

Utilization of low-cost bio-waste adsorbent for methylene blue dye removal from aqueous solutions and optimization of process variables by response surface methodology approach

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ABSTRACT

In the present study, the sesame seed cake was utilized as an adsorbent to remove methylene blue which is one of the most used cationic dyes in various industries. The proper design of experiments conducted to adsorb methylene blue dye on sesame seed cake was carried out by using response surface methodology, Box–Behnken design. The adsorption experiments were carried out for 25 min using the initial concentration of methylene blue solution of 200 mg/L at various temperatures (20°C–40°C), pH (3–9), and adsorbent dosage values (1–3 g/100 mL). The results obtained from the adsorption experiments were evaluated by using an analysis of variance, and the statistically significant quadratic model was developed. The possible functional groups and morphological structure of sesame seed cake before and after the adsorption process was revealed by using Fourier transform infrared, Brunauer–Emmet–Teller, and scanning electron microscopy with energy-dispersive X-ray spectroscopy analysis. The comprehensive investigations about the adsorption kinetic, isotherm, thermodynamic, and reusability studies were performed to enlighten the possible adsorption mechanism of methylene blue on sesame seed cake. The various adsorption kinetic and isotherm models were examined for the data obtained from the adsorption experiments at optimum methylene blue dye removal. The data obtained from the adsorption studies indicated that the methylene blue removal on sesame seed cake fit the pseudo-second-order kinetic model and Freundlich adsorption isotherm. Thermodynamic analysis pointed that the adsorption had an endothermic nature and spontaneous at all studied temperatures. Eventually, the findings obtained from the present study indicated that the sesame seed cake is an efficient adsorbent for removing methylene blue dye from aqueous solutions in a dramatically short time with a reusability performance of three times.

Keywords: Methylene blue; Sesame seed cake; Adsorption; Response surface methodology; Box–Behnken design; Adsorption isotherm model; Adsorption kinetic model; Thermodynamic analysis; Reusability performance

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