

Adsorption of Dyes Using Coral Wood Tree Legume Pod as a Natural Adsorbent

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ABSTRACT: Industrialization and urbanization is considered as, one of major threats to environmental pollution of air, soil and water systems. Among these, water pollution is considered as important one. Out of many water pollutants, dyes are considered as most hazardous for the plants, animals and human beings. In the present study, Coral wood tree legume pod was investigated for the removal of dyes from aqueous solution in batch mode experiments. Parameters like contact time, pH, adsorbent concentration, adsorbent dose were studied. The results show that, coral wood tree legume is a very good adsorbent for the removal of dyes from the aqueous medium. To characterize the adsorbent material, FTIR spectra were used.

KEYWORDS: Coral wood legume pod, Natural adsorbent, dyes, column method, adsorption, FTIR

I. INTRODUCTION

Water is an important component of environment and is essential for the existence and well being of human beings. The quantity of uncontaminated ground water seems to be deteriorating at an alarming rate. Wastewater from textile industries poses major environmental problems. The wastewater from textile industry destroys the water, in which they are discharged. Textile wastewater is of varied composition often containing dyes, salts, organic surfactants and solvents (Katyal and Daga, 2003). Recent estimates indicate that, each year many dyes are lost during manufacturing and processing operations and 20% of these lost dyes enter the environment through industrial wastewater. Most of the dyes have complex aromatic structures, which are resistant to light, biological activity and other degradation processes and hence not readily removed by typical waste treatment processes. The decolorization of textile industries wastewater is a worldwide problem. Various treatment methods for removal of colors and dyes are coagulation, ozonisation, membrane separation, anaerobic decolorization, oxidation, flocculation and adsorption. Among all these methods, adsorption appears to be the best process for overall treatment of dyes stuff effluents (Sonawane & Shrivastava, 2009). The number of adsorbents like Low cost adsorbent (mohammed M.A *et al.*, 2014), Neem leaf and orange peel powder (Indira khatod, 2013), potato husk (Pooja V Shrivastava 2012), Moringa oleifera seeds (Rezamarandi *et al.*, 2011), Ghassoul (Elass K. *et al.*, 2010), Magellan peat (Luisa A. Sepulveda – Cuevasa *et al.* 2008,), Sugarcane bagasse (Liew Abdullah *et al.*, 2005), Akash Kinari coal (Tabrez A Khan *et al.*, 2004), Silkworm pupa (B. Noroozi *et al.*, 2004), Rice husk and Saw dust (Malik 2002), Powdered Activated Carbon (Sheng H. Lin 1993), Egg shell (Geetha and Belagali , 2012), Garlic husk (Geetha and Belagali, 2012) ,Chewing Tobacco (Geetha and Belagali, 2011). According to literature survey; it reveals that, there is in need of new adsorbents to remove many dyes with maximum adsorption capacity and coral wood legume can be considered as one of the alternative to other natural adsorbents. An attempt has been made to use this adsorbent Coral wood tree legume, since its availability is more.

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II. MATERIALS AND METHOD

Naturally available coral wood legume pod was collected as adsorbant. Dyes were procured from SDFine chemicals. To avoid the ionic contamination double distilled, demineralised water was used. And absorbance of dye solutions was measured by Systronics UV-Visible-118 Spectrophotometer.

1. Processing of the Adsorbent for the study: One of the legume plants "Adenantera pavonina" was collected, washed with water and dried in sunlight followed by hot air oven at 150°C. Dried legume was crushed into small pieces by hand, it was then powdered by the mixer grinder for 10-15 min into very small size particles. It was then sieved. By sieving, we got different size particles of adsorbent. Only uniform particle size of adsorbent was collected for adsorption. The uniform size particles of adsorbent were treated with 2N HCl and 2N NaOH solutions for half an hour. The adsorbent pH was maintained at '7' by adding dilute NaOH and HCl solution and washed thoroughly with distilled water.

2. Preparation of dye solutions: The dyes selected for the removal study are Malachite green, Victoria blue, Chrysoidine R and Bismarck brown R. 0.01g of dye was weighed and dissolved in 100 ml of distilled water to give 100 ppm of dye solutions which was diluted for required concentrations. The preparation procedure was same for all the dyes.

