Clean Techn Environ Policy
DOI 10.1007/s10098-013-0659-6

ORIGINAL PAPER

Fluoride removal on Fe–Al-impregnated granular ceramic adsorbent from aqueous solution

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Received: 24 August 2012 / Accepted: 19 June 2013

Abstract A novel Fe–Al-impregnated granular ceramic adsorbent has been developed for fluoride removal from aqueous solution. Batch experiments were performed to investigate the effect of contact time, initial pH, adsorbent dose, and the presence of competing anions on the adsorption of fluoride. More than 96 % removal of fluoride was achieved within 48 h from 10 mg/L initial fluoride solution at neutral pH. The adsorption process was well explained with pseudo-second-order and pore diffusion models. The maximum adsorption capacity of adsorbent for fluoride removal was 3.56 mg/g according to the Langmuir isotherm model. The optimum fluoride removal efficiency was observed between pH ranged of 4.0–9.0. The fluoride removal efficiency was significantly decreased in the presence of carbonate and phosphate anions. Results from this study demonstrated potential utility of Fe–Al-impregnated granular ceramic adsorbent that could be developed into a viable method for fluoride removal from aqueous solution.

Keywords Adsorption · Fluoride removal · Granular ceramics · Kinetics and isotherms

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Introduction

Fluoride is one of the three important potentially toxic chemicals, in addition to arsenic and nitrate, which causes large-scale health problems by exposure through drinking water. Widespread occurrence of fluoride above the limit in drinking water has caused multidimensional health problems such as dental caries; bone fluorosis; lesions of the thyroid, endocrine glands, and brain; osteoporosis; and arthritis (Meenakshi et al. 2004; Chen et al. 2010a , b). The guideline value established by the World Health Organization (WHO) is 1.5 mg/L, but this is not a fixed value which will be intended to be adapted to take account of local conditions (WHO 2004). In China, the standard of fluoride concentration in drinking water is 1.0 mg/L (GB 5749, 2006). High fluoride levels in drinking water are a world-wide problem, including various regions in India (Meenakshi et al. 2004), Mexico (Rivera et al. 2002), Africa (Reimann et al. 2003), as well as China (Wang et al. 2012). The available statistics indicate that more than 60 million people are seriously affected by the high fluoride concentration in drinking water, especially in some rural areas in China (Ding et al. 2008).

The most important remedial action is the prevention by keeping fluoride intake within the safe limits. Various technologies such as precipitation (Tor 2007), ion-exchange (Chubar et al. 2005), reverse osmosis (Joshi et al. 1992), electro-dialysis (Ergun et al. 2008), and adsorption (Tor et al. 2009) have been employed for fluoride removal from water. Among these methods, adsorption is a common technique used for fluoride removal from aqueous solution due to its universal, inexpensive, easy handling, and applicable for the removal of pollutants even at low concentration. Large numbers of adsorbents have been investigated for fluoride removal from water based on

Published online: 28 June 2013