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Activated Carbon from Sugar Waste Bagasse is used for Removal of Colour from Dye Solution

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Abstract - Sugar cane bagasse pith is the main waste from sugar industry in India. Main use of bagasse is for the power generation in sugar industry and as a fertilizer, but large amount of waste bagasse is generated from sugar industry. In view of this bagasse can be used as a raw material for the preparation of activated carbon. Activated carbon were prepared from bagasse pith by a chemical activation with 14% H_3PO_4,Pre-carbonization and followed by pyrolysis at 800°C by physical activation in absence of air. The Activated carbon has been employed as adsorbent for the removal of Methyl Orange dye solution. The nature of possible adsorbent and dye interaction was examined by the SEM and EDAX technique. Batch experiments were carried out at various adsorbent dose, dye concentration & contact time for optimum condition.The adsorption of 100 ml dye solution (50 ppm) was found to be maximum (98 %) at contact time 40 minute and dosage of adsorbent3.5 gm. The extent of removal of Dye was found to be dependent on adsorbent dose, temperatures and contact times.

Key Words: *Methyl orange dye,sugar cane bagasse pith,Activated carbon, SEM, EDAX.*

1. INTRODUCTION

Activated carbon is widely used for a number of applications, such as separation of gases, recovery of solvent and removal of organic pollutants from drinking water, among many other operations. Activated carbons are important adsorbents in various industrial sectors such as the food, pharmaceutical and chemical industries**[1]**.The activated carbon is widely used as adsorbent due to its higher adsorption capacity, but activated carbon is very expensive. To find out inexpensive alternative adsorption of dye on formaldehyde and sulfuric acid treated bagasse has been compared with activated carbon**[2]**. By utilizing chemically modified sugar cane bagasse has good potential for the removal of dye by the batch adsorption process**[3]**. Activated carbons were prepared from bagasse pith by Chemical treatment of $ZnCl_2$ & H_3PO_4followed by pyrolysis and have been used as solid adsorbent for the removal of reactive orange dye and found the removal efficiency increasing with increasing the dose of adsorbent**[4]**. Water nut activated carbon was prepared from the agricultural waste material and it can be successfully used for the removal of dye. SEM images shows that the adsorbents having greater surface area followed by activation**[5]**. Dyes are the important class of industrial pollutants including textile effluent**[6,7]**. Textile industries consume large quantities of water and chemicals, especially in dyeing and finishing processes. On average, 60–90% of total water consumption is spent in washing processes**[8]**. Dyes used in the textile industry may be toxic to aquatic organisms and can be resistant to natural biological degradation**[9-11]**. Therefore the development of efficient, low cost and eco-friendly technologies is needed to reduce the dye content in waste water. Among treatment technologies adsorption is extremely gaining prominence**[12-13]**. In the present work Activated carbon were prepared from bagasse pith by a chemical activation with 14% H_3PO_4, Pre-carbonization and followed by pyrolysis at 800°C by physical activation in absence of air. Activated carbon is well known as a porous material and has a large specific surface area and has been used successfully as an adsorption agent for the removal of dye from aqueous solution.

2. MATERIAL & METHOD

2.1 Preparation of Activated Carbon

The bagasse pith collect from sugar industry were washed several time with distilled water and left to dry then sieved to an arrange particle size. The raw material was subjected to activation chemical treatment followed by pyrolysis. The activation was carried out using 14% H_3PO_4 solution 24 hours. In the pre-carbonization process bagasse was heated to 110°C for about 24 hour to remove excess of H_3PO_4 and then cooled down to room temperature. After this dry bagasse is heating to the 800°C for 1.5 hour, after that activated carbon was washed successfully for several time with hot water until pH become neutral and finally with cooled water to remove the excess phosphorus compound. The washed sample was dried at 110°C to get the final product**(AC-1)**.

