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EQUILIBRIUM STUDIES ON REMOVAL OF INDIGO CARMINE BY JACKFRUIT (*Artocarpous Heterophyllus*) LEAF POWDER AS LOW COST ADSORBENT

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ABSTRACT

The Jackfruit leaf (Artocarpous Heterophyllus) powder was activated by sulphuric acid for the removal of Indigo Carmine dye from aqueous solution as low cost adsorbent. Adsorption characteristics were evaluated in batch experiments as a function of contact time, adsorbent dose, pH, initial concentration and temperature. Adsorption equilibrium was attained after 60 minutes of contact time. The equilibrium data were best described by Langmuir and Freundlich isotherm models over the given range of concentration from 10 to 50 mg/L and maximum dye adsorption with monolayer formation was found to be 156.25 mg/g .The results of thermodynamic parameters such as ΔG^0, ΔH^0 *and* ΔS^0 *indicated that adsorption is spontaneous, endothermic physical adsorption with increased randomness at the dye - adsorbent interface. The characteristics results and dimensionless separation factor* R_L *proved that Jackfruit leaf powder can be used as excellent adsorbent in the removal of indigo carmine dyes from aqueous solution.*

KEYWORDS: *Indigo Carmine, Jackfruit leaf powder, Adsorption isotherm, Adsorbent*

INTRODUCTION-

During past few decades, There has been increased use of dyes by textile, tannery, cosmetic, paper, plastic and pharmaceutical industries. Most of these dyes are hazards for human beings. The improper discharge of these dyes into water sources causes environmental pollutions which have adverse effect on human health and aquatic life[1-3]. Therefore it is necessary to remove these dyes from industrial effluents before their discharge into water streams. There are large number of methods available for dyes removal such as adsorption, reverse osmosis, ion exchange, coagulation and membrane filtration .In these methods adsorption is effective and extensively used process for removal of dyes and pollutants from wastewater. Adsorption of dyes using various adsorbents have been studied by many investigators using Ashoka leaf powder[4] Bamboo[5], coconut shell[6], Teak wood leaves[7], sunflower stalk[8], wheat straw [9], rice husk[10].

In this research work, locally and abundantly available plant leaves of jackfruit (*Heterophyllus Artocarpous*) have been utilized for removal of indigo carmine from aqueous solution

Materials and Methods

Adsorption studies on Indigo carmine were carried out using jackfruit leaf powder as adsorbent. The effect of adsorbent dose, concentration, pH, contact time and temperature were studied. The dye adsorption isotherm was carried out at 30 ^{0}C. The effect of solution pH on adsorption of dye was studied by changing pH of medium from 2 to 12.The effect of adsorbent dose was studied by varying the dose at constant dye concentration, pH and Temperature. Initial dye concentration was taken in the range of 10 to 50 mg/L. Jackfruit leaves after H_2SO_4 and formaldehyde treatment were heated and grinded into powder This activated powder was used as adsorbent for removal of indigo carmine dye from aqueous solution and residual dye concentration were determined by UV/VIS Spectrophotometer (Elico -1245) at 610 nm .The pH of solution was adjusted using 0.1 N HCl or 0.1 N NaOH solution

RESULTS AND DISCUSSION

Effect of contact time

The effect of contact time was studied by contacting 50 mg/L of 50 ml dye solution with 1.2 g of adsorbent dose for 5 to 60 minutes at pH 6 .The dye removal % has shown in Figure 1 indicated that % dye removal was increased from 32.09 to 84.64 % The equilibrium was reached at 60 minutes .Similar results were reported by others [11].

Effect of dye solution pH

The effect of solution pH was evaluated in the pH range of 2 to 10 with 50 ml dye solution for 50 mg/L concentration, 1.2 g adsorbent dose, 60 minutes contact time and 30 ^{0}C temperature. Figure 2 showed that 91.10 % dye was removed at 2 pH and at pH 6, it was found to be 84.64 % and equilibrium was attained at pH 6. Similar results were reported by other workers[12]

Effect of dye initial concentration

The effect of initial dye concentration of indigo carmine (10 to 50 mg/L) on adsorption was studied with 50 mL volume, adsorbent dose 1.2 g /L, pH 6. From figure 3, it was observed that % removal of dye was decreased from 90.47 to 84.64 % whereas the amount adsorbed increased with increased concentration. It may be due to surface activity and monolayer formation in the given range of concentration. Similar results were reported by other researchers[13]

Effect of adsorbent dose

The effect of adsorbent dose was studied by taking 50 mL of 50 mg/L dye solutions with varied dose from 0.2 to 1.4 g. the removal of Indigo carmine observed was from 31.25 to 84.64 % as shown in Figure 4. The increased dye removal % with dose was due to presence of more active sites on adsorbent surface[14].

