Effective Removal of Methylene Blue from Aqueous Solution using Charcoal

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Abstract **- The present research was investigated to eliminate the Methylene Blue (MB) from the aqueous solution. Charcoal is used as the adsorbate. The effect of varied factors like adsorbent concentration, initial dye concentration, contact time and pH was studied. Adsorption experiments were conducted as batch studies at different contact time, pH, and initial dye concentration. The dye adsorption equilibrium was attained after 50 min of contact time. Present investigation concluded that, Charcoal can be used as a low-cost attractive option for removal of MG from aqueous solution.**

Index Terms **- Adsorption, Methylene Blue, activated carbon, Contact Time, Adsorbent Dosage.**

1.INTRODUCTION

Dyes are used in colossal amounts in different industries like textile, leather, cosmetics, paper, printing, plastic, pharmaceuticals, food, etc. to colour the products, which pollute water sources [1, 2]. The majority industries, without proper treatment, effluents are discharged into water resources. Industrial effluents can be remediated to remove hazardous chemicals, which can further be utilized for industrial or other activities [3–4]. A big number of unsafe chemicals are present in dye effluents. These chemicals pollute water and cause harmful effects on the aquatic environment also. This reduces the amount of dissolved oxygen in water bodies [5]. Human health is also affected by these harmful chemicals [6, 7]. Some of them are carcinogenic too. Bountiful treatment technologies are available to remove the dyes which diminish water pollution [8]. Principally, adsorption process is a better choice in water and wastewater treatment because of convenience, handiness and simplicity of design [9.10]. In wastewater treatment plants, adsorption processes are applied for the removal of both cationic and anionic pollutants in effluent [11, 12, 13, 14].

The adsorption of Methylene Blue (MB) dye on charcoal was investigated in this study by using batch adsorption experiments. MB dye is applied in colouring paper, Hair colouring, dyeing cotton and wools, and colouring of paper [15]. It is a cationic dye. The effluent when discharged into water sources, it can cause rigorous harm to the environment due to the deep colour and low degradation rate. The chemical oxygen demand also. The side effects of Methylene Blue to humans are mild bladder irritation, dizziness, headache, increased sweating, nausea, vomiting, abdominal pain, diarrhoea, etc. So, Methylene blue should be removed from wastewater before discharge in water bodies [16].

The study was carried out in order to evaluate the effectiveness of using charcoal in the removal of MB from aqueous solution. The result of pH, contact time, initial dye concentration and adsorbent dosage on percentage of removal of MB was studied.

The chemical formula of MB is $C_{16}H_{18}ClN_3S$and Molecular Weight is 319.85

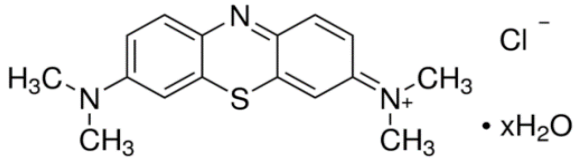

Figure 1 Structure of Methylene Blue

2. MATERIALS AND METHODS

2.1 Preparation of Adsorbate

Chemicals Methylene Blue and Charcoal used were of analytical grade. A stock solution of dye (1000 ppm) was prepared with distilled water. Working solutions were obtained by diluting the stock solution with distilled water to the necessary concentrations.

2.2 ADSORPTION STUDIES

The batch experiments were performed using a set of 250-mL Iodine flasks containing a known quantity of adsorbent (0.5g) and 100 ppm of 100 ml of dye solution at pH-3. The conical flasks were well agitated in a shaker. The concentration of the residual dye solution was measured using UV- Visible spectrometer (systronic) at λ_{nm} value of 700 nm. The percentage removal of dye from solution was calculated by the following:

$$\% \text{ Removal} = \frac{C_0 - C_t}{C_0} \times 100 \text{ -------- (1)}$$

Where C_0 and C_t are the initial and concentration at time't' respectively.

