Effect of Important Parameters on Adsorption Efficiency of Methylene Blue Dye

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Abstract- *Adsorption plays a significant role in efficiently decolourizing synthetic dyes like Methylene Blue dye. The percentage dye removal is found to increase with increase in initial concentration of Methylene Blue dye from 100 mg/L to 500 mg/L, contact time between adsorbate and adsorbent from 15 min to 75 min as well as adsorbent dose from 0.1 gm to 0.5 gm. However the percentage dye removal decreases with increase in pH. For Methylene blue dye, the percentage removal is high in acidic range of pH 4 and decreases in alkaline range with pH 8. Thus this research highlights that the parameters like initial dye concentration, pH, contact time and adsorbent dose have a vital impact on the efficiency of adsorption.*

Keywords- Adsorption, Methylene Blue Dye, Adsorbate, Adsorbent, Acidic, Alkaline, pH

I. INTRODUCTION

Wastewater from dye-processing or textile finishing industries contain large amounts of different types of dyes, which exhibit carcinogenic and mutagenic effects on the environment when discharged without treatment. Research is on to find cost effective treatment methods. Among physico-chemical methods, adsorption is quite popular due to simplicity, cost effectiveness, ease of operation, insensitivity towards toxic substances and high efficiency, as well as the availability of a wide range of adsorbents. It has proved to be an effective method for decolourization of dye from wastewater(Sharma *et al.,* 2005; Tahir *et al.,* 2008; Vinoth *et al.,* 2010; Abbas *et al.,* 2011; Karthik *et al*, 2012). In this research, Methylene Blue is chosen for studying the effect of parameters on adsorption efficiency and adsorbent chosen is low cost, easily available waste *Carica papaya* seeds. Methylene Blue is a basic aniline dye having molecular formula of $C_{16}H_{18}N_3Scl$ with molecular weight of 319.85. At room temperature, it appears as a solid, odorless, dark green powder. When hydrated, it gives deep blue colour. The chemical name of methylene blue dye is 3, 7- bis (Dimethyl amino) phenothizin- 5- ium chloride or tetra metheyln thionine. Methylene Blue is the most commonly used dye for dying cotton, wood and silk (Teka and Enyew, 2014).

II. MATERIALS AND METHODOLOGY

2.1 Preparation of Adsorbent

Waste *Carica papaya* seeds are collected from home and washed with distilled water and allowed to dry under the sun till these have become crisp and easy to crush. These are then powdered in mixer and are passed through sieve of 0.246 mm to obtain uniform particle size of adsorbent and this is stored in air tight container.

2.2 Preparation of Adsorbate

A stock solution of 1 g/L of Methylene Blue (MB) dye is prepared and stored in volumetric flask. Optical Densityis taken using Systronics Photoelectric Colorimeter 114 at 650 nm and the pH is measured using Digital pH meter MK VI.

2.3 Batch Studies

The methodologies for effect of initial dye concentration, pH, time of agitation and adsorbent dose are studied in accordance to the research work done by Rao *et al*., 2011, Basu *et al*., 2013 and Ladhe and Patil, 2014.

2.3.1 Effect of Initial Dye Concentration: For this aliquots of Methylene Blue dye solution are prepared to get concentrations of 100– 500mg/Land the volume is made to 100 mL and these are taken in 5 conical flasks and 0.5 g of *Carica papaya* seedsadsorbent is added to each flask. The solutions are agitated at a constant room temperature of 33^0C and speed of 240 wrist action per minute using Secor India Griffin Flask Shaker for 60 minutes. The adsorbate is filtered out using ordinary filter paper from each of the conical flasks in order to get a clear solution and the optical density is measured.

2.3.2 Effect of pH: For this aliquots of Methylene Blue dye are prepared to get concentrations of 100– 500mg/L. For each concentration, the pH is adjusted from 4 to 8 with a range of 0.5 by adding 0.1N HCl or 0.1NNaOH and 0.5 g of *Carica papaya* seedsadsorbent is added to each flask. This is repeated for all concentrations. The solutions are agitated at a constant room temperature of 33^{0}C and speed of 240 wrist action per minute using Secor India Griffin Flask Shaker for 60 minutes.The adsorbate is filtered out using ordinary filter paper from each of the conical flasks in order to get aclear solution and the optical density is measured.

2.3.3 Effect of Contact Time: The aliquots of the dye are prepared to obtain solutions with concentrations of 100 – 500 mg/L and the volume is made to 100 mL and 0.5 g of adsorbent is added to each flask.These are kept in the shaker for different time intervals of 15,30, 45, 60 and 75 minutes. The solutions are agitated at a constant room temperature of 33^{0}C and speed of 240 wrist action per minute using Secor India Griffin Flask Shaker.The adsorbate is filtered out using ordinary filter paper from each of the conical flasks in order to get aclear solution and the optical density is measured.

