Removal of Methylene Blue from Aqueous Solution by Adsorption Using Low Cost Activated Carbon Derived From Delonix Regia

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Abstract— The present study deals with removal of methylene blue (basic dye)from aqueous solution using a low cost activated carbon prepared from Delonix regia(gulmohar seed pods).Batch adsorption studies were conducted by varying the contact time adsorbent dosage and pH

Key words: Adsorption, Methylene blue , Delonix regia(Gulmohar seed pods)

I. INTRODUCTION

Industry used dyes to color their products. As a result, the residual and unspent dyes are discharged into the environment, particularly aquatic environment. Color is the most obvious indicator of water pollution. Wastewaters from dyeing and finishing operations in the textile industry are generally high in both colour and organic content. Recent estimates indicate that approximately 12% of synthetic textile dyes used each year are lost during manufacturing and processing operations and 20% of these lost dyes enter the environment through effluents that result from the treatment of industrial waste water. Most of the dyes have complex aromatic structures, which are resistant to light, biological activity and other degradative environments and hence not readily removed by typical waste treatment processes [1].

Dye-bearing wastes impose a serious threat to the surrounding environment matrix by creating imbalance in the aquatic eco-system by disturbing the symbiotic equilibrium (venkatamohan and Karthikeyan, 2003). Effluents with dye pollutants discharged are highly coloured due to the residual dyes and when they are disposed to the natural water sources, they pollute water. Thus the removal of dyes from coloured effluents, particularly from textile industries, is one of the major environmental concern these days. Various techniques have been employed in the past for the removal of dyes from waste water. Most of these conventional treatment techniques are rather expensive. But adsorption process has been found to be more effective method for treating dye-containing effluents. Although the activated carbon is most effective for adsorption of dyes however all these methods suffer from one or another limitation and none of them were successful in completely removing the colour from wastewater. Although the activated carbon is most effective for adsorption of dyes. [2]

II. LITERATURE REVIEW

A. In 2005 B.H.Hameed, A.T.M.D

in, A.L.Ahmad carried out adsorption of methylene blue by bamboo-based activated carbon. Bamboo was used to make activated carbon by physiochemical activation with potassium hydroxide and carbon dioxide. Adsorptiobn models and kinetic studies were also conducted and it was found that pseudo-second-order model best described the process.[3]

B. G.H.sonawane and V.S.shrinivastava(2009)

The results of the this study show that the BLP (Banana Leave Powder) is an agro based waste biomaterial and can be used as an effective adsorbent for removal of methylene blue from aqueous solution. Adsorption followed both the Langmuir and Freundlich isotherms. Kinetic data follows pseudo second order kinetic model with good correlation. The adsorption capacity of BLP for methylene blue was found to be 65.48 mg/g. The equilibrium adsorption is practically achieved in 30 minutes. The complete removal of dye can be achieved by using an appropriate dosage of adsorbent and pH from waste water. As banana leaves are a agricultural waste material available at negligible or no cost, thus adsorbent BLP is economical, biodegradable and ecofriendly alternative for removal of methylene blue with better efficiencies. The data may be useful for designing and fabricating an economically cheap treatment process using batched or stirred tank flow reactors for the removal of methylene blue from dilute industrial effluents.[5]

C. N.Renugadevi, M.Sangeetha And B.Kavitha (2010)

Have been studied the adsorption using low-cost activated carbon prepared from the fruits of Mimusops elengi is an efficient adsorbent for the removal of methylene blue from aqueous solution. Maximum Methylene blue removal (99.1%) in this study achieved in 180 minutes of contact time at pH 6 with 400mg of low-cost adsorbent using the 100ml dye solution containing 100mg of the dye [6].

