EQUILIBRIUM ISOTHERM STUDIES FOR THE ADSORPTIVE REMOVAL OF RHODHAMINE-B DYE USING BIOSORBENT POLYALTHIA LONGIFOLIA SEEDS (ASHOKA)

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Abstract:
This paper presents the feasibility of removal of basic dye Rhodamine-B from aqueous solutions by using a low cost natural adsorbent. Adsorption of Rhodhamine-B from aqueous solution were studied at 610 nm through a batch study. It was found that adsorption process was depends on adsorbent dose, contact time, pH, initial concentration and temperature. Solutions of Rhodhamine-B having concentrations 10, 20, 30 & 40 ppm were used. Maximum removal of dye was found to be 93% for 10 ppm solution, in 120 min with 6.5 pH, 250 mg/50 ml as dose and 60°C temperature. The equilibrium data were described by Freundlich, Langmuir & Tempkin isotherm model. Result suggests that carbonized powder can be used as a efficient biosorbent for the removal of Rhodhamine-B from aqueous solution and can be used for the development of clean and cheap technology for effluent treatment.
Keywords: Rhodhamine-B, Polyalthia Longifolia, Freundlich, Langmuir, Tempkin, Clean & Cheap, Biosorbent

INTRODUCTION

Industrial effluents contain organic and inorganic pollutants. According to U.S. Environmental Protection Agency (EPA) every year approximately 10 million tons of toxic chemicals are released into our environment by industry. Out of these over 2 million tons pollutants are recognized as carcinogenic i.e. this amounts to about 65 kg per second. To remove these pollutants different methods are used for e.g. Membrane filtration, Chemical treatment, Photo-catalysis, Ion exchange. One of the most simple and cheap method is adsorption of the pollutants on an adsorbent like carbon.

A Polyalthia Longifolia seed gives an alternative source for preparation of bio adsorbent. Not only activated carbon prepared from seeds of Polyalthia Longifolia but also powder of seeds without any activation has proved to be a good adsorbent. Depending upon the source of raw material the surface of powder material or activated carbon has different functional groups. Which can be used for the removal of cationic and anionic dyes, and can also in the pharma industry. The surface study of the adsorbent gives clear idea about presence of different functional groups on the surface of carbonized material20. Surface studies will also help to identify which type of dye (Cationic/Anionic) can be removed from industrial waste water. Agricultural bio waste is a proven source for preparation of activated carbon. Husk, fruit and seed shell, peels of fruits etc. are used as raw material for preparation for the activated carbon14. Rhodamine B (RB) is used mostly in paper printing, textile dyeing, and leather industries15. It is carcinogenic, and may cause irritation, redness and pain in eyes and skin. When inhaled, it causes irritation in respiratory tract with symptoms of coughing, sore throat, breathing and chest pain16. If swallowed, RB is likely to cause irritation to the gastrointestinal tract. Therefore, it is imperative that proper treatment of the dye effluents for color removal is carried out before its discharge.

MATERIALS AND METHODS

For this experimental work all chemicals used were of analytical grade. To measure the absorbance and pH Digital colorimeter (Make:

Equiptronics) Model EQ-650-A and Digital pH Meter (Make: Equiptronics) Model EQ-610 were used.

Preparation of Carbonized Powder of Polyalthia Longifolia Seeds (CPPL)

Seeds of polyalthia Longifolia were collected from the garden of local area Hadapsar Pune district, India. The seeds were washed with water and dried at 110oC to 120oC in the oven. Then they are crushed into small pieces then carbonized in the muffle furnace at temperature 600oC in presence of inert medium of nitrogen gas for 6-7 hrs. Carbonized material was grinded into fine powder with the help of mortar and pestle. Then it was passed through a 63 mesh sieve to get particles of uniform size and stored in air tight container.

Preparation of dye solutions

Different concentrations solutions (10 to 40 ppm) were prepared by using the stock solution (1000 ppm) with distilled water. The pH adjustment was carried out using 0.1 N HCl or NaOH solutions.

Batch adsorption studies

To find out the equilibrium point for adsorption of Rhodamine B dye onto carbonized powder of Polyalthia Longifolia seeds (CPPL), 250 mg of carbonized powder were added into 50 ml solution of Rhodhamine-B with concentration 10 ppm and kept in contact for different time intervals at room temperature. During adsorption process of dye solution stirring of solution continuously takes place on magnetic stirrer with heater. After given time interval solution was filtered through Whatman filter no. 41 and equilibrium concentration (Ce) of the dye was determined by measuring the absorbance of solution at a λmax = 610 nm. Same procedure was repeated for solutions of different concentration (20, 30 & 40 ppm) of Rhodhamine-B.

