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REMOVAL OF CONGO RED AND MAGENTA DYES FROM INDUSTRIAL WASTE WATER BY THORN APPLE LEAF POWDER

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ABSTRACT

The adsorption methods have been extensively used by various researchers for the removal of dyes from industrial waste water. In the current work, the leaves of Thorn apple [Datura staramonium] treated with sulphuric acid and formaldehyde were used as an adsorbent for the elimination of congo red and magenta from an industrial waste water. The adsorption characteristics of these two dyes on activated Thorn apple leaf powder (TALP) were evaluated as a function of pH, adsorbent dose, initial concentration of adsorbate, temperature. The efficient adsorption was established to be in pH range 3.8 to 7.4, adsorbent dose 0.5 g to 0.8 g, initial concentration (1 x 10^{-5} to 5 x 10^{-5} M) and Temperature range (308 to 318 K). The results tell that ceiling adsorption of two dyes onto TALP is in the range of 63.8% to 89.7%. The adsorption data fixed well into Freundlich and Langmuir adsorption models. The results show that Thorn apple leaf powder holds a great prospective in removal of congo-red and magenta dyes from industrial wastewater.

Key words: Congo red, Magenta, Thorn apple leaf powder, Freundlich isotherm, Langmuir isotherm.

INTRODUCTION

Dyes are highly colored polymers and low biodegradable in nature. Dye being one of the important recalcitrant, persist for long distances in flowing water, delays photosynthetic activity, inhibit the growth of aquatic biota by blocking out the sunlight and utilizing dissolved oxygen and also decrease the activity value of stream. Synthetic dyes have been increasingly used in the textile, paper, rubber, plastic, cosmetics, pharmaceutical and food industries because of their all eviate of use, cheap cost of production, stability and variety of color compared with natural dyes[1-3]. Now a day there are more than 10,000 dyes existing

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commercially[4] the majority of which are thorny to biodegrade owing to their complex aromatic molecular structure and synthetic origin[5]. The widespread use of dyes habitually poses pollution tribulations in the form colored wastewater discharge into water bodies which hampers with diffusion of sunlight into streams, therefore, diminishes photosynthetic action[6]. In addition, some dyes or their metabolites are either toxic or mutagenic and carcinogenic unfavorable effect of dyes on environment and human such as skin, lung and other respiratory disorders are also accounted[7-9]. Conventional physico-chemical and biological treatment methods are fruitless for the removal of dyes due to the large measure of organics present in these molecules[10-11], hence there was a need for other valuable methods. Adsorption techniques for wastewater management have become more accepted in recent years due to their effectiveness in the exclusion of pollutants. Activated carbon is the most widely used adsorbent but commercially available activated carbons are very expensive[12-13], consequently, many investigators have studied feasibility of using low cost substances such as rice husk[14], orange peel[15] walnut shell charcoals[16], rice bran[17], Euphoria antiquorum L Wood[18], Jute and Sunnhemp[19], Teak leaves[20]. The main objective of the work is to investigate the adsorption properties of Thorn apple leaf powder for the removal of dyes i.e. congo red and magenta. The study comprises adsorption as a function of time, adsorbent dose and concentration of dye solution, pH of the solution and temperature of the system. The isotherm studies were fixed for Freundlich and Langmuir adsorption isotherm.

EXPERIMENTAL

Materials and methods

Adsorbent

The adsorbent used in the present investigation were leaves of Thorn apple plants collected from Kanchipuram District of Tamil Nadu State (India). The leaves of Thorn apple were dried in shadow avoiding direct sunlight on them. The dehydrated plant leaves were grinded into powder and boiled in distilled water to eliminate the suspended dust for one hour and filtered. The residue left was treated with formaldehyde and finally with very dilute solution of sulphuric acid, mixed for 60 minutes strongly using mechanical stirrer at room temperature, it was filtered and washed with distilled water repeatedly to eliminate free acid. After treatment, residue were desiccated first in air and finally in oven at 100^{o}C for 8 hrs and powdered using electric chopper. The identical powder was then passed to mesh for preferred particle size (9.5 to 42.5 micron). The adsorbent once ready were used all over the experimental job. The particle size chosen for these experiments were on the origin of their clearance at the bottom of the system, so that the fraction of the solution could be taken out properly from the supernatant liquid.

Preparation of adsorbate solution

Congo red and magenta were the dyes selected for the current analysis.

The adsorbate dyes used were of Analar grade and used without further purifications. The adsorbates were equipped in doubly distilled water.

Batch adsorption experiments

Each batch adsorption study was carried out by contacting activated Thorn apple leaf powder (TALP) with congo red and magenta under different conditions for 60 min in a glass tube. Stock solutions (1.0 x 10^{-3} M) were prepared by dissolving weighed quantities of adsorbates in double distilled water. The concentration of dye solutions were calculated from calibration curve spectrophotometrically at their particular wavelength, i.e. congo red (λ_{max} = 497 nm) and magenta (λ_{max} = 510).

