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Measurement of methane production from pig and cattle manure in Lithuania

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Abstract

The current experiment was conducted to quantify methane (CH_4) productivity from pig and cattle manure. The manure was collected from twenty commercial farms in different parts of Lithuania. The biogas production and ultimate methane production were measured in a batch experiment according to the international standard. Manure was stored for a period of up to 70 days at constant 35 ± 1°C temperature. Infrared or electrochemical detection was adopted to analyze the methane and carbon dioxide content in biogas. Theoretical methane production was calculated according to the chemical composition of manure. In our study, the theoretical methane production from the total volatile solids (VS) for both pig and cattle manure was in the range of 0.41–0.46 m^3 kg^{-1} CH_4 VS. Theoretical methane production from easily degradable volatile solids was by 26.72% lower than that from total volatile solids. During the storage period, up to 64% of total manure volatile solids and up to 89% of easily degradable volatile solids had decomposed. The ultimate methane production for pig liquid manure was the highest and reached 0.29 m^3 kg^{-1} CH_4 VS. The methane production for pig solid fraction of manure was 0.12 m^3 kg^{-1} CH_4 VS, for the liquid fraction of pig manure – 0.18 m^3 kg^{-1} CH_4 VS. The methane production for dairy cattle liquid and solid manure, also non dairy cattle solid manure reached 0.20–0.21 m^3 kg^{-1} CH_4 VS. For dairy cattle slurry the methane production was the lowest – 0.05 m^3 kg^{-1} CH_4 VS, in comparison with other samples. Our study showed that methane production for pig and cattle manure in Lithuania was from 13% to 36% lower than the default values recommended for Europe (IPCC Guidelines…, 2006) and are used for calculations of national methane emission from manure.

Key words: cattle, manure, methane productivity, pig.

Introduction

The global temperature has increased during the last century. Anthropogenic greenhouse gas (GHG) emission substantially contributes to that process. Globally, agriculture contributes 30% of anthropogenic methane release (Sommer et al., 2009). Emission of greenhouse gases is regulated as part of the Kyoto Protocol, which was developed under the United Nations framework Convention on Climate Change. The aim of the Kyoto Protocol is to reduce greenhouse gas emission. To achieve the objective of the Protocol, the countries that have signed it are obliged to estimate GHG emissions.

Methane is the most abundant organic chemical in the earth's atmosphere (Steed, Hashimoto, 1994). One of the sources of anthropogenic methane emission are livestock wastes – manure and slurry. Recent inventories of greenhouse gases suggested that livestock manure makes a large contribution to GHG emission (Møller et al., 2004 b; Petersen, Miller, 2006; Gill et al., 2010). Methane emission from manure can be influenced by many factors, particularly the diet and accordingly the composition of manure, i.e. mainly the amount of organic matter in manure (Sommer, Møller, 2000), also temperature (Varel et al., 1980; Ahring et al., 2001; Massé et al., 2003; Umetsu et al., 2005), storage duration (Møller et al., 2004 b), manure management system used (Steed, Hashimoto, 1994; Wang et al., 2010), surface cover, redox potential of manure (Brown et al., 2000), climatic conditions (Sommer et al., 2009). These factors have a significant impact on the accurate estimation of greenhouse gas emission. Either due to differences in climate or to regional individuality of agricultural practices, these values can disguise a wide variation and make impact on the accurate estimation of emission (IPCC Guidelines…, 2006).

Literature analysis indicates that methane emission factor can vary ±20% and more (González-Avalos, Ruiz-Suárez, 2001; Møller et al., 2004 a; Park et al., 2006). The study of Park et al. (2006) showed that methane emission from stored liquid swine manure in a cold climate differs 41% from the value recommended by IPCC Guidelines. The methane emission factor for cattle manure, obtained in the study of González-Avalos and Ruiz-Suárez (2001), was at least a factor of 5 smaller than that proposed in the IPCC Guidelines. The average ultimate methane production determined in the study of Møller et al. (2004 a) for dairy cattle was by 38% lower, for pig fatteners – 21% and for sows – 39% than the IPCC Guidelines default values. Therefore, the correctness of the coefficients, used in calculations of emissions of GHG, are one of the main sources of errors (European Commission, 2011). As such, regionally or better – nationally appropriate values of coefficients should be developed and used (IPCC Guidelines…, 2006). The biodegradability of manure or a ultimate methane production is an important value for calculation of the emission factor, the same as the data of daily volatile solids excreted for livestock category and the methane conversion factor for particular manure management system.

The ultimate methane production is one of the main coefficients used in the calculations of methane emission from manure management. However, currently Lithuanian specific ultimate methane production is not available. As a result, the default values from IPCC Guidelines are used for the calculation of greenhouse gas emission from manure. Consequently, by using default values, the estimation of the emission can be misjudged markedly. This suggests that more scientific research in that area is needed. Therefore, the main purpose of this study was to determine the ultimate methane production for pig and cattle manures that would be most representative for local conditions.

