REMOVAL OF RHODAMINE B DYE FROM AQUEOUS SOLUTION BY ADSORPTION USING LOW COST ADSORBENT OBTAINED FROM *Centella asiatica* LEAVES

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Abstract: Adsorbent obtained from *centella asiatica* leaves is employed for the removal of the Rhodamine –B dye from aqueous solution. Batch adsorption studies were carried out by observing the effects of various experimental parameters such as the effect of pH, adsorbent dose, dye concentration, contact time and temperature. The equilibrium data fitted well to Langmuir isotherm model. The results indicate that the adsorbent obtained from *centella asiatica* leaves is a good adsorbent for the removal of Rhodamine-B from aqueous solution.

Index terms – Rhodamine-B, isotherm models, Adsorbent dose, Thermodynamic parameters.

I. INTRODUCTION

Textile industries use large amount of water in their production and discharge large amounts of waste water. This water contains various dyes and heavy metals[1]. These dyes are mainly used as coloring agents in textile, paper printing, and leather industries. Most of the dyes are toxic and non- biodegradable, hence the removal of this dye from wastewater is important.

Numerous methods have been designed to remove dyes from waste water[2], and such methods can be divided into physical, chemical and biological methods. Among these, the adsorption technique using low cost adsorbents derived from various natural, agricultural and industrial wastes[3] are effective in removing various dyes from waste waters

Many low cost adsorbents were prepared from waste materials such as coconut husk and bunch waste [4-6], date stone[7], jujuba seed[8], garlic peel[9], olive waste cake[10], apple wastes[11], periwinkle shell[12], oil palm fruit waste[13], Bengal gram seed husk[14], castor bean cake[15], maize stem tissue[16]. In this study we employed, the adsorbent obtained from the leaves of *centella asiatica* for the removal of Rhodamine-B from the waste water.

II.EXPERIMENTAL

Preparation of adsorbate

Rhodamine B stock solution was prepared by dissolving appropriate amount of dye in double distilled water, and lower concentrations were obtained by dilution of the stock solution.

Preparation of adsorbent material

Centella asiatica leaves were collected and washed with tape water several times to remove soil dust and finally washed with DD water. It is dried in sun shade. The dried leaves were powdered and soaked in con.H_2SO_4(1:1,w/w), for a day, then filtered and dried. The charred mass was kept in a muffle furnace at 400^0C,for 1 hour, it was taken out, ground well to fine powder and stored in vacuum desiccators. The Characteristics of the adsorbent is presented in the table-1

pH	6.5
Moisture Content, %	13.5
Ash Content, %	10.2
Volatile Matter, %	21.3
Water Soluble matter, %	0.45
Acid Soluble Matter, %	0.89
Porosity, %	48.1
Micropore volume cm^3/g	0.194194
Average pore width ^0A	28.2065
BET Surface Area, m^2/g	604.27

Table-1 Characteristics of the adsorbent

Batch equilibrium studies

Batch experiment was carried out with different concentrations of dye solutions from 10mg/l to 50mg/l was taken in a 250ml clean Erlenmeyer flasks. A certain amount of adsorbent dose was mixed with Rhodamine B dye solution and kept in an orbitary shaker with a speed of 120rpm.

Experimental parameters such as, adsorbent dosage 100mg, contact time is 90min, pH-2 to 10, initial concentration 10mg/l to 50mg/l and temperature 30^0C were investigated by changing one parameter at a time, while other parametes are kept constant. After filtration, the dye solutions were analyzed by UV-visible spectrophotometer. The percentage of Rhodamine B dye removal was calculated by using the following equation.

$$\% \ Dye \ \text{Re} \, moval = \frac{(C_0 - C_e)}{C_0} \ X \ 100$$

Where Ci = initial concentration(mg/l),Ce = equilibrium concentration(mg/l)

The adsorption capacity Qe (mg/g), is obtained from the following equation

$$q_e = (C_0 - C_e)\frac{V}{M}$$

Where, Q_e = adsorbent capacity(mg/g), C_i= initial Nickel concentration (mg/l),V = volume of the solution(l), M = mass of the adsorbent (g).

III.RESULT AND DISCUSSION

Effect of pH

Effect of pH on the adsorption capacity of adsorbent dose was studied in the pH range 1 to 10. The percentage of dye adsorption was determined by varying the pH of the solution, fixing the other parameters constant and the results are given in fig-1. The pH of the solution was adjusted by adding 1NHCl or 1NNaOH solution. When the pH increased and reached a maximum at pH 6 and the decreased. At low pH the Rhodamine B molecules readily enter into the pore structure of the adsorbent surface but at high pH , the zwitter-ionic form of Rhodamine B in water aggregated to form a dimer which could not easily enter into the pores due to the bulkier structure of the dimer [17]. Hence the pH of the medium was maintained at 6 for further studies.

