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Ammonia emission factors within the agricultural emission inventory – Part 1: Dairy cattle

The annual emissions report covering ammonia within German agriculture represents an important component of international agreements and is produced by the Institute of Agricultural Climate Research of the Johann Heinrich von Thünen-Institut (vTI), Braunschweig, in close cooperation with the Association for Technology and Structures in Agriculture (KTBL), Damstadt. Important prerequirements for the preparation of these inventories comprise information on the number of sources and the amounts emitted. Necessary within the animal husbandry sector in this context is information on livestock numbers and the amount of emissions per animal place coming from, among other sources, livestock housing. Presented in this report are the updated emission factors for the dairy cattle sector.

Keywords
Ammonia emission factors, abatement measures, dairy cows

Abstract
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The first agricultural emissions inventory covering Germany was published between 1999 and 2001 by FAL, KTBL and ATB [1]. A brief description on the production of emission inventories is given in [2] whilst the current and detailed documentation over the production of the German agricultural emissions inventory is to be found in [3].

Important parameters applied in the models used in calculation of emissions concern the livestock management system involved, the numbers of livestock and the amount of emissions produced per animal place. The emissions per animal place currently applied in inventories, so-called emission factors, were compiled in 2000 by a KTBL working group and documented in [1]. Hereby, the emission factors presented the specific ammonia losses in the respective housing system and were given in kg NH_3-N per animal place and year.

To take account in the emission calculations of the results of more recent emission measurements as well as the development of newer management systems, the emission factors applied and also the management systems involved are periodically checked as part of the inventory. The KTBL working group „Emission Factors Livestock Production“ has once again applied itself to checking ammonia emission factors and further measures for reducing emissions.

Method

The two main source groups, dairy cattle and fattening pigs, formed the focus of the verification action in that these are responsible for the highest ammonia emissions in the livestock sector. New management systems for poultry production mean that new emission factors are required and these have also been compiled by the working group. The emission factors apply only to the management system within the housing and do not take account of any emissions from storage of the manure produced or its application on the land. In this article will first of all be presented the data for dairy cattle management. Later, results for fattening pigs or poultry production will be presented.

Table 1

Ammonia emission factors and amount of litter (straw) in housing systems for dairy cows

Housing systems – dairy cows	Emission factor NH_3-N [kg • animal place^{-1} • year^{-1}]	Amount of litter [kg • animal place^{-1} • day^{-1}]
Tied system, slurry	4	-
Tied system, farm yard manure	4	5
Cubicle housing system, slurry	12	-
Cubicle housing system, farm yard manure	12	5
Loose housing system, deep litter	12	8
Loose housing system, sloped floor	13	5

Through researching the literature (national and international) emission data from numerous research projects were evaluated and the results compiled as emission factors per animal place and year. The experts reviewed the quality of this emission data and applied them to develop emission factors for the different management systems. In the assessment of emission data only the results were used that had a direct connection with the management system. Further differentiation on the highly aggregated emission factors was not possible because in many cases multifactor effects were involved which could not then be attributed to a specific individual influence factor. In addition, the mid-range emission factors covered a wide spectrum of location-specific, meteorological, ventilation-linked and management-associated variants. In total, the compilation of the emission factors was based on an expert assessment and not on the result of calculations.

A similar approach was taken regarding emission reduction methods. These, too, were assessed by literature research for quality and information on efficiency. As assistance in this respect served a guidance document on control techniques for preventing and abating emissions of ammonia [4] compiled by a UNECE working group in which document numerous reduction measures are described and the assessment categories explained.

Table 2

Reduction potential for ammonia emission of dairy cow/cattle housings related to the emission factors, agreed by KTBL working group 02/2010

