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Optimized alkaline pretreatment of sludge before anaerobic digestion

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HIGHLIGHTS

- ▶ NaOH pretreatment was systematically analyzed for anaerobic digestion.
- ▶ The optimized condition of NaOH dose and pH control was concluded.
- ▶ The effects of high pH and high salinity on anaerobic digestion were investigated.
- ▶ The influence of alkaline pretreatment on sludge settleability was compared.

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ABSTRACT

NaOH was used to disintegrate a mixture composed mainly of primary sludge with biofilm sludge before anaerobic digestion in batch experiments. NaOH pretreatment dissolved some organic substances, and the optimum dose was 0.1 mol/L. After the alkali-treated sludge was fed into the digesters, the higher pH delayed the start of digestion and reduced the biogas production during the initial stage, although the system recovered after a lag phase when the dose was lower than 0.04 mol/L. Acid conditioning was necessary, but the increased salinity also impacted on the digestion efficiency. For sludge pretreatment, the optimum NaOH dose was 0.1 mol/L, and the initial pH of the batch digesters needs to be controlled at less than eight. Under optimized conditions, the organic degradation rate was 38.3% and the biogas yield was 0.65 L/g volatile suspended solid (VSS), whereas these values for the control were 30.3% and 0.64 L/g VSS, respectively.

1. Introduction

Waste activated sludge (WAS) is the main by-product of wastewater treatment plants (WWTPs). The disposal of sludge accounts for up to 50% of the operating costs of a WWTP. To minimize WWTP costs, anaerobic digestion is commonly used. This can transform organic matter into biogas, thereby reducing the amount of final sludge solids that need to be disposed of while destroying most of the pathogens in the sludge and limiting odor problems associated with residual putrescible matter (Appels et al., 2008). However, an anaerobic digester requires a large volume due to the long sludge retention time. Since the hydrolysis of sludge particles is the rate-limiting step, pretreatment to disintegrate the sludge is used to accelerate sludge digestion or increase the degree of degradation in a fixed digestion time. Methods of sludge disintegration include mechanical (Hwang et al., 1997; Nah et al., 2000), thermal (Bougrier et al., 2008; Appels et al., 2010; Nielsen et al., 2011), chemical (Lin et al., 1997; Navia et al., 2002; Devlin et al., 2011), ultrasonic (Neis et al., 2000; Hogan et al., 2004; Kim and Lee, 2012) and biological pretreatments. Some methods can be combined to disintegrate the sludge (Chiu et al., 1997; Vlyssides and Karlis, 2004; Takashima and Tanaka, 2010; Vigueras-Carmona et al., 2011; Saha et al., 2011). These pretreatments can disrupt sludge flocs and cells, release inner organic matter, accelerate sludge hydrolysis and, consequently, improve the performance of subsequent anaerobic digestion (Weemaes and Verstraete, 1998; Kim et al., 2003).

Compared with other methods, alkaline pretreatment has several advantages, i.e. simple devices, easy to operate and high efficiency. Most of the investigations exhibited an increase in methane production and decrease in volatile suspended solids (VSS), especially during low-dose alkaline treatment (Lin and Chang, 1997; Lin and Wang, 2009; Navia et al., 2002; López Torres and Espinosa Lloréns, 2008). The preferred reagent, in most cases, was sodium hydroxide (NaOH), which was reported to yield greater solubilization efficiency than calcium hydroxide ($Ca(OH)_2$) (López Torres and Espinosa Lloréns, 2008). The dose of NaOH was commonly controlled at a low level of 0.08–0.16 g/g total sludge solids (TS) (Lin and Chang, 1997; Lin and Wang, 2009) or 0.25 g/g TS (Navia et al., 2002), although increasing the dose enhanced alkaline sludge disintegration (Li et al., 2008). If a high dose of NaOH

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