Bioresource Technology 126 (2012) 425–430

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Effect of inoculum to substrate ratio on the hydrolysis and acidification of food waste in leach bed reactor

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ARTICLE INFO

Article history:
Received 8 October 2011
Received in revised form 11 December 2011
Accepted 12 December 2011
Available online 17 December 2011

Keywords:
Acidogenesis
Anaerobic digestion
Inoculum to substrate ratio
Kinetics study
Proteolytic bacteria

ABSTRACT

The aim of present study was to determine an appropriate ISR (inoculum to substrate ratio) to enhance the hydrolysis rate and reduce the solid retention time of food waste in hydrolytic-acidogenesis leach bed reactor (LBR). LBR 1–4 were inoculated with 0%, 5%, 20% and 80% (*w/w* basis) of anaerobically digested sludge, respectively, using artificial food waste as substrate. Experiments were conducted in batch mode at mesophilic condition (35 °C) for 17 days. Higher ISR resulted in 4.3-fold increase in protein hydrolysis; whereas, only a modest increase in the decomposition of carbohydrate. Two kinetic models for carbohydrate and protein degradation were proposed and evaluated. The differences among four ISRs in volatile solids removal efficiencies were marginal, i.e. 52.4%, 62.8%, 63.2% and 71.7% for LBR 1–4, respectively; indicating that higher ISR was insignificant in enhancing the overall hydrolysis rate in LBR. Therefore, a lower ISR of 20% was recommended in the hydrolytic-acidogenic process.

1. Introduction

The demands for reduction and effective utilization of municipal solid waste (MSW) have increased immensely for Hong Kong in recent years due to the limited landfill space. Anaerobic digestion of sorted organic fraction of MSW, especially food wastes, is the utmost attractive alternative and one of the most cost-effective technologies. Anaerobic digestion (AD) of organic matter is generally considered to be a two-step process in which the acidogenesis and methanogenesis are in dynamic equilibrium (Vavilin et al., 2001). Therefore, it is logical to develop a two-stage anaerobic digestion system, consisted of leach bed reactor (LBR) and upflow anaerobic sludge blanket (UASB) that can separate acidogens and methanogens spatially for the regulation of the two groups of microbial communities.

In general, the growth rates of acidogens ranged from 0.05 to 1.79 h^{-1}, which is about ten times higher than that of acetogens and methanogens ranging from 0.008 to 0.173 h^{-1} (Kalyuzhnyi, 1997; Vavilin et al., 2001). The imbalance between acid production by the acidogens and the acid consumption by the methanogens resulting from the different growth rate is the principle incentive and momentum of the stage separation. In the start-up of an anaerobic digester, an appropriate ratio of inoculum to substrate (ISR) should be added to enhance the hydrolysis of particular organic matter, accelerate biogas production rate, and consequently reduce the operation time (Raposo et al., 2009). About 80% of total biogas yield was achieved after the first 8 days of digestion for an ISR of 0.35 (*vs/vs* on the basis of volatile solid) with a single-stage batch AD of food and green wastes, where it was only 47% for ISR of 0.25 (*vs/vs*) (Liu et al., 2009).

However, due to the higher growth rate of acidogens than methanogens (Qi et al., 2003), it is reasonable to expect a lower ISR in the separated acidogenic reactor than methanogenic reactor. Nevertheless, previous studies on ISR were mostly investigated in the single-stage methanogenic reactor (Neves et al., 2004; Liu et al., 2009), and rarely on the startup of an acidogenic reactor. Furthermore, a wide range of ISR values were employed in existing studies and it is hard to make a comparison among the different substrates used. For example, an ISR of 1.0 (*vs/vs*) was suggested for the acidogenic fermentation of grass (Jagadabhi et al., 2010), whereas 0.02 (*vs/vs*) for manure (Demirer and Chen, 2008) and 0.13 (*vs/vs*) for food waste (Stabnikova et al., 2008) were reported.

Therefore, the objective of the present study was to determine the hydrolysis and acidogenesis rate of food waste under different ISR values, i.e. 0%, 5%, 20% and 80% (*w/w*) within lab scale LBR at 35 °C. The kinetics of hydrolysis rates of the particulate matters were then evaluated by the first-order equation and Contois equation.

2. Methods

2.1. Food waste and inoculum

Selected properties of the food waste and inoculum used in the study are described in Table 1. Synthetic food waste with a total

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doi:10.1016/j.biortech.2011.12.059