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Adsorptive removal of Cd (II) from aqueous solutions by sand/graphite oxide nano-composites: characterization, isotherm, and kinetic studies

Perera W. P. R. T.[1*], Perera P. L. R. A.[2], Kumarasingha A. R.[3], Liyanage J. A.[4]

Core-shell absorbent granules were developed by coating commercial sand gravels with graphite oxide (few-layer oxidized graphene sheets). Graphite oxide (GO) is synthesized chemically from vein graphite, a rare form of high-purity natural graphite (NVG). Modified Hammer's method was followed in order to synthesize graphene oxide from the NVG. Repeated coatings of graphite oxide on the sand followed by low temperature (120 ^{0}C) thermal pyrolysis resulted in core-shell granules with a hierarchical structure in which sand gravels are covered by graphite oxide layers. Five times GO coated water stable sand/graphite oxide nano-composites (M-S/GO) were developed for further adsorption studies. The adsorption performance and mechanism of Cd (II) removal were investigated and FT-IR, SEM, EDX, and XPS were used to characterize the (M-S/GO) as spectroscopic and microscopic characterization methods. Optimization studies were carried out to find the effective pH of the media, dosage, initial concentration of Cd (II), and contact time that reached the equilibrium. Apart from that, the models of kinetics (pseudo-first order and pseudo-second order), and isotherms (Langmuir and Freundlich) were introduced. Characterization findings indicated that un-uniform graphene oxide coatings had been constructed on the sand surface and the surface of the nano-composite comprised of oxygen-based functional groups. Under optimum conditions (0.08 g/L of dosage, 65 mg/L initial Cd concentration, 120 min of contact time), the M-S/GO removed 93.8% of Cd (II) from simulated water at pH 8.0 (30 ± 2 °C) and the process reached equilibrium after 120 minutes. The adsorption capacity of Cd (II) was augmented when increasing the pH of the medium up to pH=8, and then it tended to reduce. Further, the experimental data have been fitted with the Langmuir isotherm model indicating that monolayer adsorption of Cd (II) occurs on the surface of M-S/GO. Apart from that, M-S/GO had a maximum adsorption capacity (mg/g) (Q_{max}) value for Cd (II) adsorption (16.12 mg/g) than sand and GO, the equilibrium parameter (R_L) value in this study was 0.071, which indicates that Cd (II) adsorption onto the surface of the M-S/GO is favorable. The experiment kinetic data were best fitted to a pseudo-second-order kinetic model indicating that Cd (II) has adsorbed onto the surface of the M-S/GO by a chemical sorption mechanism. These findings imply that M-S/GO could be used as an effective adsorbent for removing Cd (II) from contaminated water sources. More research is required to determine the reusability of M-S/GO in the adsorptive removal process.

Keywords: Adsorption, Cadmium, Graphene oxide, Isotherm, Kinetics, Sand

[1] Department of Indigenous Medical Resources, Faculty of Indigenous Health Sciences and Technology, Gampaha Wickramarachchi University of Indigenous Medicine, Sri Lanka
[2] Department of Chemistry, Faculty of Science, University of Kelaniya, Sri Lanka
[3] Department of Physics, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka
[4] CKDu Information and Research Centre, University of Kelaniya, Sri Lanka
* wprtp@gwu.ac.lk