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COVERING SLURRY STORES TO REDUCE AMMONIA EMISSIONS: SETTLING EFFECTS AND CHEMICAL COMPOSITION CHANGES

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ABSTRACT

The aim of this study was to evaluate the effects of different covering of slurry stores on slurry settling characteristics and ammonia emission during storage at the laboratory and following surface application in the field. Laboratory trials were carried out for 15 days using a pilot scale device designed to measure ammonia emission. Samples of 5 kg slurry, corresponding to a 15 cm depth column, were used. The space between the rim of the chambers and the slurry surface was used to place the cover. At the end of the storage period, distributions of dry matter (DM), pH, total ammoniacal nitrogen (TAN) and total nitrogen (TN) in slurry for each 5 cm depth layer were characterized. In the field, ammonia volatilisation was measured for 3 days following slurry application with a conventional spreader using a wind tunnel system . Three types of cover were tested : (1) physical barrier, (2) barrier which reduced the emitting surface and (3) adsorbent cover. The first retained all ammonia in the slurry, whereas, the others reduced ammonia volatilisation by reducing the emitting surface or by adsorbing ammonia. Over the whole process studied [storage followed by application] ammonia emissions were reduced by 40% by covering with oil, 59% with plastic film, and 57 to 63% with different type of peat.

INTRODUCTION

Ammonia emissions from agricultural systems is of increasing public concern due to its health and environmental consequences (Seedorf et Hartung, 1999). Covering slurry stores is one of the techniques in farming practices, which may reduce ammonia emission. Intensive research work on covering slurry stores has been conducted since the beginning of the 1990s and the results of various experiments have been reported in literature (Sommer et al., 1993; Barrington et Moreno, 1995; Sommer, 1997; Hörnig et al., 1999). However, the processes and mechanisms involved are still not fully understood and there are not many quantitative data available on the effectiveness of covers on reducing ammonia emission following surface application. The use of covers may also have consequences on slurry settling characteristics; and particularly on chemical composition changes (TAN concentration gradient) within the different virtual slurry layers. This finally would affect the ammonia volatilisation process (Zhang et Day, 1996; Ni et al., 2000). This study was undertaken to: (i) assess the potential of different covers on NH_3 volatilisation during slurry storage at laboratory scale, (ii) evaluate the effects of such covers on the evolution of different slurry characteristics, and (iii) examine further their potential efficiency subsequent to the spreading on land.

MATERIALS AND METHODS

Figure 1: Methodology

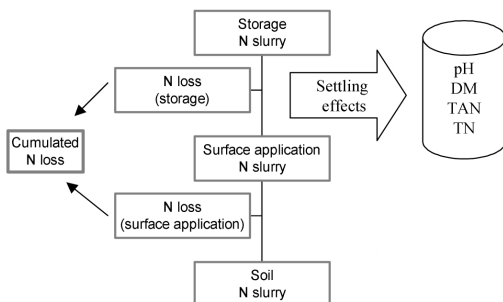


Figure 1 showed the procedure used for each experiments.

Ammonia emission: simulation of slurry storage

A special pilot scale device was developed to standardize the experimental conditions and to be able to evaluate the effect of different treatments on ammonia emission from slurry surface (figure 2). An almost

unlimited number of experiments can be performed simultaneously under identical experimental conditions. Nevertheless, caution must be taken when transposing the results to practical conditions. Therefore only relative effects are given here. The pilot consists of an inox frame enabling to position 10 systems of measure. Each system is composed of two impingers, one glass volatilisation chamber of 23 cm depth and 20 cm diameter, a gas counter and a flow controller. All systems are connected on the same pump. One chamber is used to measure the ammonia concentration in the air and the other nine the ammonia volatilisation in presence of slurry with different type of covers (uncovered slurry and two or three types of cover).

Figure 2: The pilot



The ammonia emission was determined for a period of 15 days. Samples of 5 kg slurry were placed corresponding to a 15 cm depth column of slurry. The space between the rim of the chambers and the slurry surface was maintained towards the cover. Ammonia emission was determined following the procedures described by Moal (1995). Air was humidified in the first impinger before entering the volatilisation chamber. Ammonia in the outgoing air was trapped by passing through the second impinger containing 50 ml H_2SO_4 (2N). The air left the system after passing a gas counter, a flow controller adjusted to 5 l/min and the pump. The second impinger containing the acid trap was replaced daily. The ammonia concentration and the mass of liquid were determined in the second impinger. The cumulative ammonia emission for each treatment was calculated by multiplying the mass by the ammonia concentration. The slurry used was collected from a commercial pig farm before the beginning of each experiments. Table 1 shows the tested covers and their characteristics.

At the end of each experiment, the column of slurry was vertically divided into three layers of 5 cm depths, which were sampled by using a peristaltic pump and analysed for DM, pH, TAN and TN. After the sampling, the three layers were pooled for surface application.

Table 1: Additional cover and their characteristics.

