Reducing Emissions by Combining Slurry Covering and Acidifying

***W. Berg*[1] *and I. Pazsiczki*[2]**

ABSTRACT

Different materials for covering of slurry storage facilities to reduce odour and ammonia emissions were investigated. Other research was focused on emission reduction by lowering pH value with acid addition.
The investigations with several slurry cover materials and on acidifying slurry with lactic acid led to the idea to combine both effects – covering and acidifying slurry. The aim is to reduce emissions more effectively with a lower expenditure of cover material and acid, and to reduce ammonia and methane emission without negative impacts on other emissions as nitrous oxide. Results from laboratory investigations are reported done with the cover materials perlite, as customary in trade, and combinations of perlite and straw with lactic acid, and straw combined with saccharose. The pH values below the slurry surface and above the ground of the slurry container were measured as well as the gaseous emissions of ammonia, methane and nitrous oxide. The investigation periods were 71 and 92 days.

KEYWORDS: Animal Husbandry, Slurry Storage, Emission, Ammonia, Methane, Nitrous oxide, Cover Material, Lactic Acid

INTRODUCTION

Different cover materials for slurry are used successfully to reduce odour and ammonia emissions during storage. But emissions of methane or/and nitrous oxide can occur under certain circumstances (Berg et al. 2003, Clemens et al. 2003). 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 both – covering and acidifying – shall reduce all mentioned emissions effectively. The granule is used not only as a cover but also as a carrier of the acid. In this way the pH value of the slurry shall be lowered above all near the surface, the place of emission, and less on the bottom of the storage facility.
After first positive results (Berg, 2002) further investigations were done with different combinations of perlite and lactic acid and also with chopped straw. The investigations were carried out in 2 laboratories, at ATB in Germany and at FVMMI in Hungary, using the same method.

[1] Institute of Agricultural Engineering Bornim (ATB), Division of Technology Assessment and Substance Cycles, Max-Eyth-Allee 100, D-14469 Potsdam, Germany. wberg@atb-potsdam.de
[2] Hungarian Institute of Agricultural Engineering (FVMMI), Tessedik Sámuel utca 4, H-2100 Gödöllö, Hungary. ipazsi@fvmmi.hu

METHOD

Investigations were done in 2 laboratories: at the Institute of Agricultural Engineering Bornim (ATB) and at the Hungarian Institute of Agricultural Engineering in Gödöllö (FVMMI).
Pig slurry was stored in containers with 65 l, respectively. The dry matter content of the slurry used at ATB lab was 6.3 or 6.7 %, that one used at FVMMI lab was nearly 10 %.
The granule – a perlite – was used customary in trade (Pegülit™), and combined with lactic acid. The granule combined with lactic acid was mixed with 80 % concentrated lactic acid before the beginning of the measurements. The amount was 100 ml lactic acid per litre perlite. Afterwards the perlite was hydrophobined. The perlite layer thickness was 4 cm respectively. These two variations were compared with the control sample, the uncovered and untreated slurry in both labs respectively.
Another cover material – chopped straw – was investigated in the ATB lab with pig slurry. Two different variations were investigated: the combination of straw with lactic acid, and with saccharose instead of lactic acid. The amount was 200 ml lactic acid per litre straw, respectively 90 g saccharose per l straw. The function of the saccharose was to be the basis for microorganism activities producing lactic acid. The straw layer thickness was 8 cm respectively. Also these two variations were compared with the control sample.
The storage period was between 71 and 92 days. The slurry 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 slurry surface in the closed container was changed one time per minute (ATB) respectively one time per two minutes (FVMMI). The measured parameters were:

· content of ammonium (NH_4^+) and total nitrogen (N_t) in the slurry by chemical analysis (ATB),
· room temperature,
· pH value below the surface and above the ground of the slurry (ATB),
· concentrations of ammonia (NH_3), nitrous oxide (N_2O) and methane (CH_4) by a photoacoustic multigas monitor,
· air flow rate through tanks by flow meters,
· odour concentration by an olfactometer (ATB),
· sedimentation.

Fig. 1: Experimental Equipment for Investigation of Gas and Odour Emissions as well as Storage Behaviour in both Laboratories

RESULTS

Courses of pH value and Temperature

Initially the pH values of the control and the perlite samples went down to 6.5 because of biological activities (Fig. 2). These processes occurred mainly in the sediment, thus pH values in the sediment were about 0.1 lower than near the slurry surface. After 2 weeks these activities diminished and pH values were increasing gradually.

