

## METHANE EMISSION FROM LIVESTOCK IN THE PODLASKIE VOIVODESHIP

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### ABSTRACT

The purpose of the analysis, the results of which are presented in this paper was to determine the amount of methane emitted from livestock farming into the atmosphere from the area of the Podlaskie Voivodeship in the years 1999–2012. The analysis was conducted according to guidelines developed by the IPCC and concerned two sources of methane: enteric fermentation and manure management. According to KOBIZE data, in Poland, in both cases systematic decrease in CH<sub>4</sub> emission into the atmosphere is observed. In contrast to this trend, in Podlaskie Voivodeship methane emission, related to enteric fermentation in the period of 1999–2012 increased by 32%, while the amount associated with manure by about 15%. The main reason for these differences is a steady increase of the number of cows, which are the main source of methane.

**Keywords:** methane emission, livestock, Podlaskie Voivodeship.

### INTRODUCTION

Agriculture has a major share in the global production of greenhouse gases. It is assumed that methane emissions from manure from livestock accounts for about 4% of the total pool of anthropogenic methane, which with gases from other sources influences global warming [USEPA 2006]. Emissions of all greenhouse gases from agriculture is associated with several processes: enteric fermentation of livestock (CH<sub>4</sub>) emission from animal manure (CH<sub>4</sub> and N<sub>2</sub>O) emission from agricultural soils (N<sub>2</sub>O) and the burning of plant residues (CH<sub>4</sub> and N<sub>2</sub>O). In Poland, these processes are responsible for 8.6% of the total greenhouse gases emission from the country [KOBIZE 2013].

In the process of enteric fermentation microorganisms in the digestive tract of animals ferment the food eaten by them. The amount of emitted methane mainly depends on the construction of the digestive system and the type and quantity of consumed food. Ruminants (e.g. cattle, sheep) are the major producers of methane. Other animals e.g. pigs, horses have indirect significance, while poultry is not included in this process [IPCC 2006].

The amount of methane emitted from livestock manure depends primarily on storage method, animal species, food composition (related to the energy value of food provided to animals) and climatic conditions [Brown et al. 2002, Yamulki et al. 1999]. Larger quantities of CH<sub>4</sub> are produced in conditions characterized by elevated temperature and humidity, when the animal faeces are collected in a liquid form [IPCC 2006]. In Poland, the share of solid manure system is about 80% in the case of cattle, and about 75% for pigs (data from 2009), while contribution of slurry manure system is approximately 10% and 25% respectively. Comparison of these values with the year of 1988, revealed a significant increase in the share of slurry manure system [KOBIZE 2013]. Similar trends can also be seen in other countries where it is mainly related to the development of large animal farms where manure is collected mainly in a liquid form. Such a method of management will result in increased emission of CH<sub>4</sub> in the near future [Thornton 2010, Holm-Nielsen et al. 2009, Steinfeld et al. 2006]. This emission can be reduced to some extent by reducing the quantity of easily decomposable organic matter in the slurry [Amon et al. 2006].

The purpose of the analysis, the results of which are presented in this paper was to determine the amount of methane emitted from livestock farming into the atmosphere from the area of the Podlaskie Voivodeship in 1999–2012.

## MATERIAL AND METHODS

The emission of methane from livestock was calculated on the basis of *Tier 1* method according to the methodology of the IPCC [2006]. The emission from enteric fermentation was calculated using equation 10.19 (1):

$$CH_{4\text{Enteric}} = \sum_{(T)} \frac{(EF_{(T)} \cdot N_{(T)})}{10^6} \quad (1)$$

where:

- $CH_{4\text{Enteric}}$  –  $CH_4$  emission from enteric fermentation,  $GgCH_4 \cdot y^{-1}$ ,
- $EF_{(T)}$  – emission factor for the defined livestock category,  $kgCH_4 \cdot head^{-1} \cdot y^{-1}$ ,
- $N_{(T)}$  – number of head of livestock for category T,
- T – category of livestock.

The emission factors ( $EF_{(T)}$ ) for the defined livestock category were taken from tables 10.10 and 10.11 [IPCC 2006].

Methane emission from manure management was calculated according to equation 10.22 (2):

$$CH_{4\text{Manure}} = \sum_{(T)} \frac{(EF_{(T)} \cdot N_{(T)})}{10^6} \quad (2)$$

where:

- $CH_{4\text{Manure}}$  –  $CH_4$  emission from manure management,  $GgCH_4 \cdot y^{-1}$ ,
- $EF_{(T)}$  – emission factor for the defined livestock category,  $kgCH_4 \cdot head^{-1} \cdot y^{-1}$ ,
- $N_{(T)}$  – number of head of livestock for category T,
- T – category of livestock.

