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Adsorption studies of methylene blue dye using prepared low-cost activated Kaza's Carbons

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ABSTRACT

Activated Carbons are prepared using bio-waste materials- Phaseolus trilobus, Leucena leucocephala and Casuarina collected from agricultural field. Phaseolus trilobus is a grass material and branches of Leucena leucocephala and Casuarina. . Using the prepared carbons adsorption studies of Methylene Blue dye are made .Effect of adsorbent dose,contact time etc., on the percentage color removal of the dye was studied with the sorbents.

Key words : Adsorption studies, Methylene Blue dye, Activated Kaza's Carbons.

INTRODUCTION

During the sorption process, solute is transferred from solution to the surface of the solid phase, where its concentration increases until a dynamic equilibrium is reached. At the equilibrium, there is a defined distribution of solute between the liquid and solid phases. The concentration of solute (dye) in the sorbent depends not only on the solute concentration in solution, but also on some parameters that may influence potentially the sorption equilibria. pH is probably the most important parameter affecting the sorption of ionic species. In general, active sites on the sorbent surface may undergo dissociation/protonation in dependence on the pH value. A point of zero charge is an important parameter characterizing the surface properties of the sorbent [1,2]. Dye

molecules contain often strongly acidic or basic groups (e.g. sulphonic); which degree of dissociation remains virtually unchanged over a wide pH range.

Apart from the dyes, wastewaters from dye-processing or textile finishing industries contain large amounts of dissolved substances, especially of inorganic salts that may potentially affect an effectiveness of the dye removal. An effect of the salt concentration on the dye sorption was studied in several research works. It was observed a certain increase in the azo dye sorption [3] onto starch-based polymers in the presence of inorganic salts (NaCl) and explained this phenomenon as a result of the charge reduction on the sorbent surface. Similarly, the sorption of reactive (acid) dyes on activated carbon increased (but not dramatically) in the presence of NaCl ($0.1 - 0.5 \text{ mol l}^{-1}$) [2]. It could be concluded that inorganic salts do not significantly effect in the sorption of either basic or acid dyes on the non-conventional sorbents even at high concentrations, which is important for potential practical applications.

EXPERIMENTAL SECTION

Preparation of activated carbons:

The raw materials were collected, crushed into small pieces, washed with water and dried under sunlight for two days. The dried materials were carbonized in uniform nitrogen flow in a horizontal tube furnace electrically heated at 500°C for 4 h, cooled to room temperature and ground to 45 mesh. These powdered carbons were subjected to liquid phase oxidation with 1N HNO_3 . After that the carbons were washed with double-distilled water to remove the excess acid and dried at 150°C for 12h. These activated carbons which are prepared from *Phaseolus trilobus*, *Leucena leucocephala* and *Casuarina* are named as NPTC, NLLC and NCC respectively. These are also collectively named as Kaza's carbons after the name of Kaza Somasekhara Rao.

Reagents and apparatus:

Methylene Blue (MB) is supplied by ATUL LIMITED, Colours Division, Atul 3962020, Gujarat, India. All the reagents used are of analytical reagent grade. The reagents prepared are given below.

Preparation of stock solutions of dyes:

Stock solutions of selected reactive dye prepared separately. 1g of methylene blue is weighed accurately and transferred into 1000ml volumetric flask. The substance is dissolved in double distilled water and then the solution is diluted to 1 litre. The resultant solution contains 1000 mg l^{-1} of MB. This solution is said to be stock solution of Methylene Blue (MB).

By using the stock solutions of this dye, various solutions of concentrations 10, 20, 30, 40, 50, 60, 70, 80 mg l^{-1} of dye are prepared. 20 mg l^{-1} concentration of dye is taken as initial concentration for practical purpose.

From stock solutions, different concentrations of dye 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 in mg l^{-1} are prepared. The absorbance of all these solutions are measured using the double distilled water as reference solution at a wavelength of 665 nm for methylene blue dye solution were separated using filtration method [4,5,6]. The samples were filtered using Whatman no. 42 filter paper, the first part of the filtrate was discharged to avoid the effects of adsorption on to the filter paper and

the remaining filtrate was analyzed for residual dye concentration using UV-visible spectrophotometer. To correct any adsorption of dye on containers, control experiments were carried out in duplicate. Batch study was conducted to determine the optimum conditions and to study the effect of pH, adsorbent dose and contact time on test solution. The effect of pH on dye was studied by adjusting the pH of test solution using 0.1N HCl or 0.1N NaOH on fixed quantity of adsorbent, while effect of adsorbent dose and contact time were studied by varying dose and contact time, respectively. Optimum conditions were selected for further studies. The percentage removal of the dye and the amount of dye adsorbed were calculated by the following equations. All the experiments were done separately for MB at the wavelengths 610 nm for each adsorbent NLLC, NPTC and NCC separately.

$$\% \text{ removal} = \frac{(C_i - C_e)}{C_i} \times 100 \dots \dots \dots \text{Amount adsorbed } (q_e) = \frac{(C_i - C_e)}{m} V \dots \dots \dots$$

where C_i = initial concentration of dye solution in mg l^{-1}

C_e = equilibrium concentration of dye solution in mg l^{-1}

m = mass of the adsorbent in grams (g)