Materials and methods

Experimental procedure. The trials were carried out in 2011–2012, at the Institute of Animal Science, Lithuanian University of Health Sciences. Samples of pig and cattle manure were collected from twenty commercial farms in different parts of Lithuania. The test medium was fresh pig and cattle liquid and solid manure, also slurry, liquid fraction and solid fraction of manure (Table 1).

Table 1. Description of the samples

Animal	Sample
Fattened pigs	liquid manure solid fraction of manure liquid fraction of manure
Dairy cattle	liquid manure solid manure slurry
Non dairy cattle	solid manure

The ultimate methane production (B_o) was determined in a batch experiment according to the international standard ISO 11734 (ISO, 1995). On the ground of the standard, the manure and inoculum (i.e. media which contain methanogenic bacteria) were diluted with dilution medium and incubated at 35 ± 1°C in sealed vessels after purging the bottles with pure nitrogen (N_2). The capacity of vesels was 1000 ml. Each vessel has a valve on the top, for gas measurement purpose. The inoculum was collected from the bottom of the liquid manure storage, and was kept for two weeks before the test at 35°C to remove the most of the remaining methane production. To check if the inoculum still has the remaining methane production, blank samples, i.e. vessels containing only inoculum and dilution medium were used. The remaining gases, produced by blank samples, were subtracted from the gases, produced by test solutions. The measurement period extended for up to 70 days unless the biodegradation curve from the pressure measurement reached a plateau phase.

Measurement of gases. The volume of biogas produced was calculated by measuring pressure (ISO, 1995; Møller et al., 2004 a). The gas samples were collected periodically by connecting the vessels to a syringe, and immediately analyzed for the content of methane (CH_4) and carbon dioxide (CO_2) using infrared and electrochemical gas analyzers. The gas measuring devices – ALMEMO 2890-9 (Ahlborn Mess- und Regelungstechnik GmbH, Germany), Dräger X-am 7000 (Dräger Safety AG & Co., Germany) and M40 (Industrial Scientific Corporation, USA) were adopted to analyze the gas concentrations (Fig. 1). All measurements were made weekly.

Analysis of manure. At the beginning of the experiment, the manure was analyzed for: pH, total solids, volatile solids (VS), total Kjeldhal nitrogen and total ammonium nitrogen, also protein, volatile fatty acids (VFA), lipids, lignin and crude fibre. The manure pH was measured with a pH meter HI 98128 (Hanna Instruments, Italy). The total solids content was determined after drying in an electric oven at 105 ± 2°C for 24 h (Peters et al., 2003). Volatile solids and ash content were determined after burning total solids in a muffle furnace at 550°C for 4 h. The total nitrogen was measured by the Kjeldahl method (Peters et al., 2003); the total ammonium nitrogen in the manure – by distillation and a device FOSS Tecator™ (FOSS, Denmark). The sum of volatile fatty acids concentration was determined using steam distillation. The lipid content was analyzed by measuring the amount of the material that can be extracted with petrol ether in a special lipid extraction system – "Gerhardt Soxtherm Extraction system" (C. Gerhardt GmbH & Co. KG, Germany). The protein content was determined by multiplying the difference between total Kjeldhal nitrogen and total ammonium nitrogen by a factor of 6.25 (Møller et al., 2004 a). The lignin was determined by using special filtration bags ANKOM Technology F57 Filter Bags (ANKOM Technology, USA) and fibre analyzer ANKOM^{220} (ANKOM Technology). The manure was boiled with a detergent in 1 mol l^{-1} sulphuric acid (H_2SO_4) followed by rinsing in 72% H_2SO_4 (ANKOM, 2005). The crude fibres were analysed using ceramic fiber filter method (AOAC, 1982). Their content was calculated from suspended volatile solids determined after boiling with 0.255 ± 0.005 N H_2SO_4 and potassium hydroxide dissolution, drying and burning in a muffle furnace at 600 ± 10°C.

Calculations and statistical analysis. The theoretical methane production (B_u) was calculated from Bushwell's formula (Møller et al., 2004 a) according to the chemical composition of the manure used in this experiment. The B_u was calculated for both – total volatile solids and for easily degradable fraction of volatile solids. Easily degradable volatile solids in this study were equated for the difference between the total

