

Use of Aquatic Plant (*Lemna minor*) as Adsorbent Materials to Removal of Methylene Blue Dye from Aqueous Solution

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ABSTRACT

The present work deal with the study of adsorption of the methylene blue dye from aqueous solution using neutral material from aquatic plant (*Lemna minor*) collect from local habitat as low cost and eco-friendly adsorbents. Each adsorption studies are carried out by observing the effect of experimental parameters such as amount of adsorbents, contact time, and concentration of dye. This study design to remove the dye from different industries effluents such as textile industries and sewage water. The results showed the removal percentage increasing with increasing adsorbent dosage and contact time, but decreasing with increasing of concentration of dye. The optimum time removal was found to be 90 minutes.

1. Introduction

The world now is facing many problems regarding water pollution that resulting from industrial pollution, examples for these industries textile, leather, food, agro industries, have brought many dangerous atmospheric changes [1, 2]. The big problem is come from effluent from textile industries, which has created environmental problems around all the world areas. Especially the effluent contain many type of dye which use in the plastic, paper, textile and cosmetics Industries use these dyes to color their products [3]. The presence of these dyes in water, even at low concentrations, is highly visible and undesirable [4]. And Because of the complex aromatic structure of these dyes are have high stability and resistance the bio, photo, and thermal degradation [2, 5]. So that it is tend to persist in the environment and inter to the water system bodies (streams, rivers, etc.) and this creating public health problems (allergic dermatitis, skin irritation, cancer and mutation), and inhibiting sunlight penetration into these waters [6]. Furthermore, these dyes are toxic to micro-organisms and may cause direct destruction or inhibition of their catalytic capabilities [7, 8]. Generally there are many types of dye are used in textile industries such as directive, reactive, acid and basic dyes [5, 9]. There are many various physical and chemical techniques have been employed to eliminate dyes from wastewaters, like adsorption [4, 10], reverse osmosis [3, 11], coagulation [12], flocculation [11, 13], membrane technology [9, 14], and biological treatments. Adsorption technique is by far the most versatile and widely used. Common adsorbents materials are: activated alumina, silica gel, metal hydroxides, alumina silicates (molecular sieves) and activated carbon [15]. In this work study the ability to remove of methylene blue from aqueous solutions by low cost, neutral materials, eco-friendly, highly efficient such as *Lemna minor* under various experimental conditions, such as effect of contact time, effect of adsorbent dose, and effect of concentration of dye. This work an ideal alternative to the current expensive methods of removing the dye from waste water.

2. Experimental Methods

2.1 Preparation of Adsorbent

The aquatic plant was used as adsorbent were collected from lotic aquatic system in Hilla city middle of Iraq. The unwanted materials (suspended impurities) like soils, dust etc., were removed by extensively washed in running tap water for 2-3 hours for removing. It was followed by washing with distilled water. The washed material was oven dried at 25 °C for 24 hours. It was ground in pulverized mill. This ground powder was treated with water till the color leached out and the powder was over dried at 25 °C for 24 hours.

2.2 Preparation Adsorbate Solution

Methylene Blue supplied by BHD Chemicals. The solution of methylene blue were prepared by dissolving appropriate amounts (accurate weighed) of dry powdered dye in double distilled water to prepare Stock solution (1000 mgL⁻¹). The experimental solution was obtained by dilutions were made to obtain the working solution at desired concentrations. Dye concentration was determined by using absorbance value measured before and after the treatment with UV-Visible spectrophotometer.

2.3 Adsorption Study

Exact value of 0.5 g of limner powder (adsorbent) was weighted each into 250 mL conical flasks. 100 mL of the solution methylene blue was measured and added to the content in each conical flask. The content was shaken rigorously and continuously for 30, 60, 90, 120, 150, 180, 210, 240, 270 and 300 min respectively. The particles of the adsorbent was separation by centrifuged from solution to obtain the equilibrium concentration. The final concentration of methylene blue was estimated for each sample spectrophotometrically at the wavelength corresponding to maximum absorbance for Congo red ($\lambda_{\text{max}} = 497 \text{ nm}$) using a spectrophotometer (UV/VIS-Shimadzu, 1800, Japan). A graph of removal Congo read percentage (g/L) versus time (hour) was plotted for Congo red. Generally the amount of dye removal was calculated from following equation:

$$\text{Removal \%} = (A^{\circ} - A) A^{\circ} \times 100 \quad (1)$$

Where, A° and A is the absorption of concentration of dye before and after adsorption respectively.

