INFLUENCE OF DIFFERENT LEVELS OF COVERING ON GREENHOUSE GAS AND AMMONIA EMISSIONS FROM SLURRY STORES

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ABSTRACT

Different levels of covering slurry stores may influence ammonia and GHG emissions. Emissions were followed from storage of untreated slurry with and without a wooden cover and from anaerobically digested slurry without any cover, with a layer of chopped straw and with a layer of chopped straw and a wooden cover. Experiments were carried out under cold winter and under warm summer conditions. Slurries were stored in 10 m^3-pilot scale slurry tanks and emissions were quantified with a large open dynamic chamber. Anaerobic digestion was found to be an effective mitigation option for greenhouse gas emissions from slurry stores. A wooden lid placed on the slurry tank reduced CH_4 and NH_3 emissions, whereas NH_3 emissions from uncovered anaerobically digested slurry were high. A layer of chopped straw was less effective in reducing NH_3 emissions and has the potential to increase greenhouse gas emissions. It is recommended that slurry tanks, and particularly those used for storage of slurry treated in biogas plants, are equipped with a solid cover.

Keywords: *biogas, nitrous oxide, methane, manure management.*

INTRODUCTION

Slurry stores are a significant source of ammonia, methane and nitrous oxide. Some countries require that the surface of the store is covered as a measure to reduce ammonia volatilisation. Stored slurry may form a natural surface crust if the dry matter content is high enough. Alternatively, an artificial crust may be established using materials such as straw or leca pebbles. Slurry contains considerable amounts of easily degradable carbon that serves as nutrient source to microbes. During slurry storage, organic matter is degraded. As conditions in the slurry are anaerobic, degradation of organic matter must always occur with anaerobic pathways. This means, that CH_4 and CO_2 are formed as end products. It is thus to be assumed that high dry matter slurry bears a greater risk for CH_4 emissions. Some studies have observed that the presence of a surface crust may reduce methane emissions (Husted 1994, Sommer et al. 2000), indicating that methane is consumed within the crust environment. A surface crust is a heterogenous environment at the interface between the anaerobic slurry phase and the atmosphere. Nitrous oxide (N_2O) formation via both nitrification and denitrification is stimulated under conditions of oxygen limitation, and the potential for nitrous oxide formation must therefore also be considered.

The experiments aimed at identifying the effect of different levels of covering slurry stores on ammonia and greenhouse gas emissions from untreated and anaerobically digested slurry.

MATERIALS AND METHODS

Slurry was stored in five 10 m^3-pilot scale slurry tanks. The tanks were made from concrete and buried in the ground, with 5 cm of the wall above the soil surface (Fig. 1). Emissions of

NH_3, N_2O and CH_4 were quantified by moving a large open dynamic chamber on a slurry tank and collecting the emissions. Emissions of each variant were measured at least twice a week for several hours.

For the determination of the air flow over stored manure a large open dynamic chamber was used. The mobile chamber covers an area of 27 m^2 and can be built over emitting surfaces in the animal housing, on manure stores and over spread manure. Fresh air enters the chamber at the front. In the chamber the fresh air accumulates the emissions and leaves the chamber on the far side. Gas concentrations are measured alternately in the incoming and in the outgoing air. The air flow is recorded continuously by a fan-based flow meter (Amon et al. 1996).

NH_3, N_2O, and CH_4 concentrations were quantified by FTIR spectroscopy, which is a reliable possibility for continuous online detection of gaseous emissions in the field. The applied FTIR spectroscope has a spectral resolution of 0.25 cm^{-1}. It is operated with a white cell with 8 m light path. The detection limit is 0.5 ppm for ammonia and ambient air level for carbon dioxide, methane, and nitrous oxide. Slurry temperature was continuously measured at two heights in each slurry tank. Samples for the analysis of slurry composition were taken at weekly intervals in the first few weeks of storage and biweekly during the rest of the storage. Slurry samples were analysed for dry matter, ash, pH, NH_4-N, total nitrogen, and total carbon.

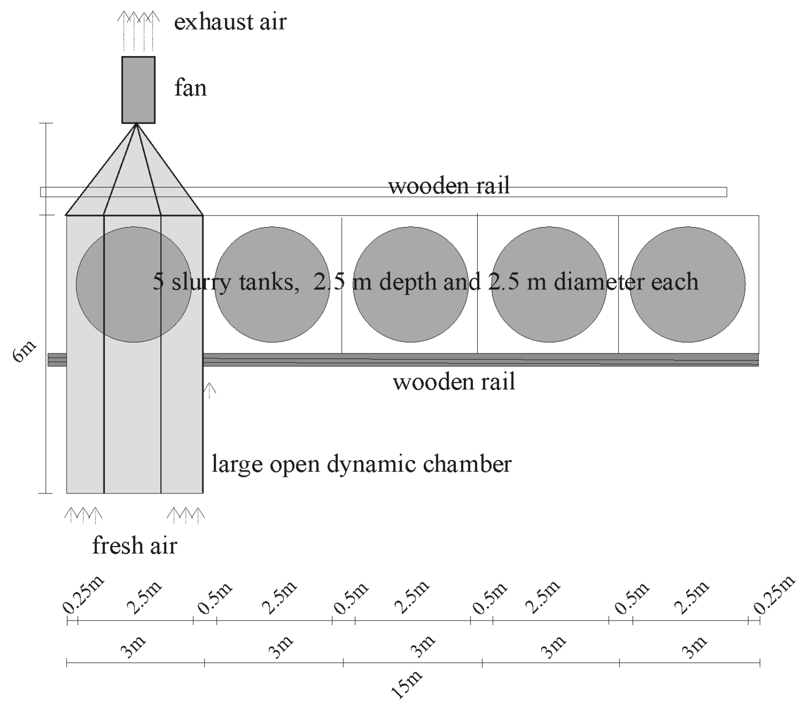

***Figure 1**. Design of the experimental facility for quantifying emissions from slurry stores (Amon et al. 2002).*

Emissions were followed from storage of untreated slurry with and without a wooden cover and from anaerobically digested slurry without any cover, with a layer of chopped straw and with a layer of chopped straw and a wooden cover. Experiments were carried out under cold winter and under warm summer conditions to cover the year-round range in temperatures. The winter and summer storage lasted for 100 and 140 days, respectively.