Effect of temperature

The effect of temperature was evaluated by varying temperature from 30 to 60 ^{o}C. Figure 5, it was observed that, dye removal % increased from 84.64 to 88.55 % with temperature[15].

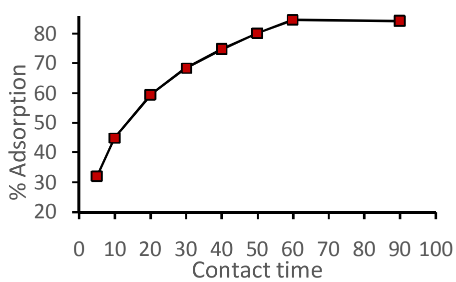

Figure :1 Effect of contact time on adsorption of indigo carmine by JLP

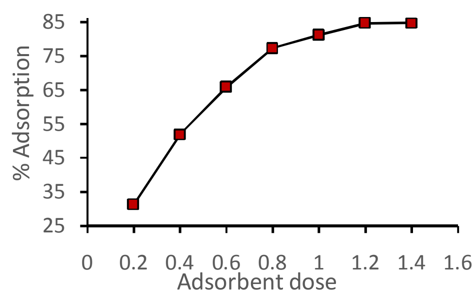

Figure :2 Effect of adsorbent dose on adsorption of indigo carmine by JLP

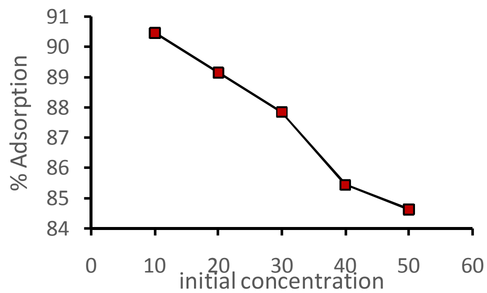

Figure :3 Effect of initial concentration on adsorption of indigo carmine by JLP

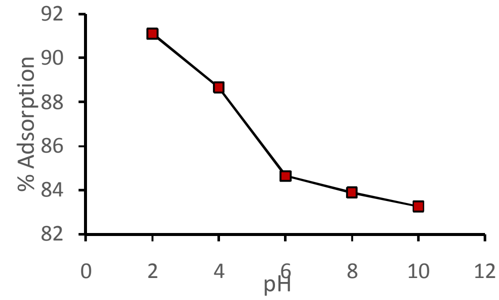

Figure :4 Effect of solution pH on adsorption of indigo carmine by JLP

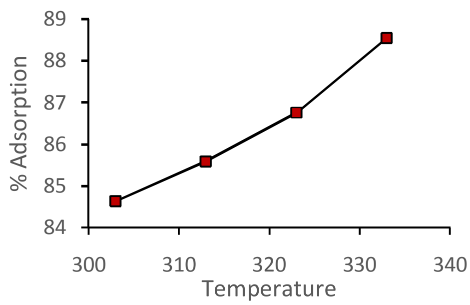

Figure :5 Effect of temperature on adsorption of indigo carmine by JLP

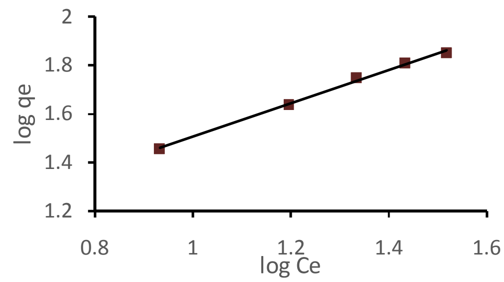

Figure :6 Freundlich isotherm for adsorption of indigo carmine by JLP

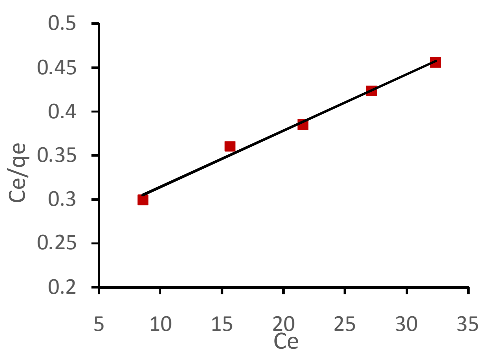

Figure :7 Langmuir isotherm for adsorption of indigo carmine by JLP

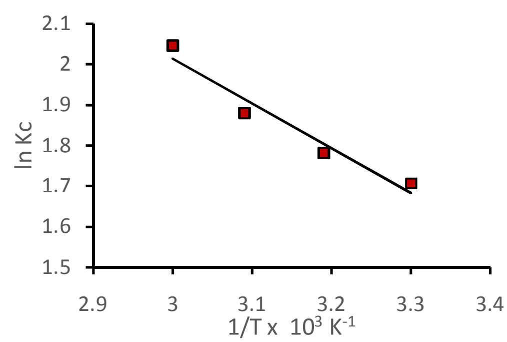

Figure :8 Van't Hoff's plot ln K_c vs 1/T for adsorption of indigo carmine by JLP

Adsorption isotherms

The adsorption of indigo carmine was studied Freundlich and Langmuir isotherm models

The linear form of Freundlich isotherm can be given by[16]

$$lnq_e = lnK_F + \frac{1}{n} lnC_e \qquad (1)$$

Where q_e is the amount adsorbed (mg/g), C_e is dye equilibrium concentration (mg/L) K_F and 1/n are Freundlich constants of adsorption capacity and intensity respectively (Table 1)[17].The linear plot of *ln* q_e *vs ln* C_e given in Figure 6

The linear form of Langmuir isotherm is given as [18]

$$C_e/q_e = 1/q_m b + 1/q_m C_e \qquad (2)$$

Where C_e is equilibrium dye concentration (mg/L), q_e is the amount adsorbed (mg/g), b is adsorption equilibrium constant and q_m is maximum adsorption capacity of monolayer formation on surface. q_m and b are evaluated from slope, intercept (Table 1) from the plot of C_e/q_e vs C_e is given in Figure 7. The higher R^2 indicated that indigo carmine adsorption obeys Langmuir isotherm model. The dimensionless separation factor $R_L = 1/(1+bC_i)$ is measure of ease of adsorption to occur [19].The R_L value between 0 to 1 indicate feasibility of process

