RESEARCH IN MANURE MANAGEMENT IN LATVIA

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Abstract. The article presents short information on the research in manure management performed in Latvia. New methodology for determination of percentage of manure management systems, developed at the Latvia University of Agriculture in accordance with the 2006 IPCC Guidelines, is described. To compare the new and the existing methods, calculation of a manure management system for milk cow herds was performed. It was stated that applying the new methods the amount of manure left on the pastures reduces but the output of slurry increases. It is related mainly with the changes of the marginal size of the cow herds, at which obtaining of litter manure is changed to obtaining of slurry. According to our research, at present this marginal number is 65 cows.

Keywords: greenhouse gas emissions, manure management, calculation methods.

Introduction

In accordance with the Regulations No. 217 of the Cabinet of Ministers „Regulations on the national inventory system of greenhouse gas emission units" [1] annual summarising of information on the possible greenhouse gas (SEG) emissions from different economic activities, including manure management systems, should be performed in Latvia.

For this reason different data on the technologies of manure removal, storage and application used in Latvia are needed. Therefore, already in the questionnaires during the farmers' poll in 2001 and 2010 there were questions included on the solutions of manure storage used on farms. More thorough information on the number of animals on farms and manure management was obtained in 2010 and 2014 in inquiries organized by the "Latvian Rural Advisory and Training Center" (LLKC). Still, the inquiry in 2010 included only the farms which are located in environment sensitive territories. In turn, the enquiry in 2014 included the other Latvian farms. But, this inquiry was not methodically correctly prepared and therefore the obtained data had to be processed accordingly. Besides these sources of information, also other published and unpublished data can be used for analyses of manure management issues, for instance, from the Central Statistical Bureau of Latvia (CSP) [2], Rural Support Service, different sources of literature etc.

Since 1990, in Latvia annual information on the possible greenhouse gas emissions (SEG) from different agricultural activities, including from manure management systems has been summarized. In the SEG inventory seven groups of farm animals were included: cows, cattle, pigs, poultry, sheep, goats and horses. The kinds of manure management were divided in four groups: slurry, litter manure, pastures and application for production of biogas.

At present, in Latvia calculation of greenhouse gas emissions is being introduced in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories [3]. Therefore, more detailed percentage of the kinds of livestock and manure management, than it was obtained in the previous research and from summaries of the statistical data, is needed. In turn, to develop methodology for prognosticating the manure management system the size and composition of the herd, handling conditions and other input data are necessary.

The aim of the present article is to provide information on the development of the new methodology for calculation of percentage of manure management systems considering the regulations given in the 2006 IPCC Guidelines.

Materials and methods

According to the 2006 IPCC terminology [3], all manure management systems can be dividend in 16 big groups. Performing more detailed analysis of these manure management systems we have stated that in further research it is necessary to include 7 from all manure management systems that are classified in the 2006 IPCC terminology and for classification of farm animals it is rational to choose 18 groups (Table 1).

Table 1

Manure management systems used for different farm animal groups

Animal group	Manure management systems						
	Pastures	**Litter manure**	**Slurry**	**Anaerobic digester**	**Ewes and goat deep bedding**	**Poultry manure with litter**	**Poultry and fur-animal manure without litter**
Milk cows	x	x	x	x			
Other cattle older than 2 years	x	x					
Young stock 1-2 years old	x	x		x*			
Calves till 1 year old	x	x		x*			
Swines		x	x	x			
Pigs, gilts, fattening pigs		x	x	x			
Sheep	x				x		
Goats	x				x		
Horses	x	x					
Laying hens	x	x		x			x
Chicken and poulets	x	x		x			x
Broilers						x	
Geese						x	
Ducks						x	
Turkeys						x	
Rabbits		x					
Fur-bearing animals							x
Deer	x						

* only milk cow calves and young stock

In order to determine the percentage of manure management solutions in every separate group of farm animals, the amount of manure stored or used in every definite place as well as the total amount of manure obtained from the corresponding group of farm animals should be known. Therefore, for milk cows, for example, the percentage of manure management systems can be calculated according to the following formulae

$$\lambda_{g.gan} = \frac{Q_{g.gan}}{\sum Q_g} \cdot 100, \ \lambda_{g.pak} = \frac{Q_{g.pak}}{\sum Q_g} \cdot 100, \ \lambda_{g.sk} = \frac{Q_{g.sk}}{\sum Q_g} \cdot 100 \quad (1, 2, 3)$$

where $\lambda_{g.gan}$, $\lambda_{g.pak}$, $\lambda_{g.sk}$ – percentage of cow manure: part of manure left in the pastures, part of litter manure and part of slurry, %;

