

THE DIFFERENCES IN AMOUNTS OF METHANE EMISSIONS FROM ENTERIC FERMENTATION FROM SLOVAK EWE FARMING BETWEEN 2015 AND 2016

Zuzana Palkovičová, Vojtech Brestenský, Jan Brouček

National Agricultural and Food Centre, Research Institute for Animal Production Nitra,
Hlohovecká 2, 951 41 Lužianky, Slovakia

Abstract

In this article, we calculated methane emissions from enteric fermentation in ewe farming in 2015 and 2016. Subsequently, we investigated the causes of differences in their amounts in the observed years. We used established methodology (2006 IPCC) for calculation and we also accepted country-specific conditions of sheep farming. The amounts of methane emissions were dependent on their emission factors and the number of ewes in that year. In 2016, the average value of methane emission factor reached the value of 10.21 kg per ewe and year, which was 0.12 kg per ewe and year less than in 2015. We kept 155,828 ewes, which was 4,107 less than in 2015. The decrease of these parameters caused a decrease in amount of total methane emission in this year. The total methane emission from enteric fermentation represented 1,591.5 t of methane in 2016, which was 60.2 t less than in 2015.

Keywords: ewe farming, methane, emission, emission factor, enteric fermentation

1. INTRODUCTION

Livestock farming brings high-quality animal proteins into the food chain in the form of meat, milk or eggs. At the same time, it also becomes an environmental pollutant by producing toxic ammonia and greenhouse gases. The most important greenhouse gas in the atmosphere is water vapor (H_2O), which causes about two thirds of the greenhouse effect. It is formed by respiration and excretion of animals, as well as by evaporation of water from drinking troughs and water used to cool or clean the housing areas. Its content in the atmosphere is determined by the natural cycle of water i.e. the difference between evaporation and precipitation (6). Another greenhouse gas is carbon dioxide (CO_2), which occurs in the process of animal respiration (8). It is also produced by combustion of natural gas in gas aggregates used to heat the housing areas (10). A small amount of CO_2 is produced during decomposition of animal excrements (7). The most significant source of carbon dioxide is the combustion of fossil fuels, which accounts for more than 95 % of the total anthropogenic CO_2 emissions in the territory of Slovakia (6). Methane is also a greenhouse gas. Its biggest source is agriculture. It originates as a direct product of herbivorous metabolism and organic degradation of animal excrements (6). Methane is produced in an environment without direct access of oxygen. Its production is related to the activity of methanogenic bacteria and increase with the temperature of the environment (13). Nitrous oxide (N_2O) is the last greenhouse gas produced in agriculture. The main causes of N_2O emissions are the surplus of mineral nitrogen in the soil (intensive fertilization) and the unfavorable air regime of soils (the use of heavy machinery during cultivation) (6). A certain amount of N_2O comes from decomposition of animal excrements during their storage and application (9). In addition to greenhouse gases, agriculture is also the dominant producer of ammonia (NH_3) emissions. 80-95 % of the total NH_3 emissions in Europe come from farming practices with more than 80 % from the animal excretion and less than 20 % from the use of fertilizers (15). Ammonia emissions are damaging to the environment by contributing to the occurrence of acid rains and eutrophication of soil and aquatic ecosystems (3). From the aspect of human and animal health, ammonia emissions cause irritation of the eyes, throat and nose, with redness, coughing and sneezing. Important is its meta-toxic effect during long-term accumulation in the body, which manifests by weakening of animal immunity and easier penetration of infectious agents (16). Most of the released ammonia comes from the decomposition of organic waste and various industrial processes including fertilizer production (12). Ammonia emitted from agriculture represents an altered product of organic nitrogenous compounds from excreta of farm animals. Its origin is in urea contained in urine (1). The process of its formation begins in the housing area, where liquid and solid excrements

are mixed and ammonia is formed by enzymatic decomposition of urea. In this area, the most suitable conditions for the conversion of ammonia are secured, especially the optimal temperature, humidity, pH, large-scale distribution of excrements and access to air (14). Ammonia and greenhouse gas emissions recorded a significant decline over the period 1990 to 2003 due to decrease of numbers of farm animals. At this time, the numbers of farm animals are stabilized and the Slovak government is planning to increase their numbers. As a result, it is no longer possible to further reduce emissions of these gases this way. Low-emission techniques should be used to further reduce them. However, these are mainly aimed at reducing ammonia emissions. Their research and further use in practice is very important because methane and nitrous oxide have a high global warming potential (CH₄: 28-36, N₂O: 265-298) (4) making a significant contribution to the greenhouse effect and the warming of the ground atmosphere. Measurements of methane and nitrous oxide emissions in practice are also very difficult and require appropriate measurement techniques. The measurement based on the principle of the photoacoustic detection method appears to be an optimal method. This method was also used in pig and poultry fattening in the territory of Slovakia (5, 11). In view of the need for a uniform greenhouse emission assessment procedure, the countries of European Community adopted a common methodology for determination of these emissions. It is based on long-term scientific results in this area and it is being elaborated in the form of guidelines. In this paper, we used the above mentioned methodology to determine methane emissions from enteric fermentation in ewes farming.

