AMOUNT OF NITROGEN IN CATTLE MANURE

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Abstract. To develop the Latvian National Inventory reports on greenhouse gas emissions it is necessary to have data on the amount of nitrogen (N) in livestock manure. Such data are available in the Regulations of the Latvian Cabinet of Ministers No. 834. Still, these data can be also obtained from the available literature or calculated according to the methods given in the 2006 IPCC Guidelines, or determined in experimental investigations of the farm manure samples taken on the farms and analysed in laboratories. Therefore, the aim of the present research is to compare the data from literature (L), calculations (T), the Regulations of the Cabinet of Ministers (MK) and the experimental research (E) on the amount of N emitted with cattle manure and to evaluate further suitableness of application of the above mentioned methods. In Latvia, different farm animals are bred, but in the previous research it has been stated that approximately 75 % of the total greenhouse gas emissions created by animal breeding are caused by cattle. Therefore, in the present article the amount of N in manure is analysed for six groups of cattle: dairy cows, their calves and young stock, other (beef) cattle, their calves and young stock. In the research it has been found that all the above described methods give correct research results. But the amount of N in cattle manure is a variable value as it depends on the productivity of the animals, live weight, feeding and other factors. Because of this reason it is necessary to specify the amount of N emitted with cattle manure regularly, and the method of theoretical calculations is the most suitable in the given case. This method can be employed using the statistical data and zootechnical information, but special developed software programme can be used for calculation.

Keywords: cattle, amount of N in manure, research methodology.

Introduction

Nitrogen is one of the main important plant nutrients. It stimulates formation of the plant green mass and promotes their growth as well as controls ingestion of nutrients by plants. If the plants lack nitrogen, they start to wither reducing the potential yield of agricultural crops.

To supply the plants with the necessary amount of nitrogen, livestock manure is very important as it contains all most essential nutrients needed for their development. Therefore, livestock manure is considered to be a full value fertilizer. Still, during collection, storage and usage nitrogen is emitted in the atmosphere as nitrogen oxide promoting creation of greenhouse gases that cause warming of the earth atmosphere. Nitrous oxide is produced naturally in soils through the microbial processes of nitrification and de-nitrification. During nitrification, ammonium (NH_4) produces nitrates (NO_3). During de-nitrification, nitrates (NO_3) are reduced to nitrogen gas (N_2). An intermediate step in both of these processes is the creation of nitrous oxide (N_20). In practice, precise information is needed on the amount of nitrogen in manure – firstly, to state the value of manure from the point of view of plant fertilization, secondly, to determine the possible nitrogen emissions into the earth atmosphere. Therefore, the aim of the present investigations was to compare different research methods that can be used for determination of the amount of N in cattle manure and to evaluate further usefulness of application of these methods.

Materials and methods

To state the amount of nitrogen in cattle manure four different methods were used: analysis of the sources of literature (L), experimental (E) and theoretical (T) research and comparison of the obtained results with the data given in the Regulations No. 834 of the Cabinet of Ministers (MK) of the Republic of Latvia [1]. The information necessary for the research is summarized for six separate groups of cattle, i.e. 6 cattle groups considering the recommendations given in the 2006 IPCCGuidelines [2]. In these groups the following cattle were included: dairy cows, their calves and young stock up to the age of 1 year, their young stock 1-2 years old, other beef cattle older than 2 years (suckler cows), their calves up to the age of 1 year and their young stock 1-2 years old.

In the studies from the literature the data on the amount of nitrogen and the norms used in 22 countries according to the greenhouse gas inventories were obtained (Austria, Belarus, Belgium (Flanders), Belgium (Walloon), Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland,

Germany, Hungary, Iceland, Italy, Lithuania, Norway, Poland, Romania, Slovakia, Slovenia, Sweden, Switzerland). Additionally, the national norms of separate countries are summarized including the data on the amount of N emitted with cattle manure – in total 8 countries (Estonia, Lithuania, Poland, Czech Republic, Russia, the USA, Sweden, Finland) [3-5].

During the experimental research cattle manure samples from particular farms were collected, their analyses were performed in the certified laboratory of "Vides Audits" Ltd. in compliance with the following standards:

Table 1

Methods used for farm manure analyses

Farm manure composition chemical indicators	Testing method in compliance with Reg. No.506 (15.09.2015.) of the CM
Dry matter (or moisture)	LVS EN 13040:2008
Total nitrogen N	LVS EN 13654-1: 2003 LVS EN 13654 -1/NAC:2004
Ammonium nitrogen N-NH_4	ISO 14256-2:2005

Considering that the research was performed within the frame of the contract No. 2014/94 [6], it was possible to analyze 73 samples of cattle manure using the granted finances. To specify the number of samples necessary for cattle manure analyses as well as the distribution of these samples in separate regions, the methods described in literature were used [7].