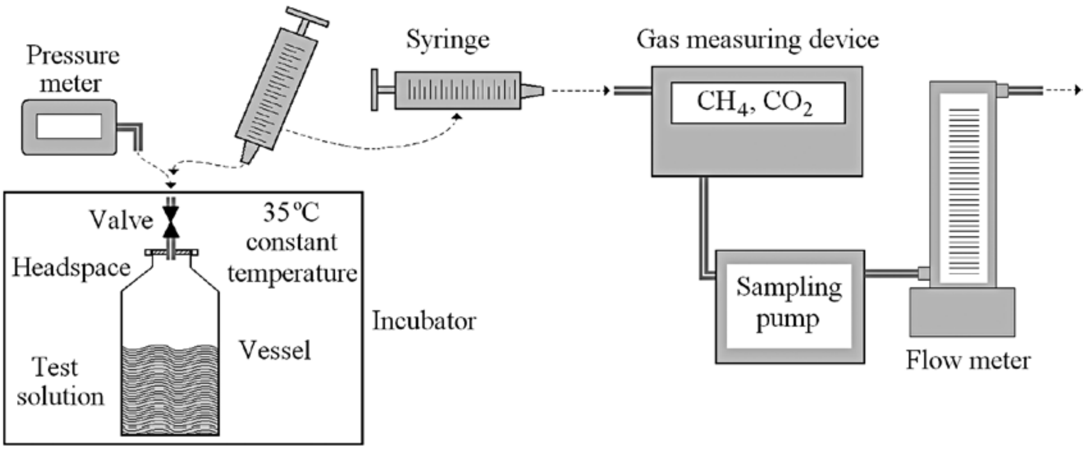

Figure 1. Schematic diagram of the gas measuring system

volatile solids and crude fibre as characterized by Sommer et al. (2009). The results are expressed as mean values ± standard deviation. Statistical analyses were performed using the software *Statistica*, version 7.0 (StatSoft Inc., USA). All the differences quoted in the text are significant at $P \leq 0.05$ unless stated otherwise.

Results

Composition of manure. The pH, of the pig manure used in this experiment, varied from neutral to slightly alkaline (Table 2).

The contents of volatile solids also protein, lipids, crude fibre and lignin in pig manure were dependent on total solids. The manure at low total solids content had lower concentration of volatile solids and other above mentioned values. The highest content of total solids was in the solid fraction of pig manure if the same amounts of manure were compared. However, if we compare the same amount of total solids, liquid manure has 4.2 times more volatile solids than the solid fraction of pig manure, and 5.5 times more volatile solids than the liquid fraction of pig manure. The above mentioned difference could affect the methane production. The acetic acid is a direct precursor of methane (Massé et al., 2003). The amount of volatile fatty acids (i.e. mainly acetic acid) was higher in liquid manure and the liquid fraction of manure than in the solid fraction of manure, by 5.7 and 4.2 times, respectively. The pH, of the cattle manure used in this experiment, varied from neutral to slightly alkaline (Table 3).

Table 2. Characteristics of the pig manure

Sample	pH	Total solids %	Volatile solids %	Total Kjeldahl nitrogen %	Total ammonium nitrogen %	Protein %	Lipids %	Crude fibre %	Lignin %	Volatile fatty acids %
Liquid manure	7.43 ± 0.45	3.46 ± 2.91	11.41 ± 2.38	0.68 ± 0.13	0.30 ± 0.09	2.34 ± 0.47	0.35 ± 0.09	2.80 ± 0.75	0.94 ± 0.25	0.34 ± 0.26
Solid fraction of manure	7.65 ± 0.01	20.28 ± 0.03	16.00 ± 0.01	0.61 ± 0.05	0.07 ± 0.00	3.34 ± 0.31	0.05 ± 0.00	4.48 ± 0.16	3.31 ± 0.83	0.06 ± 0.04
Liquid fraction of manure	7.60 ± 0.27	0.88 ± 0.57	0.53 ± 0.46	0.06 ± 0.01	0.04 ± 0.02	0.13 ± 0.09	0.00 ± 0.00	0.02 ± 0.03	0.02 ± 0.03	0.25 ± 0.28

Table 3. Characteristics of the cattle manure

Sample	pH	Total solids %	Volatile solids %	Total Kjeldahl nitrogen %	Total ammonium nitrogen %	Protein %	Lipids %	Crude fibre %	Lignin %	Volatile fatty acids %
Dairy cattle liquid manure	7.40 ± 0.42	7.91 ± 2.86	6.66 ± 2.57	0.28 ± 0.10	0.14 ± 0.04	0.92 ± 0.54	0.12 ± 0.06	2.08 ± 1.11	0.88 ± 0.39	0.30 ± 0.17
Dairy cattle solid manure	7.35 ± 0.33	13.05 ± 2.72	10.67 ± 2.60	0.37 ± 0.05	0.15 ± 0.04	1.36 ± 0.45	0.13 ± 0.04	3.54 ± 0.99	1.92 ± 0.51	0.40 ± 0.20
Dairy cattle slurry	7.27 ± 0.51	2.16 ± 1.08	1.45 ± 0.77	0.15 ± 0.05	0.12 ± 0.05	0.15 ± 0.22	0.02 ± 0.02	0.17 ± 0.18	0.22 ± 0.14	0.19 ± 0.11
Non dairy cattle solid manure	8.13 ± 0.07	12.09 ± 4.55	8.27 ± 4.89	0.41 ± 0.05	0.14 ± 0.02	1.66 ± 0.45	0.17 0.05	2.83 ± 0.37	2.46 ± 0.83	0.10 ± 0.07

