Removal of copper, nickel, lead, and zinc using chitosan-coated montmorillonite beads in single- and multi-metal system

Wan-Chi Tsai*, Sonia Ibarra-Buscano*, Chi-Chuan Kan*, Cybelle Morales Futalan*, Maria Lourdes P. Dalida* & Meng-Wei Wan*

Abstract
In this study, the removal of Cu(II), Ni(II), Pb(II), and Zn(II) from aqueous solution in single and multi-metal system using chitosan-coated montmorillonite (ChiMC) beads was investigated. The non-crosslinked and crosslinked ChiMC beads were characterized using SEM–EDX, Fourier transform infrared, and Brunauer, Emmett, and Teller analysis. The effect of ionic strength and pH on the adsorption capacity and percent (%) removal of ChiMC was examined. Kinetic studies revealed that adsorption using ChiMC follows the pseudo-second-order equation with high correlation coefficient values ($R^2 > 0.95$). The equilibrium data were correlated with Langmuir and Freundlich isotherm models, where crosslinked ChiMC provided higher maximum adsorption capacity over ChiMC. The calculated Langmuir adsorption capacities for Cu(II), Ni(II), Pb(II), and Zn(II) using ChiMC in single-metal system are 13.04, 12.18, 29.85, and 13.50 mg/g, respectively. An increase in the calculated adsorption capacities derived from Langmuir isotherm was observed in multi-metal system, indicating a synergistic effect. The adsorption capacity in single- and multi-metal system followed the order: Pb(II) $>$ Cu(II) $>$ Zn(II) $>$ Ni(II). The kinetic rate and adsorption capacity of the four metals were observed to increase in multi-metal systems. The removal of Cu(II), Ni(II), Pb(II), and Zn(II) from groundwater by adsorption onto ChiMC was also investigated.

Keywords: Chitosan, Groundwater, Hydrated ionic radius, Ionic strength, Multi-metal system