Oriental Journal of Chemistry Vol. **24**(3), 983-988 (2008)

Experimental investigation of the adsorption of Rhodamine-B from aqueous solution onto activated carbon from water hyacinth

P. LALITHA and S. NITHYA SANGEETHA

Avinashilingam University for Women, Coimbatore - 641 043 (India).

(Received: July 25, 2008; Accepted: October 06, 2008)

ABSTRACT

In the present work activated carbon prepared from water hyacinth is used as an adsorbent for adsorption of Rhodamine B. The process of adsorption of Rhodamine B onto activated carbon and the effect of concentration variation has been simulated by using the software program-'visual basic'. The maximum percentage (83%) of removal of dye was noted at 60min with 1mg/100ml of dye. Approximately 50% of dye removal was noted on varying the contact time (15 to 75min). The data on adsorption of dye to the adsorbent were found to fit well with the first order kinetics as modified by Lagergrens equation. Simulation studies done by Visual Basic program offer a means of studying the process of adsorption at varied dosage of adsorbent, concentration of dye etc.

Key words: Rhodamine B, activated carbon, water hyacinth.

INTRODUCTION

The presence of dyes in wastewater possesses a severe problem, as they are toxic to life as well as damaging to the aesthetic nature of the environment [1].Rhodamine-B is a color additive but due to its toxic property it is restricted to use as a color additive in foods and beverages. Rhodamine-B is widely used in various industries for coloring as well as other purposes. Due to the concern for environmental protection, it becomes essential to remove Rhodamine-B from industrial wastewater before discharging them into water bodies and onto land.

In the present work activated carbon prepared from water hyacinth is used as an adsorbent for adsorption of Rhodamine B. Although a number of methods such as coagulation [2], ozonation[3] membrane process[4], filtration and coagulation[5], equalization, neutralization, flocculation and coagulation, advanced oxidation process [6], screen method, pH controlling method, activated sludge method, sedimentation, sludge disposal, contacting aeration method, sprinkling filtration process and adsorption method have been used for this purpose, the adsorption process [7] remains the best one as it is universally applicable and is the most versatile process for the pollutants removal from waste waters [8].

The pollution level has been increased due to increase in the growth of water hyacinth, and also the entry of sewage raised the pollution level (The Hindu, 2006). The presence of weeds (water hyacinth) had made the boathouse in Ooty an eyesore and people in the vicinity had converted it into an open-air toilet. The weed problem in Ooty Lake has reached alarming proportions. Out of a 45-acre water spread, 30 acres has been rendered useless with the weeds spreading close to the boat jetties (The Hindu, 2007).

In the present work, the menace - water hyacinth has been utilized as an adsorbent for the removal of dye - Rhodamine-B from the aqueous solution. The main object of this study is to convert 'waste to wealth' via employing a hazardous pollutant - water hyacinth to treat a pollutant dye - Rhodamine B. The process of adsorption of Rhodamine B onto activated carbon and the effect of concentration variation has been simulated by using the software program-'Visual Basic'.

MATERIAL AND METHODS

The stock solution containing the 1000 mg/l, concentration of Rhodamine-B was prepared by dissolving 1000 mg of Rhodamine-B in 1000 ml of distilled water. Rhodamine-B was procured from Loba chemie.

Preparation of adsorbent

The adsorbent used in this study was prepared from water hyacinth which was collected from the local water bodies (Kuruchi and Singanallur Pond, Coimbatore). The collected plant was washed with water and then it is dried for one week. Then the dried plant was powdered and carbonized using muffle furnace.

Continuous - flow sorption column studies

The powdered plant was taken in small quantity in silica crucible and kept inside the furnace. The plant material was carbonized at 270°C and was used for packing the column.

For continuous-flow adsorption studies, a column of 9 cm diameter and 35 cm length was used. The column was packed with the dried and weighed adsorbent. From the standard stock solution, 100 mg of dye was dissolved in 100 ml of distilled water to make 1 ml of Rhodamine-B equivalent to 1 mg. Then suitable concentrations of Rhodamine-B were prepared for the studies and taken in the column and the unadsorbed Rhodamine-B was collected from the outlet at a constant rate. The concentration of the residual dye was analyzed spectrophotometrically.

