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Bia agus Mara  
Department of Agriculture,  
Food and the Marine

# Code of Good Agricultural Practice for reducing Ammonia Emissions from Agriculture



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## **1. ABOUT THE CODE OF GOOD AGRICULTURAL PRACTICE FOR REDUCING AMMONIA EMISSIONS FROM AGRICULTURE**

Ammonia is one of the gaseous phases of nitrogen and is an air pollutant, which has an adverse effect on human health and the environment. Agricultural activities account for over 99% of the national ammonia emissions. This code of good agricultural practice for reducing ammonia emissions (which will be referred to in the document as “the Code”) is a guidance document, that outlines the best practice measures for removing or lowering ammonia emissions associated with agricultural activities. The objective of the Code is to help farmers identify appropriate measures for their individual farm enterprise that will reduce ammonia emissions. Many farms are already delivering a good standard of environmental protection, maintaining land in good agricultural and environmental condition<sup>1</sup> however; there are always practices that can be enhanced. The measures contained within the Code are not exhaustive and are not intended to be taken in isolation. There are co-benefits to be obtained from reducing emissions to air, including reducing loss of nutrients to water bodies and reducing biodiversity loss. The measures in the Code complement good agricultural practices for the protection of waterbodies<sup>2</sup>.

It is important to seek professional guidance from an agricultural adviser or consultant when considering implementing a best practice measure outlined in the Code. Some relevant links for further technical information and guidance is provided at the end of each section. It is also vitally important to be mindful and take the necessary health and safety precautions when working on the farm to avoid unnecessary risk to you, others, livestock and the environment.

The following agricultural management activities contribute to ammonia emissions:

- Fertiliser application;
- Manure application;
- Animal feeding strategies;
- Animal housing and manure storage.

Ammonia is a significant precursor for secondary fine particles in the air. These are known to have an adverse effect on human and animal health and the environment. Therefore, reducing agricultural ammonia emissions will improve the air quality and benefit our health. As well as potentially damaging the environment, the release of ammonia is a cost to the farmer through the loss of a valuable plant nutrient. It is important that nutrients are applied using what can be referred to as the 4R principles: using the right nutrient source, at the right rate, at the right time and in the right place.

Nitrogen is a key farm input (through fertilisers and feedstuffs) and the priority should be to take steps to (i) introduce no more nitrogen into the production systems than is necessary and

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<sup>1</sup>

<https://www.agriculture.gov.ie/farmerschemespayments/crosscompliance/goodagriculturalandenvironmentalconditiongaec/>


<sup>2</sup>

<https://www.agriculture.gov.ie/media/migration/ruralenvironment/environment/nitrates/2019/NitratesExplanatoryHandbook070619.pdf>

efficient, and (ii) retain it within the production system rather than releasing it to the atmosphere. Utilising nitrogen efficiently will result in higher nutrient use efficiency on farm allowing farmers to be less dependent on purchased or imported fertilisers, and less exposed to price variations or supply issues. In addition, by managing nutrients more efficiently farmers can assist and adapt to challenges of climate change, sequester more carbon in soils, and reduce greenhouse gases (GHG) emissions. This is a win-win both for the farmer and the environment.

There are reduction targets for ammonia that Ireland must adhere to as a Member State (MS) to the European Union (EU). Under the National Emissions Ceiling Directive (NECD) Ireland must reduce ammonia emissions by 1% below 2005 levels by 2020 and 5% below 2005 levels by 2030. In order to avoid potential fines and negative reputational damage on Irelands green image for breaching ammonia ceilings, ammonia emissions must be significantly reduced. It is imperative that existing efficient livestock production and manure management practices are encouraged along with adopting additional practices to reduce ammonia losses.

A summary of key good agricultural practice measures to reduce ammonia emissions are shown in the following chart. A star rating indicates the level of ammonia emission reduction associated with adopting the measure (1 star (0-40% reduction) to 5 stars ( $\geq$ 80-100% reduction)). These good agricultural practice measures will be discussed in more detail in the main body of the Code.

Farming Activity	Good Agricultural Practice to reduce Ammonia Emissions	Percentage Ammonia Emission Reduction
<p><b>Application of Fertilisers (organic and inorganic)</b> <i>(Section 3.1, p.13-16)</i></p> <p>0-40% ↓            ≥50% ↓            ≥60% ↓            ≥70% ↓            ≥80-100% ↓</p> 	<ul style="list-style-type: none"> <li>Preparation and effective use of a Nutrient Management Plan</li> <li>Limiting ammonia emissions from nitrogen fertilisers               <ul style="list-style-type: none"> <li>reducing the use of urea</li> <li>Replace with protected nitrogen products<sup>3</sup></li> <li>Soil incorporation<sup>4</sup></li> </ul> </li> </ul>	<p>★★★★</p> <p>★★★</p> <p>★★★★★</p> <p>★★</p>
<p><b>Manure Application</b> <i>(Section 3.2, p.17-19)</i></p>	<ul style="list-style-type: none"> <li>Timing of manure application<sup>5</sup></li> <li>Incorporation of manures into the soil<sup>6</sup></li> <li>Using low emission manure spreading techniques (LESS)</li> </ul>	<p>★</p> <p>★★★★★</p> <p>Injection<sup>7</sup>: ★★★★★</p> <p>Trailing shoe<sup>8</sup>: ★★★</p> <p>Trailing hose<sup>9</sup>: ★</p>

<sup>3</sup> Forrester, P.J., Harty, M., Carolan, R., Lanigan, G.J., Watson, C.J., Laughlin, R.J., McNeill, G., Chambers, B.J. and Richards, K.G., 2016. Ammonia emissions from urea, stabilized urea and calcium ammonium nitrate: insights into loss abatement in temperate grassland. *Soil use and Management*, 32, pp.92-100.

