EVALUATION OF THREE APPROACHES TO DECREASE AMMONIA EMISSION FROM SOLID MANURE STORAGE FACILITIES

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ABSTRACT

Ammonia emissions from manure storage facilities are one of the most important sources of nitrogen losses from Swedish agriculture. Three possible methods to minimise ammonia emission from solid manure storage facilities were investigated in this study. The studied methods included the coverage of the manure using a rubber sheet, amending the manure with peat as well as the introduction of improved drainage conditions. A micrometeorological mass balance method was used to measure the ammonia emissions. Both the rubber sheet cover and the peat amendment reduced the ammonia emissions by one third, while the improved drainage conditions had no effect. It was concluded that covering the manure with a rubber sheet and the addition of peat when mocking out are the most feasible methods to reduce ammonia emissions from a full-scale solid manure storage facility.

INTRODUCTION

A large portion of the nitrogen lost from agriculture is directly linked to the emission of ammonia (NH_3) from manure. Ammonia emissions lead to eutrofication, acidification and to the indirect emission of nitrous oxide (N_2O), a strong greenhouse gas. In addition, there is a direct toxic effect of ammonia on plants (Kirchmann et al., 1998). In Sweden, solid manure is often automatically transported out to a concrete storage pad. The function of the urine separation, if present, is often compromised by clogging. This clogging causes a large proportion of the urine to follow the manure out onto the pad. Exposed urine has a high potential for ammonia emissions since it has a high concentration of ammonium nitrogen (NH_4^+) as well as a high pH level. Furthermore, the storage pad will be affected by precipitation and as a result more nutrients will be leached from the stored manure. According to Bussink et al. (1998) the emissions of ammonia from manure is proportional to the exposed surface area of the ammonia emitting substrate. It is therefore reasonable to assume that urine and leachate accumulation in puddles with large surface areas results in a higher total ammonia emission from the solid manure storage facility. The objective of this pilot study was to evaluate three methods to limit the exposed ammonia-emitting surface and thereby lower the total ammonia emissions. This pilot trial was then used as guidance when selecting the most promising method/methods for a full-scale trial.

MATERIALS AND METHODS

Four smaller manure storage modules were set up in low, open containers, 6 m long by 2.5 m wide and 1.4 m high. Manure was stacked against the back wall of the container while the front wall was open so that the storage module would resemble a full sized solid manure storage pad with three concrete walls. The bottom of the containers had an incline of 1 to 2%. All of the pilot sized storage modules were orientated on a straight line in the north-south direction, perpendicular to the prevailing wind direction in order to avoid interference with ammonia measurements caused by drifting ammonia from the neighbouring storage modules. The manure used in this experiment was classified as manure class 3 according to the European Committee for Standardization (2002). The chemical and physical properties of the manure can be seen in Table 1. Table 2 provides a summary of the trial specifics.

Table 1. *Physical and chemical properties of the manure used in this pilot trial.*

Manure	Bulk density (kg/m^3)	DM (%)	Tot-N (kg/ton)	NH4-N (kg/ton)	Tot-C (kg/ton)	P (kg/ton)	K (kg/ton)	C/N ratio	pH
Manure class 3	817	18.4	5.7	2.6	79.7	0.8	5.1	14.1	8.6

Table 2. *Trial descriptions.*

Trial code	Manure load (kg)	Incline of container	Treatment
Covered	3921	1%	The container was covered by a EPDM-rubber sheet
Peat	3764	1%	374 kg of peat was mixed in with the manure
Drained	3956	2%	Drainage was improved by a steeper incline and a clean-kept container floor in front of the manure
Control	3707	1%	No measures taken

The ammonia measurements were carried out according to the micrometeorological mass balance method described by Schjoerring et al. (1992) and Karlsson (1994). Each sampling device consists of a pair of glass tubes where the inner surfaces are treated with oxalic acid in order to trap ammonia. The sampling tubes are known as passive flux samplers or Ferm-Tubes. Four masts with four pairs of passive flux samplers each were placed around all of the manure storage modules. The heights of the samplers were 0.18, 0.73, 1.82 and 4 m above the container rim. Three measurement periods were carried out from November 3rd to December 17th at a mean temperature of 3.5°C. Table 3 shows the specifics of each measurement.