Measure	Reduction potential [%]	Remarks	Categorie
Feeding according to requirement *- Feeding according to nXP-requirement,* *- Compensating for positive rumen nitrogen balance (RNB) with grass products etc.,* *- Improving exploitation of microbial nitrogen,* *- Optimising lactation start,* *- Improving microbe energy supply,* *- Synchronisation of energy and protein,* *- Use of „protected" proteins*	*Up to 25*	*Able to be monitored accurately through urea content in milk.* *Possibilities of reduction are reduced where there's poor protein availability from basic ration (maize silage, pressed pulp silage, etc.)*	1
Design of cow movement area	*Up to 20*	*Solid flooring with 3% downward slope towards passage centre-line and a gutter at lowest point for urine drainage and optimised manure removal*	2
		Solid flooring with gutters and run-off openings into the underlying liquid manure channel, comb-type scraper enabling rapid separation of solid manure and urine, operated several times per day	3
Pasture	*Up to 15*	*Only in the case of a minimum 6 hours on pasture, building continues as emission source; leads in total to less ammonia emissions, deposition of N on pasture → providing sufficient area*	2
Flushing the cow movement areas with water	*Up to 20*	*Categorised as impractical through high water use involved, also higher costs for dirty water storage and bringing out, limiting water use to a maximum 20 l AP^{-1} d^{-1} (animal place per day)*	3
Adding acid to liquid manure	*Up to 40*	*High costs for addition of organic acids; inorganic acids: increased risks in handling, corrosion, higher costs*	3
Application of urease inhibitors	*Reduction potential not able to be established*	*Reduction potential available; technical transference in practice has not yet been introduced, distribution still in development; costs currently still very high; health/environment tested*	3
Addition of minerals, bacteria, microorganisms to the liquid manure	*Reduction potential not able to be estimated*	*No repeatable reduction effect*	*No categorisation*
Scraping frequency of cow movement areas (more than 12 times/day)	*Reduction potential not able to be estimated*	*There is no way of verifying this method. The method can also lead to an increase in emissions. Good management practice recommends scraping several times per day*	*No categorisation*

Category 1: *There exists a proven emission reduction effect. The reduction method is practical and easy to monitor.*

Category 2: *The reduction effect of the method has been proven according to practical standards, but is not easy to monitor.*

Category 3:

Emission reducing potential exists but cannot be confirmed. One of the following points applies:
The emission reduction effect is not always able to be proved or is insufficiently proven.
The application in practice appears less than realistic.
The costs involved are too high.
Undesirable side effects can occur.
Reduction potential unable to be assessed or no provable reduction potential; no categorisation.

Ammonia emission factors

Table 1 shows the current results regarding ammonia emission factors in dairy cattle management. The management systems continue to be differentiated between tie-up and free moving housing with solid and liquid manure systems. In the case of the tie-up cowsheds fully enclosed buildings were assumed, and natural ventilation with the free-movement housing. Compared with 2000 no changes were involved regarding management systems and emission factors, which can be mainly attributable to the limited research activities and recording in dairy cattle management. Some new measurements in naturally ventilated dairy cattle housing, carried out by the Saxony State Office for Environment, Agriculture and Geology, correspond with specified values.

Reduction measures

Measures for reducing emissions are required for forecasts on reduction potentials that are produced regularly every five years. Regular forecasts each year are required for national political guidance.

Over and above this, there are some reduction measures (including keeping livestock on pasture, feeding according to requirements) that are already included in the calculations of emission inventories.

Table 2 presents selected measures in dairy or beef cattle management. For evaluation of reduction measures three categories are differentiated between.

Identified as one of the most important measures is feeding according to requirements because this can lead to reduced N excretion resulting in lowered emission potential. Also representing a measure for reduction of emissions in the cattle sector is the keeping of livestock on pasture. Through rapid percolation of urine into the ground, conversion of urea and subsequent production of ammonia is reduced. In the case of a system with housing and access to pasture the reduction effect through pasture access is only significant where more than six hours are spent outside in that less time in the field means the barn continues as an effective emission source. Only after the cattle movement areas within the housing have dried out can a reduction in emissions be assumed.

The application of urease inhibitors also offers an emission reduction potential. However in this case practical application possibilities are still wanting and at the moment the costs are also assessed as definitely too high.

Conclusions

Following detailed literature research and assessment by the KTBL working group no changes are to be made for ammonia emission factors in dairy cattle management. Only the amount of straw that is used in straw-littered housing systems has been adjusted.

The possibility of reducing emissions in milk or beef cattle housing systems continues to be regarded as limited. Reduction potential could be attributed to a few measures and these could be assessed as practicable. Other actions are not recommended because of their limited practicability or also their not clearly demonstrable reduction potential. Here, continued research activities are required towards reduction of emissions from livestock housing.

Literature

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Comment

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