

Biosorption behavior of copper onto curry leaves (*Murraya koenigii*): isotherm, kinetic and thermodynamic perspectives

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Industrial activities have increased heavy metal contamination in water, creating significant environmental and health concerns. This study investigates the potential of curry leaves (*Murraya koenigii*), widely used in Sri Lankan cuisine as a flavoring ingredient, as a sustainable biosorbent for copper (Cu) remediation. Curry leaves were washed with deionized water, dried, and ground to a particle size less than 1 mm. Isotherm, kinetic, and thermodynamic studies were conducted to understand adsorption mechanisms. Fourier Transform Infrared Spectroscopy revealed the presence of carboxyl, hydroxyl, and amine groups on the biosorbent surface, suggesting that Cu adsorption may occur via surface complexation and ion-exchange interactions. Optimum adsorption conditions ($84.9\% \pm 0.7\%$) were observed at an initial Cu concentration of 0.6 ppm, an adsorbent dosage of 0.04 g, pH 6, a temperature of 40 °C, and a contact time of 80 min. The moderate adsorption efficiency observed under optimized conditions may be due to the limited availability of active binding sites and the untreated nature of the biomass. Langmuir isotherm gave the best fit ($R^2 > 0.89$), indicating monolayer adsorption on a homogenous surface with

an adsorption capacity of 0.3398 mg g⁻¹. Kinetic data followed the pseudo-second-order model ($R^2 = 0.90$), suggesting chemisorption as the dominant mechanism. Thermodynamic parameters were revealing an exothermic process ($\Delta H = -10.15$ kJ mol⁻¹), suggesting a mechanism closer to physisorption with decreased randomness at the solid–solution interface ($\Delta S = -28.27$ J mol⁻¹ K⁻¹). A positive Gibbs free energy value ($\Delta G = 1.727$ kJ mol⁻¹) at 298 K showed that adsorption was non-spontaneous under the studied conditions. Overall, although the adsorption capacity was comparatively lower than that of modified biosorbents reported in literature, curry leaves have the potential to remove Cu ions from aqueous medium. Further studies are recommended to enhance adsorption efficiency under realistic environmental and food-related conditions.

Keywords:

Curry leaves, Adsorption, Biosorbent, Isotherm, Kinetic