3. Experimental section

Batch Experiment: Dyes adsorption experiments were conducted in batch mode with 100 ml stock solution. The variables studied were adsorbent dose, concentration of adsorbate, pH and contact time. The mixture was observed for adsorption process after keeping the solution for adsorption to take place

- Five numbers of 50 ml samples of 10 ppm/L dye solutions were taken in beakers and 1-4 g of dose of adsorbent was added and studied for adsorption.
- Constant dose of adsorbent (1 g) was separately added to 50 ml samples with different concentration of dye solutions (10, 20, 30 and 40 ppm) in 4 beakers, at room temperature and studied the adsorption process.
- Five numbers of 50 ml samples of dye solutions from 10-40 ppm and varying doses of adsorbents from 1-4 g were added in series. Then, the solutions were kept for adsorption to take place.
- The effect of contact time with 1g of adsorbent dose in 50 ml of 10 ppm dye solution was studied.

Adsorption isotherms:

In order to determine the sorption potential of adsorbent, the study of sorption isotherm was essential in selecting an adsorbent for the removal of the dyes. The adsorption process was studied with the Freundlich and Langmuir isotherms (Adamson, 1960).

Freundlich isotherm: $\log q_e = \log K + (1/n \log C_e)$

Where, K and (1/n) are the measures of adsorption capacity and intensity of adsorption, respectively q_e is the amount of dye adsorbed per unit mass of adsorbent (in mg/gm). C_e is the equilibrium concentration of dye.

Langmuir isotherm: $(C_e/q_e) = (1/Q_0b) + (C_e/Q_0)$

where, q_e is the amount of dye adsorbed per unit mass of adsorbent at equilibrium (in mg/g), K and n are respectively the measures of sorption capacity and intensity of adsorption, C_e is the equilibrium concentration of dyes (in mg/L) and Q_0 and b are the Langmuir constants indicating the sorption capacity (in mg/g) and energy of adsorption (in gm/L) respectively from the slope and intercept.

Kinetics of the adsorption: The adsorption kinetics was found to be of first order. The following equation proposed by Kannan and Vanamudi (1991) was employed for adsorption data:

$$K_1 = (2.303/t) \log (C_0/C_t)$$

where, C_0 and C_t are concentrations of dyes at zero time and at time t (min). The values of $\log (C_0/C_t)$ were found to be linearly correlated with the contact time for all the above dyes.

Further, the essential characteristics of the Langmuir isotherm can be described in terms of a dimensionless constant, namely separation factor or equilibrium parameter, R_L which was defined by Weber and Chakravorti (1974) in the equation: $R_L = 1/(1+bc_i)$, where, b is the Langmuir constant and C_i is the initial concentration of dye (in ppm). The value of the parameter, R_L indicates the nature of the isotherm as given below. Standard R_L value which indicates the nature of the developed Model.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016

R _L value	Nature of isotherm
$R_L > 1$ $0 < R_L < 1$ $R_L = 1$ $R_L = 0$	Unfavorable Linear Favorable Irreversible

III. RESULTS AND DISSCUSSION

1. Effect of pH on the rate of adsorption:

- a) Malachite green dye got adsorbed in 5hrs in acidic medium but less adsorption in neutral and basic medium.
- b) Victoria blue got adsorbed in 18 hrs in acidic medium but less adsorption in neutral and basic medium.
- c) Chrysoidine R dye got adsorbed in 17 hrs in acidic medium but less adsorption in neutral and basic medium
- d) Bismark brown R dye got adsorbed in 48 hrs in acidic medium but less adsorption in neutral and basic medium.

From the data

Malachite green, Victoria blue , Chrysoidine R and Bismark brown R dyes adsorbed at faster rate in acidic medium.

2. Effect of adsorbent dose:

Five numbers of 50 ml samples of 10 ppm dye solutions were taken in beakers and 1 to 4 g of dose of adsorbents were added and studied for adsorption. In case of all dyes, as dose increased, adsorption increased it is shown in Fig. 1.

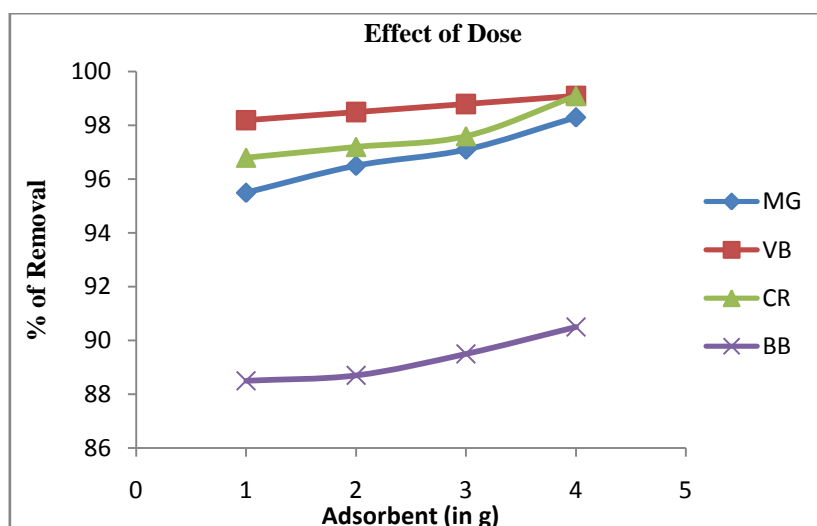


Fig 1 Effect of Dose

In fig. 1the graph shows that percentage removal of dyes in aqueous medium (adsorption) increases with dose. Here percentage removal of Victoria blue is maximum and bismark brown is minimum . We can see adsorption rate as follows, bismark brown < chrysoidine R< malachite green< Victoria blue. This is may be due to the interaction of different dyes with the adsorbent.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016

