Bioresource Technology 130 (2013) 710–718

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Optimization of biological hydrogen production for anaerobic co-digestion of food waste and wastewater biosolids

Peiqing Zhou [a], Elsayed Elbeshbishy [b,*], George Nakhla [a]

[a] Civil and Environmental Engineering Department, University of Western Ontario, London, ON, Canada N6A 5B9
[b] Trojan Technologies, London, ON, Canada N5V 4T7

HIGHLIGHTS

- ▶ Anaerobic co-digestion of 21 mixtures of FW, PS, and WAS were evaluated.
- ▶ The maximum hydrogen yields of FW + PS and FW + WAS were achieved at ratios of 75:25.
- ▶ The maximum hydrogen yield FW + PS + WAS was achieved at ratio of 80:15:5.
- ▶ Optimum COD/N of FW + PS, FW + WAS, and FW + PS + WAS were 26, 31 and 30, respectively.
- ▶ A synergistic effect of co-digestion was observed and quantified.

ARTICLE INFO

Article history:
Received 28 September 2012
Received in revised form 6 December 2012
Accepted 10 December 2012
Available online 20 December 2012

Keywords:
Biohydrogen
Co-digestion
Food-waste
Sewage sludge
Dark fermentation

ABSTRACT

Batch anaerobic co-digestion studies were conducted using 21 mixtures (M1–M21) of food waste (FW), primary sludge (PS), and waste activated sludge (WAS) at 37 °C and an initial pH of 5.5 ± 0.2. The results showed that co-digestion of FW and sludges had a positive impact on the hydrogen production. The maximum hydrogen yields by co-digestion of FW + PS, FW + WAS, and FW + PS + WAS were achieved at volumetric ratios of 75:25, 75:25, and 80:15:5, respectively, with corresponding optimal COD/N mass ratios of 26, 31 and 30, respectively. Furthermore, the synergistic effect of co-digestion was proven and quantified: the measured hydrogen productions were higher than the sums of the hydrogen productions calculated from each fraction, and the highest percentage increase above the calculated value of 101%, was achieved in the FW + PS + WAS mixture (80:15:5).

1. Introduction

Minimal or zero use of hydrocarbons, with only water as a combustion production and a high energy yield of 122 kJ/g (2.75 times greater than that of hydrocarbon fuel) render hydrogen as one of the promising sustainable energy resources (Han and Shin, 2004). Hydrogen production addresses three of today's major energy problems: soaring energy demand, environmental pollution, and fossil fuel dependence (Momirlan and Veziroğlu, 1999). Due to high electricity requirement by conventional physico-chemical hydrogen production methods (such as water electrolysis, chemical cracking of hydrocarbons, etc.) biological hydrogen production has recently attracted more attention (Hawkes et al., 2002). Photo-fermentation and dark fermentation are the two main types of biological hydrogen production (Antonopoulou et al., 2010). Lower operational cost, greater hydrogen production rate, wider range of organic substances and simplicity rationalize the superiority of dark fermentation over photo-fermentation (Xie et al., 2012; Hallenbeck and Benemann, 2002).

Since carbohydrates are the preferred substrates for dark fermentative hydrogen-producing bacteria such as *Clostridium* species, food waste (FW) with its high content of organic matter and carbohydrates, and its easily hydrolysable nature has a high hydrogen production potential (Kim et al., 2004). Moreover, FW, as an important municipal and agricultural waste, can be an economical source for fermentative hydrogen production (Zhu et al., 2008). FW

Abbreviations: C/N, carbon to nitrogen ratio; DOPF, dufferin organics processing facility; FA, free ammonia; FW, food waste; PS, primary sludge; SCOD, soluble chemical oxygen demand; SSO, source separated organics; S^0/X^0, initial substrate-to-biomass ratio; TA, total ammonia; TCOD, total chemical oxygen demand; TN, total nitrogen; TP, total phosphorous; TSS, total suspended solids; TVFAs, total volatile fatty acids; VSS, volatile suspended solids; VS/TS, volatile solids to total solids ratio; WAS, waste activated sludge.

* Corresponding author. Tel.: +1 519 860 3556.
E-mail addresses: sayedbesh@yahoo.com, eelbeshb@uwo.ca, selbeshbishy@trojan.com (E. Elbeshbishy).

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.12.069