REDUCING AMMONIA EMISSIONS BY COMBINING COVERING AND ACIDIFYING LIQUID MANURE

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ABSTRACT

Emissions from animal husbandry can be reduced by covering storage facilities as well as by lowering the pH value of the liquid manure. Investigations on several cover materials and on acidifying liquid manure with lactic acid led to the idea to combine both effects – covering and acidifying liquid manure, to reduce emissions more effectively.

Investigations were carried out with granule combined with lactic acid or with saccharose at lab-scale in storage containers with 65 l liquid swine manure, respectively. They were compared with trials made with nothing but granule and an uncovered control sample. The layer thickness of the covered samples was 6 cm. Gaseous emissions (NH_3, N_2O, CH_4) and odor were measured. The pH value of the liquid manure below the surface and above the ground, the dry matter, ammonium, and total nitrogen content of the liquid manure were determined.

The combination of a perlite with lactic acid lowered the pH value of liquid swine manure below the surface more than that above the ground. The combination reduced the pH value with a lower amount of acid than acidification without cover material.

All samples reduced ammonia and a little bit lower also methane emission effectively, except for the samples with saccharose. The samples with lactic acid or saccharose could avoid nitrous oxide emission, contrary to the granules customarily in trade.

None of the investigated samples reduced odor emission during the whole storage period.

KEYWORDS. Animal husbandry, Emission, Ammonia, Methane, Nitrous oxide, Odor, Liquid manure, Cover material, Lactic acid

INTRODUCTION

High emission rates of ammonia and other gases from animal husbandry can cause health problems and negative impacts on the environment. Regulations in Germany stipulate upper limits for ammonia concentration in animal houses. In international notes, Germany undertakes to reduce ammonia emission drastically. About 90% of ammonia emission comes from animal husbandry. There is a great demand for the development and use of abatement techniques.

Different cover materials are used successfully to reduce ammonia and odor emissions during storage of liquid manure, such as chopped straw, granules or foils. However, emissions of methane or/and nitrous oxide occur under certain circumstances. Manipulating the balance between ammonia and ammonium by lowering the pH value of a slurry is a promising possibility to reduce not only ammonia emissions but also methane and nitrous oxide (Berg and Hörnig, 2000). Combining covering and acidifying liquid manure shall reduce all mentioned emissions effectively. The cover material is used both as a cover and also as a carrier of the acid. In this way, the pH value of the liquid manure should be lowered above all near the surface, the place of emission, and less on the bottom of the storage facility.

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METHODOLOGY

Investigations were carried out at laboratory scale in storage containers with 65 l liquid swine manure. The manure, with a dry matter content of 6.3%, was gained from a pig pen by pumping from a reservoir near the manure pit.

Two different granules were used: a perlite (Pegülit™) and a lightweight expanded clay aggregate (Leca™). They were applied customarily in trade and combined with lactic acid or with saccharose. These three variants respectively were compared with the control sample, the uncovered and untreated liquid manure. The granule layer thickness was 6 cm respectively. Before the beginning of the measurements the granule was mixed with 80% concentrated lactic acid (“perlite + lactic acid”, “leca + lactic acid”) or with saccharose (“perlite + saccharose”, “leca + saccharose”). The amount was 200 ml lactic acid/l granule or 120 g saccharose/l granule. Afterwards the granule was hydrophobined.

The storage period was 162 days. The manure was stored in open containers which were closed and ventilated only during measurement – open chamber (Fig. 1). The ventilation rate was regulated so that the air volume above the liquid manure surface in the closed container was changed one time per minute. The measured parameters were:

· content of ammonium (NH_4^+) and total nitrogen (N_t) in the manure by chemical analysis,

· room temperature,

· pH value below the surface and above the ground of the liquid manure,

· concentrations of ammonia (NH_3), nitrous oxide (N_2O) and methane (CH_4) by a photoacoustic multigas monitor, and air flow rate through tanks by flow meters,

· odor concentration by an olfactometer,

· sedimentation.

Figure 1. Experimental Equipment for Investigation of Gas and Odor Emissions as well as Storage Behaviour in Lab.

