Focus Areas - Section 8

Slurry Management

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Reducing ammonia emissions through low emissions slurry spreading equipment (LESSE)

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Figure 1: Slurry spreading by dribblebar (trailing hose)

Key Messages

- Ammonia emissions from livestock systems are high and regularly affect the biodiversity of plants, especially in sensitive habitats.
- Slurry spreading is one of the biggest causes of ammonia emissions on the island of Ireland.
- Ammonia lost from slurry also translates to loss of plant-available nitrogen for the crop.
- This paddock-scale trial showed that slurry spread by three types of Low Emission Slurry Spreading Equipment (LESSE) reduced ammonia emissions by 37% on average compared to slurry spread by splashplate.

Background

Ammonia is an atmospheric pollutant, which negatively impacts both sensitive habitats, such as bogs, and human health. Ammonia can also drive the formation of greenhouse gases and, when dissolved in water, contribute to algal blooms.

Agriculture accounts for about 90% of ammonia emissions from the island of Ireland, with much of this originating from cattle systems. Slurry spreading causes over a third of Northern Ireland's and 40% of the Republic of Ireland's ammonia emissions.

Low emission slurry spreading equipment (LESSE) is known to reduce ammonia emissions from slurry by spreading closer to the ground and reducing the slurry surface area, thereby reducing volatilisation. However, the efficacy of LESSE is not well known under Irish conditions.

Research studies

The AFBI-led DAERA-funded LESS project and the Teagasc-led DAFM-funded Abating Ammonia from Agriculture (Triple A) project are aiming to find out how much LESSE can reduce ammonia emissions from Irish soils. These projects use paddock-scale (0.25 ha) plots to compare ammonia emissions from slurry spread by splashplate to that spread by LESSE. The AFBI site in Northern Ireland uses trailing hose (dribblebar; Figure 1) and trailing shoe for LESSE and the Teagasc site in the Republic of Ireland uses trailing shoe and open-slot injection. To date, these trials have run for two years, with three applications at each site per year, and ammonia emissions monitored for five days on each occasion after slurry application.

Research findings

Usually, ammonia emissions were highest on the day of spreading, regardless of spreading method, and reduced rapidly thereafter. The emissions were lower during spring (March/April) trials, when temperatures were cooler and plants were growing rapidly, and highest in late summer (August). On average, the Teagasc site emitted 33% more ammonia than the AFBI site did, due to higher temperatures at this site, which increased volatilisation. However, the highest rate of ammonia loss was from the AFBI site during a spring application. This came from an area spread by splashplate, which lost nearly 6 kg of ammonium-nitrogen per hectare per hour.

On average, over the 5 days of each trial, plots with slurry spread by splashplate emitted the most ammonia. At the AFBI site, splashplate plots lost 37% (range: 26-55%) of the total ammoniacal nitrogen (TAN) applied to them as slurry, whilst dribblebar plots lost 21% (range: 7-44%) and trailing shoe plots lost 20% (range: 5-49%) (Figure 2). At the Teagasc site, 29% (range: 24-41%) of the TAN applied to the splashplate plots was lost as ammonia, whilst 20% (range: 16-28%) was lost from open-slot injection plots and 22% (range: 11-42%) from trailing shoe plots (Figure 2).

This means that, on average, slurry spread by LESSE emitted 37% less ammonia than slurry spread by splashplate, meaning more nitrogen remained on the soil for the plants and less was lost in the air.

