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Farm manure amount calculation using statistical data in Latvia

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Abstract. To calculate ammonia emissions caused by production, storage and application of farm manure, it is necessary to know the amount of farm manure obtained in the country and also the kinds of manure. For this purpose, methodology and computer software are developed to calculate the amount of farm manure based on the data of the Central Statistical Bureau, the technology of farm animal handling in the country and the respective valid normative documents. Upon calculating the amount of farm manure produced in Latvia in 2016, it was stated that approximately a half of the manure is litter manure, one third – liquid manure, and one fifth – manure left in the pastures. The most of manure in Latvia (69% of the total amount) is obtained from milk cows, their calves and young stock.

Key words: amount of farm manure, farm animals, statistical data.

INTRODUCTION

Farm manure is an important soil fertilizer. However, production and management of farm manure cause emissions of gases that lead to the greenhouse gas (GHG) effect, ammonia, smells and other unfavorable emissions (Directive 2003/35/EC; Agriculture as an air pollutant source, 2016). Therefore, in all European Union member states annual inventory of GHG emissions as well as ammonia emissions is carried out (UNECE Protocol, 1991; 2006 IPCC Guidelines; EMEP/EEA emission inventory guidebook, 2013). For this purpose, it is necessary to know what amount of farm manure in the country is obtained from every group of farm animals and the proportion of separate kinds of farm manure (litter farm manure, liquid manure, manure left in the pastures).

To determine the amount of farm manure obtained in the country, it is necessary to know the number of animals in every farm animal group and the average farm manure output. Problems are caused by the fact that usually from animals of one animal group several different kinds of farm manure are obtained and the output of farm manure is different. Besides, the statistical data do not reflect the proportion of these kinds of farm manure that are produced in every separate group of farm animals.

Therefore, the aim of the present research is to develop methodology for the calculation of the amount of farm manure produced in the country from every group of farm animals, using the statistical data as well as the coefficients obtained in the research

that characterize the technological parameters of farm animal handling: the length of the pasture period, the size of the herd at which the transition from production of litter manure to liquid manure takes place.

MATERIALS AND METHODS

In compliance with the Regulations of the Cabinet of Ministers No 829 in Latvia, farm manure groups are split according to moisture:

- litter farm manure – the content of moisture less than 85%;
- semi-liquid farm manure – the content of moisture 85–90%;
- liquid farm manure –the content of moisture 90–98%;
- slurry – the content of moisture higher than 98%.

The obtained kind of farm manure depends on the group of farm animals, way of handling them and the amount of water added to the farm manure.

If, for instance, dairy cows are kept tied in the stalls, a comparatively large amount of litter is used (2–2.5 kg of straw per one stall per day). In the result, hard litter farm manure is produced. If, in turn, dairy cows are kept in high boxes, the consumption of litter does not exceed 0.5 kg per animal per day. Besides, to the manure collected in the barn the waste water used for washing the dirty floors is also added.

Therefore, in this case liquid manure is produced in the barn. There is also a situation possible that in warm weather the cows are pastured, and then a part of manure is left in the pastures.

In turn, the calves of dairy cows and young stock are kept only on deep litter and liquid manure is not produced in this case.

The general situation of the farm animal groups included in the research and the kinds of the obtained farm manure is summarized in Table 1.

Table 1. Farm animal groups grown in Latvia and kinds of farm manure (Priekulis et al., 2015b)

Farm animal group	Kinds of farm manure			
	Manure left in pastures	Litter manure	Liquid manure, slurry	Manure without litter
Dairy cows	x	x	x	
Calves of dairy cows up to the age of 1 year	x	x		
Young stock of dairy cows 1–2 years old	x	x		
Beef cattle older than 2 years	x	x		
Beef cattle calves up to the age of 1 year	x	x		
Beef young stock 1–2 years old	x	x		
Sows, breeding boars		x	x	
Pigs up to 50 kg (up to 4 months)		x	x	
Breeding gilts and fattened pigs		x	x	
Sheep	x	x		
Goats	x	x		
Horses	x	x		
Laying hens	x	x	x	x
Broilers		x		
Ducks	x	x		
Geese	x	x		

The total amount of farm manure produced by dairy cows is a sum of the total amount of the produced litter farm manure and liquid farm manure as well as the manure left in the pastures.

$$M_g = M_{g.gan} + M_{g.pak} + M_{g.sk}, \quad (1)$$

where M_g – total amount of farm manure produced in the country in the group of dairy cows, kg·year^{-1}; $M_{g.gan}$, $M_{g.pak}$, $M_{g.sk}$ – respective amount of manure left in the pastures, litter manure produced in the barn and liquid manure from dairy cows, kg·year^{-1}.

