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BATCH STUDIES ON REMOVAL OF ACID RED18 DYE BY USING IRON DOPED CORNCOB CHARCOAL

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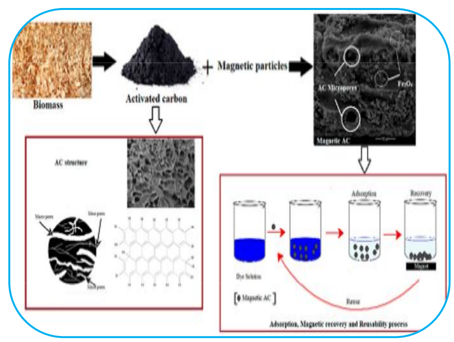
ABSTRACT:
Dyes are an important class of pollutantsthatlead to the deterioration of preciousfreshwater resources, making the need to remove dyes crucial for environmental protection.Recently, bio-sorption techniques have been employed to remove these dyes from water resources, due to their efficient and low-cost treatment. In the present work, modified adsorbent Iron Doped Corncob Charcoal(IDCC) is used for the removal of acid red (AR18)dyefrom synthetic wastewater.The batch mode adsorption studiesshowmaximum removal efficiency of AR18 dye is 97 % at pH=3. The adsorption data fittedwell into Freundlich and Langmuir adsorption isotherms. Keeping in consideration these findings, we recommend usingIron Doped Corncob Charcoal (IDCC) as a low-cost water purifier, for the removal of AR18 dyefrom industrial wastewater.



KEYWORDS: *Acid red18 (AR18); corncob; adsorption, Freundlich and Langmuir isotherms.*

INTRODUCTION:

Safe potable drinking water for every human is necessary. India is a highly populated country and they needsafe drinking and domesticwaterin high demand. Different coloring substances are widely used in industries such as textiles, rubber, plastics, printing, leather, cosmetics, etc., to color their products. [1]

One of the largest groups of the synthetic color which belongs to azo dyes contains one or more azo bonds –N=N-. The dye under consideration AR18 is an azo dye.It is estimated that about 50% of the annual worldwide production of colorants (700 thousand tons) is the azo type. About 15% of the generated colour discharge in dye-bearing wastewater into natural streams and rivers causes pollutionand hence severe problems to the aquatic life, and food web and causes damage to the aesthetic nature of the environment [2-3].

The adsorption of dye from textile wastewater can be performed by chemical, biological, and/or physical treatment methods [4]. Activated carbon (AC) has been widely used as an adsorbent in the purification of aqueous media, gas/solid phase separation, catalysis, electrochemical processes, etc. The surface characteristics of activated carbon, i.e. the extended range of porosity and high surface area, ease of separation, low operational cost, and significant sorption affinity make AC a versatile and preferred material for various applications [5, 6]. To further improve its efficiency, research on the modification and the reusability of AC has been carried out [7].

Among different agricultural adsorbents, corncob (central core of maize ear) has been reported as a low-cost and more efficient biosorbent [8] with high biomass production [9]. According to a study, 100 kg of corn grain produces approximately 18 kg of corncob [9]. India isthe largestcorncob producing country. Therefore, this is an innovative solution in environmental technologies bringing its direct use in dye removal. Furthermore, necessary modifications in such agricultural by-productsmay improve its sorption affinity towards AR18 and resulting in higher removal rates. The present study shows the adsorption of AR18from wastewater using a modified iron-doped corncob charcoal (IDCC).

MATERIALS AND METHODS:

Preparation of biosorbent

Corncob is obtained from a local marketand was oven dried at 90°C. The dried corncob was then grounded using a mortar grinding machine.Then burning in an air-tight cauldron until it is converted to charcoal with approximate output being 700 g/kg. The synthesis of IDCC was carried out by following the procedure described in our recently reported work [10].Initially, 100 g corncob charcoal was stirred with1 M $KMnO_4$ solution for 30 min at 250 rpm. Afterward, added distilled water to dilute the suspension before it was filtered. The residue obtained was then mixed with 1 M $FeSO_4.7H_2O$ and stirred up to 8 hrs. at the same speed. The suspension was filtered, washed with 1% $NaHCO_3$ and soaked in 1% $NaHCO_3$ solution overnight. Later, the suspension was decanted, washed with distilled water, and filtered again. Finally, the solid residue was air dried for 2 hrs. and then kept in an oven at 110°C up to 6 hrs. for complete drying. IDCC further ground to obtain particle size 300 μm mesh. The adsorbent once prepared was used throughout the experimental work.

