RESEARCH ARTICLE

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REMOVAL OF METHYLENE BLUE USING A LOW-COST TEA WASTE

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SUMMARY

Dyes are widely used in different industrial dying purpose such as textiles, food, cosmetics and paper printing, Leather etc. Among those dyes, Methylene blue (MB) is the most common one which is used in various industries. Moreover, Tea is one of the most popular beverages and about 3.5 million tons of tea was consumed annually in the world (Kumar and al., 2005). In this study, Tea Waste (TW) has been used as an absorbent for the removal of MB. Varying experimental conditions are tested at different ranges such as adsorbent dosage, pH and contact time. Adsorption equilibrium of tea waste reached within 2 hours for methylene blue concentrations of 30 ppm and pH value of 4. The efficiency of dye extraction increased with increasing time and the decreasing of pH value of adsorption. The maximum removal efficiency was found on the addition of 0.7gm doses. It removed maximum dye at pH 4 in which removal efficiency was 97.87%. On the other hand, that the percentage of removal efficiency maximum when the testing time 120 min. The results revealed that tea waste appears as a very low-cost adsorbent for the removal of methylene blue.

Keywords: Methylene Blue, Tea Waste, adsorbent, adsorption, dose, Removal efficiency.

1. INTRODUCTION

The first acquainted use of an organic colorant was much later, c. 4000 years past when the blue dye indigo was found in the wrappings of mummies in Egyptian tombs (Berton and Gordon, 1983). There are more than 100,000 commercially available dyes with over 7107 tons of dyestuff produced annually worldwide (Silveira and al., 2009). Dyes are widely used in different industrial dying purpose such as textiles, food, cosmetics and paper printing, Leather etc. These industries release a greater amount of waste to water along with different dyes. The

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discharge of dye-containing effluent without proper treatment into water bodies causes both environmental and public health risks (Hwang and Chen, 1993). Some dyes are toxic and carcinogenic. For example, azo dyes are well known which can enter into the body through ingestion. Then it is mobilized by intestinal microorganisms causing DNA damage. There are many types of dyes which are not biodegradable and travel a long distance in the surface water affecting the environment. Coloring water may bear so many harmful dyes that threaten to the plant, aquatic life, at a glance, overall ecosystem. Methylene blue (MB) is the most commonly used substance in various industries.

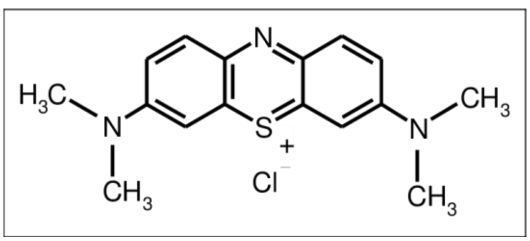

Fig. 1. Methylene Blue Chemical Structure.

Methylene blue (MB), as shown in Fig. 1, a stable cationic dye, is difficult to decolorize due to its complex structure and stable chemical properties (Liu and al., 2012). It has some harmful effects on animal and the human body. It can cause eye burns which may be responsible for permanent injury to the eyes of human and animals (Pirbazari and al., 2015). Acute exposure to MB can cause enhanced heart rate, vomiting, shock, Heinz body formation, cyanosis, jaundice and quadriplegia and tissue necrosis in humans (Kumar and al., 2005). It is necessary to reduce this dye content from waste water which leads to a good environment for our ecosystem. In the past decades, serious research efforts on how to efficiently remove dyes from industrial effluents have resulted in the investigations of methods such as adsorption, advanced oxidation, and membrane separations (Ahmad and al., 2015; Kyzas and al., 2015). Reports have shown that these techniques proved to be effective and displayed a varying degree of dye removal from the industrial wastewater (Yagub and al., 2014; Kyzas and al., 2015). In present days, the adsorption technique is widely used to reduce the dye. Adsorption has some advantage when compared aforementioned conventional methods in terms the simplicity of utilization, effectiveness, low cost, etc.

There are various types of adsorbent available under natural and chemical adsorbent to conduct the technique in which many adsorbents are cheaper and more easily available (EL Alouani and al., 2018).

The efficiency and superiority of the adsorption technique are mainly relying on the possible

harmless of the treated water (Moussavi and Mahmoudi, 2009). Since the performance of an adsorptive separation is directly dependent on the quality and cost-effectiveness of the adsorbent, the last decade has seen continuous improvement in the development of effective adsorbents in the form of activated carbon (Christie, 2007), zeolites (Nabil et al., 2014), clay minerals (Kumar and al., 2005), chitosan (Al-Degs and al., 2001), lignocelluloses (Mahmoud and Al-Bishri, 2011), natural minerals (Shafeeyan and al., 2010), functionalized polymers (Panuccio and al., 2009), coal fly ash, sewage sludge, agriculture waste and biomass. Therefore, there's a desire to appear into alternatives to research a low-priced adsorbent that is effective and economic, for a potential approach is that the use of tea waste (TW). Tea is one of the most popular beverages and about 3.5 million tons of tea was consumed annually in the world (Boonamnuayvitaya and al., 2004). In 2017, Bangladesh produced a total of 78.95 million kg tea in which most of it is consumed by its people and so TW is much more available.

