MEASUREMENT AND ABATEMENT OF AMMONIA EMISSIONS FROM HARD STANDINGS USED BY LIVESTOCK

S.L. Gilhespy[1], V. Camp[1], A. Retter[1] T.H. Misselbrook[1], J. Webb[2]
[1]Institute of Grassland and Environmental Research, North Wyke Research Station, Okehampton, Devon, EX20 2SB. sarah.gilhespy@bbsrc.ac.uk
[2]ADAS Research, Wergs Road, Wolverhampton WV6 8TQ, UK.

ABSTRACT

Ammonia emissions from agriculture are a cause for environmental concern contributing 226 kt NH_3-N per year to the atmosphere. Emissions from outdoor concrete yards or hard standings represent a previously ignored but potentially significant source of ammonia. To increase the robustness of estimates of ammonia emission from hard standings, measurements were made on 13 commercial farms (dairy, beef and sheep). Dairy farms were found to be the most significant source, in particular, feeding/loafing yards emitting 462 mg NH_3-N m^{-2} hr^{-1}. During the winter of 2002 an experiment was carried out to assess potential ammonia abatement measures that may be used on hard standings. Of the four abatement measures tested daily scraping and pressure washing proved to be most effective at reducing ammonia emission. These results together with those a repeat experiment during summer 2003 and testing of selected abatement measures on commercial farms will serve to provide more concrete evidence on how to reduce ammonia emissions from hard standings.

INTRODUCTION

Ammonia emissions from UK agriculture have recently been estimated at 226 kt NH_3-N per year. This accounts for 80% of the total emission of ammonia to the atmosphere (Misselbrook *et al*, 2000). Ammonia volatilisation is not only a cause for environmental concern, but represents a substantial loss of fertiliser N value. Environmental damage is inflicted following (long-range) transport and deposition through direct toxicity to plants (van der Eerden, 1982), changes in plant species composition of natural ecosystems (Heil & Diemont, 1983), eutrophication and soil acidification (van Breeman, 1988).

Recent research findings suggest that unroofed concrete yards or hard standings may represent a previously ignored and potentially significant source of ammonia emissions (22 kt NH_3-N yr^{-1}) accounting for 10% of the ammonia emission from UK agriculture. However, this current estimate is subject to much uncertainty, due to insufficient information on the frequency of use and stocking densities on hard standings, and the fact that data are limited to a small number of farms. The aim of this project was firstly to carry out additional measurements on commercial farms to address these uncertainties. In addition, experiments were carried out on a hard standing to which cattle had controlled access to establish the effect of stocking density and to assess a number of potential abatement measures including the use of urease inhibitors and improved yard cleaning methods.

MATERIALS AND METHODS

Ammonia emission measurements

Measurements of ammonia emissions were made using an equilibrium concentration technique employing a system of small dynamic chambers previously described by Svensson (1994) and Misselbrook (2001). Briefly the technique uses the micrometeorological law of resistance to determine the flux of ammonia from an emitting surface. Passive diffusion samplers, impregnated with 2% tartaric acid, were used to determine ammonia concentration within and outside the chambers. For a particular measurement site, 6 chambers together with 4 ambient samplers, were used for ammonia emission measurements. Typically during each sampling occasion there were 3-4 periods when gaseous emission measurements would be made from each chamber. Sampling times were 1-2 hours, or occasionally longer when very low emission rates were expected, i.e. from hard standings used by sheep. Animals were excluded from the hard standing during sampling times to prevent damage to the equipment.

On farm measurements

Ammonia emission measurements were made on 13 commercial farms (dairy, beef and sheep) at different times of the year, between February 2002 and January 2004, to reflect seasonal changes in conditions and usage of the hard standings. Measurements were made from all hard standings used by livestock on each of the farms. On each measurement occasion the frequency of use and stocking densities were recorded. A visual observation was made of the extent to which the whole hard standing was fouled. In addition, estimates were made of the quantity of urine and faeces deposited and samples were taken and analysed for total-N, ammonium-N, dry matter content and pH.

Development of abatement strategies

In order to assess ammonia abatement strategies a series of measurements were made on concrete yards at IGER North Wyke for a period of five weeks from 11th November 2002. Two groups of nine suckler cows were each held on a designated ‘treatment’ and ‘control’ hard standing for a period of 2 hours at the same time each day. The following treatments were imposed in consecutive weeks i) no cleaning, ii) daily scraping, iii) daily washing and scraping, iv) use of a the urease inhibitor N-(n-butyl) thiophosphoric triamide (NBPT) plus daily scraping and, v) reduced area allowance per animal plus daily scraping. The control yard was subjected to daily scraping during treatment weeks iii) to v) to simulate commercial practice and to assess any reduction in emission attributable to the abatement measures used in addition to scraping. Each treatment was imposed on the hard standing from days 1 to 5, with ammonia emission being made on the final two days. The area of both hard standings was 44m^2 providing an area allowance of approximately 5m^2 this being reduced to 3m^2 per animal on the treatment yard in the final week. A repeat experiment was carried out during the summer of 2003, the results of which will be available for presentation at Ramiran 2004.