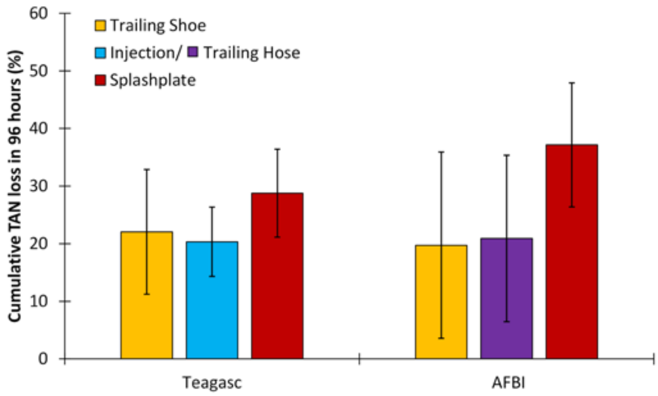

Figure 2: The average (with standard deviation error bars) percentage of total ammoniacal nitrogen (TAN) lost over five days from the slurry applied by splashplate and by three forms of LESSE.

Potential Impact for Farming for the Future

Using LESSE provides the simultaneous benefits of reducing the amount of ammonia emitted to the local atmosphere, protecting both human and sensitive habitat health, whilst increasing the amount of nitrogen available to the plants and thereby reducing additional fertiliser costs to the farmer.

These projects were funded by DAERA and DAFM.

A comprehensive approach to addressing ammonia nitrous oxide emissions from slurry storage and field application

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Reducing ammonia (NH_3) emissions from slurry stores and nitrous oxide (N_2O) emissions from the field-applied slurry

Key Messages

- Anaerobic digestate emits more ammonia during storage than cattle slurry
- Slurry acidification reduces ammonia and methane emissions during slurry / digestate storage
- Reducing dietary crude protein reduces ammonia emissions
- Supplementing animal diets with seaweed and seaweed extracts and covering slurry stores with biochar floating covers may reduce ammonia emissions
- Acidification of slurry or digestate may increase nitrous oxide emissions at landspreading, further research is needed

Background

Animal slurry is rich in plant nutrients and is landspread to agricultural fields. Slurry may also be processed in Anaerobic Digestions (AD) plants to harness biomethane for energy generation, with the resultant digestate also typically being landspread. Ammonia (NH_3) is produced and emitted during slurry or digestate storage, and NH_3 and nitrous oxide (N_2O, a potent greenhouse gas) are emitted during slurry field application.

Both NH_3 and N_2O emissions need to be reduced from NI's livestock systems to protect biodiversity and improve air quality.

Research Studies

AFBI is undertaking research to measure and reduce emissions from livestock slurries and digestates. Several materials have been tested to determine their impact on NH_3 emissions from cattle slurry stores; biochar of different origins, biochar with acid activation, light-expanded clay materials (LECA) and seaweed and its extract as a dietary additive. Currently, a slurry / digestate storage experiment is being carried out, with 18 700 L tanks of cattle slurry or digestate in a 1 m^3 store equipped with real-time monitoring of ammonia, methane and nitrous oxide emissions and evaluate reduction potentials. The treatments include cattle slurry, digestate and the liquid fraction of digestate, with or without acidification (to pH 5.5) of each. In a separate experiment, the same cattle slurry and digestate has been applied to the field using a trailing hose system, covering all slurry spreading seasons, to assess the N_2O emissions.

Research Findings

Preliminary results from the slurry storage study show that acidification reduces NH_3 emissions significantly during storage both for slurry and digestate (Fig. 1).

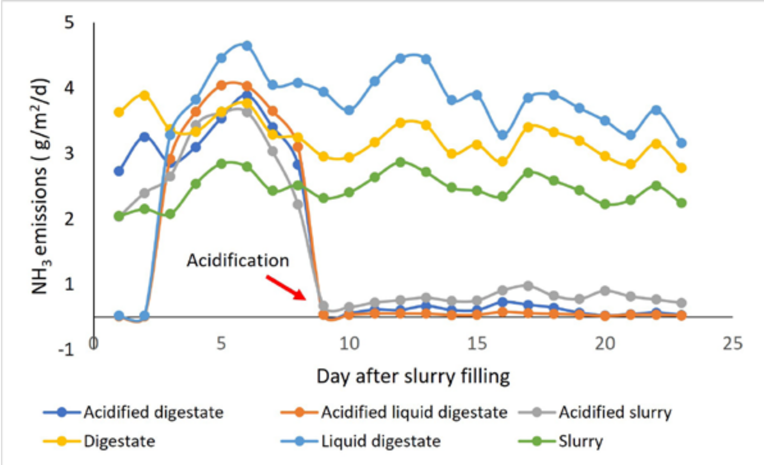

Fig.1. Daily NH_3 emissions from slurry or digestate stores with various treatments. The red arrow indicates the day of acidification.

