Odour and ammonia emission control by slurry treatment and covering

Maîtrise des émissions d'ammoniac et d'odeurs par traitement et couverture du lisier.

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Abstract

We tested in a practical scale Bentonite as feed additive and lactic acid to reduce the pH-values of liquid manure. An algal material and lactic acid for slurry treatment are investigated in lab-scale, just as stone granules, chopped straw and rape oil as covering of storage tanks. Bentonite reduces both the odour and the ammonia flow rate by 33 % and 25 %, respectively. The algal substance reduces the odour emission but not the ammonia volatilization. Acidification with lactic acid has a lasting effect on ammonia, methane and nitrous oxide emission but not on odour emission. Granules and chopped straw as covering materials reduce both the odour and the ammonia release by about 80 %.

Keywords *: Odour, ammonia, emission, slurry treatment, covering*

Résumé

Nous avons testé, à l'échelle de la ferme, la Bentonite en tant qu'additif alimentaire et l'acide lactique pour réduire le pH des lisiers. Un produit à base d'algues et d'acide lactique pour le traitement du lisier a été étudié à l'échelle du laboratoire, ainsi que des granules, de la paille chopée et des tiges de colza pour la couverture des fosses. La Bentonite permet une réduction des odeurs et de l'ammoniac de l'ordre de 33% et 25% respectivement. Le produit à base d'algues réduit les émissions d'odeurs mais pas la volatilisation de l'ammoniac. L'acidification à l'aide d'acide lactique a un effet retard sur les émissions d'ammoniac, du méthane et de protoxyde d'azote mais pas d'effet sur les odeurs. Les granules et les substrats chopés utilisés pour la couverture réduisent à la fois les odeurs et les émissions d'ammoniac de 80%.

Mots-clés : odeurs, ammoniac, émission, traitement lisier, couverture.

1. Introduction

Farms with animal husbandry have to protect the neighbours against nuisance caused by odours, and the nature against harmful gas emissions e. g. ammonia, methane and nitrous oxide.

The required distance between odour emitting animal production facilities and residental areas is regulated by the so-called "Distance regulation" enclosed in the VDI-guideline "Emission control - Livestock farming". If this distance is not sufficient additional measures are necessary to reduce emissions. For the limitation of noxious gas emission there are no instructions. Only the decrees for the keeping of pigs and calves contain a limit of 20 ppm for ammonia.

Emission reduction from the stables is attainable by measures of feeding, animal keeping and ventilation, not least by a good management regarding dry and clean surfaces. The emissions from the storage containers may be reduced by the constructive design, low temperatures (e.g. shady location) and coverings.

Our research work aims to control the emissions by material and process engineering measures. In this paper it will be reported on the interaction between harmful gases and odour under use of feed and slurry additives as well as of alternative coverings for storage tanks.

2. Materials and methods

The already tested materials and those now being tested are shown in Table 1.

Material group	Material	Feed additive (F) Slurry additive (S) Covering (C)	Scale
Clay minerals	Bentonite	F	on-farm
Plant extracts	Algae	S	lab-scale
Organic acids	Lactic acid	S	lab-scale, on-farm
Swimming layers	Chopped straw Stone granules Rape oil	C C C	on-farm, lab-scale on-farm, lab-scale lab-scale

Table 1
Tested feed and slurry additives as well as swimming covers

Two groups of growing pigs (390 pigs in control group, 367 in trial group) were kept under almost identifical conditions in a forced ventilated stable. The pigs of the trial group received 2 % **Bentonite** with feed during 10 weeks.

Treatment of pig slurry with a **algal material** was investigated in Perspex containers on a 50 litres scale. The DM content of slurry was to 8.0 %, the addition range 0.02 %. The investigation covered a period of eight weeks.

Acidification of pig and cattle slurry with **lactic acid** was carried out in a 75 litres scale. Adjusted pH values came to 3.8, 4.3 and 4.8. The dry matter content was between 5.5 % and 10.4 %. The slurries were stored over a period of 183 and 190 days, respectively.