Preparation of Adsorbate Solution

The AR18was dissolved in 1000 ml of distilled water to prepare a stock solution of 1000 mg/L of adsorbate. Appropriate concentrations of the stock solution were obtained by diluting it with distilled water. The molecular formula and λ_{max} (nm) of the dyes selected for adsorption studies are shown, and some of their properties are given in the tablebelow:

Dye	Molecular formula	Molecular weight	λmax(nm)
AR18	$C_{20}H_{11}N_2Na_3O_{10}S_3$	604.461gm/mole	506

Batch Adsorption Studies:

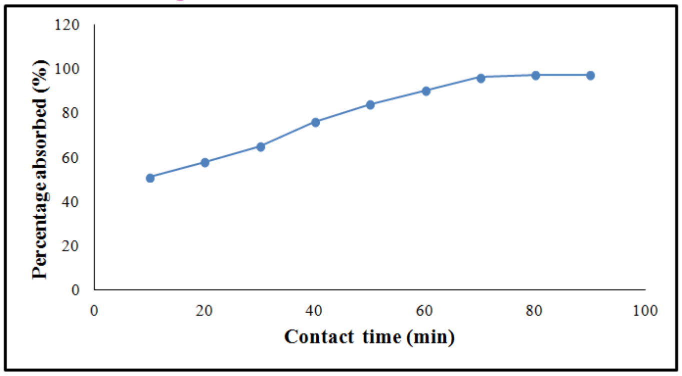
The batch mode adsorption experiments were carried out by varying the contact time, pH, adsorbate concentration,and absorbent concentration. The adsorption studies were carried out in 250 mL tight-lid reagent bottles by agitating 1g of adsorbent with 100 mL of aqueous dye solution. The agitation was carried out by placing the contents of the flask in a temperature controlled orbital shaker (Universal Make). A UV-Visible spectrophotometer determined the maximum absorption of AR18 solutions at 506 nm wavelength. (Perkin Elmer Lambda 25)

RESULT AND DISCUSSION:

Effect of contact time

The absorption efficiency of AR18 on IDCC was a function of contact time (Figure 1). The experiment is carried out by taking the dye concentration100 mg/l, IDCC concentration 10g/lkeeping pH=3and temperature 25 ^{0} C, Figure 1 depicts that the adsorption capacity for AR18 dye increases with the contact time. Maximum adsorption occurs at 90 minutes at constant stirring.

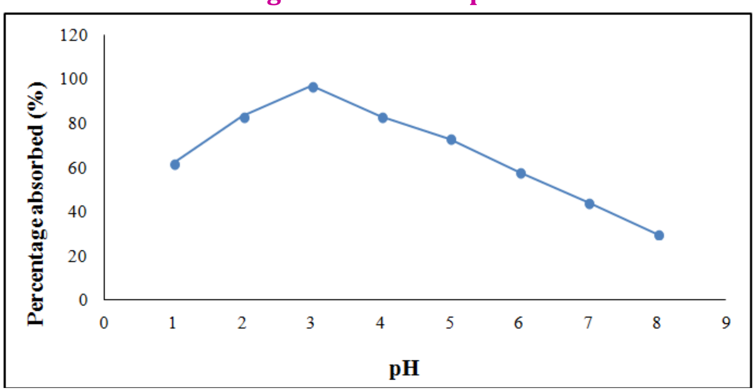
Figure1: Effect of contact time



Effect of pH

The adsorption capacity of adsorbent is the function of pH as their properties are directly altered by hydrogen ion concentration in the dye solution [11]. The study was restricted at higher pH levelsup to8because 30% removal efficiency was observed. Our findings are supported by previous studies [12].The maximum adsorption of the AR18 was observed at pH 3 (Figure 2).A decrease in adsorption occurs below pH3 as anions in the solution compete with the anionic dye [13].The effect of pH was studied by keeping the dye concentration: 100 mg/l, IDCC concentration: 10g/l, and the total contact time of 90 min, at temperature 25 ^{0} C.