RESULTS AND DISCUSSIONS

pH-value and Temperature

The granules customarily in trade influenced the pH value of the liquid manure hardly(Fig.2 and 3). There was nearly no difference between the pH values below the surface and above the ground of the manure. At the begin of the storage period, there was a little decrease because of natural biological activities in the manure. After 2 weeks, the pH values started to increase. After 4 weeks, they reached their initial situation, and then they increased further into the basic area (>7.0). Approximately 10 weeks after the beginning, the pH values reached their maximum, and then they started to slightly decrease.

The combination of perlite with lactic acid caused a pH value around 5.5. It was reached after a certain amount of lactic acid went into solution (liquid manure) after 2 weeks of storage. There was a noticeable difference of about 0.4 between the pH value below the surface and above the ground of the manure. In the course of the further storage, the pH below the surface was rather steady, and the pH above the ground decreased slightly. After 4 month, it approached the level of the pH value below the surface.

The combination of exclay with lactic acid showed a quite different effect on the pH value of the liquid manure. A higher amount of lactic acid went into solution very fast, but after 2 weeks, the effect wore off very rapidly, and there was nearly no difference between the pH value below the surface and above the ground of the manure. Nevertheless, in the course of further storage, the pH values started to decrease slightly.

In combination with saccharose the sample with exclay had a better effect on reducing the pH value than that of the perlite sample. The combination of exclay with saccharose caused a pH noticeable below 6. During the first 4 weeks the pH value below the surface was slightly lower than the pH value above the ground of the manure. The combination of perlite with saccharose led to a pH value below 6 only for a very short time, then the pH value started to slightly increase.