III. MATERIAL AND METHODS

A. Adsorbent

The material used in this research study is Delonix regia (Gulmohar seed pod) as an adsorbent. The Methylene blue (basic dye) (chemical formula=$C_{16}H_{18}N_3SCl$ having molecular weight=319.86) has been used in the study

For removal of Methylene blue from aqueous solution, adsorption technique was employed using activated carbon prepared from gulmohar seed pods. There are two methods to prepare activated carbon, namely

(1) Physical activation(taking three sizes 75,150and300microns)
(2) Chemical activation (using K_2POH_4 and Na_2CO_3)

B. Impregnation Ratio

In chemical activation the degree of I.R. play an important role. It is the ratio of weight of anhydrous activation salt to the dry carbonizing material. The effect of the degree of impregnation ratio on the porosity of the resulting product is apparent from the fact that volume of pores increases with I.R. When degree of impregnation is further raised the number of pores with large diameter increases and the

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volume of the smallest decreases. In this study 0.25, 0.50 and 0.75 I.R'S. are used.

C. Batch Sorption Experiment

In batch sorption, a pre-determined amount of adsorbent is mixed with the sample, stirred for a given contact time and subsequently separated by filtration. Powder adsorbent is more suitable for the batch type contact process.

D. Selection Of Optimum Contact Time

The adsorption is strongly influenced by the contact time. To study the effect of contact time, 25mL 0f 20mg/L methylene blue solution was mixed with 0.1g of activated carbon, stirred at different contact times varying from (5mins, 10mins, 15mins up to 60mins). Then filtrate was analyzed for methylene blue concentration using spectrophotometer at 665nm wave length.

E. Determination Of Optimum Dosage Of Adsorbent:

To determine the optimum dosage of activated carbon, it was added to the conical flask in different dosage varying from (20mg, 40mg, and 60mg up to 200mg), containing 25mL concentration of methylene blue solution (20mg/L). The solution in the conical flask was subjected to stirring for optimum contact time, filtered and analyzed for residual Methylene blue concentration. The dosage which gives minimum residual concentration is chosen as optimum dosage.

F. Selection Of Optimum Ph On Methylene Blue

The extent of adsorption is strongly influenced by the pH at which adsorption is carried out. The effect of pH on methylene blue adsorption was studied by performing equilibrium adsorption tests at different initial pH values. i.e. from 6 to 10. The pH of solution was adjusted by using 0.1N H2SO4 or 0.1N NaOH. The pH which gives minimum residual concentration is chosen as optimum pH.

IV. Results And Discussion

This chapter deals with the efficiency of prepared carbon for removing Methylene blue for:

(1) Effect of contact time
(2) Effect of dosage
(3) Effect of pH

A. Effect of Contact Time:

Contact time has greater influence in the adsorption process. The effect of contact time on removal of methylene blue from synthetic sample on physically and chemically activated carbons prepared from gulmohar seed pods with I.R. 0.25, 0.50 and 0.75 are shown in figure 4.1, and 4.2 and 4.3, . Model values are as shown in the tables 4.1. From the graph it is evident that the extent of methylene blue adsorption increases with increase in time and remains constant and the variation of %removal with contact time is as shown in table 4.1, 4.2 and 4.3.

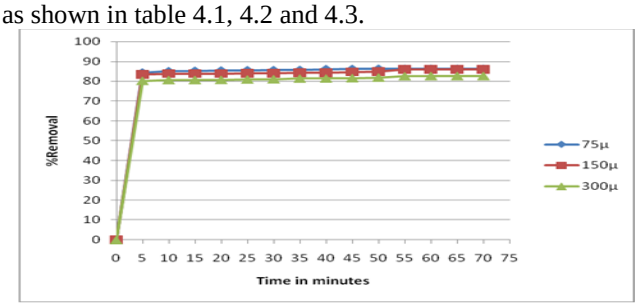

Fig. 4.1: Effect of Contact time on Methylene blue Removal by Physically activated carbon

