KINETIC STUDIES OF ADSORPTIVE REMOVAL OF FLUORIDE FROM DRINKING WATER USING γ–Fe_2O_3 COATED SAND

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Safe and readily available water is an important basic need of humans, whether it is used for drinking, domestic use, food production or recreational purposes. Hence, the Sustainable Development Goals (SDG 6) of the United Nations is to make sure universal access of safe drinking water to all by 2030. The problem of fluoride in water has become a major issue in different countries such as Pakistan, India, Sri Lanka, Germany, Sweden, Netherlands, and Japan. Fluoride is considered as an important element that prevents dental caries. Hence, fluoride is added to several water systems and toothpaste. However, daily consumption of fluoride concentrations over 1.5 mg L^{-1} is toxic for health. The removal of fluoride from drinking water has received much attention recently and, different fluoride removal methods have been tested. Adsorption is an efficient and economic method with a high potential for the removal and recovery of fluoride from water. In the present study, an adsorbent material was synthesized using sand and γ-Fe_2O_3 nanoparticles. The adsorption capacity of synthesized γ−Fe_2O_3 coated sand was 0.501 mg dm^{-3} g^{-1} at optimum conditions. The adsorption data for the removal of fluoride fitted with Langmuir isotherm for all concentrations and indicated that the monolayer adsorption process for the removal of fluoride. The first adsorbed fluoride ion initiates the next fluoride ion, and the second fluoride ion adsorbs adjacent to the first molecule because of the strong adsorbent-adsorbate interaction. Kinetic studies were performed to predict the mechanisms of fluoride adsorption on iron oxide coated sand. Reaction kinetics showed the mechanism of adsorption fitted with second-order kinetics. According to the adsorption kinetic data, fluoride ions are chemisorbed to the surface of the adsorbent and the adsorption mechanism is chemically controlled. Fluoride interaction with the γ-Fe_2O_3 surface may happen electrostatically through protonated iron hydroxyl sites or via ligand exchange with the uncharged surface sites. γ-Fe_2O_3-fluoride interaction was strong and fluoride is well chemisorbed to the γ-Fe_2O_3 surface. Raman spectra also showed the formation of Fe-F complexes as the characteristic Fe-F stretching band at 465 cm^{-1} was present in the Raman spectrum of fluoride-treated sample.

Keywords: Adsorbent, Adsorption, Fluoride, Sand, γ-Fe_2O_3 nanoparticles

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