Figure 2. UV-spectrophotometer used for determining the % absorbance pH meter

3. RESULTS AND DISCUSSION

3.1 Effect of pH

The effect of the initial pH value of the solution on the adsorption process was investigated under conditions of 100 ppm initial dye solution concentration, 0.5 g 100 ppm of adsorbent concentration, 120 mins. The pH varied between 1 to76. It is given in Table 1 and figure 4.

Table 1. Effect of pH on percentage removal of MG

pH	MB Removal (%)
1	43
2	63
3	86
4	74
5	65
6	41
7	40

The maximum adsorption takes place at acidic pH 3 with 86 % removal of MG dye. This may be due to the fact that, at low pH values, the surface of the adsorbent is negatively charged and the adsorption of dye molecules increases due to the electrostatic attraction between the surface and positively charged MB dye molecules. As the pH values increases from 3, the adsorption decreases. At higher pH the surface become positively charged. So electrostatic repulsion take place between positively charged dye molecules and the positively charged surface of the adsorbent.

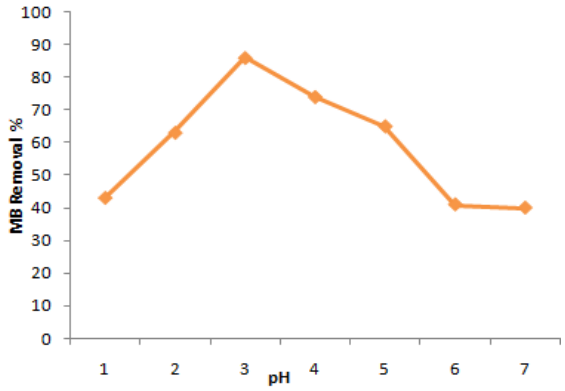

Figure 3. Effect of pH on MB removal (C_0 = 100 ppm, concentration of adsorbent = 0.5 g /L, Temp. = 25^{0}C, and contact time = 120 min)

3.2 Effect of Adsorbent Dose

The effect of adsorption dose of MB was studied by keeping the subsequent values as constant: 100 ppm dye concentration, 120 minutes contact time, a temperature of 25^{o}C, a stirring speed of 120 rpm, and different adsorbent concentrations from 0.5 gm to 3.5 gm in 100 ml. The results are given in Table 2 and figure 4.

Table 2. Effect of adsorbent Dosage on percentage removal of MG

Adsorbent Dosage (gm)	Removal of MB (%)
0.5	35
1	45
1.5	75
2	88
2.5	72
3	70
3.5	65

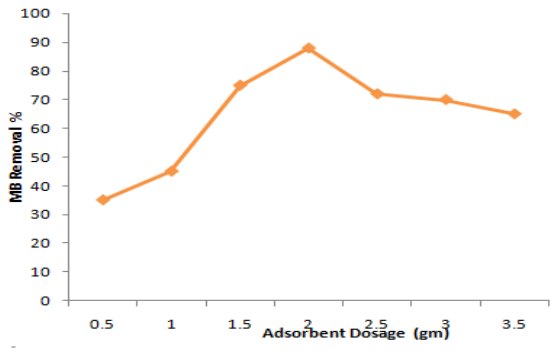

Figure 4. Effect of adsorbent dosage on MB removal (C_0 = 100 ppm, concentration of adsorbent = (0.5 g /L to 3 gm), Temp. = 25^{0}C, and contact time = 120 min).

As the adsorbent concentration increases, the removal of dye percentage increases. There was maximum removal 88 % take place, when the concentration of adsorbent is 2 gm. This was the maximum removal of adsorbent MB. After increasing the adsorbent concentration, the percentage removal of MB decreases. This is due to the fact that, as the adsorbent dosage increases, the surface area of adsorbent increases. So large molecules of adsorbate adsorbed on the surface of adsorbent. After formation of equilibrium, it was observed a decrease in amount of adsorption, when increasing the adsorbent concentration. This may be associated due to overlapping of adsorption sites resultant in a decrease in total adsorbent surface area available to MG (17, 18).

