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Removal of Congo red Dye from Aqueous Solution by Using Saw Dust as an Adsorbent

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ABSTRACT
The removal of this dye from the industry waste water is environmentally significant. In the present work, easily available, and low cost adsorbent i. e. saw dust was employed to remove congo red dye from water. The effects of parameters like pH, amount of adsorbent dose, contact time, temperature were studied. The result showed that 90% dye was removed when p^H= 9 and contact time is 120 minutes.when the temperature increases from 298 K, 303 K and 308 K, the rate of adsorption also increases. The Freundlich and Langmuir adsorption isotherm were also studied. The kinetic study shows that the system follows pseudo 2nd order. The ultrasonic velocities of dye solution were studied. The result shows that the velocity increases with adsorption increases.
Key words: adsorption, adsorption isotherm, congo red, kinetc study, saw dust.

I. INTRODUCTION

The release of large quantities of dyes into water by textile industries possesses serious environmental problems [1] due to its persistent nature. The coloured effluent have an inhibitory effect[2] on the process of photosynthesis and affecting aquatic eco system. Azo dye like congo red not degradate completely produces toxic amines in water [3]. Dyes have a tendency to produce metal ions in textile water produces micro toxicity in the life of fish [4]. Thus the removal of dyes from coloured effluents in textile industry is one of the major environmental problem.

There are various methods which have been employed for removal of dyes from effluent [5]. Most of these methods are expensive. The adsorption process [6] has been found to be more effective method over all other treatments. Therefore proposed work were undertaken using agriculture waste like saw dust for the removal of dye material[7-11] from aqueous solution.

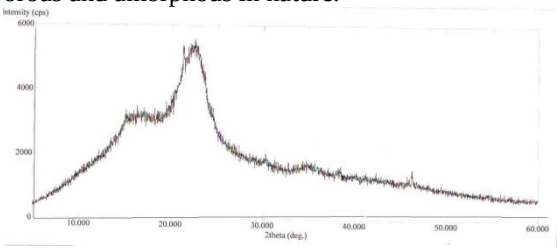
II. MATERIALS AND METHODS

2.1 MATERIALS

Saw dust was collected from a local saw mill in Solapur city. It was then washed with distilled water and dried in an oven at 120^0 C. It was then seived through sieve no. 100(150µm).

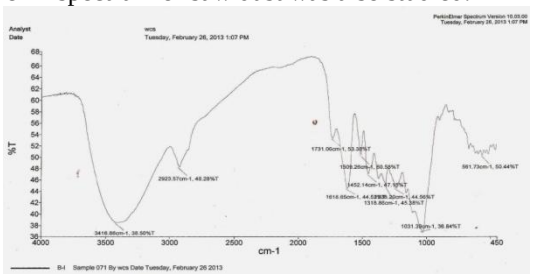
The BET surface area of saw dust was 40.2 m^2/gm. obtained from BET technique. Congo red dye used was (AR grade Finar chemicals limited.). Molecular formula : $C_{32}H_{22}N_6Na_2O_6S_2$

The X-ray diffraction study of saw dust was carried out by X-ray Fluoroscence spectrometer (Philip model PW 2400). The morphological and XRD study clearly indicates that the adsorbent is porous and amorphous in nature.



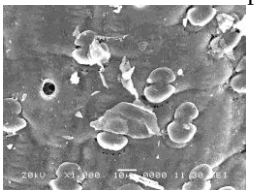
X-ray diffraction pattern of saw dust.

The IR spectrum of saw dust was also studied.

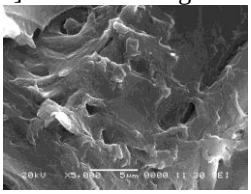


IR spectrum of saw dust

From the **SEM** analysis it was found that there were holes and cave type openings on the surface of adsorbent which would have more surface area available for adsorption[12] as shown in fig 1.



Saw dust (Before adsorption)



Saw dust (After adsorption)

Scanning electron micrograph (SEM) of the adsorbent

2.2 CHARACTERIZATION OF ADSORBENT

1. The BET Data shows that the saw dust is having a surface area 40.4 m^2/ gm.
2. The Scanning Electron Microscope (SEM) technique was used to study the structure and porosity of saw dust before adsorption and after adsorption. The photographs shows that the size of the pores reduces after adsorption.

