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Ammonia emission factors within the agricultural emission inventory – Part 2: Poultry and fattening pigs

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 poultry and fattening pigs sector.

Keywords
Ammonia emission factors, abatement measures, poultry, fattening pigs

Abstract
Landtechnik 66 (2011), no.1, pp. 60–63, 4 tables, 2 references

Verification of emission factors in poultry and pig production is of especial importance. This is because new production systems within the poultry sector mean other emission factors are necessary. Also, fattening pigs, along with dairy cattle, represent a main ammonia source group within the agricultural emission inventory. The methods for verification and deduction of emission factors (E-factors) and the associated abatement potential are explained in more detail in [1]. Verification of ammonia emission factors and further abatement measures have been undertaken once again by the KTBL working group "Emission Factors Animal Husbandry", the members of which are presented at the end of this article.

Ammonia emission factors for laying hens

Following a review of the literature and latest results from the Saxony State Office for Environment, Agriculture and Geology, the laying hen production systems and associated emission factors have been recompiled (**table 1**). Emission factors on battery cage production are not applied, as such cages are no longer used in Germany. Only emissions from inside the actual housing are taken account of. This includes so called verandas. No account is taken of manure stores. It is assumed that the manure handling systems used are dry ones. Where an outdoor area is used (on-floor or aviary system plus outdoor run) the emission factor is increased by 10%. The aviary housing systems used in Germany are either compact, closed or open systems. The differences between them have no decisive influence on resultant ammonia emissions. But their influence on still-to-be-recorded dust emissions cannot, so far, be ruled out. With this as foreground, the systems require to be described in still more detail.

Abatement measures

The abatement percentage figures are taken account of in the emission factors of the respective production systems. It is not possible to identify these separately. Constructional factors that are taken account of are manure belt and aeration of the manure belt. Storing manure externally is identified as a further abatement option. The influence of the external manure store on emissions cannot be determined because emission data in this respect are not available. On the other hand, the intervals between manure removal via manure belt play an important role in reduction of emissions. Assumed as standard is a weekly manure removal via manure belt, although a twice per week routine is better. The manure belt aeration should be carried out with 0.4 to 0.5 m^3 per bird and hour.

Table 2 presents ammonia emission factors and abatement measures for pullet rearing and fattening poultry production. Because only few information about abatement measures in the poultry sector is available, no categorisation was made like in the pig and dairy cattle sector.

Table 1

Ammonia emission factors for various laying hen housing systems (KTBL working group 4/2010)

Laying hen housing systems	Emission factor NH_3 [g • animal place $^{-1}$ • a^{-1}] [1)]
Enriched cages [2)], unventilated manure belt, manure removal once weekly	150
Enriched cages [2)], ventilated manure belt, manure removal once weekly	40
On-floor system with aviary equipment, unventilated manure belt, manure removal once weekly [3)]	56
On-floor system with aviary equipment, unventilated manure belt, manure removal once weekly [3)]	91
On-floor system with aviary equipment, ventilated manure belt, manure removal once weekly [3)]	46
On-floor system, manure bunker, manure stored in-house throughout the year[3)]	315

[1)] Figures for ammonia; [2)] In Germany the term used translates as "small group system" and required floor space per bird is greater than for the EU enriched cage standard.
[3)] Emissions from housing without the proportion from systems with outdoor access.

Table 2

Ammonia emission factors and emission reduction measures in pullet rearing and fattening poultry production (KTBL working group 4/2010)

Bird category	Emission factor NH_3 [g • animal place^{-1} • a^{-1}] [1)]	Reduction measures	Remarks
Pullets	Because available data in this respect is insufficient the figures come from laying hen housing with a reduction of 30 %	The same reduction measures apply as with laying hen systems	
Broiler – deep litter system, short feeding period, 33 days	35	Floor heating in combination with floor cooling; mixed air system	Without storage, 9 fattening cycles/year
Broiler – deep litter system, long feeding period, 42 days	48.6		No recent emission data available
Turkey cocks	680	No technical reduction measures available	(5^{th}–21^{st} weeks of life)
Turkey hens	387		Calculated from the liveweight of the cocks
Ducks	146	No technical reduction measures available	No recent emission data available

[1)] Emissions from housing, without the proportion from systems with outdoor access

Table 4

Reduction potential for ammonia emissions in fattening pig production based on the emission factors (KTBL-Agru 04/2010)