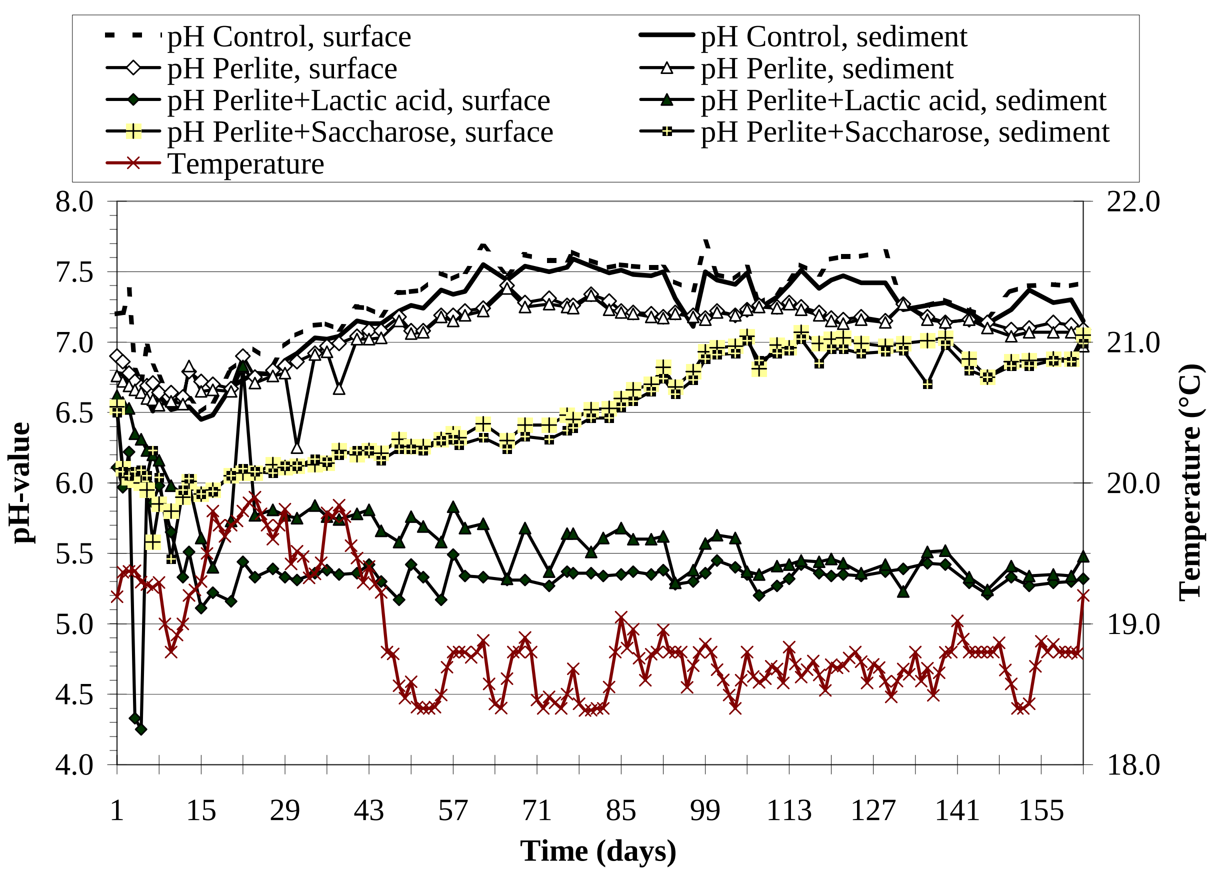

Figure 2. Courses of Temperature and pH values of the Perlite Samples.