V = Volume of test solution in litres (l)

RESULTS AND DISCUSSION

Effect of adsorbent dosage:

The study of effect of adsorbent dosage is necessary and very useful to find the optimum amount of carbon required for the removal of dye. The percentage removal of MB dye by adsorption onto activated carbon samples *viz.*, NLLC, NPTC and NCC in the range 0.1 to 4.0 g with 20 mg l^{-1} initial concentration of dye and agitation time of 45 min at pH 7 and at temperature ($25 \pm 2^\circ\text{C}$) were studied separately for dye. The results are presented as percentage removal of The results are presented as percentage removal of dye versus adsorbent dosage in Figure.1 for MB and the corresponding values are tabulated in Table 1.

In the case of MB dye removal, the removal of dye increased from 22 to 91.9% for NLLC, 18.5 to 86.75% for NPTC and 13.9 to 83% for NCC.. Initially the rate of removal of dye was found to increase rapidly with increase of carbon dosage and slowed down later when the dose increased from 2 to 4 g in each case.

From the observed results, the optimum dose of adsorbent fixed for all carbons is 2 g. It can also be seen from Figures 1. that after dosage of 2 g, there was no significant change in percentage removal of dye. Though the percentage removal increased with increased adsorbent dosage, from the Table. 1, it is obvious that the adsorption capacity (q_e) relatively decreased. There are many factors, which can contribute to this adsorbent dose effect. (i) as the dosage of adsorbent is increased, the adsorption sites remain unsaturated during the adsorption reaction leading to drop in adsorption capacity; (ii) the aggregation/agglomeration of sorbent particles at higher doses, which would lead to decrease in the surface area and an increase in the diffusional path length [7]. However, the observed increase in the percentage of dye removal with adsorbent dosage could be attributed to increase in the adsorbent surface areas, augmenting the number of adsorption sites available for sorption process [8].

From the results, at the optimum dosage of adsorbents for MB dye, the decreasing order of percentage removal of dye is NLLC>NPTC>NCC.

Effect of contact time:

In the adsorption system contact time plays a vital role, irrespective of the other experimental parameters affecting the adsorption kinetics. In order to study the effect of contact time which is related to kinetics of adsorption of dye by carbon adsorbent samples *viz.*, NLLC, NPTC and NCC, the adsorption experiments have been conducted (separately) in the extent of removal of dyes at an optimum initial concentration of dye of 20 mg l⁻¹ with optimum dose (2 g) of adsorbent at pH 7 and at temperature (25±2°C) by varying the agitation time from 5 to 50 min for MB dye. The time profile of adsorption of dye MB onto adsorbents is presented in Figure 2 and the corresponding values are given in Table 2 .

In case of MB dye, the removal of dye increased from 58 to 89.5% for NLLC, 54.25 to 85.5% for NPTC and 48 to 81.5% for NCC. As contact time was increased, initially, percentage removal also increased, but after some time, it gradually approached almost constant value, denoting attainment of equilibrium. It was assumed that the equilibrium time is that at which curves appear nearly asymptotic to the time axis. The equilibrium time was obtained at 30 min for MB dye for all the three sorbents NLLC, NPTC and NCC. The changes in the rate of removal with time might be due to the fact that initially all adsorbent sites were vacant and the solute concentration gradient was high. Later, the dye uptake rate by adsorbent had decreased significantly due to the decrease in adsorption sites. Decreased removal rate, particularly, towards the end of experiment, indicates the possible monolayer of adsorbate on the outer surface and pores of the adsorbent leading to pore diffusion onto inner surface of adsorbent particles [9].

From the results, at the optimum contact time for MB dye , the decreasing order of percentage removal of is NLLC>NPTC>NCC.

Effect of initial concentration:

Initial concentration of adsorbate has its own importance in adsorption process and variation in its concentration shows significant effect. The effect of initial concentration of dye on the extent of removal of dye in terms of percent removal and amount of the dye adsorbed on prepared activated carbon adsorbents *viz.*, NLLC, NPTC and NCC has been studied by varying the initial concentration of dye (range: 1 – 60 mg l⁻¹) and keeping the other control parameters at their optimum conditions. The results of MB dye adsorption onto adsorbents are tabulated in Table 3, and the corresponding graph is shown in Figure 3.

In case of MB dye removal, the results indicate that when NLLC is used an adsorbent, the dye removal decreases from 97 to 58.33% while the amount adsorbed increases from 0.049 to 1.75 mg g⁻¹. For NPTC the dye removal decreases from 94 to 50.83% and amount adsorbed increases from 0.047 to 1.525 mg g⁻¹. In the case of other adsorbent NCC, dye removal decreases from 90 to 45.17% and the amount adsorbed increases from 0.045 to 1.355 mg g⁻¹.