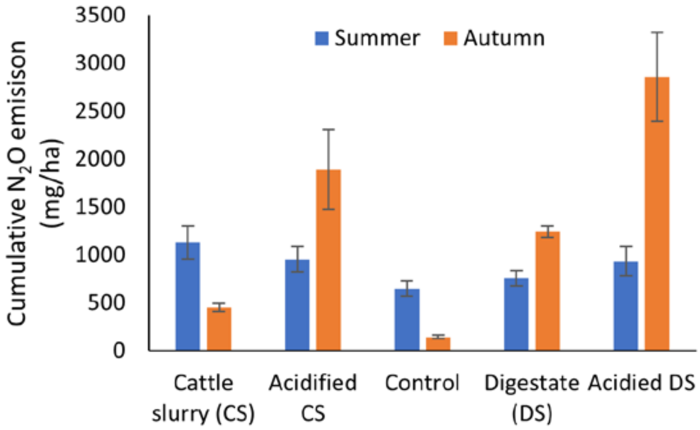

Fig. 2 Cumulative N_2O emissions of slurry and digestate during summer and autumn field application.

Among the non-acidified treatments, the highest emissions were produced by the digestate liquid fraction, followed by digestate and raw slurry. In smaller-scale trials (20 L containers), dietary supplements with seaweed and seaweed extract reduced NH_3 emissions during storage by 44% and 30% respectively in 36-day incubation experiments. In the same small-scale study, the use of acid-activated biochar as a floating cover reduced NH3 emissions by 37–51% in the first month and 25–28% over 4 months. Further research is needed on these treatments at larger experimental scales.

When cattle slurry or digestate was spread in the field as a fertilizer, N_2O emissions for cattle slurry, acidified cattle slurry and acidified digestate were comparable in summer application (Fig. 2). In turn, digestate had 33% lower N_2O emissions compared to cattle slurry. In autumn, acidified cattle slurry, digestate and acidified digestate increased N_2O emissions by 4-fold, 3-fold and 6-fold, respectively, compared to CS, suggesting that seasonality (particularly soil moisture) has a significant impact on N_2O emission.

Potential Impact for Farming for the Future

The sustainability of NI agriculture depends on the closing of nutrient cycles by utilising available nutrient resources such as animal slurry or digestate, and reducing the environmental impacts associated with manure management. Emission mitigation techniques should be assessed considering both slurry store and field emissions and suitable techniques need to be applied in each step of the manure management chain. Further research is needed to determine the trade-offs between different gases, as some treatments e.g. slurry acidification significantly reduce ammonia and methane emissions but may cause increases in nitrous oxide emissions following landspreading. Ultimately, solutions for better nitrogen management should be designed around increasing nitrogen use efficiency (NUE) and must consider losses to both the air and water.

This project was funded by DAERA.

Phosphorus Stock and Flows in the Northern Ireland Food System

Chris Johnston

The RePhoKUs project integrates biophysical, social, and economic perspectives to analyse phosphorus (P) distribution within the food system.

