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Removal of Pb(II) from water by carbonized walnut shell: characterization of adsorbent, adsorption capacity, kinetic, thermodynamic and isotherm studies

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ABSTRACT

The aim of this study is to investigate the efficiency of the carbonized walnut shell (CWS) as adsorbent on the removal of Pb(II) from an aqueous solution. Walnut shell was carbonized in a 500°C heated oven passing N_2 and then characterized by using Brunauer–Emmett–Teller (BET), scanning electron microscopy and Fourier transform infrared spectroscopy (FT-IR). The specific surface area of the sample is 431.99 m^2/g. Adsorption of Pb(II) by various batch experimental conditions such as pH (1.2–6), temperature (26°C, 37°C and 45°C), adsorbent dose (0.4, 0.8, 1 g/L) and metal ion concentrations (50–150 mg/L) was investigated. The maximum adsorption capacity of CWS was obtained as 120.48 mg/g. Three empirical adsorption models (i.e., Langmuir, Freundlich and Temkin) were used for the evaluation of the adsorption equilibrium data. The equilibrium data fitted very well with all of the investigated isotherm models. The adsorption results were also investigated in terms of kinetic and thermodynamic. The kinetic studies showed that the better applicability for the adsorbent was the pseudo-second-order model. The thermodynamic parameters, such as Gibb's free energy change ($\Delta G°$), standard enthalpy change ($\Delta H°$) and standard entropy change ($\Delta S°$), were also evaluated. The results of the thermodynamic parameters ($\Delta G° < 0$, $\Delta S = 40.81$ J/mol/K, $\Delta H° = 9.45$ kJ/mol) showed that the adsorptions were spontaneously endothermic reactions.

Keywords: Pb(II); Adsorption; Kinetic; Isotherm; Thermodynamic

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