RESULTS AND DISCUSSION

Effect of pH

The initial pH value of the solution can extensively influenced the adsorption of dyes. In the existing study the effect of pH on the amount of dye removal was analyzed over the pH series from 3.8 to 7.4 and is offered in graphical form as given in Fig. 1.

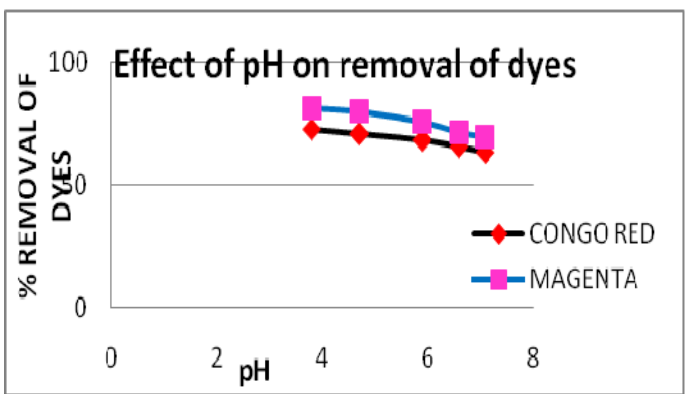

Fig. 1: Effect of pH on removal of dyes

The adsorption at lower pH may be accredited to the enhance in the concentration of hydrogen ion in adsorbate solution which neutralizes hydroxyl group in the neighborhood of adsorbent surface and ease the flow of dye molecule towards the plane of adsorbent. Similar decreasing adsorption was also reported by Bahadur et al.[22], at higher pH which may be appropriate to the accessibility of large number of OH-(hydroxyl ions) and accordingly the transmission blockade is increased, which consequences in reduced adsorption. Our conclusions are in good concurrence with Prasad et al.[23] The study constrained at higher pH level up to 7.1, which may be endorsed to the adsorbent which is a plant matter and consists of a variety of organic acid components and may lead to the aqua complex formation and thus hinders dye adsorption onto the surface of TALP. Our outcomes are supported by Mohan et al.[24]

Effect of temperature

The records of dye adsorption onto TALP at different temperature specify a change in the dye exclusion efficiency. This conclusion is shown in Fig. 2. The augment in the equilibrium adsorption capability of dyes indicates that a high temperature favors dye removal. Definitely by increasing the temperature of the reaction from 308 K to 318 K, the percentage removal of two dyes average increased range was from 62.7% to 83.8%. As a result it is explicable that adsorption equilibrium is a thermo-reliant process. This outcome may be due to the fact that at higher temperature, an increase in the alliance of the solute occurs. Similar conclusions are also reported by other researchers[25].

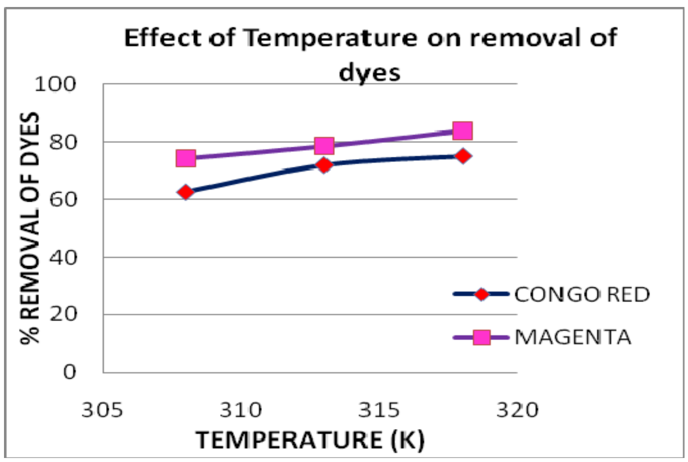

Fig. 2: Effect of temperature on removal of dyes

Effect of adsorbent dose

Consequence of adsorbent dose plays a significant role in standardizing the adsorption method with amount of adsorbate solution and the adsorbent. In our current analysis, with increase in the quantity of TALP adsorbent i.e. from 0.5 g to 0.8 g the deduction efficiency of the two dyes increase rapidly (Fig. 3), which may be recognized to the greater accessibility of the transferable sites or surface areas at higher concentration of the adsorbent. Our conclusions are in good support with Hussein et al.[26,27]