The content of total solids was higher in the solid dairy cattle manure by 1.6 and 6.0 times than in the liquid dairy cattle manure and slurry, respectively, provided that the same amount of manure is compared. However, the highest content of volatile solids was in dairy cattle liquid manure, if we compare the same amount of total solids. In this instance, the content of volatile solids was 2.9, 20.3 and 18.8 % higher in cattle liquid manure in comparison with dairy cattle solid manure, slurry and non dairy cattle solid manure, respectively. The amount of crude fibre, including lignin, which is slowly degradable part of volatile solids, was larger in dairy cattle solid manure from 1.7 to 20.8 times, than in dairy cattle liquid manure and dairy cattle slurry, respectively. The concentrations of total Kjeldahl nitrogen, total ammonium nitrogen and proteins were higher in pig than in cattle liquid manure by 58.8, 53.3 and 60.7 %, respectively.

Gas production from manure. During manure incubation period the plateau phase for pig manure was reached after 20–40 days (Fig. 2).

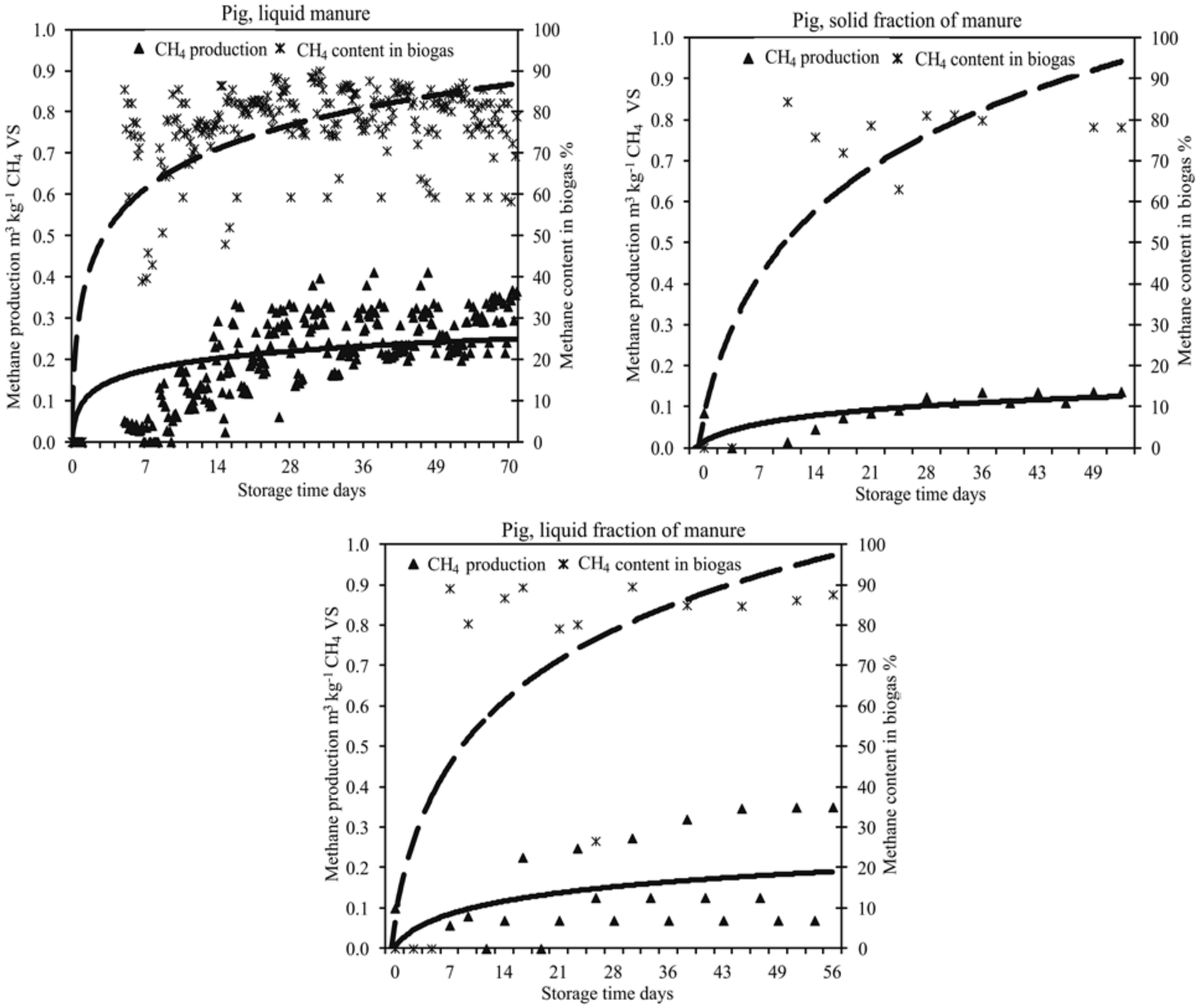

Figure 2. Cumulative methane (CH_4) production from pig manure

The plateau phase for pig and cattle manure was reached in approximately similar time, except for cattle slurry that has the shortest retention time (Fig. 3). However, cattle slurry produced the lowest amount of methane. The highest cumulative amount of methane was produced by pig liquid manure – up to 411 litres methane from kg volatile solids. Methane was the predominant gas in the biogas for all samples. The biogas production and methane content of the biogas was higher ($P < 0.01$) by 30.9% in pig than dairy cattle liquid manure. The average methane content of the biogas for liquid manure was in range of 55.5% and 77.8%. The highest content of methane was for pig liquid manure and the lowest – for non dairy cattle solid manure. The average carbon dioxide content of the biogas was in range of 19.6% and 44.5%. The highest content of carbon dioxide was for non dairy cattle solid manure and the lowest – for dairy cattle solid manure.

The ultimate (B_o) and theoretical (B_u) methane production from pig manure as well as biodegradability (B_o B_u^{-1}) is given in Table 4.

The maximum value of the ultimate methane production was detected for pig liquid manure (0.41 $m^3 kg^{-1}$ CH_4 VS) and it was higher by 7.3% than the maximum value detected for cattle manure (0.38 m^3 kg^{-1} CH_4 VS). The average values show a similar tendency – the ultimate methane production from pig liquid manure was 1.5 times higher ($P < 0.01$) than that from cattle liquid manure (Table 5). The lowest amount of methane was produced from dairy cattle slurry. The volatile solids of cattle slurry show a tendency ($P > 0.05$) to produce 3.6 times less methane than the liquid fraction of pig

