

AMMONIA EMISSION REDUCTION MEASURES IN DAIRY CATTLE FARMING

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Abstract. The article discusses the possibilities of ammonia emission reduction in dairy cattle farming. In earlier research by the authors of the article it has been found that updating of the production technology and production of liquid manure increase ammonia emissions approximately 1.8 times. Therefore, it may hinder implementation of the national aims determined in the country on a gradual reduction of ammonia emissions. Therefore, the ammonia emission reduction measures recommended in special literature are summarised as well as their evaluation by application of the expert method is presented. The measures approved by the experts are divided into three groups depending on the capital investments that are needed for their implementation. In the research it has been stated that for further reduction of ammonia emissions in dairy farming it is sufficient to improve the animal welfare measures and enlarge usage of liquid manure chemical or biological additives, but it is not necessary to invest large capital investments for the building of new dairy cattle housing facilities and farm manure storages.

Keywords: ammonia emissions, dairy cattle, liquid manure.

Introduction

Dairy cattle farming is one of the most important branches of agriculture in Latvia, which gives on average 24 % of the total income from agriculture [1]. Besides, today gradual updating of this branch is taking place. For instance, in all large dairy cattle farms today liquid manure is produced and its volume increases every year by approximately 2.5 % [2]. Compared to solid manure, it is easier to mechanise management of liquid manure, necessity for litter material essentially reduces and consumption of work on the farm also reduces. Nevertheless, the earlier research by the authors of the article [3] shows that introducing loose handling of dairy cattle and producing liquid manure the area of dirty and wet floor in the farm increases by approximately three times. It increases ammonia emissions. This trend is observed not only in Latvia, but also elsewhere in the world. For instance, Fangueiro et al. [4] stressed that ammonia emissions are a major problem associated with animal slurry management, but Bougouin et al. [5] indicated that liquid manure management systems had greater ammonia emissions than slatted or solid floors in barns. This situation is also affirmed by the calculations of the authors of the article using the methodology *Tier 2* [6]. The calculations show that transition to loose handling of cows and production of liquid manure increase the total ammonia emissions from manure produced on the farm and stored in storages approximately 1.8 times.

Therefore, implementation of the national aims stated in the country, which envisage a yearly reduction of ammonia emissions by 1 % per year [7;8], is in danger. In order to improve the situation and reduce ammonia emissions by the implementation of additional measures that are indicated in special literature, for instance, the measures described in the recommendations of the United Nations Economic Commission for Europe (UNECE) Task Force on Reactive Nitrogen [9-11]. Though, not all of these measures are suitable for implementation in the circumstances of our country.

Therefore, the aim of the present research is to state the most suitable measures for ammonia emission reduction that could be implemented in Latvia's dairy cattle farms, where loose housing is used and liquid manure is produced.

Materials and methods

In order to size up the present situation information was summarised on the farm manure management technologies that are used in dairy farming [12] as well as literature data were gathered about the possible sources of ammonia emissions, the measures to reduce these emissions and the possible volumes of their reduction [9-11]. For evaluation of this information the expert method was applied [13]. For this purpose the survey questionnaire for experts was created, where the potential measures of reduction of ammonia emissions that are caused by the removal of manure from dairy cattle housing facilities and storage of manure had been included. There were not only questions about

the priority of implementation of the corresponding measure, but also the necessary state support needed for implementation of the measures included in the survey questionnaire.

Altogether there were two groups of questions – on the emission reduction measures in cold barns and in liquid manure storages.

For evaluation of every group of questions 12-15 experts were involved. They were external experts from the Latvian Rural Advisory and Training Centre, the Latvia University of Agriculture and the specialists working in the large animal breeding farms. The Internet was used to send the survey questionnaires and to receive the replies. For processing of the obtained information the methods described in the literature [14;15] were applied. Accordingly the priority range of every emission reduction measure was determined and the measures that are suitable for the conditions of Latvia were stated.

