Brigitte Eurich-Menden and Helmut Döhler, Darmstadt, and Ulrich Dämmgen, Brunswick

Ammonia Emissions of German Agriculture

Technical Reduction Potential

Ammonia emissions from agriculture must be considerably reduced in the future. Using two enterprises as examples, the emission reductions attainable in pig fattening and dairy farming are presented, as well as the costs incurred per animal place.

Dr. Brigitte Eurich-Menden and DIa Helmut Döhler belong to the scientific staff of the KTBL, Bartningstr. 49, D-64289 Darmstadt;
e-mail: *b.eurich-menden@ktbl.de*
Dr. Ulrich Dämmgen is a scientist at the Institut für Agrarökologie of the FAL, Bundesallee 50, 38116 Braunschweig.

Keywords

Ammonia emissions in agriculture, effectiveness of abatement measures

According to [1], the ammonia emissions from livestock alone amounted to about 457 500 t in 2002. Furthermore about 108 500 t were generated by mineral fertilisation and more than 30 000 t are assumed to be emitted from other sources (traffic, industry and domestic animals).

Distribution of ammonia emissions in Germany

The largest proportion of ammonia emissions from agriculture is caused by cattle (52%), followed by pig husbandry (22%), the application of mineral fertilisers (19%), poultry (6%), horses (1%) and sheep (<1 %).

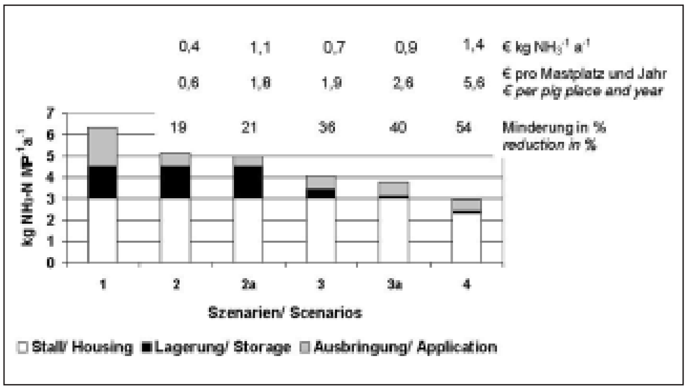

Fig. 1: Emissions, reduction in % and costs for a fattening pig housing system with 1000 places iwith various reduction scenarios [2]

Although the figures for the total emissions of ammonia are relevant with regards to their environmental effects, the regional concentrations of livestock production are especially important. In the intensive livestock production areas of north-west Germany, Bavaria, Baden-Württemberg, Thuringia and Saxony, regionally high environmental strain with ammonia can be found. In this connection, pig and poultry husbandry lead to locally increased emission concentrations, for example in north-west Germany (in terms of kg ammonia per hectare). The emissions for Germany as a whole, however, are mainly caused by cattle husbandry.

Model farms, mitigation options, potentials and costs

In order to show the possibilities to reduce ammonia emissions, a pig fattening farm and a dairy farm are presented as examples.

Pig fattening model farm

A pig fattening farm with 1000 fattening places was chosen. This size of farm was chosen because, bigger farms, particularly, have faced and will continue to face increased demands to reduce emissions.

Calculations were carried out on the basis of several measures, which represent the whole production process, from feeding to the status of the ammonia in the soil. Using this single farm example, the possible cumulative effects of measures to reduce emissions are also presented. The assumptions made for the scenarios are shown in *Table 1*.

Table 1: Scenarios for reducing ammonia emissions, pig fattening

Measure	**Scenarios**					
	1*	**2**	**2a**	**3**	**3a**	**4**
Housing	insulated and closed building, fully slatted floor, mechanically ventilated, small groups of 12 animals, 1000 fattener places					
Feeding	Conventional feeding, one phase feeding, excretion 13 kg N per fattening place per year					Protein-- adapted feeding
Storage	circular slurry tank, storage capacity 7 months, no natural crust			straw chaff	tent	
Application	*splash plate* 70 % without incorporation 30 % on growing crops	*splash plate* 50 % with incorporation 50 % on growing crops	*splash plate* 50 % with incorporation *trailing hose* 50 % on growing crops	*splash plate* 50 % with incorporation *trailing hose* 50 % on growing crops	*splash plate* 50 % with incorporation *trailing hose* 50 % on growing crops	*splash plate* 50 % with incorporation *trailing hose* 50 % on growing crops

*basic scenario (scenario 1) presents the situation before German fertilising ordinance came into force

When selecting the scenarios, adaptation possibilities were considered, which can be implemented on farms in the short term, e.g. changes in the application period of slurry and immediate incorporation of the slurry, as well as in the middle term (replacement of splash plate by trailing hoses) and long term measures, e.g. changing the feeding technology to a protein adapted feeding regime. The situation in 1990, i.e. before the German fertilising ordinance came into force, which requires that slurries have to be incorporated, was taken as the basic scenario.

The costs of the measures are presented either as total costs considering the production process, and as specific costs for the reduction in emissions in € per kg ammonia. So the costs of cheap (e.g. incorporation) and expensive measures were averaged. A conversion rate of 10% of the organically fixed nitrogen in the slurry into ammonia during storage was included in the calculation.

The results in *Figure 1* show that with only a change in the management of the slurry application, the losses of ammonia can be reduced by 20%. The costs for incorporation are 0.77 €/m^3, which is around 0.40 € per kg ammonia (scenario 2). Only part of the machinery costs were attributed to the slurry incorporation, as a cultivation of the soil has to be done anyway. However, the additional use of trailing hoses on growing crops brings little additional effect, hence the specific reduction costs almost triple (scenario 2a).