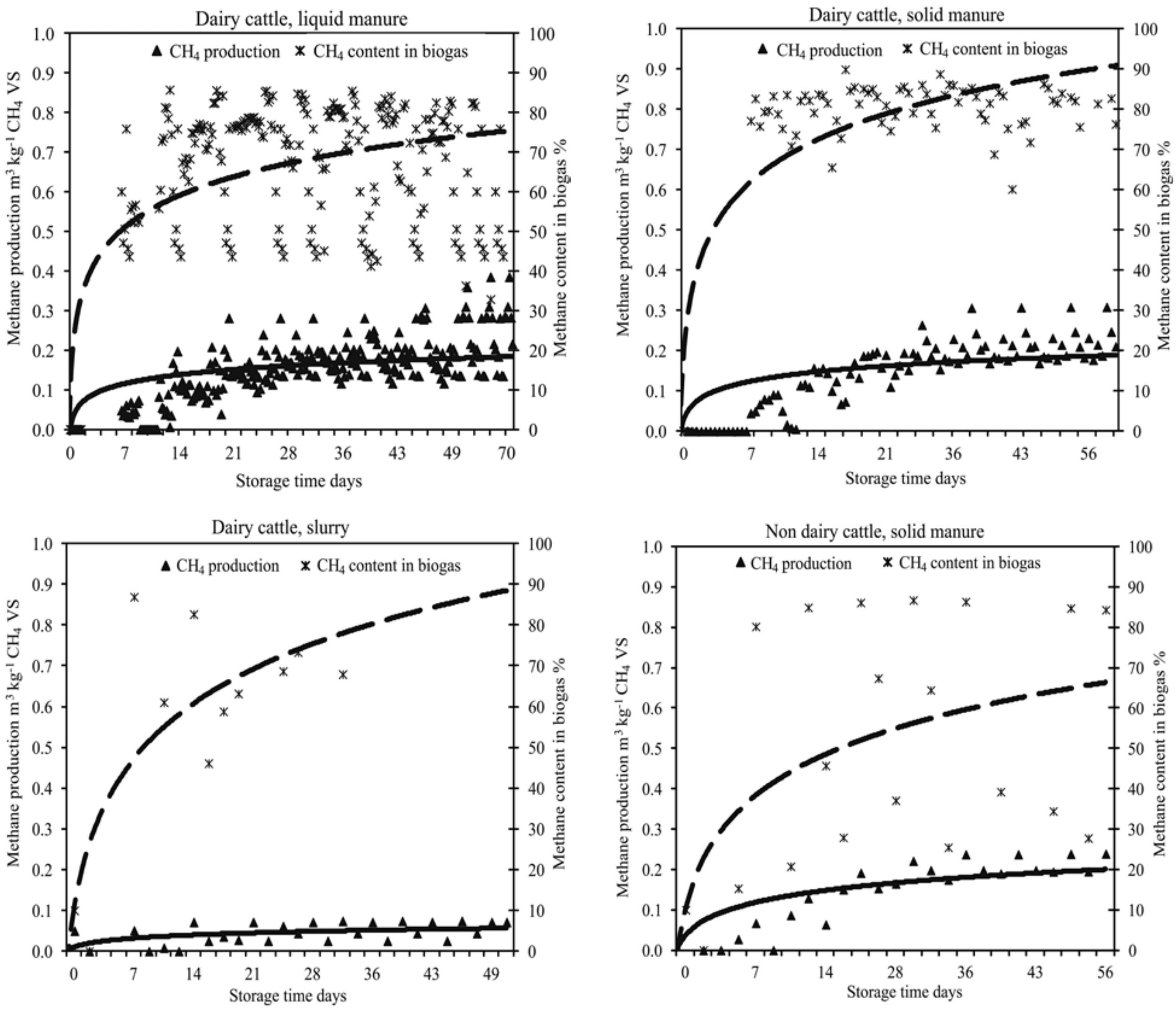

Figure 3. Cumulative methane (CH_4) production from cattle manure

Table 4. Ultimate and theoretical methane (CH_4) production from pig manure

Sample	Ultimate CH_4 production m^3 kg^{-1} CH_4 VS	Theoretical CH_4 production m^3 kg^{-1} CH_4 VS		Biodegradability	
		from total VS	from easily degradable VS	from total VS	from easily degradable VS
Liquid manure	0.29 ± 0.06	0.45 ± 0.01	0.35 ± 0.01	0.64 ± 0.12	0.83 ± 0.16
Solid fraction of manure	0.12 ± 0.02	0.43 ± 0.00	0.32 ± 0.00	0.28 ± 0.04	0.39 ± 0.06
Liquid fraction of manure	0.18 ± 0.15	0.42 ± 0.02	0.40 ± 0.03	0.43 ± 0.37	0.45 ± 0.40

VS – volatile solids

Table 5. Ultimate and theoretical methane (CH_4) production from cattle manure

Sample	Ultimate CH_4 production m^3 kg^{-1} CH_4 VS	Theoretical CH_4 production m^3 kg^{-1} CH_4 VS		Biodegradability	
		from total VS	from easily degradable VS	from total VS	from easily degradable VS
Dairy cattle liquid manure	0.20 ± 0.06	0.44 ± 0.01	0.31 ± 0.02	0.45 ± 0.14	0.65 ± 0.17
Dairy cattle solid manure	0.21 ± 0.04	0.43 ± 0.00	0.29 ± 0.01	0.49 ± 0.09	0.71 ± 0.13
Dairy cattle slurry	0.05 ± 0.02	0.42 ± 0.01	0.36 ± 0.02	0.13 ± 0.05	0.15 ± 0.07
Non dairy cattle solid manure	0.21 ± 0.02	0.44 ± 0.02	0.30 ± 0.09	0.47 ± 0.07	0.89 ± 0.15

VS – volatile solids

manure. The solid fraction of pig manure produced 2.4 times less ($P < 0.01$) methane than pig liquid manure. The ultimate methane production for the liquid fraction of pig manure and for solid fraction of manure did not differ significantly. Furthermore, methane production for liquid fraction had high variation. The average maximum methane production for all samples of cattle manure, except dairy cattle slurry, was approximately similar and reached 0.20–0.21 m^3 kg^{-1} CH_4 VS. However, the CH_4 production from the liquid or solid manure of dairy cattle varied considerably more than for the dairy cattle slurry or non dairy cattle solid manure.

