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College of Agriculture,
Food & Rural Enterprise

Code of Good Agricultural Practice for the Reduction of Ammonia Emissions

DAERA
Department of Agriculture,
Environment and Rural Affairs
www.daera-ni.gov.uk

Contents

About this code

This Code of Good Agricultural Practice for the Reduction of Ammonia Emissions (referred to as "the Code") is a guidance document which explains how farmers, growers, land managers, advisers and contractors can minimise ammonia emissions from agriculture.

This can be achieved by making changes to the way in which livestock are housed and fed, the use of fertiliser and especially through the management of slurries and manures.

The Code sets out voluntary best practice measures and does not override or change any current or future statutory requirements.

The Code has been written by DAERA in collaboration with the Ulster Farmers' Union, the Northern Ireland Grain Trade Association and the Agri-Food and Biosciences Institute.

The Code applies to Northern Ireland and is not intended to replace any existing Codes. It supplements The Code of Good Agricultural Practice (CoGAP) for the Prevention of Pollution of Water, Air and Soil, published by DARD in 2008.

The Code has been written to help farmers, growers, contractors and others involved in agricultural activities identify appropriate action for their individual situation. Many farms and holdings are already delivering a high standard of environmental protection, but there are often ways to make improvements.

The measures outlined in this Code are not exhaustive and are not intended to be taken in isolation. If you carry out any practices that are not covered in the Code you should protect the environment by following the general principles that are outlined in it.

The ammonia emission reductions associated with each mitigation method are United Nations Economic Commission for Europe (UNECE) recommended estimates.

For further guidance on the measures set out in this document we suggest reading the UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. You can download at http://www.unece.org/info/ece-homepage.html (ref 1).

Technical support to reduce your ammonia emissions

Before making investments such as purchasing equipment or updating livestock buildings, changing the diet of your livestock or if you need help to improve the efficiency of your fertiliser use, you should consider what is suitable for your farm, the welfare of your livestock, the need to comply with existing regulations, and the needs of any assurance or certification schemes. If you are unsure of what is suitable in your particular circumstances you should consult existing support services, available guidance and/or seek professional advice.

Sources of specific support are signposted in each of the following sections.

General sources of advice regarding the concepts in this Code include:

- The Making Ammonia Visible document produced by an Expert Working Group, December 2017 https://www.daera-ni.gov.uk/sites/default/files/publications/daera/Ammonia%20Annex-%20Expert%20Working%20Group%20%28final%29.pdf
- CAFRE training courses on nutrient management, nitrates and other environmental topics. For further information see www.cafre.ac.uk/industry-support/industry-training/
- Detailed support for farm business development through the CAFRE Business Development Groups, Farm Family Key Skills, Farm Innovation Visits and Technology Demonstration Farms, details at www.cafre.ac.uk/industry-support/industry-training/.
- Information on livestock nutrition is available from a Registered Feed Adviser to ensure that the appropriate dietary requirements of the animals are being met. Make sure they have an up-to-date Feed Adviser Register (FAR) card.
- Guidance on legislation regarding livestock diets is available from the Food Standards Agency www.food.gov.uk
- FACTS Qualified Advisers deliver up-to-date nutrient management advice for crops and grassland. Make sure they have an up-to-date 'FACTS Qualified Adviser' (FQA) card. https://www.basis-reg.co.uk/Schemes/FACTS/About-FACTS

1. Introduction

Ammonia (NH_3) is a natural gas containing nitrogen. However in this context it is an atmospheric nitrogen pollutant primarily emitted from agricultural activity. This reactive gas is released when urea in urine (or uric acid in poultry) comes into contact with the enzyme urease in faeces. The amount of ammonia released to the atmosphere varies with the temperature, pH and degree of air-flow. The vast majority of Northern Ireland's (NI) ammonia emissions come from the housing of livestock and the storage and spreading of livestock manures.

1.1 Why ammonia is a problem?

Ammonia is a key air pollutant that can have significant effects on the environment and it can also indirectly affect human health.

Environmental concerns

In many habitats, naturally occurring forms of reactive nitrogen are usually scarce and limit growth of competitive nitrogen-loving plants. It is this low nitrogen status that a number of our semi-natural habitats and species are adapted to.

All plants need nitrogen to grow. However when nitrogen is available in excess it can negatively affect naturally nutrient-poor habitats. Nitrogen deposition is the term used to describe when reactive nitrogen gases such as ammonia are emitted to the atmosphere, and transferred to land and water bodies, either in gaseous form (dry deposition) or in rainfall (wet deposition).

In high concentrations, ammonia can cause direct toxicity to plants and, when deposited on land, can acidify and enrich soils and freshwaters and 'over-fertilise' natural plant communities. The extra nitrogen has negative effects on sensitive habitats causing changes in plant and animal communities through increased growth of some species (such as rough grasses and nettles), which out-compete other species (such as sensitive lichens, mosses, and herb species) that have lower nitrogen requirements.

Significant long-term harm can be caused to sensitive habitats once the soil quality has changed. The balance of plant species on the land is altered and the animal species that depend on these plants are also affected. It takes a long time, and can be costly, to restore these habitats. When plants are saturated, and can no longer take-up nitrogen, they leach excess nitrogen back into the soil, where it can then be leached to freshwater and marine ecosystems causing eutrophication.

Ammonia emissions which are subsequently deposited as nitrogen, can also indirectly lead to emission increases in nitrous oxide from wet soils. Nitrous oxide is a potent greenhouse gas with a Global Warming Potential 298 times greater than carbon dioxide (The 'Making Ammonia Visible' document, ref 3).

The careful location of ammonia sources can be very important for reducing the risk of detrimental effects on Public Health and the Environment. Where possible, ammonia sources should be positioned as far as possible from sensitive receptors, such as people and protected habitats. Protected habitats within proximity of your farm can be identified using the natural environment map viewer found at **www.daera-ni.gov.uk/services/natural-environment-map-viewer**

Public health concerns

In very low concentrations, ammonia is not harmful to human health. However, when ammonia emissions combine with pollution from industry and transport (for example diesel fumes) they form very fine particulate matter ($PM_{2.5}$), which can be transported significant distances, adding to the overall background levels to which people are exposed. When inhaled, this very fine particulate matter can penetrate deeply into body organs and contribute to causing cardiovascular and respiratory disease. It is estimated that particulate matter emissions as a whole result in 29,000 early deaths every year in the UK (ref 2).

NB $PM_{2.5}$ is particulate matter 2.5 micrometres or less in diameter. $PM_{2.5}$ is generally described as fine particles. By way of comparison, a human hair is about 100 micrometres, so roughly 40 fine particles could be placed on its width.

1.2 Ammonia and farming

Agriculture is the dominant source of ammonia emissions in NI with **94% of all ammonia emissions in NI in 2016 coming from agriculture.**

In 2016, cattle production was responsible for 69% of agricultural ammonia emissions and 22% of ammonia came from the intensive pig and poultry sectors.

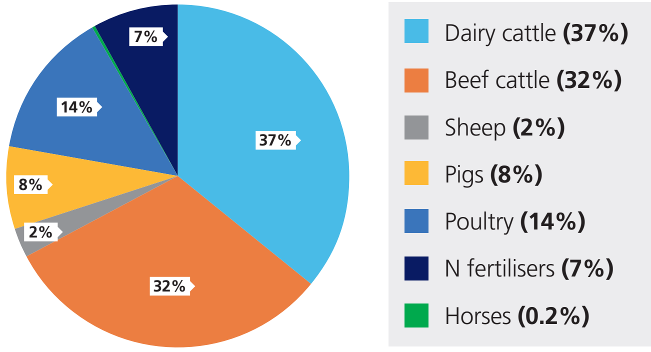

Figure 1:
The breakdown of the UK agricultural ammonia emissions in 2016.