Preparation of Dye Solution

The methyl orange dye was obtained from local market and dissolved in distilled water with the help of magnetic stirrer at 150 rpm to get a clear solution of different concentration. In the same way 50 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm, 300 ppm and 350 ppm dye solution were prepared. Color removal efficiency was measured at 510 nm by UV Spectrophotometer 106.

3. EXPERIMENTAL STUDY

BATCH EXPERIMENT:

Batch adsorption experiments were carried out at room temperature (25°C ± 2°C). Exactly 100 ml of dye solution of known initial concentration (50–350 ppm) was stirrer at the constant agitation speed (150 rpm) with a required dose of adsorbents (1-4 g/100ml) for a specific period of contact time (2–50 min) by magnetic stirrer.At the end of experiment the solution was filtered and the filtrate was analyzed by UV spectrophotometer(Systronics Spectrophotometer 106) at 510 nm. The dye concentration is determined with the absorbance value of solution before and after contact with adsorbent. The final concentration (C_e) was measured after equilibrium. The percentage removal of dye was calculated using the following relationship:

$$\% \text{ age Removal of Dye} = (C_i - C_e) / C_i \times 100 \rightarrow (1)$$

Where C_i and C_e are the initial and final (equilibrium) concentrations of dye (mg/L) respectively. Blanks containing no dye were used for each series of experiments as controls.

4. RESULT AND DISCUSSION

4.1 Effect of contact time

The effects of contact time with 1.5 g adsorbent dose in 100 ml dye solution of concentration 50 ppm were investigation, the colour removal increases with increase in time. The colour removal reached 94% within 10 minutes. However contact time required reaching equilibrium is 40 minutes. At equilibrium the colour removal was 98%. The results are given infig.1.

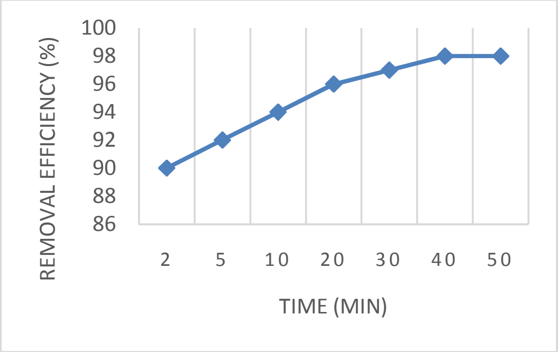


Fig.1: Shows the Effect of contact time

4.2 Effect of Activated Carbon dosage

To study the effect of activated carbon quantity on the dye solution, several 100 ml samples of 50 ppm dye solution were taken and the dosages of activated carbon varies from 1.0 g to 4.0 g was added. In analysis of this experiment activated carbon dosage is directly effects on the removal efficiency of dye solution as shown in fig 2. When dosage of activated carbon is increase then removal efficiency is also increase. At equilibrium the colour removal was 99% and the result are given in the fig.2.

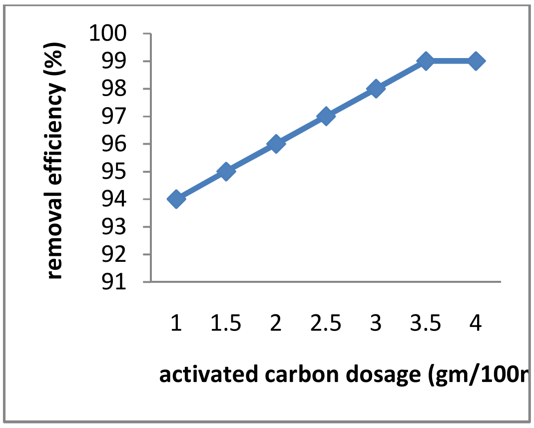


Fig.2: Shows the Effect of Activated carbon dosage

4.3 Effect of Dye concentration

The effect of initial concentration of dye on the removal of methyl orange dye in terms of percentage removal on adsorbent was studied as shown in fig.3. The percentage removal of dye was found to decrease with the increase in initial dye concentration. The results shows that the percentage removal of dye decreases from 94 % to 60 % as the initial dye concentration increase from 50 to 350 ppm respectively.

