Effect of Cow Dung Inoculum on Biogas Generation from Anaerobic Digestion of Organic Fraction of Municipal Solid Waste – A Case Study of India

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1. Introduction

India has witnessed a tremendous growth in municipal solid waste (MSW) generation in the last two decades. The generation of MSW in India has increased from 51,535 tonnes/d (TPD) in year 1999-2000 to 143,449 TPD in year 2014-2015. Waste management is one of the major issues that India is facing currently, as more than 80% of the total generated wastes reaches the landfills. Basically, there are two types of methods (thermal conversion and mechanical biological treatment) by which MSW can be treated. Thermal conversion technologies such as incineration, gasification and pyrolysis are not suitable for Indian conditions due to poor calorific value and high moisture content of the waste stream. The organic content in the MSW of India is more than 50% (Yap and Nixon, 2015). Therefore, due to high organic and moisture content, anaerobic digestion (AD) could be the best option for the treatment of organic fraction of MSW (OFMSW). However, due to lack of technical expertise, operational issues and process instability, AD is still not commercialised to recover energy from MSW. For efficient AD process, maintaining an appropriate environmental conditions inside the reactor is necessary. The present study aims to identify the parameters which influences the biogas generation rate in Indian scenario.

2. Materials and methods

2.1. Feedstock and inoculum materials

The feedstock for the reactor was separately collected degradable OFMSW from households of the Dhanbad City, India. The OFMSW used in the present study composed of food waste, paper/cardboard and yard waste (Kumar and Samadder, 2017). The inoculum for this study was fresh cow dung (CM) collected from a farm. Zamanzadeh et al. (2017) reported that CM is an excellent co-digestion substrate for OFMSW and have higher biogas yield as compared to sewage.

2.2. Reactor set-up

Aspirator bottles made of glass of capacity 1000 mL with bottom sampling ports were used as bioreactors in the present study. The effective working volume of the reactor was 700 mL. For optimal AD process and high methane yield, Neves et al. (2004) reported substrate to inoculum (S/I) ratio ranging from 0.5 to 2.3. The total solids (TS), volatile solids (VS), pH, moisture content, elemental carbon and nitrogen were measured using standard procedure. The characteristics of feedstock (OFMSW and inoculum) are shown in Table 1. The reactors were filled with three different S/I ratio (0.5, 0.63, 0.75 and 1.0) based on VS contents (Table 2). The inoculum and substrate were thoroughly mixed in the blender before pouring into the reactor. The digestion system was batch anaerobic fermentation at mesophilic temperature (35°C) maintained using hot water bath. Water displacement method was used for measurement of biogas production at a fixed time every day.

Table 1. Characteristics of feedstock

Parameter	OFMSW	CM
Moisture content (%)	81.2	84.4
pH	5.3	7.4
Total Solid (TS) (%)	18.8	15.6
Volatile Solid (VS) (%)	90	79.3
COD (mg/L)	79800	19600
Carbon, C (% d.b.)	45.12	37.34
Nitrogen, N (% d.b.)	1.58	3.03
C/N ratio	28.56	12.32

Table 2. Feedstock combinations in batch reactors

Reactor	Mix. ratio (on VS basis)	OFMSW (g VS/L)	CM (g VS/L)	Org. loading (g VS/L)
R1	-	0	20	20
R2	0.50	10	20	30
R3	0.63	12.6	20	32.6
R4	0.75	15	20	35
R5	1.00	20	20	40

3. Results and discussion

3.1. *Effect of pH on the reactors*

The AD process starts with hydrolysis in which the substrates get converted into amino acids and fatty acids which lead to accumulation of volatile fatty acids (VFA) resulting in a decrease in pH of the reactor. After the start of the reactor till 12-15 days, the pH in all the reactors gradually decreased (Fig. 1). Due to the presence of CM as a co-substrate which has high buffering capacity, the pH of the reactors again increased which created favourable environment for the methanogenic bacteria.

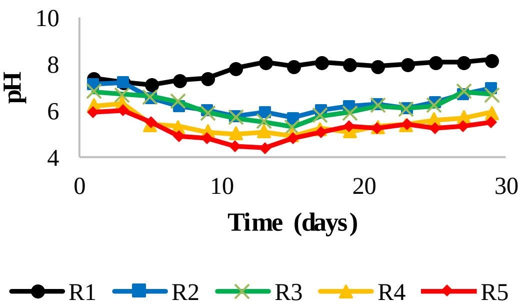

Fig. 1. Variation of pH of the reactors

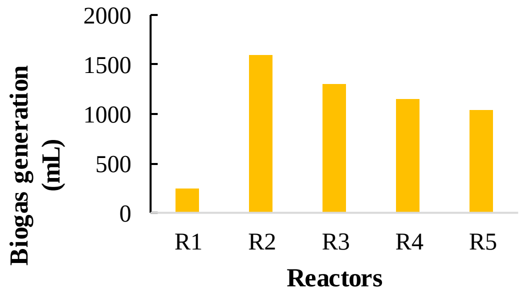

Fig. 2. Biogas generated in the reactors

3.2. *Biogas generation*

Fig. 2 shows the biogas generation in the different set of reactors. The maximum biogas production was found in reactor R2. In this study, it was observed that AD of OFMSW with CM used as an inoculum provided maximum biogas production of 1594 mL at S/I ratio of 0.5, followed by 1301 mL at 0.63, 1152 mL at 0.75 and 1037 mL at 1.0. Very less biogas was generated from mono-digestion CM (R1) due to presence of high nitrogen content in the CM. Fig. 3 shows the cumulative biogas generation in the reactors.

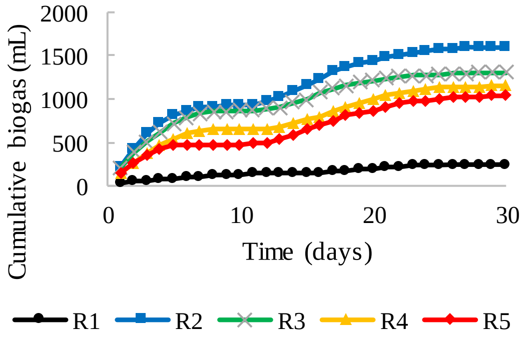

Fig. 3. Cumulative biogas generation

Initially, the biogas generation in all the reactors was high for a few days, but after 5-6 days the VFA accumulation was high ultimately lead to drop the pH of the reactors. The biogas production again reached the peak due to high buffering capacity of CM. The production of biogas stopped after 30 days in all the reactors.

4. Conclusions

The study found that biogas yield in the different reactors are not very encouraging. In the present study, the maximum biogas yield of 106.27 mL/g VS was observed in reactor R2. The order of biogas yield in all the reactors are R2>R3>R4>R5>R1. The reason for lesser biogas production in all the reactors was due to the accumulation of VFA at initial stage of the reaction.

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