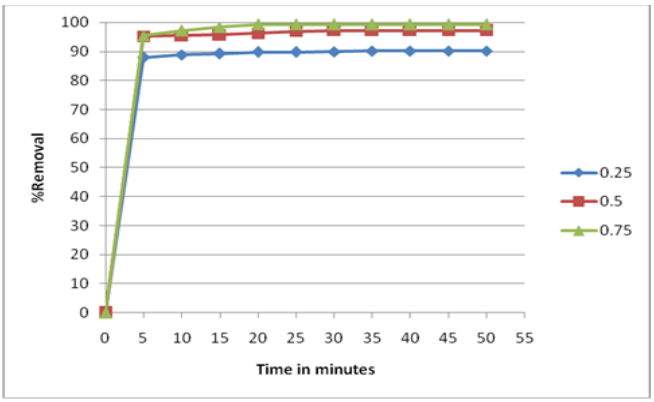

Fig. 4.2: Effect of Contact time on Methylene blue Removal by chemically activated carbon (K_2HPO_4)

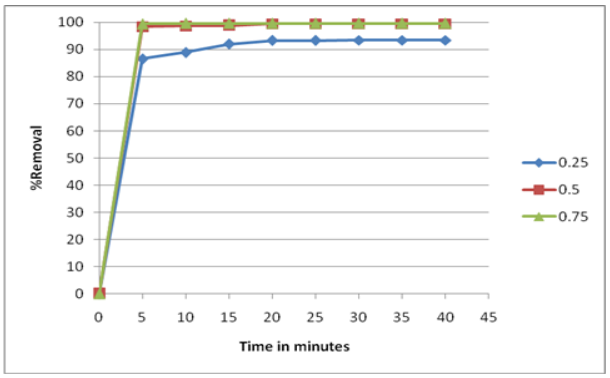

Fig. 4.3: Effect of Contact time on Methylene blue Removal by chemically activated carbon (Na_2CO_3)

Time in minutes	% Removal of MB		
	75µ	150µ	300µ
5	84.470	83.450	80.280
10	85.128	83.780	80.720
15	85.308	83.810	80.750
20	85.488	83.840	80.780
25	85.600	83.87	80.990
30	85.660	83.900	81.110
35	85.780	84.170	81.440
40	86.170	84.230	81.470
45	86.260	84.680	81.650
50	86.350	84.760	81.950
55	86.350	85.960	82.610
60	86.350	85.960	82.700
65	86.350	85.960	82.700
70	86.350	85.960	82.700

Table 4.1: Effect of Contact Time On Methylene Blue Removal By Physically Activated Carbon

Time in minutes	% Removal of MB		
	I.R=0.25	I.R=0.50	I.R=0.75

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5	87.880	95.218	95.517
10	88.810	95.510	97.194
15	89.200	95.690	98.422
20	89.760	96.326	99.350
25	89.790	96.860	99.350
30	89.880	97.164	99.350
35	90.180	97.164	99.350
40	90.180	97.164	99.350
45	90.180	97.164	99.350
50	90.180	97.164	99.350

Table 4.2: effect of contact time on methylene blue removal by chemically **(k_2hpo_4)** activated carbon activated carbon

Time in minutes	**% Removal of MB**		
	I.R=0.25	**I.R=0.50**	**I.R=0.75**
5	86.505	98.452	99.380
10	88.871	98.661	99.550
15	91.925	98.721	99.550
20	93.242	99.410	99.550
25	93.272	99.410	99.550
30	93.422	99.410	99.550
35	93.422	99.410	99.550
40	93.422	99.410	99.550

Table 4.3: Effect of Contact Time on Methylene Blue Removal by Chemically **(Na_2Co_3)** Activated Carbon

B. Effect of Adsorbent Dosage:

Adsorption is a process in which continuous transfer of solute from solution to adsorbent occurs, until residual concentration of solution maintains equilibrium with what adsorbed by the surface of adsorbent at constant contact time. Effect of adsorbent dosage is studied and graph of percentage of Methylene blue removal versus dosage is plotted as shown in figure 4.4 and 4.5 and 4.6 the variation of %removal with adsorbent dosage is as shown in table4.4, 4.5 and 4.6