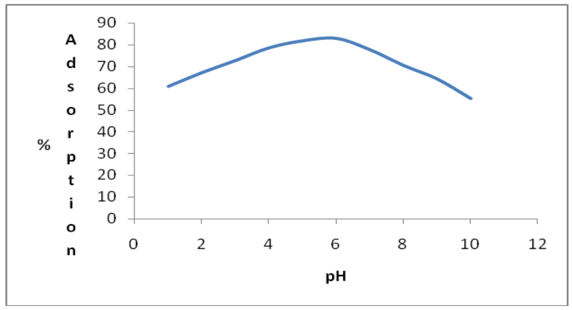

Fig:1 Effect of pH on the adsorption of Rhodamine b on to the adsorbent

Effect of adsorbent dose

Effect of adsorbent dose on the removal of Rhodamine B dye from aqueous solution was investigated by varying adsorbent dose from 25mg to 150mg for 10mg/l of dye concentration, keeping the other parameters constant, and the results are presented in the fig-2. When the adsorbent dosage was increased the percentage of adsorption increased and reaches the maximum at an adsorbent dosage of 100mg, further addition of the adsorbent dosage has no significant effect. The maximum dye uptake occurred at 100mg dose, hence it was chosen as the optimized dose.

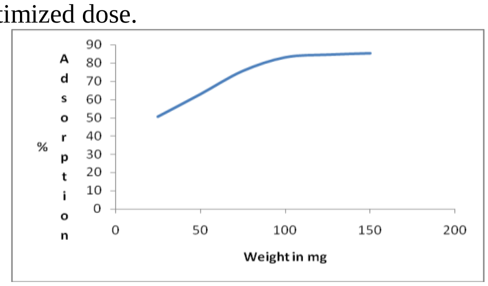

Fig:2 Effect of adsorbent dosage on the adsorption of Rhodamine b on to the adsorbent

Effect of dye concentration

The effect of dye concentrations on the adsorption capacity is shown in fig-3. When the initial dye concentration increased from 10mg/l to 50mg/l, the percentage removal of Rhodamine B dye decreased. This is because when the dye concentration increased the ratio of the number of vacant sites on the adsorbent to the dye molecule decreases .

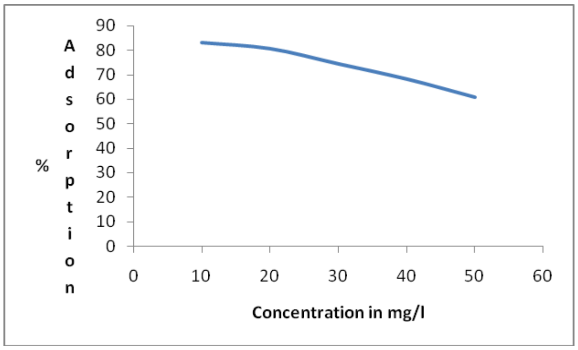

Fig:3 Effect of dye concentration on the adsorption of Rhodamine B on to the adsorbent

Effect of contact time

The effect of contact time on the removal of the dye is shown in fig-4. It is observed that initially the percentage removal of the dye increases rapidly and then increases in a slow and gradual manner till it reaches the equilibrium. This is because a large number of surface sites are available for adsorption at the initial stages and as the adsorption process continues the adsorption sites available decreases. There was no appreciable change in the adsorption percentage above 90min. Hence all the experiments were conducted for a period of 90min.

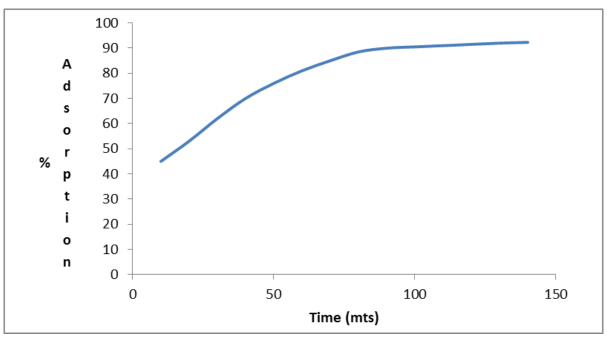

Fig:4 Effect of contact time on the adsorption of Rhodamine B on to the adsorbent

IV. ADSORPTION ISOTHERMS

Adsorption data were fitted to the Langmuir, and Freundlich isotherms and isotherm parameters were calculated .

Langmuir isotherm model

It is based on the assumption of equally available adsorption sites, monolayer surface coverage, and no interaction between adsorbed species. The linear form of Langmuir equation[18] is expressed as follows

$$\frac{Ce}{Qe} = \frac{Ce}{Q_0} + \frac{1}{Q_0 b}$$

The values of Q_0 and b were calculated from the slope and intercept of the linear plots of C_e/Q_e verses C_e. Langmuir adsorption isotherm is presented in fig-5. Higher value of correlation co-efficient (0.999) indicates that the experimental data fits well with the Langmuir equation. The values of Q_0 and b are given in Table-2.

