Methane Production from Anaerobic Co-Digestion of Poultry Manure

Roshani, A.[1], Shayegan, J.[2*], Babaee, A.[3]
1- M.Sc., Department Of Chemistry Engineering, Azad University of Tehran, Tehran- Iran
anisroshani@ymail.com
2- Prof., Department Of Chemistry and Petrol Engineering, Sharif University of Technology, Tehran- Iran
3- M.Sc., Department Of Chemistry and Petrol Engineering, Sharif University of Technology, Tehran- Iran
a.babaee.h@gmail.com
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Introduction

Annually, approximately 400 million tons of wastes have been produced by Iran livestock industry (cattle and poultry) and agriculture sector. This means that an integrated waste management system is really necessary. In the past few decades, large amounts of animal manure and slurries have been produced by animal breeding sector as well as wet organic waste streams, which represents a constant pollution risk with a potential negative impact on the environment, if not managed optimally. When untreated or poorly managed, animal manure becomes a major source of air and water pollution. Nutrient leaching, mainly nitrogen, phosphorus and ammonia evaporation and pathogen contamination are some of the major threats. Animal production sector is responsible for 18% of the overall green house gas emissions. Anaerobic co-digestion of organic matters results in waste stabilization as well as in biogas production. This gas usually contains more than 50% of methane. Therefore, it can be used as a bio-fuel in power generation systems to produce heat and energy. Other Benefits of the anaerobic digestion of animal manure are pathogen reduction through sanitation, improved fertilization efficiency, less nuisance from odors, flies, etc. The feasibility of methane production from poultry manure was studied in the present paper. Thereafter, the effect of loading and temperature on the anaerobic digestion of the mixture of poultry manure and wheat straw was investigated in mesophilic semi-continuously fed digester.

Materials and methods

Waste characteristics

The poultry waste and straw were obtained from a local farm in Tehran and stored at 4°C. Poultry manure and straw were mixed together, straw with portion of 80% by weight and Poultry manure 20% by weight in order to supply a proper C/N ratio (C/N≈23). The waste mixture consists of a total 90% solid (TS), and 80% of TS was Volatile Solids.

Experimental set-up

A cylindrical CSTR reactor with a working volume of 60 l (total digester volume 70 l) was operated at a 15d HRT for all runs. The reactor was made from Plexiglas, fitted with 2 plates as top and bottom. The top plate supported 3 mixers and mixer motors (24V, 5000 r/m). The contents of the reactor were mixed as controlled by a timer, which was activated for 30 min every hour. Adjusting the temperature was done with 3 electrical heaters that were fixed in the bottom of the reactor and a fiberglass jacket that covered external surface of the digester. The amount of biogas was measured with a water displacement system.

Reactor operation

First, 40 l of anaerobic sludge from a dairy factory and 20l of water were transferred to the reactor. Daily feeding was commenced approximately 24 days after the start-up. Raw waste characteristics over the study period are given in Table 2. Effluent data are average values from 5 samples at each temperature/OLR combination. For preventing accumulation, because of daily feeding, 4 liters of content were removed every day. It was calculated according to HRT 15 days.

Corresponding author: Tel: 09121022273 Shayegan@sharif.edu

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Analytical methods

Mixed samples were daily drawn from the reactor and measured to determine several parameters: total solid (TS), volatile solid (VS), chemical oxygen demand (COD), total nitrogen, total phosphorous, alkalinity and pH in the feed and samples of the substrates were all analyzed according to the Standard Methods. Total nitrogen was measured by Kjeldahl method, COD analyzed colorimetrically as described in the standard methods and the gas samples were analyzed for CH_4 with gas chromatography (PERICHROM-PR2100). Measuring pH was carried out by a pH paper (MN 6-8).

Results and discussion

According to Figure 1 maximum biogas and methane production was estimated to be at the rate of 3.0 kg VS/m^3.d. Operation was started with the loading rate of 1.0 kgVS/m^3.d. Because of low soluble COD (600 mg/l), methane production data is less than 0.65 l/d and microorganisms had not been adapted to feed and the population of anaerobic microorganisms typically takes a significant period of time to establish themselves to be fully effective.