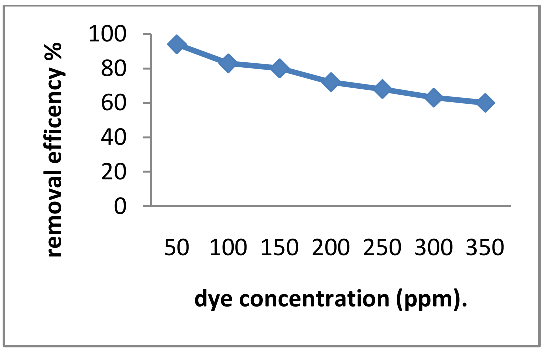


Fig.3: Shows the Effect of Dye concentration

5. ADSORPTION ISOTHERMS:

In order to optimize the design of an adsorption system to remove the dye, it is important to establish the most appropriate correlations for the equilibrium data for each system. Two isotherm models have been tested in the present study; Langmuir and Freundlich models.

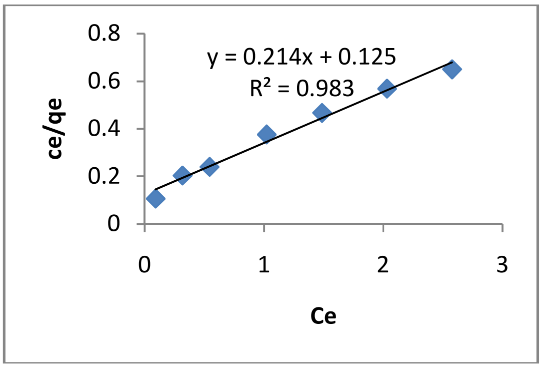


Fig.4: Langmuir isotherm for adsorption of methyl orange dye on activated carbon **(AC-1).**

5.1 Langmuir model

Langmuir theory was based on the assumption that adsorption was a type of chemical combination or process and the adsorbed layer was unimolecular. The theory can be represented by the following linear form:

$$C_e/q_e = (1/Q_0 b) + (Ce/Q_0) \quad \rightarrow (2)$$

Where C_e is the equilibrium concentration (mg/L), q_e is the amount adsorbed at equilibrium (mg/g) and Q_0 (mg/g) and b(L/mg) are Langmuir constants related to adsorption capacity and energy of adsorption respectively. The linear plot of C_e/q_e vs. C_e shows that the adsorption obeys Langmuir isotherm model for adsorbent(fig 4). The values of Q_0 and b were determined for adsorbent from intercept and slope of the linear plot of C_e/q_e vs. C_e.

Table-1 : Langmuir and Freundlich adsorption constant for adsorbent.

Adsorbent	Langmuir constants			Freundlich constants		
	Q_0 (mg/g)	b (L/gm)	R^2	K_f	1/n	R^2
(AC-1)	10.406	0.239	0.983	3.7596	0.4346	0.999

The essential characteristics of Langmuir dimensionless constant separation factor or equilibrium
Parameter, R_L, which is defined by the following equation[**14**]:

$$R_L = 1/(1+bC_0) \quad \rightarrow (3)$$

Where, C_0 is the initial dye concentration mg/ L. The value of separation factor R_L, indicates the nature of the adsorption process as given below:

RL value	Nature of adsorption process
RL > 1	Unfavorable
RL = 1	Linear
0 < RL < 1	Favorable
RL = 0	Irreversible

Table-2: Intraparticle diffusion rate parameter and diffusion coefficient at different initial dye concentration.

Dye concentration (ppm)	The value of R_L **AC-1**
50	0.817
100	0.691
150	0.598
200	0.528
250	0.472
300	0.427
350	0.389

In the present study, the values of R_L [Table-2] are observed to be in the range 0–1, indicating that the adsorption process is favorable for prepared Adsorbent **(AC-1)**.