2. MATERIALS AND METHODS

2.1. Materials

Monitored farm animal: dairy sheep, category ewes

Monitored gas: methane (CH₄)

Location of methane production: enteric fermentation

Monitored years: 2015, 2016

Input data: Statistical office of the Slovak Republic, farmer's questionnaires, researchers focused on sheep farming from Research Institute for Animal Production Nitra, Slovakia

2.2. Methods

For determination of methane emissions from ewe farming, we used TIER 2 methodology of 2006 IPPC Guidelines for National Greenhouse Gas Inventories (2). We divided the territory of Slovakia into 8 regions, in which we calculated CH₄ emissions. For the calculation of emissions, we had to find out the numbers of ewes and CH₄ emission factors in individual regions. We obtained information about the numbers of ewes from Statistical office of the Slovak Republic. We determined CH₄ emission factors for each region from need of gross energy (GE) and methane conversion factor (Y_m). For calculation of GE, we had to identify the amount of net energies for maintenance, activity, milk and wool productions, pregnancy, as well as digestibility (DE) of feed ration. For calculation of net energies and DE of feed ration, we used some information from farmer's questionnaires and researchers focused on sheep farming (live weight, walk up meters per day, annual milk and wool productions, duration of grazing, number of lambs per ewe). The values of Y_m were the same. We multiplied detected CH₄ emission factor by the number of ewes in this region and obtained CH₄ emission from enteric fermentation in the region. We repeated this procedure in each region. Subsequently, we summed the emissions from all regions and determined the total CH₄ emission from enteric fermentation of dairy ewes in the territory of Slovakia. This calculation method was used for both monitored years.

3. RESULTS

In 2015, we kept 159,935 ewes in the territory of Slovakia. In 2016, it was 155,828 ewes, which was 4,107 ewes fewer than in 2015. The largest number of ewes was kept in the middle of Slovakia in the region of Zilina and the least number of ewes in the west of Slovakia in the region of Bratislava. The

representation of individual breeds was as follows: Improved Valachian - 30 %, Tsigai - 28 %, Slovak Dairy sheep - 18 %, Lacaune - 15 %, East Friesian sheep - 3 %, crossbreeds - 6 %. Their average live body weight was approximately 60 kg. The ewes grazed for 184 days and stayed in housing area for 181 days. Digestibility of feed ration was 65.04 % and derived from it, the value of methane conversion factor amounted 6.5 %. Values of net energies for maintenance, activity and pregnancy amounted 4.68, 0.99 and 0.45 MJ.ewe⁻¹.day⁻¹, respectively. Above mentioned was valid for both monitored years (tab. 1., 2.).

In 2015, the average milk yield amounted 0.39 kg.ewe⁻¹.day⁻¹. The highest milk yield was detected in the region of Trenčín (0.48 kg.ewe⁻¹.day⁻¹) and the lowest in the region of Bratislava (0.17 kg.ewe⁻¹.day⁻¹). From milk yield, the need of net energy for lactation was derived. The average net energy for lactation amounted 1.78 MJ.ewe⁻¹.day⁻¹. The highest was found in the region of Trenčín (2.21 MJ.ewe⁻¹.day⁻¹) and the lowest in the region of Bratislava (0.78 MJ.ewe⁻¹.day⁻¹). In 2016, the average milk yield amounted 0.37 kg.ewe⁻¹.day⁻¹. It was 0.02 kg.ewe⁻¹.day⁻¹ less than in 2015. The highest and the lowest milk yield were found in the same regions and they had the same values as in 2015. The average net energy for lactation amounted 1.70 MJ.ewe⁻¹.day⁻¹, which was 0.08 MJ.ewe⁻¹.day⁻¹ less than in 2015. The highest was found in the region of Trenčín (2.21 MJ.ewe⁻¹.day⁻¹) and the lowest in the region of Bratislava (0.78 MJ.ewe⁻¹.day⁻¹), which was the same as in 2015 (tab. 1., 2.).

