Removal of Grey BL dye from waste water by Arasu (ficus relegosia) leaf powder by adsorption

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ABSTRACT

The dye, Grey BL was adsorbed on an absorbent prepared from mature leaves of the Arasu tree (ficus relegosia) leaves powder(ALP). In order to understand the adsorption behavior of Arasu Biomass Carbon, batch type experiments, effect of PH Contact time, Carbon dose are conducted and properly examined. At PH 7 the dye studies could be removed effectively. The Isothermal data fitted with both Langmuir and Freundlich model. The adsorption processes followed the first order rate kinetics. Mathematical Equations have been designed for the wide range of applications. The results in this study indicated that Arasu Leaves Powder was an attractive candidate for removing dye from industrial effluent and waste water.

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caps. 100ml of 100ppm of dye solution under investigation was taken in each stoppered reagent bottle (10Nos). After addition of biomass the stoppered reagent glass bottles were equilibrated for the predetermined period of time in a rotatory mechanical shaker. Then the solutions were filtered using G-3 sintered crucible and adsorbents of the filtrates were measured. Batch experiments, were conducted for maximum biosorption of the dye ions through the following parameters. 1. Effect of initial concentration, 2. Effect of contact time, 3. Effect of pH, 4. Biomass dose and 5. Adsorption Isotherms and 6. Kinetics.

Results and Discussions

Effects Biomass dose
To find out the minimum amount of biomass required for maximum adsorption percentage, 100 ml of 100 ppm dye solutions (adjusted to PH=7) were added with varying amount of biomass ranging from 0.1 to 1.5 grams and equilibrated with stirring for 5 hours. The plot of Biomass dose against percentage of dye removal is shown in Fig.1. From the figure it is observed that 65.51% of adsorption, Biomass dose of 1 to 1.5gms are required. Hence in all the further studies the optimum weight of 1gm of Biomass dose was maintained.

Effect of PH
Batch adsorption tests to find the effect of PH on the color removal of the dye were conducted using 100ml of 100 ppm dye solutions with one gram Biomass dose and adjusted to different PH values of 2 to 10 with 0.1N sulphuric acid and 0.1N sodium hydroxide. The systems were equilibrated for 5 hours. The absorbance of the filtrate were measured and shown in Fig.2. It is observed that in PH range 7-8, Biomass adsorb to the extend of 63.25% of coloring matter. Hence in all the studies an optimum PH of 7.0 is used.

Effect of equilibration period
Under optimum PH 7.0 and Biomass dose, the dye systems were equilibrated for adsorption under varying time intervals. The systems are Isolated in 30 minutes interval in the range of 30 to 240 minutes. The absorbance of the filtrate were measured and shown in Fig.3.

From the figure it is concluded that an equilibration period of 240 minutes are necessary for the maximum percentage of dye removal for Arasu biomass carbon.

Langmuir adsorption Isotherm
The Langmuir adsorption Isotherm studies were conducted with experimental data at equilibrium condition. The following Langmuir equation can be used for calculations

\[
\frac{X}{M} = \frac{a \cdot c_e}{1 + a \cdot c_e}
\]

Where \(X\) = amount of dye adsorbed, \(M\) = weight of adsorbent used, \(c_e\) = equilibrium dye concentration, \(a\) = constant and \(b\) = Langmuir parameter. From the experimental results, the essential characteristics sorption intensity “b”, adsorption capacity “a” and linearised Langmuir equations are present in Table-II. A plot of \(c_e \times \frac{X}{M}\) Vs \(c_e\) is shown in Fig.4. The Linear plot indicate formation of monolayer coverage of the adsorbate on the outer surface of the adsorbent and support the Langmuir adsorption isotherm model.

