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Fluoride Adsorption Using Novel Hydroxyapatite-coated Calcite: Synthesis, Modeling, and Simulation Studies

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Combatting fluorosis in developing regions requires the establishment of effective, low-cost, and culturally acceptable fluoride removal technologies. One adsorbent, hydroxyapatite, is known to be capable of removing fluoride from solution. However, to lower cost and improve flow dynamics, the adsorption capacity of a novel hydroxyapatite coated calcite (HAC) material was investigated.

This calcite-hydroxyapatite material was then characterized via XRD spectra and SEM images to confirm fluoride adsorption on a hydroxyapatite surface. The ratio of reactants, diameter, and surface area were then optimized for maximum fluoride adsorption. The equilibria, kinetics, and column dynamics were then measured. The effect of operational parameters including: influent concentration and composition, flow rate, column size and number, on fluoride adsorption were investigated experimentally in a packed column and theoretically through a 1-dimensional transport model with adsorption and a thermodynamic equilibrium model.

The results indicated that the Langmuir model provided a good fit for the HAC adsorption equilibrium data. Several kinetic models produced a good fit with the adsorption experiments, and the first order kinetic was applied in the transport model.

The findings indicated that fluoride breakthrough time decreases with an increase in initial concentration, increasing flow rate, and with a decrease in column length. By coupling columns in series, filters take advantage of residual adsorption capacity with increases in volumes processed by 5%. Although the adsorption capacity may be lower than commercial adsorbent materials, its abundant availability and low cost allows HAC to be an economical alternative for commercially available sorbents for removing fluoride from groundwater.