Some of the acid of the combination of perlite and lactic acid went into solution within the first week, another part after homogenization at day 21. As a result pH went down to 6.0, then it was increasing gradually. Within the first 6/7 weeks of storage the pH value near the slurry surface was lower than in the sediment, in contrast to the non acidified samples.

The combination of straw and lactic acid lost a large part of the acid within the first 2/3 days (Fig. 3). Consequently pH dropped down to 4 and below very rapidly. After 5 weeks of storage pH values were rising steeply up to 6, but then they were constantly. Because of the high solution rate of the acid at the beginning pH values in sediment were lower than near the surface, after the steep rise they were nearly the same.

The straw combined with saccharose showed a more balanced pH course. The biological activities were much more intensively and persistently than in the control. The pH values went down to 5.7 near the slurry surface and 5.9 in the sediment after 3 weeks of storage. Then they were increasing gradually and nearly the same.

The air temperatures in the labs were rather balanced, so it is assumed that they corresponded very closely with the slurry temperatures.

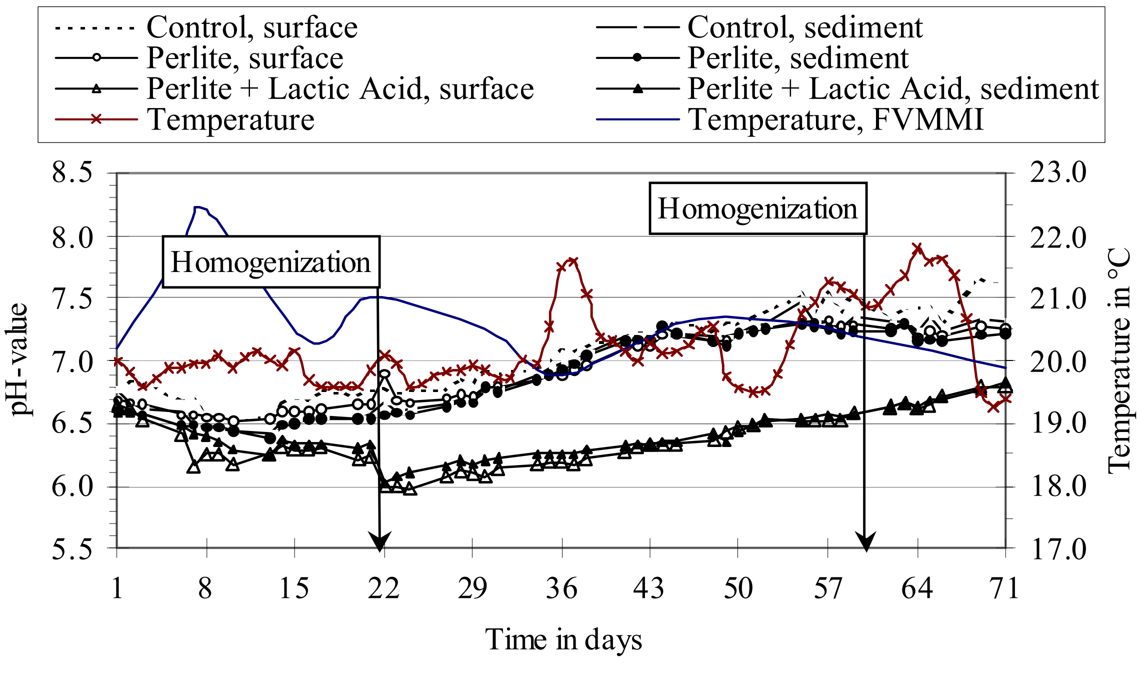

Fig. 2: Courses of pH Values and Temperature of the Perlite Samples

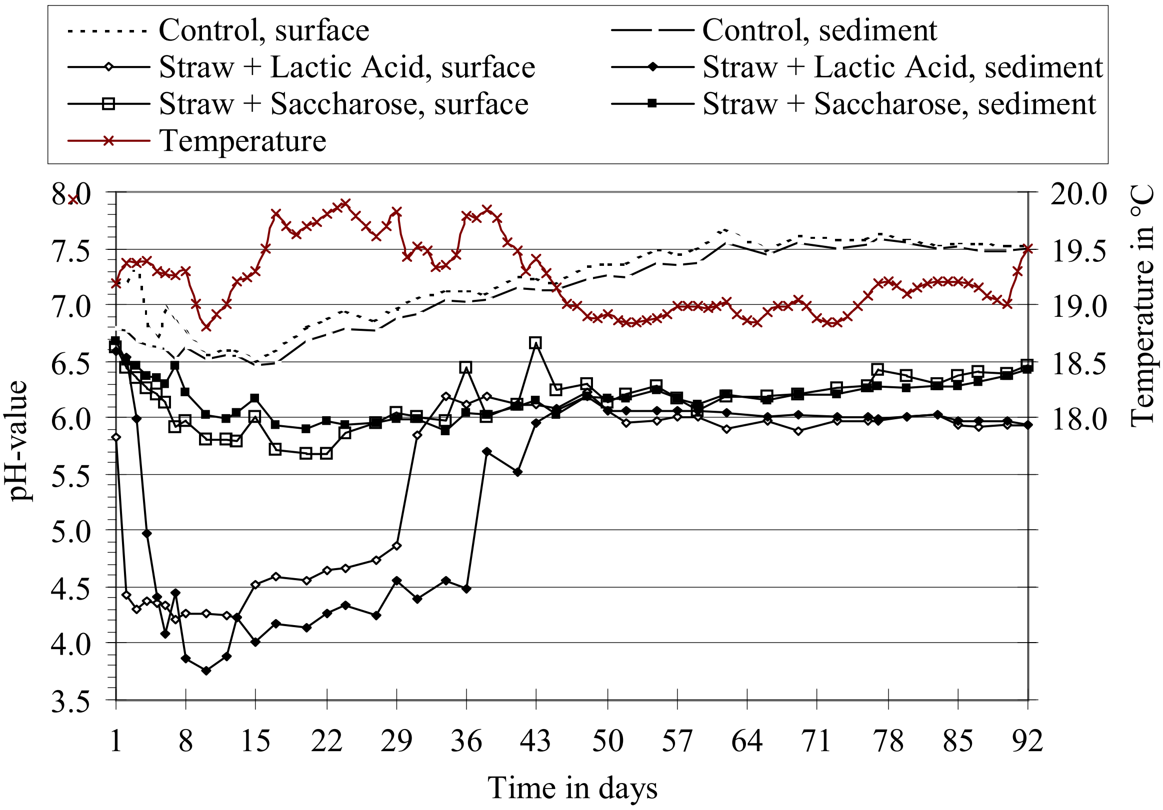

Fig. 3: Courses of pH Values and Temperature of the Straw Samples

Ammonia Emission

First of all it shall be mentioned here that the recommended layer thickness of cover materials is 10 cm, against that the investigated layer thickness was only 4 cm in order to discover the minimal limit necessary.

