AMMONIA EMISSIONS FROM POULTRY MANURE MANAGEMENT SYSTEMS: HOUSING, STORAGE AND LAND SPREADING LOSSES

F. N. Nicholson, B. J. Chambers, A. W. Walker
ADAS Gleadthorpe, Meden Vale, Mansfield, Notts, UK, NG20 9PF

ABSTRACT

This study assessed the potential to reduce ammonia emissions by altering the ways in which poultry manures were managed. Ammonia loss measurements were made from complete broiler litter and laying hen manure management cycles (housing → storage → land spreading). Ammonia losses were higher ($P<0.05$) from winter-housed broilers on straw (mean 2.0 g NH_3-N/hr/500kg liveweight - lw) than those on woodshavings (mean 1.0 g NH_3-N/hr/500kg lw), but there were no differences in emissions ($P>0.05$) between the different litter types/rates during storage and following land spreading. The overall balance of ammonia emissions from the broiler litter studies during housing, storage and following landspreading was 31, 19 and 50%, respectively. In the laying hen housing studies, ammonia losses from weekly belt-scraping (mean 3.3 g NH_3-N/hr/500 kg lw) were more than double ($P<0.05$) those from daily belt-scraping (mean 1.3 g NH_3-N/hr/500 kg lw), with twice weekly belt-scraping estimated to reduce ammonia losses by *c.*50% compared with weekly cleaning. The overall balance of ammonia emissions from the layer manure studies during housing, storage and land spreading was 40, 5 and 55% respectively. These findings indicate that strategies to reduce ammonia emissions from poultry farming would be most effective if focused on housing and land spreading practices.

INTRODUCTION

Around 4 million tonnes of poultry manure are produced annually in the UK, with ammonia (NH_3) losses estimated at 45 kt in 2000 (equivalent to *c.*17% of estimated NH_3 emissions from UK agriculture). Ammonia volatilisation losses through the manure management continuum (housing → storage → land spreading) represent a substantial loss of potentially crop available nitrogen (N). Moreover, environmental damage may be caused following ammonia deposition through direct toxicity to plants, changes in the plant species composition of natural ecosystems, eutrophication and soil acidification. As part of the EU Directive on Integrated Pollution Prevention and Control (IPPC) member states are required to prevent or reduce pollution in order to achieve a high level of protection for the environment. As part of this overall objective, the UK government needs to take action to reduce ammonia emissions from large pig and poultry units.

Previous UK studies have largely focussed on measuring ammonia losses from individual components of poultry manure management systems (i.e. housing, storage, land spreading), which has limited the ability of desk-study exercises to make balanced system comparisons. It is therefore important, if valid conclusions are to be drawn on ammonia emissions from contrasting manure management systems or on the effectiveness of abatement techniques, that measurements follow through the whole manure management continuum (housing → storage → land application). The objective of this study was to quantify and compare ammonia losses from different broiler litter and layer manure management systems, along with the individual components of each manure management system.

MATERIALS AND METHODS

The effects of contrasting litter types and quantities on ammonia emissions were studied for winter (November 1998 - January 1999) and summer (August – October 2000) housed broiler flocks reared over 46 (winter) and 43 (summer) day periods (600 male and 600 female birds at 14.3 birds/m^2) in the Climate House facility at ADAS Gleadthorpe. Two types of litter (straw and woodshavings) were provided at depths representative of current commercial practice (5 cm) and 1.5 times commercial practice (7.5 cm), with 2 replicates of each litter treatment. Continuous measurements of ammonia emissions were made using 0.02M orthophosphoric acid traps (Lockyer, 1984) located at the air outlet and inlet of each room.

In a second experiment, the effect of different layer manure removal frequencies (daily or weekly) on ammonia emissions from a belt-scraped cage system was studied at ADAS Gleadthorpe. The flock consisted of *c*.3,500 birds housed in cages in 3 banks of 3 tiers, with the manure collected on a belt beneath each bank. Measurements of ammonia emissions from each manure removal frequency treatment were made on the first two weeks of alternate months between September 1998 and July 1999, using the acid trap methodology described above. During these two weeks the belts were scraped either daily or weekly, thus allowing seasonal variations in ammonia losses from housing to be studied. Whilst ammonia measurements were not taking place, the house was belt-scraped weekly.

