Fluoride adsorption modeling and the characterization of clays for defluoridation of natural waters.

Summary

High F^- groundwaters occur in various parts of South Africa, namely, the larger part of the Karoo, Limpopo, North West and Northern Cape Provinces. The use of these waters for drinking purposes on continual basis can lead to fluorosis. Fluorosis is a debilitating disease caused by drinking water with F^- concentrations higher than ca. 1 $mg.L^{-1}$. The disease is characterized by mottled teeth in dental fluorosis and brittle bones in severe skeletal fluorosis. Solution to this problem involves the implementation of a method for F^- removal from water.

Defluoridation has become a widely practiced process worldwide due to the problem of fluorosis caused by the presence of F^- in drinking waters. Methods such as adsorption, precipitation, ion exchange and membrane processes have been employed for F^- removal. Adsorption techniques, in particular using activated alumina have proven successful in removing F^- from water. However, this method can not always be used in rural areas because of high costs and technical requirements.

In this study, locally available clays were studied as potential substrates for F^- removal from water. The first part of the study focused on the explanation of mechanisms and the development of an adsorption model. The exchange of OH^- by F^- in the clay structure is the principal mechanism that takes place during adsorption. The change in pH during this exchange process was studied to support and verify the fluoride-hydroxide exchange mechanism.

In the second part of the study, locally available South African clays were studied as possible adsorbents for F^- removal from water. Clays containing aluminium and iron oxide surfaces proved to be useful substrates for F^- adsorption. The adsorption of F^- onto clay samples was found to be pH dependent. Maximum adsorption was achieved at pH 5 for aluminium oxide type sorbents and pH 4 for iron oxides types such as goethite. The effect of physical and chemical pretreatment improved the adsorption capacity of some clays. Coating clay samples with aluminium and iron oxides enhanced the adsorption capacity of clays.

The last part of the study involves the development of a cost-effective and quick way to assess the performance of clays as adsorbents for F^- removal using laboratory scale defluoridation columns.