The perlite customary in trade reduced ammonia emission by one (ATB lab) respectively two third (FVMMI lab) (Fig.4 and Tab. 1). Even bigger was the difference of the relatively reduction values between both labs concerning the combination of perlite and lactic acid. During the measuring period of 77 days at the FVMMI lab the ammonia emission of this combination material was less than 6 % of the control. Whereas the absolute emission values were more similarly, excepting the control samples. The ammonia emission of the FVMMI control was more than the triple of the ATB control, which was rather low. It was caused mainly by the higher dry matter content of the slurry at FVMMI lab. The other reason for the differences between the relatively emission reductions in both laboratories was the lower ventilation rate used at FVMMI lab. Without the peeks at the beginning in the FVMMI lab the perlite customary in trade would have halved ammonia emission and the combination with lactic acid would have reduced it by 90 %. The efficiency of the investigated cover materials was the higher the higher control emission was, especially the efficiency of the combination of perlite with lactic acid. A pH value below 6.5 was necessary to reduce ammonia emission effectively.

The combination of straw and lactic acid reduced ammonia emission very effectively (Fig. 5 and Tab. 1), due to the low pH value. The reduction rate was 94 %. Whereas the reduction rate of the combination of straw and saccharose was only about 55 %. The decreasing ammonia emission after day 62 was caused by surface encrustation and was accompanied with a slightly emission of nitrous oxide after day 85 (cp. para. Nitrous Oxide Emission).

