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An evaluation of strategies to control ammonia emissions from the land - spreading of cattle slurry and cattle wintering facilities

The experimental slurry tanker and ammonia flux gradient mast

Key external stakeholders:

Livestock farmers
Department of Agriculture, Food & Fisheries
Environmental Protection Agency

Practical implications for stakeholders:

This research demonstrates the effectiveness of altered timing and application technique on ammonia emissions abatement. This will enable stakeholders to make informed decisions as to which strategy to adopt in order to reduce N losses to the atmosphere.

Farmers: This research demonstrates that N losses to the atmosphere can be reduced without any outlay in terms of new machinery simply by targeting application either early in the season or be evening application. This will increase the N-fertiliser efficiency of slurry (demonstrated in RMIS 5512).

Policymakers: This research has quantified the abatement benefits of adopting trailing shoe technology and altered timing. Results are also feeding into a revision of the national ammonia inventories which should lead to reduced estimates of housing emissions.

Scientific: This research quantifies ammonia emissions from out-wintering pads in Europe for the first time.

Main results:

- On average, 54% of total ammoniacal nitrogen (TAN) was lost when slurry was applied by splashplate. Emissions were highest on hot, dry days. Application was targeted for cooler periods, particularly during spring, reduced emissions by over 30%. Emissions were also reduced by application in evening.
- The adoption of trailing shoe technology reduced ammonia emissions by an average of 36%. Under low emission weather conditions, there was no significant difference between application techniques.
- Ammonia emissions from slatted sheds were lower than those used by the EPA in the national ammonia inventories such, indicating a substantial overestimation of cattle housing emissions within the inventory. By comparison, emissions from an outwintering pad (OWP) were higher, particularly dry periods. Emissions were substantially reduced (90%) if pads were regularly cleaned. However, OWP's are in general, *not* an effective ammonia abatement technique.

Opportunity / Benefit:

Application technique and timing are both effective measures for reducing ammonia emissions following landspreading. Therefore, farmers can reduce emissions without the requirement to adopt more expensive machinery. Ammonia emissions from slatted cattle housing is towards the low end of European figures and lower than default values derived from UK data. In addition, it was also demonstrated that whilst out-wintering facilities be advantageous in terms of animal welfare, ammonia emissions per animal were higher.

Collaborating Institutions:

University College Dublin; ADAS Wolverhampton; Rothamstead – North Wycke; and Westlakes Scientific

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1. Project background:

Irish agriculture faces considerable challenges in reducing N inputs both in terms of financial sustainability and complying with future emissions targets. The loss of N via ammonia volatilisation represents a challenge both in terms of atmospheric pollution and a loss of resource for the farmer. Under the terms of the National Emissions Ceilings Directive (2001) ammonia (NH_3) emissions are limited to 116,000 tonnes by 2010; with further, more stringent, reductions currently under discussion. Agriculture comprises 98% of national ammonia emissions, with cattle accounting for 80% of this total. In terms of agricultural practices, the land spreading of slurry and animal housing comprise 47% and 34% of total emissions, respectively; whilst the remainder is split between manure storage and animal deposition. In terms of atmospheric pollution, ammonia is both a local and trans-boundary pollutant, and also indirectly contributes to greenhouse gas emissions. Ultimately, however, these emissions represent a considerable loss of N to the farmer. Indeed, the economic cost associated N loss via volatilization is c. €60 million. As a result, there is an urgent need to develop abatement strategies to reduce these losses.

2. Questions addressed by the project:

This project had two principle research goals. The first was to assess the effect of timing and application technique on ammonia emissions. The second objective was to assess the emissions from housing and to evaluate the efficacy of Out-Wintering Pads (OWP's) as a housing control measure.