Data source:
National Atmospheric Emissions Inventory (ref 4)

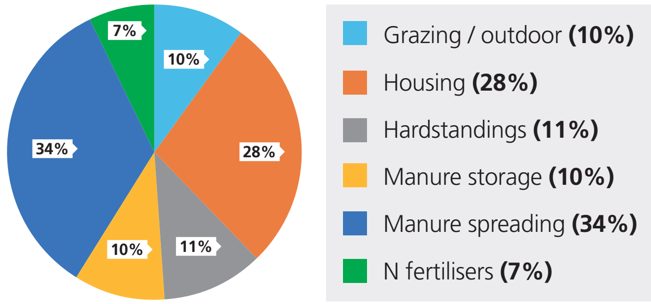

Figure 2:
The breakdown of agricultural ammonia emissions in NI in 2016 by source

Data source:
National Atmospheric Emissions Inventory (ref 4)

Most ammonia comes from livestock manures in animal housing and stores, and when manures and nitrogen fertilisers are applied to land.

1.3 Why we need to reduce ammonia emissions

The UK Government has international obligations under the UNECE Gothenburg Protocol and the EU National Emissions Ceilings Directive to meet targets for limiting ammonia emissions to protect human health and the environment.

There is also a legal requirement to protect sites such as Natura 2000 sites, Areas of Special Scientific Interest (ASSIs) and priority habitats. Our protected areas represent the very best of our natural landscapes and biodiversity, forming the cornerstone of nature conservation by supporting plants, animals and habitats that are rare or unique and worthy of protection.

Most of the land area of NI, including our designated sites and other priority habitats, is experiencing exceedance of the critical thresholds for ammonia emissions and associated critical loading of nitrogen deposition. Indeed, 95% of Northern Ireland's Special Areas of Conservation, amongst our most prized habitats as designated under the Habitats Directive, have been reported to the European Commission as part of the EU reporting requirements (Article 17) as being under threat of damage from N deposition. Our nationally important ASSIs are also being impacted as 93% of sites with sensitive plants and habitats exceed damage thresholds for nitrogen deposition.

The UK Government is committed (and legally obliged) under the UN Gothenburg Protocol to reduce ammonia emissions by 8% by 2020 and by 16% in 2030, compared to 2005 levels. By following the good practice set out in this guide you will be contributing to improving air, land and water quality and therefore helping to protect human health and wildlife habitats.

As previously highlighted, agriculture is the dominant source of ammonia emissions, making up 94% of NI's current emission levels. Northern Ireland currently contributes 12% of the total UK emission levels however, it has just 2.8% of the UK's population and 5.8% of the UK's land area. This underlines the need to reduce ammonia emissions from agriculture in NI to help meet the overall UK targets.

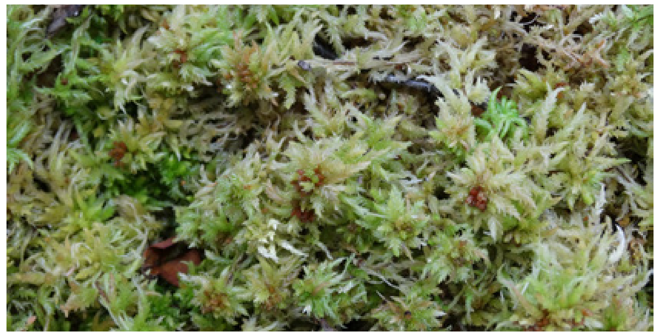

Figure 3a

Figure 3b

Figure 3c

Figures 3a and 3b show healthy moss. The impact of ammonia on sensitive bog species is shown by Figure 3c where the moss has become overgrown with algal slime. Peat bogs have a damage threshold of 5kg N/ha/yr. This particular lowland raised bog is experiencing levels of up to 41kg N/ha/yr. The ability of the bog to function, grow and accumulate peat is compromised.

Figure 4

Figure 4 is an image of Cladonia lichen from a bog in NI. Lichens are known to be indicators of air quality and are usually pale greyish-green in colour. The 'pinking' of this species is a well-studied response by the plant to toxicity from ammonia emissions (ref 5).

1.4 How farmers can help

Farmers can help protect the environment by using nitrogen efficiently and reducing ammonia emissions.

Organic manures (such as slurry, solid manure and litter, digestate, sludge and compost) are natural sources of nitrogen and are used to build soil fertility and support plant growth, commonly supplemented with chemical fertilisers.

However, nitrogen in the form of ammonia is lost from organic manures when they come into contact with air, particularly on warm or windy days. The more nitrogen is lost as ammonia, the less effective the manure will be as a fertiliser. Therefore, measures to reduce ammonia emissions and improve your overall nutrient management practices will help to reduce the amount and cost of any additional chemical fertiliser needed.

Ideally, measures to reduce ammonia emissions should be applied to all stages of the farming process, from livestock diet and housing to manure storage and spreading. Otherwise, nitrogen retained at one stage could be lost at the next stage as ammonia. A fixed cover on an above ground slurry store can reduce ammonia emission by up to 80% during storage. However, if this slurry is then spread with a splash-plate very high losses of up to 100% of the total ammoniacal-nitrogen (TAN) can occur. Spreading losses can be reduced by up to 60% if slurry is applied by low emission spreading equipment such as the trailing shoe system.

Your aim should be to integrate and balance all nutrient sources to improve crop nitrogen use efficiency. Manures and chemical fertilisers should be applied in the right amount, at the right time and in the right place. If too much manure and/or fertiliser is applied to land, or is applied in unsuitable weather conditions, the soil and crops cannot use the nitrogen quickly enough and a percentage is lost from the farming system as ammonia or nitrous oxide to air and nitrate to water. This pollution can be substantially reduced and significant fertiliser made through consistent use of good nitrogen management practices.

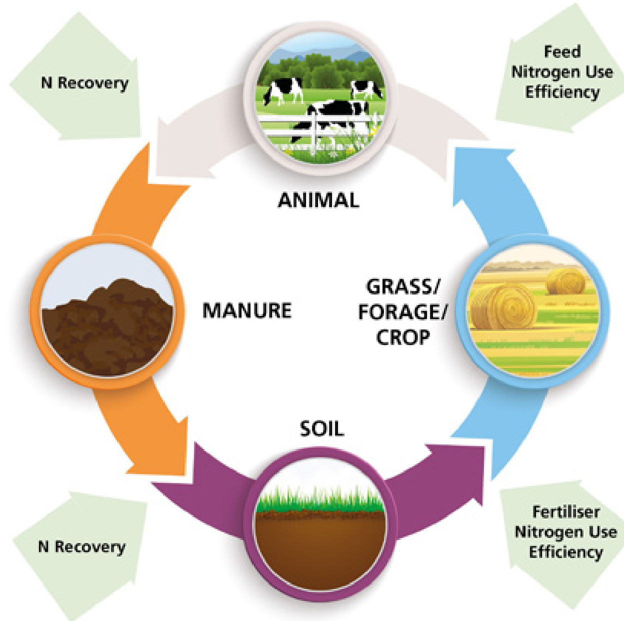

Figure 5: The Nutrient Loop

Nitrogen needs to be preserved at each stage of the farming process. Nitrogen Use Efficiency (NUE) is a unit of efficiency used in livestock or crop production. NUE is increased by increasing farm output per unit of nitrogen input. Techniques to improve N recovery include improved livestock housing and slurry storage and also low emission slurry spreading systems.

(Image credit: Agricultural Industries Confederation).

2. Reducing ammonia emissions when storing organic manures

All slurry and manure stores must comply with Nutrients Action Programme 2019 - 2022* These regulations include requirements on the design, location, construction and maintenance of silage and slurry stores to stop water pollution.

See NAP Regulations on the DAERA website for full details.

Nitrogen, in the form of ammonia, is lost from organic manures when they come into contact with air. Covering the manures or reducing the surface area of exposed material will reduce the amount of contact with air. This reduces the amount of ammonia released, meaning more nitrogen is retained in the manure.

2.1 Solid manures

It is important to minimise the movement of wind over solid manure in order to reduce ammonia emissions.

Cover manure heaps. Where practical cover with plastic sheeting, making sure that it is well secured to avoid it being blown away. This will also help to retain the nutrients within the solid manure and reduce odour.