3.3 Effect of Contact time

The effect of contact time and initial dye concentration was studied by using 100 ppm of MB dye at pH-3 with adsorbent dosage of 0.5gm. The results are presented in table 4 and figure 5.

Table 4 .Effect of Contact Time on Removal of MB

Time (mins)	Removal of MB Dye (%)
10	25
20	43
30	62
40	71
50	85
60	75
70	70

The mixture was shaken at constant speed of 120 rpm/min . Final dye concentration measured after different time intervals (10 – 70 mins). The highest absorption of 85% removal at an equilibrium time of 50 min. The relative increase in the removal of dye after a contact time of 50 min was insignificant. So 50 mins was fixed as the most favourable contact time [19].

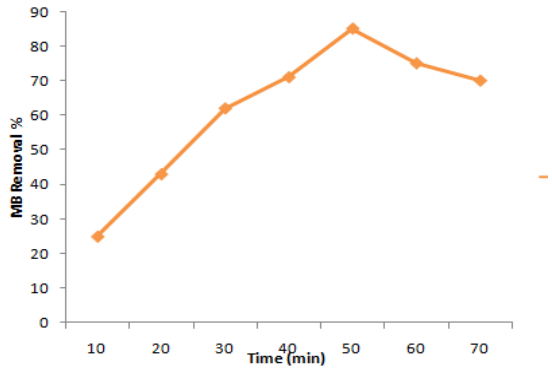

Figure 5 .Effect of Contact Time (10 to 60 min) on MB removal (C_0 = 100 ppm, concentration of adsorbent = (05 g), Temp. = 25^0C, and contact time = 120 min)

3.4 Effect of Adsorbate concentration on dye removal

The influence of the concentration of MG in the solution on the rate of adsorption on charcoal was investigated. The experiment was carried out with fixed adsorbent dosage, constant temperature, at pH - 3 conditions (Table 5 and figure 6).

Table 5.Effect of Adsorbate Concentration

Concentration of MB Dye (ppm)	Removal of MB Dye (%)
100	85
200	75
300	62
400	55
500	42
600	37

100 ml of MB blue solution of concentrations of ppm (100, 200, 300, 400, 500 and 600) were taken in 6 different conical flasks, to which 0.5 gm of charcoal was added and shaken in a shaker at 120 rpm and 25 °C. Maximum dye removal occurred for low initial concentration of MB 9100ppm). After 100 ppm there is a gradual reduction in MB removal. With increase in dye concentration, the adsorption sites were rigid and achieved saturation at low dye concentration. Hence, with increase in dye concentration, no further adsorption could be achieved.

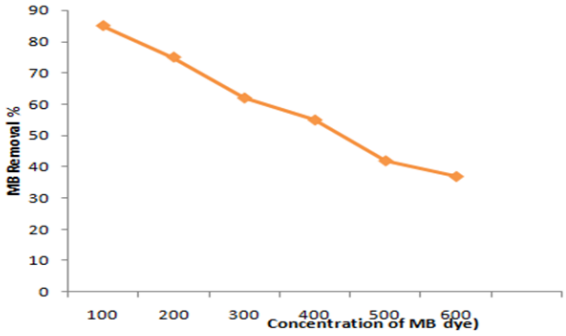

Figure 7. Effect of Adsorbate Concentration (100 to 600 ppm) on MB removal (C_0 = 100 ppm, concentration of adsorbent = (05 g), Temp. = 25^0C, and contact time = 120 min).

4. CONCLUSIONS

Charcoal can be as a low-cost alternative adsorbent for the removal of hazardous dye MG. The maximum adsorption takes place at acidic pH 3 with 86 %

removal of MG dye. There was maximum removal of MB 88 % take place, when the concentration of adsorbent is 2 gm. The highest absorption of 85% removal at contact time of 50 min. Maximum dye removal 85 % occurred at 100 ppm concentration of MB. So charcoal can be used for the removal of MG from aqueous solution very effectively and economically.

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