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ScienceDirect

Energy Procedia 79 (2015) 436 – 441

Energy Procedia

2015 International Conference on Alternative Energy in Developing Countries and Emerging Economies

Biogas Production from Vegetable Waste by using Dog and Cattle Manure

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Abstract

This research investigates the effect of ratios between dog and cattle manures on anaerobic digestion in batch digesters under mesophilic conditions. The batch test was conducted for 28 days. Mixed Chinese cabbage and cabbage as the major wastes have been filled up in 200-liter digester. The vegetable wastes loading per day were studied under the specific increasing loaded weight as 0.5 kg and 1.0 kg each week. The additional waste load of 1.0 kg showed the optimum condition with the high biogas yield. The biogas accumulated from dog manure 10 wt% and 20 wt% were calculated using total amount of biogas produced per day; the results were 0.602 m^3 and 0.711 m^3, respectively. The methane content increased used higher percentage of dog manure.

Peer-review under responsibility of the Organizing Committee of 2015 AEDCEE

Keywords: biogas, anaerobic digestion, dog manure, vegetable waste, methane content

1. Introduction

Recently, the problem of municipal solid waste (MSW) disposal has been a critical situation in Thailand, as the rapid urbanization and economic growth. The department of Pollution Control reported that huge amount of MSW, approximate 26.17×10^6 tons per year was collected each year. However, in the year of 2014 the amount of disposal was approximate 14.81×10^6 tons. Organic wastes have been treated by composting, landfill and incineration together with other MSW. Energy productions from biomass or organic wastes were considered as a renewable energy source, because the methane-rich biogas produced is suitable for fuel gas. It can replace liquid petroleum gas (LPG) in household uses. Due to its nature and composition, it can be deteriorated easily and causes bad smell. In the traditional system for MSW treatment, the spread of odor during composting produce serious greenhouse gas, and huge leachate

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doi:10.1016/j.egypro.2015.11.515

discharges during landfill, with unsteady burning, resulting in dioxin production during incineration [1]. Considering the high moisture and organic content, these wastes should better be treated in biological treatment like anaerobic digestion than other techniques such as incineration and composting [2].

Garbage and manure from livestock for methane fermentation have been wide studied. However manure is known to have a poor methane yield and it is not common to use manure as only substrate for biogas production. Methane production of cattle manure is low, normally in range of 30-43% yielding 150-240 l CH_4/kg-volatile solid (VS) [3].The feasibility to increase the biogas production from manure is to co-digest it with other organic waste such as garbage from household. The main advantage of co-digest technology are improved methane yield because the supply of additional nutrients for co-digest substrates and more efficient use of single accommodation [4]. Co-digestion of swine manure (SM), dairy cattle manure (DSM) showed much lower volatile total solid (VTS) digestion efficiency and methane yield than that of garbage, while DCM showed the worst performance [5].

The aims of this research were to determine the effects of vegetable loading rate of 0.5 kg and 1.0 kg per week on biogas production under mesophilic conditions. Then the most applicable loading rate was studied by considering the effect yield from alter percentages of dog manure to cattle manure at 10 wt% and 20 wt%.

2. Materials and methods

2.1 Feedstock

The feed consisted of mixed vegetable wastes between Chineses cabbages and cabbages were collected from traditional market nearby Rajamangala University of Technology Thanyaburi (RMUTT), grinding as feedstock for manicipal anaerobic digester. The starter used in the research was mixed dog manure with cattle manure. The dog manure were collected from Phasukmaneejak Temple and cattle manure were collected from farm located in Agricultural Faculty of RMUTT. Both manures were unscreen.

2.2 Experimental design and biogas measurement

The digestion tests were performed on a single stage fed-batch anaerobic digester with total volume of 200 liters. It was operated at ambient temperature in mesophilic conditions for 28 days (4 weeks). Each digester was mixed manually for 1 minute once a day before gas volume measurements. The first part of this research studied addition of vegetable waste loaded by started addition 0.5 kg for the first week and then increased 0.5 kg per week (0.5, 1, 1.5 and 2 kg). The second batch test increased waste loading 1.0 kg per week (0.5, 1.5, 2.5 and 3.5 kg) with only cattle manure was the starter. The temperature and pH were monitored daily used thermometer and pH meter. The daily biogas production of each digester was determined by the volume of biogas produced, that was calculated from the height of collected gas tank and diameter of the tank. The biogas samples were collected by Tedlar sample bags from digesting tank and determinate amount of biogas by Geotech Biogas check analyzer. The composition of biogas (concentration of methane, carbon dioxide, oxygen, hydrogen sulfide and the others) in digester was monitored weekly. The second part studied mixing of starter between dog manure at 10 wt% and 20 wt% in cattle manure.