Frenudlich adsorption Isotherm
In order to analyze the nature of biomass adsorbent Frenudlich Isotherm was employed. Experiments were conducted with varying amount of biomass dose and dye solution at equilibrium conditions. The modified form of Frenudlich equation is given by

\[
\log\left(\frac{X}{M}\right) = \log k + \frac{1}{s} \log c_e
\]

Where \(X\) = amount adsorbed per unit mass of adsorbent, \(M\) = weight of adsorbent, \(c_e\) =equilibrium dye concentration, \(k\) =adsorption capacity and \(\frac{1}{s}\) = sorption intensity. A plot of \(\log\left(\frac{X}{M}\right)\) Vs \(\log c_e\) was shown in Fig.5. The straight line nature of the graph indicates the monolayer formation and fitted with Frenudlich adsorption Isotherm. From the straight line we can calculate the slope \(\frac{1}{s}\) from the slope.
and intercept log k. The value of k is obtained from intersect of log \((\frac{c}{e})\) at log ce. The essential characteristics of Freundlich Plot are presented in Table-III.

The value of k and the value of \(\frac{1}{n}\) less than 1 indicate favorable for Freundlich adsorption. Moreover the steep slopes(\(\frac{1}{n}\)) which is very close to 1 indicate high adsorption capacity at higher equilibrium concentration which rapidly diminishes at lower equilibrium concentration.

**Fig.5**

**Kinetics of adsorption**

To study the kinetics of adsorption, varying concentration of dye solution ranging from 30 to 60 ppm were added to 100mg of biomass system and equilibrated in a mechanical shaker with different time intervals under optimum PH condition. The result of study was shown in Fig.6. The kinetic figure suggest that the dyes adsorbed very rapidly and 80 to 90% of adsorption is virtually completed before two hours.

**Fig.6**

**Rate Constant studies**

The interpretation of adsorption data can be best explained by the following expression

\[ K = K_c + K_1 = K_1 + K_c = K_1 + K_c \] \((1+1)\)

Where \(K_1\) and \(K_c\) are rate constant for forward and backward reaction, \(K_c\) is equilibrium constant and \(K\) is the overall rate constant. All the rate constants calculated are presented in Table-IV.

The Rate constant plot log \((1-u(t))\)verse contact time was shown in Fig.7. The straight line nature of the graph indicate the reaction follows first order kinetics.

**Fig.7**

**Sem of Adsorbent**

The figure.8 shows the SEM micrographs of ALP samples before dye adsorption. It shows Arasu leaves powder posses rough surface morphology with pores of different sizes. These pores for useful for dye adsorption.

**Fig.8**

**Conclusion**

The Arasu biomass carbons are prepared from locally available Ficus religiosa plant tree. After removal of chlorophyll 400µ size of biomass particles are selected for adsorption study. Batch experimental were conducted for study their nature of biomass adsorbent towards dye solution. This study showed that Arasu leaves powder particle (ALP) could be effectively removed Grey BL dye from aqueous solution. All the studies carried out under PH 7. The percentage of dyes sorbed increased than reached maximum values as the sorbent dose was increased. The maximum adsorption is completed within 5 hours. The adsorption isotherms fitted with both Langmuir and Freundlich model. The adsorption processes followed the first order rate kinetics.

**Acknowledgement**

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**References**

Table I

<table>
<thead>
<tr>
<th>S.No</th>
<th>Control Test</th>
<th>Arasu Biomass</th>
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<tr>
<td>1</td>
<td>Moisture Content (%)</td>
<td>10.300</td>
</tr>
<tr>
<td>2</td>
<td>Ash Content (%)</td>
<td>0.189</td>
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<td>3</td>
<td>Bulk Density (A/B g/ml)</td>
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<tr>
<td>4</td>
<td>Phenol removed (%)</td>
<td>96.53</td>
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<tr>
<td>5</td>
<td>Decolorising power</td>
<td>112.5</td>
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<td>6</td>
<td>Phenol Number</td>
<td>227.5</td>
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<td>7</td>
<td>Surface area m²/g (P.Nitro Phenol method)</td>
<td>474.31</td>
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Table II

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<tr>
<th>S No</th>
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<th>'b' (mg/g)</th>
<th>'a' (l/mg)</th>
<th>Ce (mg/g)</th>
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<td>1</td>
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<td>0.155</td>
<td>0.589</td>
<td>10.95 + 1.697 Ce</td>
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Table III

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<th>S. N</th>
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<td>x/m = 0.095 Ce^{0.62}</td>
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Table IV

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<td>k_i = x 10^0</td>
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