Keep poultry manure and litter dry. This is particularly important as when it becomes wet it can lead to higher emissions of ammonia.

Make the surface area of the manure stack as small as possible. For example, storing in 'A' shaped heaps or constructing walls to increase the height will reduce the exposed surface area of manure. Take into account all health and safety considerations.

2.2 Slurry and other liquid organic manures

The Nutrients Action Programme 2019 - 2022* requires farmers planning to store poultry litter in fields to contact the NIEA's Agricultural Regulation Team for approval prior to placing the litter in the field. Poultry litter may only be stored in field heaps for a maximum of 120 days in the field where it is to be applied and must be covered with an impermeable membrane within 24 hours of placement in the field.

See NAP Regulations on the DAERA website for full details.

It is important to minimise the exposure of slurry and other liquid organic manures to air and wind in order to reduce ammonia emissions.

You must have enough storage capacity for slurry and manures.

This allows you to spread slurry and other liquid organic manures onto land when:

- your crops need it and maximum benefit can be obtained from the nutrients available.
- weather and soil conditions are right.

  This will help to minimise the loss of nitrogen to air and water. It is also important to ensure your slurry store is well maintained and replaced when necessary to prevent pollution incidents.

* https://www.daera-ni.gov.uk/publications/nutrient-action-programme-regulations-northern-ireland-2019-22-and-associated-documents

The Nutrients Action Programme 2019 - 2022* requires livestock farmers to provide minimum manure storage capacity:

All farms with livestock must provide a minimum of 22 weeks storage capacity.

However, pig and poultry farms with more than 10 breeding sow places or 150 finishing pig places or with more than 500 poultry places must provide a minimum of 26 weeks storage capacity.

See NAP Regulations on the DAERA website for full details.

Slurry stored in slatted tanks within livestock buildings

Methods to reduce ammonia emissions from slurry stored in tanks within livestock housing are covered in sections **5.2** and **6.2.**

Cover your outside slurry store

Putting a cover on your above-ground store or lagoon decreases airflow across the surface and reduces the amount of ammonia emitted into the air. The slurry surface will be shielded from wind, allowing ammonia concentrations to build up beneath the cover, suppressing further emissions from the slurry. This helps retain valuable nutrients within the slurry and can reduce the amount of any additional chemical fertiliser required.

Impermeable slurry store covers will also prevent rain from filling the storage. This can result in more predictable store capacity and, with less water, there will be less slurry volume to store, haul and apply. Costs associated with storage, haulage and application of slurry may be reduced, particularly in areas of high rainfall.

A rigid or fixed cover fitted to a concrete or steel slurry store **can reduce ammonia emissions during storage by up to 80%.** This is a requirement for all new, substantially enlarged or reconstructed above ground slurry stores from 2020 under the Nutrients Action Programme 2019 - 2022. You must ensure the store has enough structural integrity to support the weight of the cover. If adding a cover to an existing store, seek advice before starting construction to ensure the structure can support the extra weight and strain of the tensioned cover. You should contact the store supplier or the manufacturer before considering any modifications as stores can fail leading to disastrous consequences.

Figure 6: Fixed cover on an above-ground concrete slurry store at CAFRE.

A floating cover placed on top of the stored slurry **can reduce ammonia emissions during storage by up to 60%.** Floating sheeting can be used on concrete or steel slurry tanks but is best suited to small earth-banked lagoons. The sheeting may be made of plastic, canvas or other suitable materials. Rainwater collected on the sheeting can be removed using a small submersible pump which can significantly increase the storage capacity over the closed period.

Figure 7a:

Figure 7b

Figure 7a and 7b: A floating cover system on a NI dairy farm supported by central polystyrene floats and an outer ring pipe float. This has been successfully installed for 10 years.

Figure 8: Detail of tank fill pipe. Note that the tank fill pipe is extended down the inside of the tank to facilitate filling from the bottom when a floating cover is installed.

Considerations for large lagoons:

- Storage systems that have a large surface area per unit volume have more slurry exposed to the movement of air.
- The large exposed surface area makes it more difficult to control ammonia emissions from lagoons.
- Before constructing a lagoon, plan effective mitigation measures for reducing emissions, such as installing a cover.
- When designing any new structures for slurry storage, consider increasing the depth in order to reduce the ratio of surface area to volume of the store.

Apply an artificial floating crust to your slurry

Adding Hexa-cover (hexagonal shaped plastic units) or LECA (light expanded clay aggregate) pellets or other similar products to non-crusting slurry **can reduce ammonia emissions during storage by up to 60%.** These products rise to the surface and quickly form a barrier, reducing the interaction between the movement of air and the ammonium (dissolved ammonia) in the slurry. However, they will not reduce the amount of rainfall which can get into the store. Care may be required to avoid management issues when mixing or emptying the slurry store.

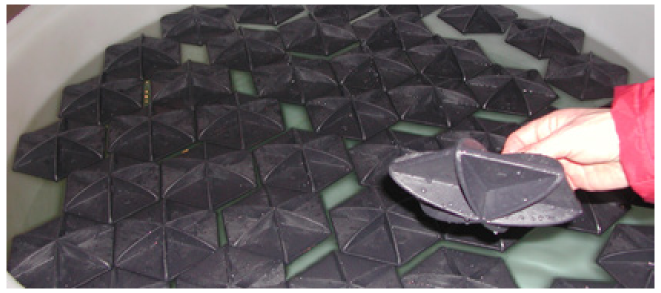

Figure 9: Demonstration of floating hexagonal plastic units

Allow a natural crust to develop

Where the fibre content of the cattle or pig slurry is high allow the slurry to develop a natural crust. **This can reduce ammonia emissions during storage by up to 40%.** A natural crust will not reduce the amount of rainfall which can get into the store.

Figure 10: Slurry tank with crust which can help to prevent ammonia loss.

Can slurry separation reduce ammonia emissions?

Manure separation can reduce ammonia emissions first by a reduction in ammonia formation, and then by a reduction in ammonia losses at application. However, overall ammonia emissions can be significantly higher if the separated liquid and solid are not managed correctly so this is not a recommended method for reducing ammonia emissions.

Mechanical separation of slurry and digestate removes solids (such as proteins and fatty acids) which restricts ammonia forming in the liquid fraction. However, emissions from the solid fraction could be higher than if it is stored as slurry under anaerobic conditions, particularly if it is uncovered or applied to grassland rather than by rapid incorporation into arable land. Emissions from the solid portion should be minimised during storage by covering the heap and during spreading by rapid incorporation into soil although this is only applicable in an arable or grass reseed situation. As with raw slurry and digestate, the liquid fraction should only be applied to soils that support infiltration (i.e. not saturated or very compacted). The low dry matter of the applied liquid fraction allows faster infiltration to the ground so reducing ammonia emissions and causing less soiling of grass swards.

Slurry gases can kill. Ensure all slurry stores and working practices comply with the necessary regulations.

Follow the code when mixing slurry -

www.hseni.gov.uk\\news\\farmers-remember-follow-slurry-mixing-code

2.3 Trees and their impact on ammonia emissions from the farmyard.

Trees are particularly effective at intercepting air pollutants, including ammonia. Trees and woodlands have the potential to reduce, capture or disperse ammonia emissions from animal housing, manure storage or areas where animals graze or range under the canopy.

Trees are also effective in reducing ammonia emissions by slowing the wind speed over the surface of stored manures, particularly from slurry lagoons.

Capture emissions

Trees are tall, have rougher surfaces (leaves, twigs etc.) and higher surface areas than a smooth surface like water or lower vegetation. Air movement through trees generates more mechanical turbulence which promotes dry deposition of ammonia onto the leaf surface.

Scientific modelling estimates indicate that up to 27% of ammonia emissions from livestock houses and up to 19% from other sources such as lagoons may be captured or deposited within the scrub, upper leaf canopy and coniferous backstop of semi-mature plantings. Up to 60% of ammonia emitted from livestock grazing or ranging under trees could be recaptured (ref 6).