Adsorption isotherms were also studied by using 250 mg/ 50 ml of adsorbent for different concentrations of Rhodhamine-B solutions (10 to 40 ppm) up to their equilibrium contact time (120 min) at different temperatures (25, 30, 40, 50 & 60oC). The dye which remained unadsorbed was calculated by measuring the absorbance of the solution using colorimeter.

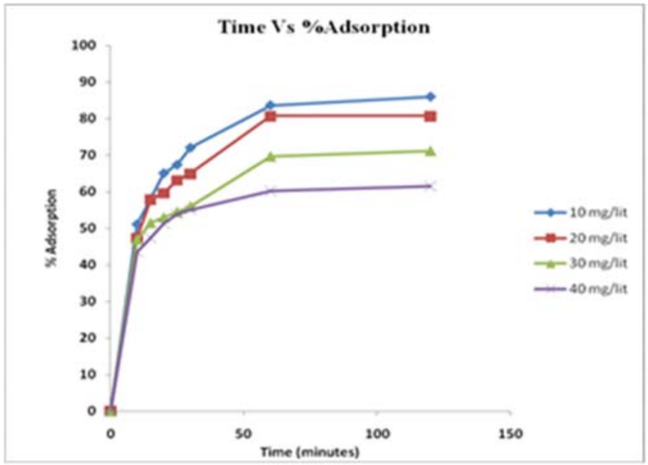

Figure 1. Effect of contact time on %adsorption

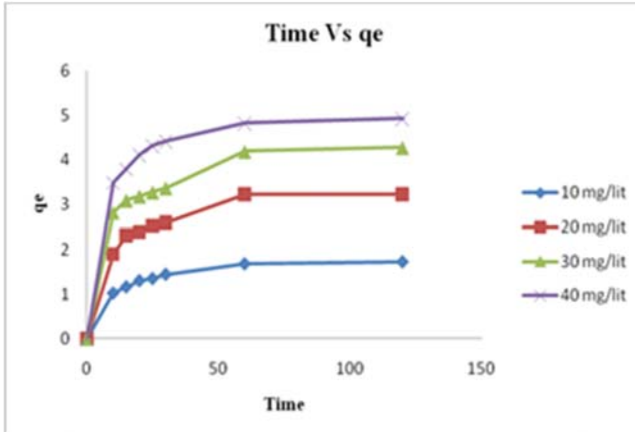

Figure 2. Effect of contact time on adsorption capacity

RESULTS AND DISCUSSION

Effect of contact time

Experiment of adsorption of Rhodhamine-B was carried out with 10, 20, 30 & 40 ppm of Rhodhamine-B solution by using 250 mg of carbonized powder of Polyalthia Longifolia seeds for 10 to 120 min at different pH (3 to 6.5) after completion of experimentation results are depicted in Figure 1 & 2. The results indicate that the rate of adsorption of Rhodhamine-B solution for all concentrations greater in the initial stage up to 25 min. Later the percentage of adsorption increases slowly for solutions with concentrations 10 ppm to 30 ppm, however the % adsorption from the 40ppm solution is negligible after 30 min. This indicates that surface saturation occurs for the 40 ppm solution around 30 min.The carbonized powder provides sufficient surface area for adsorption with adsorption capacity (1.0 to 1.7 mg/gm) and percentage removal 86% at equilibrium time 120 min. If adsorption process is continued after equilibrium point then repulsion between molecules of Rhodhamine-B take place which causes desorption process.

Effect of pH

Change in adsorption rate due to change in pH of Rhodhamine-B solution was studied at various pH (3 to 6.5) for that all the concentration solutions were used with 250 mg of adsorbent for time 10 min to 120 min. It was observed that 10 ppm of solution gives maximum adsorption. At room temperature as the pH increases from 3 to 6.5 the value of qe increases from 1.02 to 1.72 mg/gm and percentage removal (51.16% to 86.05%) adsorption capacity and %removal also goes on increasing 1.35 to 1.86 mg/gm (67.44% to 93.02%) These observations are in agreement with those results obtained on other adsorbents where with increase in pH the rate of adsorption goes on increasing.

Effect of Adsorbent dose

Change of rate of adsorption rate of Rhodhamine-B solution on CPPL with change in dose of adsorbent was also studied by changing the amount of CPPL (50 mg to 250 mg). For each concentration of the solution (10 to 40 ppm) as the amount of adsorbent goes on increasing the % removal goes on increasing but adsorption capacity goes on decreasing. For 10 ppm solution of Rhodhamine-B adsorption capacity decreases from 3.26 to 1.20 mg/gm and %adsorption increases 32.56 to 72.09%. Maximum %removal was observed for dye 10 ppm concentration with amount of absorbent 250 mg and therefore it is selected as optimized dose.

