Green Synthesis of Iron oxy-hydroxide Nanoparticles from Buttala Magnetite for Removing Multivalent Ions from Contaminated Drinking Water

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The groundwater contamination with various ions poses a serious risk to human health and the environment. In response to the urgent need for sustainable water decontamination technologies, this study produced an environmentally friendly synthesis of iron oxide nanoparticles (IONP) from the natural magnetite using waste tea extract as a reducing agent. Batch experiments examined the adsorption behaviour of anions and cations with different oxidation states. Variables such as contact time, the dosage of adsorbents, and the initial concentration of the parameters were considered during the experiments. Fourier Transform Infrared spectroscopy (FT-IR) and Scanning Electron Microscopy (SEM) methods characterized materials before and after the adsorption experiments. The green synthesized IONP showed a higher binding affinity for tri-valent cations with a maximum removal efficiency of 88% at an optimum dosage of 10 g/L over 60 min. The removal of the mono-valent anion was up to 11% at 1.0 g/L dosage after 30 min of contact time. In contrast, mono-valent and di-valent cations showed very low adsorption, reflecting the selective behaviour of the nanoparticles. Among the adsorption isotherms, the Temkin model was the most suitable for the tri-valent cation and mono-valent anion, reflecting a heterogeneous surface with different adsorption energy. The green synthesis process was found to have an average IONP yield of 87.4%, reflecting its cost and scalability. This study highlights the potential of green-synthesised IONPs for selective ion removal, particularly tri-valent cations, offering a sustainable, cost-effective solution for water treatment. Specific ion removal by these eco engineered IONP offers promising applications for water filtration at household and community levels, which will enhance sustainable development towards access to clean water.

Keywords: Batch adsorption, magnetite, green synthesis, groundwater contamination, water purification