In this study, TW has been used as an absorbent for the removal of MB. Tea waste is cost effective and less biodegradable adsorbent. Here, the effects of different doses, pH and contact time on the amount of color removal was investigated.

2. MATERIALS AND METHODS

2.1. Adsorbate

Methylene Blue, used as an adsorbate in this study, was bought from India. Chemical formula and molecular mass of MB is $C_{16}H_{18}ClN_3S$ and 319.85g/mol respectively. The MB was selected in this study due to its known strong adsorption onto solid. The maximum wavelength of this dye is 670nm.

2.2. Preparation of adsorbent

The spent tea bag was collected from nearby tea stall around Institute of Leather Engineering and Technology, University of Dhaka, Hazaribag, Dhaka. The spent tea leaves were then opened up from the bag and washed with tap water and distilled water several times to remove all the dirt particles. It was then spontaneously boiled with distilled water to remove caffeine, tannin and other dyes and washed with distilled water till the washing water contains no color. The washed materials were then dried at 95 ◦C for 6 h. The dried materials were then crushed and sieved to get a particular size range 0.5-1.0mm and stored in bottles for uses.

2.3. Chemicals

The test solution was prepared by adding 3g of MB in 1L distilled water. This was done to get the desired

concentration. It is essential to adjust the pH of the solution due to conduct the test at different pH. Analytical grade dilutes HCl acid and NaOH were used for this adjustment.

2.4. Effect of adsorbent dose

The effect of spent Tea leaves dose on the amount of MB adsorbent was studied by adding different amounts (0.50, 0.60, 0.80, 1.2 and 1.5 g) of the spent tea leaves into a 250 mL conical flasks. The flask contained a definite volume (50 mL in each flask) of fixed initial concentration (30 ppm) of the dye solution at the temperature of (25±2) ◦C and of pH 4. The flasks were then placed in a shaker to perform agitation for two hours.

2.5. Effect of Solution pH

In this study, 50mLof dye solution of 30 ppm initial concentration at different pH values (2.0–13.0) was agitated with 0.7 g of STL in a water-bath shaker at (25±2) ◦C. Agitation was made for 120 min. The dye concentrations were measured by a double beam UV–vis spectroscopy. The pH was adjusted with 0.1N NaOH and 0.1N HCl solutions and measured using a pH meter.

2.6. Effect of Contact time

The amount of MB absorbed by the adsorbent was studied at different contact. Here, a total of 0.7 g of adsorbent was added to 50 ml MB with a concentration of 30 ppm at definite pH 6.2 and temperature. The test was performed at different time category according to 20 min, 40 min, 60 min, 80 min, 100 min, and 120 min.

2.7. Removal Efficiency

As the test was done at different amount adsorbent doses, different pH and different time interval, so it's need to be calculated for removal efficiency. The dye removal percentage is carried out through this equation,

$$\text{Removal Efficiency } \% = \frac{(\text{Ci}-\text{Cf})*100}{\text{Ci}}$$

Here, C_i and C_f is the concentration of MB initial and final respectively.

2.8. Analytical Method

The entire test has been carried out by UV-Vis spectrophotometer. Before doing the experiment, the MB solution sample was tested to obtain the molar absorptivity constant and calibration curve. This is accomplished with the equation of Beer-Lambert Law.

$$\mathbf{A = \mathcal{E}lC}$$

Where A= Absorbance

Ɛ= Molar Absorptivity Constant

l= Path length

C= Concentration of the sample

All the absorbance values were taken at the maximum wavelength and a calibration curve was established using Excel software. To do this job, a concentration of 30, 40, 50, 60 and 70 ppm sample solution was taken into UV spectrometer. Then the resulted data was taken for the calculation.

3. RESULTS AND DISCUSSIONS

Figure 2 shows the calibration curve of Methylene Blue. At 30 ppm concentration, it gives highest absorbance value 2.82 at maximum wavelength 670nm. After plotting the different concentration and absorbance value at a 670nm wavelength in the graph, we got linear tread line showing below figure. The calculated molar absorptivity constant, Ɛ was $3*10^4 Lmol^{-1}cm^{-1}$

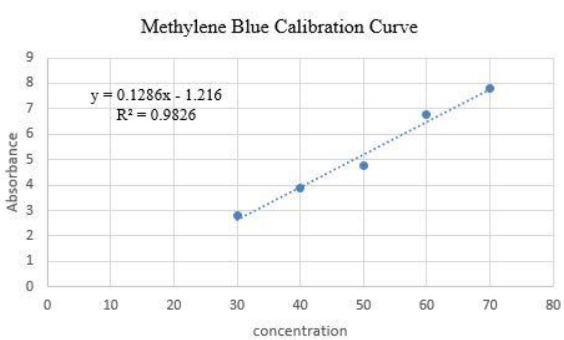

Fig. 2: Methylene Blue Calibration Curve.

