

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect

[www.elsevier.com/locate/jes](http://www.elsevier.com/locate/jes)

**JES**  
 JOURNAL OF  
 ENVIRONMENTAL  
 SCIENCES  
[www.jesc.ac.cn](http://www.jesc.ac.cn)

Q1 **Combined zero valent iron and hydrogen peroxide**  
 2 **conditioning significantly enhances the dewaterability of**  
 3 **anaerobic digestate**

Q3 Q2 **Qilin Wang<sup>1,2</sup>, Jing Sun<sup>3</sup>, Kang Song<sup>1,4,\*</sup>, Xu Zhou<sup>5,\*</sup>, Wei Wei<sup>1</sup>, Dongbo Wang<sup>1</sup>,**  
 5 **Guo-Jun Xie<sup>1</sup>, Yanyan Gong<sup>6</sup>, Beibei Zhou<sup>4</sup>**

6 1. Advanced Water Management Centre, The University of Queensland, St Lucia, Queensland 4072, Australia

7 2. Griffith School of Engineering, Griffith University, Nathan Campus, QLD 4111, Australia

8 3. State Key Laboratory of Pollution Control and Resource Reuse, College of Environmental Science and Engineering, Tongji University,  
 9 Shanghai 200092, China

10 4. Institute of Engineering, Tokyo University of Agriculture and Technology, Tokyo 184-8588, Japan

11 5. Harbin Institute of Technology Shenzhen Graduate School, Shenzhen 518055, China

12 6. School of Environment, Guangzhou Key Laboratory of Environmental Exposure and Health, Guangdong Key Laboratory of Environmental  
 13 Pollution and Health, Jinan University, Guangzhou 510632, China

## ARTICLE INFO

## Article history:

18 Received 19 January 2017

19 Revised 6 April 2017

20 Accepted 6 April 2017

21 Available online xxxx

## Keywords:

36 Anaerobic digestate

37 Dewaterability

38 Sludge

39 Zero valent iron

40 Hydrogen peroxide

## ABSTRACT

The importance of enhancing sludge dewaterability is increasing due to the considerable 23  
 impact of excess sludge volume on disposal costs and on overall sludge management. This 24  
 study presents an innovative approach to enhance dewaterability of anaerobic digestate 25  
 (AD) harvested from a wastewater treatment plant. The combination of zero valent 26  
 iron (ZVI, 0–4.0 g/g total solids (TS)) and hydrogen peroxide (HP, 0–90 mg/g TS) under pH 3.0 27  
 significantly enhanced the AD dewaterability. The largest enhancement of AD dewaterability 28  
 was achieved at 18 mg HP/g TS and 2.0 g ZVI/g TS, with the capillary suction time reduced by 29  
 up to 90%. Economic analysis suggested that the proposed HP and ZVI treatment has more 30  
 economic benefits in comparison with the classical Fenton reaction process. The destruction 31  
 of extracellular polymeric substances and cells as well as the decrease of particle size were 32  
 supposed to contribute to the enhanced AD dewaterability by HP + ZVI conditioning. 33

© 2017 The Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences. 34

Published by Elsevier B.V. 35

## Introduction

48 The most commonly used technology for wastewater treatment  
 49 is the activated sludge process. However, a huge amount of  
 50 excess sludge is generated in this process, which causes  
 51 environmental problem (Foladori et al., 2010; Wang et al.,  
 52 2013a, 2013b; Zhao et al., 2016). Nowadays, excess sludge  
 53 management is one of the major challenges in wastewater  
 54 treatment plants (WWTPs). In fact, treatment and disposal of

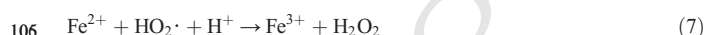
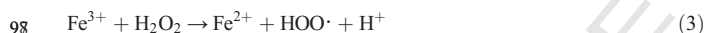
excess sludge incurs large expenditures, which occupy up to 56  
 30%–60% of the total cost of a WWTP (Foladori et al., 2010; Wang 57  
 et al., 2017). 58

The sludge treatment and disposal procedure usually 59  
 encompasses thickening, stabilization, conditioning, dewatering 60  
 and disposal (Foladori et al., 2010). Dewatering has been proven to 61  
 be an efficient method to reduce sludge volume, cutting sludge 62  
 transport and disposal cost. Since sludge has poor dewaterability, 63  
 conditioning process is commonly used to enhance the sludge 64

\* Corresponding authors. E-mails: [songgenhai@gmail.com](mailto:songgenhai@gmail.com) (Kang Song), [zhouxu@hit.edu.cn](mailto:zhouxu@hit.edu.cn) (Xu Zhou).

dewaterability prior to dewatering (Wang et al., 2013c). Sludge comprises free water and bound water. The free water combines with the sludge structure in a loose manner and hence is able to be removed much more easily during the dewatering process. On the contrary, the bound water is combined with the sludge via capillary forces or chemical bonds, which is much more difficult to be eliminated compared with the free water. Sludge conditioning could transform the bound water in sludge into the free water to enhance sludge dewaterability (Wang et al., 2014; Li et al., 2016; Liu et al., 2016a, 2016b; Zhang et al., 2016).

