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Removal Of Textile Dyes By Adsorption Column And Its Studies

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Abstract: In this work waste obtained after extraction of juice from oranges has been evaluated to be used as an adsorbent for removal of textile dye Congo Red. The waste was processed and dried for use. The effect of contact time, pH, and initial concentration of dye was evaluated. Adsorption isotherms were prepared and analyzed to understand mechanism of adsorption. Dye removal was found to decrease with increasing pH. Percent dye removal was found to go down with increase in initial dye concentration. Adsorption isotherms and their analyses revealed that it follows Langmuir pattern.

1. INTRODUCTION

Dyes have been conveniently used in various applications of coloring and providing colorful way to life. One of the major applications of dyes is in textiles which provides various shades to out attire and impart joy in our daily life. These dyes were used to be natural in historical times [1], but currently synthetic dyes are being used for the purpose [2]. These synthetic dyes are more stable on the fiber hence becomes durable and can be varied in shades. Although synthetic dyes are having better applicability, they are supposed to be unfriendly to environment [3].

Textile industry uses various chemical like acids, organic solvents, salts, dyes and range of different polishing and finishing chemicals for the manufacturing and processing purposes [4,5]. It's been found that some textile dyes carry mutagenic characters. For example, a high incidence of bladder cancer was detected in Mataro, Spain among the textile workers using reactive dyes [6]. It is clear that if dyes can cause such harmful effect on humans, it is also dangerous for the aquatic species where the waste water having these chemical dyes are released [7]. This makes it more necessary to treat the waste water containing textile dyes.

Various methods have been utilized for removal of textile dyes from aquatic environments. The best way is to remove it from the effluent before being released to natural environment. This has been referred to as point source of pollution which can be tackled easily. For doing this numerous techniques like biosorption [8], electrocatalytical removal [9], nano based techniques [10] have been developed. A comparision of these have been reviewed elsewhere [11].

Here in this work we have developed a new adsorbent using orange peel waste. This natural adsorbent is easily available from fruit shops and is a waste product for them. We have shown that how can we use a waste as a valuable resource.

2. Materials and methods

2.1 All the analytical chemicals were purchased from Merck and Sigma.

2.2 Preparation of adsorbent: Adsorbent was prepared from orange peel left after extraction of juice. This was procured from local juice vendors and washed thoroughly with tap water.

This was dried for 72 hours at 90 C. Wet weight and dry weight were measured. This was crushed with mortar and pestle was sieved with a mesh of size 150µm.

2.3 Preparation of dye: Stock solution (1000mg/L) of Congo red (MW=991.82) dye was used for the experiments. It was prepared in double distilled water and was diluted as and when required.

2.4 Batch experiment studies: Batch experiments were performed in shake flask of 50 mL capacity at 25 C to optimize parameters like pH, contact time, initial dye concentration, and temperature. For optimizing pH, 30 mL of dye solution (concentration 300 mg/L) were mixed with 0.03 g of adsorbent in a shaker at 180 rpm for 24 hrs to ensure complete equilibrium. The pH of flasks was made between 3-10 with HCl and NaOH solution. After reaching equilibrium, the sample was centrifuged to get clear supernatant in which dye which remained to bind was measured using UV spectroscopy.

The adsorptivity was calculated as follows:

$$q = \frac{C_i V_i - C_f V_f}{M},$$

In this equation, C_i and C_f are the initial and final dye concentrations in the solution (mg/L), V_i and V_f are the initial and final solution volumes, and M is the mass of adsorbent (g).

2.5 Adsorption isotherms: Adsorption isotherms were plotted between "q" and "C_f". These are useful in understanding the mechanisms and development of further equipment using the given adsorbent. For the study, isotherms were plotted at 25 C and 35 C. The initial concentration of dye was varied from 50 to 300 mg/L.

3. Results and discussions

3.1 Effect of pH: Because the functional groups on the dye are modified with pH, it plays a important role in adsorption process [12]. The effect of pH of adsorption capacity is shown in Fig 1. The adsorption capacity is favored in acidic conditions and lowered in basic condition. This is clearly due to the structural and functional features of the molecule which gives it a better affinity in the acidic environment. In basic environment the negative charges on the absorbent surface could be the reason for repulsion between dye and adsorbent. It may also be possible that OH(-) ions may compete with dye in binding to adsorbent and leads to competitive binding at higher pH.

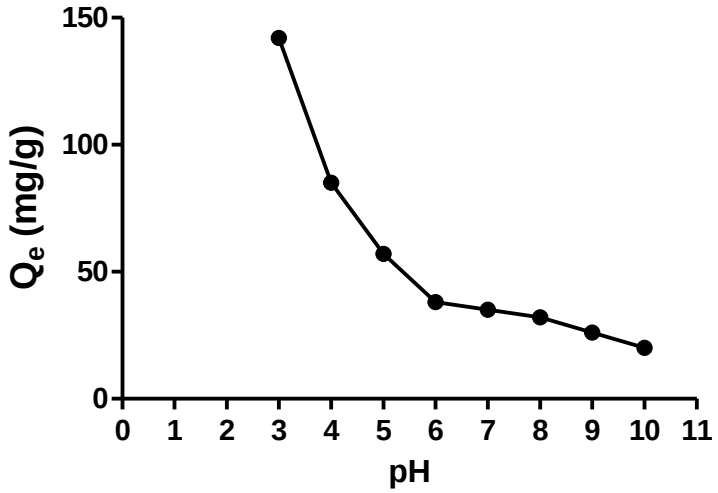

Fig 1: Effect of pH on adsorption capacity of dried orange peel

3.2 Effect of contact time: The effect of contact time on adsorption capacity of dried orange peel with Congo red was evaluated at various initial concentrations (50-150 mg/L) is shown

in Fig 2. In the beginning, the dye binds with a greater velocity, which eventually decreases with time. This is a general observation as this is a monolayer binding where the binding sites get saturated with time. Also, dye removal is higher at lower initial concentrations because less amount of dye is present which is obviously much removed in percent amount.