2.3 BATCH ADSORPTION EXPERIMENTS

Batch adsorption experiments were conducted by shaking 150 ml of dye solution having concentration (50mg/l) i.e. 50 ppm with different amount of adsorbent and having different p^H values, at different temperatures as well as different time intervals. The adsorbent was then removed by filteration and the concentration of dye was estimated spectrophotometrically at λ_{max}= 580 nm. The amount of dye adsorbed was then calculated by mass balance relationship equation,

$$q_e = \frac{Co-Ce}{x} \quad \text{_____}$$

Where,

C_o = Initial dye concentration
Ce= Equilibrium dye concentration
q_e =Amount of dye adsorbed per unit mass of adsorbent.
x=dose of adsorbent

III. RESULT AND DISCUSSION

For getting highest amount of dye removal various factors were optimized.

3.1 EFFECT OF CONTACT TIME:

In order to get minimum amount of adsorbent for removal of maximum amount of dye. The contact time was optimized. The results showed that the extent of adsorption is rapid at the initial stage, after 70 minutes the rate of adsorption is constant. About 80% dye was removed.(fig.1).

3.2 EFFECT OF P^H :

From fig.2 it reveals that an increase in p^H is accompanied with increase in percentage of dye removal. At p^H= 8, adsorption is maximum. Therefore it is chosen as optimum p^H. The percentage removal of basic cationic dye increases with increase in p^H [13,14]. By further increase in p^H adsorption slightly decreases.

3.3 EFFECT OF ADSORBENT DOSE:

From the results, it is clear that the optimum dose is 3gm/150ml. (Fig.3). By further increase of adsorbent dose, the removal of adsorbent decreases due to some of the adsorption sites remains unsaturated during the process [15].

3.4 EFFECT OF TEMPERATURE:

The perusal of fig.4 it is clear that adsorption capacity of adsorbent increases as the temperature increases due to increase in the mobility of dye ions increasing temperature also causes a swelling effect within the internal structure of adsorbent. So that large number of dye molecules can easily penetrate through it[16,17].

IV. ADSORPTION ISOTHERM

4.1 LANGMUIR ISOTHERM

In order to study the adsorption of dye according to Langmuir isotherm, following equation was used.

$$C_e/q_e = 1/Qm \times b + C_e/Qm$$

A graph of C_e/ q_e against C_e was plotted.

The correlation factor is closely related to unity, which indicates that the Langmuir isotherm model is applicable [18, 19]. The formation of monolayer takes place on the surface of the adsorbent [20,21].

4.2 FREUNDLICH ISOTHERM

In order to study the Freundlich isotherm the following equation was used[22].

$$\log q_e = \log Kf + \log Ce/ n$$

The graph of $\ln q_e$ against $\ln C_e$ was plotted.

The value of correlation factor is closely related to one. So it indicates that the Freundlich isotherm also satisfied. The value of n is greater than 1. So the Freundlich adsorption develops appropriately.

4.3 ADSORPTION KINETICS

4.3.1 PSEUDO 1^{ST} ORDER MODEL

The pseudo 1^{st} order kinetics model is used to understand the kinetic behavior of the system [23, 24]. It is given by the equation.

$$\frac{dq}{dt} = k_i (q_e - q_t)$$

A graph of $\ln(q_e - q_t)$ vs time was plotted.

4.3.2 PSEUDO 2^{ND} ORDER MODEL

The pseudo 2^{nd} order kinetic model was studied using equation [25].

$$t/q_t = q_e^2/K_2 + t/ q_e$$

Where q_e = dye adsorbed at equilibrium
q_t = dye adsorbed at time t

A graph t/ q_t of against time was plotted.