Disperse emissions

The turbulence created by trees increases mixing of the air which can lead to increased dispersion above the tree canopy. This can help to lower the local impacts of ammonia emissions from your farm, such as damage to nitrogen-sensitive soils, habitats or water nearby.

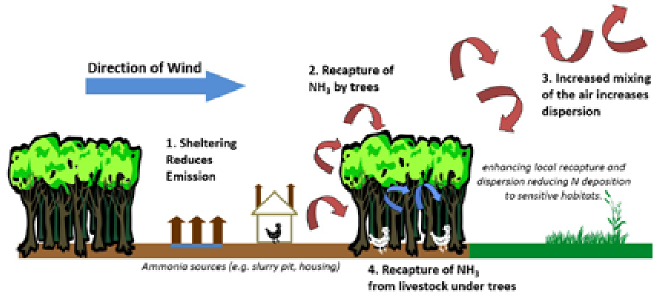

Figure 11: Diagram showing how trees can shelter livestock buildings and also both capture and disperse ammonia from livestock buildings

(Image credit: The Centre for Ecology and Hydrology, Edinburgh).

Planting trees should be considered as a complementary measure in reducing ammonia loss from farms alongside housing design, manure storage and manure spreading techniques.

Recommended types of tree planting:

- A distinct block of woodland (shelterbelt) located either upwind of the ammonia source to slow the wind speed or downwind to capture or disperse ammonia.
- An open plantation of trees, spaced to allow animals to graze or range through the area.

When designing tree shelterbelts to capture ammonia, there are two important objectives:

1. To ensure the ammonia enters the woodland through the main canopy requires an open understorey which prevents ammonia passing over the top of the woodland.
2. To prevent the loss of ammonia out of the downwind edge of the woodland. This requires a region of dense vegetation planted at the downwind edge (and sides if possible) to act as a backstop and force the ammonia up through the canopy.

Shelterbelt design will vary according to the site, predominant wind direction and ammonia source. For example, greater capture from low height emission sources such as a lagoon will be achieved by an immediate dense conifer belt whereas a combination of mixed understorey, higher tree canopy with a conifer backstop is more effective for taller sources such as livestock houses (ref 6).

Planting downwind of your housing and no further than 10-20m from the housings will maximise the capacity of the shelterbelt for ammonia capture.

It is important to seek advice before planting to ensure the trees are placed in an appropriate location to maximise their impact. In addition, care should be taken with site and species selection to minimise any potential damage trees could do to nearby buildings.

Other benefits associated with planting trees

Tree shelterbelts offer a package of benefits and can be seen as highly beneficial to farmers and to society as a whole. These 'added value' benefits include:

- Carbon sequestration and greenhouse gas reductions. Carbon and nitrogen captured by the trees contribute to carbon and nitrogen sequestration and play a role in achieving the UK's emission reduction targets for greenhouse gases (carbon dioxide, methane and nitrous oxide).
- Visibility screening around housing units
Visibility impacts can be improved as trees can break up and soften the look of the geometric shape of a building or hide them completely.
- Improved animal welfare for agro-forestry systems
Improved animal welfare using agro-forestry type tree planting systems can be achieved through providing shelter for protection from:
  - predators
  - the sun in hot weather (reducing heat stress)
  - rain and wind during inclement weather.

  As a result, productivity can be improved and mortality reduced.
- Reducing ammonia critical load exceedance on protected sites.
Reducing the impacts of eutrophication (when N in excess of ecosystem demand) from ammonia emissions supports the goals of the Habitats Directive where critical load exceedance across the EU is high (70%).
- Reducing impacts of eutrophication on surface waters due to reduced nutrient run-off supporting goals of the River Basin Planning Process and Water Framework Directive.
- Increasing biodiversity
Providing new or increased wooded habitat of both broadleaves and conifers would increase the above and belowground biodiversity of the land and contribute to national targets for tree planting.

2.4 Where to get more advice

- The Construction Industry Research and Information Association (CIRIA) have produced free guidance on the selection, design and maintenance of farm nutrient storage: available at https://www.ciria.org/ItemDetail?iProductCode=C759F&Category=FREEPUBS
- You can get further information on the types of storage systems and covers available at https://www.unece.org/index.php?id41358 in the UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions (p15-18).
- The CAFRE Nutrient Calculators which are available in DAERA Online services at www.daera-ni.gov.uk/services/daera-online-services include a Manure Storage Calculator which is designed to help farmers comply with slurry storage requirements.
- The Nutrients Action Programme Regulations https://www.daera-ni.gov.uk/publications/nutrient-action-programme-regulations-northern-ireland-2019-registered-sr
- Information on shelterbelts for farmyard emission capture can be accessed through http://www.farmtreestoair.ceh.ac.uk/. While this tool is not fully operational for NI it contains good reference material and will help in determining ammonia capture.
- The Best Available Techniques Reference Document for the Intensive Rearing of Poultry or Pigs (BREF) can also be used as voluntary guidance for the rest of the sector and you can download it from the European Commission website https://eippcb.jrc.ec.europa.eu/reference/BREF/IRPP/JRC107189_IRPP_Bref_2017_published.pdf
- Depending on siting and specification, grant aid may be available for tree planting under DAERA Agri-Environment Schemes or Woodland Schemes.

For further information contact DAERA:

Agri-environment schemes
Telephone: 0300 200 7842

Woodland grants
Telephone: 0300 200 7847

3. Apply organic manures effectively and efficiently

You must ensure you apply organic manures in accordance with the Nutrients Action Programme (NAP). The NAP can be accessed at https://www.daera-ni.gov.uk/publications/nutrient-action-programme-regulations-northern-ireland-2019-22-and-associated-documents

Ammonia emitted during the application of organic manures to land accounts for 34% of total agricultural emissions.

Ammonia emissions and therefore nitrogen losses occur during spreading when the organic manures are in contact with the air. To make the most of the fertiliser value of slurry and to reduce emissions you should adopt methods which place slurry or digestate straight onto or into the soil. In arable and reseeding situations you should incorporate solid organic manures into the soil as soon as possible and at least within 12 hours to minimise nitrogen losses.

To gain the maximum agronomic and financial benefit from your organic manures, and to avoid increasing the risk of ammonia emissions and nitrate leaching into water, you should plan how to apply them according to soil type, nutrient status and crop needs. Testing of the organic manures should be used in conjunction with nutrient management plans to work out an appropriate application rate, together with appropriate times and methods of application. If you do not have these plans and would like to develop them, please see the references in Section 3.3.

3.1 Slurries, digestate and other liquid manures

You can reduce the amount of ammonia emitted during application of liquid organic manures (such as slurry and digestate) by decreasing the surface area exposed to the air.

Stop using splash plate slurry spreading systems

Splash plate systems are not recommended for spreading liquid organic manures because they create high ammonia emissions and they can also increase the risk of surface run-off into water.

Inverted splashplate systems operate by forcing liquid at high pressure onto an inclined plate and spraying the liquid into the air. The act of this spraying, together with the placement of the liquid on all of the soil or crop surface, means much of the nitrogen in the slurry or digestate is able to react with the air, forming ammonia, and less nitrogen remains in the material to fertilise the crops. If you are spreading on bare soil, you should incorporate the slurry or digestate into the soil immediately after application and at the latest within 12 hours. This can be done with a disc or a tine cultivator as, unlike for solid manures, they are just as effective at reducing emissions from slurry as using a plough.

Use low emission slurry spreading (LESS) techniques

Trailing hose, trailing shoe and injection systems are collectively known as 'low emission slurry spreading (LESS) systems'. They place the slurry or digestate onto or into the soil which means that more nitrogen is retained and less is able to react with the air to form ammonia. In some cases, this may mean it is cost effective to spread liquid organic manures with a LESS system rather than using a splash plate system, as you are getting more fertiliser value from the slurry. LESS systems are more precise, reduce overlapping and so result in a more even distribution of slurry or digestate and considerably reduced odours, compared to splash plate application.

