Treatment of Textile Wastewater Using Bioadsorbent

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***Abstract*—**Huge quantity of dyes and pigments produced annually throughout the world and used by textile industries. Effluents from textile industries are color dye wastewater and the disposal of these wastes to receiving freshwater bodies causes damage to environment. Among the treatment technologies, the adsorption is an attractive and viable treatment option, if the sorbent is an inexpensive and ready for use. In this study, typical cationic dyes, methylene blue, and malachite green were treated from the synthetic wastewater using waste biomass. The effects of contact time, adsorbent amount and particle size, initial dye concentration, were investigated on the removal efficiency of adsorbent for both the dyes. Complete removal of the dye attained at higher adsorbent dose of 3g/L with 50 mg/L initial dye concentration. The maximum adsorption was at 200 minutes whereas more than 90% removal with 105 µm particle size of 1g/L adsorbent for same initial dye concentration. The adsorption data best fit with the Langmuir isotherm model.

***Keywords*—** Dyes, adsorption, isotherms, waste biomass.

I. Introduction

THE effluents from textile industries are colored wastewaters and their disposal into the receiving freshwater cause impairment to the environment. They can be damaging to aquatic life even at very ignoble concentrations. Existing physiochemical methods for dye removal suffer from higher operational cost, lower efficiency, and huge sludge production [1]. Adsorption has been accepted as a cheaper and effective treatment for dye containing wastewater. Some of the reported adsorbents are activated carbon [2], bagasse [3-5], cotton seed shells [6], activated carbon coir pith [7, 8], cotton hull [9] and C. tropicalis [1]. The adsorption through activated carbon is a very useful technique; however, the major constraints are high production cost and energy. Therefore, the forest and agriculture waste materials or waste biomass can be an alternative choice for dye removal from wastewater because of their good performance and low cost. The large amount of saw dust is produced, which is considered to be waste biomass and have disposal issues. In this regard, saw dust from Melia azedarach (MA) was investigated for methylene blue (MB) and malachite green (MG) removal in a batch experiment. The maximum dyes removal was tested as an effect of bioadsorbent contact time, dose, size and dye concentration.

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II. Materials And Methods

The sawdust of *Melia azedarach* (MA) was obtained from local wood workers' Abbottabad, Pakistan. It was washed, dried and sieved to variable sizes (400, 177, 125 and 105 µm) before being used. The MB C.I. 52015 and MB C.I. 42000 (Merck, Germany) dyes were used as a reagent. The 1000 ppm stock solutions of both the dyes were prepared in deionized water.

The adsorption study was carried out by batch experimentation. Adsorption studies were conducted by placing 0.050 grams of adsorbent in 50 ml of dyes with 50 mg/L initial dye concentration in 100 ml Erlenmeyer flacks. The solutions were agitated at 220 rpm for eight hours at 30 °C. The solution agitated at 20, 40, 60, 140, 180, 200, 480 minutes to check the effective contact time for maximum dye uptake by bioadsorbent. The effect of bioadsorbent dose, size and dye concentration was also measured. The solution were centrifuged at 4000 rpm for 10 minutes to separate bioadsorbent. The UV- visible spectrophotometer was used to measure the solution' dye concentration. The MB and MG λ Max found to be 668 nm and 616 nm respectively. The percentage of dye removal and the bioadsorbent capacity for dye uptake was calculated using the equations below.

$$Percent\ (\%)removal = \frac{Ci - Cf}{Ci} X\ 100$$

$$q = \frac{Ci - Cf}{m} V$$

Where *q* (adsorption capacity) is the amount of dye uptake (mg/g) at equilibrium. *Ci* is the initial dyes concentration (mg/L), *Cf* is final dyes concentration (mg/L). *V* is quantity (L) of dye solution used, and *m* is the mass (g) of bioadsorbent.

III. Results And Discussion

A. Bioadsorbent Contact Time

The time for maximum dyes uptake was investigated using MA saw dust (Fig. 1). The contact time ranges from 20-480 minutes with interval of 20 minutes. The results indicate that adsorption of MB and MG increases rapidly with time during

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first several minutes, and saturation point reached in 200 minutes. It was because freer sites available for the dye molecules to bind in early a couple of minutes of bioadsorbent contact. The maximum adsorption at this stage was found to be 40 and 42 milligrams of MB and MG respectively per gram bioadsorbent.