Thermodynamic studies

The change in thermodynamic parameters such as ΔG^0, ΔH^0 and ΔS^0 were studied by following equations[20]

$$K_c = \frac{C_0 - C_e}{C_e} \quad (3)$$

$$\Delta G^0 = -RT \ln K_c \quad (4)$$

$$\ln K_c = \Delta S^0/R - \Delta H^0/RT \quad (5)$$

ΔG^0 values were obtained from equation (4) ΔH^0 and ΔS^0 were obtained from slope and intercept of a plot of $\ln K_c$ versus $1/T$ Figure. 8 represented in Table 2. The values of Gibbs free energy change, enthalpy change and entropy change, indicated Indigo carmine adsorption was spontaneous, endothermic and favorable with increased randomness during adsorption process.

Table: 1 Langmuir and Freundlich parameters for adsorption of Indigo Carmine on JLP

Langmuir constants			Freundlich constants		
q_m (mg/g)	b (L/mg)	R^2	K_f	n	R^2
156.25	0.0256	0.989	6.592	1.456	0.997

Table: 2 Thermodynamic parameters for adsorption of Indigo Carmine dye by JLP

K_c				R_L	$-\Delta G^0$	ΔH^0	ΔS^0
303	313	323	333		$kJmol^{-1}$	$kJmol^{-1}$	$Jmol^{-1}$
5.560	5.944	6.553	7.741	0.438	4.913	9176.2	44.271

CONCLUSIONS

In present study, the equilibrium and thermodynamics of Indigo carmine adsorption by Jackfruit leaf powder were investigated. The isotherm equilibrium data were best fitted with both Freundlich and Langmuir isotherm equation with R^2 = 0.989 to 0.997. The monolayer adsorption capacity q_m was found to be 156.25 mg/g. The change in Gibbs free energy, enthalpy and entropy, indicated Indigo carmine adsorption is spontaneous, endothermic and favorable with increased randomness during adsorption process. Therefore Jackfruit leaf powder can be better substitute for the expensive activated carbon.

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