



Defluoridation of groundwater using Fe³⁺-modified bentonite clay: optimization of adsorption conditions

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ABSTRACT

Groundwater is the most appropriate and widely used source of drinking water for many rural communities in Sub-Saharan Africa. Studies reveal that in some of the boreholes, F⁻ concentration may be way beyond the recommended limits for drinking water. This study evaluates the use of raw unprocessed bentonite clay and its Fe³⁺-modified form for fluoride adsorption. A series of batch adsorption experiments were carried out to evaluate parameters that influence the adsorption process. Loading of Fe³⁺ on bentonite was achieved by contacting the powdered clay with 80 ppm Fe³⁺ solution for 15 min at S/L ratio of 2 g/100 ml. The raw unprocessed bentonite clay was observed to increase the pH of the F⁻ solution as opposed to the Fe³⁺-modified bentonite. Fe³⁺ bentonite exhibited ≈100% F⁻ removal as opposed to unprocessed bentonite <5% at initial concentration of 10 ppm F⁻. The Fe³⁺-modified bentonite exhibited ≈100% F⁻ removal over the pH range 2–10 decreasing at pH > 10, while the unprocessed raw bentonite clay showed release of F⁻ over the same pH range. This is crucial for the application of this adsorbent, since defluoridation can be carried out at the normal pH of the groundwater with no adjustment unlike most other adsorbents. The Fe³⁺-modified bentonite was effective in F⁻ removal in high fluoride borehole water samples. The adsorption data fitted well to Langmuir adsorption model indicating a monolayer coverage of the adsorbent. The adsorption process was also observed to be favorable at room temperature. The results indicate that Fe³⁺-modified bentonite has potential for application in groundwater defluoridation and more so as a candidate adsorbent for point of use water defluoridation systems for household use in rural areas in South Africa.

Keywords: Batch experiments; Groundwater; Defluoridation; Bentonite clay; Adsorption Isotherms; pH; Cation exchange capacity

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