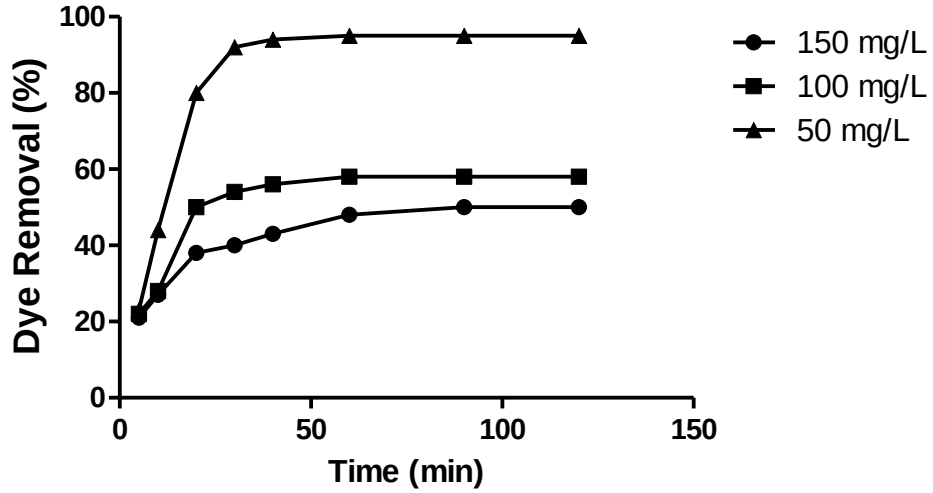

Fig 2: Effect of contact time with different initial concentrations

3.3 Adsorption isotherm study: Adsorption isotherms are used to predict the mechanisms of adsorption [13]. The most common type of isotherms which are studied in the given case of solid liquid mass transfer is Langmuir and Freundlich isotherms. They are well established equations which gives a way to predict the behavior of adsorption. Fig 3 shows the isotherm for 25 C and Fig 4 for 35 C.

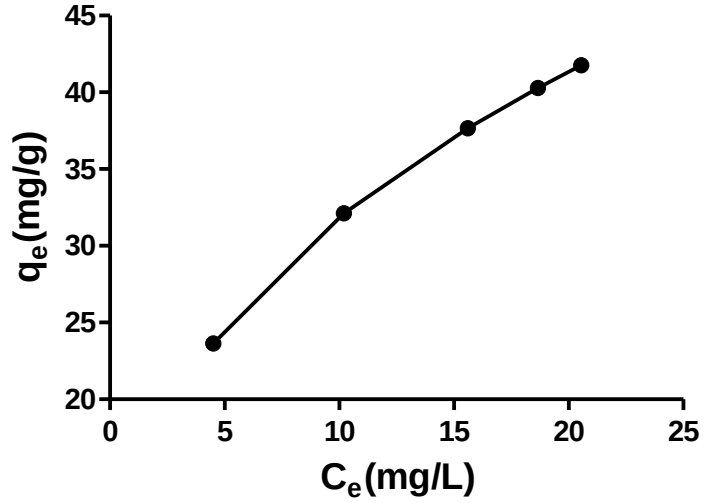

Fig 3. Adsorption isotherm at 25 C

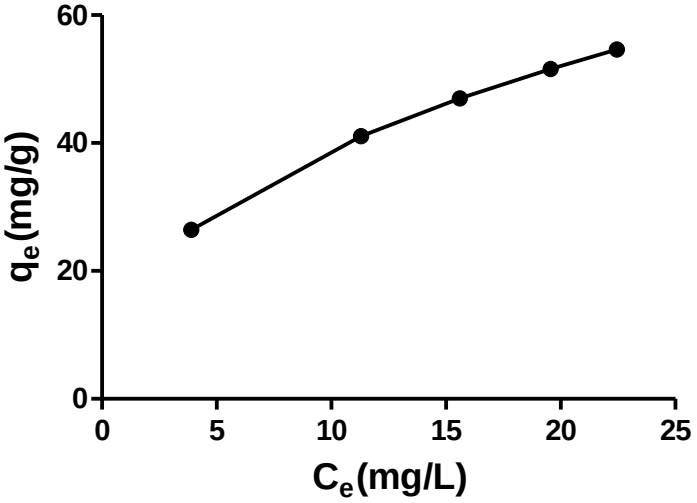

Fig 4. Adsorption isotherm at 35 C

3.4 Data analysis: The data thus obtained is fitted to both Langmuir plot and Freundlich equations. Graphpad PRISM V8.0 was used for data analyses. The results are summarized in table 1 below. It can be seen that the curves are fitting better to Langmuir isotherms which suggests a monolayer type of adsorption.

Temp	Langmuir			Freundlich		
	q_{max}	b	R^2	K_f	n	R^2
25 C	121.8	0.024	0.9963	14.46	2.37	0.9831
35 C	160.1	0.023	0.9964	16.02	2.21	0.9717

Table 1: Values of constants obtained after modeling of isotherms

Various studies are going on based on adsorption technology with substantial findings in this direction [14-24].

4. Conclusion: It can be concluded from this study that waste of orange fruit can be effectively use as an adsorbent for removal of Congo red dye. This study can be further extended to adsorption column for more insights into the mechanisms and development of a proper technology which can be transferred to sites.

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