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MANAGEMENT PRACTICES TO REDUCE AMMONIA EMISSIONS FROM PIG AND CATTLE MANURE STORES

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ABSTRACT

This study compared several practical management techniques that could be used to reduce ammonia (NH_3) emissions from pig and cattle farmyard manure (FYM) heaps, including covering heaps with plastic and the effect of additional straw use in the animal house to immobilise ammonium-N. In addition, the impact of turning heaps (i.e. active composting) on emissions was also studied for pig manure. In the study we also collected leachates and assessed changes in manure composition. Ammonia emissions from the pig FYM heaps showed that the turned treatment had the highest mean cumulative emission (407g NH_3-N/$m^2$of initial heap surface area) and the sheeted heap the lowest (31g NH_3-N/m^2). For cattle FYM, the highest cumulative emission was from the conventionally stored treatment (100g NH3-N/m2) and lowest from the sheeted treatment (34g NH_3-N/m^2). Covering the heaps reduced emissions ($P<0.05$) compared with conventional uncovered storage by 86% (pigs) and 60% (cattle). Increasing the straw addition rate reduced emissions by c.12% (range 8-15%) compared with the 'normal' rate of straw use. Ammonia emissions from the conventional pig and cattle FYM heaps represented *c.*40% (range 21-67%) of total N losses, and from the turned pig FYM heap *c*.80% of total N losses.

INTRODUCTION

Ammonia (NH_3) emission followed by long-range transport and deposition to natural and semi-natural ecosystems on weakly buffered, nutrient poor soils, can lead to soil acidification and N enrichment (Schulze *et al.*, 1989), resulting in damage to ecosystems, e.g. shifts from native diverse oligotrophic plant communities to communities dominated by competitive grass species (van Breemen and van Dijk, 1988). It also represents inefficient use of a valuable resource. The NH_3 emissions inventory for UK agriculture estimates that 36% of NH_3 emissions (82 k tonnes) are from the management of solid manures, with *c*.46 million tonnes of solid manure handled annually in the UK (data derived from Pain *et al.*, 1998). Manure storage and land application are estimated to be responsible for c.52% (41 k tonnes) of the solid manure emission total (16% and 36%, respectively).

EC Directive 96/61 on Integrated Pollution Prevention and Control (IPPC) (MAFF, 1997) and other impending Directives, e.g. The EU National Ceilings Directive arising from the EU Acidification Strategy and N protocol of the UNECE Convention on Long-Range Transboundary Air Pollutants, will require the UK to reduce NH_3 emissions from pig, poultry and cattle farms. The requirement for the UK may be to decrease NH_3 emissions by 15-30% by 2010. Such a target may not be met through the use of current abatement techniques which are applicable to slurry rather than solid manures. Therefore, in this study we investigated the effect of different pig and cattle farmyard manure (FYM)

management practices during storage on NH_3 emissions, in order to produce practical guidelines to minimise losses. Manure storage conditions also influence the quantity and nutrient forms leached from solid manure heaps, as well as the chemical composition of the manure at the time of land spreading. The experimental design allowed us to collect leachates and assess the composition of the manure throughout the storage period.

MATERIALS AND METHODS

Specially designed concrete bunkers were constructed to contain the manures heaps and facilitate the collection of gaseous emissions and leachates. There were 4 storage treatments for each of the FYM types, with 3 replicates per treatment. **Pig FYM** - 1) conventional straw use, 2) conventional straw use + 50%, 3) conventional straw use + covered with plastic, and 4) conventional straw use + turned. **Cattle FYM** - 1) conventional straw use, 2) conventional straw use + 50%, 3) conventional straw use + 100%, and 4) conventional straw use + covered with plastic.
The pig FYM was stacked in concrete bunkers with a base area of 3.9 m x 3.9 m at ADAS Gleadthorpe (Nottinghamshire) and the cattle FYM on an area of 3 m x 5 m at IGER North Wyke (Devon) The pig and cattle FYM were obtained from farms where groups of the same numbers of animals had been housed on different straw use regimes. Between 3.4 and 5.2 t of fresh manure were loaded into each heap and stored under different conditions from 6 months. Plastic sheeting was used to cover 3 replicate heaps immediately after heap establishment.