Effect of adsorbent dosage

In this study, the adsorbent dosage was varied as 200mg, 400mg, 600 mg, 800 mg and 1000 mg. The standard solution of Rhodamine-B (1 mg/100 ml) was prepared and taken in the adsorbing column. The flow rate was maintained at (100 ml/hr

Effect of concentration of rhodamine-B

Three different concentrations (0.4 mg/100 ml, 0.6 mg/100 ml, and 0.8mg/100 ml) of Rhodamine-B were prepared and 400 mg of adsorbent was maintained as the adsorbent dosage. This study was carried out for this three different concentration at different contact time (100 ml/15 min, 100 ml/30 min, 100 ml/45 min, 100 ml/60 min).

Effect of contact time

Rhodamine-B of concentration 1 mg/100ml was prepared and the adsorbent dosage was taken as 400 ml. The study was carried out at different rate 100ml/15 min, 100ml/30 min, 100ml/45 min, 100ml/60 min/ 100ml/75 min).

Kinetics of the process

The kinetics of the adsorption process was studied by the use of Lagergren's first order equation.

Simulation of the adsorption process

The process of adsorption has been simulated using the VB program. This offers a method of finding the adsorption process in varied concentration of dye, dosage of adsorbent etc without conducting the laboratory studies.

RESULTS AND DISCUSSION

Effect of variation of dosage of adsorbent

A good percentage (83%) of removal of dye occurred at a dosage level of 1000 mg. An increase in adsorption of dye (38-83%) on to the

Table 1: Variation of adsorbent (water hyacinth) dosage for the removal of rhodamine B

S. No	Amount of Carbon in mg	Final concentration of dye mg/100ml	% of adsorption
1.	200	0.62	38
2.	400	0.53	47
3.	600	0.40	60
4.	800	0.31	69
5.	1000	0.17	83

activated carbon with increase in carbon dosage (200-1000mg) was noted (Table 1). The maximum adsorption of dye with increase in the dosage level is due to the availability of more surface area of the adsorbent for adsorption.

Effect of initial concentration of dye

The results obtained show that at lower concentration of dye (0.4 mg/100 ml) the removal efficiency is higher (62.5%). The removal efficiency of dye decreases when the dye concentration increases (Table 2). At higher concentrations of dye, the surface area available for larger number of adsorbent is less; hence less is the efficiency of adsorption.

Effect of contact time

The result obtained from this study show that the percentage adsorption of dye increases (35 to 52 %) with increase in contact time (15 to 75 min) (Table 3). As more time is available for contact of the activated carbon with the dye, greater is the adsorption.

Kinetics of adsorption study using lagergren equation

The Lagergren equation for a first order process is,

$\log (q_e - q) = \log q_e - Ka / 2.303\ t.$

q = amount of dye adsorbed at time t

Table 2 : Variation of initial concentration for adsorption of rhodamine b onto activated carbon (water hyacinth)

S. No	Time in min	Amount of carbon in mg	Initial concentration of dye in mg/100ml	Final concentration of dye in mg/100ml	% of adsorption
1	15	400	0.4	0.31	22.5
	30			0.26	35.0
	45			0.19	52.5
	60			0.15	62.5
2	15	400	0.6	0.48	20.0
	30			0.40	33.3
	45			0.31	48.3
	60			0.25	58.3
3	15	400	0.8	0.65	25.0
	30			0.56	30.0
	45			0.43	46.25
	60			0.36	55.0

Table 3: Variation of contact time for the adsorption of dye rhodamine b onto activated carbon (Water hyacinth)

S. No.	Time in min	Amount of Carbon in mg	Final concentration of dye mg/100ml	% of adsorption
1.	15	400	0.65	35
2.	30	400	0.62	38
3.	45	400	0.59	41
4.	60	400	0.53	47
5.	75	400	0.48	52

Table 4: Interpretation of results of adsorption of rhodamine b onto adsorbent dosage in terms of lagergren's rate equation

Condition
Concentration of Rhodamine B = 0.6 mg/ml
Carbon dosage = 400 mg

S. No.	Contact time (Sec) X-axis	Amount of dye absorbed mg/100ml	log q_e-q Y-axis	Intercept log q_e	Slope- K_{ad}/2.303	Correction cofficeient r
1	900	0.12	-0.6383			
2	1800	0.20		-0.3116	-0.2416	-0.9786
3	2700	0.29	-0.8239			
4	3600	0.35	-1.2218			

K_{ad} = 4.7492×10^{-4} Sec^{-1}

Table 5: Interpretation of results of adsorption of rhodamine B onto adsorbent dosage in terms of lagergren's rate

