INVESTIGATION OF BIOGAS PRODUCTION FROM MINK AND COW MANURE

Vilis Dubrovskis, Imants Plume, Indulis Straume
Latvia University of Agriculture
vilisd@inbox.lv, imants.plume@llu.lv, indulis.straume@llu.lv

Abstract. Anaerobic fermentation of mink manure and cow manure was investigated to estimate the volume and quality of the biogas produced. The process was performed in 4 batch reactors at the temperature 37 ˚C. The average biogas or methane yields were 303 l kg_{vsd}^{-1} or 168 l kg_{vsd}^{-1} obtained from a substrate of cow manure with inoculum 25 %. The investigated average biogas or methane yields from mink manure with inoculum 25 % were 730 l kg_{VSd}^{-1} or 512 l kg_{VSd}^{-1} respectively. The average methane content was 56 % or 70 % in biogas from cow manure or mink manure during the anaerobic fermentation process.

Key words: mink manure, cow manure, anaerobic fermentation.

Introduction

Biogas production is an energy-efficient and environmental way to produce heat, cold and power energy from biomass. The EU Committee on Agriculture and Rural Development recognizes that biogas is a vital energy resource that contributes to sustainable economic, agricultural and rural development and environmental protection, and use of biogas especially for heat and power production could contribute significantly to the binding target of 20 % renewable energy in overall European Union energy consumption by 2020 [1]. Biogas from manure has numerous environmental advantages, such as the reduction of methane (CH_4) and carbon dioxide (CO_2) emissions, reduction of emissions of particulate matter and nitrous oxides, a far less obnoxious odor, hygienisation of slurry and better fertilizing capacity of the nitrogen in the treated manure, which means that less nitrogen is needed to achieve the same fertilizing effect [1].

There are two biogas cogeneration units utilizing landfill gas, one utilizing biogas wastewater sludge and one utilizing biogas from animal wastes and energy crops in Latvia. Agricultural and municipal wastes are the great potential resources for biogas production in Latvia (Fig. 1). It is of importance to utilize in biogas digester most of livestock manure (slurry), as the methane emissions from manure storages can contribute to greenhouse gas (GHG) emissions 23 times more, compare to carbon dioxide, unless methane is utilized in heat (cold) and power cogeneration (trigeneration) process or burned in flare.

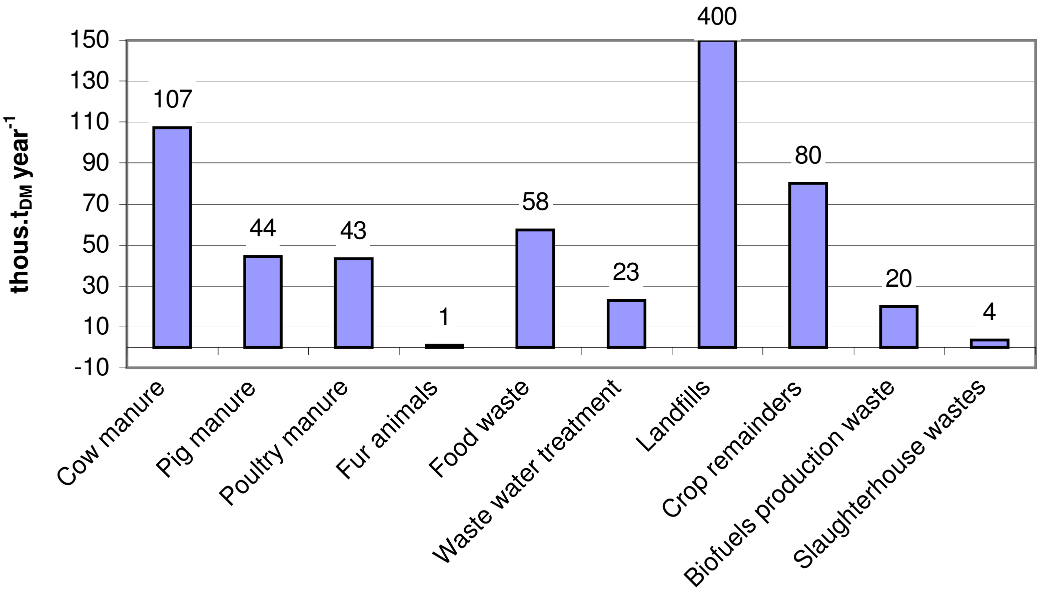

Fig. 1. **Agricultural wastes usable for biogas production in Latvia**

Biogas installations are especially important for fur animal farms, which encounter many problems due to an increased number of complaints from neighbors and general public. Fur animals breeding were realized in 37 farms, including 13 farms with breeding mink or fox and 24 small chinchilla farms with the total of about 7000 chinchillas in 2007. Total number of mink was around 556800 and number of fox was 19000, including two large mink breeding farms with more 100000 fur animals and one fox farm with more than 8000 fur animals in Latvia in 2007. Fresh mink manure have high content of nitrogen 16.7 % in dry matter and low carbon to nitrogen ratio C:N = 7:1 [3], therefore mink manure have much higher emissions risk of nitrogen in environment compare to cow manure, having nitrogen content in dry matter within range 2-3 % only [4]. Preliminary estimates (Denmark) indicate that the present loss of about 75 percent of the nitrogen excreted by the mink can be reduced to 56 % by establishing manure collection gutters under all cages and emptying them weekly. Emptying them daily reduces the loss to 46-49 % and a more than two-fold increase in the amount of nitrogen applied [5]. Reduction of nitrogen losses from mink manure can be provided by mucking manure out of cages as frequently as possible and usage of anaerobic treatment process for mink manure or for manure mixtures with different biomass.