It should be noted that slurry application using LESS techniques increases the nitrogen available to the crop meaning that there is the potential to reduce chemical fertiliser application rates or to achieve an increase in crop yield. AFBI trials have found a 21% increase in silage yields using the trailing shoe system to spread slurry (ref 7).

	Inverted splash plate	Trailing hose (low emission)	Trailing shoe (low emission)	Shallow injector (low emission)	Deep injector (low emission)
Typical range of dry matter	Up to 12%	Up to 9%	Up to 6%	Up to 6%	Up to 6%
Requires separation or chopping	No	Yes (if over 6% DM)	Yes	Yes	Yes
Relative work rate	→→→→	→→→	→→→	→→	→
Uniformity across spread width	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Ease of bout matching	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Crop damage	Moderate	Low	Low	Moderate	High
Relative odour	High	Moderate	Low	Low	Very low
Relative ammonia reduction	0%	30-35%	30-60%	70-80%	90%
Capital cost	£	££	£££	£££	££££

Table 1: Comparison of slurry distribution systems.

Levels of odour and ammonia emissions are given relative to surface broadcast application and assume that the slurry is not incorporated after spreading (ref 8).

Take particular care when crossing slopes with trailed equipment, especially tankers with heavy implements on the rear e.g. trailing shoe system or with equipment fitted with low ground pressure tyres and where possible avoid turning downhill. The following document provides advice when working on slopes - www.hse.gov.uk/pubns/indg185.pdf

See NAP Guidance (currently under review) on the DAERA website for further details on slurry spreading requirements https://www.daera-ni.gov.uk/publications/nutrient-action-programme-regulations-northern-ireland-2019-22-and-associated-documents

The trailing hose spreading system, sometimes referred to as dribble bar, can achieve a 30-35% reduction in ammonia emissions compared to splash plate slurry application and is suitable for grassland and arable crops (where the slope is less than 15%). Hoses connected to the boom of the spreader distribute the liquid organic manure directly onto the ground. For best performance i.e. to minimise the ammonia loss and to maximise the fertiliser value of the slurry, the hoses should be kept as close to the ground as possible. This should also minimise sward contamination.

Figure 12a

Figure 12b

Figure 12a shows that the trailing hose systems can be used by tanker and by umbilical hose as shown in **Figure 12b**.

The trailing shoe spreading system can achieve a 30-60% reduction in ammonia emissions compared to broadcast slurry and is suitable for grassland and arable land (pre-sowing). Metal 'shoes' ride along the soil surface, parting the vegetation and ensuring that the liquid organic manure is placed on the soil surface.

In addition to delivering a higher nutrient value from the slurry the grass leaf is not coated with slurry with benefits of reduced contamination at ensiling or earlier availability for grazing.

As the slurry is in bands it can be more susceptible to surface run-off if the bands run down the slope. The bands should be spread along the contours (across the slope) of the field and a large unspread gap of at least 10–15 m left before any open drains to prevent surface run-off.

The trailing shoe allows slurry to be applied to fields with a grass cover of up to 2250kg DM/ha giving a wider window of opportunity to spread the slurry. Spreading slurry with a trailing shoe into a grass sward with a cover of up to 2250kg DM/ha (i.e. longer grass) will also 'shelter' the slurry from wind and so help to reduce ammonia emissions post spreading.

Figure 13a: Close up of the trailing shoe parting the grass and the hose delivering the slurry.

Figure 13b: Trailing shoe slurry application into silage stubble.

Figure 13c: Bands of slurry after trailing shoe application. Note the much reduced surface area with very much reduced ammonia emissions and also reduced sward contamination.

Slurry injection systems can achieve a 70-90% reduction in ammonia emissions compared to splash plate slurry application. There are various types of injectors, which can be classed as either a shallow or deep injector based on how deep the liquid organic manure is placed in the soil.

Shallow injectors are suitable for arable land or grassland. Shallow injectors place the organic manure typically 4-6 cm deep in narrow slots cut into the soil, typically 25-30 cm apart.

Deep injectors are best suited to arable land (due to the damage that can occur to grass or crops). Deep injectors should only be used when the soil is sufficiently dry and not on land with a drainage system shallower than 70 cm depth in order to prevent water pollution. Deep injectors cut slots 10-30 cm deep and are spaced about 50 cm apart.

Injectors have limitations for use. They are not suitable for use on slopes greater than 15%, shallow soils, stony soils, highly compacted soils, high clay soils (over 35% clay) in very dry conditions, peat soils (over 25% organic matter content) or perforated-pipe drained soils that are susceptible to leaching.

Figure 14a

Figure 14b

Figure 14a and 14b: Shallow injection equipment

The most effective application type may not be appropriate for your land. For example, small irregular shaped fields may present difficulties for large machines and hilly terrain or stony, dry soils may prevent certain application methods. Use of an injector in unfavourable soil or weather conditions, and/or at too high an application rate, could lead to surface water and/or groundwater pollution. Seek advice before purchasing new equipment to ensure it is appropriate for your land and to see if any financial support is available. In some cases, it may be more cost-effective to use a contractor.

Time your application appropriately

Ammonia emissions almost double with every 5°C increase in temperature and also increase with wind speed due to the increased movement of air over the organic manures.

To reduce ammonia emissions and retain nitrogen for crop use, you should aim to apply slurry, digestate and other liquid organic manures:

- under cool, windless and damp conditions (not raining or waterlogged)
- when wind speed and air temperature are decreasing.

High levels of ammonia emissions will occur when slurry is applied in the higher temperatures of mid-summer especially in windy and dry conditions.

Maximise the use of the nitrogen content in slurries by applying at or before times of maximum growth and when losses through ammonia emissions will be lowest. In general, spring is the most efficient application period for nitrogen in slurry.

To avoid odour nuisance when spreading near to residential areas you should consider wind direction and time of day, and use low emission spreading equipment wherever possible.

Slurries and other liquid organic manures should only be applied to soils that support infiltration (not saturated or very compacted) to minimise both air and water pollution.

Umbilical systems can be used with all low emission spreading technologies. Using an umbilical system will reduce the machinery weight and corresponding soil compaction, particularly at times when soils are wet and therefore more vulnerable.

Take care when using umbilical systems to ensure they are not near waterways in case of leakage

Slurry acidification before spreading

Lowering the pH of slurry or digestate to pH 5.5 – 6.0 will reduce the amount of ammonia released to the atmosphere by up to 70%, helping to retain nitrogen so it can be used by crops. This method, normally using sulphuric acid, is applicable to pig slurry, cattle slurry and digestate, as used in Denmark.

Specialist commercial equipment must be used to acidify slurry and you must ensure that your building or store will not be damaged. Only commercially available acids that are recommended for slurry/manure pH reduction purposes should be used.

Concentrated sulphuric acid is hazardous and you must comply with all relevant health and safety regulations regarding the storage, handling and use of acids.

Ref. HSENI at www.hseni.gov.uk

Acidification can be carried out either in the housing period or at the time of application:

- Housing period acidification involves using a pH monitoring and pumping system which in effect adds acid to the slurry in the tanks under the livestock. This means that ammonia losses are controlled at an early stage and there are also claimed improvements to the air quality in the building.
- Application acidification involves using specialist equipment (which can be retrofitted to some tankers) to apply acid to the slurry or digestate immediately prior to application. A computer system controls the acid application rate to ensure that the target pH level is achieved.

Figure 15: Tanker and tractor with slurry acidification system operated by a contractor in Denmark.

Whatever system is used it is important to have an effective pH regulation system to lower the pH of the slurry or digestate to the target level (usually between pH 5.5 – 6.0). **It is important that the pH never goes below pH 5.0 as this leads to an increase in hydrogen sulphide generation and would be especially dangerous for the housing period acidification.**

Applying anything slightly acidic to the land will have an impact on soil pH. However, it is important to note that rainfall is slightly acidic and the quantity of acid applied via treated slurry is minimal compared to the soil volume total. In theory 1 kg of additional lime would be required per kilogram of added sulphuric acid which over a 5 year period would equate to approximately 500 kg of additional lime requirement on one hectare of heavily slurried silage ground.