It is observed that, as dye concentration increases, the percentage removal decreased but the adsorbed amount of dye increased. These results may be explained by the fact that, at low

adsorbate concentration, the ratio of surface active sites to total dye is high; hence the dye ions could interact with the sorbent to occupy the active sites on the carbon surface sufficiently and can be removed from the solution [10]. But with the increase in adsorbate concentration, the number of active adsorption sites is not enough to accommodate dye ions.

The data in Tables 3 also reveal that under optimum experimental conditions, the order of adsorption capacity of the studied adsorbents is NLLC>NPTC>NCC for dye.

Effect of pH:

The effect of pH of the dye solution on the amount of dye adsorbed on carbon adsorbents was studied by varying the pH from 3 to 11 for MB dye under constant process parameters i.e., the initial concentration of the standard dye solution which is 20 mg l⁻¹, the dose of adsorbent is 2 g l⁻¹ and contact time of 30 and 35 min for MB, at temperature (25±2°C). The results were presented in Tables 4 and the influence of the pH on the sorption rate is shown in Figure 4 for MB.

The results indicate that all the selected adsorbents showed good adsorption capacity in acidic medium than in basic medium. The percentage removal of dye by adsorption on these adsorbents progressively decreased as the pH of the solution increased from 3 to 11.

This pH dependence of dye sorption onto carbon adsorbents could be well explained in terms of their p*H*_{ZPC}. When pH < p*H*_{ZPC}, the net surface charge on solid surface of carbon adsorbents is positive due to adsorption of excess H⁺, which favours adsorption due to coulombic attraction. At pH > p*H*_{ZPC}, the net surface charge is negative due to desorption of H⁺ and adsorption must compete with coulombic repulsion. The low percentage of dye removal in the pH range 3–8, could be due to the combined effect of both chemical and electrostatic repulsions between adsorbent surfaces and positive charge on dye. The observed increase in dye adsorption above pH 8 may suggest that the strong negative surface charge developed may cause attraction for the available adsorption sites. Another factor is that in acidic medium, lower adsorption capacity may be due to the competition of H⁺ ions with dye cations [11]. The decrease in dye adsorption is particularly sharp below pH 8, as the surface charge becomes more positive. Hence, dye ions would have to overcome electrostatic forces as there would be a higher density of positive charge very close to the surface, hence greater electrostatic repulsion.

To study the variation in pH of the solution during dye adsorption, 2 g of each carbon adsorbent is agitated with 100 ml of 20 mg l⁻¹ dye solutions (separately) at pH 7 up to their corresponding optimum contact times without controlling the pH of the solution. After this, those agitated carbon adsorbents are dried and again tested for their p*H*_{ZPC} values. In case of MB dye, the p*H*_{ZPC} values are changed from 8.6 to 6.2 for MB dye loaded NLLC, 8.1 to 5.1 for MB dye loaded NPTC and 8.65 to 5.8 for MB loaded NCC which are named as NLLC-MB, NPTC-MB and NCC-MB correspondingly. This shifting of p*H*_{ZPC} may be attributed to the fact that the active sites on sorbent surface are occupied by dye ions.

However, the percent removal of dye at pH 11 of NLLC is 93.5 %; NPTC, 87.5%; and for NCC, 83.4 % for MB dye. This indicates that the adsorbent has high adsorption capacity in alkaline medium and can be useful in removal of dye from bases like sodium hydroxide and industrial

effluents of textile industry which generally contain bases. The adsorption capacities of these adsorbents for dye in the neutral medium are 89, 85 and 82% for NLLC, NPTC and NCC respectively for MB dye. The prepared activated carbon adsorbents showed good adsorption capacity in the neutral medium also.

Effect of particle size:

To evaluate the influence of the particle size of the adsorbent on the removal of dye MB, for a constant weight (2 g), experiments are conducted with carbon particle size below 45, 75, 90 and 150 μ at an initial concentration of 20 mg l⁻¹ of adsorbate solution with equilibrium time 60 min for MB dye, and at pH 7 and at temperature 25 \pm 2 $^{\circ}$ C. In case of MB dye removal, as the particle size increased from 45 to 150 μ , the adsorption of dye is decreased from 89 to 61 % for NLLC, 85 to 57.5 % for NPTC and 81 to 51 % for NCC.

The percentage removal of dye decreased with increase in particle size of the carbons may be due to non-availability of more surface active sites for adsorption. Maximum percent removal is possible with particle size below 45 μ due to the presence of large number of smaller particles which provide the sorption system with larger surface area available for the dye adsorption.

Recycling:

When the discharge of effluents is of large quantity, continuous cyclic adsorption process is always effective and cost affordable. Hence the adsorption capacity of the adsorbent for their continuous use in further decolorization experiments was studied. By keeping all the control parameters at their optimum conditions, each carbon adsorbent was treated separately with the 20 mg l⁻¹ standard dye solution for MB dye and after filtration the same carbon was reused for the next decolorization experiment i.e., dye loaded carbon again treated with another 20 mg l⁻¹ standard dye solution. The results are compiled in Table 5 and the corresponding graph is shown in Figure 5 for MB. In this recycling process for MB dye, the dye adsorption was decreased from 89 to 19.5% for NLLC, 85 to 16.25% for NPTC and 81 to 12.5% for NCC. The decrease in percentage removal of each adsorbent with increasing the number of recycles may be due decrease in the availability of active sites on adsorbent for dye adsorption.