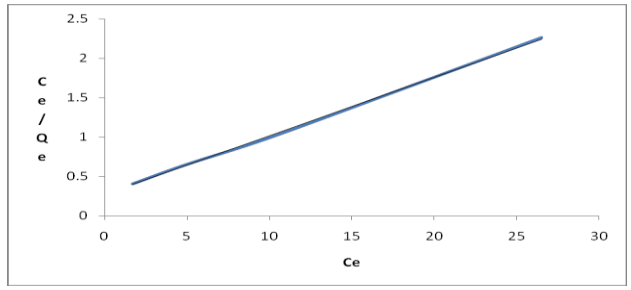

Fig:5 Langmuir isotherm for the adsorption of Rhodamine B on to the adsorbent

Qo(mg/g)	b	R^2
19.6078	0.1588	0.999

Table-2. Langmuir constants

The essential characteristics of the Langmuir adsorption isotherm are expressed by a dimensionless constant called separation factor. This value indicates whether the adsorption is favorable or not.

R_L is defined by the following equation

R_L = 1/ (1+bCo)

Where,R_L _ dimensionless separation factor[19], Ci – intial concentration , b – Langmuir constant (Lmg-^{1}),The parameter $R_L$indicates the type of the isotherm.

Values of R_L	Types of isotherms
R_L>1	Unfavourable
R_L = 1	Linear
0<R_L<1	Favourable
R_L = 0	Irrevisible

The R_L value obtained using the above equation for 10mg/l Rhodamine concentration is 0.3863. This R_L value lies between 0 and 1 indicating the favourability of the adsorption.

Freundlich isotherm model

The Freundlich isotherm considers multilayer adsorption with a heterogeneous distribution of active sites, accompanied by interactions between adsorbed molecule The linear form of the Freundlich equation[20] is as follows

$$\log \mathrm{Qe} = \log \mathrm{K_F} + \frac{1}{n}\log Ce$$

Where Qe , amount of dye adsorbed (mg/g),K_f ,adsorption capacity, n, adsorption intensity. By ploting logQe Vs logCe, the values of n and K were calculated from slope and intercept respectively (fig-6). The values of K_f and n are given in table-3. The value of linear regression co-efficient (R^2) was found to be 0.969.This indicates that the adsorption process follows Langmuir adsorption isotherm more than Freundlich adsorption isotherm.

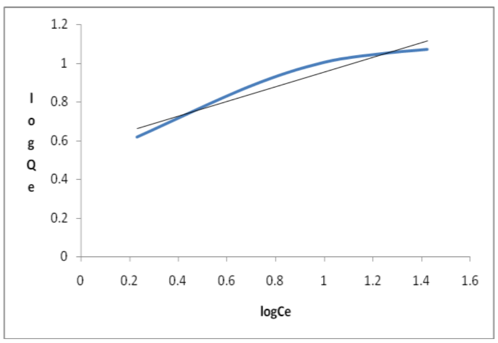

Fig:6 Freundlich isotherm for the adsorption of Rhodamine B on to the adsorbent.

n	K_f(mg/g)	R^2
2.0618	3.5399	0.970

Table-3. Freundlich constants

The value of n in the range 2-10 indicates favorable adsorption.

VI. THERMODYNAMIC PARAMETERS

The thermodynamic parameters, standard free energy (ΔG^o), change in Standard enthalpy(ΔH^o) and change in Standard entropy(ΔS^o) for the adsorption of Rhodamine B onto the adsorbent were calculated using the following equations.

$$K_0 = \frac{C_{solid}}{C_{liquid}}$$

$$\Delta G^0 = -RT \ln K_0$$

$$\log K_0 = \frac{\Delta S}{2.303R} - \frac{\Delta H}{2.303RT}$$

Where Ci is the concentration of the dye at equilibrium and Ce is the amount of dye adsorbed on the adsorbent

The values of ΔG^o (KJ/mol), ΔH^o(KJ/mol^{-1}) and ΔS^o (J/K/mol) can be obtained from the slope and intercept of a linear plot of log K_o verses 1/T and are presented in table-4.

Conc.of MG dye (mg/l)	$-\Delta G^o$ (KJ/mol)				ΔH^o (KJ/mol)	ΔS^o (J/k/ mol)
	30^0 C	40^0 C	50^0 C	60^0 C		
10	4.0770	4.8375	5.2245	6.0488	14.821	62.41
20	3.5691	4.1077	4.5294	3.1972	12.332	52.44
30	2.7526	3.1494	3.7298	4.4640	14.333	56.10
40	1.9020	2.4073	2.5998	3.3228	11.386	43.80
50	1.2546	1.6025	1.8372	2.4536	10.161	37.52

Table-4 Thermodynamic parameters for the adsorption of Rhodamine B on to the adsorbent.

The negative values of ΔG^o indicates that the adsorption process is spontaneous and highly favorable . The positive values of ΔS^o indicates the increased randomness at the solid solution interface. The positive values of ΔH^o indicates that the adsorption process is endothermic and physical in nature.

VI.CONCLUSIONS

The equiliIbrium and thermodynamic studies related to the uptake of Rhodamine B dye by centella asiatica adsorbent from aqueous solution was studied. The adsorption was found to highly dependent on various parameters like adsorbent dosage, contact time, pH, initial concentration, and temperature. The adsorption data was fitted the best in Langmuir adsorption model. The result of this study indicates that this adsorbent can be successfully utilized for the removal on rhodamine B from aqueous solution.

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