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Novel insights into enhanced dewaterability of waste activated sludge by Fe(II)-activated persulfate oxidation

Guangyin Zhen [a], Xueqin Lu [b], Yuyou Li [c], Youcai Zhao [a,*], Baoying Wang [d], Yu Song [d], Xiaoli Chai [a], Dongjie Niu [a], Xianyan Cao [d]

[a] The State Key Laboratory of Pollution Control and Resource Reuse, School of Environmental Science and Engineering, Tongji University, Shanghai 200092, PR China
[b] School of Environmental and Chemical Engineering, Shanghai University, Shanghai 200072, PR China
[c] Graduate School of Environmental Studies, Tohoku University, 6-6-06 Aza-Aoba, Aramaki, Aoba-ku, Sendai, Miyagi 980-8579, Japan
[d] Shanghai Tongji Construction Co. Ltd., Shanghai 200092, PR China

HIGHLIGHTS

- Fe(II)–$S_2O_8^{2-}$ oxidation is very capable of enhancing the sludge dewaterability.
- 80–86% CST reduction efficiency was obtained within the first 1 min.
- EEM analysis was used to explore the roles of different EPS fractions in sludge dewatering.
- The oxidation destroyed the EPS and cells, releasing EPS-bound water and water of hydration.

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ABSTRACT

The potential of Fe(II)-activated persulfate ($S_2O_8^{2-}$) oxidation on enhancing the dewaterability of sludge flocs from 3-full scale wastewater treatment plants (WWTPs) were investigated. Normalized capillary suction time (CST) was applied to evaluate sludge dewaterability. Both extracellular polymeric substances (EPS) and metabolic activity of microorganisms were determined to explore the responsible mechanism. Fe(II)–$S_2O_8^{2-}$ oxidation effectively improved sludge dewaterability. The most important mechanisms were proposed to be the degradation of EPS incorporated in sludge flocs and rupture of microbial cells. Three-dimensional excitation–emission matrix (EEM) fluorescence spectroscopy confirmed that the powerful $SO_4^{-\cdot}$ from Fe(II)–$S_2O_8^{2-}$ system destroyed the particular functional groups of fluorescing substances (i.e., aromatic protein-, tryptophan protein-, humic- and fulvic-like substances) in EPS and caused cleavage of linkages in the polymeric backbone and simultaneous destruction of microbial cells, resulting in the release of EPS-bound water, intracellular materials and water of hydration inside cells, and subsequent enhancement of dewaterability.

1. Introduction

The activated sludge process is the most widely used biological process for wastewater treatment but has a serious drawback of high excess sludge (Neyens et al., 2004) with water content greater than 95%. Sludge dewatering is of major interest in sludge volume reduction, and facilitation of its transport and ultimate disposal. Such sludge is, however, often difficult to be dewatered, presumably due to the strong hydrophilicity. Different strategies have been studied for sludge dewatering, which include the addition of calcined aluminum salts (Zhen et al., 2011), Fenton pretreatment (Tony et al., 2008), ultrasound conditioning (Feng et al., 2009), microwave irradiation (Yu et al., 2009), and electrolysis (Yuan et al., 2011). Effective dewatering requires the attack of extracellular polymeric substances (EPS) and microorganism cells in sludge flocs. In our previous study (Zhen et al., 2012), first scientific attempt on the use of Fe(II)-activated persulfate oxidation in sludge dewatering has been performed. It showed a sufficiently marked effect in enhancing the sludge dewaterability with approximately 88% CST reduction within 1 min, and therefore was regarded as an efficient and promising technology for the improvement of dewaterability and reduction of excess activated sludge. However, the previous study has mainly focused on the optimization of pretreatment condition, the responsible influencing mechanism, especially the exact roles of different EPS fractions on sludge dewaterability, have not been elucidated clearly by now.

* Corresponding author. Address: The State Key Laboratory of Pollution Control and Resource Reuse, Tongji University, 1239 Siping Road, Shanghai 200092, PR China. Tel.: +86 21 6598 0609; fax: +86 21 6598 0041.
E-mail address: zhaoyoucai@tongji.edu.cn (Y. Zhao).

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