Regeneration:

In majority of applications, the disposal of adsorbent as waste is not an economic option and therefore regeneration is carried out. For the regeneration studies, each of the dye loaded carbon sorbent was transferred to a separate 250 ml conical flask containing 100 ml of distilled water and agitated at 120 rpm for about 45 min by varying pH (3.0–12.0) with 0.1N NaOH or 0.1N HCl. Dye desorption is not observed in acidic as well as alkaline mediums. However, when treated with 1N acetic acid, little desorption started. The behaviour of the three sorbents is consistent with the study of the effect of pH on adsorption capacity.

So, dye loaded carbon adsorbents were tried to regenerate by passing through 1N CH₃COOH solution and they were reused for decolorization at optimum conditions. The results are tabulated in Table.6 and the corresponding graphs were shown in Figure.6. for MB.

The MB dye adsorption is decreased from 89 to 27.5% for NLLC, 85 to 21% for NPTC and 81 to 18.5% for NCC as the number of regenerations increase. The poor efficiency of regenerated

carbon adsorbents in further decolorization studies may indicate that dye is strongly bound to the adsorbent surface and the availability of number of active sites are not much increased during regeneration. However, in the present study, the adsorbents are prepared from bio-waste materials, regeneration of the carbon may not be a vital economic option.

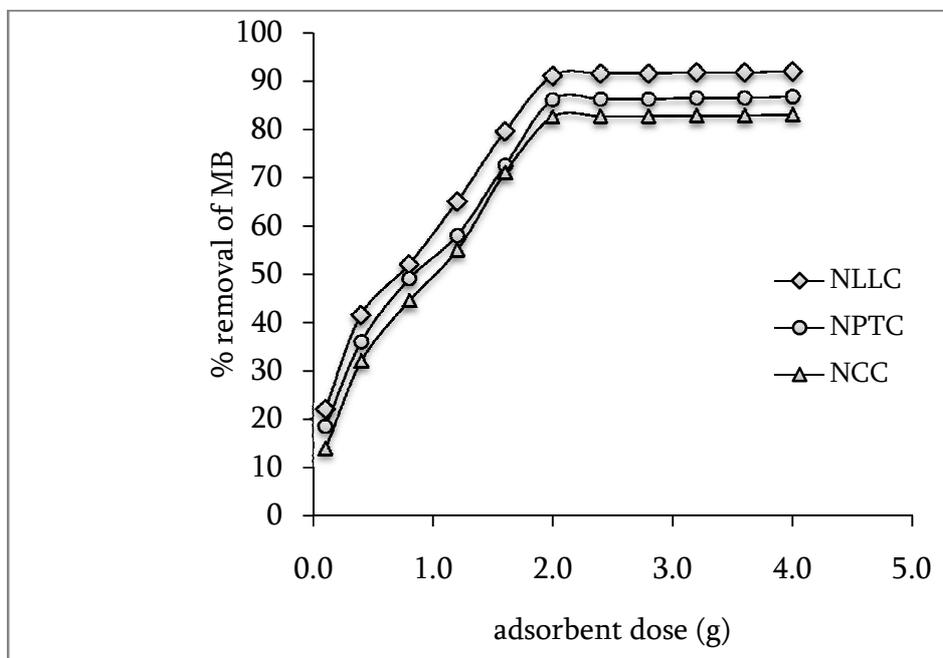


Figure 1. Effect of adsorbent dose on MB dye removal

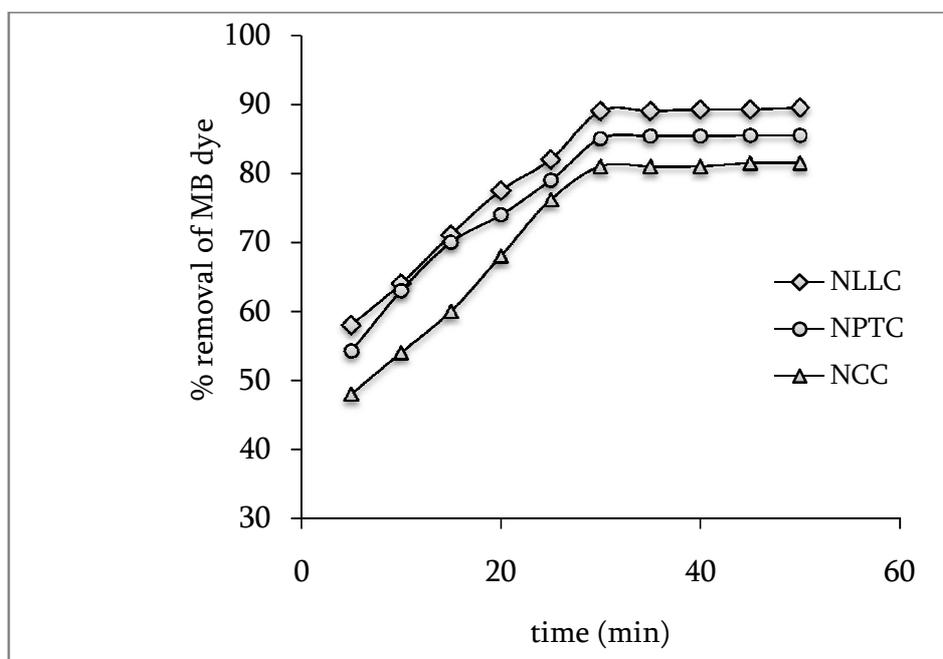


Figure 2. Effect of contact time on MB dye removal

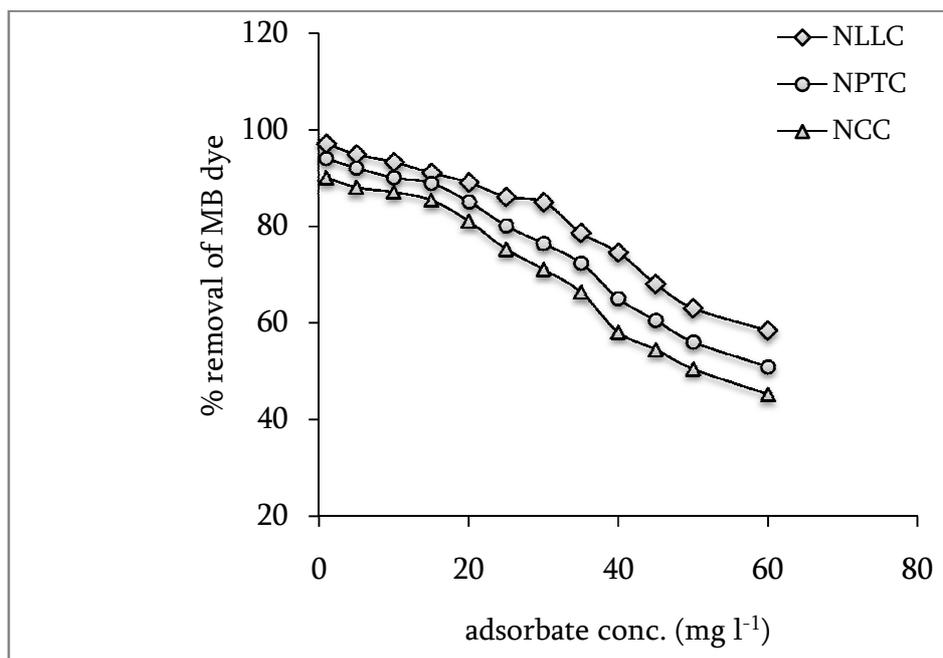


Figure 3. Effect of adsorbate concentration on MB dye removal

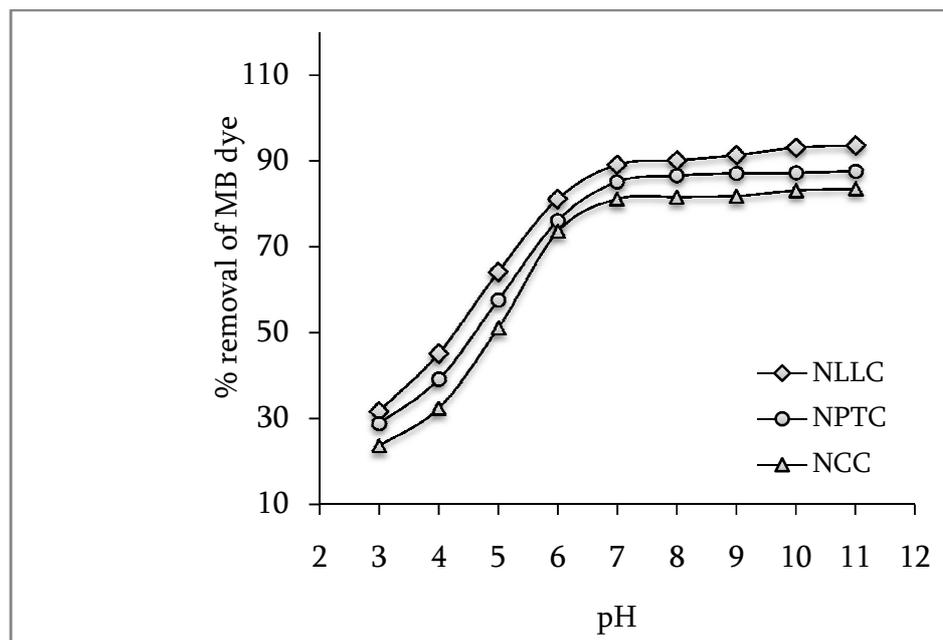


Figure 4. Effect of pH on MB dye removal

Effect of ionic strength:

In general, reactive dyes are applied to fabric in high salt concentrations in order to lower the dye solubility[12]. In textile effluents commonly high concentrations of chloride and sulphate ions will present. So, the effect of sodium salts of these ions in the concentration range 1000 to 5000

mg l⁻¹ on MB dye adsorption was investigated separately with an initial dye concentration of 20 mg l⁻¹ by keeping other control parameter at their optimum conditions.