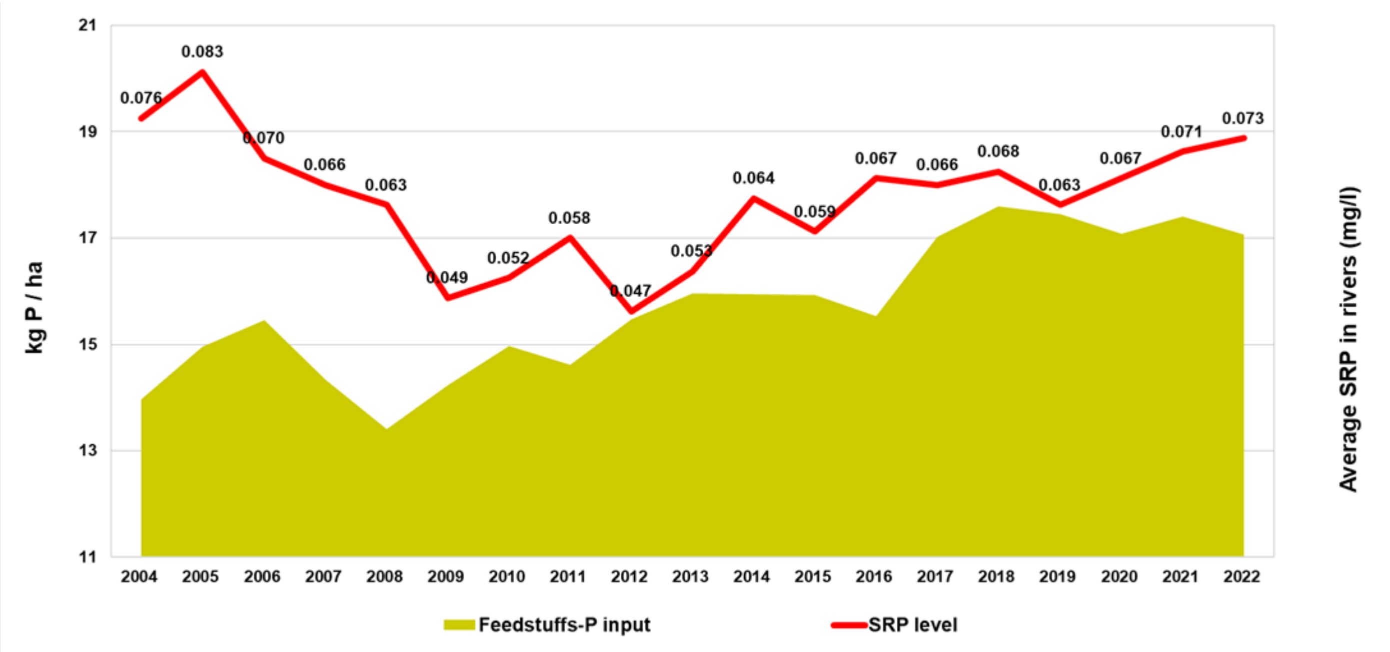

Figure 1. Feedstuffs Phosphorus inputs vs Soluble reactive Phosphorus in Rivers 2004 - 2022

Key Messages

- Excess Phosphorus (P) is one of the main drivers of poor quality water in Northern Ireland (NI).
- Imported P in fertiliser and feed concentrates are the main sources of excess P.
- Significant improvements have been made over the past 20 years as indicated by the reduction in the national P surplus and the decrease in Soluble Reactive Phosphorus (SRP) concentration in many waterbodies (Figure 1).
- However, recent trends have shown an increase in both the national P surplus and SRP concentrations in rivers (Figure 1).
- Managing and reducing excess P reaching waterways is a key intervention to improve NI's water quality.

Background

The UK lacks domestic phosphorus (P) deposits and relies on imports, primarily from Morocco and China. Eutrophication, stemming from excess P in water bodies, poses significant societal and environmental costs in NI. P is an essential nutrient in the production of meat and milk. However, efficient P use will reduce supply chain vulnerability and environmental pollution, crucial for sustainable food production and ecosystem preservation.