2.3.4 Effect of Adsorbent Dose: The aliquots of the dye are prepared to obtain solutions with concentrations of 100 – 500 mg/L and the volume is made to 100 mL and the dye is taken in 250 mL conical flasks and 0.1g of *Carica papaya* seeds adsorbent is added to each conical flask. This is repeated with adsorbent dose of 0.2, 0.3, 0.4 and 0.5 g. The solutions are agitated at a constant room temperature of 33^{0}C and speed of 240 wrist action per minute using Secor India Griffin Flask Shaker for 60 minutes. The adsorbate is filtered out using ordinary filter paper from each of the conical flasks in order to get aclear solution and the optical density is measured.
The percentage removal of adsorbate adsorbed on the adsorbent is calculated as

$$\%Dye\,Removal = \frac{(C_0 - C_f)}{C_0} * 100 \qquad \text{----------------- (1)}$$

Where C_0 = Initial Concentration of Dye (mg/L)
C_f = Final Concentration of Dye after Adsorption (mg/L)

III. RESULTS AND DISCUSSIONS

3.1 Effect of Initial Dye Concentration

The percentage dye removal is found to increase with increase in initial concentration of Methylene Blue dye (100 – 500 mg/L). However, the initial stage of dye removal is slow at 28.43 % at initial concentration of 100 mg/L (Figure 1). This might be due to the fact that the dye molecules have to encounter the boundary layer effect before diffusing from boundary layer film on to adsorbent surface and then its diffusion into porous structure of adsorbent. The percentage dye removal is 81.94 % at a final dye concentration of500 mg/L. The higher initial concentration provides a larger driving force needed for adsorption process. Thus, it can be seen that higher percent removal of dye is achieved at higher initial concentration. This is similar to the research by Ozer *et al*., 2006 and Abdul – Karim *et al*., 2015.

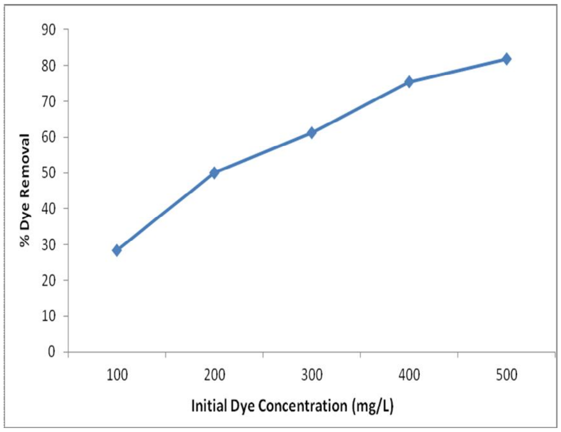

Figure 1 Effect of Initial Dye Concentration on Percentage Dye Removal with Constant Adsorbent Dose of 0.5 g and Contact Time of 60 min

3.2 Effect of Ph

The efficiency of adsorption is dependent on the pH of solution as pH leads to the variation in the surface properties of the adsorbent and the degree of ionization(Vinoth *et al.,* 2010). Figure 2 shows the pH variation over thepH range of 4 to 8for Methylene Blue dye with *Carica papaya* seeds adsorbent. It is observed that the percentage removal decreases with increase in pH. The maximum dye removal at pH 4 is 55.88%, 65.57%, 70.8%, 74.83% and 79.35% with initial dye concentrations of 100 mg/L, 200 mg/L, 300 mg/L, 400 mg/L and 500 mg/L respectively. The percentage dye removal is decreased to 5.88%, 23.77%, 36.5%, 42.18% and 47.74% at pH 8 with initial dye concentrations of 100 mg/L, 200 mg/L, 300 mg/L, 400 mg/L and 500 mg/L respectively. Hence it can be concluded that the acidic range and higher concentration of dye is favourable with the adsorbent. This is in accordance with the studies carried out by Karthik *et al.*, 2012. The lower percentage removal inalkaline range may be due to competition from hydroxide ions with the anionic dye molecules for the adsorption sites and this is also in line with the studies done by Vinoth *et al.*, 2010.

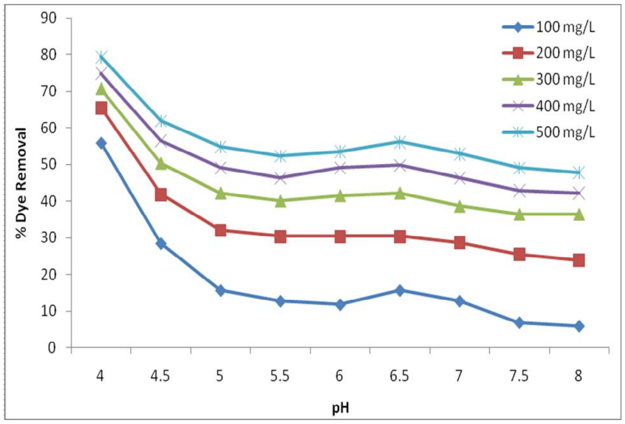

Figure 2 Effect of pH on Percentage Dye Removal with Constant Adsorbent Dose of 0.5 g and Contact Time of 60 min