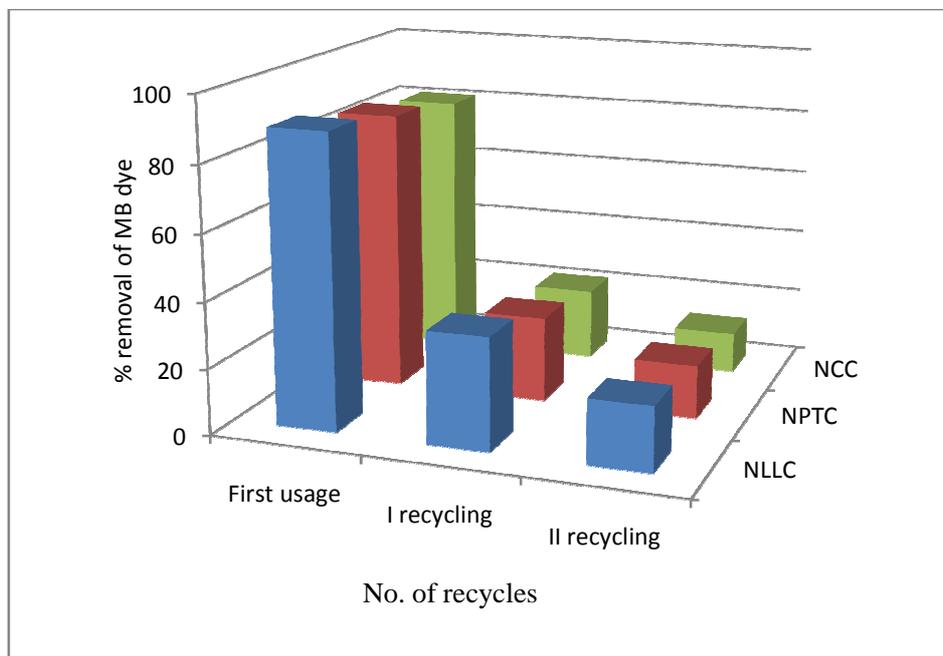


Figure 5. Effect of adsorbent recycling on MB dye removal

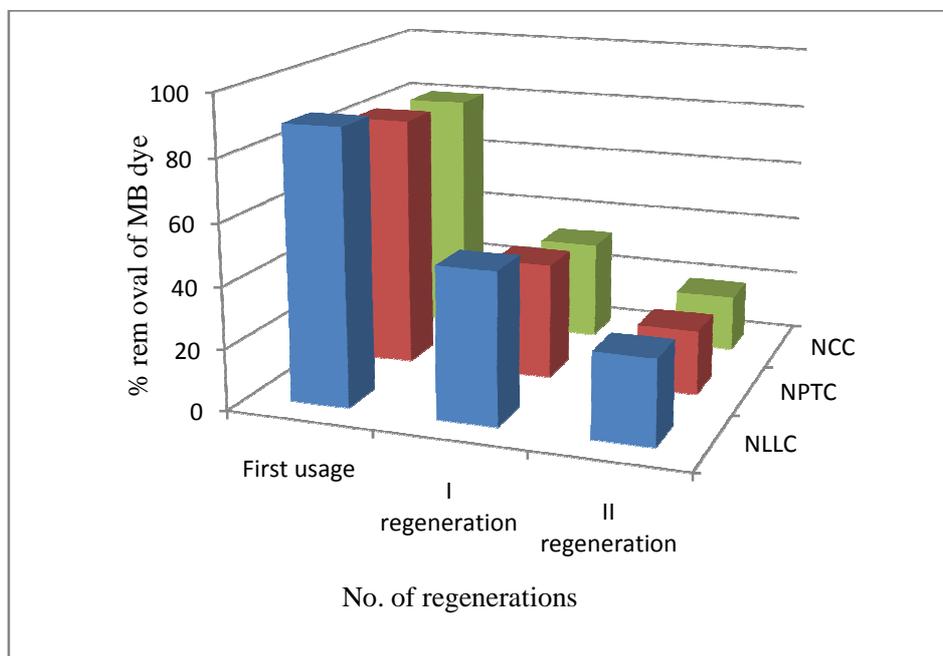


Figure 6. Effect of adsorbent regeneration on MB dye removal .