RESULTS AND DISCUSSION

On farm measurements

The results available to date of the on-farm measurements are presented in Table 1. Hard standings used by dairy cattle have so far proved to be the most significant source of ammonia emission, with dairy cow feeding/loafing yards providing the highest mean emission overall as found by Misselbrook *et al* (2001). Webb *et al* (2001) reasoned that this was due to the greater amounts of excreta deposited by dairy cows compared with other livestock, and the less frequent removal of dung and urine compared with dairy cow collection yards. The mean emission rate measured from beef cattle feeding/loafing yards was 271 g NH_3-N m^{-2} hr^{-1} which compares favourably with the findings of Misselbrook et al (2001) who measured an emission rate of 220 g NH_3-N m^{-2} hr^{-1} from beef cattle feeding/loafing areas.

The lowest emissions were to be found a hard standing used as a handling/feeding area to which sheep had access for just two hours per day and a self feed silage area used by beef cattle at a low stocking density during the night time only.

Table 1. *Mean ammonia emission rate measured from each yard type*

Yard type	No. of observations	Range of emission rates (mg m^{-2} hr^{-1})	Mean NH_3 emission rate for yard type (mg m^{-2} hr^{-1})
Beef cattle feeding/loafing yard	23	60-600	271
Beef cattle self-feed silage area	6	10-140	53
Dairy cow collecting yard	64	70-1010	388
Dairy cow feeding/loafing yard	20	60-760	462
Sheep yard	10	0-570	150

Development of abatement strategies

During the first week of ammonia measurement no treatment was imposed and no significant difference in ammonia emission was found between the treatment and control yard. As the experiment progressed, there was a lot of variation in ammonia emissions from the control yard (Figure 1) in response to weekly changes in temperature, wind speed, rainfall etc. thus highlighting the need for the direct comparison to the treatment yard.

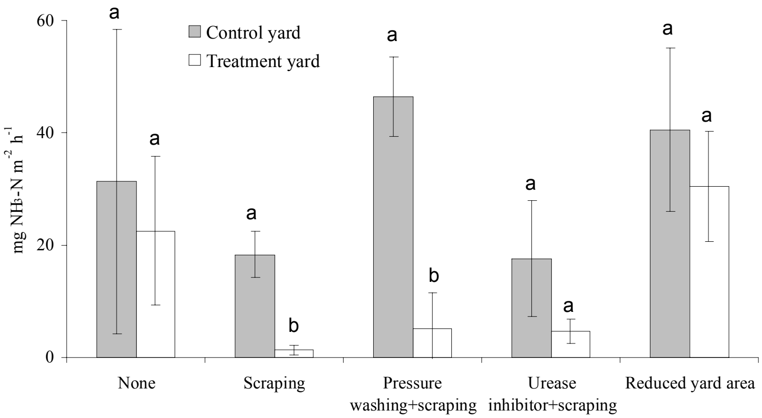

Figure 1. *Mean ammonia emission rate from different abatement strategies.*

**Vertical bars represent s.e.m. Means denoted by different letters are significantly different (P<0.05).*

Scraping proved to be an effective abatement measure achieving a 93% reduction in ammonia emission compared to the non-scraped control yard (P=0.03). This result should however be treated with caution when scaled up to the farm level as scraping effectiveness was found to range from 18% to 80% in the on-farm studies, with large differences even on different yards within the same farm. The scraping method used in this experiment was a hand-held scraper and thus may be more effective and reliable than a tractor mounted scraper. Heavy rainfall may also have helped to overestimate this abatement option.

Pressure washing following scraping compared to scraping alone achieved an 89% reduction in ammonia emission (P=0.002) and proved to be an effective means of reducing ammonia emission. However, large volumes of water are required for this type of cleaning and the impacts that this may have on costs, farm storage capacity and subsequent land spreading operations require careful consideration.

The use of a urease inhibitor following scraping when compared to scraping alone resulted in a 74% reduction in ammonia emission (NS). Varel et al (1997) found that by applying NBPT to manure in feedlots urea hydrolysis could be delayed for up to 28 days. Given that the surface area to volume ratio for hard standings is greater than for manure stores, delaying hydrolysis of urea on hard standings could significantly reduce ammonia emissions and is worth further exploration.

Reducing the area over which a given quantity of excreta is deposited should in theory reduce the potential for ammonia volatilisation. In this experiment we found that a reduction of the area allowance by 39% lowered ammonia emission by 25% (NS). This abatement method when compared to the others tested is unlikely to be a feasible abatement option when animal welfare is taken into account.

CONCLUSIONS

Preliminary results from this study have shown that there are promising abatement options amongst those tested, notably scraping, pressure washing and the use of a urease inhibitor. Results of the repeat summer 2003 experiment will be available for presentation at Ramiran 2004. This together with testing of selected abatement measures on commercial farms will provide further evidence of the potential of these abatement measures.

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