As in the case of the ultimate methane production, the theoretical methane production from total volatile solids or easily degradable volatile solids was higher by 2.9% ($P < 0.05$) and 12.0% ($P < 0.05$) for pig than for dairy cattle liquid manure, respectively. The theoretical methane production from total volatile solids of all the samples was in the range of 0.41–0.46 m^3 kg^{-1} CH_4 VS. The theoretical methane production from easily degradable volatile solids of all the samples was in the range of 0.20–0.44 m^3 kg^{-1} CH_4 VS. The theoretical methane production from easily degradable volatile solids was lower ($P < 0.01$) by 26.7% than that from total volatile solids. The average theoretical methane production was generally higher than the ultimate methane production. Though, in 16.2% of pig liquid manure, in 3.0% of dairy cattle liquid manure, in 9.1% of dairy cattle solid manure and in 66.7% of non dairy cattle solid manure, B_o reached B_u which was calculated for easily degradable volatile solids, but never reached B_u which was calculated for total volatile solids. The biodegradability of volatile solids used was in the range of 13–64% when calculated by total volatile solids, and it was in the range of 15–89% when calculated by easily degradable volatile solids. When considering total volatile solids, they were biodegrading most easily ($P < 0.05$) for pig liquid manure. Up to 64% of the total volatile solids biodegraded within 70 days of the storage period. When considering only easily degradable volatile solids, for non dairy cattle solid manure and for pig liquid manure they were biodegrading most easily ($P < 0.05$). In this case, up to 89% of easily degradable volatile solids biodegraded. The worst biodegradation was found for dairy cattle slurry either in the case of total volatile solids or easily degradable volatile solids.

