



Experimental and modeling study of a two-stage pilot scale high solid anaerobic digester system

Liang Yu, Quanbao Zhao, Jingwei Ma, Craig Frear, Shulin Chen *

Department of Biological Systems Engineering, Washington State University, Pullman, WA 99164, USA

HIGHLIGHTS

- ▶ A new high solid anaerobic digestion (HSAD) system was constructed.
- ▶ Establish a comprehensive model to configure HSAD system.
- ▶ Methane production was enhanced by increased UASB section area.
- ▶ UASB height had little impact on methane production.

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ABSTRACT

This study established a comprehensive model to configure a new two-stage high solid anaerobic digester (HSAD) system designed for highly degradable organic fraction of municipal solid wastes (OFMSW). The HSAD reactor as the first stage was naturally separated into two zones due to biogas floatation and low specific gravity of solid waste. The solid waste was retained in the upper zone while only the liquid leachate resided in the lower zone of the HSAD reactor. Continuous stirred-tank reactor (CSTR) and advective–diffusive reactor (ADR) models were constructed in series to describe the whole system. Anaerobic digestion model No. 1 (ADM1) was used as reaction kinetics and incorporated into each reactor module. Compared with the experimental data, the simulation results indicated that the model was able to well predict the pH, volatile fatty acid (VFA) and biogas production.

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1. Introduction

Anaerobic digestion (AD) for converting the organic fraction of municipal solid wastes (OFMSW) to renewable energy and reducing environmental impact of late has focused on the use of high solid anaerobic digester (HSAD) designs. This results primarily from their ability to substantially reduce the size of the reactor, thus reducing the footprint and improving the economics of the system (Rivard et al., 1989; Yu et al., 2011). Given the large biodegradable organic content of OFMSW (i.e. food waste, green waste), a major limitation of AD of these wastes in a one stage system is rapid uncontrolled acidification and decrease in pH within the reactor, which inhibits the activity of methanogenic bacteria (Arvanitoyannis, 2008; Schievano et al., 2010). Furthermore, it is difficult to optimize the AD process in the one stage system because methanogenic and non-methanogenic bacteria are significantly different with respect to physiology, nutritional requirements, growth and

metabolic characteristics, environmental optima and sensitivity to environmental stress (Jagadabhi et al., 2011). Therefore, two-stage systems appear to be more efficient technologies for AD of food waste (Demirel and Yenigun, 2002).

Various two-stage technologies have been used to overcome the above problems in converting OFMSW into bio-methane. Leach bed reactors (LBR) have often been used as first stage digesters in previous research (Lehtomaki et al., 2008; Nizami et al., 2011). However, LBR are prone to mass transfer limitations because the solids tend to be agglomerated, resisting enzyme and microorganism diffusion. Some researchers have employed continuous stirred tank reactors (CSTR) as the first stage digesters to reduce this concern and enhance hydrolysis of the solids (Cavinato et al., 2011; Dinsdale et al., 2000). However, total mixing may impair the separation of liquid from solid, a step required for effective feed of liquid and soluble organics to the second stage digester. Although a rotating drum mesh filter has been designed to mix and separate solids and liquid simultaneously in a first stage digester (Walker et al., 2009), high energy consumption and complicated manufacture remain a concern to project costs. In order to design and

* Corresponding author. Tel.: +1 509 335 3743; fax: +1 509 335 2722.

E-mail address: chens@wsu.edu (S. Chen).