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Published in:
Bioresource Technology

DOI:
10.1016/j.biortech.2013.12.054

2014

Bioresource Technology

Volume 154, February 2014, Pages 215–221

http://dx.doi.org/10.1016/j.biortech.2013.12.054

Comparison of high-solids to liquid anaerobic co-digestion of food waste and green waste

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Highlights

- High-solids and liquid co-digestion of food waste (FW) and green waste (GW).
- Optimal biogas production was achieved at FW:GW mixing ratio of 40:60.
- Methane yields at 15–20% total solids (TS) were higher than that at 5–10% TS.
- Organic overloading at high TS content (25%) caused inhibition of methanogenesis.
- Volumetric productivity at 15–25% TS was 3.8- to 4.6-fold higher than that at 5% TS.

Abstract

Co-digestion of food waste and green waste was conducted with six feedstock mixing ratios to evaluate biogas production. Increasing the food waste percentage in the feedstock resulted in an increased methane yield, while shorter retention time was achieved by increasing the green waste percentage. Food waste/green waste ratio of 40:60 was determined as preferred ratio for optimal biogas production. About 90% of methane yield was obtained after 24.5 days of digestion, with total methane yield of 272.1 mL/g VS. Based the preferred ratio, effect of total solids (TS) content on co-digestion of food waste and green waste was evaluated over a TS range of 5–25%. Results showed that methane yields from high-solids anaerobic digestion (15–20% TS) were higher than the output of liquid anaerobic digestion (5–10% TS), while methanogenesis was inhibited by further increasing the TS content to 25%. The inhibition may be caused by organic overloading and excess ammonia.

Keywords

High-solids anaerobic digestion; Co-digestion; Food waste; Green waste; Biogas

1. Introduction

Bioenergy recovery and pollution control through anaerobic digestion (AD) of organic wastes is a promising greenhouse gas mitigation option and considered to be a sustainable waste treatment practice (Pantaleo et al., 2013 and Rajagopal et al., 2013). Since methane rich biogas is the main end product of AD, methane production must be improved to maximize revenues from energy generation and hence, to make digestion facilities more profitable (Fdez-Güelfo et al., 2012). Driven by a complex and diverse community of microbial organisms, the performance of AD is affected by a variety of operational factors, such as temperature, pre-treatment of substrates, and digester mixing. The total solids (TS) content in association with the organic loading rate is also one of the key factors that affect the performance, cost and stability of AD systems (Alvarez and Liden, 2008 and Wu et al., 2009). It has been reported that the TS content affects the following parameters: rheology and viscosity of the digester contents, fluid dynamics, clogging, and solid sedimentation that can directly influence the overall mass transfer rates within the digesters (Karthikeyan and Visvanathan, 2013).

Since the TS content is an important parameter, two main types of AD processes have been developed: liquid and high-solids AD. Liquid AD (L-AD) systems typically operate with 0.5–15% TS, while high-solids AD (HS-AD) refers to a process that generally operates at 15–40% TS (Shi et al., 2013). It has been claimed that HS-AD is advantageous over L-AD for a number of reasons including higher volumetric loading capacity, reduced energy input for heating and mixing, and greater ease in handling the compost-like digestate (Li et al., 2011). However, both HS-AD and L-AD have their own advantages and disadvantages with respect to methane production maximization and process optimization. Even though the HS-AD process is reported to tolerate high organic loadings, low operational stability still hinders wide application of HS-AD technology (Schievano et al., 2010). HS-AD may be particularly sensitive to the inhibition caused by overproduction of volatile fatty acids (VFAs) and ammonia, due to organic overloading. However, so far, information is lacking concerning the quantitative threshold of the TS content below which methane production from HS-AD is higher or comparable to the output of L-AD.

There are some studies related to the effect of the TS content on the performance of AD process. Forster-Carneiro et al. (2008) analyzed the AD process of food waste with three different TS levels. The results showed that reactors at 20% TS achieved a higher methane production compared to 25% and 30% TS. In a study conducted by Wu et al. (2009), no significant differences were observed in the methane production ranging from 351 to 381 mL/g $VS_{feedstock}$, applied to four TS contents of 1%, 2%, 5% and 10%. Recently, Brown et al. (2012) evaluated several lignocellulosic feedstocks (switchgrass, corn stover, wheat straw,