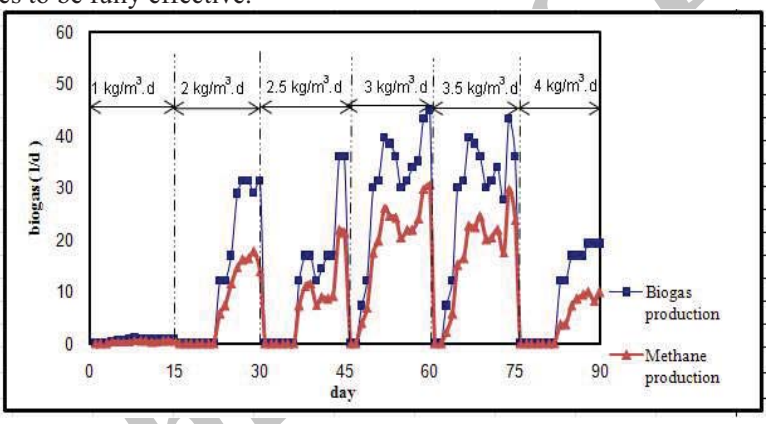

Fig.1: The amount of biogas and methane production for various loading rates

Loading rate was increased to 2.0 kg VS/m^3.d and 2.5 kg VS/m^3.d. Load Increase caused accumulation of soluble COD up to 2100 and 3010 mg/l, respectively and methane production was observed to increase. After a gradual increase in the OLR, up to 3.0 kg VS/m3.d, methane production increased up to 31.4 l/d. At the end of experiments, the soluble COD in the digester with the loads of 3.5 and 4.0 kgVS/m^3.d were up to 3800 and 4900 mg/l, respectively. The process appeared to be inhibited and/or overloaded, as caused by the accumulation of volatile fatty acids that lead methanogens to be inactive. The reactor showed stable performance with highest methane (70.2%) during the loading rate of 3.0 kg VS/m^3.d. Variation of soluble COD and VS removal are shown in Figures 2 and 3, respectively.

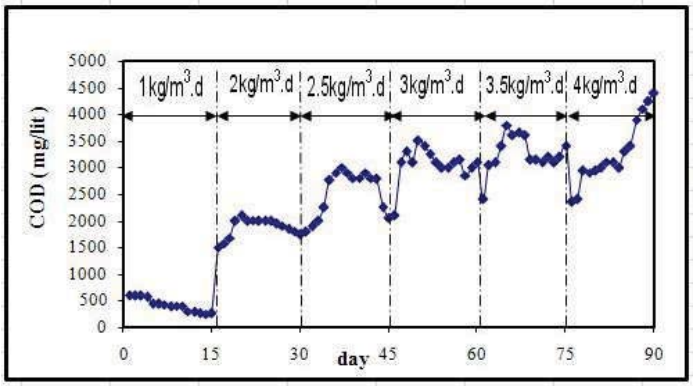

Fig.2: Values of COD for various loading rates

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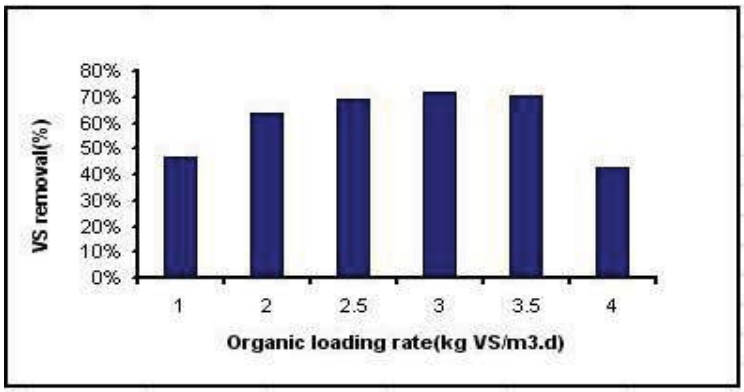

Fig.3: VS degradation for various organic loading rates

In the next step, the effect of different temperatures of 25, 30 and 34°C on the optimum load of the first stage was studied. By decreasing temperature from 34 to 30°C, methane production dropped from 31 to 26 l/d. By gradual decrease in temperature (25°C), methane production was calculated to be about 20 l/d. Soluble COD increased up to 3700 mg/l that means methanogenic microorganisms can not be efficient at low temperatures (25°C). By decreasing the temperature from 34 to 25°C, methane yield had a 50% drop. Variation of methane yield in different temperatures at the load of 3.0 kg VS/ m^3.d is shown in Figure 4.

Conclusion

According to the results, anaerobic co-digester appeared to be feasible with the loading rate of 3.0 kg VS/ m^3.d at 34°C and biogas production rate of 44.8 l/d, which can be used as a fuel resource. It should be mentioned that more heat input is required to achieve the correct operational temperature. This increase in energy may not be outweighed by the increase in the outputs of biogas from the system. Therefore, it is important to consider an energy balance for these systems.

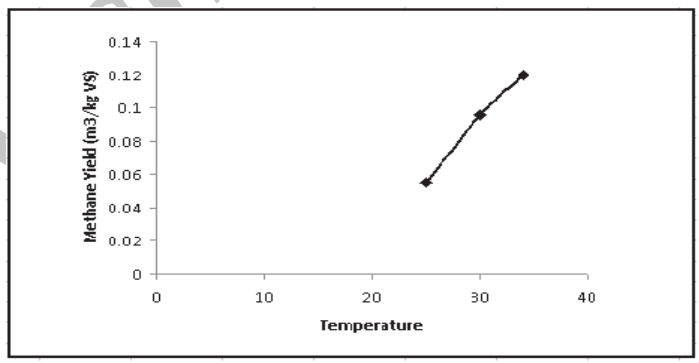

Fig.4: Variation of methane yield

Key words
Anaerobic digestion, Biogas, Poultry manure, Straw

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