The aim of the study is investigation of biogas and methane production from cow and mink manure in the anaerobic digestion process.

Materials and methods

The anaerobic fermentation process was performed for cow and mink manure. Cow manure samples were mixed with inoculum (fermented cow manure) and filled in digesters D1 and D2. Mink manure samples were mixed with inoculum (fermented cow manure) and water, and filled in digesters D3 and D4. Each digesters volume was 5l, and digesters were equipped with heating devices for automated regulation of inside temperature 37 ˚C ±1.0˚. The anaerobic digestion process was provided in batch mode, i.e. without circulation of substrates or leached liquid.

Table 1

Substrate and biogas parameters

No.	Parameter	Unit	D1	D 2	D3	D4
1	Substrate composition	%	25 in. 75 cm	25 in. 75 cm	25in 75mm+w	25in 75mm+w
2	Total substrate weight	kg	4.092	4.108	3.945	3.951
3	Total solids raw material	%	13.8	13.8	12.2	12.1
4	Organic solids raw material	%	11.8	11.9	10.0	9.9
5	Biogas yield	$l\,kg_{VSd}^{-1}$	292.6	312.8	734.1	725.2
6	Average methane content	%	57	54	69	71
7	Methane yield	$l\,kg_{VSd}^{-1}$	165.9	169.8	507.9	516.9
8	Conversion rate	%	56	57	73	74

Remarks: cm – cows manure; in – inoculum (fermented cows manure); mm – mink manure; w – water; VSd – volatile solids destroyed.

Substrates composition and parameters of biomass in all digesters at the start of process are showed in rows 1-4 Table 1. Digesters were equipped with sensors for automated registering of pH and gas volume data in computer. Fermented cow's manure was added 25 % of substrate weight in all digesters to provide microbial inoculum for a successful anaerobic fermentation process.

Substrates were analyzed for organic matter, total solids, organic solids and moisture content before filling in and after extracting out of digesters. The accuracy of measurement was ±0.02 for pH value, ±0.0025l for the gas volume and ±0.1˚C for the temperature. The anaerobic fermentation in digesters was provided during a 3-6 month period and finished when biogas producing ceased.

Results and discussion

Results of the anaerobic fermentation of biomass in digesters are shown in rows 5-8 in Table 1. The average parameters of cow and mink manure digestion are shown in Fig. 2 and Fig. 3. The average yield of biogas 303 $l\,kg_{VSd}^{-1}$ and methane 168 $l\,kg_{VSd}^{-1}$ were obtained from cow manure (Fig. 2). The nvestigated methane yield from mixture of cow manure (75 %) + inoculum (25 %) is lower by 23 % compared to the methane volume (219 $l\,kg_{VSd}^{-1}$) obtained earlier from fresh cow manure in the anaerobic digestion process [6].

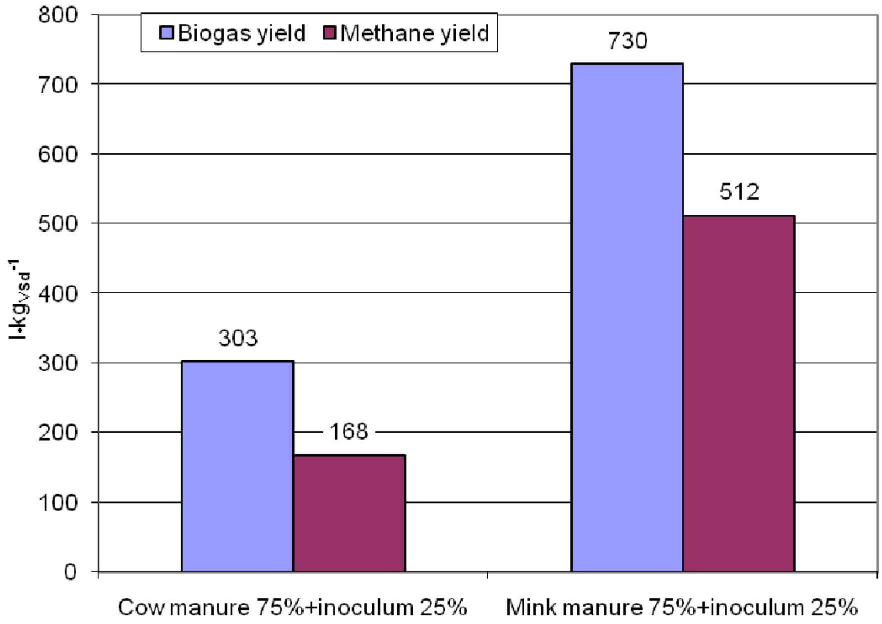

Fig. 2. **Average biogas and methane yields obtained from cow and mink manure**

High average volumes of biogas 730 l kg_{VSd}^{-1} or methane 512 l kg_{VSd}^{-1} were obtained from mink manure (Fig. 2), that were 2.4 or by 3.1 times more compared to the output from cow manure respectively.

