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FULL LENGTH ARTICLE

Batch and packed bed column study on removal of Malachite Green Dye from aqueous solution using water hyacinth

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ABSTRACT
The present study deals with the removal of Malachite Green (MG)by biosorption using root powder of water hyacinth(Eichhornia crassipes). Experiments were performed to find the effect of initial pH (2.0-10.0), contact time (10min-300 min), biosorbent dosage (0.5g/l-5g/l), initial dye Concentration (200ppm-1000ppm) and temperature (308-318 K) on the MG biosorption.Further continuous biosorption of MG was carried outin a fixed bed column of length 27cm and diameter 5 cm. Dried water hyacinth roots were used as the column packing, the packing height used was 10cm.The breakthrough time $t_b$was found to be 4830 min. The saturation time t_e for 10 cm bed was found to be 8220 min.
Key words: Malachite Green (MG); Water Hyacinth; Dye Removal; Fixed bed column.

INTRODUCTION

The effluent coming from the dyeing industry primarily comprising of dyes has been a predicament to the environment. It is necessary that we find a solution, keeping in mind the urgency drawn by this long standing problem. Of the many toxic dyes being released as effluents, Malachite Green (MG) is known for its biohazardous nature. The present study deals with the removal of MG by biosorption on the root of water hyacinth (*Eichhornia crassipes*).Known to be a tumour promoter, MG is found to be hazardous to mammalian cells and is known to cause kidney tumours in mice and problems to the reproductory systems to mammals [1,2]. The dye causes severe health complications in humans especially when they find entry to the respiratory system in considerable quantities. The use of root to decolorize the effluent is not only an economic technique but also reduces the problems associated with water hyacinth plants.

MATERIALS AND METHODS

A. *Adsorbate*

Malachite Green dye was purchased from Merck (India) Ltd.Stock solution of MG was prepared by dissolving 0.5g of accurately weighed dye in 1000ml of distilled water to obtain 500ppm dye solution. The solution was then diluted to prepare standard solutions of different concentration to study the effect of initial dye concentration. The dye concentration was measured in the UV spectrophotometer at the wavelength of 616.6 nm. The initial pH of dye solution was adjusted by using dilute hydrochloric acid orsodium hydroxide solution.

B. *Biosorbent preparation*

Water hyacinth plants were obtained from Hebbal Lake, Bangalore and were washed with water extensively to remove earthly impurities. The roots were separated from the rest of the plant roots were sun dried for 5 days, crushed and then sieved to an average particle size of 100µm.Water hyacinth root powder was used as biosorbent.

C. *Biosorption experiments*

Biosorption experiments were carried out in reagent bottles containing 100ml of dye solution in an incubator orbital shaker to analyze the effect of various parameters on the removal of MG by water hyacinth root powder. The effect of initial pH(2.0-10.0),contact time(10-300min), biosorbent dosage (0.5-5g/l),initial dye concentration (200-1000ppm) and temperature (308-318K) on biosorption of MG were examined. After biosorption, the samples were filtered and residual dye concentration was analyzed.Dye uptake and percentage biosorption were calculated by using Eq. (1) and Eq. (2).

$$q = \frac{V(C_i - C)}{m} \quad (1)$$

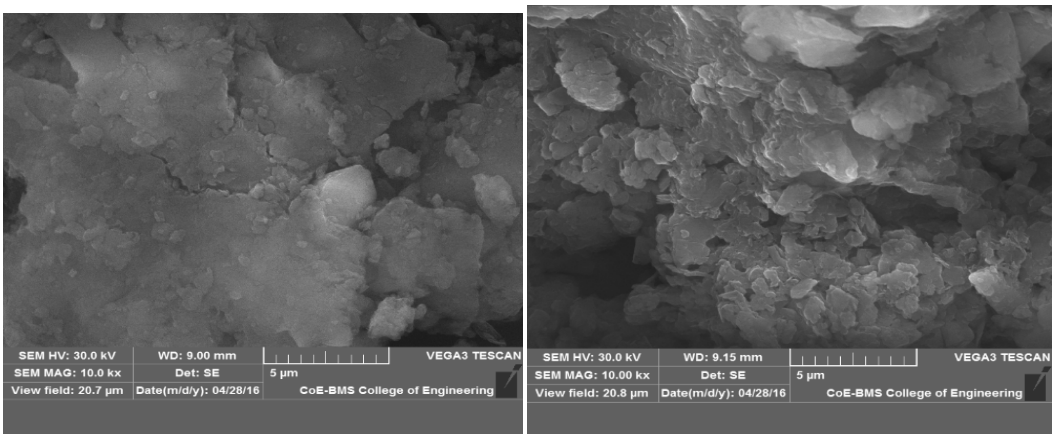
$$\%\ Biosorption\ = \frac{(C_i - C_f)}{C_i} \times\ 100 \quad (2)$$

where q is the dye uptake (mg/g),V is volume of dye solution (l), $C_i$and C_f arethe initial and final concentration of MG in the solution (ppm) and m is the amount of water hyacinthroot powder (g).