Research studies

The RePhokus project developed a Phosphorus Substance Flow Analysis (SFA), focusing on NI's food system. It quantified phosphorus stocks and flows within livestock, crops & soil, waste management, and wastewater treatment

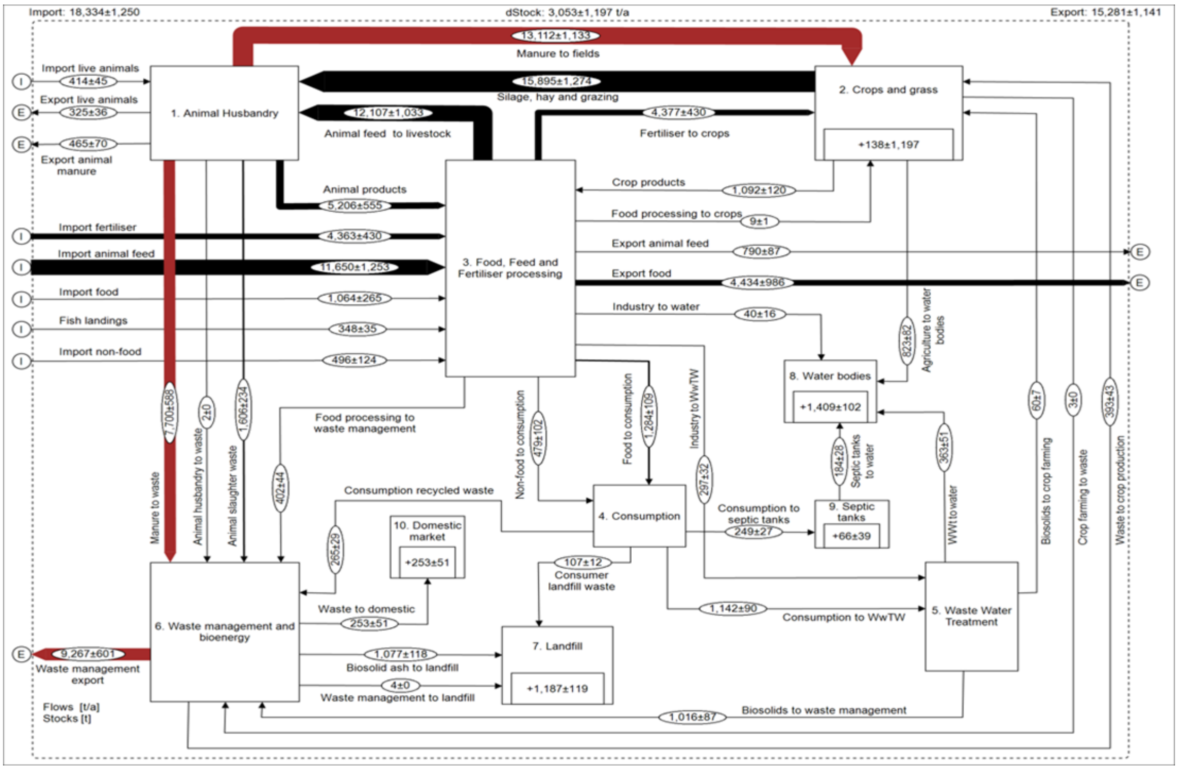

Fig 2. Manure export: 35% of manure P is 'processed' and exported

subsystems. Stakeholder engagement, including workshops and meetings, were aimed at discussing sustainable phosphorus management strategies. The report discussed the historical context of phosphorus regulation in NI and presented future scenarios for phosphorus management. Finally, it evaluated strategies for sustainable phosphorus management in intensive livestock systems. The report can be found at www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/RePhoKUs%20October%202x.pdf

Research findings

Efficient phosphorus (P) use within the food system is crucial for meeting water quality targets while sustaining agricultural production. Stakeholders favoured reducing the national P surplus to 1.5 kg/ha (from current levels of almost 11kg/ha), requiring decreased P fertilizer use and an increase in manure export. Challenges include biosecurity, logistics, and economic viability. A holistic approach to manure management considering carbon sequestration and nitrogen/carbon interactions is essential. Managing legacy soil P is vital to mitigate water quality impacts. The Soil Nutrient Health Scheme will help farmers reduce P levels in soil. Increasing P circularity could establish a strategic reserve but requires understanding the agronomic efficiency of recycled P products. Despite available technology and expertise, governance and collaboration remain key barriers to sustainable P management.