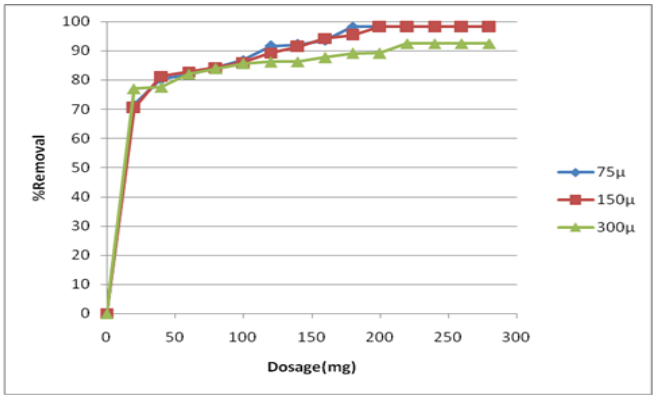

Fig. 4.4: Effect of adsorbent dosage on Methylene blue removal by physically activated carbon

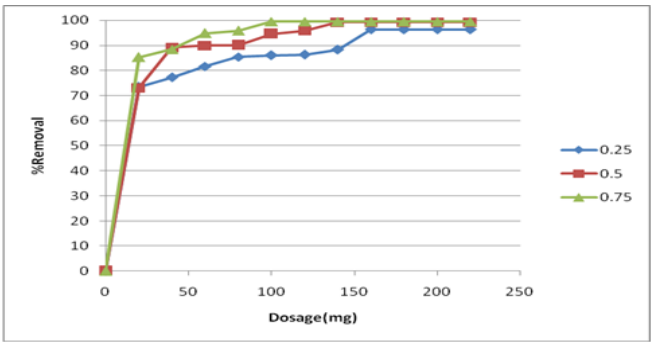

Fig. 4.5: Effect of adsorbent dosage on Methylene blue removal by chemically (K_2HPO_4).activated carbon

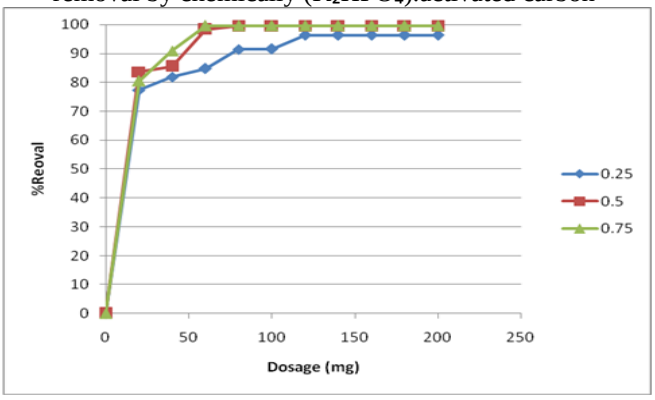

Fig. 4.6: Effect of adsorbent dosage on Methylene blue removal by chemically (Na_2CO_3).activated carbon$_2$HPO

Adsorbent dosage in mg	**% Removal of MB**		
	75µ	**150µ**	**300µ**
20	71.535	70.368	77.044
40	80.278	81.236	77.583
60	81.925	82.733	81.985
80	84.290	84.230	83.841
100	86.715	85.967	85.667
120	91.655	89.239	86.206
140	92.134	91.356	86.266
160	93.661	94.200	87.703
180	98.212	95.338	89.080
200	98.212	98.182	89.200
220	98.212	98.182	92.494
240	98.212	98.182	92.494
260	98.212	98.182	92.494
280	98.212	98.182	92.494

Table 4.4: Effect of Adsorbent Dosage on Methylene Blue Removal by Physically Activated Carbon

Adsorbent dosage in mg	**% Removal of MB**		
	I.R=0.25	**I.R=0.50**	**I.R=0.75**
20	73.392	73.122	85.278
40	77.224	89.170	88.422
60	81.595	89.889	94.799
80	85.398	89.979	95.877
100	86.026	94.529	99.470
120	86.266	95.817	99.470
140	88.272	99.260	99.470
160	96.266	99.260	99.470