V. GRAPHS AND TABLES

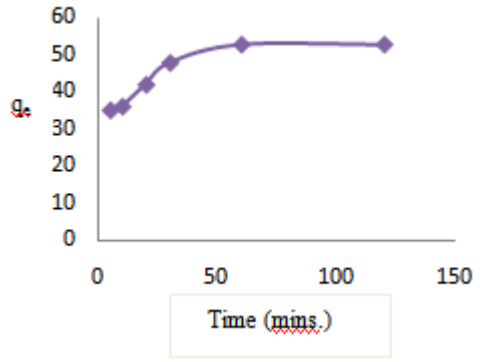


Fig. 1

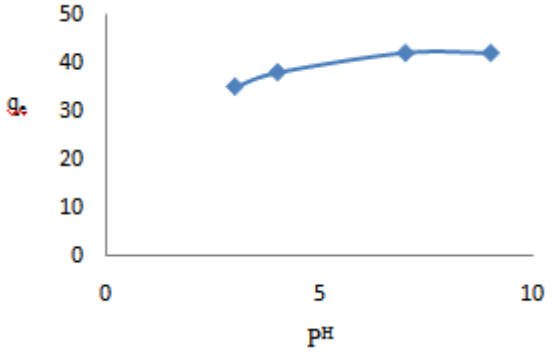


Fig. 2

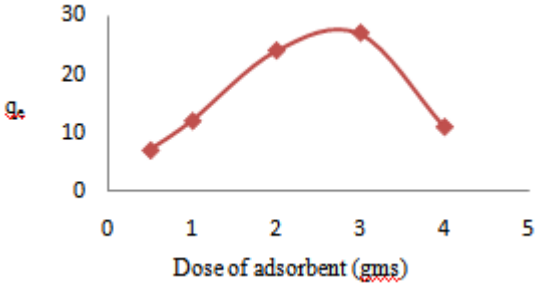


Fig. 3

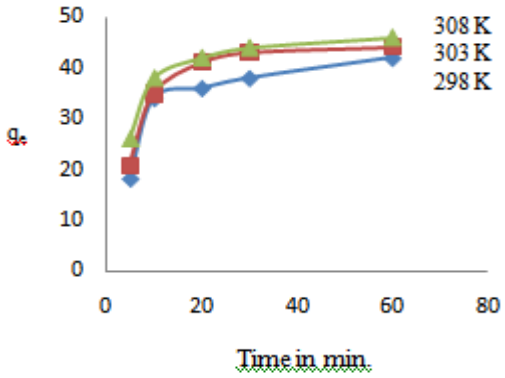


Fig. 4

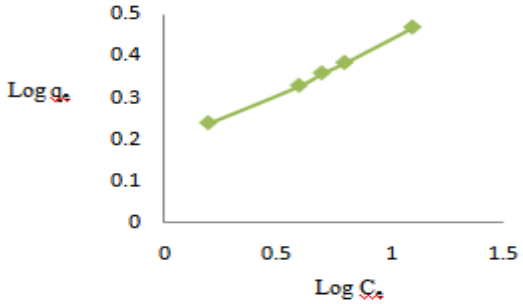


Fig. 5

From the slope, the value of n and correlation factor can be calculated.

Q_m	b	Correlation factor
130	0.04	0.990

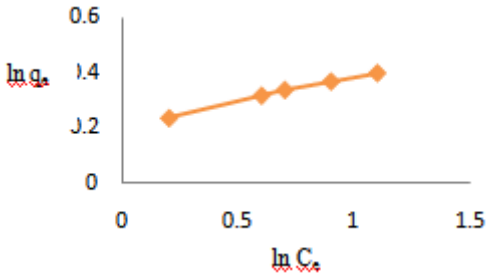


Fig. 6

From the slope, the value of n and correlation factor can be calculated.

Slope (1/n)	n	Correlation factor
0.2	5	0.9965

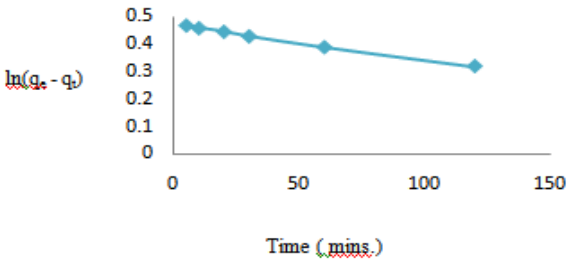


Fig. 7

Slope (K_i) (correlation coefficient)	Intercept (q_e) (Max. adsorption capacity)	Correlation Factor
-0.0011	0.402	-0.990

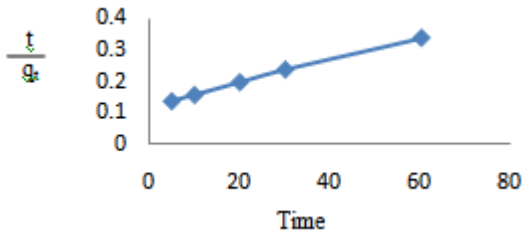


Fig. 8

Slope (K_2)	Intercept (q_e)	Correlation factor
0.0032	0.120	0.9996

In case of pseudo 1st order kinetic model, the value of slope and correlation factor are negative. While in case of pseudo 2nd order kinetic model, the value of slope and correlation factors are positive. Which implies that, the system is more fevourable for pseudo 2nd order kinetics.

VI. CONCLUSION

Saw dust an agriculture by-product acts as an effective adsorbant for the removal of basic dye like congo red from its aqueous solution. Batch adsorption study was shown that the percentage of colour removal increases with increase in adsorbant dosage upto certain limit, increasing contact time, increasing p^H as well as increase in temperature. The optimum conditon for equilibrium is achieved after 120 min. When adsorbent dose increases above 3gm., the adsorption decreases. The Langmuir isotherm model is applicable for this system, which shows that, there is a formation of monolayer, present on the surface of adsorbent. Similarly the kinetic study shows that the pseudo 2nd order kinetc model was more fevourable for the present system.

