Fluoride adsorption on carboxylated aerobic granules containing Ce(III)

Xin-Hua Wang, a, Rui-Hong Song, a,b, Hui-Chun Yang, c, Yi-Jing Shi, a, Guang-Bin Dang, a, Sen Yang, a, Yu Zhao, a, Xue-Fei Sun, a, Shu-Guang Wang, a,*

*Corresponding author. Tel.: +86 531 88362220; fax: +86 531 88364513.
E-mail addresses: xinhuawang@sdu.edu.cn (X.-H. Wang), wsg@sdu.edu.cn (S.-G. Wang).

⇑

a Shandong Key Laboratory of Water Pollution Control and Resource Reuse, School of Environmental Science and Engineering, Shandong University, Jinan 250100, China
b Shandong Institute of Metrology, Jinan 250014, China
c Shandong Environmental Audits and Reception Center of Construction Projects, Jinan 250013, China

ABSTRACT

Aerobic granules (AG) were carboxylated and Ce(III) was incorporated to obtain modified granules (Ce(III)–MAG) for removal of fluoride from aqueous solutions. The Ce(III)–MAG was characterized by SEM, FTIR, XRD and pHpzc, and the introduction of carboxyl groups and Ce(III) was confirmed. The adsorption capacity of Ce(III)–MAG for fluoride was 45.80 mg/g at neutral pH, an increase of 359% compared to the capacity of pristine AG. Adsorption was highest at pH range of 3.0–5.0. A positive effect on fluoride removal in the order of K+/C25 > Ca2+ > Na+ and a negative effect in the order of NO3/C0 > Cl–/C0 > SO4/2 > HCO3/CO3 > PO4/3 was observed. Fluoride adsorption followed the Redlich–Peterson model and the pseudo-first order model with correlation factors of 0.999 and 0.950, respectively. Ce(III)–MAG held up to 790 bed volumes and the effluent fluoride concentration remained below 1.0 mg/L (influent fluoride 10 mg/L).

1. Introduction

In concentrations above 1.5 mg/L, fluoride can be harmful to the environment and human health (WHO, 2006). Removal of fluoride from water sources is sometimes necessary and defluoridation has been achieved by adsorption, chemical precipitation, ion exchange, membrane separation and electrodialysis (Amor et al., 2001; Meenakshi et al., 2008; Reardon and Wang, 2000). Adsorption, especially biosorption is economical and efficient (Sun et al., 2010; Wu and Yu, 2008), and a wide variety of biosorbents such as algal and fungal biomass, and alginate have been explored for fluoride removal (Ramanaiyah et al., 2007; Venkata Mohan et al., 2007; Vijaya et al., 2011). However, a drawback of these biosorbents is their poor settling qualities, leading to washout of the active biomass.

Aerobic granules (AG), which are formed by self-aggregation of microorganisms in the absence of a carrier material, can be an attractive alternative biosorbents for fluoride removal due to their superior settling capability (Liu et al., 2005; Maszenan et al., 2011). AG have been used as biosorbents for the removal of pigments, dyes, and heavy metals (Sun et al., 2008a; Wang et al., 2010; Xu and Liu, 2008); however, biosorption of fluoride onto AG has apparently not been tested.

Amino, hydroxyl, and carboxyl groups on AG have been identified as binding sites for biosorption (Sun et al., 2010; Wu and Yu, 2008), and a wide variety of biosorbents such as algal and fungal biomass, and alginate have been explored for fluoride removal (Ramanaiyah et al., 2007; Venkata Mohan et al., 2007; Vijaya et al., 2011). However, a drawback of these biosorbents is their poor settling qualities, leading to washout of the active biomass.

The main objective of the present study was to prepare carboxylated aerobic granules containing Ce(III) (Ce(III)–MAG) by converting hydroxyl groups to carboxyl group and chelating the