Discussion

There are numerous studies, where methane emission was estimated. However, there are only few studies, where maximum methane producing capacity was determined using the same or similar methodology, experimental design and conditions as described in the international standard ISO 11734 (ISO, 1995) that was used in our study. Consequently, the variation of the results in different studies is high, and comparisons can be complicated.

Our experiment showed that the plateau phase started after 20–40 days of manure storage period. After the plateau phase started, no further measurable amounts of gases were produced. El-Mashad and Zhang (2010) also reported that 87–95% of the biogas production can be obtained after the first 20 days of digestion. In our study, 28–64% of total volatile solids and 39–83% of easily degradable pig manure volatile solids was biodegraded; for cattle manure the biodegradability of total volatile solids was in the range of 13–49% and for easily degradable volatile solids it was in the range of 15–89%. The above mentioned results of our study showed similar tendency as the results of Varel et al. (1980) and Møller et al. (2004 a). Varel et al. (1980) measured 46–54% biodegradability of cattle manure, Møller et al. (2004 a) found 47–78% biodegradability of pig manure and 21–34% of cattle manure. It is evident that all studies showed lower average biodegradability of volatile solids of cattle manure in comparison with pig manure.

In accordance with the results of our study that are similar to those of Varel et al. (1980) and Møller et al. (2004 a), it seems that practically, complete degradation of all organic components of the manure, especially crude fibre, could not be realized. The current proposition was confirmed by the study of Angelidaki and Ahring (2000), who found that only additional chemical, biological or mechanical treatment of fibres can increase biogas production by 16–20%.

The results of our study showed that the ultimate methane production cannot reach a theoretical production which is calculated for total volatile solids, but ultimate methane production can be similar to theoretical production which is calculated for that part of volatile solids which is easily degradable. Angelidaki and Ahring (2000) also found that actual methane production can reach the theoretical production from easily degradable volatile solids. In our study, the theoretical methane production from easily degradable volatile solids of cattle manure was in the range of 0.29–0.36 m^3 kg^{-1} CH_4 VS. The study of Angelidaki and Ahring (2000) showed similar tendency as ours – a range of 0.30–0.35 m^3 kg^{-1} CH_4 VS. However, we found a higher theoretical methane production from easily degradable volatile solids of pig manure in Lithuania (i.e. 0.32–0.40 m^3 kg^{-1} CH_4 VS) than was reported by Hansen et al. (1998) in Denmark (i.e. 0.30 m^3 kg^{-1} CH_4 VS).

The ultimate methane production from cattle manure that was found in our study (i.e. average – 0.20 ± 0.06 m^3 kg^{-1} CH_4 VS) showed a similar tendency as the production reported by Varel et al. (1980), Angelidaki and Ahring (2000), Ahring et al. (2001), Møller et al. (2004 a), Umetsu et al. (2005), Vedrenne et al. (2008) and El-Mashad and Zhang (2010). However, the results of Rico et al. (2007) and Wang et al. (2010) showed that the ultimate methane production was markedly higher than that found in our study. Besides, the results of Kaparaju (2003) and Massé et al. (2003) showed that the ultimate methane production was even lower than that found in our study. All those results confirm that the ultimate methane production from cattle manure is country-specific, consequently, the values that were determined abroad are hardly applicable to Lithuanian cattle manure. Till now, a higher coefficient 0.24 m^3 kg^{-1} CH_4 VS (as it is recommended by the IPCC Guidelines…, 2006) than was found in our study has been used for calculations of Lithuanian methane emission from dairy cattle manure. According to our results, last-mentioned calculations are magnified.

The ultimate methane production from pig manure, that was determined in our study (i.e. 0.29 ± 0.06 m^3 kg^{-1} CH_4 VS), showed a similar tendency as the production reported by Kaparaju (2003), Møller et al. (2004 a) and Vedrenne et al. (2008). However, the results of Birchall (2010) showed that the ultimate methane production was markedly higher than that found in our study. Besides, the results of Hansen et al. (1998) and Massé et al. (2003) showed that the ultimate methane production from pig manure was even lower than that found in our study. Till now, a higher coefficient 0.45 m^3 kg^{-1} CH_4 VS (as it is recommended by the IPCC

Guidelines…, 2006) than was found in our study has been used for calculations of Lithuanian methane emission from pig manure. According to our study, last-mentioned calculations are magnified.

