Coir pith activated carbon for the removal of dyes from aqueous solutions

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Abstract

Adsorption of methylene blue, malachite green and nylosan blue dyes onto carbonized coir pith from aqueous solutions will studied. Adsorbent was prepared by carbonizing coir pith at 700 °C for 1 hr. Batch experiments showed that solution pH and adsorbent dose affects the adsorption capacity. The adsorption capacity was highest at solution pH 2 for nylosan blue and above pH 5 for methylene blue and malachite green. The kinetic data fits to second order model. The equilibrium data were satisfactorily fitted to Freundlich isotherm.

1. Introduction

Textile, paper and dyeing industries continuously release dyes into water sources. Colour in water streams causes aesthetic and real hazard to the environment. Removal techniques for dyes include coagulation, ozonation, membrane processes and adsorption. Adsorption is an efficient method for the removal of tracer components from water. Coir pith is the waste material produced when the coir fibre (commonly known as coir) is removed from the coconut husk. Coir pith is available in large quantities in tropical countries such as Sri Lanka and India. Several workers have tested coir pith based adsorbents for wastewater treatment (Santhy and Selvapathy, Namasivayam and Sangeetha). This work investigates the potential of carbonized coir pith for the removal of dyes from aqueous solutions.

2. Methodology

Coir pith obtained from local coir processing plant, were first ground and sieved prior to its use in experiments. Coir pith was then washed with distilled water and oven dried for 12 hrs at 100 °C. The material was thermally treated at 700°C for a period of one hour in a muffle furnace. Then it was washed and sieved to 500-710 µm particle size and kept in sealed polythene bags. Synthetic dye solutions were prepared by dissolving the dye powder in distilled water to obtain required solution concentrations. Three dyes namely methylene blue (MB), malachite green (MG), Nylosan blue (NB) were used for experiments.

Batch experiments were conducted by adding a known weight of adsorbent to the dye solution in a conical flask and agitating it at 200 rpm in a rotary shaker (Stuart® Orbital Shaker). Dye concentration was estimated by measuring the absorbance by a spectrophotometer (ERMA Inc. Photic-100 Spectrophotometer). pH was measured using HANNA pH 211 Microprocessor pH meter. Effect of solution pH, agitation time and adsorbent dose on dye removal was investigated. Equilibrium characteristics were also investigated.

3. Results and Discussions

3.1 Effect of pH

Effect of solution pH on dye adsorption is shown in Fig. 1. MB and MG showed higher removal above pH 5 and NB removal was highest at pH 2. This phenomenon can be explained by the surface charge of the adsorbent and the H' ions and OH- ions present in the solution. At high pH anionic dyes (NB) competes with the OH- ions in the solution for the active sites and therefore lower adsorption. As the pH of the adsorption solution was lowered, the positive charge on its surface increased. This would attract the negatively charged functional groups located on the anionic dyes. Similarly for cationic dyes (MB and MG) high solution pH is favorable for adsorption.

3.2 Effect of adsorbent dose

The percentage of dye removal increased when adsorbent dose is increased for all three types of dyes. The number of adsorption sites or surface area increases with the weight of adsorbent and hence results in a higher percent of dye removal at a high dose. Maximum percentage dye removal observed for a adsorbent dose of 2.5 g/l were 96%, 90% and 88% for MB, MG and NB respectively. So this adsorbent can be successfully used for the removal of dyes.

3.4 Adsorption kinetics

Fig. 2 shows variation of dye concentration with time. This data were fitted to pseudo-first order and second order models data showed good agreement with the second order model.
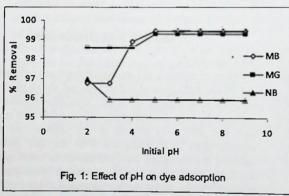
3.5 Adsorption equilibria

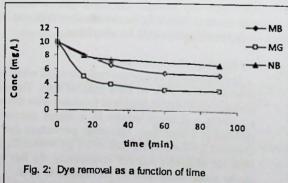Equilibrium data were fitted to the Freundlich isotherm (equation 1) and the results are shown in Table 1.

$$q_e = kC_e^{1/n} \tag{1}$$

Where q_e is the amount of solute adsorbed per unit weight of adsorbent at equilibrium, C_e is the residual liquid phase concentration at equilibrium, k and n are constants related to adsorption capacity and adsorption intensity.

Table 1: Freundlich isotherm constants for dye adsorption onto carbonized coir pith at 30 °C.

Dye	k	n	R^2
MB	69	1.3	0.99
MG	102	2.2	0.89
NB	69	2.3	0.98

Fig. 1: Effect of pH on dye adsorption

Fig. 2: Dye removal as a function of time

References

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