VII. ACKNOWLEDGEMENT

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REFERENCES

[1] Mcmullan G., Meehan C., Conneely A., Kirby N., Robinson T., et. al., Microbial decolourization and degradation of textile dyes, Appl Microbiol Biotechnol 56, (2001), 81-7.

[2] Nigam P., Armour G., Bonant I. M., Singh D., Marchant R., Physical removal of textile dyes and solid state fermentation of dye-adsorbed agricultural residues, Bioresour Technol, 72, (2000), 219-226.

[3] Wolfe N. L., Weber E., Environ. Toxicol Chem., 6 (1987) 911-927.

[4] Nagda, G. K. , Diwan A. M.and Ghole, V. S., App. Eco. & Enviro. Res. 2 (2007) 1, 2.

[5] Bozdogan A., Gokunil H., The removal of colour of textile dyes in waste water by use of recycled coagulant, M. U. Fena Billimleri Dergisi, 4 (1987) 83-96.

[6] Khatri S. D., Singh M. K., Colour removal from synthetic dye waste water using a biadsorbent, Water Air Soil pollut. 120 (2000) 283-294.

[7] Singh B. K., Rawat N. S., Comparative sorption equilibrium studies of toxic phenols on fly ash and impregnated fly ash, J. Chem. Technol. Biotechnol. 61 (1994) 307-317.

[8] McKay G., Prasad G. R., Mowli P. R., Equilibrium studies for the adsorption of dyestuff from aqueous solutions by low cost materials, Water Air Soil Pollut. 29 (1986) 273-283.

[9] Khare S. K., Panday K. K., Srivastava R. M., Singh V. N., Removal of Victoria blue from aqueous solution by fly ash. J. Chem. Technol, Biotechnol. 38 (1987) 99-104.

[10] Juang R. S., Wu F. C., Tsang R. L., The ability of activated clay for the adsorption of dyes from aqueous solutions. Environ. Technol. 18 (1997) 525-531.

[11] Theng B. K. G., Wells N., Assessing the capacity of some New zealand clays for decolourizing vegetable oil and butter. Appl. Clay. Sci. 9 (1995) 321-326.

[12] Khatri S. D., Singh M. K., Adsorption of basic dyes from aqueous solutions by natural adsorbent. Ind. Chem. Technol. 6 (1999) 112-116.

[13] Ferro F., Journal of Hazardous Material 142 (2007) 144.

[14] Jain R. and Sikarwar S., Journal of Hazardous Material 152 (2008) 942.

[15] K. Bhatti, Z. M. Pervez, Journal of the Chemical Society of Pakistan, 33 (2011) 522.

[16] Garg V. K., Kumar Rakesh, Gupta Renuka, Basic dye (Methylene blue) removal from simulated waste water using Indian Rose wood Saw dust a timber industry waste Dyes and pigments 63 (2004) 243-250.

[17] Yamin Yasin, Mohd. Zobir Hussein, Faujan Hj Ahmad, Adsorption of Methylene blue on to treated activated carbon. Malaysian Journal of analytical sciences. 11 (2007) 400-406.

[18] Reuy-Shin Juang, Tseng Ru-Ling, Feng-Chin Wu, and Suen Ji-Lin. Use of CChitin and Chitosan in Lobse shell waste for colour

removal from aq. Solution. J. Environ. Sci. Health A31 (1996) 325-338.

[19] Sen A. K. and De. A. K., Adsorption of mercury (II) by coal fly ash. Water Res. 21 (1987) 885.

[20] Thievarasu C., Mylsamy S. and Sivakumar N., Cocoa shellas adsorbent for the removal of the methylene blue from aqeous solution for kinetcs and equilibrium study. Universal Journal of Env. Research and Tech. 1 (2011) 70-78.

[21] Parvathi C. Sivamani S., Prakash C. "Biosorption studies on Malenchite green dye." Colourage Environmental solution. LV I 10 (Oct 2009) 54-56.

[22] Arivoli S., Hema N., "Comparative study on the adsorption kinetics and thermodynamics of dyes on to acid activated low cost carbon." Int. J. Phys. Sci. 2 (2007) 10-17.

[23] Karabulut S. "Batch removal of Copper (II) and zinc (II) from aqueous solution with low rank Turkish coals." Sep. purif. Tech. 18 (2000) 177-187.

[24] Guruswami, Annadurai, Ruey-Shin Juang, Duu-Jong Lef. "Use of cellulose based waste for adsorption of dyes from aq. Solutions." J. Hazard. Water B92 (2002) 263-274.

[25] Paul S. A., Chavan S. K., Oriental Jr. Chem. 27 (2011) 41-44.