To maximise nutrient uptake and therefore efficiency it is essential that all land is routinely soils tested every 4 years to enable soil pH to be maintained at the optimum of 6.0-6.2 for mineral soils.

3.2 Solid manures

These include poultry and farmyard manures, sewage sludge cake, separated digestate fibre and compost made from green waste.

In arable situations incorporate solid manures into bare soil as soon as possible.

An integrated system with cultivation equipment following application equipment is ideal. Ploughing is generally more effective than disc or tine at reducing ammonia emissions from solid manures, despite the longer timeframe involved.

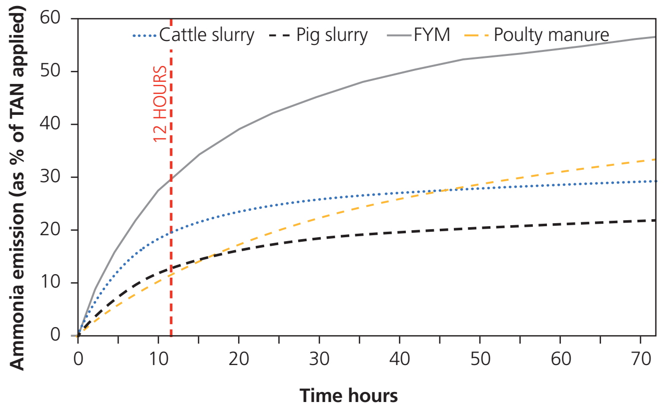

Figure 16: Ammonia loss as a percentage of Total Ammoniacal Nitrogen (nitrogen in the form of ammonia) applied (%TAN) with time following application if the manures are not incorporated. The maximum 12 hour recommended target for incorporating the material is shown as the vertical red dashed line.

(Graph courtesy of Rothamsted Research, ref 9)

Figure 17: The earlier organic manure is incorporated the less nitrogen is lost. For example, the difference between incorporation of cattle slurry within 1 hour versus 12 hours is 3% ammonia emissions as TAN compared with 20% ammonia emissions at 12 hours.

(Image credit Allan Chambers, Downpatrick).

3.3 Where to get more advice

DAERA has issued Regulations on the use of organic manures and manufactured fertilisers on farmland in the Nutrients Action Programme https://www.daera-ni.gov.uk/publications/nutrient-action-programme-regulations-northern-ireland-2019-22-and-associated-documents

CAFRE has incorporated the NAP Regulations and the Nutrient Management Guide (RB209) into the CAFRE Nutrient Calculators available at https://www.daera-ni.gov.uk/services/daera-online-services

An additional calculator which allows you to calculate the dry matter content of your slurry has been included for 2019. These calculators are easy to use and will calculate the nutrients supplied by organic manure applications and the requirement for chemical fertiliser. The Nutrient Management Guide (RB209) provides guidelines for crop nutrient requirements and the nutrient content of organic manures and is maintained by the Agriculture & Horticulture Development Board (AHDB). Please note that NI has its own figures for nutrient content of some manures, for example, poultry manures. These are incorporated into the CAFRE Nutrient Calculators.

For more information on soil testing and testing organic manures call with your local DAERA office.

4. Use chemical nitrogen fertilisers effectively and efficiently

You must ensure you apply chemical fertilisers in accordance with the Nutrients Action Programme https://www.daera-ni.gov.uk/publications/nutrient-action-programme-regulations-northern-ireland-2019-22-and-associated-documents

All applications of chemical nitrogen fertilisers should be based on a nutrient management plan, integrating fertiliser and manure supply. As with organic manures, you should only apply chemical nitrogen fertiliser according to crop requirement and when weather and soil conditions are suitable. Regularly maintain, calibrate and test all application equipment as appropriate to ensure efficient distribution and utilisation of the nutrients supplied. Consult the National Spreader Testing Scheme or your machinery dealer and the spreader handbook to test your equipment and change settings, as prill size and density varies with different fertilisers.

When applying any chemical fertiliser N or organic manure N there will be lower emissions where soils are at the optimum pH. (The target pH for mineral and organic soils is 6.2 for grass and 6.7 for arable, and 5.5 for grass and 6.0 for arable in peaty soils.) Soils should be routinely tested every 4 years to allow nutrient management planning to maximise nutrient recovery efficiency, and particularly to ensure that soil pH is maintained at optimum levels.

4.1 Urea and Calcium Ammonium Nitrate (CAN)

Up to 45% of nitrogen can be lost from urea-based fertilisers as ammonia, depending on conditions such as weather and soil type. Whilst losses as ammonia are very low from CAN it has much higher susceptibility for N losses as nitrous oxide (N_2O), which is one of the most potent greenhouse gases.

Consider using stabilised urea instead of straight urea fertiliser.

Ammonia emissions have been shown to be reduced by up to 78.5% when stabilised urea (urea with NBPT) is used instead of straight urea whilst also maintaining agronomic yields relative to CAN. Stabilised (also known as treated or protected) urea has reduced ammonia emissions because it contains a urease inhibitor eg. NBPT. Use of a proven urease inhibitor will delay the breakdown of urea to allow subsequent rainfall to wash it into the soil.

Consider potential nitrogen loss when selecting chemical fertiliser.

AFBI and Teagasc collaborative research has shown that using stabilised urea (urea with NBPT) instead of CAN may reduce greenhouse gas emissions by 71% on average in grassland whilst maintaining comparable yields.

4.2 Time your application appropriately

To reduce emissions of ammonia, you should apply chemical fertilisers to the soil during favourable conditions, maximising the adsorption of ammonium ions onto the clay component of the soil and organic matter, and at a time when crops can make maximum use of the nitrogen.

For CAN:

- You should plan applications in cool but moist conditions and do not apply when rainfall is expected. This will minimise the risk of nitrogen loss (to both air and water).

For urea and stabilised urea:

- You should plan applications when soils are moist (not wet), or when light rain is expected in the 12 hours after application, and the weather is cold. Be aware of the potential for run-off and leaching so, when feasible, in arable situations you should incorporate it into the soil immediately after application.

- Timing: do not apply slurry close to and definitely not within 10 days either before or after urea or stabilised urea application. Do not apply urea or stabilised urea close to and definitely not within 10 days before liming. In addition, when changing fertiliser products such as a change from CAN to stabilised urea ensure that your fertiliser spreader is calibrated for urea and also note that the bout width is also likely to change.

4.3 Use low emission application techniques

Use the following measures to help minimise ammonia emissions from the application of chemical nitrogen fertiliser:

- Use of urea with urease inhibitors can reduce ammonia emissions by 78.5% relative to solid urea.
- In arable situations rapid incorporation of urea fertiliser into the soil can reduce ammonia emissions by over 50%.
- In irrigated systems, irrigate to at least 5 mm immediately after urea application to encourage adsorption into the soil.

Avoid:

- The use of foliar sprays of urea when vegetation or soil is wet or when windy, dry and sunny conditions are forecast.
- Urea application on light sandy soils. The low clay content results in limited capacity to adsorb ammonium.
- Non-stabilised urea application to grassland and arable crops in dry periods.

4.4 Where to get more advice

FACTS Qualified Advisers deliver current nutrient management advice for crops and grassland.
For more information visit
http://www.factsinfo.org.uk/facts/home.eb
Make sure they have an up-to-date 'FACTS Qualified Adviser' (FQA) card.

CAFRE has incorporated the NAP regulations and the Nutrient Management Guide (RB209) into the CAFRE Nutrient Calculators available at www.daera-ni.gov.uk/onlineservices

These calculators are easy to use and will calculate the nutrient requirements for crops and grass and help determine appropriate application rates for manures and chemical fertilisers.

You may want to consider using specialists to check your fertiliser spreader is working efficiently, such as those available through the https://www.nsts.org.uk/ which also covers fertiliser spreaders.