In accordance to our developed methodology (Priekulis et al., 2015a; Priekulis & Aboltins, 2015), the amount of manure left in the pastures can be calculated according to the following formula, kg year^{-1}

$$M_{g.gan} = k_{g.gan} \cdot Z_g \cdot \frac{\chi_{g.pak}}{100} \cdot q_{g.pak} \cdot \frac{S_{g.sv}}{S_{g.pak}} \quad (2)$$

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

The amount of litter farm manure produced by dairy cows, kg year^{-1}:

$$M_{g.pak} = (1 - k_{g.gan}) \cdot \frac{\chi_{g.pak}}{100} \cdot Z_g \cdot q_{g.pak}. \quad (3)$$

The amount of liquid farm manure produced by dairy cows, kg·year^{-1}:

$$M_{g.sk} = (1 - \frac{\chi_{g.pak}}{100}) \cdot Z_g \cdot q_{g.sk} \quad (4)$$

where $q_{g.sk}$ – liquid farm manure output from one cow, kg year^{-1}.

The proportion of the animals from which litter farm manure is obtained, i.e. the coefficient $\chi_{g.pak}$ for dairy cows can be calculated according to the formula

$$\chi_{g\,pak} = \frac{Z_{g.pak}}{Z_g} \cdot 100, \quad (5)$$

where $Z_{g.pak}$ – number of cows in the country from which litter farm manure is obtained; Z_g – total number of cows in the country.

The value of this coefficient depends on the level of animal farm modernisation. If all cows are handled in stalls, the coefficient $\chi_{g.pak}$ = 100%, but if all cows are kept in boxes, then the coefficient is $\chi_{g.pak}$ = 0%. Therefore, it is not a constant, but rather a variable value.

To determine this coefficient, the expert method was used (Laurs et al., 2016a; Laurs et al., 2016b), as well as the statistical data from Central Statistical Bureau, available in the country on the percentage of the number of cows depending on the size of the herd.

First of all, by the expert method the following was stated: at what average cow herd size the transition from production of litter farm manure to liquid farm manure takes place. After that the value of the coefficient $\chi_{g.pak}$ was calculated using the statistical data. By means of this methodology, it was stated that in 2016 in Latvia the transition from

production of litter farm manure to liquid farm manure took place, if the average size of the herd reached 80 cows, but the value of the coefficient $\chi_{g.pak}$ was 60%.

In turn, the pasture usage coefficient can be calculated using the following formula:

$$k_{g.gan} = \frac{t_{g.gan}}{24 \cdot 365}, \quad (6)$$

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

For calculation of this coefficient, also the expert method was used (Laurs et al., 2016a). In the research, it was stated that in Latvia dairy cows are pastured in the average 165 days per year and for 10 hours every day. Therefore, the pasture usage coefficient is 0.188.

In order to calculate the amount of farm manure that can be obtained from calves of milk cows (up to the age of 1 year), it must be considered that calves are kept on deep litter. Therefore, in this case only litter farm manure is produced. Besides, in small farms, where cows are pastured, also calves are pastured. Therefore, the total amount of the farm manure from the calves

$$\sum M_{g.t} = M_{g.t.gan} + M_{g.t.pak}, \quad (7)$$

where $M_{g.t.gan}$, $M_{g.t.pak}$ – amount of manure left in the pastures and the respective amount of litter farm manure produced by calves of dairy cows up to the age of 1 year, kg year^{-1}.

The amount of farm manure left in the pastures

$$M_{g.t.gan} = k_{g.t.gan} \cdot \frac{\chi_{g.pak}}{100} \cdot Z_{g.t} \cdot q_{g.t.pak} \cdot \frac{S_{g.t.sv}}{S_{g.t.pak}} \quad (8)$$

where $k_{g.t.gan}$ – pasture usage coefficient for dairy cow calves up to the age of 1 year (it is assumed to be the same as for dairy cows); $Z_{g.t}$ – total number of dairy cow calves (up to the age of 1 year) according to the statistical data; $q_{g.t.pak}$ – average weighted litter farm manure output from the respective group of calves, kg year^{-1}; $S_{g.t.sv}$, $S_{g.t.pak}$ – average dry matter content of fresh farm manure (mixture of faeces and urine) and litter farm manure for dairy cow calves, %.

The amount of the produced litter farm manure

$$M_{g.t.pak} = (1 - k_{g.t.gan}) \cdot \frac{\chi_{g.pak}}{100} \cdot Z_{g.t} \cdot q_{g.t.pak} + (1 - \frac{\chi_{g.pak}}{100}) \cdot Z_{g.t} \cdot q_{g.t.pak}, \quad (9)$$

A similar approach is used also to calculate the total amount of farm manure for the other farm animal groups as well (Priekulis et al., 2015).

Therefore, to calculate the amount of farm manure produced in the country, the following input data are needed: statistical data on the number of the respective farm animals and their proportion according to the size of the herd, farm manure output norms, the amount of dry matter in farm manure, the results of the expert enquiry on the length of the pasturing period and the size of the herd at which the transition from production of litter farm manure to liquid farm manure or manure without litter (keeping poultry in cage batteries) takes place.

The produced amount of farm manure is calculated using the above given correlations. At first, this amount is calculated for every separate group of farm animals and for every separate kind of farm manure. Summing up the obtained results, the total proportion of the amount of farm manure is obtained.