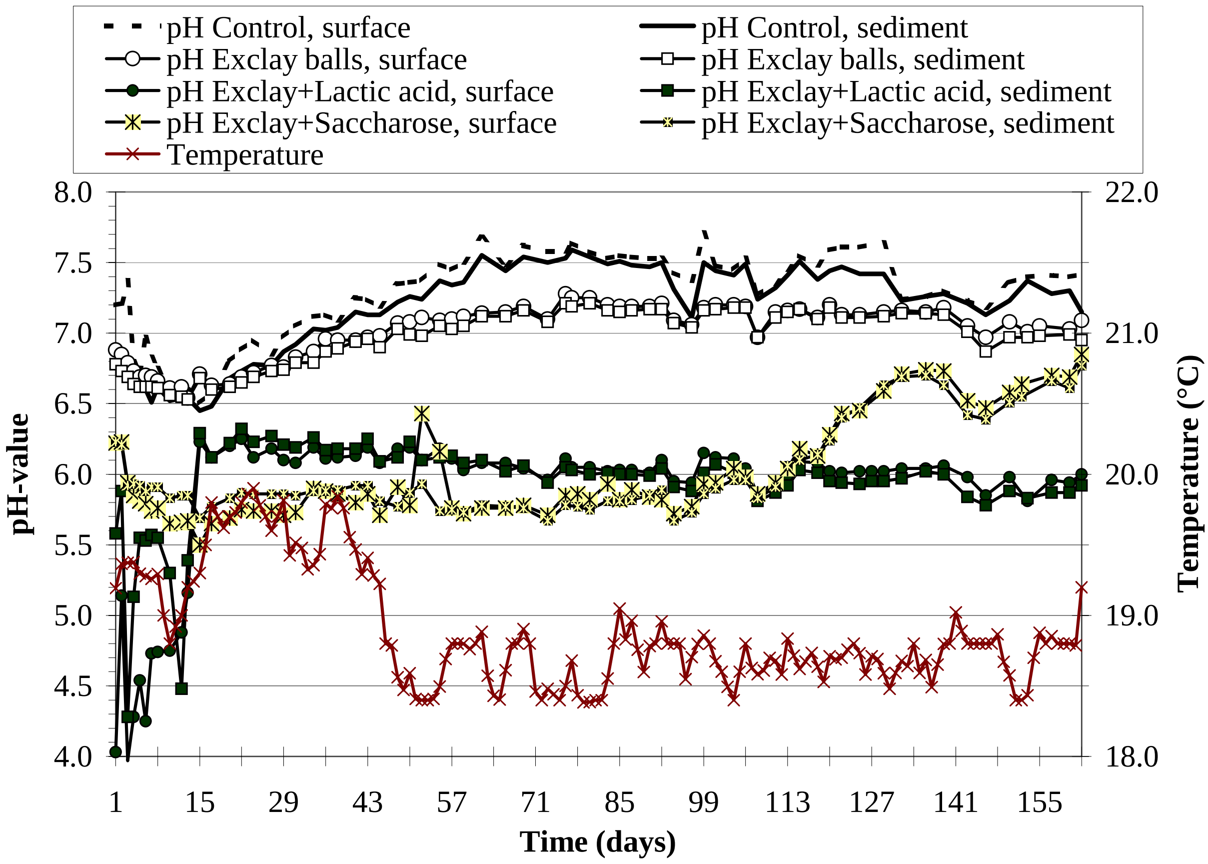

Figure 3. Courses of Temperature and pH values of the Exclay Samples.

The temperature ranged between 18 and 20 °C (64 and 68 °F). The mean value was 18.9 °C (66.0 °F).Because of the small deviation it can be assumed that the temperature did not influence the courses of emissions during the investigation period.

<u>Ammonia</u>

The granules customarily in trade and combined with lactic acid reduced ammonia emission in the range of 80 to 90% (Fig. 4 and 5). The granules customarily in trade needed some time for developing their full effect, especially the exclay, and then they worked very well. The reason seems to be that the exclay needed more time to became encrusted, because of its bigger aggregate size. The noticed encrustation was not strong. For a stronger encrustation, a thicker layer seems to be necessary.

The samples with lactic acid did not become encrusted, even their surface was wet. The combination of perlite and lactic acid had a reduction effect on ammonia between the granules customarily in trade (approx. 85%). Whereas the combination with exclay reduced ammonia emission only by 60%.

The effect of the combinations with saccharose on the ammonia reduction was unsatisfactory. It corresponded to the pH values. The mean reduction rate was about 40%. The increasing reduction effect of the perlite sample after about 10 weeks went along with the encrustation of the perlite. The course of ammonia emission from the exclay sample was quite different. The combination of the exclay with saccharose showed a very good effect at the beginning of the storage period, very similar to the combination of exclay with lactic acid. After 4 weeks, ammonia emission was increasing. After 120 days, an encrustation was observed, but also an increase of the pH values. So, the reduction of ammonia emission started only to slightly increase.