Potential Impact for Farming for the Future

The workshop on sustainable phosphorus (P) management in Northern Ireland (NI) focused on reducing P losses to water to meet Water Framework Directive (WFD) targets. Agricultural activities, despite initiatives like the Nitrate Action Programme (NAP), still contribute 62% of P to water bodies. The NI food system exhibits high P inputs relative to output, with ruminant livestock dominance leading to low P efficiency (38%). Legacy soil P accumulation further complicates management strategies. Opportunities for increased P circularity exist in the waste management sector, but face barriers like public perception concerns and regulatory requirements. Achieving a sustainable P balance requires reducing inputs from feed and fertiliser, addressing the inefficiency in the system, reducing excess manure P and ideally channelling this excess P into other industries.

This project was funded by BBSRC, ESRC, NERC, Scottish Government and ECI.

Slurry separation and the potential for the biomethane sector

Ashley Cathcart

On-farm nutrient management and valorisation of separated solids

Key messages

- Mechanical separation of slurry followed by solids removal has been identified as a method to reduce phosphorus (P) application to land.
- The solid fraction, high in carbon and phosphorus, can be used as a feedstock for anaerobic digestion (AD).
- Valorisation routes are being explored for separated solids, to exploit the carbon for green energy generation while redirecting P away from land spreading.

Background

Management of slurry is vital for the sustainability of agriculture. Northern Ireland has a large livestock sector, and imports of mineral P fertiliser and concentrate feeds has led to a national agricultural P surplus, currently estimated to be over 15kg P/ha. Spreading slurry on P-saturated land increases the risk of leaching to waterways. Mechanical separation has been identified as a method of reducing P in slurry by partitioning P into a high-solids fraction for export (Figure 1).

Separated solids can contain 20-40% of the P if separated by screw press and up to 70% if separated by centrifuge. There is potential for valorisation of separated solids through energy and nutrient recovery pathways which seek to exploit their carbon and P content.

Figure 1 – Separated slurry solids

Research studies

A comparative analysis of decanter centrifuge and screw press separation was carried out in AFBI in 2022/23 to determine the most efficient method of carbon and P recovery. The study focussed on the separation of anaerobic digestate however, an ongoing project is repeating the study with slurry.

Investigations into energy recovery from separated solids include production of fuel pellets for combustion and pyrolysis, and using separated slurry solids as a feedstock for AD. AFBI is collaborating with industry in Centre for Advanced Sustainable Energy (CASE) projects to investigate the feasibility of large-scale centralised AD plants fed with separated slurry solids from surrounding farms. The long-term goal is to reduce on-farm nutrient pressures and develop a supply and value chain for exported P while decarbonising the NI gas grid via upgrading of biogas to biomethane.

Research findings

Preliminary findings of slurry separation experiments indicate that screw presses are more efficient at separating raw slurry compared to anaerobic digestate. Screw press separated solids can be utilised as feedstock for AD due to their high carbon content.

Mobile screw press separators can visit farms where static separators may be economically or practically unfeasible.

Anaerobic digestate produced in centralised plants can then be treated by decanter centrifuges to produce a low-P liquid fraction that can be land spread as a fertiliser with reduced risk to water quality. The solids produced can be further processed to recover P, or as a potential feedstock for pellet production for pyrolysis or combustion.

Potential Impact for Farming for the Future

A movement toward widespread slurry separation can help to address Northern Ireland's long-term P-surplus issue and has the potential to assist with decarbonising the gas grid if managed correctly. Further research is required into the value chains, economic pathways, and whether any carbon value can be realised.

This project is being funded by DAERA and CASE.


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