The necessary number of farm manure samples can be calculated according to formula

$$n = \frac{t^2 \cdot s^2 \cdot N}{t^2 \cdot s^2 + \Delta_{\bar{x}}^2 \cdot N}\ , \tag{1}$$

where n – total number of number of samples, pcs.;
t – coefficient of probability, at 95 % validity [8];
s – standard deviation;
N – average number of the general group (number of farms with cattle in the particular region);
$\Delta_{\bar{x}}$ – permissible marginal error that is determined from the demanded precision of the results of the projected sampling.

The permissible marginal error can be calculated using the correlation

$$\Delta_{\bar{x}} = t \cdot s_{\bar{x}}\ , \tag{2}$$

where $s_{\bar{x}}$ – arithmetic average standard error of sampling.

$$s_{\bar{x}} = \frac{s}{\sqrt{n}}, \tag{3}$$

This latter indicator can be calculated according to the results of cattle manure chemical analyses that are obtained from the certified laboratory of "Vides Audits" Ltd.

Processing the results of eight analyses with software SPSS it was stated that

- average arithmetic content of nitrogen in the samples – $\overline{X}$ = 4.425 kg·t^{-1} manure;
- standard deviation – s = 0.644 kg·t^{-1};
- dispersion – s^2 = 0.415.

So, according to formula (3) it can be calculated that the average arithmetic standard error of the sampling $s_{\bar{x}}$ = 0.228, but according to formula (2) it can be obtained that the permissible marginal error $\Delta_{\bar{x}}$ = 0.446.

To state the necessary number of manure samples in separate cattle groups and regions the following formula is used:

$$n_{t.i} = n_t \cdot \frac{N_i}{N}, \quad (4)$$

where $n_{t.i}$ – necessary number of samples in the respective cattle group and region;
n_t – necessary number of samples to be taken in the respective region;
N_i – number of cattle in the respective group and region [9];
N – total number of cattle in the respective region [9].

For taking the manure samples, the methods described in literature [10; 11] were used. Chemical analyses of the samples were performed in the accredited laboratory of "Vides audits" Ltd. in compliance with the requirements of the Regulations of the Cabinet of Ministers No.506 [12].

In the analyses the amount of dry matter in manure as well as the percentage of total nitrogen and ammonium nitrogen in dry matter was stated. To calculate the amount of nitrogen in manure expressed in units of measure kg per animal per year, the following formula can be used:

$$M_N = \frac{q_g \cdot M_{N\%} \cdot S_{\%}}{10}, \quad (5)$$

where q_g – average manure outcome from the respective farm animal, t/year (Regulations No 834 of the Cabinet of Ministers [1]);
$M_{N\%}$ – amount of nitrogen in the manure sample dry matter, %;
$S_{\%}$ – dry matter in the sample of manure, %.

Mathematically processing the data selection the average value of every data selection, standard error and the average relative standard error were calculated using the formulas of mathematical statistics [13].

Also, it was considered that nitrogen losses occur during collection and storage of cattle manure [14]. Besides, they can reach up to 40 % of the initial amount of nitrogen in farm manure. For this reason the nitrogen amount variation margins stated before were increased by ± 20 %. Respectively

$$\Delta_k = \Delta_{\bar{x}} + \overline{X} \cdot \frac{\Delta_{zud}}{100}, \quad (6)$$

where Δ_k – total marginal error of the sampling considering N losses during manure collection and storage, kg per animal per year;
Δ_{zud} – percentual marginal deviation caused by N losses during collection and storage of manure. In the present case Δ_{zud} = 20 %;
$\overline{X}$ – average arithmetic amount of nitrogen of the sampling, kg per animal per year.

To state the theoretically calculated amount of nitrogen in cattle manure, the Tier2 approach was used. It is described in the 2006 IPCC Guidelines [2]. The input data necessary for the calculations were obtained from the statistics and literature published in Latvia [9; 15]. Considering that in the result of theoretical calculations the amount of nitrogen in fresh manure is obtained, the possible N losses caused during collection and storage should not be considered.

To be able to compare the research results with the data given in the Regulations No. 834 of the Cabinet of Ministers, the outcome of N stated in these regulations is recalculated per a unit of measure kg per animal per year using formula (7).

$$M_N = M_{Nkg} \cdot q_g, \quad (7)$$

where M_N – amount of N in manure expressed in units of measure kg per animal per year;
M_{Nkg} – amount of N in manure expressed in units of measure kg/t;
q_g – outcome of manure from an animal of the respective group, t/year.