Nevertheless, all emission reduction measures that can be introduced in dairy cattle housing vary according to the character of their introduction and the possibilities of the farms. Therefore, they can be divided in three groups.

- Group I. Measures that do not require large capital investments, but it is mainly sufficient to improve the organisation of work.
- Group II. Measures the introduction of which requires reconstruction of the dairy cattle housing facilities, but the state support for it is not needed.
- Group III. Measures involving essential reconstruction of the dairy cattle housing facilities, and therefore the state financial support is needed.

For this reason all emission reduction measures approved by the experts were additionally divided in the three above mentioned groups and for every group the possible emission reduction coefficient was calculated using the formula

$$K_s = k_{s1} \cdot k_{s2} \cdot \dots \cdot k_{sn} = \left(1 - \frac{S_1}{100}\right) \cdot \left(1 - \frac{S_2}{100}\right) \cdot \dots \cdot \left(1 - \frac{S_n}{100}\right), \quad (1)$$

where K_s – emission reduction coefficient for the corresponding group of measures;
 $k_{s1}, k_{s2}, \dots, k_{sn}$ – emission reduction coefficients for every corresponding measure of emission reduction in one group;
 S_1, S_2, \dots, S_n – amount of ammonia emissions' reduction by implementation of each corresponding measure, %.

For approximate calculations these data can be taken from the literature [9-11]. Besides, if this reduction is given in a definite interval, in the calculations its average value was used.

Results and discussion

The research results are summarised in the tables below. They show the definite ammonia emission reduction measures, their priority evaluation (range) in accordance with the expert survey data, emission reduction obtained in the result of implementation of the measures (according to the data in literature), as well as the priority group of the corresponding measure.

Table 1 shows that in dairy cattle cold barns it is essential to use moisture absorbing materials for animal bedding, for instance, straw litter. It means that possibly deep boxes with manure – straw bedding should be used. Besides, farm manure should be removed regularly [5;11;17].

Decreasing the duration of cattle in housing and increasing the grazing period are suitable techniques to reduce emissions [9;11;17]. As far as possible, grazing of dry dairy cows and young cattle could be practiced [16;17]. Within limits pasturing of dry cows and young dairy cattle (i.e., calves) should be practiced.

Building new milk dairy cattle housing facilities or reconstructing the old ones, it is advisable to install efficient ventilation systems, build roofs with heat insulation and install manure ducts with deeply grid floors [16].

Table 1

Evaluation of emission reduction measures for dairy housing

Priority range	Solution of emission reduction measure	Reduction of emissions, % [9-11;16]	Priority group
1.	Usage of moisture absorbing material for animal bedding, for instance, straw litter	~70 %	I
2.	Removal of farm manure at least 2 times per day in shallow barns	up to 20 %	I
3.	Pasturing of dry cows and young stock	up to 20 %	I
4.	Application of liquid manure chemical or biological additives	up to 68 %	I
5.	Aerating the barns effectively using the influence of the wind and installing roofs with heat insulation	20 %	II
6.	Introduction of manure ducts with deep grooved floors	25-46 %	II
7.	Usage of barns with grid floors and underfloor manure storage	25-64 %	III

Considerable effect is achieved also by usage of liquid manure chemical and biological additives that reduce the smell and gas emissions as well as improve decomposition of liquid manure solid admixtures (straw litter).

Several scholars [4; 19; 20] stressed that cattle slurry acidification minimises ammonia emissions and following manure application. Furthermore, they point out that acidification of liquid manure increases the plant available nitrogen.

The results of evaluation of ammonia emission reduction measures for liquid manure storages are presented in Table 2. Stocking liquid manure, it should be taken into consideration that it should be entered under a natural or artificially designed covering, so that it does not disrupt the incoming stream of manure. However, usually this requirement is met, as it is included in the Regulations of the Cabinet of Ministers No. 829 [20]. Therefore, calculating the coefficient of emission reduction, this emission reduction measure was not considered.