The manure management emission factors for each livestock category ( $EF_{(T)}$ ) were obtained from tables 10.14 and 10.15 [IPCC 2006].

Number of animal heads according to livestock category was obtained from Local Data Bank (BDL) available on the website of the Central Statistical Office (GUS).

## RESULTS AND DISCUSSION

In 2011, total emission of methane and nitrous oxide expressed as  $CO_2$  equivalent in Poland was about 35 Gg and was lower by about 30% comparing to 1988. This emission has stayed on similar level since 1993, when the biggest changes associated with economic transformation in Poland were finished. The majority of methane emission in 2011 – 76.7%, originated from enteric fermentation of livestock, and approximately 23.2% was due to the management of its manure. The share of the combustion of plant residues in methane emission was only 0.1% [KOBIZE 2013].

Methane emission from enteric fermentation in Poland was 442.2  $GgCH_4$  in 2011 and decreased in 1988 by 40.7%. The main factor contributing to this phenomenon was a decrease of number of livestock. The largest decrease was recorded in the sheep population, which contributed to the reduction of  $CH_4$  emission in this animal category by nearly 94% [KOBIZE 2013].

In Poland, particularly significant was the decline of numbers of cattle and pigs which are essential in methane emission. Such situation can be seen in most Voivodeships. However, Podlaskie Voivodeship is the only one, except Warmia and Mazury region, where the significant increase in the number of cows in the period of 2002–2012 was observed [Statistical Yearbook of Agriculture 2013].

**Table 1.** Livestock numbers (in thousand heads) by category in Podlaskie Voivodeship (based on data from BDL)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cows	349.3	354.2	355.1	380.0	382.3	380.4	393.1	420.9	438.9	448.7	476.6	464.9	441.4	448.9
Other cattle	279.9	269.1	264.2	280.4	310.7	323.1	347.4	331.4	351.9	378.5	447.6	453.8	453.7	433.1
Pigs	1025.0	898.4	925.9	987.5	872.4	828.8	895.5	872.6	708.1	577.8	570.0	564.4	467.4	360.3
Sheep	48.6	33.6	33.0	36.6	35.5	31.1	40.4	35.7	35.8	27.7	28.3	27.6	30.9	33.3
Goats	3.5	3.5	3.5	3.5	3.5	3.8	4.7	4.7	5.5	4.7	6.0	6.0	2.5	4.0
Horses	38.7	37.9	37.8	23.8	24.2	23.4	20.2	22.1	25.5	23.1	23.8	23.8	20.8	19.2
Ducks	57.3	55.3	35.8	26.1	31.4	30.1	28.0	11.5	18.3	9.6	28.0	56.5	20.2	22.0
Turkeys	39.3	39.4	37.5	19.8	503.4	324.4	121.9	104.2	72.4	53.4	55.0	252.6	344.9	176.2
Poultry	2127.7	2185.1	1996.7	1900.9	4608.3	4165.5	4647.9	2886.2	4940.5	3356.1	4001.8	4352.3	5070.9	4389.2

In the Podlaskie Voivodeship the number of cows increased by approximately 30%, other cattle – by about 50%, and goats – by about 15% in the considered period (Table 1). In case of the remaining animals, only the number of poultry and turkey increased, but their share in the production of CH<sub>4</sub> is relatively small. The number of other farm animals declined, the number of pigs decreased approximately about 65%, sheep – about 31%, horses – about 50% and ducks – about 61%.

This situation in the Podlaskie Voivodeship caused the increase of CH<sub>4</sub> emission to the atmosphere in the years 1999–2012 approximately about 30% (Table 2). The maximum value of 87.9 GgCH<sub>4</sub> was recorded in 2009 year.

In the Podlaskie Voivodeship the major source of methane was enteric fermentation process, whose share systematically increased, from 88.8 to 90.1%, through the whole study period. During the same period the percentage of CH<sub>4</sub> from manure decreased from 11.2% to less than 10% (Table 2), while the average value for Poland in 2011 was more than 23% [KOBIZE 2013]. These differences are probably due to the large share of farmyard manure system of animal husbandry in the Podlaskie Voivodeship, where solid manure consumption is highest in the country and in terms of pure component was 68.3 kg·ha<sup>-1</sup> in the 2011/2012 economic year, with the Polish average 38 kg·ha<sup>-1</sup> [Environmental Protection 2013].