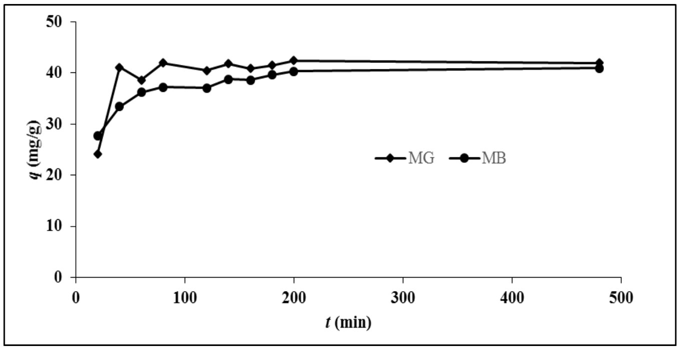

Fig. 1 Effect of contact time on MG and MG removal (T: 30 °C, Ci: 50 mg/L, dose: 1g/L, particle size 177 µm)

B. Bioadsorbent Dose

The effective bioadsorbent dose was investigated for MB and MG removal (Fig. 2). The data reflect that the dye removal also increases positively with addition of bioadsorbent. The bioadsorbent dose used in range of 0.3 to 5 g/L. Complete percent removal of the MB is attained on increasing the adsorbent dosage to 3 g/L where as 91 percent for the MG at 5 g/L. The maximum removal of the dye observed at an adsorbent dosage higher than 3 g/L is attributed to the increase of the adsorption sites, however, per gram uptake may reduce. Similar results with addition of adsorbent dose were obtained previously [10]. The surface chemistry and ionic charges of the MG components can be the hindrance in its complete removal in comparison with the MB.

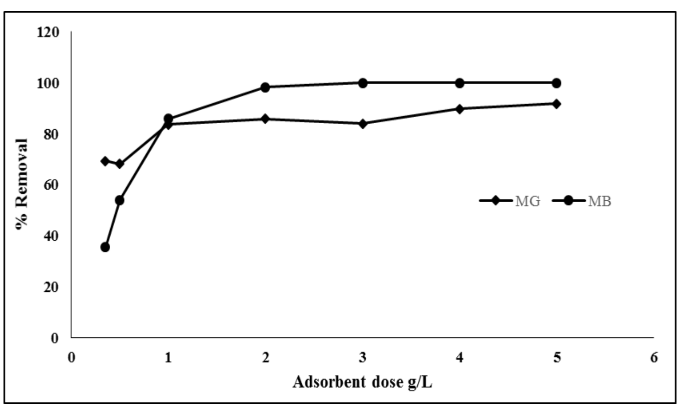

Fig. 2 Effective Bioadsorbent dose for MB and MG removal (T: 30 °C, Ci: 50 mg/L, time: 200 min, particle size: 177 µm)

C. Bioadsorbent Size

The smaller bioadsorbent size favors more removal as reflected in Fig. 3. The bioadsorbent size investigated varies in the range of 400-105 µm. The smaller particles size of the bioadsorbent show more uptake because of the more exposed surface area as in case of 105 µm size more than 90 % removal attained.

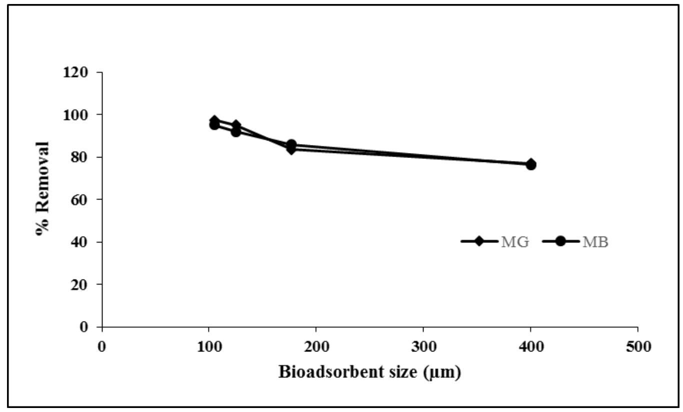

Fig. 3 Effect of particle size on MB and MG removal (T: 30 °C, Ci: 50 mg/L, dosage: 1g/L, Time: 200 min, particle size: 177 µm)

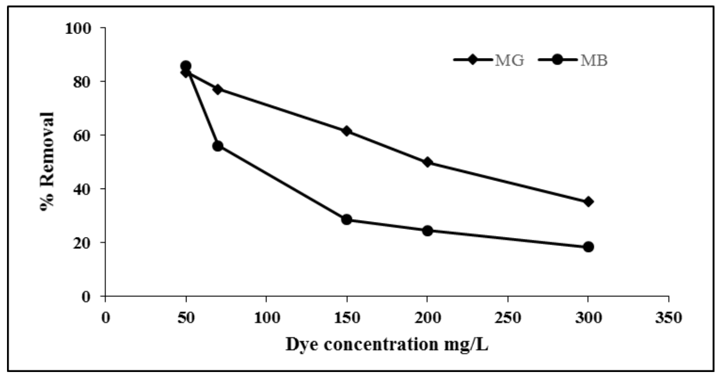

Fig. 4 Effect of dye concentration on MB and MG removal (T: 30 °C, Co: 50 mg/L, dosage: 1g/L, Time: 200 min, particle size: 177 µm)