3. The experimental studies:

Landspreading: Eight land-spreading experiments were carried out between July 2006 to August 2008 with slurry applied to grassland on a loamy soil using either splashplate or trailing shoe application methods. On all plots, application rates were 33 m^3 per hectare. All slurry used for application came from the slatted beef unit at Teagasc Environmental Research Centre, Johnstown Castle, was agitated in the shed 1-3 days prior to application and spread using the same purpose built tanker (Abbey Machinery Ltd, Nenagh, Co. Tipperary). The tanker had a capacity of 7 m^3 and had a valve which allowed slurry to be circulated inside the tank. The slurry was forced through the pipes to the 24 applicators. Each applicator had a valve to allow the selection of splashplate or trailing shoe application. In order to accurately assess the effect of timing and spreading technique on ammonia emissions, measurements were performed using the flux-gradient technique. This method measured ammonia emissions at various heights (from 0.1 to 2.2m) above the ground, with the sum of the all heights representing the emissions for an area of ground (dependent on the mast height and windspeed). Thus it provided a non-invasive technique and provided an integrated measurement over a large area (100m^2). The masts contained passive flux samplers which were coated with acid to trap the ammonia. This trap was subsequently washed and the ammonium content analysed. Experimental data was used to parameterize a statistical model

Housing Systems: A comparative assessment of emissions from both slatted sheds and OWPs was undertaken using of direct measurements from acid traps placed at 1m intervals on each side and roof of the building. In addition, emissions plumes arising from housing sources were simulated using atmospheric dispersion models, which simulate the ammonia plume emitted from the housing system. This plume modeling was undertaken as direct emissions measurements from open out-wintering pads and lagoons were impractical.

4. Main results:

- On average, 54% of total ammoniacal nitrogen (TAN) was lost when slurry was applied by splashplate. However, there was significant variation in emissions depending on the prevailing weather conditions for the first four hours after application, with up to 78% of TAN lost on hot, dry days. However, if application was targeted for cooler periods, particularly during spring, emissions were reduced by over 30%. In addition, dusk application during summer halved emissions with only 24% TAN lost.

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- The adoption of trailing shoe technology reduced ammonia emissions by an average of 36%. In addition the range of ammonia emissions across weather conditions was more consistent. However, under low emission conditions, there was no significant difference between application technique.
- Ammonia emissions from slatted sheds were 8 gNH_3-N LU^{-1} day^{-1}. This value is considerably lower than the values (38 gNH_3-N LU^{-1} day^{-1}) used by the EPA in the national ammonia inventories and as such, indicating a substantial overestimation of cattle housing emissions within the inventory. By comparison, OWP emissions were 62 gNH_3-N LU^{-1} day^{-1} with periods of higher emissions occurring during dry periods. Emissions were substantially reduced (90%) if pads were regularly cleaned. However, OWP's are in general, *not* an effective ammonia abatement technique.

5. Opportunity/Benefit:

This research demonstrates the effectiveness of both changing application technique and timing. In particular, statistical models generated in this study will provide a starting point for the construction of an Application Timing Management System for Ireland. This would allow farmers to reduce emissions without the requirement to adopt more expensive machinery.

In terms of housing, this research indicates that ammonia emissions from slatted cattle housing is towards the low end of European figures and lower than default values derived from UK data. In addition, it was also demonstrated that whilst out-wintering facilities be advantageous in terms of animal welfare, ammonia emissions, expressed on a per head basis were much higher than housing.

6. Dissemination:

The primary stakeholders for this research are both farmers and policy makers.

Main publications:

Dowling, C., Hill, R., Curran, T. & Lanigan, G.J (2010) Ammonia emissions associated with cattle housed on Out-Wintering Pads. Biosystems Engineering (accepted)
Meade, G., Pierce, K., O'Doherty, J.V., Muller, C., Lanigan, GJ and McCabe, T. (2010). Ammonia emissions following land application of high and low nitrogen manures to winter wheat at three growth stages. Agriculture, Ecosystems & Environment (in press).
Dowling, C., Hyde, B., Carton, O., Curran, T. and Lanigan G.J. (2010) Ammonia emissions associated with the landspreading of cattle slurry in Ireland. Atmospheric Environment (submitted).
Dowling, C., Curran, T. and Lanigan G.J. (2008) The effect of application technique and climate conditions on ammonia emissions from cattle slurry. In: 13th Int. RAMIRAN Proceedings, Albena, 4pages ISBN 978-954-9067671-6-3
Lalor, S. and Lanigan, G. (2010). The potential of application timing management to reduce ammonia emissions following cattle slurry application. In: 14th Int. RAMIRAN Proceedings, Portugal.

Popular publications:

Dowling, C., Curran, T. and Lanigan G.J. (2009) Reducing Ammonia Emissions. TResearch. 4(1): 40-43

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