Similarly to the total emission, for both, the enteric fermentation and manure management, the

increase of the CH<sub>4</sub> amount released to the atmosphere was observed. In first case it reached about 32%. In 1999, methane emission was 56.60 GgCH<sub>4</sub>. In subsequent years it increased steadily until 2009, when it reached 78.98 GgCH<sub>4</sub> and then was reduced to the value of 74.77 GgCH<sub>4</sub> in 2012 (Figure 1).

Cows and other cattle have the biggest share in this process and in their case methane emission increased between 1999 and 2012 (Table 3). A growth of 15% was also recorded in case of goats. Methane emission from other animals during the study period decreased. The largest, almost 65% decrease was observed in the case of pigs.

Methane emission from manure management in Poland, in 2011 year was equal to 133.8 GgCH<sub>4</sub> and in relation to emission in year 1988 decreased by 17.8%. The downward trend was observed in the majority of animal categories except dairy cows. Despite declining cows population since 1988, the large share of liquid manure systems caused the increase of CH<sub>4</sub> emission from this source in 2011 [KOBIZE 2013].

In the Podlaskie Voivodeship, methane emission from manure showed a smaller increase compared to that which was caused by enteric fermentation process. In the years 1999–2012 it was about 15% and the emission in 2012 reached 8.26 Gg CH<sub>4</sub> (Figure 2).

Similarly to the case of enteric fermentation, in methane emission from manure the largest share had cattle and, in the initial period pigs. However, due to a considerable reduction in their

**Table 2.** Methane emission from the area of Podlaskie Voivodeship

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Emission [GgCH <sub>4</sub> ]	Enteric methane	56.60	56.17	56.02	59.52	61.35	61.75	64.66	66.69	69.65	71.93	78.98	78.06	75.32	74.77
	Methane from manure	7.13	6.97	6.92	7.35	7.54	7.55	7.90	8.01	8.15	8.19	8.93	8.87	8.51	8.26
	<b>Total</b>	<b>63.73</b>	<b>63.14</b>	<b>62.94</b>	<b>66.87</b>	<b>68.89</b>	<b>69.30</b>	<b>72.55</b>	<b>74.70</b>	<b>77.80</b>	<b>80.12</b>	<b>87.90</b>	<b>86.93</b>	<b>83.83</b>	<b>83.03</b>
%	Enteric methane	88.8	89.0	89.0	89.0	89.1	89.1	89.1	89.3	89.5	89.8	89.8	89.8	89.8	90.1
	Methane from manure	11.2	11.0	11.0	11.0	10.9	10.9	10.9	10.7	10.5	10.2	10.2	10.2	10.2	9.9

**Table 3.** Methane emission from enteric fermentation by livestock categories

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
[GgCH <sub>4</sub> ]														
Cows	37.73	38.25	38.35	41.04	41.29	41.08	42.46	45.46	47.40	48.46	51.47	50.21	47.67	48.48
Other cattle	16.23	15.61	15.32	16.26	18.02	18.74	20.15	19.22	20.41	21.95	25.96	26.32	26.31	25.12
Pigs	1.54	1.35	1.39	1.48	1.31	1.24	1.34	1.31	1.06	0.87	0.85	0.85	0.70	0.54
Sheep	0.39	0.27	0.26	0.29	0.28	0.25	0.32	0.29	0.29	0.22	0.23	0.22	0.25	0.27
Goats	0.018	0.018	0.018	0.018	0.018	0.019	0.023	0.024	0.027	0.024	0.030	0.030	0.013	0.020
Horses	0.70	0.68	0.68	0.43	0.44	0.42	0.36	0.40	0.46	0.42	0.43	0.43	0.37	0.34