5.2 Freundlich model

The Freundlich adsorption model stipulates that the ratio of solute adsorbed to the solute concentration is a function of the solution. The empirical model was shown to be consistent with an exponential distribution of active centers, characteristic of heterogeneous surfaces. The amount of solute adsorbed, q_e, is related to the equilibrium concentration of solute in solution, C_e, following:

$$Q_e = k_F \times (C_e)^{1/n} \rightarrow (4)$$

This expression can be linearized to give the following equation:

$$\text{Log } q_e = \log K_F + 1/n \log C_e \rightarrow (5)$$

Where K_F is a constant for the system related to the bonding energy. K_F can be defined as the adsorption or distribution coefficient and respects the quantity of dye adsorbed onto carbon adsorbents for a unit equilibrium concentration (a measure of adsorption capacity, mg/g). The slope 1/*n*, ranging between 0 and 1, is a measure of adsorption intensity or surface heterogeneity, becoming more heterogeneous as its value gets closer to zero[**15**]. A value for 1/*n* below one indicates a normal Freundlich isotherm while 1/*n* above one is an indicative of cooperative adsorption[**16**]. A plot of log (q_e) vs. log (C_e) is shown in Fig. 5, where the values of K_F and 1/*n* are determined from the intercept and slope of the linear regressions [Table-1].

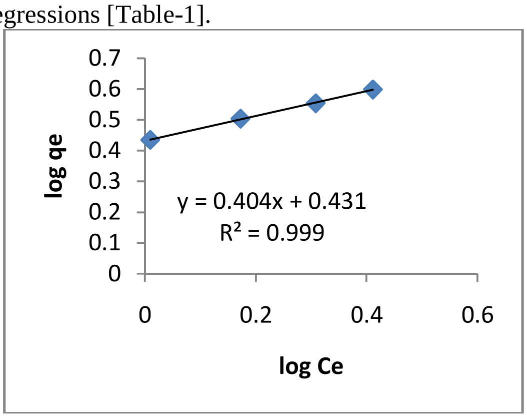


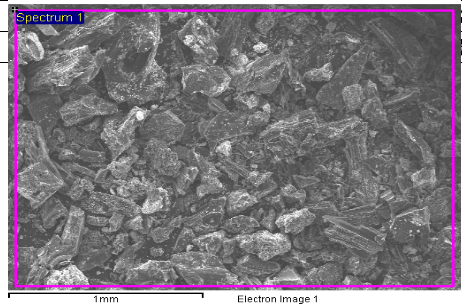
Fig.5: Freundlich isotherm for adsorption of methyl orange dye on activated carbon **(AC-1)**.

6. CHEMICAL CHARACTERISTICS OF ACTIVATED CARBON

The activated carbon **(AC-1)** prepared in the laboratory was used in this study. The chemical characteristics of the carbon **(AC-1)** as illustrated in Table-3. The dried samples were stored for further analysis such as surface morphology.

Table-3:Elemental analysis carried out by EDAX Spectroscopy of activated carbon (AC-1)

Sr. No.	Parameters	Weight(%)	Atomic(%)
1	Carbon (%)	**52.09**	**62.56**
			1.13
			6.30



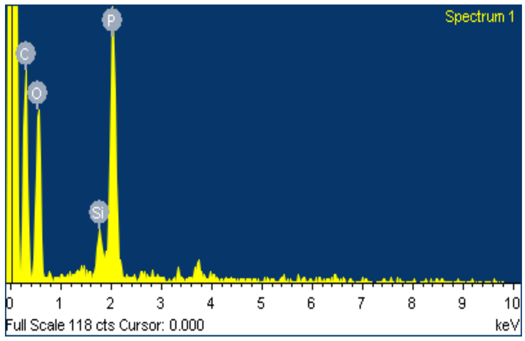
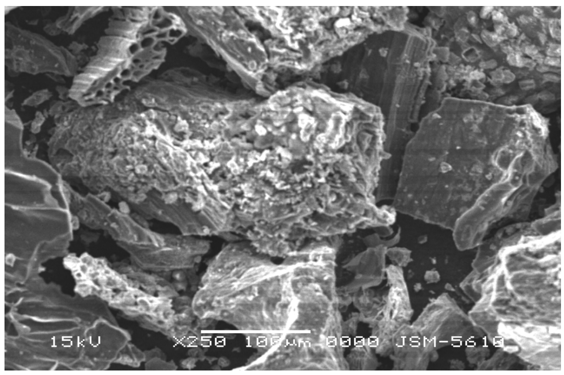