Measure	Reduction potential [%]	Remarks	Category
Reference: No phase feeding: 18 % CP Measure: Crude protein adjusted feeding through:			
- Phase feeding (2 phases)	Up to 10	Adjustment between preliminary feeding and main feeding periods (from 18 to15 % crude protein)	1
- Phase feeding (3-4 phases)	Up to 20	Adjustment every few weeks; from 18 to 13 % CP balancing of essential amino acids (lysine, methionine)	1
- Multiphase feeding plus amino acid balancing	Up to 40	Daily adjustment; from 18 to13 % CP; balancing essential amino acids (lysine, methionine)	3
Intake air cooling	Up to 10	Among other actions, through use of geothermal heat exchanger; depending on location and Δ T; only in summer with outdoor temperature of over 25 °C	1
Reduction of emitting surfaces/form of flooring	Up to 10 Piglet rearing	Functions only in piglet rearing, not in feeding pig area; e.g. solid, convex or sloped flooring with urine channels or other forms of drainage, separation of function areas	3
Exhaust air cleaning (DLG certified; chemical washer, trickle-bed reactor, 2 and 3 stage systems)	70–90	Associated with very high costs	3[1)]
Feed additives/ feed ingredients e. g. for reduction of urine pH, improving N utilisation	Reduction potential not determinable	EU feed additive regulations must be followed; associated with costs	3
Adding acid to liquid manure	Reduction potential not determinable	High costs, risks in application, corrosion can occur	3
Optimisation of housing ventilation airflow	Reduction potential not determinable	Minimising concentration gradient near ground level around the housing	3
Storage period for fattening pig manure Reference: Storage time in a fattening cycle Measure: Emptying manure canals 1 to 2 times within fattening period	Reduction potential not determinable	The emission reduction effect is not always determinable or can only be insufficiently determined, technical input required, higher labour costs	3
Flushing systems	Reduction potential unable to be estimated[2)]	High technical input, high water requirement, associated with costs	No classification
Covering manure under the slats	Reduction potential unable to be estimated	No practicable solutions exist	No classification
Large groups	Reduction potential unable to be estimated	Emission reduction effect not scientifically verified	No classification

[1)] Adjustments according to UNECE guidance document [2]: there, classification of exhaust air cleaning in category 1. The high costs involved mean that exhaust air cleaning in Germany is graded as category 3 by the working group.
[2)] Reduction potential cannot be estimated because, among other reasons, no scientifically proven emission reduction effects are available.

Category 1: There is a proven emission reduction effect. The reduction method is practicable and can be well controlled.

Category 2: The reduction effect of the method has been verified in practical terms but is not easy to control.

Category 3: Information is available regarding emission reduction effect although reduction potential cannot be clearly defined, and/or one of the following points applies:

1. The emission reducing effect is not always verifiable or has been insufficiently verified.
2. Practical application appears as not particularly realistic.
3. Costs for the measure are too high.
4. Undesirable side effects may result.

No classification: Reduction potential is unable to be estimated or no reduction potential can be verified.

Ammonia emission factors with fattening pigs

The working group estimates that production systems for fattening pigs have not altered since 2000. And currently there are also no research results upon which a decision for changing the emission factors could be based. The respective factors are summarised in **table 3**.

Table 3

Ammonia emission factors and straw requirement in fattening pig housing systems

Production system – fattening pigs	Emission factor NH_3-N [kg • animal place^{-1} • a^{-1}]	Amount of straw litter [kg • animal place^{-1} • d^{-1}]
Insulated housing, fully slatted flooring, slurry	3	-
Insulated housing, partly slatted flooring, slurry	3	-
Insulated housing, sloped floor (partly solid, partly slatted, litter only as play material), slurry	2	-
Insulated housing, pens with feeding and lying area, solid flooring, litter	4	0.3
Insulated housing, deep litter	4	1
Natural ventilated housing, kennel housing, slurry	2	-
Natural ventilated housing, kennel housing, litter	2	0.3
Natural ventilated housing, deep litter	3.5	1

For preparation of emission inventories in straw litter systems it is assumed that medium amounts of straw are used of 0.3 or 1.0 kg per animal place and day.

Abatement measures

As with dairy cows, measures and abatement potentials will be required for prognosis of future emissions in fattening pig production. **Table 4** presents selected measures. For evaluation of abatement measures, the same categories as in cattle production apply.

The most important abatement measurement in fattening pig production is, as before, the feeding of crude protein in rations exactly according to animal requirements. Through the resulting exact nitrogen intake a potential 10 to 40 % of emissions can be avoided. But a requirement here is that matching of supply is within the given limits (see column notes in **table 4**). With multi-phase feeding, a daily adjustment of the ration is assumed. The equipment must also be available to allow application of phase feeding or multi-phase feeding.

Conclusions

Within the laying hen sector the production system for the emission inventory has been revised and here in particular the emission reduction possibilities through manure belt and manure belt drying is included in the emission factors. The remaining emission factors in broiler production have been adjusted for. In general, the KTBL working group feels there is a very high requirement for research to determine valid emission factors in poultry production.

In fattening pig production there have been no changes in ammonia emission factors compared with 2000. Recognised as sustainable abatement measure is multi-phase feeding with the associated crude protein reduction and use of compensatory amino acids. Such measures are metabolically desirable for the animals as well as reducing the total nitrogen cycle.

Literature

[1] Eurich-Menden, B.; Döhler, H.; Van den Weghe, H. (2010): Ammoniakemissionsfaktoren im landwirtschaftlichen Emissionsinventar – Teil 1: Milchvieh. Landtechnik 65(6), S. 380-382

[2] UNECE 2007: Guidance document on control techniques for preventing and abating emissions of ammonia. http://www.unece.org/env/documents/2007/eb/wg5/WGSR40/ece.eb.air.wg.5.2007.13.e.pdf, Zugriff am 22. November 2010

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Annotation

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