AMMONIA ABATEMENT: EFFECTIVENESS AND COSTS IN TWO GERMAN MODEL FARMS

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ABSTRACT

Ammonia emissions from agriculture need to be reduced significantly. By using two model farms, a pig fattening and a dairy farm, single ammonia abatement measures as well as combination of measures are applied and their associated costs are calculated.
Keywords: *ammonia abatement measures, costs.*

INTRODUCTION

According to Dämmgen (2004), the ammonia emissions from German livestock 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).

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 %).

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

MATERIAL AND METHODS

Model farms, mitigation options, potentials and costs

A pig fattening farm with 1000 fattening places was chosen, which is a relatively large one under German conditions. This size was chosen since larger enterprises particularly have faced and will continue to face increased requirements to reduce emissions. Calculations were carried out on the basis of several measures which represent the whole process, from feeding to the application of the manure to 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 as shown in Table 1 for the pig farm and in Table 2 for the dairy farm. For applying pig slurry the model farm constists of trail hose spreaders, which lead to reductions of 50 %, when pig manure is applied to growing crops. Trailing hoses are assumed to be less effective for the application of cattle slurry, consequently trailing shoes with a reduction potential of 60 % were chosen.

For covering pig slurry stores chopped straw is assumed to be an appropriate measure. Even after stirring the slurry, the straw will again form an artificial crust. Cattle manure stores however need to be stirred more often all over the year, and physical manure properties will hinder an upflow of the straw chaff. Therefore a floating foil was assumed to be the better option.

The capital, labour, operational costs are calculated according to KTBL calculation standards regarding effects of scale. The scenarios are compared to a reference system (basic scenario), allowing to identify the extra costs. There are no benefits taken into account.

Table 1. *Scenarios for reducing ammonia emissions - fattening pigs*

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, dry feeding system, excretion:13 kg N per fattening place per year					phase feeding, excretion: 11 kg N
storage	circular slurry tank, storage capacity 7 months, no natural crust			straw chaff	tent	
applica-tion	**splash plate** 70 % without incorporation	**splash plate** 50 % with incorporation	**splash plate** 50 % with incorporation	**splash plate** 50 % with incorporation	**splash plate** 50 % with incorporation	**splash plate** 50 % with incorporation
	30 % on growing crops	50 % on growing crops	**trailing hose** 50 % on growing crops	**trailing hose** 50 % on growing crops	**trailing hose** 50 % on growing crops	**trailing hose** 50 % on growing crops

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

Table 2. *Scenario for reducing ammonia emissions - dairy cows*

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

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

RESULTS AND DISCUSSION

Pig fattening model farm

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 again as specific costs for the reduction in emissions in € per kg ammonia. The costs of cheap (e.g. incorporation) and expensive measures were averaged.

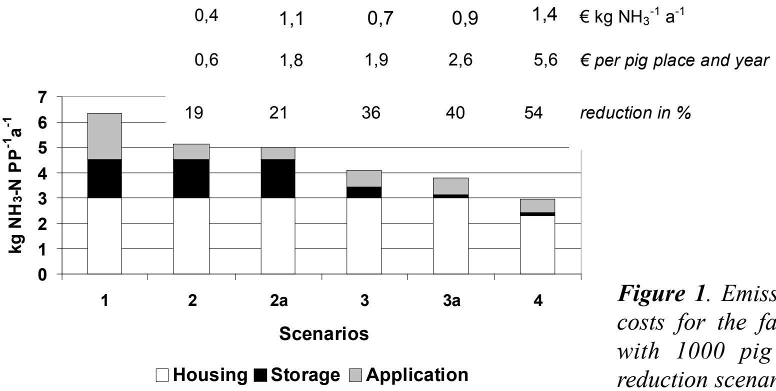

Figure 1. *Emissions, reduction (%) and costs for the fattening pig model farm with 1000 pig places, with different reduction scenarios (Döhler et al., 2002)*

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 €/m³, 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 increased effect, although the specific reduction costs almost triple (scenario 2a).

A very cost effective measure is the combination of optimised slurry application and the covering of the slurry tank with straw chaff (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 straw chaff. 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 is employed (scenario 3a). With covering the slurry tank and optimised application management ammonia emissions can be reduced by 40% at specific coast of 0,9 €, which are quite close to the mineral N fertiliser value.

A further reduction of emissions is possible by implementing additional measures in the stable. Phase-feeding technologies (assuming an additional silo, dosage and mixing equipment) turned out to reduce emissions on the model farm to under 50% (scenario 4).

The model 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

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 (Figure 2). Also in the case of the dairy farm the costs for incorporation were calculated to be 0.77 €/m³. The costs for the reduction of ammonia prevented from volatilisation 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). The reason for this lies in the small proportion of manure, which can be applied on grassland (only 30 %).

Covering the slurry tank with a floating foil (scenario 3), and also the combination of foil and the use of a trailing shoe (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 on to be the most cost-effective measures for dairy farms with arable farming.

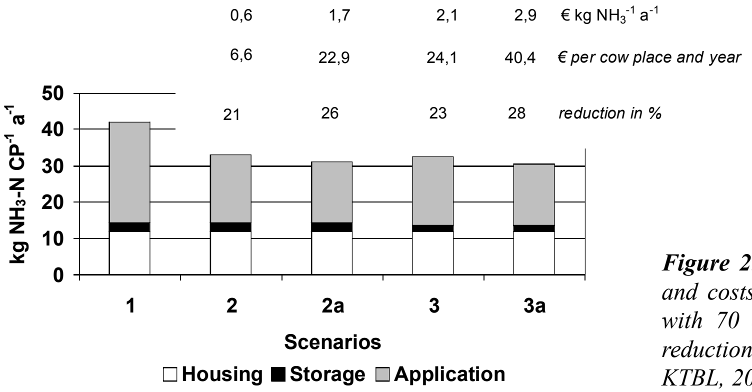

Figure 2. *Emissions, reduction (%) and costs for the dairy model farm with 70 cow places, with different reduction scenarios (calculations by KTBL, 2002)*

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