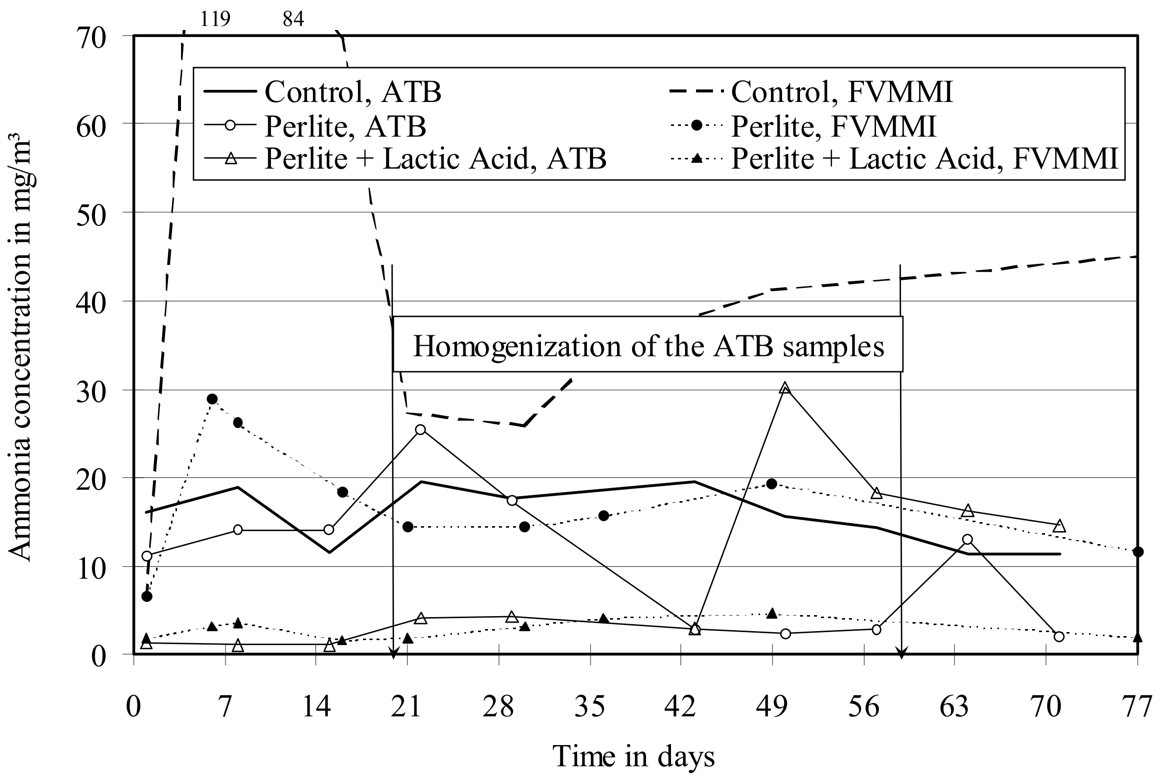

Fig. 4: Courses of Ammonia Concentration above the Perlite Covered Slurry Containers

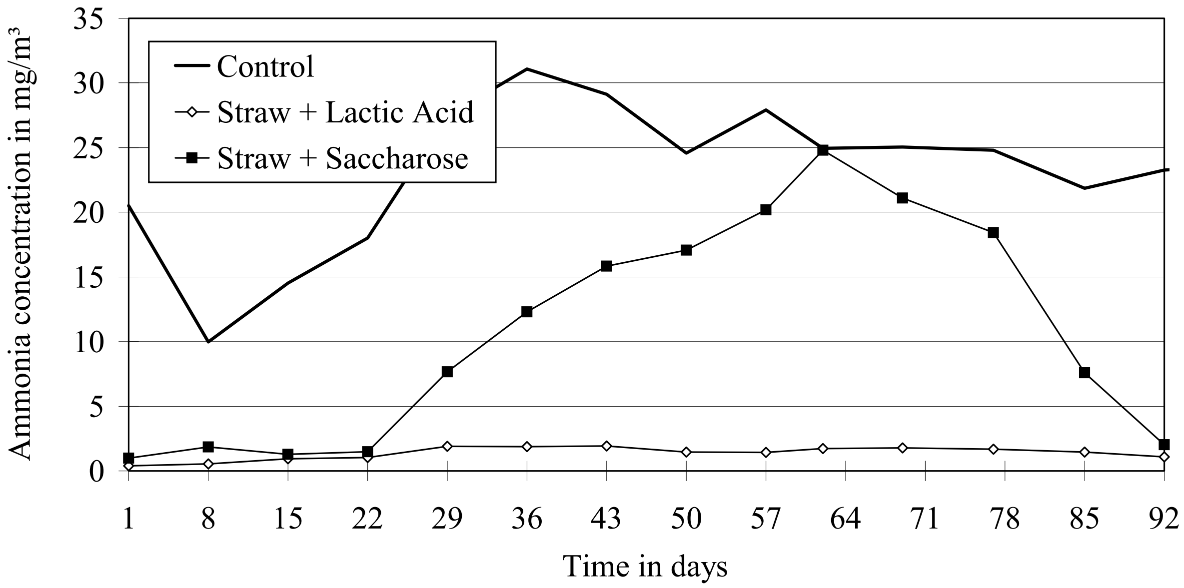

Fig. 5: Courses of Ammonia Concentration above the Straw Covered Slurry Containers