Chopped straw and floatable **stone granules** were investigated in comparable pig breeding farms in 16 m-diameter storage containers. Chopped straw in a quantity of 4 kg/m² was spread with a blower and than mixed with the slurry. The used granules called "PEGÜLIT R" and "PEGÜLIT M" consist of a white floatable natural stone with different processing. The layers with an intensity of 10 cm were spread with a blower and mixed with the slurry.

Pig slurry covered with **rape oil** was investigated in a 65 litres scale too. The investigations were carried out in transparent Perspex containers to observe and registrate the swimming behaviour of the coverings.

According to the test objectives the measured parameters were :

- ammonia, methane and nitrous oxide concentration (photoacoustic gas monitor),
- odour concentration (olfactometer),
- sedimentation, and flow properties (rotational-type viscometer).

3. Results

Bentonite

Bentonite with its main component montmorillonite as a feed additive affects the excrements by cation exchange and adsorption. So ammonia is bound in gastrointestinal tract. As a result the ammonia emission is influenced. Ammonia concentrations in the air in the trial compartment ranged between 5.9 and 10.7 mg/m³ and in the control compartment between 4.9 and 13.9 mg/m³. This is the normal range for fattening pigs. NH_3-flowrates, calculated from concentration and ventilation rate, were lower by 10 to 33 % for the experimental group than for the control group (Figure 1). The effect of emission reduction turned out even better as regards odour. An emission reduction by 26 to 37 % was observed (trial: 19 to 43 odour units/s × livestock unit, control: 32 to 59 odour units/s × livestock unit).

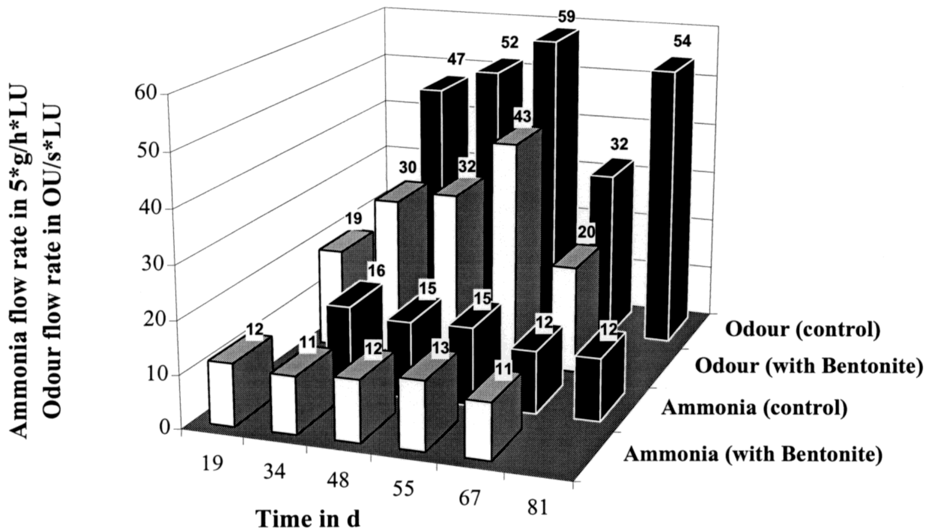

Figure 1
Ammonia and odour flow rate under use of BENTONITE as feed additive (investigations in a stable with growing pigs)

The ratio of ammonium to total nitrogen content in slurry of pigs fed with Bentonite was 15 to 20 % higher despite higher pH values (control: 0.34 to 0.44, trial: 0.45 to 0.53).

<u>*Algal material*</u>

The use of algae aims to increase of bacterial activities in the slurry. Our test results show different effects on ammonia and odour emission (Figure 2). Whereas at the beginning of the test period odour concentration of the trial samples was higher than of the control samples, the trend was turning back after one week. Then the odour emission reduction for the trial samples ranged between 35 and 55 % compared with the untreated slurry. In contrast to this no differences were ascertainable regarding the ammonia emissions.

