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Mixing effect on thermophilic anaerobic digestion of source-sorted organic fraction of municipal solid waste

Sophia Ghanimeh [a], Mutasem El Fadel [a,*], Pascal Saikaly [a,b]

[a] Department of Civil and Environmental Engineering, American University of Beirut, Lebanon
[b] Water Desalination and Reuse Research Center, King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia

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ABSTRACT

This paper examines the effect of mixing on the performance of thermophilic anaerobic digestion of source-sorted organic fraction of municipal solid waste during the start-up phase and in the absence of an acclimated seed. For this purpose, two digesters were used under similar starting conditions and operated for 235 days with different mixing schemes. While both digesters exhibited a successful startup with comparable specific methane yield of 0.327 and 0.314 l CH_4/g VS, continuous slow stirring improved stability by reducing average VFA accumulation from 2890 to 825 mg HAc/l, propionate content from 2073 to 488 mg/l, and VFA-to-alkalinity ratio from 0.32 to 0.07. As a result, the startup with slow mixing was faster and smoother accomplishing a higher loading capacity of 2.5g VS/l/d in comparison to 1.9g VS/l/d for non-mixing. Mixing equally improved microbial abundance from 6.6 to 10 g VSS/l and enhanced solids and soluble COD removal.

1. Introduction

Food waste is an attractive source of renewable energy if microorganism-based bioenergy technologies such as anaerobic digestion (AD) can successfully convert it to methane. While early work in AD has focused on mesophilic temperature regimes (35–40 °C), considerable efforts are targeting thermophilic temperatures (55–60 °C) to increase organic loading rate, gas production, and resistance to foaming, as well as enhance biodegradation of organics (Zabranska et al., 2002). However, thermophilic AD is hindered by operational difficulties and instability problems often connected with poor startup (Angelidaki et al., 2006). Indeed, successful and fast start-up is considered a challenging obstacle because of the lack of acclimated thermophilic seeds often leading to instability and failure of the system. Even where anaerobic systems are well established, the number of thermophilic digesters is still limited and it is relatively difficult to acquire sufficiently large quantities of acclimated seed for starting up new thermophilic digesters (Suwannoppadol et al., 2011).

At the micro-environment level, successful startup and stability of anaerobic digesters are highly affected by: (1) the degree of contact between the microbial consortia and the substrate, and (2) the interaction between methanogens and their syntrophs. Both are primarily a function of the mixing scheme in the reactor (Karim et al., 2005). However, the effect of mixing on microbial dynamics and digester parameters is still unclear (Ward et al., 2008). Consequently, the need for adequate mixing has been supported by many researchers (Bridgeman, 2012; Conklin et al., 2008; Elnekave et al., 2006; Gerardi, 2003; Halalsheh et al., 2011; Karim et al., 2005; Zabranska et al., 2002) and, concurrently, questioned by many others (Gomez et al., 2006; Ike et al., 2010; Kaparaju et al., 2008; Kim et al., 2002; Steinberg and Regan, 2011; Stroot et al., 2001; Suwannoppadol et al., 2011; Ward et al., 2008). The impact of mixing on startup of mesophilic co-digestion systems and thermophilic digesters fed with acetate was addressed by Stroot et al. (2001) and Suwannoppadol et al. (2011), respectively. However to date, mixing effects during startup of thermophilic digesters relying entirely on source-sorted organic fraction of municipal solid waste (SS-OFMSW), in the absence of an acclimated seed have not been reported. Therefore, the objective of this study is to assess the effect of mixing on the performance of thermophilic AD treating SS-OFMSW during the start-up phase, using cattle manure as a seeding source.

2. Methods

2.1. Waste collection and preparation

The SS-OFMSW was collected from restaurants and food markets in two consecutive batches. The waste was ground and

Abbreviations: AD, anaerobic digestion; HRT, hydraulic retention time; IA, intermediate alkalinity; OLR, organic loading rate; OFMSW, organic fraction of municipal solid waste; PA, partial alkalinity; TA, total alkalinity; TDS, total dissolved solids; TS, total solids; VFA, volatile fatty acids.

* Corresponding author. Address: American University of Beirut (AUB), Faculty of Engineering and Architecture, Bliss Street, P.O. Box 11-0236, Beirut, Lebanon. Tel.: +961 3 228 338.
E-mail address: mfadel@aub.edu.lb (M. El Fadel).

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