The broiler litters and layer manures were moved from the buildings prior to storage in field heaps using a large walled trailer. Masts were erected on each wall of the trailer and pairs of Ferm tubes (Ferm *et al*., 1991) were attached at heights of 0.2, 0.5 and 1.0 m above the sides of the trailer to measure ammonia emissions during transport. The broiler litters were stored for 6-12 months (*c*.2 tonnes/heap) and layer manures stored for 10-16 months (*c*.6-8 tonnes/heap). Four masts were erected around the sides of each heap and pairs of Ferm tubes were attached at heights of 0.2, 0.8 and 2 m above the manure heap to provide continuous measurements of ammonia emissions. Following storage, all of the manures were spread to arable stubbles at ADAS Gleadthorpe at rates supplying a target of 250 kg/ha total N. Ammonia emissions were measured using the equilibrium concentration technique as described by Svensson (1994), with measurements continued for *c*.30 days following land spreading.

RESULTS AND DISCUSSION

Housing losses

For the winter housed broiler flock, ammonia losses from broilers on straw (mean 2.0 g NH_3-N/hr/500kg lw) were higher (P<0.05) than those on woodshavings (mean 1.0 g NH_3-N/hr/500kg lw). The lower emissions from the birds on woodshavings was most probably due to the greater amount of bedding dry solids added (a mean of 480 kg woodshavings per room compared with a mean of 275 kg straw per room). For the summer housed flock, mean ammonia losses (*c*.2.8 g/hr/500 kg lw) were almost double (P<0.05) those from the winter housed flock (1.5 g/hr/500 kg lw) because of higher ventilation rates in the warmer weather (mean 1.9 m^3/s in summer compared with a mean of 0.8 m^3/s in winter), with no difference (P>0.05) between the litter types. There were no differences (P>0.05) in ammonia emissions between the two bedding addition rates (5 and 7.5 cm) for either the winter or summer housed flocks.

For the laying hen flock, ammonia losses from the weekly belt-scraped manures (mean 3.3 g NH_3-N/hr/500 kg lw; n=6) were more than double (P<0.05) those from the daily belt-scraped manures (mean 1.3 g NH_3-N/hr/500 kg lw; n=6) (Figure 1). These findings indicate that growers with belt clean systems could reduce ammonia emissions from housing by *c*.50% by scraping the belts twice weekly rather than weekly. Ammonia losses from laying hen housing were generally higher (P=0.06) in summer (mean 3.2 g NH_3-N/hr/500 kg lw) than in winter (mean 1.4 g NH_3-N/hr/500 kg lw), because of higher ventilation rates during the warmer summer months (mean 8.9 m^3/s in summer compared with a mean of 1.4 m^3/s in winter).

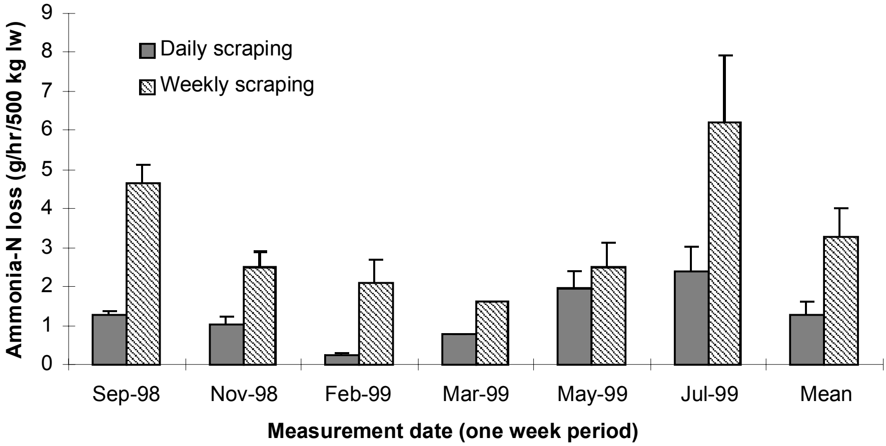

Figure 1. *Ammonia emissions during daily and weekly layer manure belt-scraping*

Storage losses

There were no differences (P>0.05) in ammonia emissions between the different litter types/rates during broiler litter storage. Total ammonia-N losses ranged from 42 to 572 g NH_3-N/m^2 of initial heap surface area (6-12 months). The layer manures were stored for a longer period (10-16 months), with total ammonia-N losses over this period of between 508 and 1,111 g/m^2 of initial heap surface area. Ammonia loss rates during manure transport from housing to field storage were high for both manure types (up to *c*.750 and 180 g NH_3-N/m^2/day for the broiler and layer manures, respectively). However, because the manures were only on the trailer for a few hours, the total amount of N lost represented only 5-10% of total ammonia-N losses measured during storage.