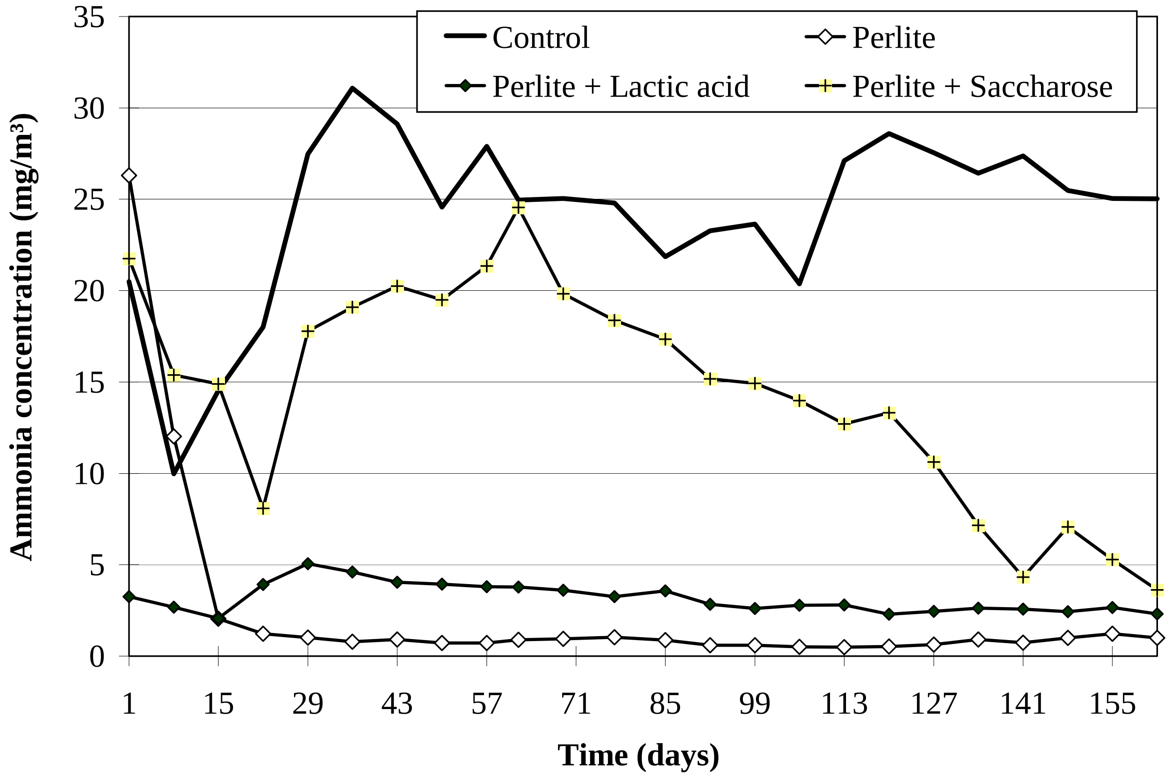

Figure 4. Courses of Ammonia Concentration of the Perlite Samples.

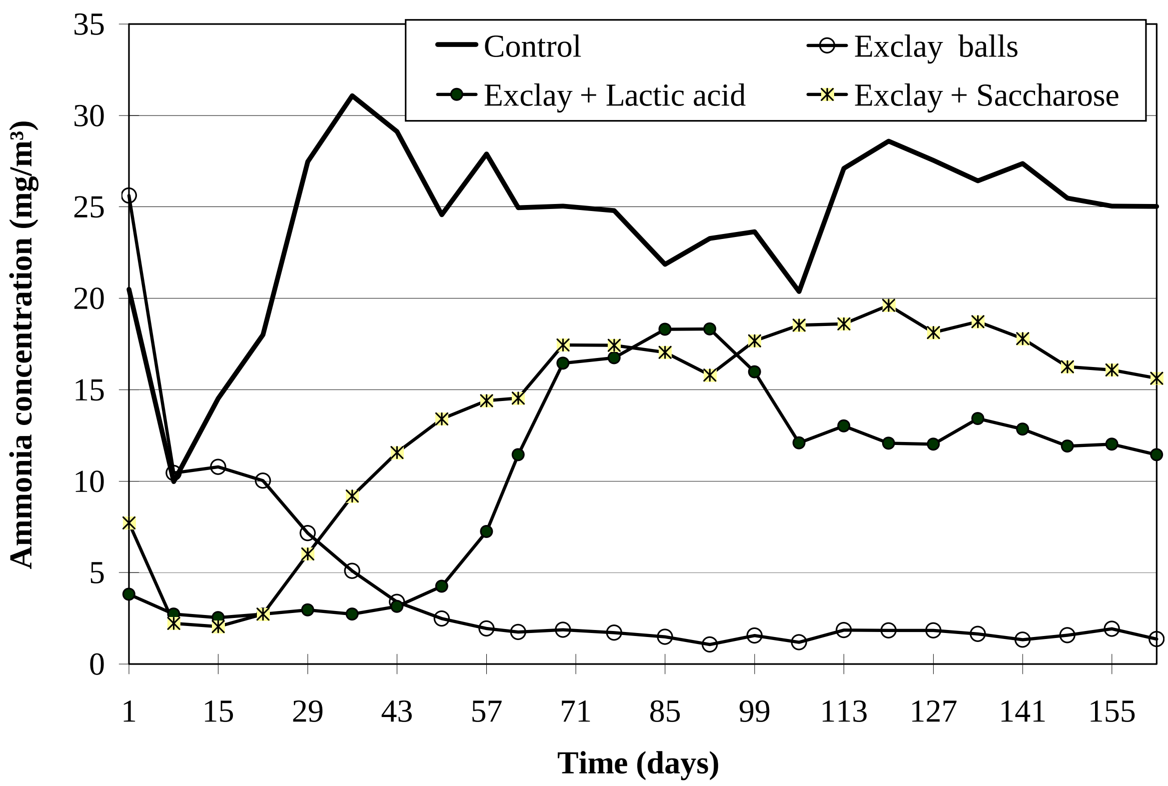

Figure 5. Courses of Ammonia Concentration of the Exclay Samples.

