q_e \) is the amount of dye absorbed per unit weight of the absorbent (mg/gm), \( C_e \) is the equilibrium concentration of the dye in aqueous solution (mg/l), \( k \) and \( n \) are constants depending upon the nature of absorbent and dye absorbed. The lined plots in figure 5 between \( \log q_e \) and \( \log C_e \) show the applicability of Freundlich isotherms. The values of \( k \) and \( n \) are found to be 1.18 and 0.75. The value of \( n \) between 0–1 indicating that adsorption is efficient.

The Langmuir isotherms represented by the following equation.

\[
\frac{C_e}{q_e} = \frac{1}{Q_0 b} + \frac{C_e}{Q_0}
\]  

(2)

Where \( C_e \) is initial concentration (mg/l), \( q_e \) is the amount absorbed at equilibrium time per unit absorbent (mg/gm) and \( Q_0 \) and \( b \) are Langmuir constants related to adsorption capacity and energy of adsorption respectively. The lined plots in figure 6 between \( C_e/q_e \) and \( C_e \) show the applicability of Langmuir isotherms. The value of dimensionless equilibrium parameter \( R_L \), where \( R_L = 1/(1+bC_0) \) where \( C_0 \) is the initial concentration. The value of \( R_L \) is found to be 0.833. The value of \( R_L \) between 0-1, showing favorable adsorption of dyes on the absorbent.

From the batch absorption studies it is confirmed that the equilibrium data’s fitted very well in both Freundlich and Langmuir isotherms.
CONCLUSION

The arecanut peels used as a new low cost adsorbent for dye removal from effluents was found to be efficient and capable of removing 92% of dye at a concentration of 5 mg/l. Large solute removal takes place immediately after mixing and agitation and equilibrium conditions are nearly obtained after around 35 minutes. Adsorption of the dye depends on initial concentration of adsorbate. The material used for adsorption, which is basically an agricultural waste, is cheap and locally available. It can be used as a replacement for commercial activated carbon for removing color in textile wastewater for a better environment.

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