Effect of Initial concentrations and temperature

Effect of initial concentrations (10 to 40 ppm) and temperature (25 to 60oC) on adsorption were studied. During the experimentation work it was observed that as the concentration of Rhodhamine-B solution increases %removal decreases (51.56 to 86.05%) to (43.59 to 61.54%) at 25oC, while at 60oC it changes from (65.12 to 93.02%) to (51.28 to 70.51%). As the concentration increases %adsorption decreases because less sites are available for adsorption, maximum dye uptake takes place at 250 mg/50 ml 10 ppm solution of Rhodhamine-B.

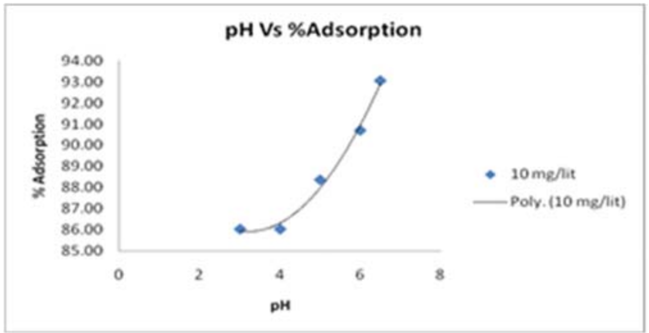

Figure 3. Effect of pH on % adsorption

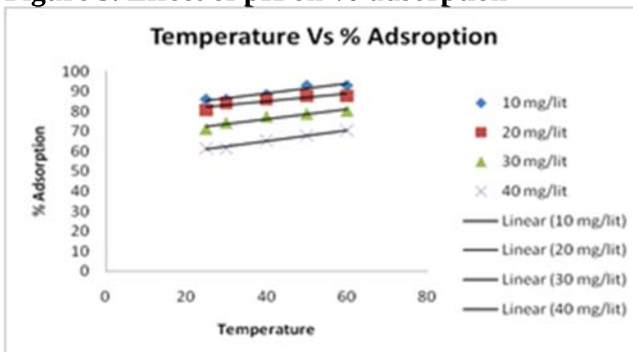

Figure 4. Effect of temperature on %adsorption

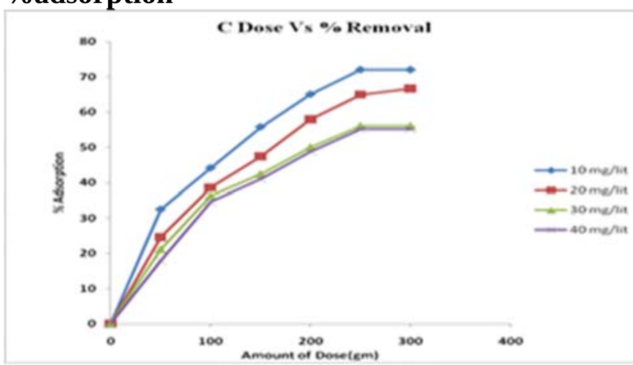

Figure 5. Effect of amount of adsorbent on % adsorption

Adsorption isotherms

In the experimentation of adsorption, isotherms play an important role in describing the adsorbate-adsorbent interaction. The isotherm data were analyzed by fitting them into Langmuir, Freundlich and Tempkin isotherm models.

