LowAmmo: measuring ammonia in agriculture

TEAGASC researchers are working to quantify NH_3 emissions from agriculture with a view to meeting Ireland's National Emissions Ceilings Directive targets.

The ammonia challenge

Ammonia (NH_3) volatilisation from nitrogen (N) fertiliser and the manure management chain (housing, storage and land spreading) reduces N use efficiency and represents a substantial economic loss of N on Irish farms. Ammonia volatilisation also contributes to eutrophication and acidification of natural ecosystems and indirect emissions of the greenhouse gas nitrous oxide (N_2O). Ireland has committed to reducing national NH_3 emissions by 5% by 2030 compared to 2005 levels under the revised National Emission Ceilings Directive. Meeting these emission reduction targets along with achieving Food Wise 2025 targets presents a significant challenge for Irish agriculture, which accounts for >98% of national NH_3 emissions. The majority of Irish NH_3 research up to now has focused on emissions from slurry land spreading and fertiliser N applications.

LowAmmo

The 'LowAmmo' project was established in 2013 and aims to close some of the gaps in knowledge related to NH_3 emissions from Irish agriculture. The project's specific objectives are:

1. To quantify NH_3 emissions associated with cattle housing, cattle excreta deposition on pasture and yards, and slurry storage.
2. To quantify the abatement potential of NH_3 mitigation strategies for yards and slurry storage.
3. To develop models to estimate NH_3 emissions from Irish farms.

Developing ammonia emission factors for Irish cattle housing

NH_3 emissions from livestock housing are derived from two sources within the house: the housing floor; and, internal slurry storage tanks. Emissions arise from the mixing of excreted dung and urine in these two areas. Urea-N present in urine is rapidly hydrolysed to NH_4^+ and NH_3 by the enzyme urease, which is present in dung. This hydrolysis reaction also leads to an increase in pH, which favours the conversion of NH_4^+ (solid) to NH_3 (gas), thus leading to NH_3 emissions. During the project, NH_3 emissions were measured from four livestock houses in the south of Ireland over three winters (2014 to 2017) using passive flux samplers (Ferm tubes). The overall mean NH_3 emission factor (EF) from the four houses was 15.6g NH_3-N/LU/d or 12.5% of total ammonical N (TAN) excreted. This is somewhat lower than the current EF of 31% of TAN excreted used in Ireland's national NH_3 inventory and highlights that NH_3 emissions from cattle housing in Ireland may be over-estimated.

Mitigation of ammonia emissions from concrete yards

Deposition of livestock urine and dung on concrete farmyard surfaces (collecting yards and livestock handling yards) has been identified as a significant source of NH_3 emissions, contributing up to 8% of Ireland's agricultural NH_3 emissions. Experiments were conducted on a livestock handling yard in August 2016 to investigate the effectiveness of different yard-cleaning options (pressure washing or scraping using a hand-held scraper) used at different time intervals (one hour or three hours after excreta deposition) at reducing NH_3 emissions. The NH_3 emissions were measured using wind tunnels.

Pressure washing at one hour was the most effective at reducing NH_3 emissions (91% reduction). Pressure washing at three hours reduced emissions by 80%, while scraping after one hour and three hours reduced emissions by 78% and 54%, respectively. Pressure washing of farmyards as soon as possible after use by livestock should be encouraged in order to minimise NH_3 emissions from this source.

Ammonia emissions from excreta deposited on pasture

Over 60% of livestock-excreted N is deposited on pasture annually in Ireland. The aim of this task within the project was to create disaggregated NH_3 emission factors for urine and dung applied to pasture, and investigate the effect of amending urine patches with N-stabilised fertiliser formulations over two grazing seasons. Urine and dung were applied with and without a nitrification inhibitor (dicyandiamide) and urease inhibitor (N-(butyl) thiophosphoric triamide) on grassland at Teagasc Johnstown Castle. Dung had a lower NH_3 EF (3.8% total N applied lost as NH_3) compared to urine (12% total N applied lost as NH_3). The N stabiliser formulations applied to urine patches had no significant effect on NH_3 emissions from urine patches.

FIGURE 1: Ammonia emissions (a) and methane emissions (b) from stored cattle slurry with and without amendments.

Reducing ammonia and greenhouse gas emissions from slurry storage

Cattle slurry was amended with sulphuric acid, acetic acid, alum, and ferric chloride ($FeCl_3$) until a target pH of 5.5 was attained. A control, with no amendment, was also included. The study was conducted using 1.6L-capacity containers, which were stored at 8.6°C. Ammonia, N_2O, carbon dioxide and methane emissions from the slurry were monitored for 83 days. The addition of amendments to the slurry reduced NH_3 emissions by 86-97% (**Figure 1a**). Alum and $FeCl_3$ produced the highest reductions. The amendments reduced methane emissions by 94-98% relative to the slurry without amendments, with $FeCl_3$ attaining the highest reductions (**Figure 1b**). Carbon dioxide emissions were similar across all treatments and N_2O emissions were negligible from both the control and amended slurry.

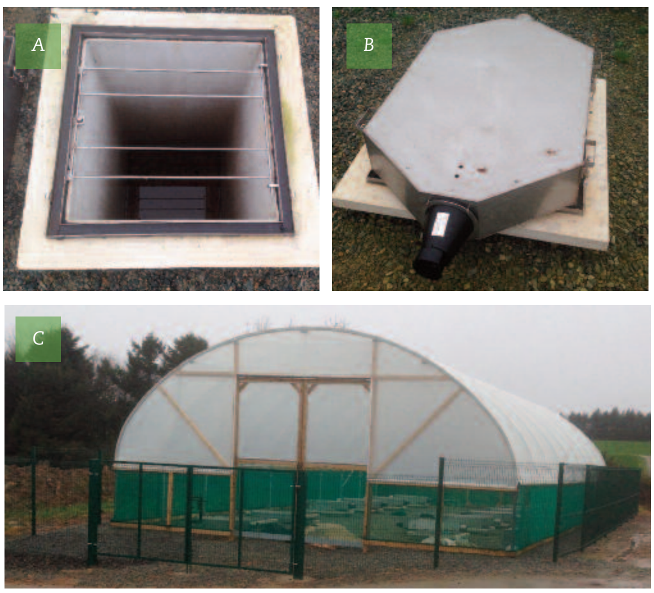

FIGURE 2: New slurry storage facility at Teagasc Johnstown Castle showing: (a) one of twelve 1m³ concrete storage tanks; (b) dynamic chamber used to measure ammonia and greenhouse gas emissions; and, (c) overview of the facility.

Conclusions and future research

The data collected on the LowAmmo project will feed directly into the refinement of Ireland's national NH_3 inventory. The mitigation options investigated in this project will also provide valuable data for the future development of the NH_3 marginal abatement cost curve (MACC) for Irish agriculture.

The recent development of the new Johnstown Castle slurry storage facility will increase the capacity to investigate the effectiveness of NH_3 and greenhouse gas mitigation strategies across the entire manure management chain. This facility contains twelve 1m³ concrete slurry storage tanks, which have been designed to simulate the storage of liquid slurry indoors in slatted storage tanks (**Figure 2**).

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