Table 1. Effect of adsorbent dose on MB dye removal. pH 7.0, contact time and initial dye concentration are 45 min and 20 mg l⁻¹ respectively for all the three sorbents

S.No.	Adsorbent dose (g)	Equilibrium concentration of dye (C _e) (mg l ⁻¹)			% removal			Amount of MB dye adsorbed (q _e) (mg g ⁻¹)		
		NLLC	NPTC	NCC	NLLC	NPTC	NCC	NLLC	NPTC	NCC
1	0.1	15.60	16.30	17.22	22.00	18.50	13.90	4.400	3.700	2.780
2	0.4	11.70	12.80	13.60	41.50	36.00	32.00	2.075	1.800	1.600
3	0.8	9.60	10.20	11.10	52.00	49.00	44.50	1.300	1.225	1.113
4	1.2	7.00	8.40	9.00	65.00	58.00	55.00	1.083	0.967	0.917
5	1.6	4.10	5.50	5.80	79.50	72.50	71.00	0.994	0.906	0.888
6	2.0	1.80	2.78	3.50	91.00	86.10	82.50	0.910	0.861	0.825
7	2.4	1.70	2.76	3.47	91.50	86.20	82.65	0.763	0.718	0.689
8	2.8	1.70	2.76	3.47	91.50	86.20	82.65	0.654	0.616	0.590
9	3.2	1.65	2.71	3.44	91.75	86.45	82.80	0.573	0.540	0.518
10	3.6	1.65	2.71	3.44	91.75	86.45	82.80	0.510	0.480	0.460
11	4.0	1.62	2.65	3.40	91.90	86.75	83.00	0.460	0.434	0.415

Table 2. Effect of contact time on MB dye removal. pH 7.0, adsorbent dose and initial dye concentration are 2 g and 20 mg l⁻¹ respectively for all the three sorbents

S.No.	Contact time (t) (min)	Equilibrium concentration of MB dye (C _e) (mg l ⁻¹)			% removal			Amount of MB dye adsorbed (q _e) (mg g ⁻¹)		
		NLLC	NPTC	NCC	NLLC	NPTC	NCC	NLLC	NPTC	NCC
1	5	8.40	9.15	10.40	58.00	54.25	48.00	0.580	0.543	0.480
2	10	7.20	7.40	9.20	64.00	63.00	54.00	0.640	0.630	0.540
3	15	5.78	6.00	8.00	71.10	70.00	60.00	0.711	0.700	0.600
4	20	4.50	5.20	6.40	77.50	74.00	68.00	0.775	0.740	0.680
5	25	3.60	4.20	4.76	82.00	79.00	76.20	0.820	0.790	0.762
6	30	2.20	3.00	3.80	89.00	85.00	81.00	0.890	0.850	0.810
7	35	2.20	2.92	3.80	89.00	85.40	81.00	0.890	0.854	0.810
8	40	2.15	2.92	3.80	89.25	85.40	81.00	0.893	0.854	0.810
9	45	2.15	2.90	3.70	89.25	85.50	81.50	0.893	0.855	0.815
10	50	2.10	2.90	3.70	89.50	85.50	81.50	0.895	0.855	0.815

The results are tabulated in Table 7. for MB dye sorption. In presence of chloride ion, the adsorption capacity has not significantly influenced for each adsorbent NLLC, NPTC and NCC for both MB dye. But in presence of sulphate ion, little increase in percent removal was observed after 2500 and 3000 mg l⁻¹ for NLLC and both NPTC, NCC respectively for MB dye; this

increase is observed after 2000 and 2500 mg l⁻¹ for NLLC and both NPTC, NCC respectively. Similar trend was observed for reactive dye adsorption onto activated carbons in literature[13].

Table 3. Effect of adsorbate concentration on MB dye removal. pH is 7.0, adsorbent dose and contact time is 2 g and 30 min for all the three sorbents.

S.No.	Initial conc. of MB dye (C _i) (mg l ⁻¹)	Equilibrium concentration of MB dye (C _e) (mg l ⁻¹)			% removal			Amount of MB dye adsorbed (q _e) (mg g ⁻¹)		
		NLLC	NPTC	NCC	NLLC	NPTC	NCC	NLLC	NPTC	NCC
1	1	0.03	0.06	0.10	97.00	94.00	90.00	0.049	0.047	0.045
2	5	0.26	0.40	0.60	94.80	92.00	88.00	0.237	0.230	0.220
3	10	0.68	1.00	1.30	93.20	90.00	87.00	0.466	0.450	0.435
4	15	1.35	1.67	2.20	91.00	88.87	85.33	0.683	0.667	0.640
5	20	2.20	3.00	3.80	89.00	85.00	81.00	0.890	0.850	0.810
6	25	3.50	5.00	6.20	86.00	80.00	75.20	1.075	1.000	0.940
7	30	4.52	7.10	8.70	84.93	76.33	71.00	1.274	1.145	1.065
8	35	7.50	9.70	11.80	78.57	72.29	66.29	1.375	1.265	1.160
9	40	10.20	14.00	16.80	74.50	65.00	58.00	1.490	1.300	1.160
10	45	14.40	17.80	20.50	68.00	60.44	54.44	1.530	1.360	1.225
11	50	18.50	22.00	24.80	63.00	56.00	50.40	1.575	1.400	1.260
12	60	25.00	29.50	32.90	58.33	50.83	45.17	1.750	1.525	1.355

Table 4. Effect of pH on dye removal. Adsorbent dose and initial dye concentration are 2 g and 20 mg l⁻¹ for all the three sorbents at a contact time of 30 min.