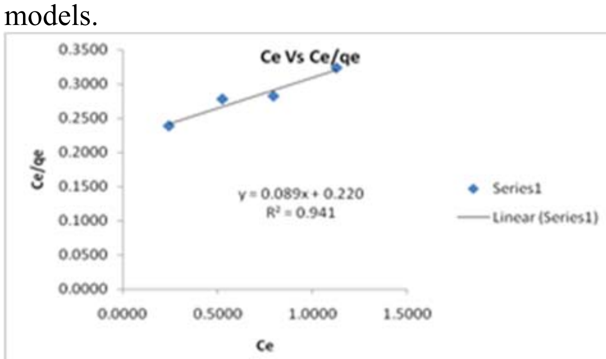

Figure 6. Langmuir isotherm

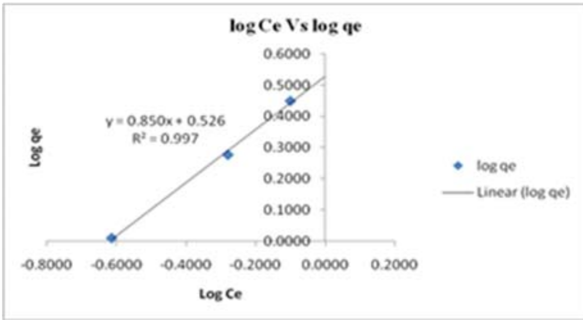

Figure 7. Freundlich isotherm

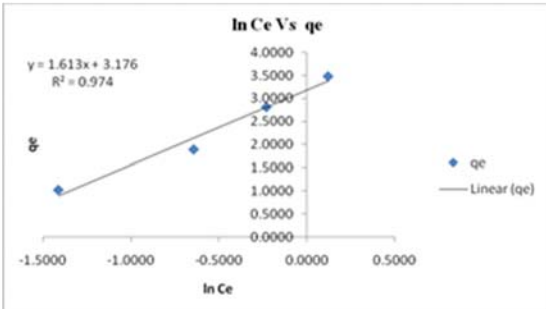

Figure 8. Temkin isotherm

Langmuir Isotherm

Langmuir isotherm considers monolayer adsorption. The linearized Langmuir isotherm equation (Equation 1) was used to obtain the maximum adsorption capacity of Rhodhamine-B

$$C_e / q_e = 1/ bQ_m + (1 / Q_m) C_e \quad (1)$$

The isotherm plots of Ce/qe vs. Ce for the adsorption of RB onto CPPL is as shown in Figure 6. The

Langmuir constants Qo, and b, evaluated from the slope and intercepts of these plots

m	C	Q_0	b	R^2
0.089	0.22	11.236	0.4045	0.941

Table: 1 Parameters in Langmuir isotherm

Langmuir Isotherm in terms of dimensionless equilibrium parameter (Halls Separation Factor) RL

RL = 1/(1+bC0)

RL = 0.05820

Here the value of RL is 0 < RL < 1

It indicates that Langmuir isotherm is favourable.

Freundlich Isotherm

The Freundlich isotherm considers multilayer adsorption. Interactions between adsorbed molecules the linear Freundlich isotherm is expressed as:

$$\log q_e = \log K_f + 1/n \log C_e \quad (2)$$

Where qe = x / m

The linear plots of log qe versus log C_e (Figure 7) shows that the adsorption of Rhodhamine-B CPPL also follows Freundlich isotherm model. The Freundlich constants (Kf and n) and correlation coefficients are recorded.

Here, the value of

0 < 1/n < 1 also,

Value of R^2 for

Freundlich isotherm > R^2 for Langmuir isotherm

This indicates that it also follows Freundlich adsorption isotherm.

m	C	n	K_f	R^2
0.85	0.526	1.176	3.357	0.997

Table: 2 Parameters in Freundlich isotherm

Temkin Isotherm

The linear form of Temkin isotherm model is given by the following Equation

$$q_e = RT/b \ln KT + RT/B \ln Ce \quad (3)$$

Plot of qe versus ln Ce (Figure 10) gives a straight line, with slope representing B and intercept equal to K. The Tempkin constants along with the correlation coefficients are as follows. The R^2 values 0.98 confirm that Tempkin isotherm provides a reasonable model for the adsorption of

Rhodhamine-B onto CPPL.

m	C	b	B	kT	R^2
1.658	4.109	1.670	1.658	11.9	0.985

Table: 3 Parameters in Temkin isotherm

Temp	25	30	40	50	60
m	1.613	1.653	1.665	1.597	1.658
C	3.176	3.366	3.648	3.848	4.109
b	1.536	1.524	1.563	1.682	1.67
B	1.613	1.653	1.665	1.597	1.658
kT	7.09	7.61	8.94	11	11.9
R^2	0.974	0.97	0.97	0.97	0.985

Table : 4 Comparision of Tempkin isotherm at different temperature

Conclusions

The Isotherm models for the uptake of Rhodamine B dye by CPPL from aqueous solution were studied. The adsorption data was fitted the best in Langmuir adsorption model.

1. The optimum dye concentration for the dye was found to be 10 ppm.
2. Increase in adsorbent dosage leads to percentage increase in Rhodhamine-B dye removal due to enhancement of adsorption sites. Maximum uptake was obtained at adsorbent dosage of 250 mg.
3. The equilibrium time for the adsorption of Rhodhamine-B was found 120 min.
4. The adsorption of RB dye onto CPPL followed Langmuir Adsorption Isotherm model.

The results indicated that the CPPL adsorbent is capable for the removal of Rhodhamine-B with high affinity and capacity indicating its potential use as a low cost adsorbent in near future.

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