As it was indicated by Møller et al. (2004 a), the ultimate methane production will always be lower than the theoretical production, because a fraction of the substrate is used to synthesize bacterial mass, a fraction of the organic material will be lost in the effluent, and lignin-containing compounds will only be degraded to a limited degree. Theoretical methane production from total volatile solids of pig manure was 0.45 ± 0.01 m^3 kg^{-1} CH_4 VS in our study, and that is equal to IPCC Guidelines (2006) recommended default B_o value, which is used for calculations of national methane emission. However, ultimate methane production should not exceed the theoretical production which was calculated for easily degradable volatile solids in our study – 0.35 ± 0.01 m^3 kg^{-1} CH_4 VS, and should not be lower than the measured ultimate methane production in our study – 0.29 ± 0.06 m^3. It was reported that default B_o values can vary by ±15% (IPCC Guidelines…, 2006). Consequently, our study showed that the ultimate methane production for pig manure in Lithuania is approximately 22–36% lower than the default value given for Europe by IPCC Guidelines (2006). The ultimate methane production for cattle manure is up to 13–17% lower than the default values.

Conclusions

1. This study showed that the theoretical methane (CH_4) production (B_u) from total volatile solids (VS) for both pig and cattle manures was in the range of 0.41–0.46 m^3 kg^{-1} CH_4 VS.

2. The ultimate methane production (B_o) for pig liquid manure was the highest and reached 0.29 m^3 kg^{-1} CH_4 VS. The ultimate methane production for the solid fraction of pig manure was 0.12 m^3 kg^{-1} CH_4 VS, for the liquid fraction of pig manure – 0.18 m^3 kg^{-1} CH_4 VS. The ultimate methane production for dairy cattle liquid and solid manure, also non dairy cattle solid manure reached 0.20–0.21 m^3 kg^{-1} CH_4 VS. For dairy cattle slurry the ultimate methane production was the lowest – 0.05 m^3 kg^{-1} CH_4 VS, in comparison with other samples.

3. Our study showed that ultimate methane production for pig and cattle manures in Lithuania was from 13% to 36% lower than the default values recommended for Europe (IPCC Guidelines…, 2006) and used for the calculations of national methane emission from manure management.

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Metano emisijos iš kiaulių ir galvijų mėšlo matavimai Lietuvoje

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Santrauka

Tyrimo tikslas – išmatuoti metano (CH_4) produkciją iš kiaulių ir galvijų mėšlo. Tyrimui atlikti mėšlo mėginiai surinkti iš dvidešimties tipinių fermų, esančių įvairiose Lietuvos vietose. Biodujų susidarymas ir metano išeiga išmatuoti panaudojus mėšlo tirpalą, paruoštą pagal tarptautinio standarto reikalavimus. Mėšlo mėginiai inkubuoti iki 70 dienų pastovioje 35 ± 1 °C temperatūroje. Metano ir anglies dioksido koncentracijos pasigaminusiose biodujose išmatuotos dujų analizatoriais, turinčiais infraraudonųjų spindulių ir elektrocheminius detektorius. Maksimali teoriškai įmanoma susidaryti metano produkcija apskaičiuota pagal rezultatus, gautus atlikus mėšlo cheminės sudėties tyrimus. Teoriškai įmanoma metano produkcija iš visų mėšle buvusių organinių medžiagų (OM) kiekio kiaulių ir galvijų mėšlo buvo panaši, t. y. 0,41–0,46 m^3 kg^{-1} CH_4 OM. Teoriškai įmanomą metano produkciją skaičiuojant tik lengvai biodegraduojančiai organinių medžiagų daliai, rezultatas buvo 26,72 % mažesnis nei skaičiuojant visam organinių medžiagų kiekiui. Tyrimo metu iki 64 % viso organinių medžiagų kiekio ir iki 89 % lengvai yrančių organinių medžiagų kiekio biodegradavo. Tyrimo metu išmatuota metano produkcija buvo didžiausia kiaulių skystojo mėšlo ir siekė 0,29 m^3 kg^{-1} CH_4 OM. Išmatuota metano produkcija iš frakcionuoto kiaulių mėšlo kietosios dalies buvo 0,12 m^3 kg^{-1} CH_4 OM, iš skystosios frakcijos – 0,18 m^3 kg^{-1} CH_4 OM. Metano susidarymas iš karvių skystojo bei tirštojo mėšlo ir nelaktuojančių galvijų tirštojo mėšlo skyrėsi labai mažai ir siekė 0,20–0,21 m^3 kg^{-1} CH_4 OM. Karvių srutoms metano išeiga buvo mažiausia – 0,05 m^3 kg^{-1} CH_4 OM, lyginant su kitais tirtais mėginiais. Atliktas tyrimas parodė, kad metano išeiga iš Lietuvoje susidarančio kiaulių ir galvijų mėšlo gali būti nuo 13 % iki 36 % mažesnė nei rekomenduojama Europos Sąjungoje (IPCC Guidelines..., 2006) ir yra naudojama Lietuvoje apskaičiuojant nacionalinę metano emisiją iš mėšlo.

Reikšminiai žodžiai: galvijai, kiaulės, metano produkcija, mėšlas.