$Q_{g.gan}$, $Q_{g.pak}$, $Q_{g.sk}$ – amount of manure left in the pastures, amount of litter manure and slurry obtained in the cow barns, t·year^{-1};

$\sum Q_g$ – total amount of manure obtained from milk cows, t·year^{-1};

For such calculations it is necessary to have a large amount of input data that can be obtained in the result of counting farm animals or performing inquiries on the farms. Therefore, this method demands considerable investment of work to collect and process the necessary information.

To make the problem simpler, by now the expert method was used introducing an index for evaluation of the marginal number of the cow herds at which transition from obtaining of litter manure to slurry takes place.

For calculation of this index the following formula was used

$$\chi_{pak} = \frac{z_{g.pak}}{Z_g} \cdot 100 = \chi_{g.pak.1} + \chi_{g.pak.2} + ... + \chi_{g.pak.n}, \quad (4)$$

where $\chi_{g.pak}$ – part of the amount of cows from which litter manure is obtained, %;
$z_{g.pak}$ – number of cows from which litter manure is obtained;
Z_g – total number of milk cows;
$\chi_{g.pak1}$; $\chi_{g.pak2}$; $\chi_{g.pak.n}$ – first part of the herd, second part of the herd and n part of the herd from which litter manure is obtained, %.

Using this index and the available statistical data [4], the percentage of the manure management systems was calculated.

In order to get more precise percentage of the manure management systems, at the Latvia University of Agriculture new calculation methodology was developed based on the distribution of the kinds of manure management shown in Table 1. For instance, the total amount of manure obtained from milk cows can be expressed as follows:

$$\sum M_g = M_{g.gan} + M_{g.pak} + M_{g.sk}, \tag{5}$$

where $M_{g.gan}$ – total amount of manure left in the pastures, t·year^{-1};
$M_{g.pak}$, $M_{g.sk}$ – amount of litter manure and slurry obtained from cows, t·year^{-1};

Amount of manure left in the pastures [4]

$$M_{g.gan} = k_{g.gan} \cdot Z_g \cdot \frac{\chi_{g.pak}}{100} \cdot q_{g.pak} \cdot \frac{S_{g.sv}}{S_{g.pak}} \tag{6}$$

where $k_{g.gan}$ – coefficient of pasture usage;
Z_g – total number of cows according to the statistical data;
$\chi_{g.pak}$ – part of the amount of cows from which litter manure is obtained, %;
$q_{g.pak}$ – outcome of litter manure at the average milk yield in the country, t·year^{-1};
$S_{g.sv}$, $S_{g.pak}$ – average content of dry matter of cow fresh manure (mixture of feces and urine) and litter manure correspondingly, %.

In turn, the coefficient of pasture usage

$$k_{g.gan} = \frac{t_{g.gan}}{24 \cdot 365}, \tag{7}$$

where $t_{g.gan}$ – average length of cow pasturing period, h·year^{-1}.

Amount of litter manure obtained from milk cows

$$M_{g.pak} = (1 - k_{g.gan}) \cdot \frac{\chi_{g.pak}}{100} \cdot Z_g \cdot q_{g.pak}, \tag{8}$$

and the obtained amount of slurry

$$M_{g.sk} = (1 - \frac{\chi_{g.pak}}{100}) \cdot Z_g \cdot q_{g.sk}, \tag{9}$$

where $q_{g.sk}$ – outcome of slurry from one cow, t·year^{-1}.

Considering the formulae (5, 6, 8 and 9), it can be obtained that

$$\sum M_g = \frac{k_{g.gan} \cdot \chi_{g.pak} \cdot Z_g \cdot q_{g.pak} \cdot S_{g.sv}}{100 \cdot S_{g.pak}} + \frac{(1 - k_{g.gan}) \cdot \chi_{g.pak} \cdot Z_g \cdot q_{g.pak}}{100} + (1 - \frac{\chi_{g.pak}}{100}) \cdot Z_g \cdot q_{g.sk}. \tag{10}$$

