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Characterisation of a new adsorbent (beta cyclodextrin modified hybrid hydrous iron-zirconium oxide) to remove fluoride from aqueous solution

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Prolonged use of fluoride contaminated water (>1.5mg L-1) causes serious problems to public health and ultimately leads to skeletal fluorosis. There is an urgent need to develop more efficient fluoride scavenging materials for designing water filters. A simple and efficient adsorbent (CHIZO, beta-Cyclodextrin (b-CD) amended hydrous iron–zirconium hybrid oxide), has been developed, characterised and tested. The results indicate the efficacy of CHIZO on fluoride removal from an aqueous solution. The agglomerated micro structured composite material has several new features such as very poor crystallinity confirmed from TEM images. BET experiment reveals a surface area of 0.2070 m2 g-1 and pore volume of 0.0476 cm3 g-1. The findings also indicate the highly pH dependent fluoride adsorption by CHIZO which decreases with an increase in pH, and pseudo-second order kinetics control the reaction.Isotherm study indicates Langmuir isotherm was the best fit model to describe the adsorption equilibrium. Significantly higher monolayer adsorption capacity of fluoride (31.35 mg g-1) than the host hydrous Fe–Zr oxide (8.21 mg g-1) at
pH 7.0 and 303 K was observed. Thermodynamic parameter indicates spontaneous nature of CHIZO which is due to the exothermic nature of the reaction. Apart from this phosphate and sulphate have some impact (interference) on fluoride adsorption. b-CD forms inclusion complexes by taking up fluoride ions from water into its central cavity. Several factors are involved regarding high efficacy of the system such as the release of enthalpy-rich water molecules from its cavity, electrostatic interactions, hydrogen bonding and release of conformational strain. However, the regeneration is difficult because of probable entrapping of fluoride inside the cavity of b-CD with hydrogen bonding. It has been found that only 0.9 g of CHIZO is able to reduce the
fluoride level to below 1.0 mg L-1 in one-litre of fluoride spiked (5.0 mg L-1) natural water sample. The study highlights the potentiality of the developed adsorbent. Examples are high adsorption capacity and economical viability.