3.1. Effect of adsorbent dose on dye adsorption

The effect of different adsorbent dose on the absorption of MB was conducted at a different adsorbent dose ranging from 0.3 gm to 1 gm shown in table 1. The doses were added to 50 ml MB solution with a concentration of 30 ppm at pH 4 and room temperature (25±2) °C for 2 hrs.

Table 1. Concentration of dye solutions at different adsorbent doses.

Sl. No.	Dose of Adsorbent (gm)	Conc. After treatment (ppm)
01	0.30	1.52
02	0.40	1.19
03	0.50	0.95
04	0.60	0.83
05	0.70	0.64
06	0.80	0.66
07	0.90	0.76
08	1.00	0.79

Figure 3 shows that removal efficiency increases with at certain doses 0.7 gm. After that, it was not increasing the efficiency. At 0.3 gm doses of adsorbent, it gave removal efficiency of 94.93%. On the other hand, the maximum removal efficiency was found on the addition of 0.7 gm doses as shown in the figure.

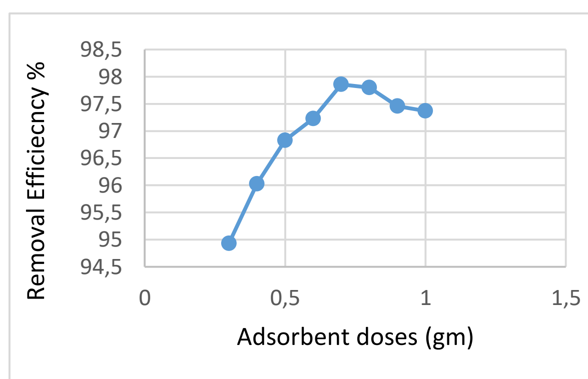

Fig. 3. Adsorbent vs removal efficiency (%) of MB at different adsorbent doses.

3.2. Effect of Solution pH on dye absorption

Table 2 shows the concentration after adding 0.7gm adsorbent at different pH. The effect of pH was studied in both acidic and basic condition ranging from 2 to 12.

Table 2. Concentration of solution at different pH after addition of doses.

Sl. No.	Solution pH	Conc. After treatment (ppm)
01	02	0.92
02	03	0.79
03	04	0.64
04	05	0.77
05	06	1.03
06	08	1.04
07	10	1.07
08	12	1.13

Figure 4 shows a different percentage of dye removal at different pH. At pH 2, it gave removal efficiency of about 96.93%. After that, it removed maximum dye at pH 4 in which removal efficiency was 97.87%. Then it is noticeable from the graph the removal efficiency percentage decreases with the increase of pH.

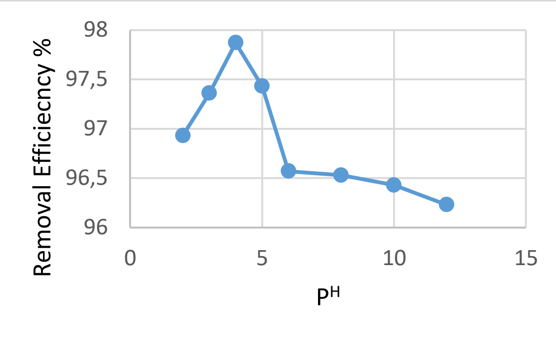

Fig. 4. Removal efficiency percentage at different pH.

3.3. Effect of Contact time on dye absorption

The effect of contact time on the removal of dye was studied in different time duration. Table 3 shows the concentration of MB after treating with the adsorbent at the time ranging from 20 to 160 minutes.

Table 3. Concentration of dye solution at the different time duration.

Sl. No.	Time (min)	Conc. after treatment (ppm)
01	20	1.23
02	40	0.95
03	60	0.91
04	90	0.89
05	100	0.80
06	120	0.64
07	140	0.68
08	160	0.69

Figure 5 shows that the percentage of removal efficiency maximum when the testing time 120 min.

At time duration 20 min, its removal efficiency 95.9%. After 120 min the percentage of removal efficiency decreases with time.

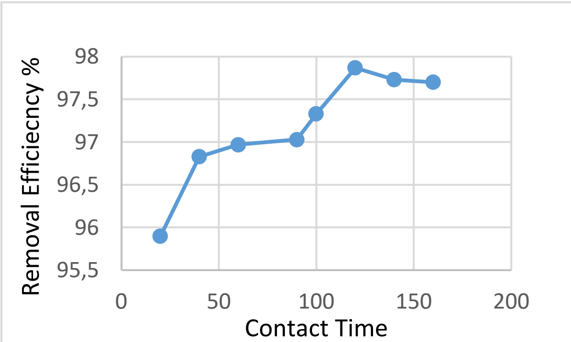

Fig. 5. Removal efficiency percentage at different time duration.

4. CONCLUSION

Spent tea leaves are very low cost and easily available material which can be used as an excellent adsorbent for Methylene Blue removal. Though it does not remove 100% dye from solution, it goes near to 100% which can be considered as good adsorbent as compared to other adsorbents. The dye removal amount was found to vary with adsorbent dose, pH and contact time. Therefore, the adsorbent is expected to be economically feasible for the removal of MB dye from aqueous solutions.

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