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3. Results and Discussion

A washing adsorbent was play an important roles in this study: first to remove impurities from the adsorbent, and second to release the color of material and avoided interfere spectrophotometrically with wave length of methylene blue, this case recognized by analyzed washing solution spectrophotometrically after each one washing time. After second washing time the absorbance was negligible at 663 nm. So the pre-treatment of two washing cycles were adequate [15].

3.1 Adsorption Studies

3.1.1 Effect of Contact Time

The experiment was achieves for a maximum period of 30 min but was extended to 90 min to establish its equilibrium point with initial dye concentration 10 mg/L at pH 6.0, room temperature ($27 \pm 2^\circ\text{C}$) and adsorbent dose 10 g/L *Lemna minor* for the adsorption of dye (methylene blue). The relation between the removal of methylene blue dye, and reaction time was studied at pH 6.0 with increase of contact time using *Lemna minor* as introduced in Fig. 1.

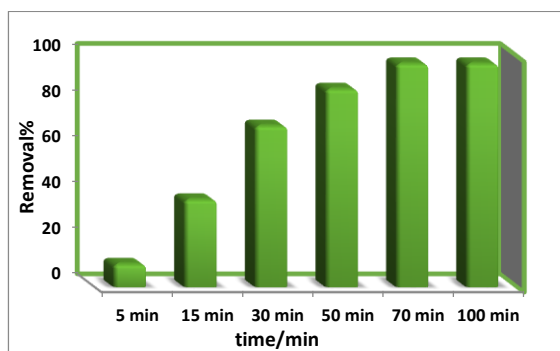


Fig. 1 The relation between the removal of methylene blue and reaction time initial dye concentration 10 mg/L at pH 6.0, room temperature ($27 \pm 2^\circ\text{C}$) and adsorbent dose 10 g/L.

At the initial stage, there was a rapid adsorption of the dyes. It was found that 91% of the dye concentrations was removed in the first 30 min, and thereafter the removal on the *L. minor* was gradual till it became constant at 25 min as shown in Figs. 2 and 3.

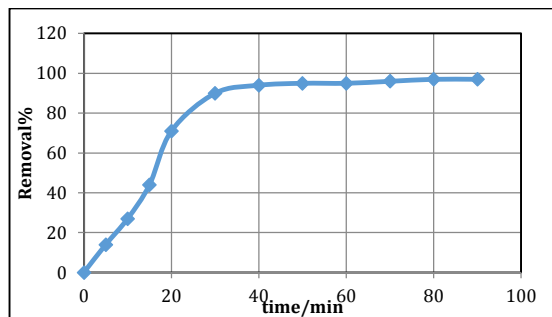


Fig. 2 Stages removal methylene blue dye by using *Lemna minor* as adsorbent

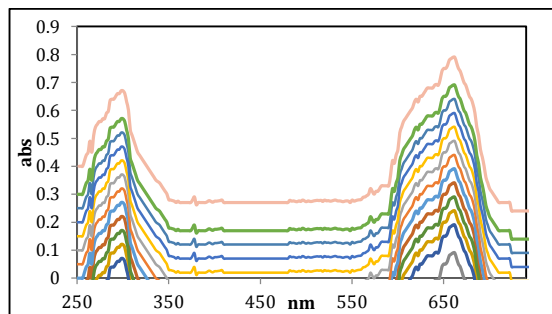


Fig. 3 Scanning relation between the removal of methylene blue and reaction time initial dye concentration 10 mg/L at pH 6.0, room temperature ($27 \pm 2^\circ\text{C}$) and adsorbent dose 10 g/L.

The rapid adsorption at the initial contact is attributed to the highly active sites available on the surface of the *L. minor* powder, so there strong attraction between active site available on the surface of the adsorbent and basic cationic adsorbate [16]. The gradual rate of adsorption is probably due to the electrostatic hindrance or repulsion between the adsorbed

positively charged adsorbate species onto the surface of the *L. minor* and the available basic cationic adsorbate species in the solution, as well as the slow pore diffusion of the solute ions into the bulk of the adsorbent (i.e. saturation of the active site which do not allow further adsorption to take place). The equilibrium was achieved at 90 min when the maximum dye adsorption onto *L. minor* powder was reached [16-18].

3.1.2 Effect Adsorbent Dose

The study carried out for adsorbent dose (2, 4, 6, 8, 10 and 12 g/L) a contact time of 90 min with initial concentration of dye 10 mg/L at room temperature ($27 \pm 2^\circ\text{C}$) and pH 6.0. The effect of adsorbent dose on the removal of methylene from the aqueous solution is shown in Figs. 4 and 5. The figures show that the removal dye percentage increases with increasing adsorbent dose and then it remains constant. An increase in adsorption with increase adsorbent dose due to increased surface area and the availability of more adsorption sites. But the amount adsorbed for unit mass of the adsorbent decreases considerably. The decrease in unit adsorption with increasing dose of adsorbent is due to the adsorption sites remaining unsaturated during the adsorption process [17, 19].