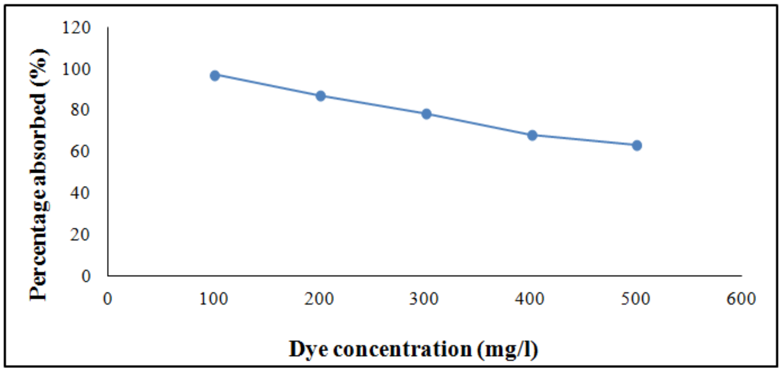
Figure 2: Effect of pH



EFFECT OF DYECONCENTRATION

The result of a change in dye concentrationshows that as the dye concentration increases the adsorption of dye on IDCC decreases[Figure 3]. In the experimental studies, the temperature is kept constant at 25^{o}C,IDCC concentration is also kept constant at 10 gm/l, and dye concentration is varied between 100 to 500 mg/l.

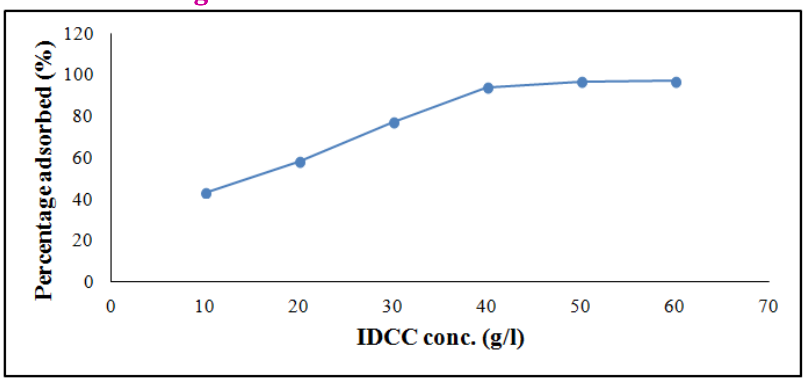
Figure 3: Effect of dye concentration



Effect of IDCCconcentration

It is observed that at lower IDCC concentrations, the adsorption of dye on IDCC increases rapidly but at higher concentrations, there is a very slow linear increase [Figure 4].In the experimental studies, the temperature is kept constant at 25°C, dye concentration is also kept constant at 100 mg/l and IDCC concentration is varied between 10 to 60 gm/l.

Figure 4: Effect of IDCC concentration



Adsorption Isotherms

The adsorption isotherms relating to the adsorbate concentration adsorbed on the surface, provide us with the capacity of the adsorbent at constant temperature [14]. The Langmuir and Freundlich adsorption isotherms have been used to study the adsorption data of dyes.

Freundlich isotherm

The adsorption data were also analyzed using the linear form of Freundlich isotherm as given in Eq. (1) [15].The linearized forms of isotherm equations used are the Freundlich equation:

$$\log q_e = \log K_F + 1/n \log C_e \quad \text{......................................} 1$$