Ammonia emissions
Purpose-built tunnels were used to capture NH_3 emitted from the heaps, during two-hour measurement periods on six occasions in the first month after bunker filling, and thereafter at monthly intervals, for a total of 6 months. The emission hoods were based on the wind-tunnel design developed by Lockyer *et al*. (1984).

FYM chemical composition and leachates from heaps
Changes in manure mass and nutrient concentrations were determined after 3 and 6 months using a litter bag technique. Total N, P, K, C, Ca, Mg and S concentrations were measured as well as NH_4^+-N and NO_3^--N, pH, dry matter content and straw length. Heap temperatures were also measured continuously. Leachates were collected over the storage period and analysed for volume, pH, total solids, total N, P, K, Mg, Ca and S, as well as NH_4^+-N and NO_3^--N concentrations.

RESULTS

Table 1 shows the cumulative losses of N from the pig and cattle FYM stores. Ammonia emission measurements from the pig FYM heaps showed that the turned treatment had the highest mean emission (407g NH_3-N/m^2 of initial heap surface area) and the sheeted heap the lowest 31g NH_3-N/m^2 of initial heap surface area. For cattle FYM, the highest emission was from the conventionally stored treatment (100g NH_3-N/m^2) and lowest from the sheeted treatment (34g NH_3 - N/m^2). The emission rates peaked during the first week, decreasing to low levels after a month's storage.

Table 1. Losses of N from pig and cattle FYM heaps.

TREATMENT	Losses of N as % of total N into store						Dry weight losses %	
	Total N losses (in/out of store)		Ammonia –N emissions		N in leachate		Difference in/out of store	
	Pig	*Cattle*	Pig	*Cattle*	Pig	*Cattle*	Pig	*Cattle*
Conventional straw use- *rate 1*	47.2	*17.7*	16.4	*7.9*	2.7	*1.9*	60.0	*37.1*
Conventional straw use + 50%- *rate 2*	36.0	*31.5*	15.1	*6.7*	2.4	*2.0*	54.4	*37.6*
Conventional straw use + 100%- *rate 3*	-	*10.1*	-	*6.7*	-	*1.8*	-	*42.3*
Sheeted heap - *Straw rate 1*	30.1	*2.9*	2.3	*3.2*	3.6	*3.6*	15.8	*36.8*
Turned heap - *Straw rate 1*	34.0	-	27.7	-	3.8	-	64.1	-

Total nitrogen losses during storage were between 30% and 47% (pigs), and between 3% and 31% (cattle) of total N inputs to the heaps. Sheeting the heaps reduced NH_3 emissions compared with conventional uncovered storage by 86% (pigs) and 60% (cattle). Ammonia emissions from the conventional pig and cattle manure heaps represented *c*.40% (range 21-67%) of total N losses, and from the turned pig FYM heap *c*.80% of total N losses.

Increasing the straw addition rate reduced NH_3 emissions by *c.*12% (range 8-15%) compared with the 'normal' rate of straw use. Pig FYM heap temperatures peaked at 55-65°C after one week followed by a gradual downward trend over the 6 month storage period. The cattle FYM heaps peaked at 40-55°C after one week and declined thereafter. Heap ammonium N contents decreased and nitrate N contents increased, over the storage period.

DISCUSSION AND CONCLUSIONS

Increasing straw rate reduced NH_3 emissions from the FYM heaps but would probably have a greater effect in reducing overall NH_3 emissions within the animal house, as previously determined (Chadwick *unpubl.*). Covering of the heaps with a plastic sheet significantly ($P<0.05$) reduced NH_3 emissions from both manure types. However, there is also a need to consider the 'down stream' impacts of the contrasting manure storage methods on NH_3 losses following land application, as management practices that retain NH_3 during storage will be beneficial only if they do not subsequently exacerbate losses following land spreading. This is currently being investigated in the study.

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