The average methane content of 56 % or 70 % was obtained from cow manure or mink manure at average organic loads 11.9 % or 10.0 % of substrates respectively (Fig. 3). A small amount of inorganic solids were containing both substrates of cow manure (1.9 %) and of mink manure (2.2 %). The average content of organic matter decreases significantly in mink manure (by 74 %) during anaerobic digestion, and the conversion rate of mink manure was higher by 17 % compared to cow manure. Such evidence can be explained by a lower content of cellulose in mink's feed compared to the cattle's fodder applied. The anaerobic treatment of mink manure can provide a 4-fold reduction of the initial mass of organic matter that is favorable for the transportation of wastes to the field.

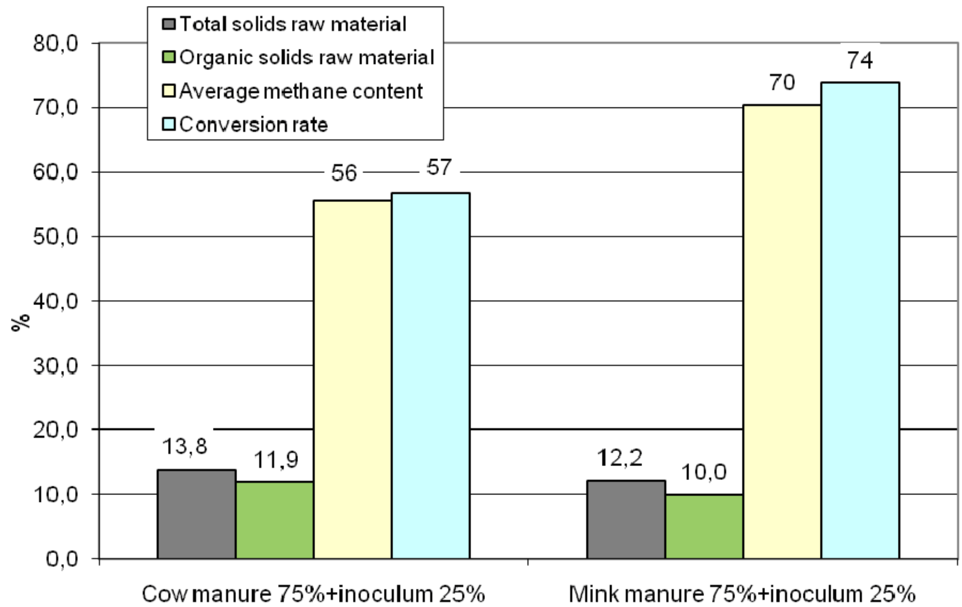

Fig. 3. **Content of total and organic solids, methane content, and conversion rate of cow and mink manure**

There is not any inhibition affect found of nitrogen in the anaerobic digestion process of mink manure, as the part of excess nitrogen was bound in litter or escaped from mink manure samples into the environment before the experiments are made. Special measures should be taken regarding fresh mink manure to decrease the high content of nitrogen (16 %), as the inhibition of methagenous bacteria is started at about 8000 mg l^{-1} [7]. Various studies have shown that free ammonia is far more toxic than the ammonium ion. Ammonia acts as a strong inhibitor of the formation of methane from H_2 and CO_2. In general, free ammonia (NH_3) levels should be kept below 80 ppm, to prevent inhibition, but a much higher concentration, about 1500 - 3000 ppm ammonium ion (NH_4+) can be tolerated [7]. Low carbon to the total nitrogen ratio (C:N=7:1) of fresh mink manure should be increased, as the C:N ratios lower than 10:1 were found to be inhibitory [7]. Fresh mink manure should be mixed with agricultural wastes rich in carbon (sawdust, straw, grasses, horses manure, and others) to provide optimal nitrogen content and the C:N ratio in the substrates to be digested.

Conclusions

1. Th average methane 168 l kg_{VSd}^{-1} yield was obtained from a substrate of cow manure (75 %) and inoculum (25 %), that was lower by 23 % compared to the methane obtained earlier from fresh cow manure (100 %) in the anaerobic digestion process.
2. High yields of biogas 730 l kg_{VSd}^{-1} and methane 512 l kg_{VSd}^{-1} were registered from the substrate of mink manure 75 % and inoculums 25 %.
3. The investigated average methane content in biogas from cow or mink manure was 56 % or 70 %, therefore biogas from both wastes is usable for heat and power production.
4. Fresh mink manure should be co-fermented with carbon rich agricultural wastes to lower the nitrogen content and to increase the C:N ratio for an optimal anaerobic digestion process.

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