Methane

The courses of methane emission from liquid manure were fluctuating (Fig. 6 and 7). Excluding the 2/3 extreme values, the perlite customarily in trade reduced methane emission by more than 50%.

The customarily in trade exclay had a reduction effect of 20 to 30%, if 2/3 extreme values were excluded, as done with the perlite customarily in trade. Calculated with whole data, there was no reduction effect.

The combination of perlite and lactic acid showed less fluctuating and decreasing methane emissions during the whole storage period. The mean reduction rate was about 40%.

The course of the methane emission from the combination of exclay with lactic acid was very similar, but on a much lower level. The mean reduction rate was nearly 80%.

The methane emissions from the combination of perlite and saccharose were also fluctuating. The mean reduction rate was nearly 15% for the whole investigation period. Excluding the 3 extreme values at the beginning, the sample reduced methane emission by about 35%.

Although the course of methane emission from the combination of exclay with saccharose was different, the mean reduction rate for the whole storage period was also 15%. And excluding 2/3 extreme values, the emission reduction would amount up to 35%.

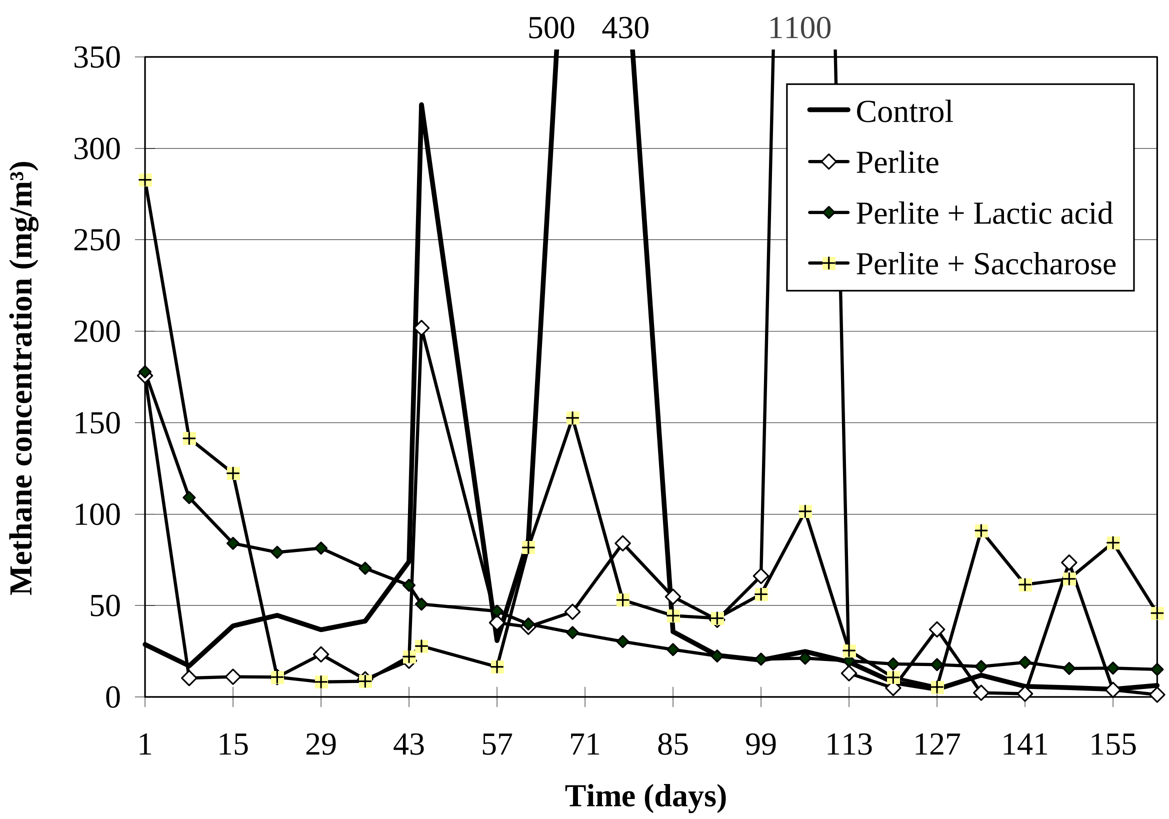

Figure 6. Courses of Methane Concentration of the Perlite Samples.