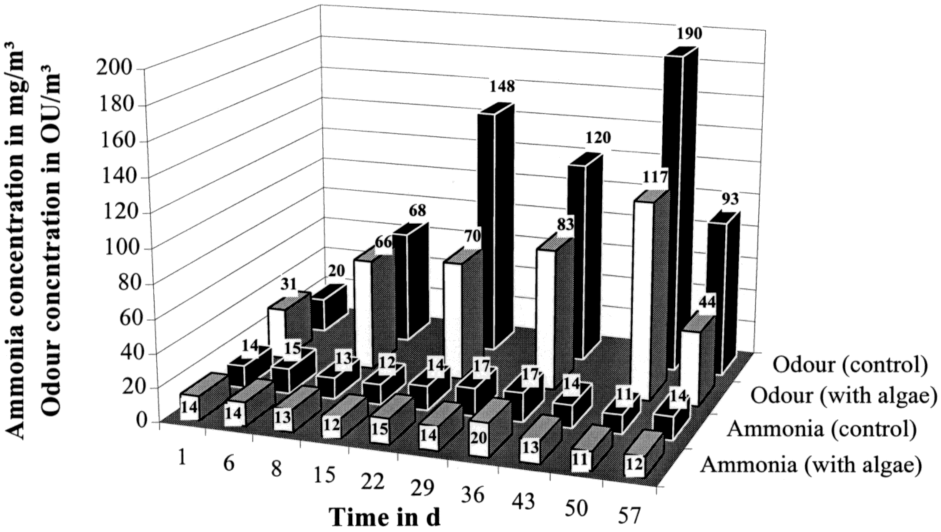

Figure 2
Ammonia and odour concentration under use of an algal material as slurry additive (pig slurry, DM = 8.0 %)

<u>*Lactic acid*</u>

As reported in former times pH values under 4.5 must be reached to reduce the noxious gas emissions noticeably. The supply of acid depends on the kind and dry matter content of slurry. Acidifying of cattle slurry at pH = 4.5 requires a lactic acid addition of about 4 % by volume. The addition rate must be little higher for pig slurry. During storage lower pH values were more steady than higher ones. To keep the pH at the desired value of 4.5 lactic acid had to be added four times. To the sample with the desired pH value of 4.0 lactic acid had to be added only one time (shortly before the end of storage time). The weekly measurements of gaseous emissions confirmed the influence of temperature, pH value and the condition of the slurry surface. So the ammonia concentration of control sample was strongly decreased by encrustation of its surface. Simultaneous with encrustation nitrous oxide emissions were detected. But even compared with encrusted control sample the reduction of pH value by acidifying with lactic acid caused a decrease of ammonia emission (Figure 3) and also of methane emission (Figure 4). Nitrous oxide emission was measured at non-acidified encrusted samples only.

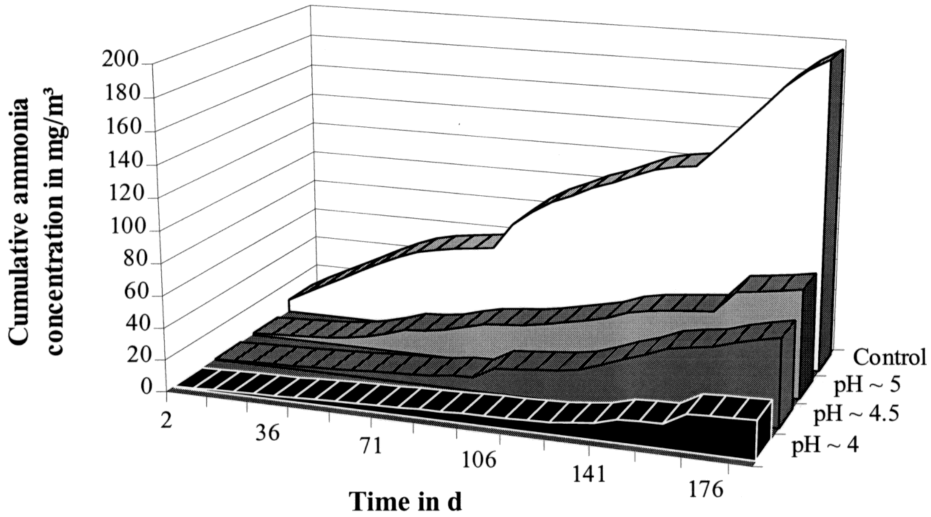

Figure 3
Cumulative ammonia concentration above cattle slurry acidified with lactic acid (DM = 7.8 %)