Cover	Description
Oil	Cover of used oil (kitchen) : thickness 1 cm
Plastic film	Floating plastic film : thickness 1 mm
Opening float	Opening polystyrene cover : thickness 4 cm, diameter 19,5 cm with 48 holes (diameter 1,6 cm). These holes represented 33% of the cover surface and were the so called "emitting surface".
Peat	Peat cover
A	directly placed on top of slurry : 188g dw
B	directly placed on slurry : 377g dw
C	on the opening polystyrene float (placed on the slurry) : 174g dw
Hydrophobic peat	Cover of peat dried for 3 d at 105°C
D	directly placed on top of slurry : 583g dw
E	on the opening polystyrene float (placed on the slurry) : 157g dw

Ammonia emission following surface-application of slurry

Each experiment included one control and two treatments. Slurry was applied at different rates varying from 40 to 60 m³/ha. Experiments were conducted on grassland. Ammonia volatilisation was measured for 3 days following slurry application using the wind tunnel method (Moal et al., 1995), each tunnel covering an area of 1 m², with wind speed through the tunnels set to 1 m/s. The concentration of ammonia in the air entering and leaving each wind tunnel was measured using absorption flask containing 50 ml H₂SO₄ (0,25N). The air was drawn by a diaphragm pump at a rate of 5 l/min. The flask was replaced daily and the cumulative ammonia emission was determined for each treatment. The wind tunnel permitted a comparative study of the ammonia volatilisation of slurry from different way of covering stores.

RESULTS AND DISCUSSION

Ammonia volatilisation during slurry storage

All the covers were effective in reducing ammonia emissions. In order to compare the loss rates for the different surface coverings, the percentage of reduction of ammonia volatilisation with regard to the control were calculated for each experiment. As shown in table 2, ammonia emission in the laboratory studies were initially reduced by up to 76% with opening float cover to 100% with plastic film and the different peat covers.

Table 2: Ammonia reduction during storage and the whole storage-application period

Cover	Percent ammonia reduction (%)	
	Storage	Whole [storage plus application] period
Oil	93	40
Plastic film	99	59
Opening float	76	-
Peat A	77	42
Peat B	88	46
Peat C	100	57
Hydrophobic peat D	100	56
Hydrophobic peat E	100	63

When cracks developed in the oil, NH₃ loss rates increase due to an increased convective transport of gaseous ammonia from the liquid slurry surface. The peat cover directly placed (A, B) on slurry absorbed liquid, sank and this affected TN and DM contents, and pH of the slurry after the storage. The same phenomenon was observed by Barrington and Moreno (1995). With the hydrophobic peat directly placed on the slurry (D), this phenomenon was less obvious and the reduction of ammonia volatilisation was close to 100%. The use of peat in conjunction with the opening float (C, E) showed that most of the ammonia lost from the slurry was retained in the peat, suggesting that the peat reduced the volatilisation by adsorbing ammonia

Settled slurry

In all the treatments (including uncovered), most solids and organic nitrogen accumulated similarly in the bottom layer, indicating that covering did not affect the resulted distribution of solids and organic nitrogen after settling. Higher solids contents resulted in a more compacted solid layer with a high organic content at the bottom of the column (Zhang et al., 1996).

The pH varied within the three layers in all the treatments. It decreased with the depth due to the production of CO₂ and CH₄. Our results showed that only oil cover affected the resulted evolution of the pH. The covers did not affect the distribution of the pH after settling.

Three basic processes are involved in ammonia emission from the slurry pit : generation, diffusion and emission. In this study, no ammonia generation was observed. Meanwhile the distribution of TAN within slurry layers was largely affected by the cover (figure 3). The distribution of TAN within layers was relatively uniform with the physical barriers (oil, plastic film), whereas TAN decreased with depth with the adsorbent covers (peat), the opening float and the uncovered slurry. The physical barriers retained ammonia in the slurry and so reduced the molecular diffusion of TAN. At the opposite, opening float and adsorbent cover reduced ammonia volatilisation by reducing the emitting surface or by adsorbing ammonia resulting in TAN diffusion in the slurry column.

Figure 3: Distribution of TAN (mg/L) in the settled slurries : a) initial, uncovered, hydrophobic peat (D) and oil; b) initial, uncovered and plastic film; c) initial, uncovered, peat (C), hydrophobic peat (E) and opening float.

a) Initial, uncovered, hydrophobic peat (D) and oil.

	Initial (d 0)	Uncovered (d 0+15)	D (d 0+15)	Oil (d 0+15)
Top	2115	1450	1607	1944
Middle	2115	1480	1665	1997
Bottom	2115	1885	2370	2282

b) Initial, uncovered and plastic film.

	Initial (d 0)	Uncovered (d 0+15)	Plastic film (d 0+15)
Top	2108	1530	2100
Middle	2108	1499	2026
Bottom	2108	1924	2382

c) Initial, uncovered, peat (C), hydrophobic peat (E) and opening float.

	Initial (d 0)	Uncovered (d 0+15)	C (d 0+15)	E (d 0+15)	Opening float (d 0+15)
Top	2208	1461	1756	1835	1939
Middle	2208	1462	1775	1846	1939
Bottom	2208	2048	2331	2401	2465

Ammonia volatilisation during the whole storage-application period

All the covers were effective in reducing ammonia emissions during the period storage-application. The percentage of reduction of ammonia volatilisation with regard to the control were calculated for each experiment except for the opening float, which slurry was not surface applied. As shown in table 2, ammonia emission were reduced by 40% with oil up to 63% with hydrophobic peat (E). The adsorbent covers were more effective than the physical barriers. The percentage of reducing ammonia volatilization was higher during storage than after surface application. Ammonia losses were higher from store covered slurry than store uncovered slurry following surface application because covering retained more ammonia in slurry.

CONCLUSION

Covering slurry store with a physical barrier or an adsorbent cover did not affect the pH and the distribution of solids in slurry after settling. The cover retained or adsorbed the ammonia resulting in a reduced volatilisation during storage. The potential efficiency was maintained subsequently to spreading even if ammonia losses following surface application were higher from covered than uncovered slurry. Over the whole, ammonia emissions were reduced by 40% with oil up to 63% with hydrophobic peat (E).

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