ANAEROBIC DIGESTION OF COW AND BROILER MANURE

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Abstract. Anaerobic fermentation of relatively dry chicken manure and sawdust litter were performed to investigate volume and quality of biogas produced. Process was performed in 2 batch reactors at temperatures 37 °C and 54 °C without infiltrate circulation for both reactors. Concentration of methane increases up to 14 % for chicken manure and slougterhouse wastes mezophylic fermentation, and up to 37 % for chicken manure thermophylic fermentation, at the and of 2-month fermentation period. Anaerobic fermentation process is ongoing more intensively at thermophilic temperature 54°C in reactor F4 compare to mezophilic temperature 37 °C provided in reactor F3. Anaerobic fermentation process is ongoing more intensively at thermophilic temperature in reactor F4 compare to mezophilic temperature provided in reactor F3.

Key words: wastes, anaerobic digestion, biogas, chichen manure, sawdust litter.

Introduction

An efficient and safe processing of chicken wastes become an urgent problem, especially if area for wastes storage is limited. Chicken wastes also releases harmful greenhouse gases during storage [1]. If composting areas are situated in vicinity to populated areas, the problem is malodour, as that evokes dissatisfaction amongst population. There are difficulties also to put into effect the compost in big poultry industrial farms, as there no more big users after privatisation, and small gardeners are not capable to utilize the whole manure produced. Therefore, broilers plant managers should to develop the technologies aimed to reduce the amount of wastes. Most effective method for waste reduction is incineration, however, burning cause environmental. Poultry manure contain large quantities of nitrogen and sulphurus, so there is increased risk of nitric oxides and other harmful substances emissions in the burning process. Total amount of wastes can be reduced in anaerobic digestion process, and that process has substantial environmental advantages compare to incineration, for example, the clean energy production and plant nutrients re-utilization within natural biologic cycle. As the mixture of broiler manure and litter contains significant amount of organic matter (OM), large amount of biogas can be produced theoretically, if the whole OM are degraded in fermentation process. However, poultry litter is composed mainly from sawdust, consisting the cellulose or lignine, those having low or very low decomposition rate in anaerobic process [2]. Manure or fodder residues decompose more rapidly. Its natural moisture has an inhibiting effect on burning process, but increased moisture is preferable for anaerobic fermentation process usually. It would be reasonable to provide anaerobic biodegradation of manure and sawdust litter mixtures with low moisture (45 – 60%), to minimize amount of wastes to be transported to field or burned at the end of process. New “dry” fermentation method was proved for broiler manure and litter manure fermentation without leachate recirculation.

Materials and methods

Anaerobic fermentation process was performed for chicken manure and sawdust litter, that was sampled from broiler farm at the end of production cycle. Chicken litter manure was mixed with anaerobically treated cows manure ferment and filled in 2 batch reactors for anerobic fermentation at temperatures 37°C or 54°C without infiltrate circulation. Parameters of biomass in both reactors are showed in table 1 at the start of process.

Chicken litter manure and slaughterhouse wastes were filled into batch reactor F3 and chicken litter manure in reactor F4. Chicken litter manure and cows manure inoculum was filled into reactor F4 for anaerobic treatment. Cows manure inoculum in volume of 1 l was flushed above mixtures in both reactors. Substrates were not mixed, allowing the reactor to infuse down into the rest material slowly. Total volatile solids were 1.10 kg or 1.00 kg in reactor F3 or F4 respectively, at the start of fermentation process. Temperature was regulated automatically at 37.0 °C or 54.0 °C in reactor F3 or F4 respectively. The same volume of inoculum was filled in both reactors (see table. 1). Substrates were analysed using approved methods for organic matter, volatile solids and moisture content before filling in digesters. Accuracy of measuring instruments for pH value was ±0.02, for gas volume was

±0.0025 l and for mass measurements was ±0.001 g. Results were fixed in computer and also by hand in notebook daily. The samples of gases were tested help by analyser GA 2000 to investigate concentration of methane (CH_4), carbon dioxide (CO_2), oxygen (O_2) and hydrogen disulfide (H_2S). Values of pH and inside temperatures were measured help by built-in sensors in each reactor and were registered continuously by data storage device as well as can be monitored on display. Fermentation was provided for relatively dry biomass having moisture 56% or 48% (see Table 1), that is substantially different compare to traditional fermentation at moistures 90 - 99 % usually.

