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The defluoridation of water by acidic alumina

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ABSTRACT

Fluoride is considered as a major inorganic pollutant present in drinking water. To remove this excess fluoride, defluoridation was done by alumina. In the present study, alumina used was acidic in nature and hence considered as a good fluoride removing adsorbent. Characterization of the adsorbent was done by XRD, SEM, BET and FTIR with BET surface area of 144.27 m^2/g. Systematic adsorption experiments were carried out with different process parameters such as contact time, adsorbent mass, pH, temperature and stirring speed. Fluoride adsorption by alumina was highly pH dependent. Maximum fluoride was removed from water at pH 4.4. At very low and very high pH, fluoride removal efficiency was affected. The study of thermodynamic parameters inferred that physical adsorption was dominant with activation energy of 95.13 kJ/mol and endothermic behavior of the process. The kinetics study concluded that pseudo second order kinetics was followed by the adsorption process. Adsorption equilibrium was studied with Langmuir and Freundlich isotherm models. The adsorption process followed Langmuir isotherm with an adsorption capacity of 8.4 mg/g. A regeneration study was proposed in order to reuse the adsorbent for better economy of the process. Finally, a process design calculation was reported to know the amount of adsorbent required for efficient removal of fluoride from aqueous medium.

Keywords: Fluoride; Adsorption; Alumina; Kinetics; Isotherm

1. Introduction

Drinking water scarcity is a major problem in present world. Although abundant sources of groundwater as well as surface water are available, sources of drinking water is very much limited due to contamination of water. Water is contaminated either due to some natural calamities or some anthropogenic activities of human. Nowadays, fluoride is considered as the most common contaminant present in water. This contamination occurs naturally by weathering of fluoride bearing rocks and minerals and volcanic eruption. Other source of fluoride contamination is the discharge of industrial effluents such as metal industry, semiconductor industry, glass and fertilizer industry to the water. This contamination affects the human health severely. Table 1 shows some health effects of fluoride bearing water (Meenakshi and Maheshwari, 2006). Although high concentration of fluoride is not favorable to the human beings, but its small quantity (>1 mg/L) is essential for the formation of teeth and bones. World Health Organisation (WHO) recommended water containing 1.5 mg/L fluoride is safe for drinking purposes (WHO (2nd edition), 1996). But many epidemiological studies have shown possible adverse effects of the long term ingestion of fluoride, even in the places where people are consuming water with fluoride content of 1.5 mg/L. The intake of fluoride comes not only by drinking water with high levels of fluoride, but also by eating food cooked with fluoride containing water. It is important to consider climatic conditions and intake of fluoride from other sources such as food and air. Therefore, by considering the climatic and other aforesaid conditions, the World Health Organisation has set a limit range between 0.5 and 1.0 mg/L (WHO (3rd edition), 2006). According to United States standards, it is in between 0.6 and 0.9 mg/L (WHO (3rd edition), 2006). The Indian standard for the presence of fluoride is 1.0 mg/L and it is the same in China and Bangladesh.

To maintain this permissible limit, various defluoridation techniques have been developed. Chemical coagulation precipitation (Meenakshi and Maheshwari, 2006), ion exchange (Viswanathan and Meenakshi, 2009), electro coagulation (Ghosh et al., 2008), membrane separation (Sehn, 2008) and adsorption (Goswami and Purkait, 2011) are considered as the main defluoridation techniques. All these techniques have

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