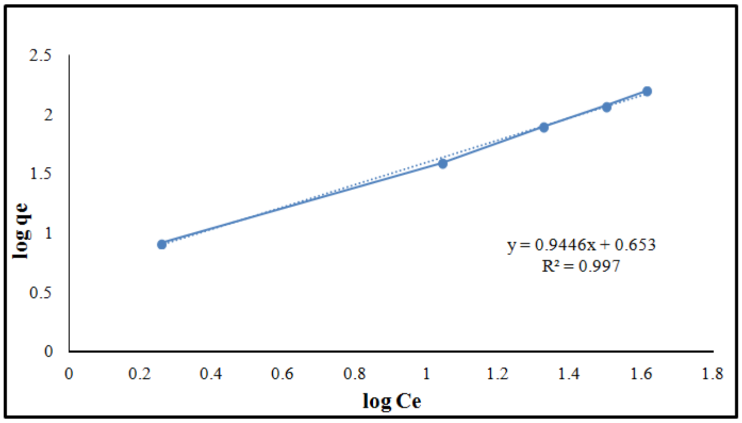
Where q_e is the equilibrium dye uptake Capacity ($mg.g^{-1}$) and C_e is the residual dye concentration atequilibrium (mol L^{-1}). The constant K_F is a measure of adsorption capacity and 1/n is the intensity of adsorption. A plot of log q_e versus log C_e gives a straight line of slope 1/n and intercepts log K[Figure 5].

K_F	n	R^2
4.4977	1.058	0.997

Table 1: Freundlich adsorption constants for AR18 used as adsorbent at IDCC at 25°C

The n value of AR18 (i.e. n = 1.058) indicated more affinity towards heterogeneous adsorption. Values of n>1 show favorable conditions for heterogeneous adsorption [15].The value R^2 (correlation coefficient) is 0.997 indicating a good fit of the data with Freundlich isotherm.

Figure 5: Freundlich adsorption isotherm



Langmuir isotherm

The adsorption data are analyzed using the linear form of Langmuir adsorption isotherm as given in Eq. (2) [15]

$$1/q_e= \quad 1/bq_mC_e+ \quad 1/q_m \text{…………………………}2$$

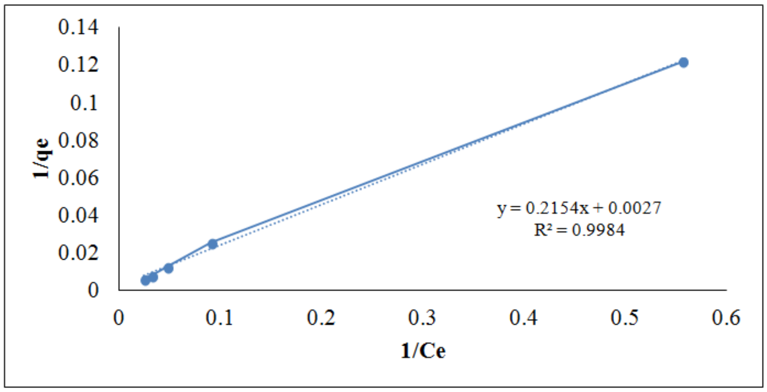
Where, q_e and $C_e$are adsorbed concentration (mg.g-1) and equilibrium concentration (g.mL-1)of the dye, respectively. The values q_m(mg. g-1) represent the maximum dye uptake and b (L. g-1) the ratio of adsorption/desorption rates related to the energy of adsorption. A plot of 1/ q_e versus 1/ C_e gives a straight line of slope 1/b.q_m and intercepts 1/q_m.

q_m	b	R^2
370.37	0.0125	0.998

Table 2: Langmuir adsorption constants for AR18 used as adsorbent atIDCC at 25°C

The value R^2 (correlation coefficient) is 0.998 indicating a good fit of the data with Langmuirisotherm.

Figure 6: Langmuir adsorption isotherm



CONCLUSION:

The present study indicates that the modified corncob with iron doping could be used as an effective tool for the removal of acid red18 dye from textile wastewater. Results revealed that the maximum removal efficiency of acid red18 dye is 97 % at pH-3, contact time 90 min, initial dye concentration 100 mg/lit, and adsorbate dose of 1gm/lit. Therefore, the study may help environmental scientists to employ IDCC in the dye industry as a low-cost and effective alternative to conventional wastewater treatment processes, minimizing the detrimental effects associated with the discharge of these hazardous dyes into the environment.

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