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Defluoridation of drinking water using physically and chemically modified chitosan

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Depending on the total intake, fluoride (F^-) is known to have both beneficial and adverse effects on humans. As the occurrence of the Chronic Kidney Disease of unknown etiology (CKDu) is thought to be linked with excess levels of F^- in drinking water, the search for efficient, readily available, more affordable and eco-friendly adsorbents that have defluoridation potential has intensified in recent years. Therefore, the current study focuses on use of chitosan-derived adsorbents, physically and chemically modified chitosan for the removal of F^- from drinking water. Physically modified chitosan; chitosan beads (CB), and chemically modified chitosan; protonated glutaraldehyde cross-linked chitosan beads ($GCLCB/H^+$) and protonated glycerol diglycidyl ether cross-linked chitosan beads ($GDCLCB/H^+$) were prepared, and characterized by Fourier Transform Infrared Spectroscopy and Scanning Electron Microscope. Batch experiments were conducted to determine the effect of adsorbent dosage, initial F^- concentration, pH and contact time on defluoridation capacity of $GCLCB/H^+$ at 30 ± 2^0C and the defluoridation capacities of different chitosan derivatives were determined under the optimized conditions (adsorbent dosage = 0.6 g, initial F^- content =15 mg/L, contact time = 30 min, pH = 7). Further, the adsorption isotherm studies were conducted to understand the F^- sorption process. The results revealed that the defluoridation capacities of CB, $GCLCB/H^+$ and $GDCLCB/H^+$ under optimized conditions at 30 ± 2^0C were 76.04 mg/kg, 576.98 mg/kg and 655.37 mg/kg, respectively and these values were significantly greater than that of unmodified chitosan flakes (44.20 mg/kg). The results indicate that physical and chemical modification of chitosan have enhanced the F^- adsorption capacity of chitosan-derived adsorbents. Further, the results of the isotherm experiments indicated that the adsorption process is well fitted to Langmuir and Freundlich isotherm models. Six water samples among the drinking water samples collected around Kirigollewa Grama Niladhari Division in Medawachchiya, have exceeded the permissible level of F^- in drinking water as defined by WHO (1.5 mg/L), but were able to successfully reduce to the permissible range by treatment with $GDCLCB/H^+$. The findings of this study demonstrate that chitosan derived adsorbents are efficient and cost-effective candidates to use in removing F^- ions from drinking water.

Keywords: Chitosan, defluoridation, fluoride, isotherms

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