The ammonia losses measured during manure transport, storage and heap break-out accounted for only 4-16% of the total N losses measured during storage. The remaining N was likely to have been lost largely via other gaseous N products of microbial respiration and denitrification (i.e. N_2O, N_2 and NO_x).

Land spreading

There were no differences (P>0.05) in ammonia emissions between any of the broiler litter or layer manure treatments following land spreading. Total ammonia-N losses were equivalent to 46, 54 and 118% of the uric acid N plus ammonium-N (UAN) applied in the winter broiler litter (65 kg UAN/ha applied), summer broiler litter (89 kg UAN/ha applied) and layer manure (134 kg UAN/ha applied), respectively.

Whole system losses

Whole system ammonia-N losses were equivalent to 2.1, 2.5 and 72 kg/500 kg lw from the winter and summer broiler litter and layer manure management systems, respectively. For the broiler litter studies, ammonia losses during housing and following land spreading comprised *c*.31 and 50% of the total system losses, respectively, with losses during storage (including handling and heap break-out) only accounting for around 19% of total ammonia losses (Figure 2). For the layer system, 40 and 55% of total ammonia losses were from housing and land spreading, respectively, with only 5% of losses occurring during manure storage (Figure 2). These findings indicate that losses during housing and land spreading are the major ammonia loss routes.

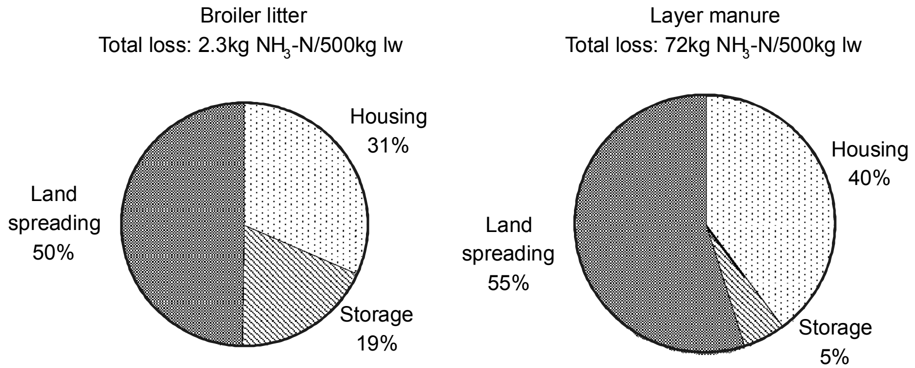

Figure 2. *Ammonia-N losses from each stage of the manure management system*

CONCLUSIONS

The results demonstrate that manure management practices (e.g. frequency of manure removal and litter types) can be changed in practical and cost-effective ways to reduce ammonia losses during poultry housing, and that these changes had no measurable effects on ammonia losses during storage or following land spreading. The whole-system ammonia loss measurements indicate that strategies to reduce ammonia emissions from poultry farming would be most effective if focused on housing and land spreading practices. However, it is important that N conserved during housing should be protected against down stream losses (i.e. during storage and following land spreading). Therefore, abatement measures during storage (e.g. non-disturbance of heaps or covering) and following land spreading (e.g. rapid incorporation) will also make a valuable contribution to reducing overall ammonia losses from poultry farming.

REFERENCES

Ferm, M., Schjorring, J.K., Sommer, S.G., Nielsen, S.B. 1991. Field investigation of methods to measure ammonia volatilisation. In Nielsen V.C., Voorburg J., L'Hermite P. (eds): *Odour Emissions from Livestock Farming.* London and New York, Elsevier Applied Science, pp 148-154.

Lockyer, D.R. 1984. A system for the measurement in the field of losses of ammonia through volatilisation. J. Sci. Food Agri., 35: 837-848.

Svensson, L. 1994. A new dynamic chamber technique for measuring ammonia emissions from land spread manure and fertilisers. Acta Agric. Scan. Sec. B. Soil Plant Sci., 44: 35-46.