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Methods of Calculating the Emissions of Greenhouse Gases from Manure from Sheep and Goat's Breeding in the Republic of Bulgaria

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Abstract. The authors propose a universal method for determining the emissions of greenhouse gases from sheep and goat's farming. The authors use specific Bulgarian energetic units for measurement of the energy in fodders/excrements and requirements of the ruminants (base - net energy). The methodology is illustrated with examples (base is a farm with 100 sheep/goats with 120% reproductive capacity) . On this basis logical reasoning calculation formulas are introduced. They are a good basis for digitizing of the calculations. The calculating procedure is universal and can be easily adapted to different conditions (number of animals, reproductive capacities, periods of realization of lambs/kids etc.).

Key words: greenhouse gases, sheep and goat's farming, volatile solid excretion.

Introduction

The exact determining of the emissions of greenhouse gases from sheep breeding is pressing in the countries of southern Europe, including the Republic of Bulgaria, due to the following main reasons:

- The development of a monitoring program for greenhouse emissions for every European Union member state in relation with the adopted strategies for their limitation (EC, 2005) and fair allocation of quotas - Directive 91/676/EC (EC, 1991), Directive 2008/101/EC (EC, 2008), Directive 2009/29/EC (EC, 2009) and the search for a sufficiently precise methodology for this.

- The education and training of students - future teachers to practically educate the growing generation in solving these problems (VAKLEVA *et al.*, 2002; VAKLEVA, 2017), and the efforts to create and apply a uniform methodology for such training (problem solving, cases, etc.).

Although in Europe and in particular in Bulgaria there is a wide variety of production systems for the production of sheep and goat breeding products, as well as animals varying in type, live mass, and productivity (VUCHKOV, 2015; DIMOV & VUCHKOV, 2017), greenhouse gas emissions do not depend much on the way animals are grown.

In our previous publications (PENKOV *et al.*, 2012; 2014), we proposed unified methods for calculating the greenhouse emissions from industrial pig and poultry production.

The purpose of this article is to propose methods of defining greenhouse emissions from the mixed excrements (faeces and urine) generated by the sheep and goat breeding sector in Bulgaria.

Material and Methods

For the equalisation of greenhouse gases from all excrements we use the officially adopted formula of the Ministry of Enwironment and Water which converts all emitted gases into a conditional „pollutant" (IPCC, 2001):

VS = (DMI*18.45)*(1-DEI/100)*(1-%ASH/100)

where: VS - volatile solid excretion per 24 hours on a dry matter weight basis – kg DM per 24 h; DMI - dry matter intake – kg/anima/24h; 18.45 – mean gross energy content in 1 kg dry matter of the fodders – MJ; DEI – digestible energy intake from 1 animal/24h (as coefficient, or percentage) from the gross energy intake; %ASH – percentage of ash in the DM of the excrements.

For greater clarity we are going to demonstrate the course of calculation with the following practical example: determine the volatile solid excretion for 1 year (365 days) on a farm with 100 sheep/goats, average annual fertility of the herd 120% (120 live lambs/kids from 100 female animals). According to the most used production system in Bulgaria, births take place in the months of January - February (provisionally we adopt February 1 as the average date). For the repair of the herd (replacing the dropped adult animals), about 10% of the female lambs/kids (in this case 10) are left, all the rest being realised for meat within 10- 15 days, between 1 and 15 May due to the traditions around the 6 May holiday (provisionally we adopt May 10 as average realisation date). Sheep milk production is 100 litres, and the total lactation milk production - 185 litres (85 litres for a sucking period).

The average data for emitted mixed excrements (faeces and urine) as well as for the dry matter and ash content in them is taken from PETROV *et al.* (1983). The data for the content of percentage/coefficient of the energy exchange as well as for the dry matter intake in each animal category is calculated on the basis of the new energy system for assessment of fodders in Bulgaria (TODODROV & DARJONOV, 1995). Although the system is based on a net energy basis, we believe it is more accurate because it also takes into account the average utilisation (and consequently the loss) of the exchange energy for the different life needs (basic metabolism, milk productivity, growth, and pregnancy). That is why we replace the digestible/exchange energy in the above formula with net energy (NE).