5. Dairy and beef sector-specific measures

5.1 Cattle diets

Before making adjustments to the diets of your livestock, you may wish to seek advice from a registered feed adviser to ensure that the appropriate dietary requirements of the animals are being met. Make sure they have an up-to-date Feed Adviser Register (FAR) card. Guidance on legislation regarding diets is available at https://www.food.gov.uk/business-guidance/animal-feed-legislation

You can reduce the amount of nitrogen excreted by your cattle by matching (as closely as possible) the nitrogen (crude protein) content of diets to the expected level of production and the particular growth stage of the livestock. The retention of dietary nitrogen (crude protein) by cattle is low with 65–90% of that fed being excreted in urine and faeces. Research has confirmed that it is possible to reduce crude protein (CP) in animal diets without affecting animal performance, health and welfare. A reduction of 1% CP content in ruminant diets can reduce NH_3 emission by 5–15%. (ref 10) The aim should be to achieve general good health and welfare and feed optimisation to improve nitrogen use efficiency.

Consider the following techniques for reducing ammonia emissions through diet selection and management and improved feed efficiency:

- Use a registered nutritionist to formulate rations for cattle, taking account of breed type, gender, stage of production and the quality of feeds available on the farm.
- Know the dietary crude protein (CP) content of home grown forage. Where possible, this should involve regular, representative sampling of Total Mixed Rations (TMR) and/or feeds with variable CP content (such as fresh grass and silage).
- Full nutritional analysis should be carried out for all forages – with feed program precisely calculated based on energy requirements and digestibility of forage, then balanced with appropriate proteins to ensure optimum nitrogen utilisation. The diet must ensure the rumen is supplied with the right balance of fermentable energy and protein and that the cow has an adequate blood glucose supply.
- Consider the farm-specific situation: higher and successful CP reductions (around 2-3% units) can be achieved more easily in TMR-based feeding systems. CAFRE has achieved a 2% reduction in overall CP content of the TMR fed to its dairy herd on a grass-silage based diet which is more applicable to NI dairy farms.
- Precise balancing of protein requirements to achieve protein levels of 15 to 16% in total ration in early lactation, depending on expected milk yields - reducing by 1 or 2% in late lactation. The priority is to maintain the cow in a positive energy balance and prolong her productive life. Adding an extra lactation in the life of the cow reduces replacement rate and greatly increases efficiency of the dairy enterprise. It is better to manage for lifetime yield than for high individual lactations.
- Recalculate the protein requirements of your cows throughout the lactation and adjust or balance feed according to yield and body condition.
- Establish the protein requirements of your animals and adjust or balance feed accordingly. Accurate determination of ruminant protein requirements and the supply of amino acid available for absorption are critical for optimising dairy cow performance, while minimising N inputs and NH_3 emissions.

- Use of grass varieties with a high content of water soluble carbohydrate can reduce N urinary excretion by 29% through more efficient utilisation of the dietary N in the rumen.
- Increasing dietary fermentable carbohydrate content and improving forage silage quality can decrease N excretion.
- Beef animals on a silage based diet can be finished offering energy feeds such as barley, without the need for additional protein supplementation.
- Avoid overfeeding dietary CP. This is the main reason for low efficiency of nitrogen utilisation. Surplus nitrogen present as crude protein in the diet is excreted by cattle mainly in the form of urea in the urine.

5.2 Cattle housing

When urea in cattle urine comes into contact with the cattle faeces an enzyme, urease, found in faeces converts the urea to ammonia which is readily lost to the air. Urine and faeces come into contact:

- on the floor surface
- in bedding
- in the slurry storage system.

Management of floor surfaces, bedding and slurry storage can reduce ammonia emissions from cattle buildings. Various techniques including the management practices and new technologies described below can be employed to reduce ammonia emissions, particularly when refurbishing or constructing new buildings.

Regularly wash or scrape floors

Peak ammonia emission rates are between 1 and 6 hours after urine deposition depending on temperature, so increasing the frequency of scraping in the cowshed will reduce ammonia losses. Scrapings should occur at least twice daily, for the collecting yard and as regularly as possible in a cubicle house with an automatic system, ideally every 2 hours.

Figure 18: Robotic scraper over grooved floors at CAFRE's Dairy Centre is used to increase scraping frequency and ensure good urine drainage.

Frequently transfer slurry to a suitable store. The sooner slurry reaches the store the lower the exposure to air and consequent ammonia loss.

Research evidence indicates that as much as 20% of urine can remain on the flat surface of slats. Modern slat design includes slats with surface grooves for improved urine drainage to the tank below.

Design floors to drain effectively so urine and slurry are not allowed to pool (pooling of urine increases the exposed surface area and increases ammonia loss). Modern floor design, using grooved flooring systems with toothed scrapers, can achieve 40–50% reduction in ammonia losses.

Grooved floors allow urine to drain into the grooves reducing the urine surface exposed to the air between scraper runs.

Figure 19: This product can be retrofitted onto existing slats to give a curved upper surface to speed up urine drainage to the tank beneath. It is often fitted over slats to improve animal comfort but it has been found to perform well in reducing ammonia emissions. Flaps can also be fitted which are designed to allow slurry to drop into the tank but reduce fresh air contact with slurry in the tank to minimise ammonia losses.

Figure 20a: This product is a complete slatted flooring system that has also performed very well in tests in reducing ammonia emissions.

Figure 20b: It also can be fitted with flaps which are designed to allow slurry to drop into the tank but reduce fresh air contact with slurry in the tank to minimise ammonia losses.

Figure 21a

Figure 21b

Figures 21a and 21b: CAFRE's Dairy Centre cow accomodation has a grooved surface to help with the separation of dung and urine and is installed with an automatic scraper system that runs every 2 hours. The dimpled surface is for cow grip. The latest 'solid floor' designs have additional grooves to further improve urine drainage.

Avoid ventilation directly above the surface of slurry in tanks to minimise the velocity of the air over the surface of the manure. Where this is unavoidable, the gap between the slats and the manure surface should be sufficiently large to minimise draughts across the surface. Slats with flaps will help reduce tank space air movement.

Reduce the pH of the slurry (acidification). See Section 3.1.

Increase the amount of straw used per animal for bedded systems. Straw can soak up urine and help to keep floors dry, preventing pooling of urine. The appropriate amount of straw depends on the size of animal, feeding system, housing system and climate conditions.

5.3 Pasture practices

Extended grazing

Urine when excreted by grazing animals does not normally mix with faeces, so the action of urease (an enzyme in present in faeces) on urea in urine is minimised, meaning very low ammonia emissions when livestock are at grass. Therefore, ammonia emissions per animal are much less for grazing animals than for those housed where the excreta is collected, stored and applied to land. Total ammonia emissions increase significantly when a dairy herd changes from a traditional winter housed, summer grazed system to total confinement. AFBI have calculated that a total confinement dairy system has an increase in ammonia emissions per litre of milk of over 30% compared to a traditional system were the cows grazed during the summer.

Clover swards

In a productive ryegrass clover sward between 100–150kg/ha of usable nitrogen is generated by Rhizobia bacteria that live in nodules on the roots of the clover plants. The symbiotic bacteria convert nitrogen from the air into nitrates which become available for sward production. The use of clover to replace chemical fertiliser eliminates the greenhouse gas emissions involved in fertiliser production and spreading.

Multi-species swards

The coarse root system of white clover and other constituents of herbal leys/multi species swards create improvements in soil structure due to greater root strength and depth. This helps tackle soil compaction by increasing gaps between soil aggregates, which enhances the speed of infiltration, hence reducing ammonia emissions from grazing animals' urine, and slurry and fertiliser applications.

5.4 Where to get more advice

The Agriculture and Horticulture Development Board (AHDB) have produced a range of relevant guidance including 'Dairy housing: A best practice guide' and 'Feeding growing and finishing cattle for better returns', PDF downloads are available at: https://ahdb.org.uk/

The UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions is available to view at: http://www.unece.org/fileadmin/DAM/env/lrtap/Publications/Ammonia_SR136_28-4_HR.pdf further information on the ways to reduce ammonia emissions through ruminant feed (p20-23) and from cattle housing (p27-32).