Results and discussion

To find the number of samples to be taken from the respective group of farm animals, the data from the report of 2014 Latvian National Inventory were taken into consideration [3]. It can be concluded from these data that the most part of nitrogen emissions (54.8 % of the total emissions

caused by livestock) are created by dairy cows, but 23 % – by other cattle (calves, young stock, suckling cows etc.). Therefore, it was planned that 30-35 samples should be taken from dairy cows, and the other samples – from beef cattle, calves and young stock herds.

Knowing the number of farms and cattle in every region of Latvia, it was possible to state the number of cattle manure samples to be taken in every separate group of cattle according to formulas (1), (2), (3) and (4). The calculated results are summarized in Table 2.

Table 2

Distribution of manure samples in regions and groups of cattle

Groups of cattle	Number of cattle, thsds.	Latvia regions					Total
		Around Riga	Vidzeme	Kurzeme	Zemgale	Latgale	
Dairy cows	165.0	2	5	5	5	13	30
Dairy cow calves up to the age of 1 year	83.5	1	2	2	2	6	13
Dairy cow young stock. 1-2 years of age	54.5	1	2	1	1	4	9
Other (beef) cattle older than 2 years	56.9	1	2	2	1	4	10
Beef cattle calves up to the age of 1 year	26.8	1	1	1	1	2	6
Beef cattle young stock. 1-2 years of age	20.8	-	1	1	1	2	5
Total	406.5	6	13	12	11	31	73

It can be seen from the table that in the regions of Latvia the distribution of cattle manure samples is not uniform. It is especially big in the region of Latgale as there is respectively larger number of farms breeding dairy cows. In turn. on the farms around Riga only 5 samples should be taken which is five times less than from the region of Latgale.

Comparison of the research results for dairy cows. their calves and young stock is shown in Fig. 1.

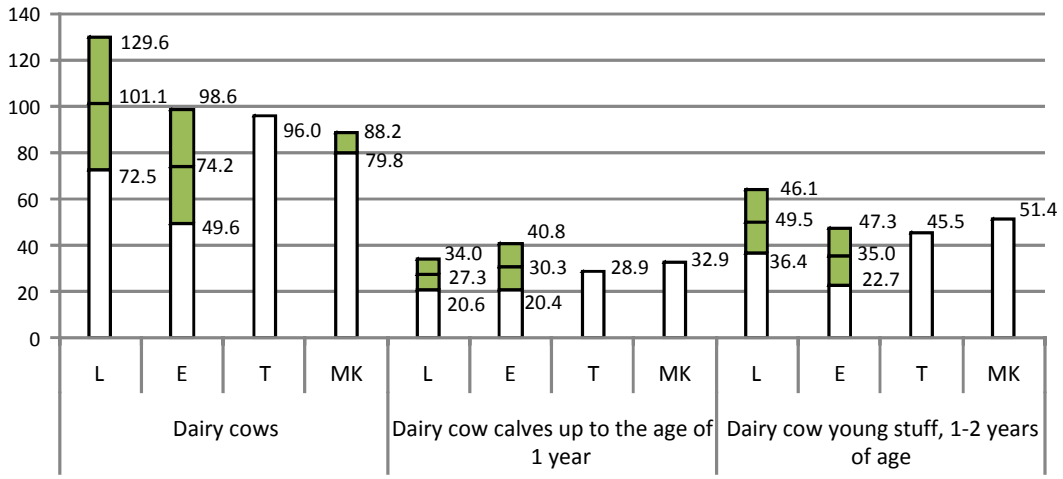

Fig. 1. **Comparison of the average values and the marginal value of the amount of N (kg per animal per year) for cows. their calves and young stock:** L – according to the sources of literature; E – according to the samples of cattle manure; T – according to the theoretical research; MK – according to the Regulations No. 834 of the Cabinet of Ministers (here the figure 88.2 is for solid litter manure. but the figure 79.8 – liquid manure)

It can be concluded from the figure that the obtained research results about separate groups of animals are comparatively identical in all cases; besides. they approximately correspond to the data calculated in the Regulations No. 834 of the Cabinet of Ministers. A little less outcome of N has been stated in the experimental investigations for dairy cows. but these deviations are within the frame of the permissible error. Also. the theoretically calculated amount of N for dairy cow calves up to the age of 1 year is slightly reduced.

