ISSN: 1391-8796
Proceedings of 11th Ruhuna International Science & Technology Conference
University of Ruhuna, Matara, Sri Lanka
January 24, 2024

Nanoscale zero-valent iron biochar composites for heavy metal removal: Thermodynamics, material regeneration, and application to simulated wastewater

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Heavy metals such as lead and cadmium are a major source of water contaminants. Nanoscale zero-valent iron (nZVI) has gained significant interest as a remediation agent, due to its low reduction potential and adsorption capabilities. However, pristine nZVI has inherent issues of agglomeration and passivation which can be mitigated by using an inexpensive support material such as biochar (BC). The carbothermal reduction of iron on BC creates a surface-deposited composite (Lig-sG@nZVI) while simultaneous pyrolysis and reduction of a mixture of iron and carbonaceous material forms an nZVI-embedded BC composite (Lig-eG@nZVI). SEM/EDX results show that Lig-sG@nZVI has a high surface iron loading than Lig-eG@nZVI. In addition, the observed XRD peak patterns confirmed that the loaded iron was present in the zero valent state. Enhanced uptake of Cd(II) and Pb(II) was observed at pH 6 and pH 5, respectively. The experimental data for both heavy metals was best fitted to the Sips isotherm model. For Cd(II), maximum Sips capacities were ×1.45 and ×1.21 higher for Lig-eG@nZVI and Lig-sG@nZVI compared to Lig-BC while for Pb(II) removal, maximum Sips capacities were ×1.44 and ×2.11 greater for Lig-eG@nZVI and Lig-sG@nZVI compared to the control material. Fast remediation kinetics were observed for Cd(II) whereas maximum adsorption was reached at 45 mins for Pb(II). According to thermodynamic studies conducted, the overall adsorption processes were confirmed to be spontaneous and endothermic in nature. Furthermore, the application of synthesized nanocomposites to simulated wastewater showed comparatively increased adsorption capacities.

Key words: Nanoscale zero valent iron, Biochar, Lignin, Heavy metal remediation

Acknowledgement: *Financial support by the Institute of Chemistry Ceylon (Research grant no 21-2)*

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