3. Results and discussion

3.1 Biogas yield at different substrates loading rate

Substrates from vegetable wastes were fed to the digester by increased addition rate as 0.5 and 1.0 kg per week. The effects of additional vegetable waste loaded with biogas yields were showed in Figure 1. After 5 days, biogas produced and increased until 28 days. The results were shown biogas accumulated as 0.5202 m^3 for additional waste load of 0.5 kg per week. The biogas yield as additional waste load of 1.0 kg per week was 0.6689 m^3. Therefore, additional waste load at 1.0 kg per week was selected for co-digestion of vegetable, dog and cattle manure.

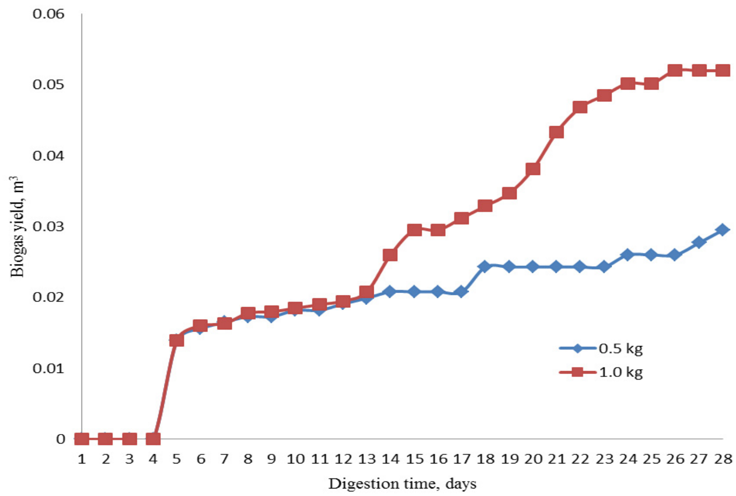

Fig. 1. Biogas yield between substrates loading rate at 0.5 kg and 1.0 kg.

3.2 pH and temperature of digestions

Fig. 2. shows both digesters were fed with vegetable waste, tap water and cattle dung slurry, used as the starter in the digesters. Liquid samples were drawn from each reactor periodically and measured for pH value. The pH was measured daily for every day until the end of digestion 28 days. The decrease in pH were observed during the first few days of digestion due to the high volatile fatty acids formation, pH of digester substrate loading at 0.5 kg and 1.0 kg varied between 6.4-7.2 and 7.1-7.6 respectively. Temperature is an important parameter in the anaerobic process. The digesters temperature were in about 31-35 ºC during the first day to 17th day. Then, from the 18th day until the end of digestion, it increased up to a range of 35-38 ºC.

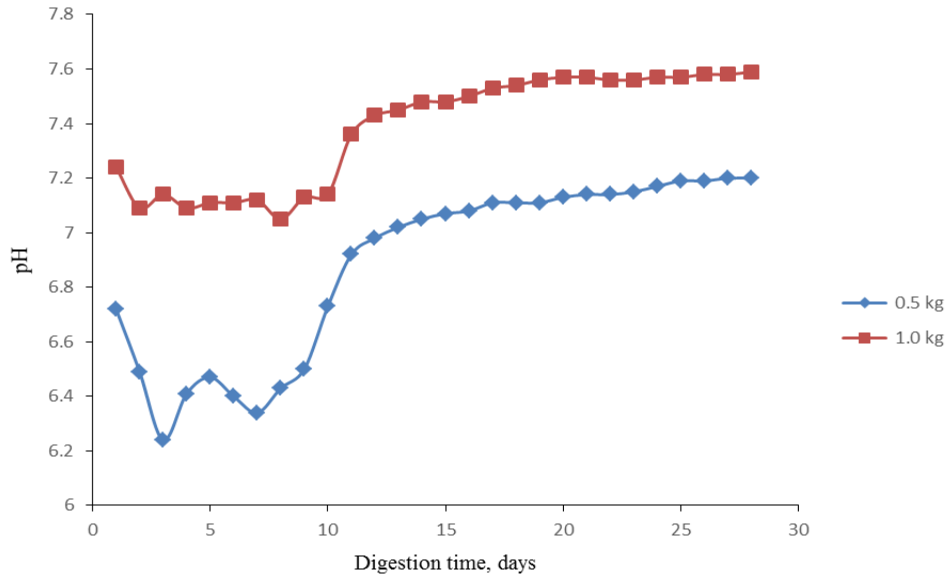

Fig. 2. pH of the digesters at difference substrate loading

3.3 Biogas yield of co-digest substrate

The co-digestions of vegetable waste, cattle and dog manure were conducted in batch to investigate the digestion performance. Fig. 3. showed biogas produced as the first day of digestion that faster than digestion by used only cattle manure The digestion of 20 wt% of dog manure was produced biogas yield more than digestion test of 10 wt%.The biogas accumulation of dog manure at 10 wt% and 20 wt% were calculated from biogas production per day, the results were 0.602 m^3 and 0.711 m^3 , respectively.