Table 1

Biomass parameters in batch reactors at the start of fermentation process

Biomass/parameters	Unit	Reactors	
		F3	F4
Chicken litter manure*	kg	1.025	1.259
Moisture	%	18.3	18.3
Dry matter	kg	0.838	1.029
Volatile solids	kg	0.718	0.884
Percentage of volatile solids in dry matter	%	85.9	85.9
Slaughterhouse wastes	kg	0.871	
Moisture	%	66.8	
Dry matter	kg	0.289	-
Volatile solids	kg	0.261	
Percentage of volatile solids in dry matter	%	90.4	
Cow manure (ferment)	kg	1.003	0.975
Moisture	%	85.3	85.3
Dry matter	kg	0.147	0.143
Volatile solids	kg	0.125	0.113
Percentage of volatile solids in dry matter	%	85.0	85.0
Total mass	kg	2.90	2.23
Total solids	kg	1.27	1.17
Temperature in reactors	°C	37±2.0	54±2.0

* – chicken litter manure means the mixture composed of chicken manure and sawdust

Results and discussion

Fermenting inoculum (cows manure) was prepared at temperature 37 °C, therefore it was expected some troubles for ferment usage at higher temperature 54 °C, provided into the reactor F4. Actually, there was observed the lower volume of gases in reactor F4 compare to F3 in the start period, but gases increases in reactor F4 after second week of fermentation period (Fig. 1).

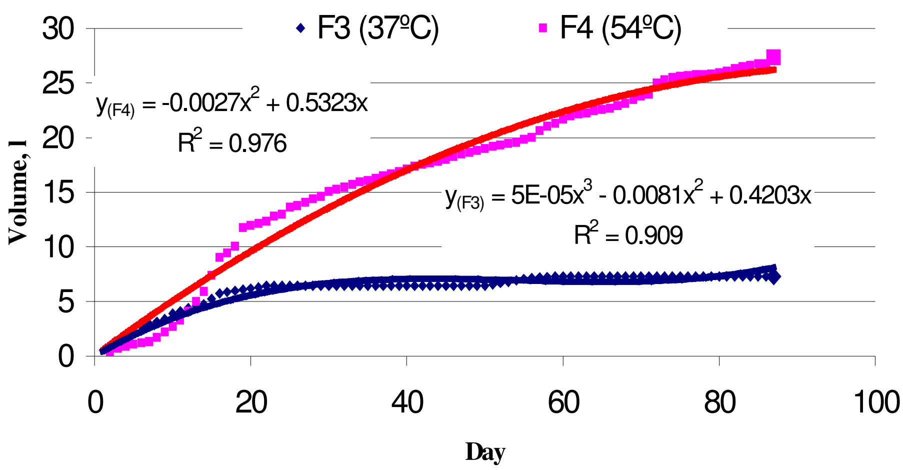

Fig. 1. **Volume of gases released in fermentation reactors F3 and F4**

The small amount of gases released in reactor F3 can be explained by too high organic load and increased concentration of disulfide hydrogen in mixture inhibiting activity of methane producing bacteria. Concentration of methane and carbon dioxide gases is showed in Fig. 2. Concentration of CO_2 gases lowered from 92 % to 45 % in reactor F4 and from 87 % to 75 % in reactor F3, however, carbon dioxide concentration was larger compare to concentration of methane in both reactors. Concentration of CH_4 gases increases in reactor F4 up to 45 % or 14 % in reactors F4 or F3 after 2-month fermentation period.