In 2015, the average production of wool achieved the value of 1.78 kg.ewe⁻¹.year⁻¹ and the highest was determined in the region of Trnava (3.09 kg.ewe⁻¹.year⁻¹) and the lowest in the region of Trenčín (1.52 kg.ewe⁻¹.year⁻¹). From wool production, the need of net energy for wool production was determined. The average net energy for wool production amounted 0.12 MJ.ewe⁻¹.day⁻¹. The highest value was detected in the region of Trnava (0.20 MJ.ewe⁻¹.day⁻¹) and the lowest value in the regions of Trenčín and Žilina (0.10 MJ.ewe⁻¹.day⁻¹). In 2016, the average production of wool reached the value of 1.69 kg.ewe⁻¹.year⁻¹. It was 0.09 kg.ewe⁻¹.year⁻¹ less than in 2015. The highest value was found in the region of Nitra (2.27 kg.ewe⁻¹.year⁻¹) and the lowest value in the region of Trenčín (1.32 kg.ewe⁻¹.year⁻¹, the same as in 2015). The average net energy for wool production achieved value of 0.11 MJ.ewe⁻¹.day⁻¹. It was 0.01 MJ.ewe⁻¹.day⁻¹ less than in 2015. The highest value was determined in the region of Nitra (0.15 MJ.ewe⁻¹.day⁻¹) and the lowest value in the region of Trenčín (0.09 MJ.ewe⁻¹.day⁻¹, tab. 1., 2.).

In 2015, the average methane emission factor reached the value of 10.33 kg.ewe⁻¹.year⁻¹. The highest value was found in the region of Trenčín (10.83 kg.ewe⁻¹.year⁻¹) and the lowest in the region of Bratislava (9.07 kg.ewe⁻¹.year⁻¹). In 2016, the average methane emission factor amounted 10.21 kg.ewe⁻¹.year⁻¹, which was 0.22 kg.ewe⁻¹.year⁻¹ less than in 2015. The highest value was detected in the region of Trenčín (10.81 kg.ewe⁻¹.year⁻¹) and the lowest in the region of Bratislava (9.10 kg.ewe⁻¹.year⁻¹), which was the same (regions) as in 2015 (tab. 1., 2.).

In 2015, the total methane emission from enteric fermentation reached the value of 1,651.7 t.year⁻¹. The highest emission was determined in the region of Žilina (479.9 t.year⁻¹) and the lowest in the region of Bratislava (2.0 t.year⁻¹). In 2016, the total methane emission from enteric fermentation amounted 1,591.5 t.year⁻¹, which was 60.2 t less than in 2015. The highest emission was found in the region of Žilina (476.7 t.year⁻¹) and the lowest in the region of Bratislava (1.1 t.year⁻¹), which was the same (regions) as in 2015 (tab. 1., 2.).

	BA	TT	TN	NR	ZA	BB	PO	KE	Slovakia
Ewes	221	429	16,085	3,799	45,908	43,060	36,471	13,962	159,935
BW (kg)	60	60	60	60	60	60	60	60	60
Milk yield (kg.day⁻¹)	0.17	0.40	0.48	0.29	0.41	0.38	0.36	0.33	0.39
DE (%)	65.04	65.04	65.04	65.04	65.04	65.04	65.04	65.04	65.04
Ym/100	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
Wool (kg.ewe⁻¹.year⁻¹)	1.88	3.09	1.52	2.92	1.57	1.93	1.71	2.11	1.78
NEm (MJ.day⁻¹)	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68
NEa (MJ.day⁻¹)	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
NEl (MJ.day⁻¹)	0.78	1.83	2.21	1.35	1.90	1.73	1.65	1.50	1.78
NEp (MJ.day⁻¹)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
NEwool (MJ.day⁻¹)	0.12	0.20	0.10	0.19	0.10	0.13	0.11	0.14	0.12
GE (MJ.ewe⁻¹.day⁻¹)	21.26	24.81	25.41	23.31	24.52	24.14	23.81	23.50	24.22
EF (kg.ewe⁻¹.year⁻¹)	9.07	10.58	10.83	9.94	10.45	10.29	10.15	10.02	10.33
Emission (t.year⁻¹)	2.0	4.5	174.3	37.7	479.9	443.1	370.2	139.9	1,651.7

BW - body weight, DE - digestibility, Ym - methane conversion factor, NEm - net energy for maintenance, NEa - net energy for activity, NEl - net energy for lactation, NEp - net energy for pregnancy, NEwool - net energy for wool production, GE - gross energy, EF - emission factor

Table 1. CH₄ emissions from enteric fermentation in individual regions of Slovakia and within all Slovakia in 2015