<sup>4</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120 . [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

<sup>5</sup> <https://www.teagasc.ie/media/website/publications/2009/Ammonia-emissions-5508.pdf>

<sup>6</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

<sup>7</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

<sup>8</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

<sup>9</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

### Agricultural Practices to reduce Ammonia Emissions (continued)

Farming Activity	Good Agricultural Practice to reduce Ammonia Emissions	Percentage Ammonia Emission Reduction
<b>Animal Feeding Strategies</b> <i>(Section 3.3, p. 20-25)</i>	<ul style="list-style-type: none"> <li>• Extended grazing <sup>10</sup></li> <li>• Maintaining the quality of crude protein when making silage</li> <li>• Use of low-crude protein animal feed and utilising the PDI system (protein digestible in the small intestine) and managing nitrogen application at grazing</li> </ul>	<p style="text-align: center;">★</p> <p style="text-align: center;">★</p> <p style="text-align: center;">★</p>
<b>Animal housing</b> <i>(Section 3.4, p. 26-28)</i>	<ul style="list-style-type: none"> <li>• Farm cleanliness<sup>11</sup></li> <li>• Improved housing management for all livestock e.g. regular and reduced yard scraping intervals</li> </ul>	<p style="text-align: center;">★★</p> <p style="text-align: center;">&gt;20-90% depending on animal type and livestock management<sup>12</sup></p>
<b>Manure storage</b> <i>(Section 3.5, p. 29-32)</i>	<ul style="list-style-type: none"> <li>• Farm yard manure storage; cover solid manure heaps<sup>13</sup></li> <li>• Covered external stores <sup>14,15</sup></li> <li>• Slurry/ manure amendments</li> </ul>	<p style="text-align: center;">★</p> <p style="text-align: center;">★★</p> <p style="text-align: center;">★★</p>

<sup>10</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

<sup>11</sup> Cited by Rachel Carolan in 'Making Ammonia Visible' An Annex to 'delivering our future, valuing our soils: a sustainable agricultural land management strategy for Northern Ireland. Produced by the Expert Working Group on Sustainable Agricultural Land Management in N. Ireland. Dec. 2017.








<sup>12</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

<sup>13</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

<sup>14</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

<sup>15</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

### Agricultural Practices to reduce Ammonia Emissions (continued)

Farming Activity	Good Agricultural Practice to reduce Ammonia Emissions	Percentage Ammonia Emission Reduction
<b>Other beneficial measures to reduce ammonia emissions</b> <i>(Section 3.6, p.33)</i>	<ul style="list-style-type: none"> <li>Planting trees as shelterbelts to capture ammonia</li> </ul>	
	<ul style="list-style-type: none"> <li>Incorporating fertiliser into the soil to minimise loss to air<sup>16</sup></li> </ul>	
	<ul style="list-style-type: none"> <li>Analysis of slurry and organic manure to determine its nutrient content</li> </ul>	
	<ul style="list-style-type: none"> <li>Inclusion of legumes and reduction of N fertiliser in grasslands</li> </ul>	
	<ul style="list-style-type: none"> <li>Protein analysis of grass to determine optimal nutrient requirements</li> </ul>	
	<ul style="list-style-type: none"> <li>Milk urea analysis and feedback to nitrogen management</li> </ul>	
	<ul style="list-style-type: none"> <li>Participation in Knowledge Transfer Groups and training courses to enhance agricultural knowledge and improve environmental awareness</li> </ul>	

**HEALTH & SAFETY SAVES LIVES:**

**Please do not take unnecessary risks while working on the farm. Please adhere to all health and safety practices.**

<sup>16</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf).

## 2. WHY IS THIS CODE NEEDED?

### 2.1. Nitrogen Loss – Why does it matter?

Nitrogen exists in several different forms, solid, gas and liquid. Ammonia is one of the gaseous phases of nitrogen and is an air pollutant. Agricultural activities account for over 99% of the national ammonia emissions. Nitrogen is one of the key farm inputs entering farms in the form of fertilisers and feedstuffs. Grasslands for example, receive the bulk of the 40 million tonnes (Mt) of animal manures produced during housing annually in Ireland, along with approximately 300,000 to 400,000 tonnes of nitrogen in fertilisers<sup>17</sup>. A proportion of nitrogen from these inputs is volatilised or lost into the air. It is estimated that approximately 15 per cent of the nitrogen in animal manures and two per cent from chemical fertilisers is lost to the atmosphere as ammonia<sup>18</sup>.