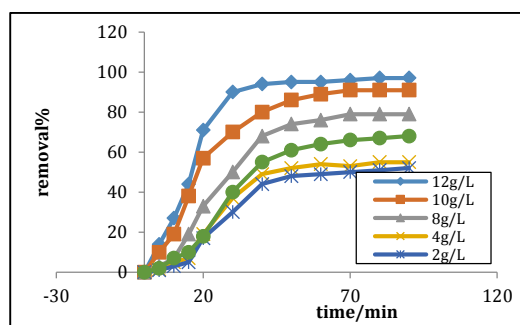


Fig. 4 Scanning relation between the removal of methylene blue and adsorbent dose, initial dye concentration 10 mg/L at pH 6.0, room temperature ($27 \pm 2^\circ\text{C}$).

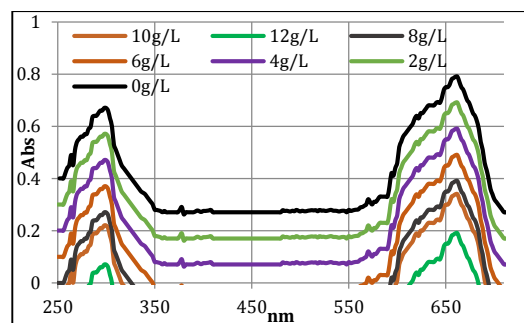


Fig. 5 Scanning relation between the removal of methylene blue and adsorbent dose, initial dye concentration 10 mg/L at pH 6.0, room temperature ($27 \pm 2^\circ\text{C}$).

3.1.3 Effect of Concentration Dye

The removal of methylene blue on *Lemna minor* powder was experimented at different methylene blue concentration (5, 10, 15, 20 and 25 mg/L), with adsorbent dose (10 g/L) a contact time of 90 min that is the time required to complete equilibrium at room temperature ($27 \pm 2^\circ\text{C}$) and pH 6.0. The effect of initial dye concentration on the removal methylene blue illustrated in Figs. 6 and 7. As shows in Fig. 5, with increase in initial dye concentration the removal of dye is increased but the removal percentage is decreased due to Reduced surface area and saturated the active sites [20-22].

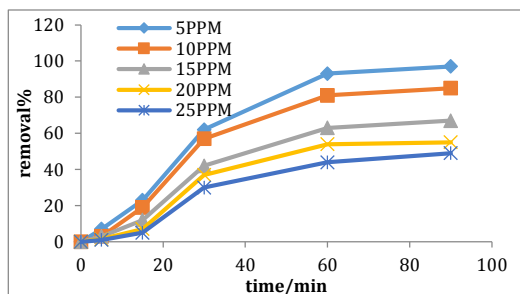


Fig. 6 Scanning relation between the removal of methylene blue and initial dye concentration at pH 6.0, room temperature ($27 \pm 2^\circ\text{C}$) and adsorbent dose 10 g/L.

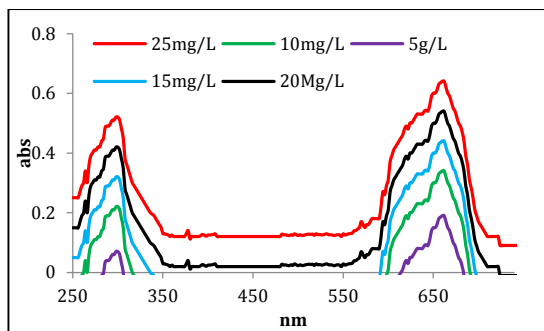


Fig. 7 Scanning relation between the removal of methylene blue and initial dye concentration 10 mg/L at pH 6.0, room temperature ($27 \pm 2^\circ\text{C}$) and adsorbent dose-10 g/L

4. Conclusion

In this study, batch adsorption experiments for the removal of methylene blue dyes from aqueous solutions had been carried out using *Lemna minor* powder as adsorbents. This adsorbent may be viewed as useful natural material while considering the economic aspects of wastewater treatment. The removal percentage increase with increasing of adsorbent dosage due to increasing of adsorption sites. The removal percentage increase with increasing of contact time. The removal percentage decrease with Increasing of concentration of dye. The equilibrium time for the adsorption of methylene blue dye from aqueous solution was 30 minutes. The optimum time removal was found to be 90 minutes.