The biggest amount of N is in manure of dairy cows (it reaches 90-100 kg per animal per year). but for dairy cow calves this figure is 20-30 kg per animal per year. for dairy cow young stock – approximately 40-50 kg per animal per year.

Comparison of the amount of N stated in manure of other (beef) cattle from the age of 2 years and their calves (up to the age of 1 year) and young stock (from 1 to 2 years of age) is presented in Fig. 2.

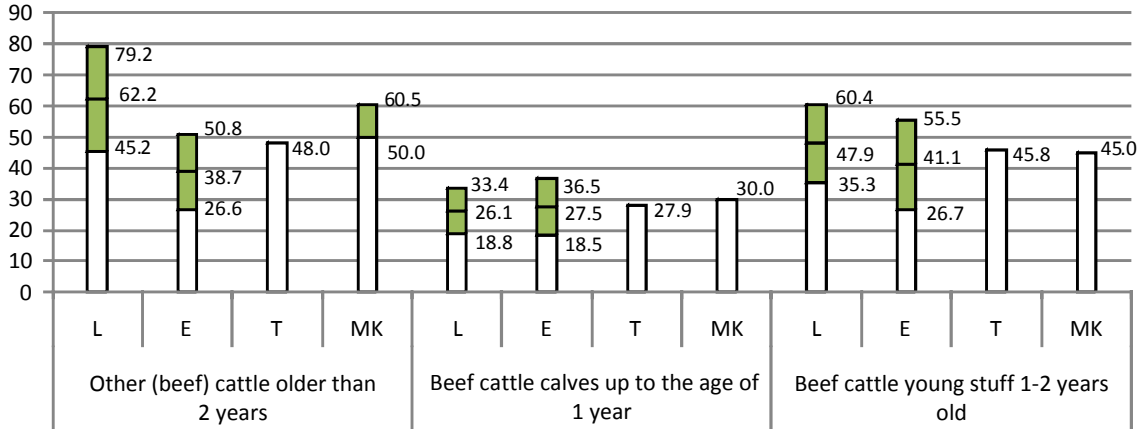

Fig. 2. **Comparison of the average values and the marginal value of the amount of N (kg per animal per year) for other (beef) cattle. their calves and young stock:** L – according to the sources of literature; E – according to the samples of farm manure; T – according to the theoretical research; MK – according to the Regulations No. 834 of the Cabinet of Ministers

Also in this case the amount of N shown in the sources of literature. kg per animal per year. complies comparatively well with the results of the experimental as well as the theoretical research and the calculated data in the Regulations No. 834 of the Cabinet of Ministers.

The biggest differences can be observed in the experimentally obtained results (according to the chemical analyses). It could be related to taking the samples. for instance. from the top layer of the manure pile. where the amount of N is smaller [14].

For beef cattle older than 2 years the emitted amount of N is in the range of 45-60 kg per animal per year. For beef cattle young stock between the ages 1 to 2 years it reaches 40-50 kg per animal per year. but for beef cattle calves – only 20-30 kg per animal per year.

Nevertheless. it should be considered that the amount of nitrogen in cattle manure is not a constant value. Taking into consideration the methods of theoretical calculations it depends on the animal productivity. live weight and other factors. Due to these reasons the amount of nitrogen in cattle manure can vary every year. Our research shows that the calculation results obtained in this way comply with the data of literature analysis and the results of the experimental investigations comparatively well. Besides. calculations of this kind are easily done using the statistical data and special literature as well as developing appropriate software.

Conclusions

1. The amount of N in cattle manure can be determined applying different research methods: by analyzing the sources of scientific literature and valid normative acts. theoretically calculating the amount of N or performing experimental investigations. The latter research method is most time consuming as it includes taking cattle manure samples on farms and their analyses in laboratory conditions. Besides. precision of these experimental investigations is essentially influenced by the quality of the samples.

2. Using four different research methods for investigating the amount of N (analysis of the sources of literature. experimental and theoretical research as well as the data calculated in the Regulations No. 834 of the Cabinet of Ministers) adequate results have been obtained.
3. Calculating per one animal. the biggest amount of N is in dairy cow manure – 90-100 kg per animal per year. For beef cattle older than 2 years and 1 to 2 years old young stock this figure is almost two times less. but for up to 1 year old calves – approximately four times less.
4. The amount of nitrogen present in cattle manure depends on the productivity of animals. live weight and other factors. Therefore. it is a variable value and for its periodical determination it is useful to use the methods given in the 2006 IPCC Guidelines. The data obtained this way correspond to the results obtained by other research methods. Besides. special developed software can be used for calculations.

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