Until now, a number of approaches for sludge conditioning have been investigated. They include classical Fenton reaction treatment, alkaline or acid treatment, flocculation agent addition, freezing and heat treatment (Wang et al., 2014; Gong et al., 2015; Li et al., 2016; Liu et al., 2016a, 2016b; Zhang et al., 2016). Amongst them, Fenton reaction is an excellent approach because it is striking in improving sludge dewaterability (Liang et al., 2015; He et al., 2015). The classical Fenton reaction is composed of a series of reactions between  $\text{Fe}^{2+}$  and hydrogen peroxide (HP) under acid condition (Eqs. (2)–(8)) (Pignatello et al., 2006). In these reactions, huge amount of hydroxyl radical ( $\text{HO}\cdot$ ) is generated (Eq. (2)), which is a much stronger oxidant in comparison to HP (Neyens et al., 2003). When the sludge contacts with hydroxyl radicals, the structure of the sludge is effectively changed and microorganisms would be decomposed by oxidation. This will improve the sludge dewaterability by facilitating the sludge conditioning (Tony et al., 2008; Fontmorin and Sillanpaa, 2015).



Nevertheless, the  $\text{Fe}^{2+}$  is instable compared with zero valent iron (ZVI). ZVI was able to be oxidized to  $\text{Fe}^{2+}$  by acid as a result of its highly reductive characteristics (Eq. (1)). Therefore, ZVI was also able to get involved in the Fenton-like reactions at acidic condition (Eqs. (1)–(8)). Recently, the HP-ZVI system has been investigated to enhance the excess sludge dewaterability (Zhou et al., 2014). The capillary suction time (CST) of excess sludge, which is an indicator of sludge dewaterability, was decreased by around 50% using combined HP and ZVI conditioning (Zhou et al., 2014). However, excess sludge usually undergoes anaerobic digestion before dewatering in most WWTPs, to produce biogas and reduce excess sludge (Foladori et al., 2010; Bacenetti et al., 2013). After this, huge quantities of anaerobic digestate (AD) are still produced, which needs to be dewatered before its final disposal. Nevertheless, the dewatering performance of AD is of great difference compared with that of excess sludge

because of the different characteristics between AD and excess sludge (Foladori et al., 2010; Zhang et al., 2015). Therefore, the efficient conditioning approach for enhancing AD dewaterability deserves to be explored.

This work aims to systematically evaluate the effectiveness of the HP-ZVI conditioning in the AD dewaterability. To the best of our knowledge, it is the first time that the HP-ZVI treatment is employed as an AD conditioning approach to improve AD dewaterability. The AD dewaterability indicator, that is CST, was measured before and after HP-ZVI conditioning. The concentrations of dissolved iron in AD were determined before ZVI-HP conditioning and after ZVI recovery. Soluble chemical oxygen demand (SCOD) concentration in AD was also measured after HP-ZVI conditioning. The economic potential of the HP-ZVI conditioning approach was determined.

## 1. Materials and methods

### 1.1. Sludge and chemicals

The AD was collected from the anaerobic sludge digester of a local biological nutrient removal WWTP. The main characteristics of AD are as following: iron  $320 \pm 5$  mg/L, total solids (TS)  $22.3 \pm 0.4$  g/L, volatile solids (VS)  $19.1 \pm 0.2$  g/L, solid content  $2.23\% \pm 0.04\%$ , moisture content  $97.77\% \pm 0.04\%$ , chemical oxygen demand (COD)  $22.1 \pm 0.2$  g/L, CST  $115.6 \pm 0.7$  sec, and pH 7.72.

ZVI power (size: 80 meshes; Australian Metal Powder Supplies Pty Ltd.) was adopted in this work. The concentration of HP stock solution (Ajax Finechem Co.) was 33%. 30% sulfuric acid was utilized to adjust the AD pH.

### 1.2. Batch experiments

Two groups of batch experiments were carried out to investigate the effects of HP and ZVI levels on the dewaterability of AD, which is shown in Table 1. The first group was to evaluate the effect of ZVI concentrations (0–4.0 g/g TS) when HP concentration was kept at 90 mg/g TS. The second group aimed to evaluate the effect of HP concentrations (0–90 mg/g TS) while the concentration of ZVI was kept at 2.0 g/g TS. All the experiments were prepared and analyzed in duplicate in this work.

**Table 1 – Experimental conditions used in the HP-ZVI enhanced AD dewaterability experiments.**

Group	HP concentration (mg/g TS)	ZVI concentration (g/g TS)
I. Effect of ZVI concentration	90	0
	90	0.25
	90	0.5
	90	1.0
	90	2.0
	90	4.0
II. Effect of HP concentration	0	2.0
	18	2.0
	45	2.0
	90	2.0

ZVI: zero valent iron; HP: hydrogen peroxide; TS: total solids.

Download English Version:

<https://daneshyari.com/en/article/8865529>

Download Persian Version:

<https://daneshyari.com/article/8865529>

[Daneshyari.com](https://daneshyari.com)