3.Effect of concentration:

Constant dose of adsorbents (1g) were separately added to 50 ml samples with different concentrations of dye solutions (10-40ppm) contained in 4 beakers at room temperature and studied the adsorption process, which indicates that, as concentration increases the adsorption decreases for all the adsorbents and dye solutions (Fig.2).As concentration increases the adsorption rate decreases for all dye solutions.

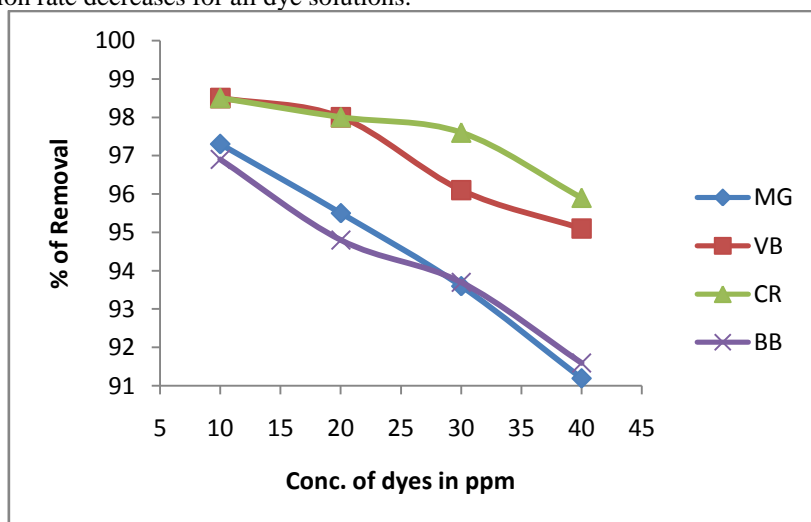


Fig 2 Effect of Concentration of dyes

In fig 2 the graph shows that percentage of removal of dyes in aqueous medium (adsorption) decreases with increase in the concentration of dye. Here the percentage removal of malachite green < bismarkbrown< malachite green < chrysoidine. This is may be due to the interaction of dye and the adsorbption capacity of the adsorbent.

4. Effect of Dose V/S Concentration:

Five numbers of 50ml samples of dye solutions (10-40ppm) and varying doses of adsorbents (1-4g) were added in series. Then, the solutions were kept for adsorption process to take place, this indicate that, the dose and the concentration of all the dye solutions, for all the adsorbents are co-related to each other

The dose and the concentrations of all the dye solutions are co-related to each other.

5. Effect of contact time:

The effect of contact time with 1g adsorbent dose in 50 ml of 10ppm dye solutions was investigated. The adsorption increased with increase in time. Contact time of all dye solutions was within 180min. The adsorption increased with increase in contact period.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016