S.No.	pH	Equilibrium concentration of MB dye (C _e) (mg l ⁻¹)			% removal			Amount of MB dye adsorbed (q _e) (mg g ⁻¹)		
		NLLC	NPTC	NCC	NLLC	NPTC	NCC	NLLC	NPTC	NCC
1	3	13.70	14.26	15.30	31.50	28.70	23.50	0.315	0.287	0.235
2	4	11.00	12.20	13.55	45.00	39.00	32.25	0.450	0.390	0.323
3	5	7.20	8.50	9.80	64.00	57.50	51.00	0.640	0.575	0.510
4	6	3.80	4.80	5.30	81.00	76.00	73.50	0.810	0.760	0.735
5	7	2.20	3.00	3.80	89.00	85.00	81.00	0.890	0.850	0.810
6	8	2.00	2.70	3.70	90.00	86.50	81.50	0.900	0.865	0.815
7	9	1.75	2.60	3.66	91.25	87.00	81.70	0.913	0.870	0.817
8	10	1.40	2.58	3.40	93.00	87.10	83.00	0.930	0.871	0.830
9	11	1.30	2.50	3.32	93.50	87.50	83.40	0.935	0.875	0.834

Table 5 Effect of adsorbent recycling on MB dye removal. pH 7.0, adsorbent dose and initial dye concentration are 2 g and 20 mg l⁻¹ for all the three sorbents at a contact time 30 min.

S.No.	No. of times adsorbent recycled	Equilibrium concentration of MB dye (C _e) (mg l ⁻¹)			% removal			Amount of MB dye adsorbed (q _e) (mg g ⁻¹)		
		NLLC	NPTC	NCC	NLLC	NPTC	NCC	NLLC	NPTC	NCC
1	First usage	2.20	3.00	3.80	89.00	85.00	81.00	0.890	0.850	0.810
2	I recycling	13.20	14.80	15.62	34.00	26.00	21.90	0.340	0.260	0.219
3	II recycling	16.10	16.75	17.50	19.50	16.25	12.50	0.195	0.163	0.125

Table 6. Effect of adsorbent regeneration on MB dye removal. pH 7.0, adsorbent dose and initial dye concentration are 2 g and 20 mg l⁻¹ for all the three sorbents at a contact time 45 min.

S.No.	No. of times adsorbent regenerated	Equilibrium concentration of MB dye (C _e) (mg l ⁻¹)			% removal			Amount of MB dye adsorbed (q _e) (mg g ⁻¹)		
		NLLC	NPTC	NCC	NLLC	NPTC	NCC	NLLC	NPTC	NCC
1	First usage	2.20	3.00	3.80	89.00	85.00	81.00	0.890	0.850	0.810
2	I regeneration	10.20	12.40	13.50	49.00	38.00	32.50	0.490	0.380	0.325
3	II regeneration	14.50	15.80	16.30	27.50	21.00	18.50	0.275	0.210	0.185

Table 7. Effect of chloride and sulphate ions on MB dye removal. pH 7.0, adsorbent dose and initial dye concentration are 2 g and 20 mg l⁻¹ for all the three sorbents at a contact time 30 min.

S.No.	Ionic strength (mg l ⁻¹)	% removal of MB dye in presence of chloride ion			% removal of MB dye in presence of sulphate ion		
		NLLC	NPTC	NCC	NLLC	NPTC	NCC
1	1000	89.00	85.00	81.00	89.0	85.0	81.0
2	1500	89.0	85.0	81.0	89.0	85.0	81.0
3	2000	89.0	85.0	81.0	89.0	85.0	81.0
4	2500	89.0	85.0	81.0	89.0	85.0	81.0
5	3000	89.0	85.0	81.0	89.5	85.0	81.0
6	3500	88.6	84.8	80.5	90.2	85.7	82.0
7	4000	88.6	84.6	80.5	90.6	86.3	82.2
8	4500	88.6	84.6	80.5	91.8	87.6	82.9
9	5000	88.4	84.2	80.1	92.7	88.2	83.7

CONCLUSION

The percent removal of dye increased with increase of adsorbent dose, contact time but decreased with increase in initial concentration and particle size. The adsorption system is pH dependent, the adsorption efficiency increased when solution changed from acidic to alkaline condition. 2 g of the three adsorbents is fixed as the optimum dosage of the carbons. With this optimum adsorbent dosage, contact time is 60 min for MB, with 45 μ particle size.

These carbon adsorbents showed low adsorption capacities for further decolorization of dye solutions in continuous cycling process. The regeneration of the adsorbents carried out by changing the solution pH from acidic to alkaline. The poor efficiency of regenerated carbon adsorbents used for further dye removal indicates that dyes are strongly bound to the adsorbent surface and the availability of number of active sites are not much increased during regeneration. In studies of ionic strength, in presence of chloride ion, with gradual increase of its concentration, considerable change in efficiency of adsorbents in decolorization is not observed and in case of sulphate ion little increase in decolorization MBdye solutions is observed.

The descending order of adsorption capacities of three activated carbons is NLLC>NPTC>NCC. These prepared activated Kaza's carbons are useful in the decolorization of Methylene Blue dye aqueous effluents from Industries.

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