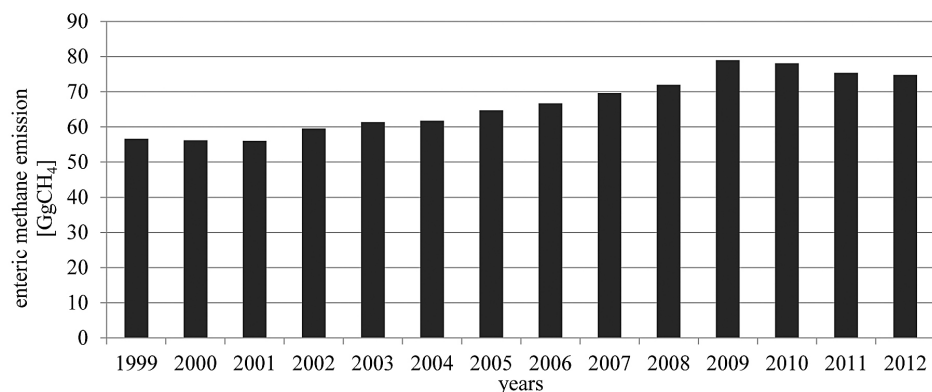


Figure 1. Methane emission from enteric fermentation

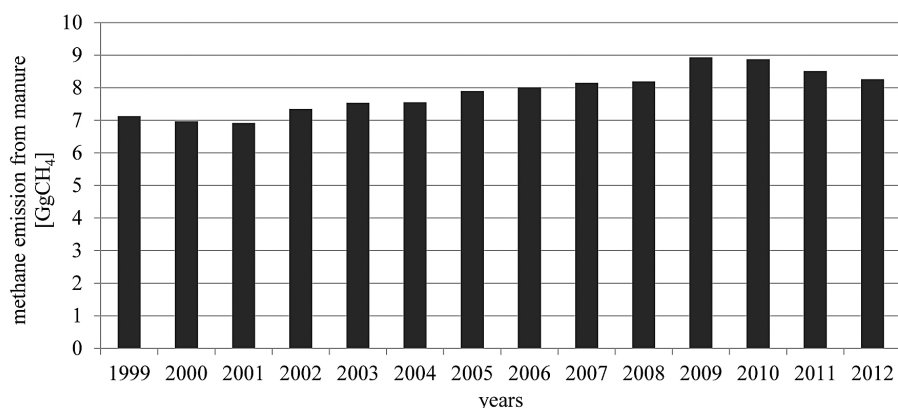


Figure 2. Methane emission from manure management

population, the emission caused by this animal category decreased from 1.48 GgCH<sub>4</sub> in 1999 to 0.54 Gg CH<sub>4</sub> in 2012 (Table 4). Big drop in emission, reaching 31% was also observed in the case of sheep.

The increase of methane emission from Podlaskie Voivodeship area in the period of 1999-2012 requires the application of measures to limit this phenomenon, both at the stage of formation and storage and further, at the stage of livestock manure managing. Emission, which is caused by

liquid manure stored in tanks below the animals' buildings can be mitigated by their frequent removal [Sommer et al. 2009], provided that the temperature outside is lower than inside [Masse et al. 2008]. Effective way to reduce CH<sub>4</sub> emission is allowing formation of a slurry crust that can produce a CH<sub>4</sub> sink as a result of its oxidation [Petersen et al. 2005]. In case of solid manure, reducing of methane emission can be achieved either by covering the faeces with sealed cover or by periodic mixing [Chadwick 2011].

Table 4. Methane emission from manure management by livestock categories

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	[GgCH <sub>4</sub> ]													
Cows	3.84	3.90	3.91	4.18	4.21	4.18	4.32	4.63	4.83	4.94	5.24	5.11	4.86	4.94
Other cattle	1.67	1.61	1.58	1.67	1.85	1.93	2.08	1.98	2.11	2.26	2.68	2.71	2.71	2.59
Pigs	1.48	1.33	1.30	1.39	1.25	1.24	1.31	1.26	1.01	0.84	0.84	0.85	0.72	0.54
Sheep	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Goats	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0007	0.0006	0.0008	0.0008	0.0003	0.0005
Horses	0.06	0.06	0.06	0.04	0.04	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.03	0.03
Ducks	0.0011	0.0011	0.0007	0.0005	0.0006	0.0006	0.0006	0.0002	0.0004	0.0002	0.0006	0.0011	0.0004	0.0004
Turkeys	0.00	0.00	0.00	0.00	0.05	0.03	0.01	0.01	0.01	0.00	0.00	0.02	0.03	0.02
Poultry	0.06	0.07	0.06	0.06	0.14	0.12	0.14	0.09	0.15	0.10	0.12	0.13	0.15	0.13

## CONCLUSIONS

On the basis of this analysis the following conclusions can be presented:

1. In the years 1999–2012 in the Podlaskie Voivodeship there was, in contrast to the rest of the country, a large increase in cattle numbers and a small in case of goats. The number of other animals has decreased, and the biggest drop was recorded in pig number.
2. Total methane emission of animal origin from the area of the Podlaskie Voivodeship increased in the years 1999–2012. The main factor contributing to this situation was an increase in the number of cows, which are the main source of this compound.
3. Increase in methane emission from enteric fermentation in the Podlaskie Voivodeship, in 1999–2012 was about 32%, while that from animal manure management – about 15%. The largest share in both cases had cattle and only in their cases there was an increase in the amount of CH<sub>4</sub> emitted. The largest decrease in emission for pigs was recorded, which was the result of a significant decrease in their population in the study period.
4. The share of methane emission from animal manure management in the total quantities emitted from livestock was about 10% in the Podlaskie Voivodeship. It was about two times lower compared to the rest of the country. This is due to a large share of farm yard manure system of animal husbandry.

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