For calculations of manure percentage the following formulae can be used:

$$\lambda_{g.gan} = \frac{100 \cdot k_{g.gan} \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.sv}}{k_{g.gan} \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.sv} + S_{g.pak}[(1 - k_{g.gan}) \cdot \chi_{g.pak} \cdot q_{g.pak} + (100 - \chi_{g.pak}) \cdot q_{g.sk}]}, \tag{11}$$

$$\lambda_{g.pak} = \frac{100 \cdot (1 - k_{g.gan}) \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.pak}}{k_{g.gan} \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.sv} + S_{g.pak}[(1 - k_{g.gan}) \cdot \chi_{g.pak} \cdot q_{g.pak} + (100 - \chi_{g.pak}) \cdot q_{g.sk}]}, \tag{12}$$

$$\lambda_{g.sk} = \frac{100 \cdot (100 - \chi_{g.pak}) \cdot q_{g.sk} \cdot S_{g.pak}}{k_{g.gan} \cdot \chi_{g.pak} \cdot q_{g.pak} \cdot S_{g.sv} + S_{g.pak}[(1 - k_{g.gan}) \cdot \chi_{g.pak} \cdot q_{g.pak} + (100 - \chi_{g.pak}) \cdot q_{g.sk}]}. \quad (13)$$

Results and discussion

According to the data in literature [5; 6] it is possible to conclude that in Latvia the pasture period lasts for 130-150 days and the cows spend in average 10 hours in pastures per day. Therefore, it is possible to assume in calculations that the average pasture period is 140 days, and the coefficient of pasture usage will be

$$k_{g.gan} = \frac{140 \cdot 10}{24 \cdot 365} = 0.16$$

To state the part of the herd from which litter manure χ_{pak} is obtained, the materials of the farm survey performed by the "Latvian Rural Advisory and Training Center " (LLKC) in 2014 were used. They include data gathered from 2550 respondents who had milk cows on their farms. Processing these data it was stated that on 94.2 % of all farms only litter manure is obtained, on 1.9 % farms – litter manure slurry and only on 3.9 % farms – slurry. Therefore, in further research percentage of the corresponding kinds of manure in animal groups was used (Fig. 1).

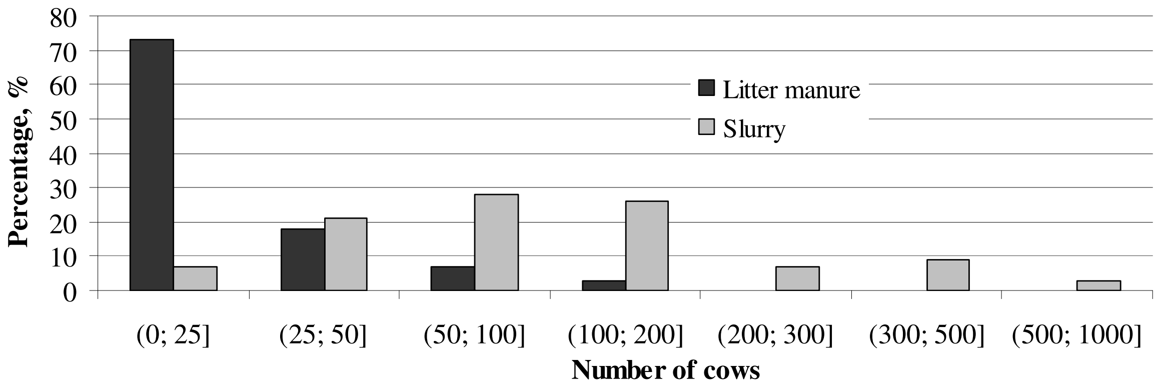

Fig. 1. **Percentage of the number of farms according to the obtained kind of manure and the size of the herd**

The research results show that on the farms with the herds bigger than 100 milk cows only in 2.8 % cases litter manure is obtained, but in 44,2 % cases mainly slurry is obtained. So, transition from usage of litter manure to slurry takes place if the size of the herd is in the frame from 50 to 100 milk cows.

For stating the coefficient χ_{pak} it is possible to use the data processing program SPSS. For this reason every kind of farmyard manure is assigned a corresponding quantitative value (1 – litter manure, 2 – litter manure and slurry, 3 – only slurry) and the regressive analysis of the obtained data is performed using the linear model without the free variable

$$Z_g = a \cdot X , \quad (14)$$

where Z_g – number of milk cows;
a – influence coefficient;
X – manure characteristics (=1,2,3).