RESULTS AND DISCUSSION

A.SEM analysis

SEM imaging of the biosorbent surface was carried out before and after biosorption of MG. The images are presented in Fig. 1(a) and Fig. 1(b) respectively. In Fig. 1(a),the surface was relatively free of any kind of aggregations. Fig. 1(b) shows after biosorption of MG, aggregations on the surface which may possibly be particles of the dyes adsorbed onto the surface at the pores and the pore walls.



(a) (b)

Fig. 1. SEM image of water hyacinth root powder (a) Before biosorption (b) After biosorption of MG.

B. *Effect of initial pH on the biosorption of MG*

The effect of initial pH was studied for a pH range of 2.0-10.0 for the biosorption of MG on the water hyacinth root powder using a biosorbent dosage of 1g/l and a contact time of 120 min, ambient temperature of 35^{0}C.The removal efficiency was observed to increase with increasing initial dye solution pH (Fig. 2). The lower percentage of removal at lower pH was observed for cationic dyes like MG due to high concentration of H^+ ions resulting in competition with the cationic groups [1,3]. As the pH increases, the attraction between positively charged dye and adsorbent increases [4] and hence also the removal efficiency increases [5, 6,7].The maximum removal was obtained at initial dye pH of 10.0.

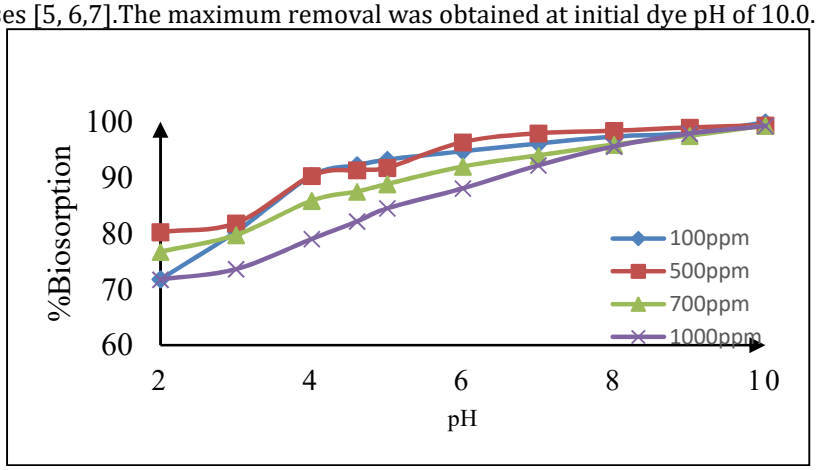


Fig. 2.Percentage Biosorption variation with initial pH for different initial concentration of MG.

C. Effect of contact time on the biosorption of MG

The effect of contact time on the removal of MG dye was studied using a working solution of 100ml of 500ppm concentration with a biosorbent dosage of1g/l and an ambient temperature of 35^{0}C.The time range studied was from 10min-300 minute. A significant increase in the dye biosorption was observed in the first 10 min of contact and equilibrium was attained at 120 min.

D. *Effect of biosorbent dosage on the biosorption of MG*

The effect of the biosorbent dosage parameter on the biosorption was studied using 500ppm solution with a contact time of 120 min at 35^{0}C temperature. The biosorbent dosage range employed was 0.5g/l to 5g/l. The results are shown in Fig.3. It was observed that with the increase in dosage from 0.5g/L to 1g/L, the percentage removal was found to significantly increase from 94.924% to 99.338% (Fig.3)due to presence of unsaturated sites and at higher biosorbent concentration there is very fast superficial adsorption which produces a very small but thereafter constant dye concentration [8].

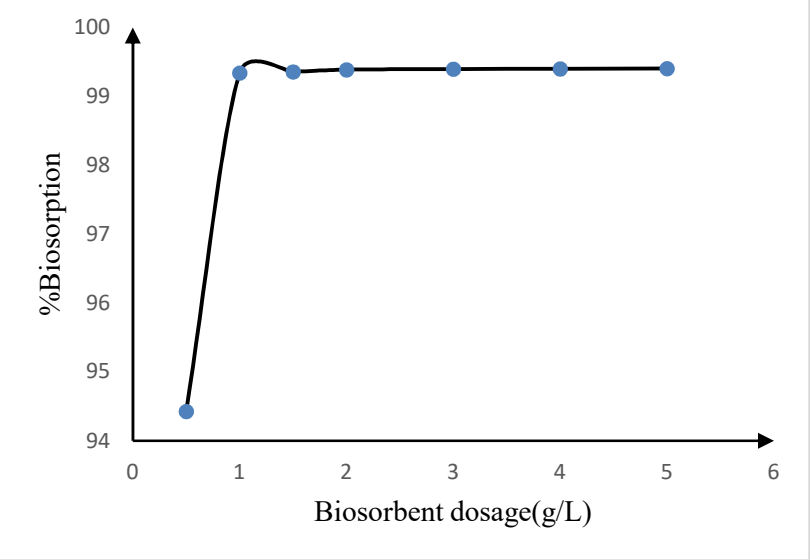


Fig. 3.Variation of Percentage Biosorption with biosorbent dosage.