Table 3. *Measurement specifics.*

Measurement nr.	Date	Duration of measurement (h)	Prevailing wind direction during measurement	Notes
1	Nov 3 - Nov 11	192	West-South-West	Occasional drizzles during measurement
2	Nov 14 - Nov 25	264	South-South-West	One wet snowfall during measurement
3	Dec 9 - Dec 17	192	South-East	Occasional temperatures below zero during measurement

RESULTS AND DISCUSSION

The peat trial resulted in the highest initial emission and was also significantly higher in temperature compared to the other trials, 12.5°C for the peat trial as compared to approximately 5°C for all other trials. By the time of the last measurement, however, the emission from the peat trial had decreased to an undetectable amount (Fig 1.). The covered trial consistently emitted less ammonia than the control, while the third approach, increased drainage had very little effect (Fig

1.). The effect of the treatments becomes more apparent when the nitrogen, lost as ammonia, is calculated as a fraction of the initial total nitrogen content (Fig 2.). The control trial and the drainage trial lost 3.5% and 3.6% of the initial total nitrogen content while the peat- and the coverage trials lost 2.3% and 2.4% respectively. The results indicate that it is possible to decrease nitrogen loss in the form of ammonia by 30% by covering the manure with a rubber sheet or by using peat as an amendment for the manure.

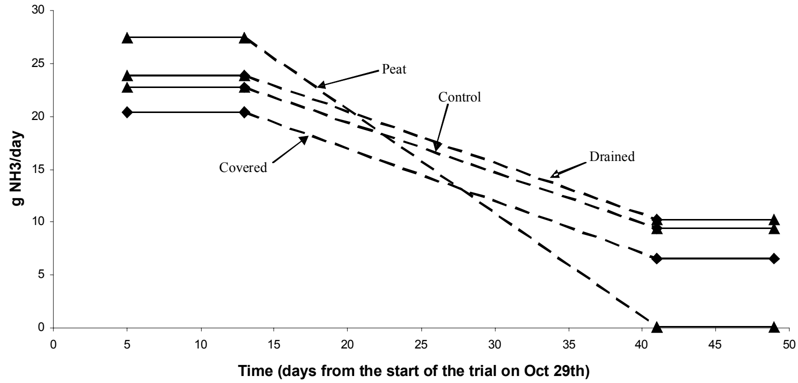

Figure 1. *Dynamics of ammonia emission from solid manure.*

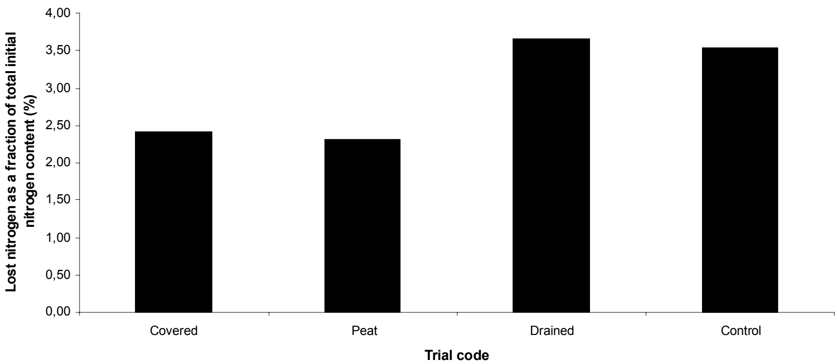

Figure 2. *Nitrogen lost in the form of ammonia as a percentage of the initial total nitrogen content (N-tot).*

It is likely that the difference between the treatments would have been more apparent had the trials been conducted during a warmer period. In addition, the unfortunate event of a wet snowfall during the second ammonia measurement led to results that were deemed unreliable and therefore disregarded. The findings of this pilot study, however, compares well with other similar trials such as Sannö et al. (2003), Karlsson (1996) and Amon et al. (2001). In spite of the above mentioned concerns, the comparable findings of this study to similar trials shows that the results of this research can be used as valuable guidance when selecting ammonia decreasing methods for full scale trials.

The reduction in ammonia emission from the covered trial was likely due to a combination of two effects. A decreased exchange rate of the air just above the manure and a decreased surface area as discussed in the introduction. In the case of the peat trial the decreased surface area of standing fluids was probably again a factor. In addition, peat has the ability to both irreversibly bind ammonia and, through its abundance of exchangeable hydrogen ions form ammonium ions together with ammonia. The trial with improved drainage did not have a measurable impact on the ammonia emission. It is possible that the measures taken in order to improve the drainage were not enough to differentiate this trial from the control, i.e. the increased incline by 1% and a clean-kept surface in front of the manure was not sufficiently different from the conditions in the control trial.

CONCLUSIONS

- The coverage of solid manure using a rubber sheet reduced the nitrogen loss in the form of ammonia with 30 %.
- Peat mixed in with the solid manure as an amendment also gave a reduction in the ammonia-nitrogen loss by 30 %.
- No reduction in ammonia emissions was achieved by improvement of drainage in this particular trial.
- It was decided that a combination of peat amendment and coverage of the manure would be tried in full-scale.

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