Table 2

Evaluation of emission reduction measures for liquid manure storages

Priority range	Solution of emission reduction measure	Reduction of emissions, % [6-8]	Priority group
1.	Feeding of liquid manure under natural or manufactured covering layer *	~40 %	I*
2.	Application of liquid manure chemical or biological additives	up to 68 %	I
3.	Installation of light construction roofs on cylindrical liquid manure storages	up to 80 %	II
4.	Replacing of lagoon type storages with cylindrical storages	30-60	III
5.	Reduction of liquid manure surface (mirror surface) in newly built storages	up to 60 %	III

*measure included in the Regulations of the Cabinet of Ministers No. 829 [20].

Another important measure of ammonia emission reduction from liquid manure is usage of chemical or biological additives, for instance, GÜLLEMAX or others. It is even better, if such additives are added already in the animal housing facilities. Then their influence continues also in the manure storage. There is another possibility to install light construction roofs over cylindrical liquid manure storages and to replace the lagoon type storages with cylindrical storages. Other investigations by the authors of the article show [21] that it is rational to build possibly deep lagoons, which have

approximately equal length of the side walls. For all that, such changes require comparatively large capital investments and therefore can be implemented only in the future.

Total evaluation of the calculated emission reduction measures is given in Figure 1.

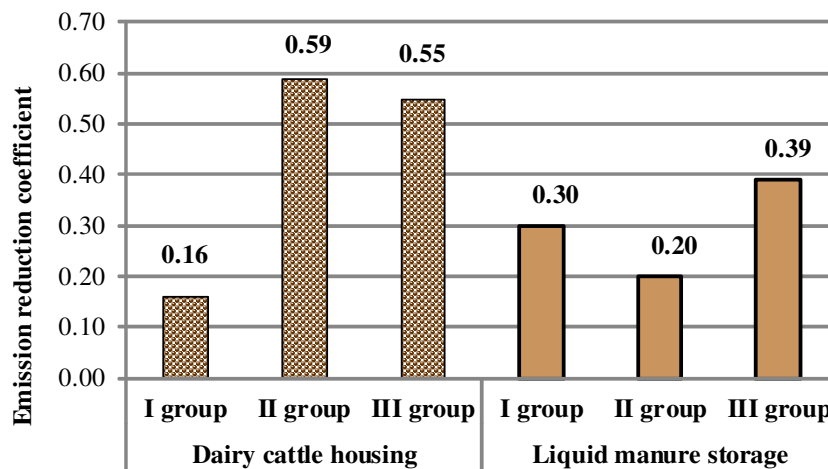


Fig. 1. Coefficients of ammonia emission reduction by implementing measures of various priority groups in dairy cattle farming

The figure shows that it is possible to achieve comparatively large ammonia emission reduction already with implementation of the measures of group I that are related to improvement of the welfare of animals as well as usage of liquid manure chemical or biological additives. Besides, their implementation does not require large capital investments.

Therefore, immediate implementation of the measures of groups II and III to reconstruct the existing housing facilities or liquid manure storages, or to build new ones, is not necessary as the obtained reduction of emissions is not always less compared to the implementation of the above mentioned measures of group I.

Conclusions

1. Most promising for dairy cattle housing are the following measures of group II and group III with the highest emission reduction coefficients (ERC). Accordingly, group II measures: 1) aerating the barns effectively using the influence of the wind and installing roofs with heat insulation and of manure ducts with deep grooved floors (ERC – 0.59); and 2) group III measure - the usage of barns with grid floors and underfloor manure storage (ERC – 0.55).
2. For liquid manure storages the highest ranked are the measures of: group I – feeding of liquid manure under a natural or manufactured covering layer (ERC – 0.30); and group III measures: 1) replacing of lagoon type storages with cylindrical storages, as well as 2) reduction of liquid manure surface (mirror surface) in newly built storages (ERC – 0.39).
3. In order to ensure further reduction of ammonia emissions in dairy cattle farming on the first stage it is sufficient to implement the measures for animal welfare improvement and to enlarge the usage of chemical or biological additives for liquid manure.

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