D. Initial Dye Concentration

The Increasing dyes concentration from 50 to 300 mg/L (Fig. 4) decrease the removal from 85 to 18 percent for MB and 83 to 35 percent for MG. The q (mg/g) uptake is increased in case of both the dyes concentration increased. However, the overall removal decreased due to the less binding sites were available to accommodate more dye molecules. Similar results were obtained with increasing dye concentration previously [11]. The variable dye concentrations, and their removal capacities were modeled with four major isotherms Tempkin, Dubinun-Raduskevich, Freudlich, and Langmuir. The adsorption data best fits (r^2=0.99) with Langmuir isotherm model which indicate the monolayer adsorption and specific site for each molecule to bind at the surface of MA.

IV. Conclusion

The study was aimed to investigate the potential of waste biomass MA saw dust as a bioadsorbent for removal dye wastewater. The adsorption process is studied as an effect of the bioadsorbent contact time, bioadsorbent dose, bioadsorbent size and variable dye concentration. The results show that MA sawdust was effective in removing both MB and MG from wastewater. In 200 minutes, 80 percent of the dyes removed at 50 mg/L initial dye concentration. More than 90 percent removal of both the dyes is reflected at 105 micrometers adsorbent particles size and only 1g/L dosage. The percent removal decreases by increasing dye concentration. However, at highest dye concentration of 300 mg/L still removes a considerable amount of 18 and 35 % for MB and MG. The experimental data best fits the Langmuir adsorption model attributed monolayer adsorption. These results revealed MA as an effective bioadsorbent for removal of the MB and MG ions from wastewaters.

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REFERENCES

[1] Charumathi, D. and N. Das, Packed bed column studies for the removal of synthetic dyes from textile wastewater using immobilised dead C. tropicalis. Desalination, 2012. 285(0): p. 22-30. http://dx.doi.org/10.1016/j.desal.2011.09.023

[2] Auta, M. and B.H. Hameed, Optimized waste tea activated carbon for adsorption of Methylene Blue and Acid Blue 29 dyes using response surface methodology. Chemical Engineering Journal, 2011. 175(0): p. 233-243. http://dx.doi.org/10.1016/j.cej.2011.09.100

[3] Chou, K.S., J.C. Tsai, and C.T. Lo, The adsorption of Congo red and vacuum pump oil by rice hull ash. Bioresource Technology, 2001. 78(2): p. 217-219. http://dx.doi.org/10.1016/S0960-8524(00)00116-4

[4] Valix, M., W. Cheung, and G. McKay, Preparation of activated carbon using low temperature carbonisation and physical activation of high ash raw bagasse for acid dye adsorption. Chemosphere, 2004. 56(5): p. 493-501. http://dx.doi.org/10.1016/j.chemosphere.2004.04.004

[5] Thinakaran, N., et al., Equilibrium and kinetic studies on the removal of Acid Red 114 from aqueous solutions using activated carbons prepared from seed shells. Journal of hazardous materials, 2008. 158(1): p. 142-150. http://dx.doi.org/10.1016/j.jhazmat.2008.01.043

[6] C. J. Kaufman, Rocky Mountain Research Lab., Boulder, CO, private communication, May 1995.

[7] Kavitha, D. and C. Namasivayam, Experimental and kinetic studies on methylene blue adsorption by coir pith carbon. Bioresource Technology, 2007. 98(1): p. 14-21. http://dx.doi.org/10.1016/j.biortech.2005.12.008

[8] Namasivayam, C. and D. Kavitha, Removal of Congo Red from water by adsorption onto activated carbon prepared from coir pith, an agricultural solid waste. Dyes and Pigments, 2002. 54(1): p. 47-58. http://dx.doi.org/10.1016/S0143-7208(02)00025-6

[9] Kadirvelu, K., et al., Utilization of various agricultural wastes for activated carbon preparation and application for the removal of dyes and metal ions from aqueous solutions. Bioresource Technology, 2003. 87(1): p. 129-132. http://dx.doi.org/10.1016/S0960-8524(02)00201-8

[10] Zhang, Z., et al., Comparative study on adsorption of two cationic dyes by milled sugarcane bagasse. Industrial Crops and Products, 2013. 42(0): p. 41-49. http://dx.doi.org/10.1016/j.indcrop.2012.05.008

[11] Feng, Y., et al., Basic dye adsorption onto an agro-based waste material – Sesame hull (Sesamum indicum L.). Bioresource Technology, 2011. 102(22): p. 10280-10285. http://dx.doi.org/10.1016/j.biortech.2011.08.090