3.4 Biogas composition and methane yield

The composition of biogas produced from digestion test (4^{th} week) used only cattle manure consist of methane 44.6%, carbon dioxide 19.3%, oxygen 5.0 %, other 31.1 % and hydrogen sulfide 1,318.0 ppm. The 10 wt% and 20 wt% of dog manure are shown in Table 1. and Table 2., respectively. The methane content of biogas at 20 wt% of dog manure higher than at 10 wt% of dog manure mixed with cattle manure. Hydrogen sulfide concentration of biogas from digestion used only cattle manure showed higher concentration than dog and cattle manure.

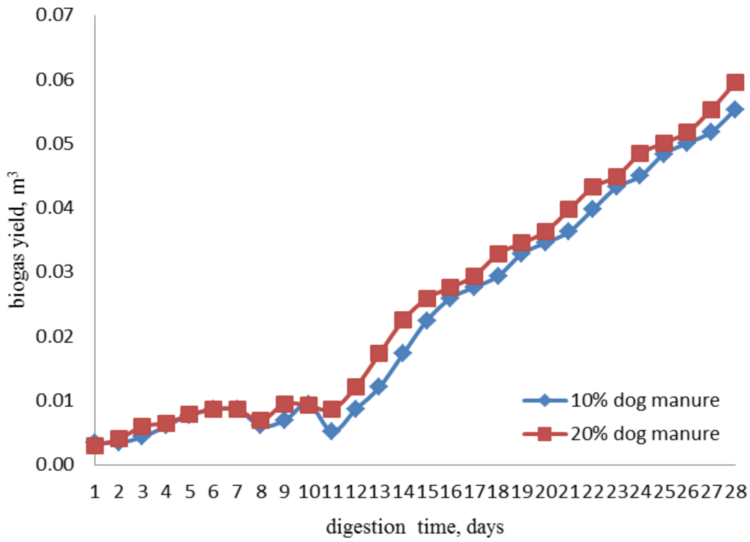

Fig. 3. Biogas yield at different percentage of dog manureof dog manure

Table 1. Biogas composition at 10 wt% of dog manure

composition	Digestion time, weekly			
	1st	2nd	3rd	4th
% CH_4	30.6	40.3	54.0	62.7
% CO_2	10.6	21.5	25.1	21.3
% O_2	7.8	3.4	1.4	1.1
% other	51.0	34.8	19.5	14.9
H_2S (ppm)	7.0	104.0	219.0	11.0

Table 2. Biogas composition at 20 wt% of dog manure

composition	Digestion time, weekly			
	1st	2nd	3rd	4th
% CH_4	42.3	65.1	65.3	69.3
% CO_2	23.2	28.8	29.9	26.6
% O_2	3.8	0.4	0.4	0.3
% other	30.7	5.7	4.4	3.8
H_2S (ppm)	1,957	618	505	367

4. Conclusions

The anaerobic digestion by used dog manure mixed with cattle manure was an appropriate in the quality and quantity of biogas. The methane content of more percentage of dog manure was increased and showed low hydrogen sulfide concentration compared with digestion used only cattle manure.

Acknowledgements

The research was financially supported by Faculty of Engineering Rajamangala University of Technology Thanyaburi. We would like to thank the National Metal and Materials Technology Center (MTEC) for providing biogas check analyzer.

References

[1] Hartmann, H., Ahring B.K., "Strategies for the anaerobic digestion of the organic fraction of municipal solid waste: an overview". Water Sci. Technol., 2006; 53:7-22.

[2] Velmurugan B.,Alwar Ramaujam R. "Anaerobic digestion of vegetable wastes for biogas production in a fed-batch reactor". Int.J. Energy. Sci.2011;1:478-486.

[3] Møller, H. B., Sommer, S. G., and Ahring, B. K.:Methane productivity of manure,straw and solid fractions of manure, Biomass and Bioenergy.2004;26:485–495 .

[4] Alatriste-Mondragón, F., Samar, P., Cox, H. H. J., Ahring, B. K., and Iranpour, R.:Anaerobic codigestion of municipal, farm, and industrial organic wastes: a surveyof recent literature, Water Environ. Res.2006;78: 607–636.

[5] Kai Liu,Yue-Qin Tang,,§Toru Matsui,Shigeru Morimura,Xiao-Lei Wu,and Kenji Kida. Thermophilic anaerobic co-digestion of garbage, screened swine and dairy cattle manure, Journal of Bioscience and Bioengineering. 2009; 107 (1): 54–60.