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Groundwater Defluoridation in a Fixed Bed of Aluminium Infused Diatomaceous Earth

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Abstract
Aluminum was infused into diatomaceous earth (AD), via the sol-gel process, to produce a functional, permeable, reactive, filter material for groundwater (GW) defluoridation. The AD was characterized and packed in a column reactor for the defluoridation of simulated water contaminated with F- and GW spiked with F-. The column breakthrough profile, the operation and mass transfer parameters were determined in the AD column reactor at two process variables (i.e. AD bed heights of 6.25, 12.5 and 25 cm and influent F- concentration of 4.16, 19.12 and 35.9 mg/L), to obtain the design parameters for the GW defluoridation in the AD column reactor. The effects of the defluoridation process on pH, electrical conductivity and Al3+ concentration of the treated water was determined. Additionally, the regeneration potential of the spent AD was appraised in different solutions (deionized water, 0.1 and 0.05M of HCl, HNO_3, H2SO4, NaOH, and CH3COOH) in a batch system. The breakthrough profile, the operation and mass transfer parameters of the column reactor, when used for the defluoridation of the simulated water, were influenced by the two process variables studied. The magnitude of the primary adsorption zone (PAZ) factors increased with increasing column bed height while reductions in the values of the PAZ factors were observed when the influent F- concentrations increased. The linear coefficient values (r2), obtained when the breakthrough profile parameters of the two process variables studied were analyzed with different mass transfer equations, showed that the experimental data fitted more to the Thomas, Yoon and Nelson model than the Bohart, Adams and Wolborska mass transfer equations. The maximum regeneration potential of the spent AD was achieved in solutions of HCl, HNO_3, H2SO4, and NaOH while deionized water showed the least regeneration ability. The spent AD exhibited poor stability, identified by high Al3+ leaching, in the solvents that showed maximum regeneration potential. Consequently, the solution of CH3COOH, which also showed appreciable F- desorption but low Al3+ leaching was prescribed as the preferred solvent for the spent AD regeneration. The Temkin equilibrium isotherm equations gave the best description of the experimental data in the simulated aqua system while in the GW system, the Freundlich isotherm equation gave the best fit to the data derived from the batch defluoridation system. The breakthrough profile and the values of the operation parameters of the GW defluoridation system showed that the defluoridation efficiency of the column was significantly reduced, in comparison with the defluoridation of simulated water of comparable influent F- concentrations.
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