References

- [1] A.S. Alzaydien, Adsorption of methylene blue from aqueous solution onto low-cost natural Jordanian Tripoli, *Am. J. Env. Sci.* 5(3) (2009) 197-208.
- [2] T. Clive, The pesticide manual, Incorporating the agrochemicals handbook, 10th Ed., British Crop Protection Council and the Royal Society of Chemistry, Farnham, UK, 1994.
- [3] O.P. Gupta, Scientific weed management, Today and Tomorrow's printers and publishers, New Delhi, India, 1984.
- [4] H. Benhima, M. Chiban, F. Sinan, P. Seta, M. Persin, Removal of lead and cadmium ions from aqueous sodium by adsorption onto micro-particles of dry plants, *Colloids Surf. Biol. Biointerf.* 61 (2008) 10-16.
- [5] A. Moulay, C. Abdelilah, Electrochemical studies of adsorption of paraquat onto $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ from aqueous solution, *Leonardo Jour. Sci.* 12 (2008) 25-34.
- [6] R. Somasekhara, K.L. Sivarama, R.A. Varada, The use of an agricultural waste material, Jujuba seeds for the removal of anionic dye (Congo red) from aqueous medium, *J. Hazard. Mater.* 203 (2012) 118-127.
- [7] S. Mehdi, M. Halimah, M. Nashriyah, B.S. Ismail, Adsorption and desorption of paraquat in two Malaysian agricultural soils, *Am. Euras. J. Sustain. Agri.* 3(3) (2009) 555-560.
- [8] I.A.W. Tan, A.L. Ahmad, B.H. Hameed, Adsorption of basic dye on high surface area activated carbon prepared from coconut husk: equilibrium, kinetic and thermodynamic studies, *J. Hazard. Mater.* 154 (2008) 337-346.
- [9] C.E. Gimba, Preparation and adsorption characteristics of activated carbon from coconut shell, Ph. D. Thesis, Ahmadu Bello University, Zaria, Nigeria, 2001.
- [10] J.M. Chern, C.Y. Wu, Desorption of dye from activated carbon beds: effect of temperature, pH and alcohol, *Water Res.* 35 (2011) 4159-4165.
- [11] J.M. Salman, A.R. Amrin, F.M. Hassan, S.A. Jouda, Removal of congo red dye from aqueous solution by using natural materials, *Mesop. Environ. J.* 1(3) (2015) 82-89.
- [12] S. Olusegun, E. Ugba, Adsorption of textile wastes containing methylene blue and Congo red using activated carbon produced from coconut shell, *Int. J. Comp. Eng. Manag.* 16(5) (2013) 21-26.
- [13] M.H. Zonoozi, M.R. Moghaddam, M. Arami, Coagulation/flocculation of dye containing solutions using polyaluminium chloride and alum, *Water Sci. Technol.* 59 (2009) 1343-1351.
- [14] G.H. Sonavane, V.S. Shrivastava, Kinetics of decolourization of malachite green from aqueous medium by maize cob (Zea maize): An agricultural solid waste, *Desalination* 250 (2009) 94-105.
- [15] V.S. Shrivastava, Photocatalytic degradation of Methylene blue dye and Chromium metal from wastewater using nanocrystalline TiO_2 Semiconductor, *Arch. Appl. Sci. Res.* 4(3) (2012) 1244-1254.
- [16] J.M. Salman, A.R. Amrin, S.A. Jouda, Aquatic crusteans shell as adsorbents for paraquate pesticide removal from its aqueous solution by thermal activation, *Mesop. Environ. J.* 1(4) (2015) 75-83.
- [17] P.K. Malik, S.K. Saha, Oxidation of direct dyes with hydrogen peroxide using ferrous ion as catalyst, *Sep. Purif. Technol.* 31 (2003) 241-250.
- [18] A. Bhatnagar, M. Sillanpaa, Utilization of agro- industrial and municipal waste materials as potential adsorbents for water treatment a review, *Chem. Eng. J.* 157 (2010) 277-296.
- [19] E.N. El Qada, S.J. Allen, G.M. Walker, Adsorption of basic dyes from aqueous solution onto activated carbons, *Chem. Eng. J.* 135 (2008) 174-184.
- [20] Z. Hu, H. Chen, J. Ji, S. Yuan, Removal of Congo red from aqueous solution by cattail root, *J. Hazard. Mater.* 173 (2010) 292-297.
- [21] H. Lata, V. Garg, R. Gupta, Adsorptive removal of a basic dye by chemically activated parthenium biomass: equilibrium and kinetic modeling, *Desalination* 219 (2008) 250-261.
- [22] B.H. Hameed, Evaluation of papaya seeds as a novel non-conventional low-cost adsorbent for removal of methylene blue, *J. Hazard. Mater.* 16(2) (2009) 939-944.