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Equilibrium studies and dynamic behaviour of cadmium adsorption by magnetite nanoparticles extracted from mill scales waste

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ABSTRACT

The main objective of the current work is to investigate the adsorption mechanism of magnetite that has been extracted from mill scale waste, for the removal of cadmium ions from the aqueous solution. The mill scale was grounded for 24 h in conventional milling and then milled 8 h in high energy ball milling to get nanoparticles. The characterizations of the magnetite mill scale nano adsorbents (MMSNA) were done with a high-resolution transmission electron microscope, field emission scanning electron microscopy, energy-dispersive X-ray spectroscopy, X-ray diffraction, Brunauer–Emmett–Teller and zeta sizer. The magnetite nanoparticles from this work are crystallite, with irregularly shaped particles, a relatively low specific surface area of 4.02 m^2/g, and have an isoelectric point at pH value 5.8. Comprehensive adsorption studies were performed to investigate the adsorption of cadmium ions on the MMSNA, including the evaluation of kinetics and isotherms, the effect of pH, contact time, and mass of adsorbent. The optimal time for removal was 30 min, although the adsorption reached equilibrium within 15 min, which was found to fit well with the pseudo-second-order and Langmuir model. The maximum Langmuir adsorption capacity of the adsorbent was about 3.06 mg/g. The adsorbent was regenerated using a little acidic deionised water and cadmium ions removal of 90% after 5 cycles, which confirms the chemical stability and reusability of the manufactured nanoparticles. The results and analysis of the MMSNA suggest that it can be one of the potential adsorbents for magnetic separation in wastewater treatment.

Keywords: Magnetite nanoparticles; Mill scales waste; Cadmium removal; Equilibrium and kinetic studies

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