Fig. 6: EDAX analysis strengthens the fact that AC-1 is the best activated carbon prepared with the highest carbon content and the lowest oxygen content.

7. SEM ANALYSIS

The surface morphology of the sample was studied using SEM. Figure 7 shows the micrograph of AC-1. The SEM images of the activated carbon show that the external surfaces are full of cavities and quite irregular. It appears to have numbers of macro pores and so there is a good possibility for dye to be adsorbed into pore.



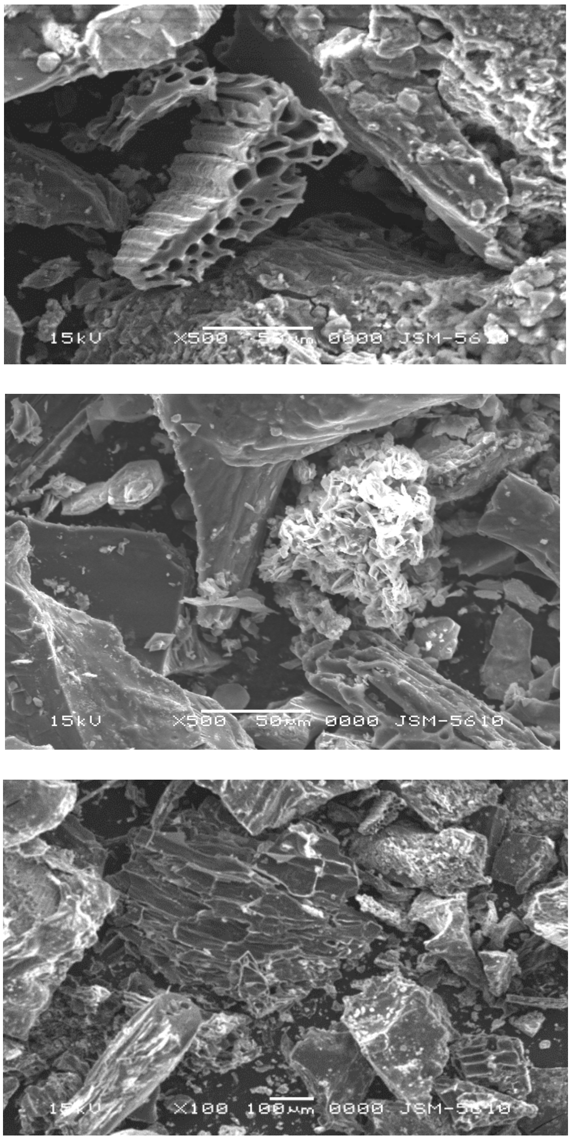


Fig.7: shows the SEM Image of AC-1

8. CONCLUSION

In this study, the activated carbon prepared from sugarcane bagasse and it was showed better result for all contact time, adsorbent dosage and all initial dye concentration. The dye removal was found to be maximum for lower initial dye concentration. The adsorption efficiency was found to be maximum over the adsorbent dosage range of 1 to 4 g/100ml. The SEM images of the activated carbon show that the external surfaces are full of cavities and quite irregular. EDAX analysis strengthens the fact that AC-1 is the best activated carbon prepared. The bagasse is an agro industry waste with this cheap & eco-friendly adsorbent considerable dye removal can be achieved, so it can be substituted for expensive activated carbon.

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