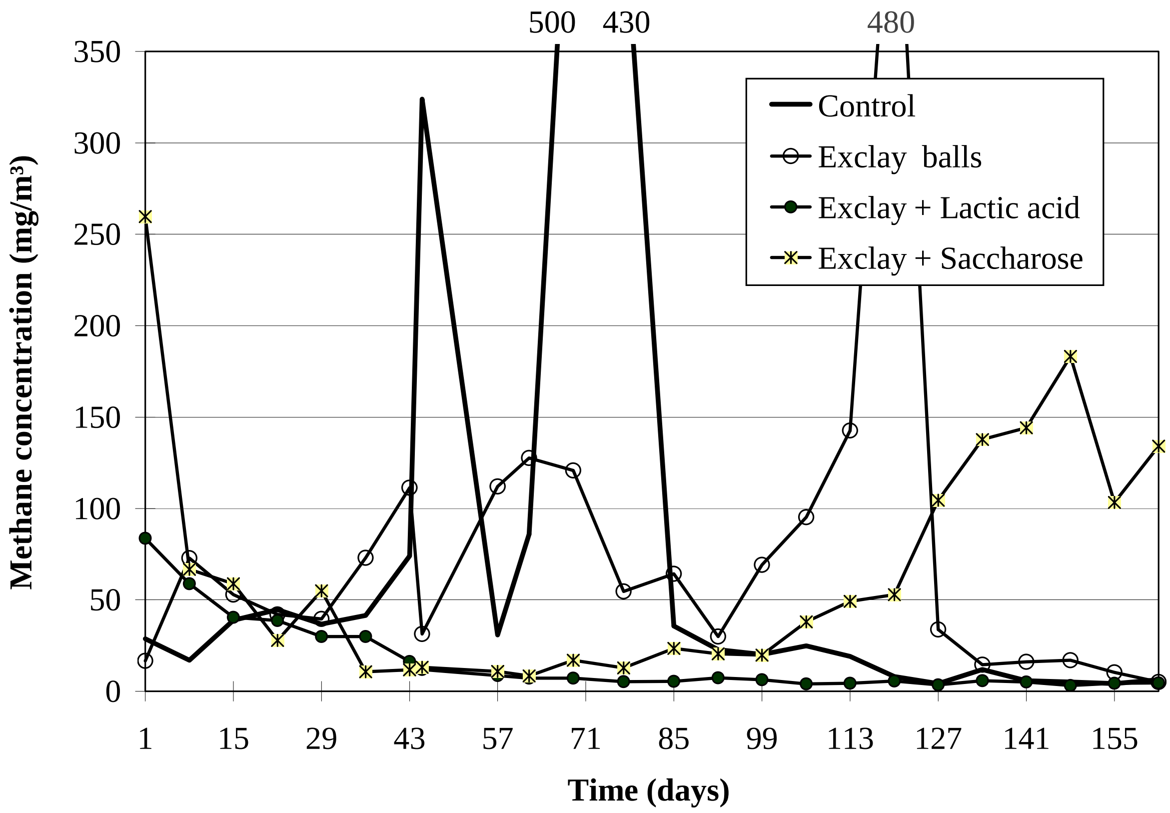

Figure 7. Courses of Methane Concentration of the Exclay Samples.

Nitrous oxide

Nitrous oxide emissions were not detected except for the samples with the granules customarily in trade. Slight emissions were also measured from the control during a period of partly encrustation, and from the combination of perlite with saccharose at the end of the storage when encrustation was at a progressed stage. The emission began after 2 weeks with perlite and 3 weeks for exclay, respectively. The courses were in accordance with the encrustation of the samples, and in opposite to the courses of ammonia emission. The amounts of nitrogen emitting as nitrous oxide and emitting in the form of ammonia were nearly the same. With a thicker layer, a stronger encrustation a higher emission of nitrous oxide is to be expected.