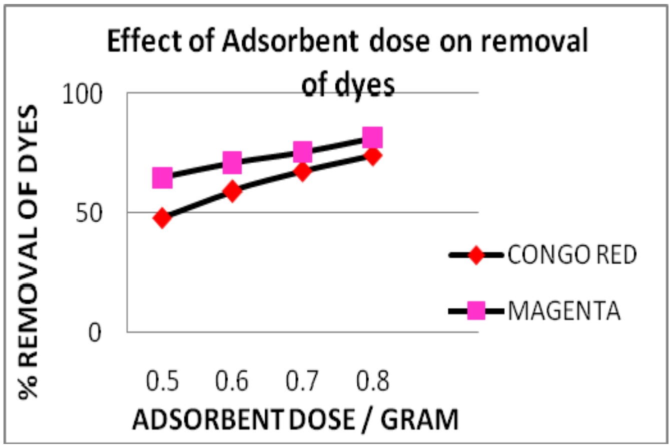

Fig. 3: Effect of adsorbent dose on removal of dyes

Effect of initial concentration

The adsorption of two dyes onto the surface of TALP were speedy initially, slow down later on and at last reached towards equilibrium (Fig. 4) representing saturated adsorption as also reported by McKay et al.[28] The increased adsorption of these dyes onto the TALP may be endorsed to enhance in surface activity and due to micelle formation or the aggregation of dye molecule in the concentration series studied. Similar outcomes have been also reported by various researchers[29].

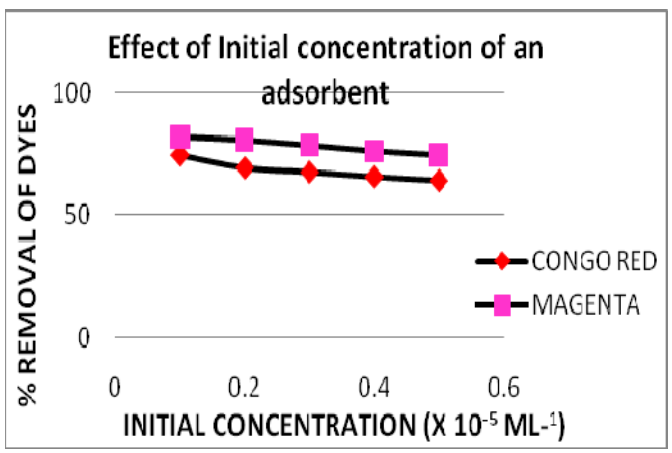

Fig. 4: Effect of initial concentration on removal of dyes

Adsorption isotherms

The adsorption isotherm data were en suite to the typical Freundlich and Langmuir isotherm equations [30]. The adsorption isotherm equation used is Freundlich equation:

$$\log Q_e = \log K + \frac{1}{n} \log C_e \qquad \ldots(1)$$

Where Qe is the equilibrium dye adsorption Capacity and Ce the remaining dye concentration at equilibrium. The constant K is an evaluation of adsorption capacity and 1/n is the concentration of adsorption. A plot of log Qe versus log Ce gives a straight line of slope 1/n and intercepts log K and the values are enlisted in Table 1.

Table 1: Freundlich adsorption constants for Congo red and Magenta dyes using TALP as adsorbent at 25°C

Dyes	Congo red	Magenta
K	0.6862	0.7784
n	1.0404	1.5435
R^2	0.9624	0.9728

The Correlation coefficient (R2) for Congo red and magenta originated to be 0.9624 and 0.9728, respectively.

Langmuir equation,

$$\frac{1}{Q_e} = \frac{1}{Q_{max}} b \times \frac{1}{C_e} + \frac{1}{Q_{max}} \qquad \ldots(2)$$

Where Q_{max} represent the maximum specific dye adsorption Ce, the remaining dye concentration at equilibrium and b the ratio of adsorption / desorption rates associated to energy of adsorption. The capacities of TALP for binding with two dyes were calculated by plotting Ce/Qe against Ce using Langmuir equation. The plot of the Specific sorption Ce/Qe against equilibrium concentration Ce gave the linear isotherm parameters Q_{max} and b are enrolled in Table 2. The correlation (R2) for congo-red and magenta dyes originated to be 0.9242 and 0.9426 correspondingly. The adsorption equilibrium data fixed well for both Freundlich and Langmuir isotherms.

Table 2: Langmuir adsorption constant for Congo red and Magenta dyes using TALP as adsorbent at 25^0C

Dyes	Congo red	Magenta
Q_{max}	1.0374	1.0586
b	0.0128	0.0132
R^2	0.9242	0.9426

CONCLUSION

It has been proved that activated Thorn apple leaf powder is an admirable adsorbent for elimination of congo-red and magenta dyes from aqueous solution, under certain physiochemical circumstances. The result indicates the potentially realistic assessment of TALP as an adsorbent. The calculated dimensionless equilibrium constraint RL originated to be in the string between 0 and 1 is methodical of beneficial adsorption onto the surface of TALP. Adsorption of these dyes onto TALP was first order kinetic process with little activation energy which is an analytic of quick adsorption practice.

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