	BA	TT	TN	NR	ZA	BB	PO	KE	Slovakia
Ewes	119	401	15,984	1,992	46,785	41,662	34,864	14,021	155,828
BW (kg)	60	60	60	60	60	60	60	60	60
Milk yield (kg.day⁻¹)	0.17	0.31	0.48	0.35	0.37	0.36	0.36	0.30	0.37
DE (%)	65.04	65.04	65.04	65.04	65.04	65.04	65.04	65.04	65.04
Ym/100	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
Wool (kg.ewe⁻¹.year⁻¹)	2.09	2.09	1.32	2.27	1.53	1.77	1.80	2.09	1.69
NEm (MJ.day⁻¹)	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68
NEa (MJ.day⁻¹)	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
NEl (MJ.day⁻¹)	0.78	1.43	2.21	1.60	1.70	1.66	1.65	1.40	1.70
NEp (MJ.day⁻¹)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
NEwool (MJ.day⁻¹)	0.14	0.14	0.09	0.15	0.10	0.12	0.12	0.14	0.11
GE (MJ.ewe⁻¹.day⁻¹)	21.33	23.29	25.36	23.85	23.90	23.86	23.83	23.18	23.96
EF (kg.ewe⁻¹.year⁻¹)	9.10	9.93	10.81	10.17	10.19	10.17	10.16	9.88	10.21
Emission (t.year⁻¹)	1.1	4.0	172.8	20.6	476.7	423.8	354.2	138.6	1,591.5

BW - body weight, DE - digestibility, Ym - methane conversion factor, NEm - net energy for maintenance, NEa - net energy for activity, NEl - net energy for lactation, NEp - net energy for pregnancy, NEwool - net energy for wool production, GE - gross energy, EF - emission factor

Table 2. CH₄ emissions from enteric fermentation in individual regions of Slovakia and within all Slovakia in 2016

4. DISCUSSION

The amount of CH₄ emission in the individual regions was dependent on the number of ewes and the CH₄ emission factor (EF) in that region. The value of EF was related to the gross energy and methane conversion factor (Y_m). The value of Y_m was the same in the individual regions of Slovakia in both monitored years. The value of GE was related to the requirement for net energies for maintenance, activity, pregnancy, milk and wool productions (N_{Em}, N_{Ea}, N_{ep}, N_{El}, N_{Ewool}) and digestibility (DE) of feed ration. N_{Em}, N_{Ea}, N_{ep} and DE of feed ration showed the same values in individual regions of Slovakia in 2015 and 2016. N_{El} and N_{Ewool} were the only variables in calculation of GE in these regions. The values of N_{El} and N_{Ewool} were associated with milk and wool productions. In 2016, the milk yield and N_{El} increased in 1 region (NR), remained the same in 3 regions (BA, TR, PO) and decreased in 4 regions (TT, ZA, BB, KE). The decrease of average milk yield and N_{El} amounted 0.02 kg.ewe⁻¹.day⁻¹ and 0.08 MJ.ewe⁻¹.day⁻¹, respectively. The wool production and N_{Ewool} increased in 2 regions (BA, PO) and decreased in 6 regions (TT, TR, NR, ZA, BB, KE). The decrease of average wool production and N_{Ewool} amounted 0.09 kg.ewe⁻¹.year⁻¹ and 0.01 MJ.ewe⁻¹.day⁻¹, respectively. In this year (2016), slight decreases were found in milk yield, wool production, N_{El} and N_{Ewool} in most regions, as well as a decrease in their average values within Slovakia. The values of average GE and EF decreased by 0.26 MJ.ewe⁻¹.day⁻¹ and 0.12 kg. ewe⁻¹. year⁻¹ in 2016, respectively. GE and EF increased in 3 regions (BA, NR, PO) and decreased in 5 regions (TT, TR, ZA, BB, KE). The small decreases of milk yield, wool production, N_{El} and N_{Ewool} in most regions caused also small decreases of GE, EF in these regions. This could subsequently manifest as a slight decline in the total amount of methane emission. However, the main impact on the total amount of CH₄ emission had the number of ewes, which dropped in all regions (except ZA, KE) with a total decrease of 4,107 ewes within Slovakia.

5. CONCLUSIONS

In 2016, the total methane emission from enteric fermentation of dairy ewes reached the value of 1,591.5 t. It was 60.2 t less than in 2015. A small share on the drop of methane emission had the decrease of CH₄ emission factor in most regions due to the reduced milk and wool production in this year. However, the total amount of methane emission was mainly affected by the decrease in the number of ewes. Our effort is not to reduce the sheep farming in the territory of Slovakia, and therefore it is necessary to use low-emission techniques for mitigation of methane emissions. It is important to use those, which would reduce methane emissions as much as possible, but would be applicable under acceptable technical and economic conditions.

