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Fluoride removal from drinking water using gamma iron oxide-coated metakaolin

A.M. Hasara[1]✉, I.A.A. Gunasekara[1], H. Wijesekara[2], L. Jayarathna[3], S.P.A.U.K. Samarakoon[4]

[1]*Department of Physical Sciences & Technology, Faculty of Applied Sciences, Sabaragamuwa University, Belihuloya, Sri Lanka*
[2]*Department of Natural Resources, Faculty of Applied Sciences, Sabaragamuwa University, Belihuloya, Sri Lanka*
[3]*National Institute of Fundamental Studies, Hanthana Road, Kandy, Sri Lanka*
[4]*Department of Nano Science Technology, Faculty of Technology, Wayamba University, Kuliyapitiya, Sri Lanka*

✉*meanuhasara@gmail.com, +94769944240*

The high concentration of fluoride ions in drinking water presents a significant health hazard to human populations globally. Fluoride can be removed using several methods, such as coagulation, ion exchange, co-precipitation, adsorption, and membrane filtration. Adsorption is an appropriate method for water defluorination due to various benefits. Gamma iron oxide (γ-Fe_2O_3) nanoparticles (NPs) have gained great interest for their potential in fluoride removal. Direct application of γ-Fe_2O_3 NPs might cause some problems, due to their tendency to aggregate in aqueous media. The synthesis of γ-Fe_2O_3 NPs-coated metakaolin was achieved using an easy and economical precipitation approach. The adsorption capacity of the synthesized material was assessed using batch adsorption tests, which examined several experimental circumstances including initial fluoride concentration, contact time, adsorbent dosage, and solution pH. Isotherm and kinetics studies were also performed for γ-Fe_2O_3 NPs coated metakaolin. The γ-Fe_2O_3 coated metakaolin was characterized by Fourier Transform Infrared spectroscopy (FT-IR), Raman spectroscopy, and Surface titration. Characteristic Raman shifts of γ-Fe_2O_3 were observed in the 223, 314, and 718 cm^{-1} band positions. The observed value for the point of zero charge was pH_{PZC} 10.13. The maximum percentage of fluoride removal 96%, was observed with the adsorption capacity of 0.12 mg g^{-1} at the optimum conditions which were obtained at 2.5 mg l^{-1} initial fluoride concentration, pH 5.2, a contact time of 6 hours, 50 rpm shaking speed, 27 °C room temperature, and 20 g l^{-1} fixed adsorbent dosage. The adsorption process exhibited kinetics by following the pseudo-second-order model, which indicates that the fluoride was chemisorbed and correlated with both Langmuir and Freundlich isotherm models according to the correlation coefficient but better with the Langmuir model. The fluoride concentration, adsorbent dosage, and solution pH considerably impacted the adsorption capacity. The results indicate that γ-Fe_2O_3 coated metakaolin can be an adsorbent for reducing fluoride concentrations in drinking water.

Keywords: Adsorption; coating; fluoride; γ-Fe_2O_3 nanoparticles; metakaolin

Underlined is the presenting author.