3.3 Effect of Contact Time

Figure 3 shows an increase in removal efficiencyof the dye with increase in time of contact with constant adsorbent dose of 0.5 gm. It is observed that with 15 min contact time, the percentage dye removal is 21.57% for initial dye concentration of 100 mg/L while it has increased to 27.05%, 32.85%, 34.69% and 36.77% for dye concentrations of 200 mg/L, 300 mg/L, 400 mg/L and 500 mg/L respectively. This can be attributed to the fact that more time becomes available for the dye to make an attraction complex with the adsorbents. This is similar to the findings of researchers Abbas *et al.,* 2011 and Karthik *et al.,* 2012.The same trend is observed at higher contact time of 75 min and percentage dye removal is found to increase from 39.22% to 48.36%, 64.96%, 71.43% and 79.35% for dye concentrations of 100 mg/L, 200 mg/L, 300 mg/L, 400 mg/L and 500 mg/L respectively. The higher initial concentration provides a larger driving force needed for adsorption process and increase contact time enhances the process of dye removal. Further the changes in the rate of removal with time might be due to the fact that all adsorbent sites are vacant and the solute concentration gradient is high (Teka and Enyew, 2014).

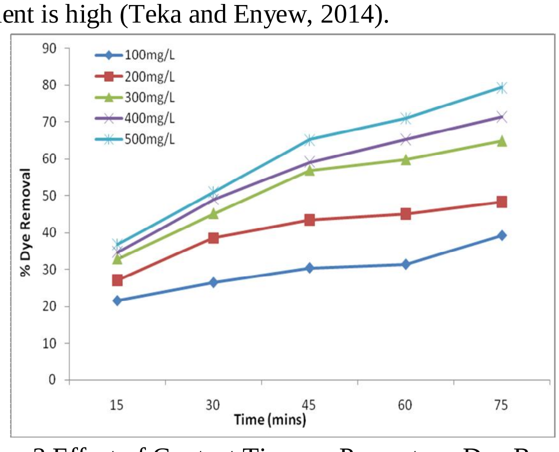

Figure 3 Effect of Contact Time on Percentage Dye Removal with Constant Adsorbent Dose of 0.5 g

3.4 Effect of Adsorbent Dose

Figure 4 shows the effect of adsorbent dose on percentage dye removal. It is seen that at a dose of 0.1 gm, the percentage dye removal varies from 14.71% for dye concentration of 100 mg/L to 21.57%, 45.26%, 50.34% and 59.35% for dye concentrations of 200 mg/L, 300 mg/L, 400 mg/L and 500 mg/L respectively. As the adsorbent concentration has increased to 0.5 gm, the percentage dye removal is found to increase and it is 38.24%, 55.88%, 76.64%, 80.95% and 87.1% for dye concentrations of 100 mg/L,200 mg/L, 300 mg/L, 400 mg/L and 500 mg/L respectively. Hence increase in adsorbent dose is found to increase the percentage dye removal. This is attributed to theincrease in pores, larger surface area with more active functional groups and availability of more number of exchangeable sites for adsorption. This is similar to the research by Raghuvanshi *et al*., 2008; Rosemal *et al.*,2010; Vinoth *et al.,* 2010; Abbas *et al.,* 2011; Basker *et al.*, 2014 and Ladhe and Patil, 2014.

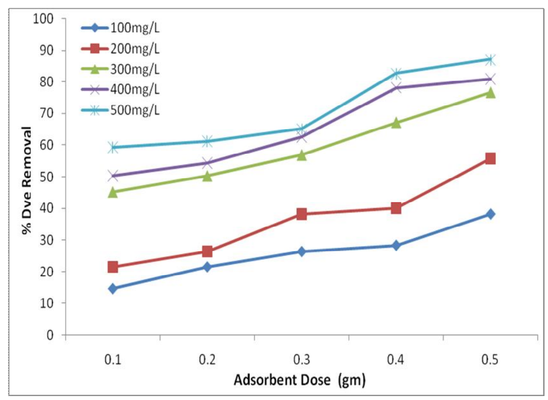

Figure 4 Effect of Adsorbent Dose on Percentage Dye Removal with Constant Contact Time of 60 min

III. CONCLUSION

This research shows that the parameters like initial dye concentration, pH, contact time and adsorbent dose have an impact on the efficiency of adsorption. The percentage dye removal is found to increase with increase in initial concentration of Methylene Blue dye from 100 mg/L to 500 mg/L, contact time between adsorbate and adsorbent from 15 min to 75 min as well as adsorbent dose from 0.1 gm to 0.5 gm. However the percentage dye removal decreases with increase in pH. For Methylene blue dye, the percentage removal is high in acidic range of pH 4 and decreases in alkaline range with pH 8.

IV. ACKNOWLEDGEMENT

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