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180	96.266	99.260	99.470
200	96.266	99.260	99.470
220	96.266	99.260	99.470

Table 4.5: Effect of Adsorbent Dosage on Methylene Blue Removal by Chemically (K_2Hpo_4) Activated

Adsorbent dosage in mg	**% Removal of MB**		
	I.R=0.25	**I.R=0.50**	**I.R=0.75**
20	77.374	83.691	80.428
40	81.925	85.517	90.907
60	84.769	98.332	99.559
80	91.416	99.410	99.559
100	91.535	99.410	99.559
120	96.386	99.410	99.559
140	96.386	99.410	99.559
160	96.386	99.410	99.559
180	96.386	99.410	99.559
200	96.386	99.410	99.559

Table 4.6: Effect of Adsorbent Dosage on Methylene Blue Removal by Chemically (Na_2Co_3) Activated Carbon

V. Effect Of Ph On Methylene Blue Removal:

The pH of solution has influence on the extent of adsorption removal efficiencies of Methylene blue by prepared activated carbon at different pH values are shown in fig 4.7 and 4.8 , 4.9. From the mentioned figures, it is observed that methylene blue is removed more effectively in slight alkaline range. The removal efficiency of methylene blue by using physically activated carbon, chemically activated carbon. Table 4.7,4.8 and 4.9 shows the variation of pH with adsorbent dosage.

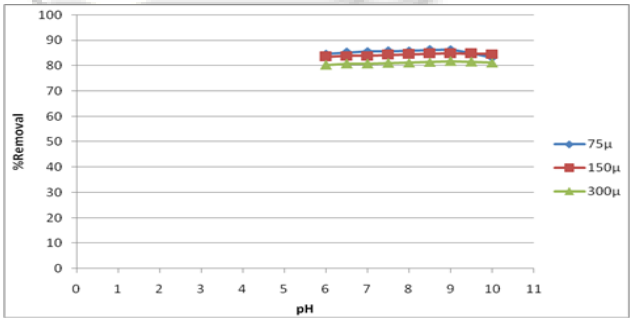

Fig. 4.7: Effect of pH on Methylene blue removal by physically Activated carbon.

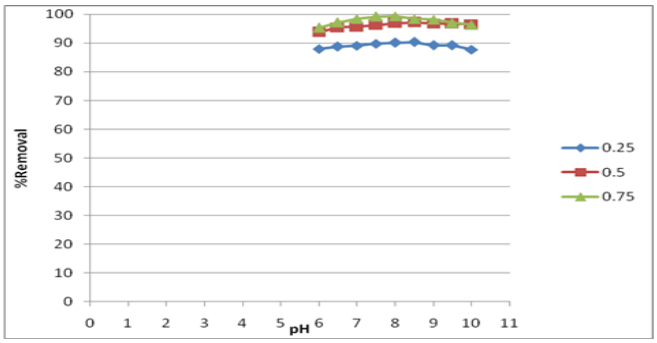

Fig. 4.8: Effect of pH on Methylene blue removal by chemically (K_2HPO_4). Activated carbon

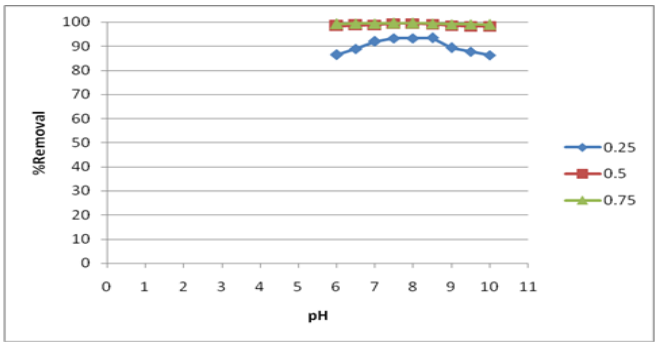

Fig. 4.9: Effect of pH on Methylene blue removal by chemically (Na_2CO_3) Activated carbon

pH	**% Removal of MB**		
	75µ	**150µ**	**300µ**
6	84.550	83.452	80.338
6.5	85.240	83.811	80.727
7	85.600	83.871	80.817
7.5	85.690	84.170	80.990
8	85.817	84.410	81.146
8.5	86.146	84.679	81.356
9	86.290	84.769	81.710
9.5	84.919	84.649	81.476
10	83.270	84.559	81.176