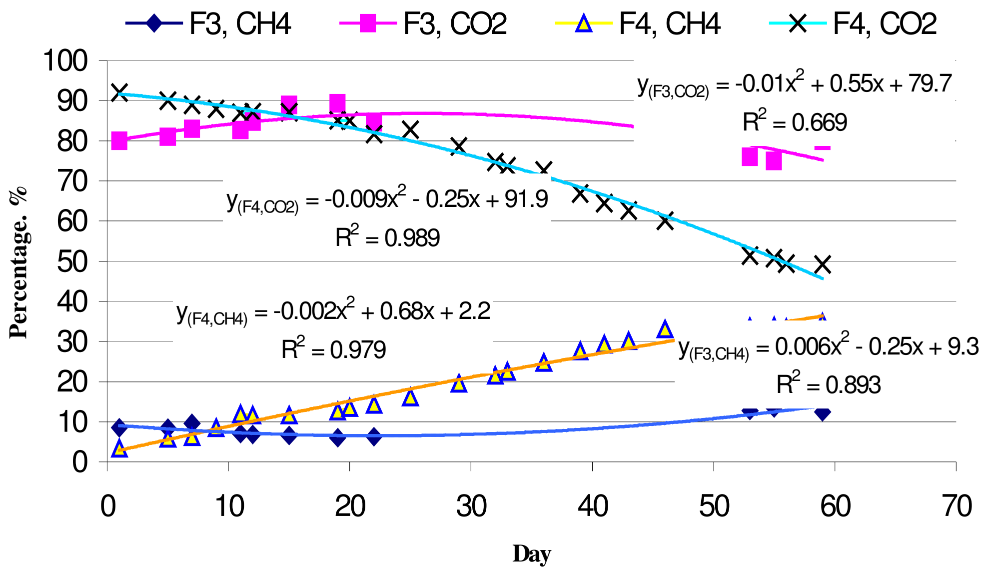

Fig. 2. **Percentage of carbon dioxide and methane in gases released in reactors F3 and F4**

Low methane content in reactor F3 can be explained by high organic load (slaughterhouse wastes) releasing hydrogen disulfide and by presence of sawdust litter inhibiting activity of methane producing bacteria in mesophilic fermentation process. Methane production was rising continuously in reactor F4 during thermophilic fermentation period, and it is expected the same tendency will proceed, as the fermentation experiment was not finished at that moment. Sawdust is the governing factor slowing down fermentation process in reactor F4 to a great extent, as the sawdust contains lignine or cellulose slowing down fermentation process.

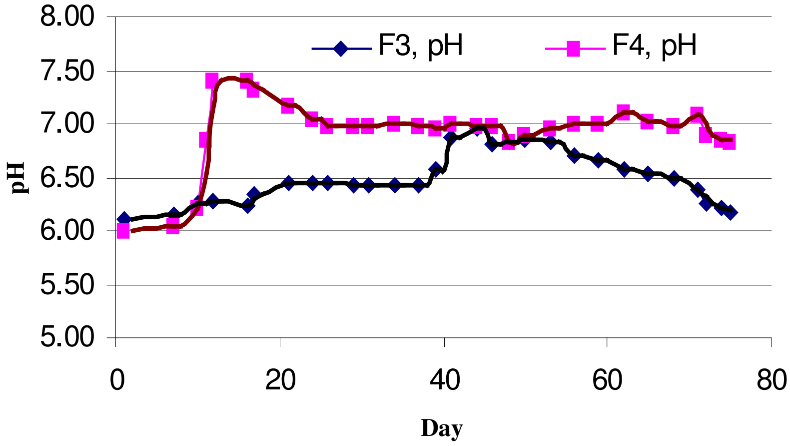

Fig. 3. **Chandes of pH value in reactors F3 and F4 during anaerobic fermentation period**

Methane production was slow in both reactors compare to traditional (wet) anaerobic fermentation. This evidence can be explained by following:

- substrates have low moisture content, as the water is needed for both growth of bacteria as well as for ongoing biochemical processes;
- moisture content was too low for successful transportation of bacteria throughout whole material to be fermented;

- relatively dry sawdust (component of chicken manure) absorbed water from inoculum, so lowering the transportation ability of bacteria;
- substrates have too high percentage of sawdust, having long period of degradation.

Value ph changes sligtly and ranges from 6.0 to7.4 during fermentation period, that is different to compare to traditional "wet" fermentation process, where strong lowering of pH vale is observed in the start period usually.

Conclusions

1. Methane production was ongoing at very unfavourable dry conditions for anaerobic fermentation process, therefore concentration of methane increases up to 14 % from chicken manure and sloughterhouse wastes in mezophilic fermentation process and up to 45 % from chicken manure in thermophilic fermentation process at 75-day of fermentation period.
2. Inoculum prepared at mezophilic temperatures is usable for starting of termophilic anaerobic process, due to high adaptation ability of bacteria.
3. Relatively dry finished digestate from fermentation can be utilized as the organic fertilizer at lowered transportation expenses, or can be burned for energy using appropriate equipment.
4. Anaerobic fermentation process is ongoing more intensively at thermophilic temperature 54°C in reactor F4 compare to mezophilic temperature 37 °C provided in reactor F3.
5. Optimization of organic load and recirculation regime of liquid infiltrate within reactor is necessary for facilitation of anaerobic fermentation of relatively dry organic biomass.

References

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