Results and Discussion

1. Defining the quantity of the manure waste from the animals in the farm and the chemical composition of the faeces and the urine:

According to the above-mentioned source, about 1.5 kg of faeces and 0.5-2 (an average of 1.2) litres of urine are emitted per day from a sheep/goat (about 55 kg of live weight) for a 24-hour period. Recalculated on a live weight basis, 0.5 kg faeces and 0.4 litres urine are emitted from one lamb/kid.

Method of calculation of emitted lamb/kid excrements:

A lamb/kid is born with a live weight of about 5 kg and is realised at a final live weight of 25 kg, therefore the average live weight will be 17.85 kg or 17.85/55 = 33% of the live weight of an adult sheep/goat. The content of dry matter and ash in the faeces is taken from scientific experience (PETROV *et al.*, 1983) - 40.3% and 4.9%, respectively.

Data on dry matter and ash content in the urine is averaged according to PETROV *et al.*, 1983 (total for ruminants) and it is respectively 4.50% and 2.2%.

2. Defining the quantity of the dry matter intake and gross energy of the animals:

1.2. For lactating sheep (medium lactation period 185 days, 185 kg lactation milk production or an average of 1 litre of

milk per day), the DMI is 2 kg (TODODROV & DARJONOV, 1995). The gross energy intake (GEI) is: 2*18.45 = 36.9 MJ.

2.2. For fertile and pregnant sheep (180 days) and 1.2 lambs set per pregnancy, the DMI is 1.7 kg. The GEI is 1.7*18.45 = 31.37 MJ.

The average daily amount of GEI will be:[(36.9*185) + (31.37*180)]/365 = 34.17 MJ, and for 365 days - 12472.05 MJ.

The old sheep are scrapped at the end of the year, so we conditionally assume that the total number of mother sheep remains 100 through the whole year.

3.2. For repaired young breeding animals: They are born with a live weight of about 5 kg and for 11 months (until the end of the year) they grow by standard to 75% of the live weight of the adults. They are not lactating and their average live weight will be: 23.13 kg. The ratio of dry matter intake will be: 23.13/55*100 = 42% of pregnant sheep or 1.7*0.42 = 0.71 kg. Their average daily GEI = 0.71*18.45 = 13.1 MJ, and for 335 days (their life cycle for the year) - 4388.5 MJ

4.2. Lambs for realisation. For 120 live births and 10 left for repairs to the herd, the total number of lambs for realisation will be 110. They stay on the farm from 01.02 to 10.05 or an average of 100 days. Their live birth weight is 5 kg, and at realisation - 25 kg, or an average live weight of 15 kg. Under these conditions, their DMI will be 0.60 kg (TODODROV & DARJONOV, 1995) and the GEI = =0.6*18.45 = 11.07MJ, and for 110 days (their life cycle for the year) - 1217.7 MJ.

3. Defining the net energy (NE) intake.

1.3. For mother sheep:

The main vital activities for which energy is needed are: Ground metabolism (GME), 0.042*pregnancy (PE), milk yield (ME) and movement on the pasture (PME). The active movement on the pasture is about 215 days and the shed period - 150 days. According to the formulas of TODOROV & DARJONOV (1995) recalculated by us, the basic formula (in MJ per 1 animal for 24 hours) is:

GME = 0.234*55 0.75 (valid for 365 days); PE = 1.11*6 (valid for 150 days); PEM= 0.042*6+1.884 (valid for 185 days);

PME = 0.00258*55*10 (valid for 215 days for an average of 10 kilometres horizontal distance covered).

The total annual net energy intake per sheep/goat:

NE=0.234*550.75*365+6.66*150+(0.042*6 +1.884)*185+(0.00258*55*10)*215 = 9070.9 MJ

2.3. For repaired female animals: the main vital activities are GME, daily growth (DGE), and PME. According to the accepted standards, their average daily growth is 0.11 kg and the pasture period is 240 days. The formulas we have recalculated on the basis of the above-mentioned source are:

GME = 0.234*23.13 0.75 (valid for 335 days)

PME = 0.0258*23.13*10 (valid for 240 days)

DGE = 2.04 MJ (valid for 335 days)

The total annual net energy intake by a female repair animal:

NE=0.234*23.130.75*335+(0.00258*23.13* 10)*240 + 2.04*335 = 1653.41 MJ.