A very cost effective practice is the combination of optimised slurry application and the covering of the slurry tank with chopped straw (scenario 3). Although scenario 3 is based on the use of costly trailing hose application, the average reduction costs reduce considerably due to the covering of the slurry tank with chopped straw. In contrast, these costs rise considerably (from 0.7 to 0.9 € per kg ammonia) if the more efficient, but more expensive measure of covering the tank with a "tent roof" is employed (scenario 3a). With covering the slurry tank and optimised application management, ammonia emissions can be reduced by 40 % at specific cost of 0,9 € perkg of ammonia.

A further reduction of emissions is possible by implementing additional measures in the stable. For the example, the long term measure of the introduction of phased-feeding technology was selected. This was done with the assumption that a replacement of parts of the existing feeding technology was necessary. Through this measure the losses can be limited to less than 50% (scenario 4).

The exemplary farm with the large pig fattening housing shows that for this size of farm highly cost effective options to reduce ammonia emissions exist. The average costs amount only to about 0.5 € per kg NH_3. However, importantly, the example presents an optimal situation which, although realistic, cannot be extrapolated onto other farm sizes, livestock species or another basic farm scenario (i.e. before the German fertilising ordinance came into force).

Dairy model farm

The assumptions which were made for the dairy farm example are as shown in *Table 2*.

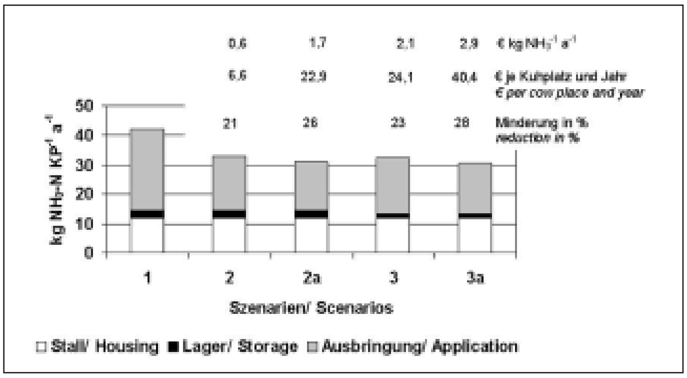

Fig. 2: Emissions, reduction in % and costs for a dairy cow housing system with 70 cow places with various reduction scenarios (Source: calculations by KTBL. 2002)

As in the example with the fattening pigs, ammonia losses can be reduced by 20% with just a change in the management of slurry application (*Fig. 2*). Also in the case of the dairy farm the costs for incorporation were calculated to be 0.77 €/m^3. The costs for the reduction of ammonia emitted per kg amount to 0.60 € (scenario 2). The use of the trailing shoe on grassland, however, brings only little additional benefits, although the costs rise significantly to 1.7 € per kg NH_3 (scenario 2a).

Covering the slurry tank with a floating foil (scenario 3), and also the combination of foil and the use of a trailing shoe to apply the slurry (scenario 3a), cannot be considered as cost-effective measures because emission reduction costs of 2.1 and 2.9 €/kg are incurred respectively.

The optimal timing of slurry application and the immediate incorporation of the slurry turned out to be the most cost-effective measures for dairy farms with arable farming.

Table 2: Scenarios for reducing ammonia emissions, dairy farming

Measure	**Scenarios**				
	1*	**2**	**2a**	**3**	**3a**
Housing	open cubicle housing, liquid slurry system, conventional feeding, 108 kg N excretion pro animal place and year, average annual milk yield of 6000 l; 70 cows plus young stock				
Storage	circular slurry tank, storage capacity of 5 months,				
	natural crust			foil	foil
Application	*splash plate* 30 % on stubble without incorporation 30 % on growing crops 40 % on grassland	*splash plate* 25 % on stubble with incorporation 45 % on growing crops 30 % on grassland	*splash plate* 25 % on stubble with incorporation 45 % on growing crops *trailing shoe* 30 % on grassland *trailing shoe*	*splash plate* 25 % on stubble with incorporation 45 % on growing crops 30 % on grassland	*splash plate* 25 % on stubble with incorporation 45 % on growing crops *trailing shoe* 30 % on grassland *trailing shoe*

*basic scenario (scenario 1) presents the situation before German fertilising ordinance came into force.

Literature

[1] *Dämmgen, U.* (ed.): Nationaler Inventarbericht 2004 -Berichterstattung unter der Klimakonvention der Vereinten Nationen: Teilbericht für die Quellgruppe Landwirtschaft. Landbauforschung Völkenrode. Sonderheft 260, 2004, im Druck

[2] *Döhler, H., U. Dämmgen, B. Eurich-Menden, B. Osterburg, M. Lüttich, W. Berg, A. Bergschmidt und R. Brunsch*: Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationale Richtlinien sowie Erfassung und Prognose der Ammoniak-Emissionen der deutschen Landwirtschaft und Szenarien zu deren Minderung bis zum Jahre 2010. Abschlussbericht im Auftrag von BMVEL und UBA, UBA-Texte 05/02, Umweltbundesamt, Berlin, 2002, 192 S.

[3] *Eurich-Menden, B., H. Döhler und E. Hartung*: Gute fachliche Praxis der Ammoniak-Emissionsminderung. Landtechnik 59 (2004), H. 2, S. 102-103