RESULTS AND DISCUSSION

Using the above described methodology and the data of the Latvian Central Statistical Bureau about the year 2016 the amount of farm manure obtained un Latvia in 2016 and its proportion in groups of farm animals was calculated, Fig. 1.

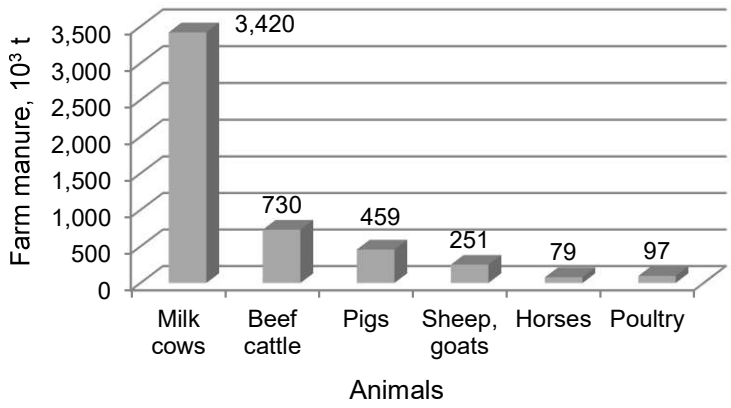

Figure 1. Calculated amount of farm manure (in thousand tons) obtained from farm animals in 2016 in Latvia.

The obtained results show that the largest amount of farm manure is obtained from the group of dairy cows, which includes also calves and young stock (3,420 thousand tons or 67%). A comparatively large amount of farm manure is obtained also from beef cattle and pigs (respectively 14.5% and 9.1% of the total amount), sheep and goats (5.9% in total). In turn, a comparatively small amount of farm manure is obtained from horses and poultry (3.5% in total). The proportion of the kinds of the obtained farm manure is shown in Fig. 2.

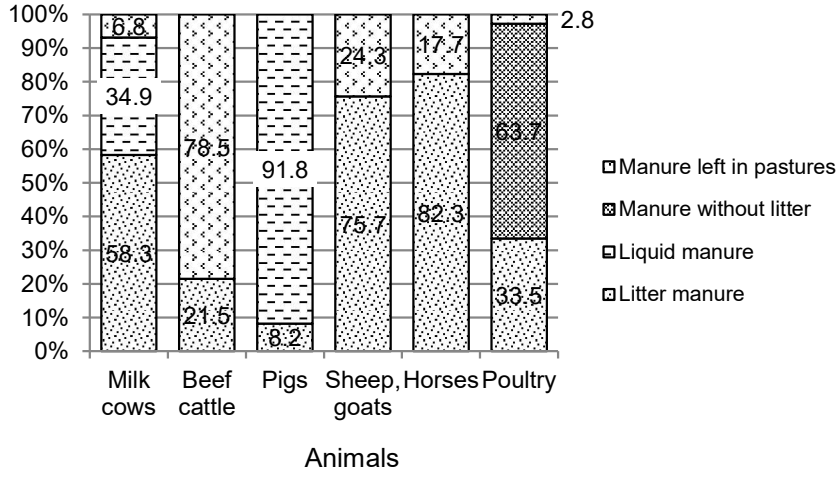

Figure 2. Percentage of kinds of farm manure.

As it was mentioned above, the proportion of farm manure kinds is essentially dependent on the farm animal handling technology. Building new barns and updating the existing ones gradual transition from production of litter farm manure to liquid farm manure takes place. It refers especially to milk farming and pig breeding. If in accordance to our research in 2016 58.3% of the total amount of farm manure in milk farming is litter farm manure, but 34.9% liquid farm manure, it can be planned that this proportion will change every year as the amount of the obtained liquid farm manure will increase.

The total proportion of the kinds of farm animal manure is shown in Fig. 3.

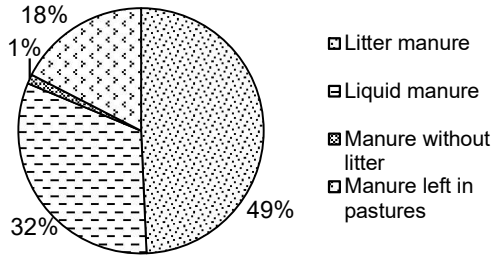

Figure 3. Total proportion of each of the kinds of farm animal manure.

As the figure shows, litter farm manure comprises almost a half (49%) of the total amount of farm manure, liquid farm manure – about one third (32%), but manure left in the pastures – approximately one fifth of the total amount of farm animal manure (18%).

CONCLUSIONS

Methodology for calculation of the amount of farm manure produced in the country from farm animals has been developed based on the statistical data, as well as considering the technological peculiarities of handling animals and the respective normative documents.

It has been stated that approximately 68% of the total amount of farm manure is obtained from dairy cows, their calves and young stock, 14.5% from the total amount of farm manure – from beef cattle, 9% from pigs, but 8.5% from other groups of farm animals.

Approximately a half of the total amount of farm manure is litter farm manure (49%), one third – liquid farm manure (32%) and one fifth (18%) – manure left in the pastures.

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