Carrying out the research applying the computer program SPSS it was stated that the value of the coefficient a is (14) 32.5 (at standard error σ = 0.75). It means that with 95 % credibility it is possible to affirm that the optimal number of cows at which the transition from usage of litter manure to slurry takes place is at the number of milk cows in the frame from 62 to 68 (in further research the average value 65 cows is assumed).

In accordance with the CSP data, in 2013 there were 165 011 cows in Latvia [2], including in the herds up to 49 animals – 93876 cows, but in the herds from 50 to 99 animals – 21617 cows. Assuming that in this interval the distribution of cows is proportional to the size of the herd, it can be calculated that in 2013 in the herd with 65 cows there were

$$Z_{65} = Z_{49} + \frac{Z_{50-65}}{Z_{50-99}} = 93876 + 21617 \cdot \frac{15}{50} = 100351 \text{ cows,}$$

where Z_{65}, Z_{49} – number of milk cows in the herds up to 65 and 49 cows correspondingly;
$Z_{50\text{-}65}$, $Z_{50\text{-}99}$ – number of cows in the herds from 50 to 65 and in the herds from 50 to 99 cows correspondingly.

Therefore, the number of cows in the herd from which litter manure is obtained

$$\chi_{pak} = \frac{Z_{65}}{\sum Z} \cdot 100 = \frac{100351}{165011} \cdot 100 = 60.8 \ \% ,$$

where ΣZ – total number of milk cows.

The calculation results are summarized in Figure 2.

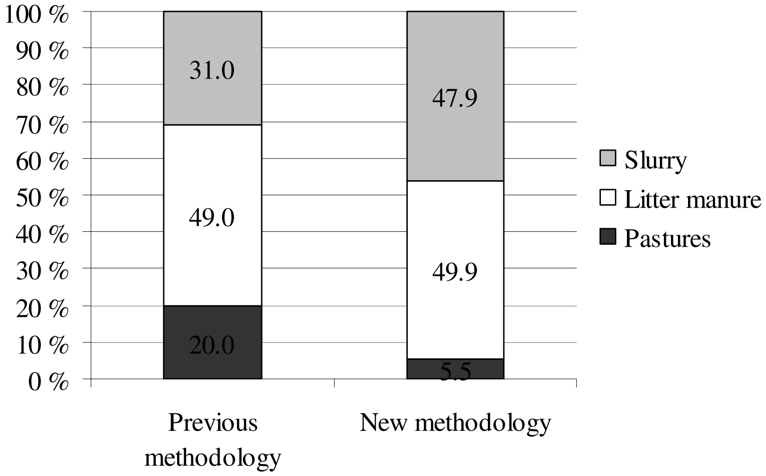

Fig. 2. **Percentage of farmyard manure management systems using the previous and new calculation methodology**

As it can be seen in Figure 2, using both methodologies similar results have been obtained on the litter manure outcome proportion. But, calculating according to the new methodology, the amount of farmyard manure left in the pastures is essentially less, but the outcome of slurry is bigger. It can be explained by the fact that using the new methodology the specific weight of the herds where slurry is obtained increases; it is shown by the changes of the coefficient χ_{pak}.

If using the previous methodology the assumed value of this marginal value (according to the expert evaluation) was 100 cows, then according to our new research it was 65 cows. Therefore, it is possible to conclude that in calculations of farmyard manure management systems this marginal value is very important. The advantage of the new methodology is the fact that for the necessary calculations appropriately constructed computer programs can be comfortably used. Besides, for these calculations only a few most important input data that can change have to be obtained, i.e. the amount of the part of the herd from which litter manure is obtained as well as the coefficient of pasture usage. In turn, the input data in relation to the farmyard manure outcome and the content of dry matter for every separate group of farm animals are comparatively constant.

Applying the above discussed principle manure management system percentage calculations have been developed also for other farm animals included in Table 1.

Conclusions

1. New methodology has been developed for calculation of farm animal farmyard manure percentage using appropriately constructed computer programs. The input data necessary for the

calculations are the outcome of farmyard manure and the content of dry matter, the coefficient of pasture usage and the part of the cow herd from which litter manure is obtained.

2. Processing the information gathered by the LLKC in 2014 from 2550 farms where milk cows are handled, it has been stated that the transition from obtaining of litter manure to slurry takes place at the size of the herd being 65 cows.
3. For milk cows the period of usage pastures depends on the climatic conditions, the quality of the pasture grass and other factors, but for calculations it is possible to assume that the average value of the coefficient of pasture usage is 0.16.

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