3.3. For animals for fattening and realisation:

Main set parameters: Average daily growth - 0.2 kg, lifecycle - 100 days, fully grown in sheds, basic vital activities - GME, DGE, average live weight (of birth weight and mass of realisation) - 15 kg.

GME = 0.234*15 0.75 (valid for 110 days);

DGE = 2.58 MJ (valid for 110 days).

The total annual net energy intake by a female animal for fattening =

NE = 0.234*150.75*110 + 2.58*110 = 480 MJ.

4. Defining the DEI coefficients in the basic formula by animal categories:

1.4. For sheep/goats: DEI = 9070.9/12472.05 = 0.73.

2.4. For young repair animals: DEI = 1653.41/4388.5 = 0.38.

3.4. For animals for fattening and realisation: DEI = 480/1217.7 = 0.394.

5. Defining the average ash content in dry matter of mixed excrements as a coefficient:

1.5. For one mother sheep/goat:

ASH = (1.5*43/100*4.9/100) + (1.2*4.5/100*2.2/100) = 0.0328.

2.5. For lambs and repair female animals:

ASH = (0.5*43/100*4.9/100)+0.4*4.5/100*2.2/100) = 0.011.

6. Defining the total amount of greenhouse gas emissions by category for the whole year (356 days), compared to the suggested calculation example:

1.6. For 100 animals of the main herd:

VS=[12472.05*(1-0.73)*1-0.0328)]*100= 326599 kg or 327 tons.

2.6. For young repair animals:

VS=[4388.5*(1-0.38)*1-0.011)]*10 = 26602.8 kg or 26.6 tons.

3.6. For livestock for fattening and realisation:

VS=[1217.7*(1-0.394)*1-0.011)]*110 = 80279.1 kg or 80.3 tons.

4.6. Total amount of farm emissions at the set parameters is 433.9 tons per year.

The proposed methods can be presented in a simpler way, but the goal of the authors is that the calculations are presented in as simplified as possible and that they can be easily modified using different breeding technologies, in different productive systems, different technological periods and different periods of stay of the technological groups.

The authors believe that their chosen case for solving is in line with the current state of sheep and goat breeding in the Republic of Bulgaria.

The authors believe that for the simplest possible solution, without significant compromises on the accuracy of the results:

1. With regard to the separation of the greenhouse emissions, no significant differences between sheep and goats should exist, therefore the methods are applicable for both types of animals.

2. In the course of the calculations some life and technological activities are disregarded, such as that a certain percentage of technological scrapping exists (not all born lambs survive) and that young repair animals are pregnant during the last two months of the year, and adult sheep/goats are not usually scrapped on 31 December, but 40-60 days earlier.

These, as well as other technological moments not covered by the methods should not have a significant effect on the final results, with the statistical error being less than 1%.

The authors believe that the replacement of digestible/exchange energy in the basic formula is necessary for the conditions of the Republic of Bulgaria, therefore, that the energy units determining the levels of nutrition and nutritional value of fodders for ruminant animals are precisely on the basis of net energy. On the other hand, defining the correction coefficients in the second part of the formula is more accurate.

Besides manure waste, sheep and goats also emit a considerable amount of fermentation gases (mainly methane) which are to be added. There gases are described in the literature (Moe et al., 1980) and they are not the subject of this article.

Conclusions

The proposed methods for calculating the greenhouse gas emissions from excrements of sheep and goats are applicable to the objective assessment of this effect, due to its reporting being as accurate as possible.

They can be corrected relatively easily, depending on the different breeding technologies, different production systems, different technological periods and different periods of stay of the technology groups.

On the other hand, the calculations can be relatively easily digitalised in different software media. emissions from the mixed excrements (faeces and urine) generated by the sheep and goat breeding sector.

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