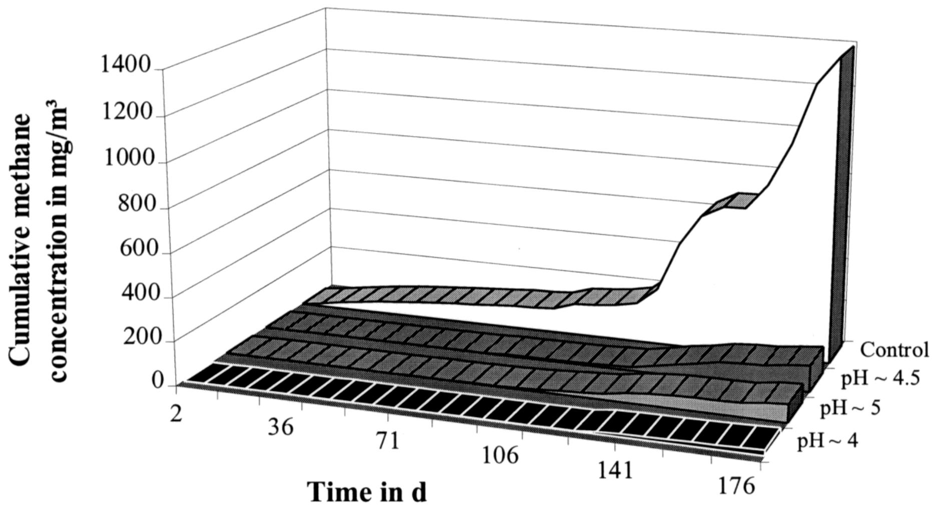

Figure 4
Cumulative methane concentration above cattle slurry acidified with lactic acid (DM = 7.8 %)

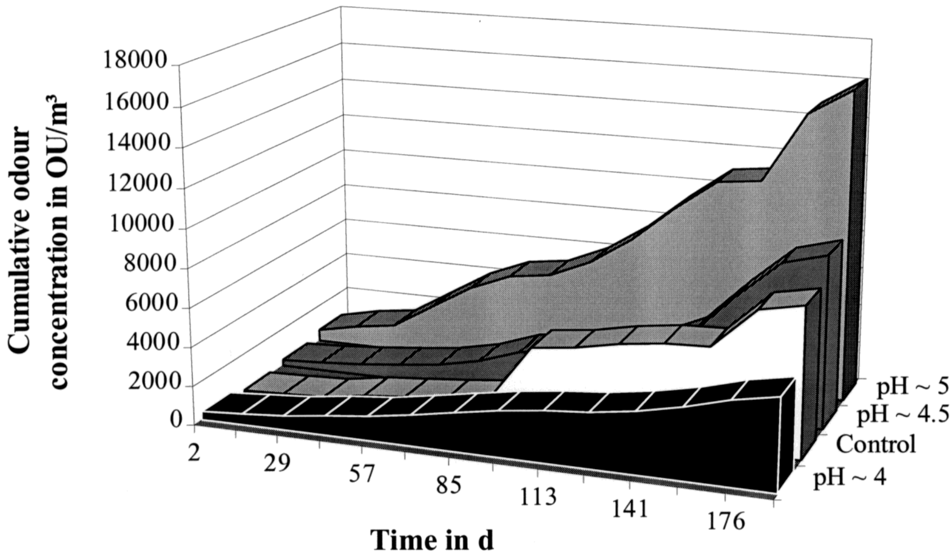

Figure 5
Cumulative odour concentration above cattle slurry acidified with lactic acid (DM = 7.8 %)

The cumulative odour concentration for the slurry with pH ≅ 4 was lower than for the control, but it was a little higher for pH ≅ 4.5 and considerably higher for pH ≅ 5. A different kind of odour was ascertainable: approximately like grass silage.

It is conclutéd that the acidification of slurry with lactic acid offers advantages concerning the reduction of environmentally relevant gases. The odour emission is rather higher compared with untreated slurry.