Condition
Concentration of Rhodamine B = 0.8 mg/ml
Carbon dosage = 400 mg

S. No.	Contact time (Sec) X-axis	Amount of dye absorbed mg/100ml	log q_e-q Y-axis	Intercept log q_e	Slope- K_{ad}/2.303	Correction cofficeient r
1	900	0.15	-0.5086			
2	1800	0.24		-0.2001	-2.9844	-0.9685
3	2700	0.37	-0.6576			
4	3600	0.46	-1.0458			

K_{ad} = 6.8730×10^{-4} Sec^{-1}

Table 6: Interpretation of results of adsorption of rhodamine B onto adsorbent dosage in terms of lagergren's rate equation

Condition
Concentration of Rhodamine B = 1 mg/ml
Carbon dosage = 400 mg

S. No.	Contact time (Sec) X-axis	Amount of dye absorbed mg/100ml q	log q_e-q Y-axis	Intercept log q_e	Slope- K_{ad}/2.303	Correction cofficeient r
1	900	0.09	-0.7959			
2	1800	0.14		-0.5460	-1.8878	-0.9399
3	2700	0.21	-0.9586			
4	3600	0.25	-1.3979			

K_{ad} = 4.3476×10^{-4} Sec^{-1}

q_e = amount of dye adsorbed at equilibrium t
K_a = rate constant

Plot of time vs. log (q_e-q) were constructed. The values of slope, intercept and 'r' are tabulated (Table 4 to 6). The curve fitting was performed as the experimental values and the rate constant 'K' for adsorption was calculated from the slope of the plots and the value shows first order equation.

Simulation studies

The software program visual basic has been used for simulating dosage of adsorbent and the concentration of dye. The program is given below:

Simulation concept for calculating percentage of adsorption using software application - visual basic

Programme

```
Dim ad As Double
Dim ic As Double
Dim fc As Double
Dim perc, x, y As Double
Private Sub Command1_Click()
If Text1.Text & Text2.Text = "" Then
MsgBox ("Enter the values")
Else
ad = Val(Text1.Text)
ic = Val(Text2.Text)
If ic = 1 Then
fc = -0.0006 * ad + 0.742
Text3.Text = fc
y = fc
Text4.Text = (ic - y) / ic * 100
Else
fc = Rnd(ic)
y = 1 + fc
Text3.Text = y
Text4.Text = (ic - y) / ic * 100
End If
End If
End Sub
Private Sub Command2_Click()
Text1.Text = ""
Text2.Text = ""
Text3.Text = ""
Text4.Text = ""
End Sub
```

CONCLUSION

The maximum percentage (83%) of removal of dye was noted at 60min with 1mg/100ml of dye. The percentage of dye adsorption was found to increase with increase in adsorption dosage and decrease with increase in the concentration of dye. Approximately 50% of dye removal was noted on varying the contact time (15 to 75min). The data on adsorption of dye to the adsorbent were found to fit well with the first order kinetics as modified by Lagergrens equation. Simulation studies done by Visual Basic program offer a means of studying the process of adsorption at varied dosage of adsorbent, concentration of dye etc. The successful conversion of 'Waste to Wealth' is quite obvious for the study

REFERENCES

1. Jain, A.K., Gupta, V.K., Bhatnagar, A., and Suhas, A comparative study of adsorbents prepared from industrial wastes for removal of dyes, *Separation Science and Technology,* **38**: 463 (2003).
2. Judkins, J.F. and Hornshy, J.S., *J. waterpollution control federation,* **50**: 2446 (1978).
3. Snider, E.H. and Porter, J.J., *J. Waterpollut.control fed.,* **46**: 886 (1974)
4. Tan, L., Sudak, R.G., Removing color from a ground water. *Source J. Am. Water works Assoc.,* **84**: 79 (1992).
5. Graham, N.J.D., Brando, C.C.S. and Luckham, P.F., *J. Am. Water Works Assocn.,* **84**: 105 (1992).

6. Aplin, R. and Waite, T.D., *Water Sci. Technol*, **42**: 345 (1992).
7. Al-Degs, Y., Khraisheh, M.A.W., Allen, S.J. and Ahmad, M.N., The effect of carbon surface chemistry on the removal of reactive dyes from textile effluent. *J. Water Res.,* **34**: 927 (2000).
8. Faust, S.D. and Aly, O.M., Adsorption process for water treatment. *Butterworth Publications* : Stoneham (1987).