Methane Emission

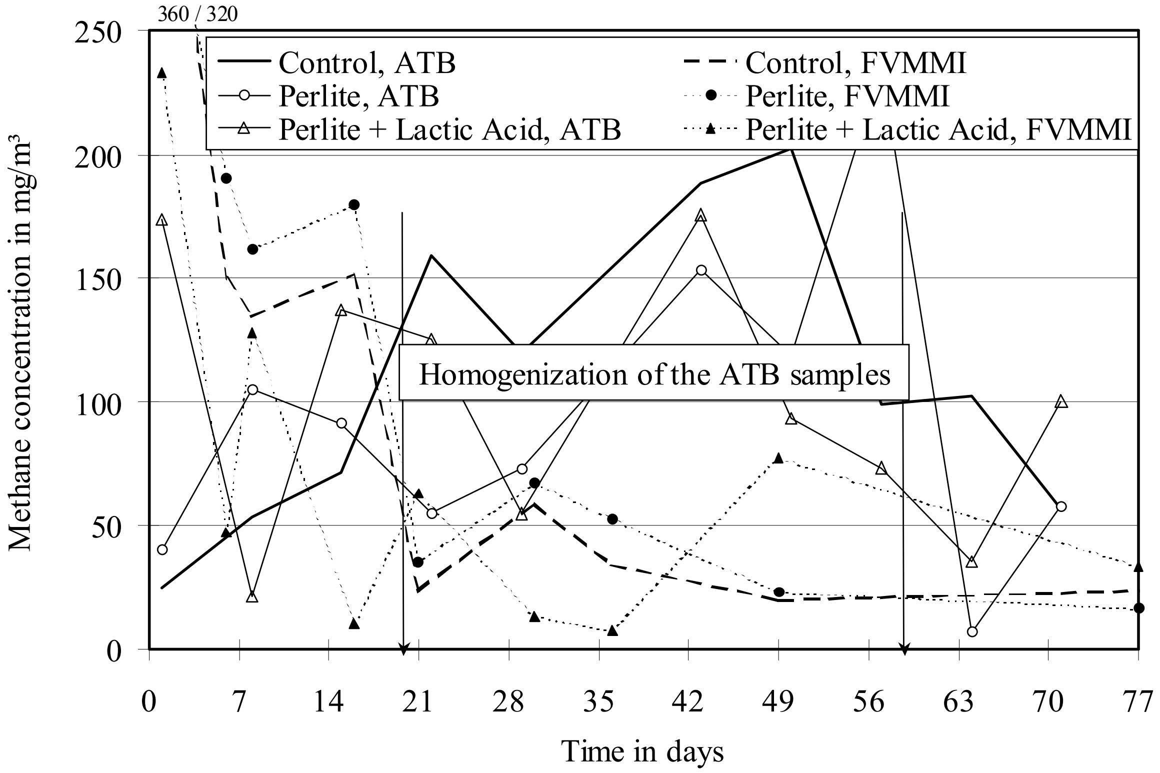

Fig. 6: Courses of Methane Concentration above the Perlite Covered Slurry Containers