Chopped straw and stone granules

The straw layer varied depending on measuring point between 5 and 15 cm. A thicker straw layer caused a higher ammonia reduction rate. The ammonia and odour emissions were reduced by about 80 % (Figure 6), the methane and nitrous oxide volatilization by 45 % and 13 %, respectively.

There were considerable differences between the two 10 cm thick granules layers (Figure 6). Pegülit M held back more NH_3 and odour than Pegülit R. The cause for that were clefts in the Pegülit R-cover caused by motion of the surface during slurry refilling. Altogether high emission reduction rates are available with coverings consisting of floating stone granules. Similar results are reported by other authors.

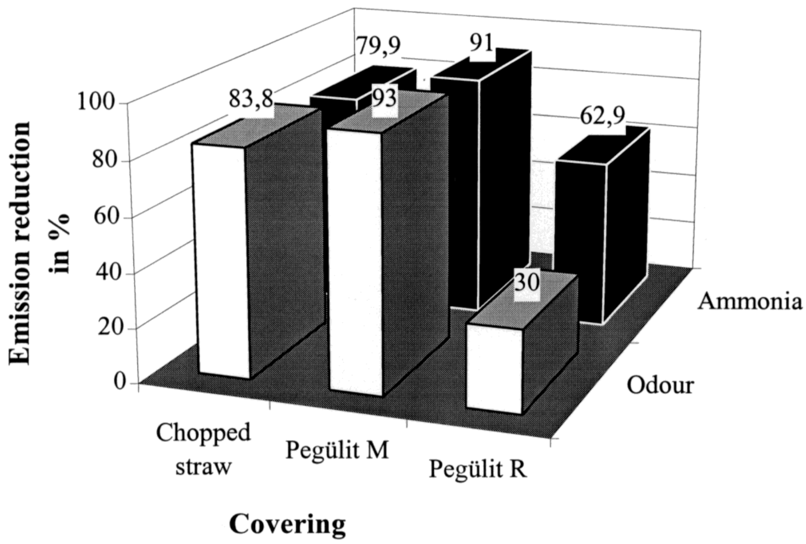

Figure 6
Emission reduction rates of different swimming covers (pig slurry, on-farm study)

Rape oil

The rape oil was applied with a thick of 3 mm and of 6 mm. The slurry in one of two containers covered with a 6 mm rape oil layer was homogenized three times.

A 6 mm rape oil layer reduced the ammonia flow rate from the slurry surface by about 85 %. There were no differences between homogenized and not homogenized slurry. The reduction rate of a 3 mm rape oil layer amounted to at least over 50 %.

An important aspect concerns the floating behaviour of such coverings after mechanical strain. Straw mixed with slurry made a compact floating layer infiltrated with gas bubbles. After homogenization the covering material went up to the surface completely in the course of a few hours. Pegülit went up to the surface very quickly, even though slurry particles were incluted in the covering layer.

Rape oil as a 3 mm or 6 mm layer rose to the surface during a period of several days also after repeated homogenizations. It formed a closed layer again, but was infiltrated with manure particles. The sealing against emitting gases was very effective. But the mixture from oil and slurry caused odour (Figure 8). So the cumulative odour concentration for the test period of 12 weeks was two times higher than for the control sample. This is an evident disadvantage of rape oil covering.

4. Conclusion

4.1. Measures of slurry treatment and covering do not have an equal effect on noxious gas and odour emission. Lactic acid as material for the slurry treatment take up the first place in reducing ammonia, methane and nitrous oxide emission, but the odour emission was rather higher compared with untreated slurry. On the other hand algal substances reduced the odour emission but not the ammonia volatilization.

4.2. Bentonite as feed additive reduced both the odour and ammonia flow rate. The same also applies to the tested granules and chopped straw. Because rape oil was mixing with slurry particles during the storage time the air pollution by odour was higher than by uncovered slurry. While a rape oil layer caused a decrease of NH_3 emission by about 85 %.

4.3. Very complex chemical and physical as well as temporally changing processes are the causes for such an irregular behaviour. This means that material and process engineering measures must be used selectively for improving of environmental situation in livestock husbandry.