E. *Effect of Initial Dye Concentration on the Biosorption of MG*

The effect of initial dye concentration on the biosorption of MG was studied using a biosorbent dosage of 1g/l employing a contact time of 120 min, pH 10.0 and a temperatures of 308^{0}K, 313^{0}K and 318^{0}K. A concentration range of 200ppm to 1000ppm was tested. It was observed that with increase in the initial dye concentration, the percentage biosorption decreased(Fig. 4). This decrease in the percentage biosorption can be attributed to the decrease in the driving force available for biosorption. This can be attributed to the fact that for a given mass of adsorbent, the active sites are fixed and as the concentrations goes on increasing the active sites will not be abundant as when compared to lower dye concentrations [9,10,11, 12].The increase in the biosorption observed with the increasing temperature for all initial dye concentrations tested can be explained by the increase in the bond strength between the dye molecules and the biosorbent surfaceindicating endothermic nature of the biosorption process.

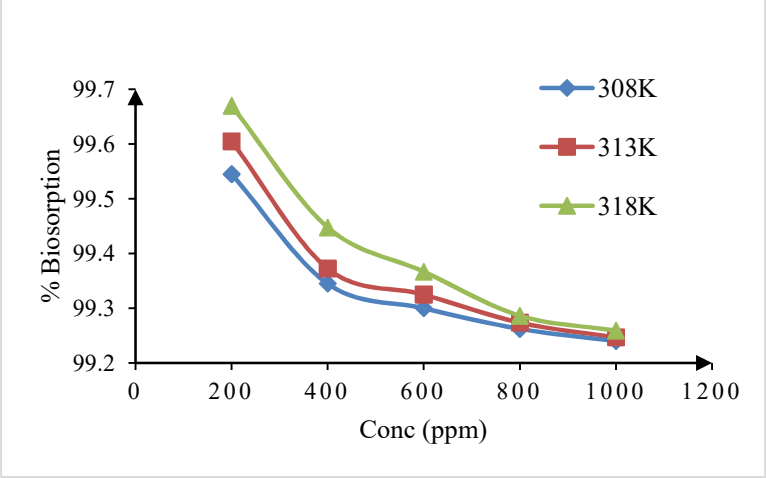


Fig. 4.Variation of Percentage Biosorption with initial dye concentration.

F. *Fixed Bed Column Study for Biosorption of MG*

A fixed bed column of length 27cm and diameter 5 cm was used for the continuous biosorption study. The L/D ratio utilized was 5.4. Dried water hyacinth roots were used as the column packing; the packing height used was 10cm. Dye solution of concentration 500ppm was pumped to the column by a peristaltic

pump with an upward direction of flow. The flowrate of 10ml/minute was maintained. The breakthrough curve was plotted C/C_o v/s time (Fig.5).breakthrough time and bed exhaustion time was found to be 4830 min and 8220 min respectively.

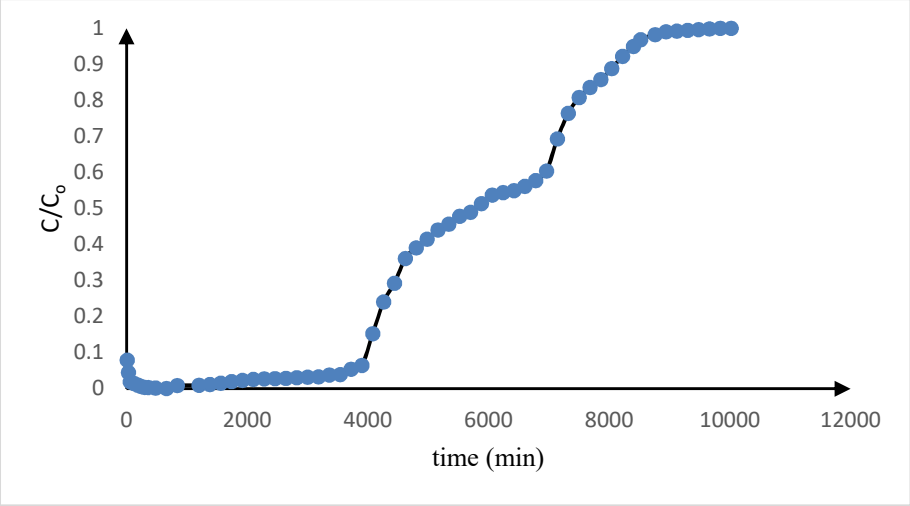


Fig.5. Fixed Bed column studies for MG

CONCLUSION

This study has dealt with the biosorption of MG using water hyacinth root powder.The potential of water hyacinth was studied for decolonization of MG. Influence of different parameters such as initial pH (2.0-10.0), initial dye concentration for MG (200-1000ppm), contact time (10-300min), biosorbent dosage (0.5-5g/L) and temperature (308-318K)on biosorption of MGwere examined. Maximum removal of dye was observed at pH 10.0 and the biosorption process has reached equilibrium at 120 min.

It is inferred from the Batch and Fixed Bed studies, that water hyacinth root can be used as a low cost biosorbent for the effective removal of MG. It offers an alternative economic and environment friendly process in the treatment of dye effluents.

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