Table 4.7: Effect of Ph on Methylene Blue Removal by Physically Activated Carbon

pH	**% Removal of MB**		
	I.R=0.25	**I.R=0.50**	**I.R=0.75**
6	88.000	93.720	95.360
6.5	88.810	95.480	97.190
7	89.080	95.660	98.392
7.5	89.760	96.260	99.260
8	90.090	96.890	99.350
8.5	90.360	97.190	98.390
9	89.260	96.860	98.240
9.5	89.230	96.740	97.010
10	87.730	96.560	96.380

Table 4.8: Effect of Ph on Methylene Blue Removal by Chemically (K_2Hpo_4) Activated Carbon

pH	**% Removal of MB**		
	I.R=0.25	**I.R=0.50**	**I.R=0.75**
6	86.470	98.330	99.260
6.5	88.870	98.690	99.380
7	91.920	98.780	99.440
7.5	93.240	99.380	99.550
8	93.270	99.410	99.610
8.5	93.422	99.140	99.380
9	89.260	98.570	99.140
9.5	87.730	98.270	99.110

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10	86.260	98.180	98.960

Table 4.9: Effect of Ph on Methylene Blue Removal by Chemically (Na_2Co_3) Activated Carbon

Type Of Carbon		**Optim Time (min)**	**Optimu Dosage (mg)**	**Optimu pH**
1.Physically activated	**Size**			
	75µ	50	180	9
	15µ	55	200	9
	30µ	60	220	9
2.Chemicall activated	**I.R**			
a) K_2HPO_4	0.25	35	160	8.5
	0.50	30	140	8.5
	0.75	20	100	8
b)Na_2CO_3	0.25	30	120	8.5
	0.50	20	80	8
	0.75	10	60	8

Table 4.10: Optimum Contact Time, Optimum Dosage And Optimum Ph For Prepared Carbons

VI. Conclusion

(1) The Experimental results shows good removal efficiency of Methylene blue from synthetic solution by using activated carbon derived from gulmohar seed pods.
(2) The kinetics of adsorption of Methelene blue with physically and chemically activated carbons were studied by estimating the effect of contact time on the percentage removal of Methylene blue. The data and results from the experiment reveal that removal of Methylene blue increases with increase in contact time and attains equilibrium at particular time. Hence optimum contact time for physically activated carbon is 50 min with removal efficiency of 81.95%, for K_2HPO_4 activated carbon at I.R. - 0.75 is 20 min with removal efficiency of93.350%. Similarly Na_2CO_3 activated carbon at I.R.-0.75 is 10 min with removal efficiency of 99.550%.
(3) The result of experiment on optimization of dosage of adsorbent reveals that, increase in amount of dosage added, increases the removal of Methylene blue from the solution. Hence Optimum dosage for physically activated carbon is 180mg with removal efficiency of 89.080%, for K_2HPO_4 activated carbon at I.R.-0.75 is 100 mg, with removal efficiency of 99.470%. Similarly (Na_2CO_3) activated carbon at I.R.-0.75 is 60 mg, with removal efficiency of 99.559.
(4) The adsorption of Methylene blue is mainly pH dependent. The removal efficiency of adsorbent increases with decrease in pH value. It has been observed that maximum adsorption takes place in slight alkaline medium

VII. Scope For Future Work

(1) Experiment can also be conducted with adsorbent of different varying sizes so as to choose the best size of the adsorbent.
(2) Experiment can also be conducted by varying temperature
(3) Experiment can also be conducted by varying concentration of adsorbate
(4) Experiment can also be conducted by taking different chemicals to activate the carbon
(5) Experiment can also be conducted by taking different low cost material as adsorbent

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