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EXTENDED ABSTRACTS

Methanogenic Activity in Biogas Production High-Solids and Liquid Anaerobic Co-Digestion of Municipal Solid Waste and Sewage Sludge

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1. Introduction

Bioenergy recovery and pollution control through anaerobic digestion (AD) of organic wastes is a promising greenhouse gas mitigation option and is considered to be a sustainable waste treatment practice (Pantaleo et al., 2013; 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).

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; 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 5-10% TS, while high-solids AD (HS-AD) refers to a process that generally operates at 15-40% TS (Shi et al. 2013).

The purpose of this study was to determine the optimal mixing ratio of co-digestion municipal solid waste and sewage sludge. Then, the effect of high-solids and liquid anaerobic digestion on the mixing ratio was investigated using pilot-scale anaerobic non-continuous bioreactors.

2. Methodology

Experiments were performed on glass digesters with a volume of 1L at 37 °C with different levels of total solid (TS) percent (5, 10, 15, 20 and 25% TS) in a completely randomized design with three replications. The volume of biogas produced, the amount of methane and pH changes were measured daily. Every day for better mixing, the digests were shaken manually for 30 seconds. Total solids, volatile solids, carbon and nitrogen percentages in raw material and C/N ratio were measured by APHA standard.

3. Results and discussion

Fig. 1 Shows the cumulative yield of biogas production from active digestion systems of solid Materials 5, 10, 15, 20 and 25%, respectively, at 376, 327, 293, 247 and 160 mL/g VS so that after 19 days, approximately 96/15, 89.30, 85.32, 79.90, and 84.93% of cumulative biogas yield were obtained. According to Fig. 1, it is observed that the retention time of the wet anaerobic digestion system (5% and 10% TS) is about 20 days and the reaction time for the dry anaerobic digestion system (15%, 20% and 25% TS) is about 30 days. Lee et al.

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Also compared the reaction time of dry and wet anaerobic digestion and reported that reaction time dry anaerobic digestion was slower than that of digestion (Li et al. 2011).

Fig. 1 shows the amount of methane produced by the joint digestion of municipal waste and sewage sludge with different percentages of TS. Statistical analysis showed significant TS on methane content. Methane content from 49.8 to 59.57% varied in the range of different TS levels. The cumulative yields of methane at different TS levels (5 to 25% TS) were measured as 222.7, 194.8, 146, 124.4 and 83.3 mL/g VS, respectively (Fig. 1). Higher methane yields at the 5 and 10% TS levels indicate that methane production in anaerobic digestion is higher than dry anaerobic digestion (Cesaro and Belgiorno, 2013). However, increasing the TS content from 5% to 25% results in a 62% reduction in methane production is one of the reasons it can be a suitable mixer, uniform distribution of microorganisms and temperature uniformity within the reactor. The results of the present study indicate the fact that methane yield of dry anaerobic digestion in comparison with less anaerobic digestion.

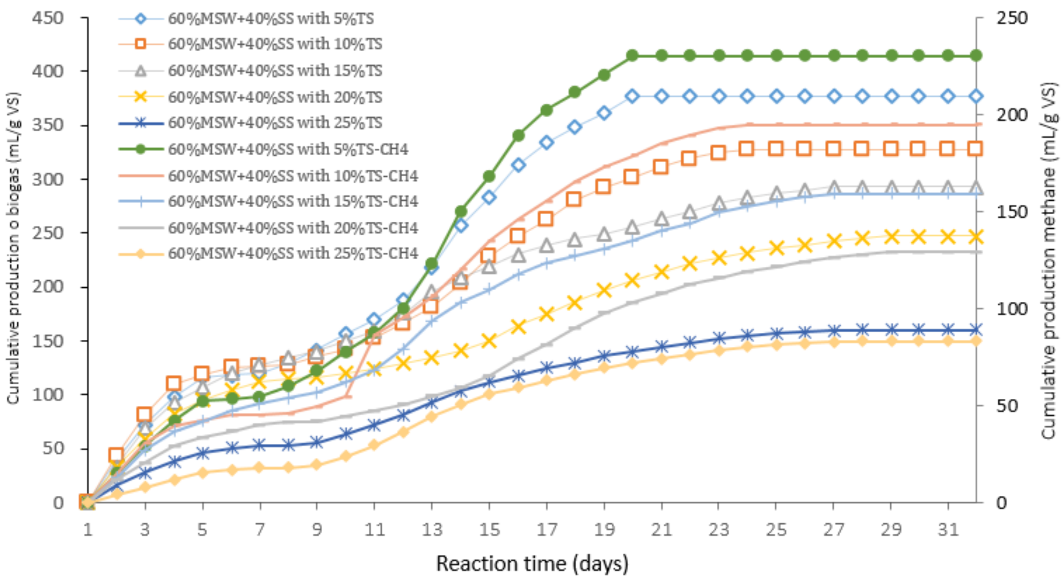

Fig. 1. Cumulative production biogas and methane at various levels of TS (T= 37 °C, F/I=105 mL, HRT=32 day)

4. Conclusions

The optimal yield was obtained for co-digestion of municipal solid waste and sewage sludge at a mixing ratio of 60:40 (60% municipal waste and 40% sewage sludge). The low C/N ratio of sewage sludge improved after the addition of municipal waste and was within the appropriate range of anaerobic digestion, and sewage sludge as an effective material for biogas production from municipal solid waste in a limited amount (up to 40% mixing ratio). Too much of it delays the fermentation process. Based on the optimum ratio, the effect of different percentages of total solids (5 to 25% TS) on anaerobic digestion in non-continuous systems was investigated. The results showed that methane yield was more favorable in wet anaerobic digestion (5 and 10% TS) compared with dry anaerobic digestion (15 to 25% TS).

5. References

Alvarez R, Liden G, "Semi-continuous co-digestion of solid slaughterhouse waste, manure, and fruit and vegetable waste", Renewable Energy, 2008, 33 (4), 726-734.

Cesaro A, Belgiorno V, "Sonolysis and ozonation as pretreatment for anaerobic digestion of solid organic waste", Ultrasonics Sonochemistry, 2013, 20 (3), 931-936.

Fdez-Güelfo L, Álvarez-Gallego C, Sales D, García R, "Dry-thermophilic anaerobic digestion of organic fraction of municipal solid waste: methane production modeling", Waste Management, 2012, 32 (3), 382-388.

Karthikeyan P, Visvanathan C, "Bio-energy recovery from high-solid organic substrates by dry anaerobic bio-conversion processes: a review", Reviews in Environmental Science and Bio/Technology, 2013, 12 (3), 257-284.

Li Y, Park S, Zhu J, “Solid-state anaerobic digestion for methane production from organic waste”, Renewable and Sustainable Energy Reviews, 2011, 15 (1), 821-826.
Pantaleo A, De Gennaro B, Shah N, “Assessment of optimal size of anaerobic co-digestion plants: an application to cattle farms in the province of Bari (Italy)”, Renewable and Sustainable Energy Reviews, 2013, 20, 57-70.
Rajagopal R, Massé D, Singh G, “A critical review on inhibition of anaerobic digestion process by excess ammonia”, Bioresource Technology, 2013, 143, 632-641.
Shi J, Wang Z, Stiverson J, Yu Z, Li Y, “Reactor performance and microbial community dynamics during solid-state anaerobic digestion of corn stover at mesophilic and thermophilic conditions”, Bioresource Technology, 2013, 136, 574-581.
Wu G, Healy M, Zhan X, “Effect of the solid content on anaerobic digestion of meat and bone meal", Bioresource Technology, 2009, 100 (19), 4326-4331.