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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.

Introduction

Saving water is to save not only the planet but also to make the future of mankind safe. At present most of water bodies are polluted by adding industrial effluent. The effluent from textile, leather, paper, Ink and cosmetic industries and also the industry that produces dyes are severely contaminated dyes and pigments. These dyes and pigments are discharged into environmental water bodies.

Dyes usually have a synthetic origin and complex aromatic molecular structures which make them more stable and more difficult to biodegrade[1]. Today more than 10,000 dyes available commercially[2]. The extensive use of dyes offen poses pollution problems in the form of colored waste water discharged in to various water bodies. Color acquired by water bodies reducing the penetration of sunlight and consequent reduction in photosynthetic activity and primary production[3]. In addition some dyes are either toxic or mutagenic and carcinogenic[4]. The conventional methods for treating dyes containing waste waters are coagulation and flocculation[5], oxidation or ozonation[6,7] membrane separation[8] and activated carbon adsorption[9]. Activated carbon is the most popular and widely used. But preparation of activate carbon and regeneration processes are very costly and disposal cause environmental, problems. Therefore, there is a growing interest in using low cost, easily available biomass materials for the adsorption of dye colors. A number of studies have been successfully carried out with investigate the efficiencies and mechanism of the removal of dyes from waste water by various types of biomass carbon.[10-14]

In this paper the feasibility of Arasu leaves powder(ALP) as adsorbent for removal of dye from aqueous solution was investigated. Arasu tree (ficus relegosia) is an evergreen plant which is largely available and cultured in India. The Arasu tree shed their leaves naturally during December-February each year and collected as waste. Most of this waste is arbitrarily discarded or set on fire. These disposals create environmental pollution. The exploitation and utilization of this bioresource must bring obvious economic and social benefit to us.

The dye selected as sorbate was Grey BL (λ_{max}=575nm). The Grey BL dyes largely used in textile, rayon, nylon, paper and leather industries. The effects of various operating parameters on adsorption such as sorbent dosage, particle size, contact time, initial dye concentration and PH were monitored and optimal experimental conditions were decided.

Materials and Methods

Preparation of Biomass Carbons

The biomass (Arasu leaves) used in this study was collected from local villages free from pollution. The biomass leaves were dried under sunlight for six hours at 40°C. These dried leaves were crushed in mechanical crusher to a constant powder size which were fractionated to 450μ by using standard American mesh. The powdered biomass is washed, repeatly with tap water to remove soil, dirt, dust and other impurities. Then biomass are washed with double distilled water and dried in an oven at 80° C. The dried powder were preserved as an adsorbent in air tight glass bottles.

Characterization of Biomass carbon samples

The Biomass samples were characterized after following ISI code[15] and results were tabulated in Table I

Selection of dye

Direct dyes which anionic in charge are the main dyes used in cotton, rayon, nylon, paper and leather industries for coloring the system. Among the direct dyes Grey BL (λ_{max}=575nm) is extensively used and discharge in to the drain system. Hence we concentrated on the removal of Grey BL from the effluent waste water.

Batch Experiments

Batch experiments were conducted in stoppered reagent glass bottles of 150ml capacity, which were provided with glass

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caps. 100ml of 100ppm of dye solution under investigation was taken in each stoppered reagent bottle (l0Nos). 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

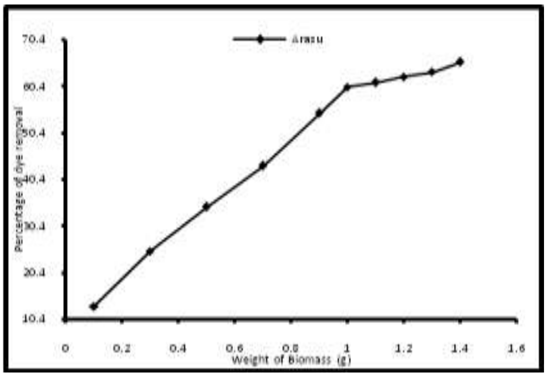

Fig.1

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 adsorbance 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.

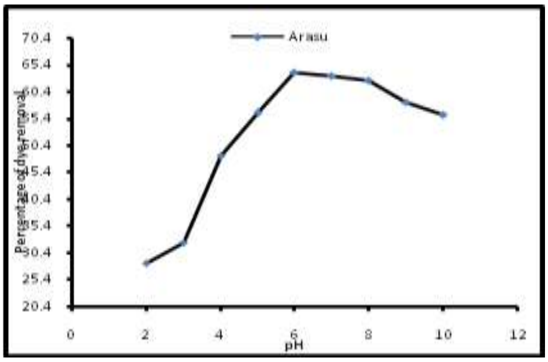

Fig.2

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 adsorbance 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.

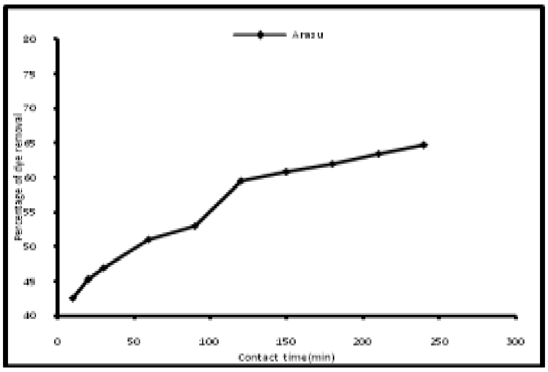

Fig.3

Langmuir adsorption Isotherm

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

$$\frac{X}{M} = \frac{a.b.ce}{1+b.ce}$$

Were X=amount of dye adsorbed, m=weight of adsorbent used ce= 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 ce/x/m Vs ce 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.