Dairy cattle slurry was received from two typical Austrian dairy farms. Farm 1 is situated in Lower Austria, in an pre-alpine region. 33 dairy cows are held in a slurry based loose house. Milk yield is 8,600 kg per cow and year with 4.0 % fat and 3.56 % protein. The dairy cows` diet consists of mainly of maize silage, grass silage and hay. In addition, concentrate is fed via a transponder system. Farm 2 supplied anaerobically digested dairy cattle slurry to the experiments. It is a typical Austrian farm similar to farm 1. Dairy cattle slurry is anaerobically digested in a fully mixed, continuously stirred concrete digester without addition of other organic substrates. The digester is operated at a mesophile fermentation temperature.

Statistical data analysis was carried out with the software package SPSS, version 10.0. Regression curves were fitted to cumulative emissions. Differences in regression equations were tested with a pairwise comparison of regression parameters by the t-test. Level of significance was set to at least 0.05.

RESULTS AND DISCUSSION

Table 1 summarises cumulated NH_3, CH_4, N_2O, and greenhouse gas emissions from untreated and anaerobically digested slurry with different levels of covering. Greenhouse gas emissions are given as CO_2 equivalents. Net total CO_2 eq. result from the addition of methane emissions * 21 and nitrous oxide emissions * 310 (Houghton et al. 1996).

***Table 1**. Cumulated CH_4, NH_3, N_2O, and greenhouse gas emissions measured in the winter and in the summer experiment.*

Treatment	*winter experiment*				*summer experiment*			
	CH_4	NH_3	N_2O	GHG^a	CH_4	NH_3	N_2O	GHG^a
		[g m^{-3}]		[kg CO_2eq. m^{-3}]		[g m^{-3}]		[kg CO_2eq. m^{-3}]
untreated_crust	164.3	72.5	44.0	17.09	3591.2	110.5	48.7	90.51
untreated_cover	142.0	52.2	38.2	14.82	2999.0	60.0	58.6	81.15
Biogas	111.3	62.0	40.1	14.77	1154.2	222.5	72.4	46.68
biogas_straw	114.5	49.6	39.9	14.77	1191.9	125.7	75.7	48.50
biogas_straw_cover	81.1	48.7	40.7	14.32	1021.4	78.1	61.4	40.48

[a]GHG = greenhouse gas emissions.

In the *winter experiments*, a linear increase in cumulated CH_4 emissions was observed in all treatments throughout the storage period (data not shown). CH_4 emissions from digested slurry were significantly lower than from untreated slurry. No significant difference was observed between CH_4 emissions from digested slurry with or without a straw cover on the slurry surface. A wooden cover significantly reduced CH_4 emissions in both untreated and digested slurry. Cumulated NH_3 emissions increased linearly throughout the storage period. Covering the tank with a wooden lid decreased ammonia emissions from untreated slurry. A layer of chopped straw on the surface of digested slurry significantly reduced NH_3 emissions. A wooden cover had no additional mitigation effect. Cumulated nitrous oxide emissions steadily increased during the 100-day-measurement period with only little differences between treatments. Total GHG emissions were highest from untreated, uncovered slurry. A wooden cover considerably reduced GHG emissions. Digested slurry emitted less GHG than uncovered untreated slurry. The combination of chopped straw and wooden lid reduced GHG emissions of digested slurry.

Under warm *summer conditions*, considerably more methane was emitted than under cold winter conditions. Cumulated CH_4 emissions followed a quadratic curve and declined towards the end of the measurement period (data not shown). Untreated slurry emitted significantly more CH_4 than digested slurry. Similar to winter conditions, a wooden lid reduced CH_4 emissions of untreated slurry. After digestion, CH_4 emissions from uncovered or straw covered slurry were similar, whereas they were reduced by an additional wooden lid. In summer, uncovered digested slurry showed the highest ammonia emissions. They were reduced by a layer of chopped straw and, further more, by a layer of chopped straw and a wooden lid. Cumulated nitrous oxide emissions showed a linear increase throughout the measurement period. Covering untreated slurry with a wooden lid increased N_2O emissions whereas the combination of chopped straw and a wooden lid decreased N_2O emissions from digested slurry. Total GHG emissions from untreated slurry were nearly twice as high as from digested slurry. A wooden cover reduced GHG emissions for both substrates. As in winter, a layer of chopped straw alone did not mitigate GHG emissions from digested slurry.

CONCLUSIONS

Anaerobic digestion was found to be an effective mitigation option for greenhouse gas emissions from slurry stores. A wooden lid placed on the slurry tank reduced CH_4 and NH_3 emissions, whereas NH_3 emissions from uncovered anaerobically digested slurry were high due to the high NH_4-N content and pH value. A layer of chopped straw was less effective in reducing NH_3 emissions and has the potential to increase greenhouse gas emissions.

It is recommended that slurry tanks, and particularly those used for storage of slurry treated in biogas plants, are equipped with a solid cover. This will reduce CH_4 release into the atmosphere, as well as NH_3 emissions. Full environmental benefits of anaerobic digestion can only be exploited, if all tanks are covered and included in the gas bearing system of the biogas plant.

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