ACKNOWLEDGMENTS

This article was possible through projects APVV of the Slovak Research and Development Agency Bratislava (0632-10 and 15-0060), and the project CEGEZ 26220120073 supported by the Operational Programme Research and Development funded from the European Regional Development Fund.

REFERENCES

1. Aarnink, AJA, Hoeksma, P, Van Ouwerkerk, ENJ 1993, "Factors affecting ammonium concentration in slurry from fattening pigs", Proceedings of the Congress on Nitrogen Flow in Pig Production and Environmental Consequences, Pido, Wageningen, pp. 413-420.
2. Dong, H, Mangino, J, McAllister, TA, Hatfield, JJ, Johnson, DE, Lassey, KR, de Lima, MA 2006, "Emissions from livestock and manure management", 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IGES Japan, pp. 10.7-10.83.
3. Hartung, JA 1992, "General code of practice to reduce ammonia volatilization from animal husbandry", Baltic-Sea-Environment-Proceedings, 44, pp. 38-47.

4. United States Environmental Protection Agency, Understanding Global Warming Potentials <<https://www.epa.gov/ghgemissions/understanding-global-warming-potentials>>.
5. Knížatová, M, Šottník, J, Karandušovská, I, Orság, J, Palkovičová, Z 2006, "Meranie koncentrácie amoniaku a skleníkových plynov v brojlerovom chove kurčiat a kvantitatívne stanovenie ich emisií", Využití doplňkové a nekonvenční péče o zdraví zvířat, 6. věd. konf. s mezinár. úč., České Budějovice, ČR, (Sbor. příspěv.), s. 49-53.
6. MŽP SR, SHMÚ 2004, "Správa o kvalite ovzdušia a podiele jednotlivých zdrojov na jeho znečisťovaní v SR".
7. Ni, JQ 1998, "Emission of carbon dioxide and ammonia from mechanically ventilated pig house" PhD thesis. Department of Agricultural Engineering, Catholic University of Leuven. Leuven, Belgium. 227 p.
8. Nick, B, Laitat, M, Vandenheede, M, Désiron, A, Verhaeghe, C, Canart, B 2003, "Emissions of ammonia, nitrous oxide, methane, carbon dioxide and water vapor in the raising of weaned pigs on straw-based and sawdust-based deep litters", Anim. Res. 52 (2003), pp. 299-308.
9. Oenema, O, Wrage, N, Velthof, GL, Groenigen, JW, Dolfing, J, Kuikman, PJ 2005, "Trends in global nitrous oxide emissions from animal production systems", Nutrient Cycling in Agroecosystems (2005) 72, pp. 51-56.
10. Olanrewaju, HA, Dozier, WA, Purswell, JL, Branton, SL, Miles, DM, Lott, BD, Pescatore, AJ, Thaxton, JP 2008, "Growth performance and physiological variables for broiler chickens subjected to short-term elevated carbon dioxide concentrations", International Journal of Poultry Science (2008) 7 (8), pp. 738-742.
11. Palkovičová, Z, Knížatová, M, Mihina, S, Brouček, J, Hanus, A 2011, "Emissions of hazardous gases from pig housing during winter and summer season", XVth ISAH Congress 2011, Vienna, Austria, Animal Hygiene and Sustainable Livestock Production, Congr. Proc. Volume III, pp. 1135-1137.
12. Patráš, P, Nitrayová, S, Brestenský, M, 2007, "Eliminácia amoniaku v chove ošípaných", Slovenský chov, roč. 12, č.6, (2007), s. 24, 44.
13. Pattey, E, Trzcinski, MK, Desjardins, RL, 2005, "Quantifying the reduction of greenhouse gas emissions as a result of composting dairy and beef cattle manure", Nutrient Cycling in Agroecosystems (2005) 72, pp. 173-187.
14. Sasáková, N, Venglovský, J, Pačajová, Z, Plachá, I, Ondrašovičová, O, Harichová, D, Novák, P 2002, "Podiel živočíšnej výroby na emisiách amoniaku a možnosti ich obmedzenia", Aktuální otázky bioklimatologie zvířat 2002, s. 84-87.
15. Van der Hoek, KW 1998, "Estimating ammonia emission factors in Europe", summary of the work of the UNECE ammonia expert panel, Atmospheric Environment 32(3), pp.315-316.
16. Vasil', M 2001, "Stav citlivosti voči antibiotikám u patogénov mliečnej žľazy izolovaných zo sekretu vemena a z ustajňovacieho prostredia dojnic", Zborník referátov z vedeckej konferencie s medzinárodnou účasťou, Michalovce, 2, (2001), s. 83-86.