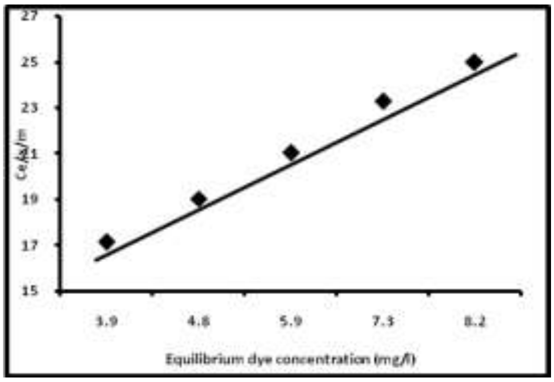

Fig.4

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

$$\log\left(\frac{x}{m}\right) = \log k + \frac{1}{n} \log ce$$

where $\frac{x}{m}$ = amount adsorbed per unit mass of adsorbent, ce=equilibrium dye concentration, k=adsorption capacity and $\frac{1}{n}$ sorption intensity. A plot of log $\left(\frac{x}{m}\right)$ Vs log ce 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 $\frac{1}{n}$

and intercept log k. The value of k is obtained from intersect of log $(\frac{x}{m})$ at log ce. The essential characteristics of Frenudlich 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.

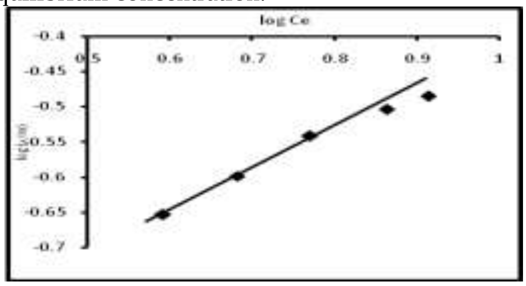

Fig.5

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.

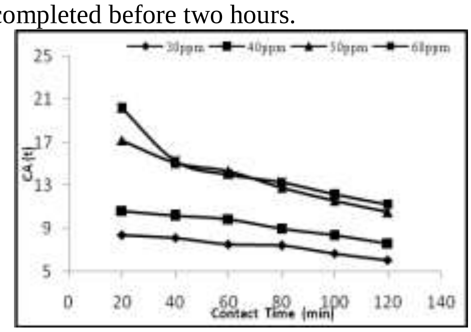

Fig.6

Rate Constant studies

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

$$K=K_1+K_{-1} = K_1 + \frac{K_1}{C} = K_1\left(1+\frac{1}{KC}\right)$$

Where K_1 and K_{-1} are rate constant for forward and backward reaction, Kc 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.

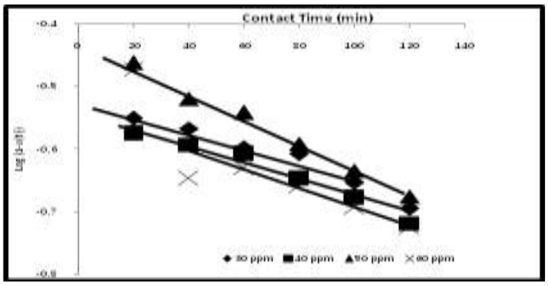

Fig.7

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.

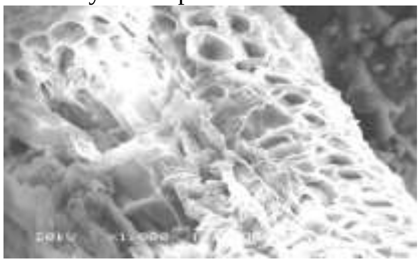

Fig.8

Conclusion

The Arasu biomass carbons are prepared from locally available Ficus relegiosa 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.

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Table-I

S.No	Control Test	Arasu Biomass
1	Moisture Content (%)	10.300
2	Ash Content (%)	0.189
3	Bulk Density (A/B g/ml)	0.259
4	Phenol removed (%)	96.53
5	Decolurising power	112.5
6	Phenol Number	227.5
7	Surface area m^2/g (P.Nitro Phenol method	474.31

Table -II

S No	Bio mass	'b' (mg/g)	'a' (l/mg)	$\frac{Ce}{x/m} = \frac{1}{ab} + \frac{1}{a} Ce$
1.	Arasu	0.155	0.589	$\frac{Ce}{x/m} = 10.95 + 1.697\ Ce$

Table -III

S. N	Bio mass system	"K"	"1/n"	$x/m = K\ Ce^{1/n}$
1	Arasu	0.0949	0.62	$x/m = 0.095\ Ce^{0.62}$

Table -IV

Name of the Dye	Conc mg/l	Arasu System			
		$k_c = x\ 10^3$	$k_1 = x\ 10^{-03}$	$k_{-1} = x\ 10^{-07}$	$K = x\ 10^{-03}$
Grey BL	30	4.99	3.247	6.507	3.2476
	40	4.99	3.339	6.691	3.3396
	50	4.99	4.813	9.645	4.8139
	60	5.45	4.698	8.620	4.6988