6. Pig sector-specific measures

6.1 Pig diet

Before making adjustments to your pig diets get advice from a registered feed adviser to ensure that the appropriate dietary requirements of the animals are being met. Make sure they have an up-to-date Feed Adviser Register (FAR) card. Guidance on legislation regarding is available at: https://www.food.gov.uk/business-guidance/animal-feed-legislation

You can reduce the amount of nitrogen excreted from your pigs by matching, as closely as possible, the protein content of diets to the requirements of the pigs. Achieving good health, welfare and performance ensures the feed, especially the protein content, is used efficiently. Consider adopting of the following techniques to reduce ammonia emissions:

- Using proven genetics whilst ensuring good health, welfare and management of pigs will help to maximise feed efficiency.
- Regularly review pig diets with your nutritionist/supplier and adjust, if required, to ensure the rations fed match nutritional requirements.
- Use multi-phase feeding to improve the precision of nutrient supply, thus reducing waste and emissions.
- Evidence suggests that a 1% decrease in crude protein in the diet of finishing pigs results in a 10% reduction in the total ammoniacal nitrogen (TAN) content of pig slurry and 10% lower ammonia emissions (ref 11 and 12). However always discuss changes in ration formulation with your nutritionist.

6.2 Pig housing

Consider the following techniques when refurbishing existing or building new pig houses.

- Using metal or plastic-coated slats for young pigs as these aid the removal of faeces to the tank.
- Using of acid scrubbers or bio trickling filters to remove ammonia from the air. These systems are fitted to the outlets of mechanically ventilated pig housing with some reducing ammonia emissions in exhaust air by up to 90%. It is important to only consider systems which have peer reviewed independent scientific research evidence.
- Avoiding ventilation directly above the surface of the slurry in channels and tanks. Minimise the velocity of air over the surface of the slurry, by providing a sufficiently large gap between the slats and the slurry surface. This gap should be at least 30 cm.
- Improving animal behaviour and pen design in part slatted systems to reduce fouling on the solid area. Provide pigs with functional areas for different activities, i.e. provide separate areas for lying, dunging, eating and exercising with the aim of keeping the solid part of the floor as clean as possible. Providing a slight slope on the solid area allows urine to drain to the channels.
- Emptying channels frequently using scrapers, a vacuum system or by flushing with water, untreated liquid manure (less than 5% dry matter) or separated slurry.
- Providing sufficient material in bedded systems to allow complete absorption of urine and changing the bedding frequently.
- Positioning water nipple drinkers on solid or part solid floor systems to avoid the solid floors and bedding from getting wet. Maintaining drinkers in good order and repairing leaking drinkers immediately will reduce water spillage.

- Installing gutters, trays or scrapers where possible, to allow for rapid drainage so that urine and faeces are kept separate.

- Reducing the exposed surface of the slurry beneath the slats by constructing V-shaped gutters or channels (maximum 60 cm wide, 20 cm deep) reduce the surface emitting areas. Gutters and walls should be smooth to prevent manure build up.

- Reducing the pH of the slurry (acidification), see Section 3.1. This can be done by two methods, either through the addition of acid to the tank or via an applicator at spreading. **Due to Health and Safety considerations this option requires expert advice.**

6.3 Where to get more advice

Pig units with a capacity for over 2,000 places for production pigs (over 30 kg) and/or over 750 places for sows require a permit to operate and they must comply with the permit conditions set by Northern Ireland Environment Agency (NIEA) under the Pollution Prevention and Control (Industrial Emissions) Regulations (NI) 2013.

In order to comply with these conditions, farms are required to use the techniques set out in The Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs (BREF) for avoiding or minimising all types of emissions. BAT is reviewed and updated periodically - a new version of the BREF was released in 2017. New PPC farms must comply with the new BAT Conclusions from first operation whilst existing PPC farms have four years to comply i.e. by 21st February 2021.
If you are considering building new sheds or facilities, expanding or changing your operation please contact NIEA to check what the new requirements are.

The BREF can also be used as voluntary guidance for the rest of the sector and you can download it at https://eippcb.jrc.ec.europa.eu/reference/BREF/IRPP/JRC107189_IRPP_Bref_2017_published.pdf

7. Poultry sector-specific measures

Most poultry producers in NI are aligned to a processor or egg packer who is responsible for the formulation of the poultry diets. These diets closely match the nutrient requirements to each stage of production. This process ensures that nitrogen is supplied and utilised efficiently by the bird at every stage through selection of the best genetics, nutrition, health and management of the poultry. For independent, small scale producers and supplier companies Section 7.1 Poultry diet, is relevant.

7.1 Poultry diet

Before making adjustments to the diets of your livestock, you may wish to seek advice from a registered feed adviser to ensure that the appropriate dietary requirements of the animals are being met. Make sure they have an up-to-date Feed Adviser Register (FAR) card. Guidance on legislation regarding diets is available at: https://www.food.gov.uk/business-guidance/animal-feed-legislation

Consider the following techniques for reducing ammonia emissions through good diet selection and management:

- **Improve feed conversion to weight gain** and reduce feed surplus by adopting high standards of management and welfare, and monitoring feed and water intake and growth rate.

- **Match the nutrient requirements** at all stages of production to improve the precision of nutrient supply.

7.2 Poultry housing

Poultry housing should be kept as dry as possible as poultry manure and litter emit more ammonia when wet.

Consider these techniques for reducing ammonia emissions from your poultry housing, particularly when refurbishing or constructing new buildings:

- Regularly check building structure and water drinkers to reduce any leaks and keep litter dry.

- Collect and remove manure frequently with a manure belt system to covered storage outside the building. Ammonia emissions become significant when the manure is one to two days old and increase rapidly at five days old, therefore the removal frequency should be two or three times per week. Manure will emit less ammonia when the surface area available to the air is reduced by storing in a covered pile.

- Manure drying systems on the manure belts will increase manure dry matter. A pipe system using recycled warm air aimed at the manure belt will reduce moisture.

- Intensively ventilated drying tunnels, inside or outside the building, can increase the dry matter content to 60%-80% in less than 48 hours.

- Ventilate the pit in deep pit systems. This reduces the moisture content of the manure.

- Use of acid scrubbers or bio trickling filters to remove ammonia from exhaust air. A multistage scrubber is recommended because of the co-benefits in reducing ammonia and other particulate emissions. These can include substantial amounts of phosphorus and other elements which can be recycled as plant nutrients. The effectiveness of scrubbers in a free range system should be explored with the equipment manufacturer.

7.3 Where to get more advice

Poultry units with a capacity for over 40,000 bird places require a permit to operate and they must comply with the permit conditions set by the Northern Ireland Environment Agency (NIEA) under the Pollution Prevention and Control (Industrial Emissions) Regulations (NI) 2013. In order to comply with these conditions, farms are required to use the techniques in The Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs (BREF) for avoiding or minimising all types of emissions. BAT is reviewed and updated periodically and a new version of the BREF was released in 2017. New PPC farms must comply with the new BAT Conclusions from first operation whilst existing PPC farms have four years to comply i.e. by 21st February 2021. If you are considering building new sheds or facilities, expanding or changing your operation please contact NIEA to check what the new requirements are. The BREF can also be used as voluntary guidance for the rest of the sector and you can download it from the European Commission website at: https://eippcb.jrc.ec.europa.eu/reference/BREF/IRPP/JRC107189_IRPP_Bref_2017_published.pdf

8. Conclusion

Protection of human health, the environment and sustainable farming

Reducing ammonia emissions from agriculture is important to:

- Reduce adverse impacts on human health.
- Prevent further damage to sensitive habitats.
- Help enable the UK to meet its internationally agreed targets for ammonia reduction.

This publication has aimed to show how widely recognised techniques, when applied in the context of Northern Ireland's agriculture production systems, can help make significant reductions to ammonia emissions.

It makes good business sense to efficiently convert the nutrients which have been brought onto the farm in the form of fertilisers and feedstuffs into products for sale such as milk and meat from livestock, grain, straw, potatoes etc. Expensive inputs are not wasted which benefits both the farm business and the environment in terms of air and water quality.

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