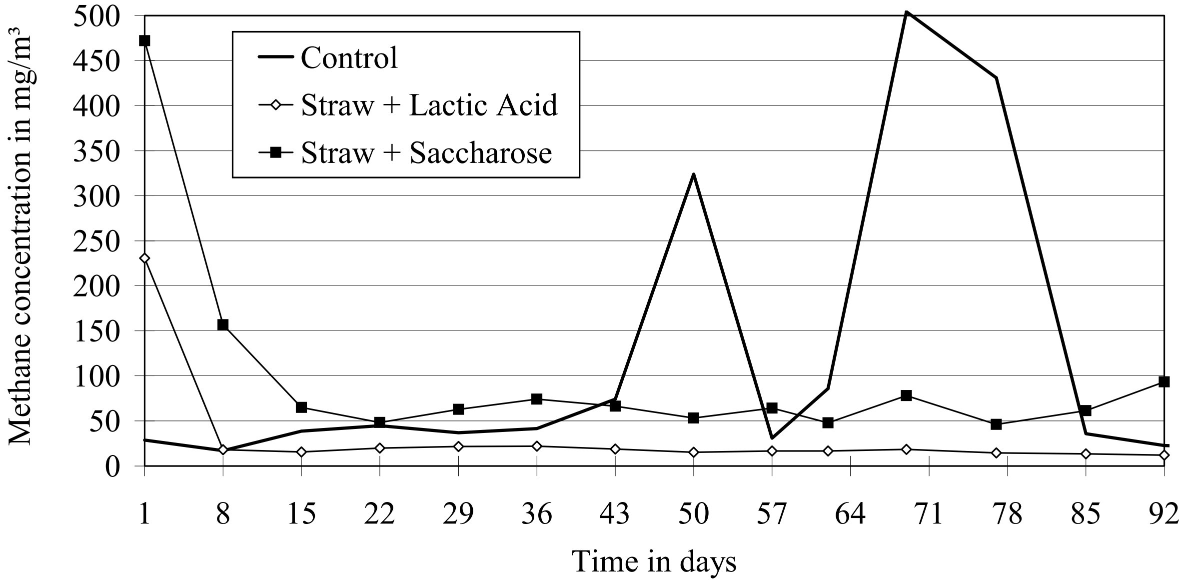

Fig. 7: Courses of Methane Concentration above the Straw Covered Slurry Containers

The perlite samples investigated at ATB reduced methane emission only minor, the reduction rates of both, the perlite customary in trade and combined with lactic acid, were about 10 % (Fig. 6 and Tab. 1). The results from the FVMMI lab showed a higher emission rate (10 %) of the perlite customary in trade and a reduction of one third for the combination of perlite and lactic acid, but with an uneven course. So the 4 cm layer of perlite customary in trade was not sufficient to reduce not only ammonia but also methane emission. Combined with lactic acid the effects were better, but not significantly.
The reduction rate of the combination of straw and saccharose was a little bit more than 10 % altogether (Fig. 7 and Tab. 1). But without the peeks of the control sample there would be a higher methane emission. So it can be assumed that this combination had nearly no reduction effect on methane.
Whereas the combination of straw with lactic acid reduced also methane emission significantly. Its reduction rate was nearly 75 % altogether, and still 60 % without the control peeks. This efficiency was also due to the low pH value.

Table 1 gives a brief overview of the mean values of the gaseous concentrations measured above the slurry containers during the whole investigation periods and which courses are shown in figure 2 till 7.

Tab. 1: Mean Values of Gaseous Concentrations

	Mean Concentration in mg/m³	
	Ammonia	Methane
Control, ATB	15.6	108
Perlite, ATB	10.5	94
Perlite + Lactic Acid, ATB	9.4	99
Control, FVMMI	50.4	106
Perlite, FVMMI	17.3	116
Perlite + Lactic Acid, FVMMI	2.9	68
Control	23.1	123
Straw + Lactic Acid	1.4	32
Straw + Saccharose	10.3	99

Nitrous Oxide Emission

The measured nitrous oxide emissions were in the range of the detectability limit.
Slightly higher emission rates were ascertained only at the sample with perlite customary in trade since day 15, and at the sample with straw combined with saccharose since day 85 as mentioned before. In both cases it was caused by the encrustation of the surface of the cover material.

CONCLUSIONS

By combination of lactic acid with perlite or straw as cover material an efficient reduction of slurry pH value is obtainable. The pH value near the surface – the place of emission – can be reduced more than in the sediment near the storage container ground. A higher amount of lactic acid causes not only a lower pH value but also a more persistently reduction of the pH value. That is the reason for the very good reduction rates of the investigated sample of straw combined with lactic acid (ammonia 94 %, methane 75 %). Further investigations have to show whether a smaller amount of acid can be absorbed better, with a similar good effect.
It is expected that the effect of the combination of perlite and lactic acid can be improved by lower pH values, respectively a higher amount of acid. That is realisable by a higher absolute acid amount per volume of cover material, or a higher amount of acid containing cover material (layer thickness). From the results of the investigations on the perlite samples it can be concluded that a layer thickness of more than 4 cm is necessary. The relation of layer thickness and acid content of the cover material influences not only the pH value of the slurry but also the process of surface encrustation. Both, pH value and surface encrustation, influence nitrous oxide emission. An optimum of necessary layer thickness and acid amount is still to be found, under consideration of all emissions and influencing processes.

REFERENCES

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.
BERG, W. (2002): Reducing Ammonia Emission by a Slurry Cover including Acid. International Conference on Agricultural Engineering AgEng 2002. Budapest, Hungary.
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.
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.