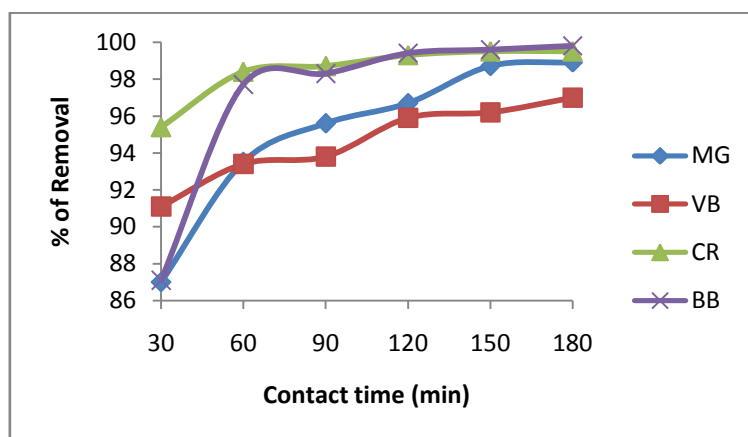
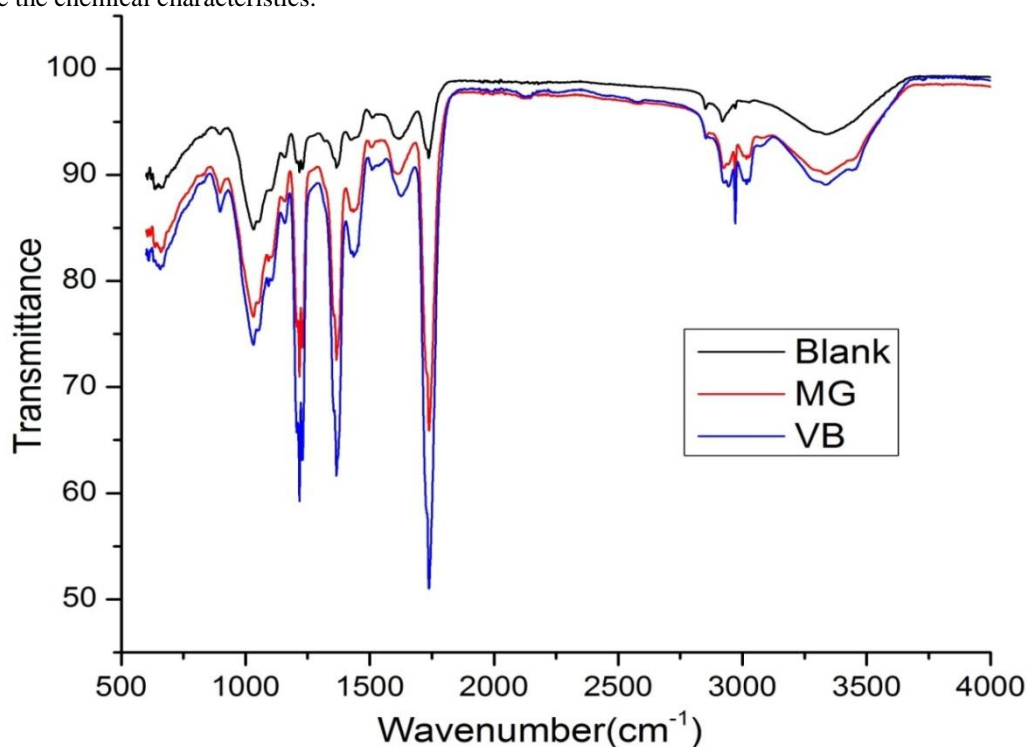


Fig 3 Contact time

In the fig 3. The graph shows that percentage removal of dyes in aqueous medium (adsorption) increases with increase in contact time. Here the percentage removal of Victoria blue < malachite green < chrysoidine R < bismark brown.

FTIR (Fourier Transform spectroscopic) study

Here we have analysed the adsorbed and unadsorbed adsorbent through the FTIR spectroscopic study in order to differentiate the chemical characteristics.



From the FTIR (Fourier transform infrared spectroscopy) spectra shows the some of the absorption peaks that indicates some of the functional groups present in the adsorbed adsorbent sample. So some of the chemical components adhere on the surface of the adsorbent this indicates adsorption has taken place. In the above FTIR spectrum the peaks 2950 cm^{-1} corresponding to alkyl C-H stretching, 1550 cm^{-1} indicates the presence of Ar-C=C, 800-1000 cm^{-1} corresponding aromatic bending to which correlates the chemical structure of Malachite green and Victoria blue.

International Journal of Innovative Research in Science, Engineering and Technology

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Langmuir and Freundlich constants for the removal of dyes malachite green, Victoria blue, Chrysoidine R and Bismark brown R using coralwood tree legume pod as an natural adsorbent

Isotherms	malachite green	Victoria blue	Chrysoidine R	Bismark brown R
Langmuir:				
Slope(a)	0.013	0.43	0.13	0.023
Intercept (b)	1.3	2.3	1.2	0.69
Correlation Coefficient	0.31	0.6	0.3	0.99
Freundlich:				
Slope(a)	0.31	0.64	0.68	1.4
Intercept (b)	1.3	2.3	1.2	0.69
Correlation Coefficient	0.31	0.6	0.3	1.0
Kinetics of adsorption:				
10²k/min.	0.31	0.28	0.34	0.28
Correlation Coefficient	0.89	0.87	0.76	1.0

IV. CONCLUSION

The present study we examined for the adsorption of malachite green , Victoria blue, Chrysoidine R, Bismark brown R in acidic condition. The result show that adsorption took place Malachite green (5hrs), Victoria blue (18hrs), Chrysoidine R (17hrs) and Bismark brown R (48hrs). So, Coral wood legume pod is a very good natural adsorption for the removal of dyes in the aqueous medium.

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International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 1, Januray 2016

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