The sample with exclay and saccharose did not emit nitrous oxide although it became encrusted.

Odor

The variation of the ascertained odor thresholds was rather high. The odor threshold of the investigated samples was not lower than that of the control. Only the perlite customarily in trade caused a noticeable reduction of odor emission, if week 4 to 8 would be excluded.

At the samples with lactic acid a different kind of odor was ascertained, but not a lower threshold than that of the other.

Table 1 gives a short overview on the effects of the investigated samples on the several emissions.

Table 1. Effects of the investigated Samples (6 cm layer thickness) on the several Emissions.

Sample investigated	Ammonia	Methane	Nitrous oxide
Perlite	+++	++	--
Perlite + Lactic acid	+++	+	+++
Perlite + Saccharose	+	(+)	(/)
Exclay	+++	+	--
Exclay + Lactic acid	++	+++	+++
Exclay + Saccharose	+	(+)	+++

+++ very positive effect (strong emission reduction) till -- very bad effect (emission increase),
/ no effect, ( ) not sure

CONCLUSION

The combination of perlite with lactic acid can lower the pH value of liquid swine manure below the surface more than that of manure above the ground. Such combinations allow to reduce the pH value with a lower amount of acid than only by acidifying without cover material. The combination of granule with saccharose could also lower the pH value of the liquid manure.

Except for the samples with saccharose, all other could reduce ammonia emission effectively, although in practise the common layer thickness of the granule customarily in trade is 10 cm, and not only 6 cm as investigated.

The granules customarily in trade also reduced methane emission, especially perlite. That is confirmed by results from on-farm studies (Hörnig et al, 1999). The strongest reduction of methane emission was obtained by the combination of exclay and lactic acid.

On the other hand the customarily in trade granules caused higher emissions of nitrous oxide, caused by encrustation of the surface. The nitrous oxide emission was confirmed by other investigations (Berg et al, 2003; Clemens et al, 2003). The combinations with lactic acid avoided emissions of nitrous oxide.

In comparison to the combination of exclay with lactic acid, the combination of perlite with lactic acid showed a better reduction effect on ammonia, but a lower effect on methane emission. Aside from avoiding emissions of nitrous oxide by the combination of exclay and saccharose, the saccharose samples reduced emissions only to a lesser extent.

None of the investigated samples could reduce the emission of odor during the whole storage period. For a reduction of odor emission, a layer thickness of more than 6 cm seems to be necessary, as it is known from the granule customarily in trade (Hörnig et al, 1999).

Further research shall focus on optimising the layer thickness, especially regarding methane and odor emissions, and on optimising the necessary amount of acid. The effects of combinations with saccharose shall be clarified.

REFERENCES

1. Berg, W. and G. Hörnig. 2000. Reducing Ammonia Emissions by Acidifying Slurry with Lactic Acid. 2nd International Conference on Air Pollution from Agricultural Operations, Des Moines, Iowa, USA. 9-11 October 2000.
2. Berg, W., Hörnig, G. und U. Wanka. 2003. Ammoniak-Emissionen bei der Lagerung von Fest- und Flüssigmist sowie Minderungsmaßnahmen. In: *Emissionen der Tierhaltung – Grundlagen, Wirkungen und Minderungsmaßnahmen.* KTBL-Schrift 406, Darmstadt, Germany.
3. Clemens, A., Wolter, M., Wulf, S. und H.-J. Ahlgrimm. 2003. Lachgas- und Methan-Emissionen bei der Lagerung und Ausbringung von Wirtschaftsdüngern. In: *Emissionen der Tierhaltung – Grundlagen, Wirkungen und Minderungsmaßnahmen.* KTBL-Schrift 406, Darmstadt, Germany.
4. Hörnig, G., M. Türk and U. Wanka. 1999. Slurry Covers to reduce Ammonia Emission and Odour Nuisance. *J. Agric. Engng. Res.* (1999) 73, 151-157.