Ammonia has been found to have a negative impact on the environment and human health. Excess ammonia adversely affects ecosystems, impacting on sensitive plant, animal and invertebrates (e.g., butterflies, insects and birds), thereby changing species biodiversity. Once an ecosystem has been changed it takes a long time, potentially decades to recover and can be costly to restore. It can also have short and long-term negative impacts on human health. In combination with other air pollutants (NO<sub>x</sub> and SO<sub>x</sub>) it can lead to the formation of secondary particulate matter (PM<sub>2.5</sub>) which can have long-term effects on the cardiovascular system and respiratory system when inhaled.

As well as the potential for environmental and human health damage, there is an economic loss to the farmer as a result of the loss of valuable plant nutrients. Utilising nitrogen efficiently will result in higher nitrogen use efficiency on farm and reduce the need for imported nitrogen. Also efficient nutrient recycling means farmers are less dependent on imported and purchased fertilisers, and less exposed to price variations or supply issues<sup>19</sup>.

The main sources of ammonia on farm (2017 figures) are shown in Figure 1.

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<sup>17</sup> EPA (2018). Ireland's Transboundary Gas Emissions 1990-2016. March 2018.

<sup>18</sup> EPA (2018). Ireland's Transboundary Gas Emissions 1990-2016. March 2018.

<sup>19</sup> EIP-Agri Focus Group Nutrient recycling. Final Report. November 2017; [https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri\\_fg\\_nutrients\\_recycling\\_final\\_report\\_2017\\_en.pdf](https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_nutrients_recycling_final_report_2017_en.pdf)



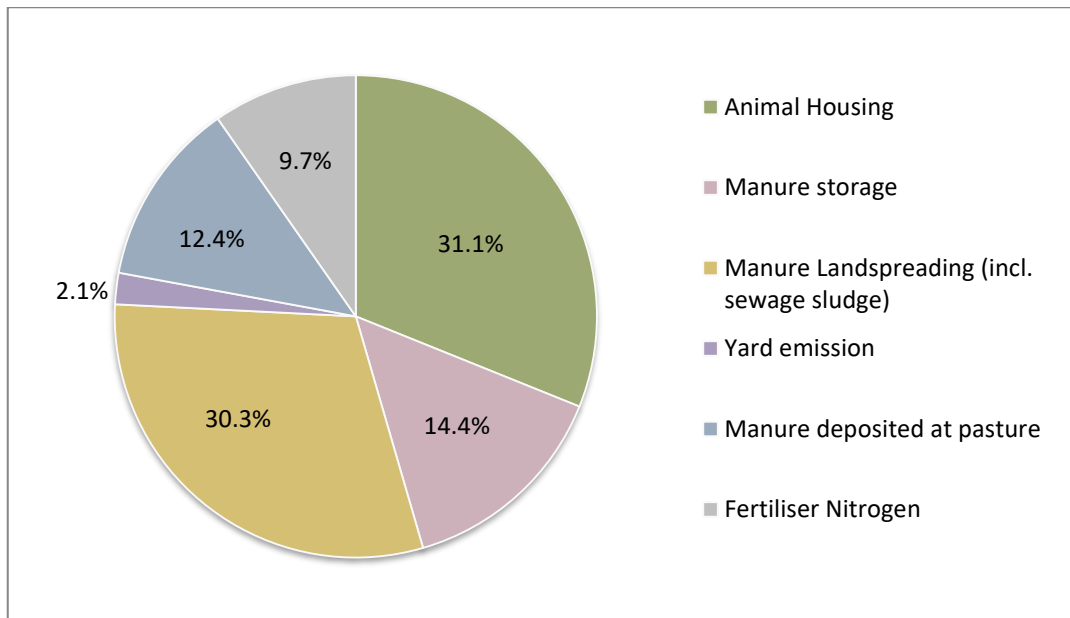


Figure 1: The main sources of ammonia emissions from agriculture (2017 EPA figures)

## 2.2. Objectives of the Code

The objective of the Code is to provide best guidance on farm practices that will reduce and limit ammonia emissions from agricultural and land management practices. The best practice measures outlined in this document will provide guidance on enhancing existing farm practices, as well as giving details about other easily adopted practices. These practices are centred on the agricultural management activities which are the key sources of ammonia emissions;

- Fertiliser application;
- Manure application;
- Animal feeding strategies;
- Animal housing and
- Manure storage.

Incorporation of some or all of these practices or enhancement of suitable manure and fertiliser strategies already on farms will reduce ammonia emissions and contribute to an overall reduction in ammonia losses. Also, manure measures are required when downstream pollution control measures are adopted to limit increased losses. The priority should be to take steps to:

- (i) Introduce no more nitrogen into production systems than is necessary and efficient;
- (ii) Retain nitrogen within the production system rather than releasing it to the environment. Utilising nitrogen efficiently will result in higher nutrient use efficiency on farm and the need for less additional bought in/ purchased nutrients. Also, efficient nutrient recycling can allow farmers to be less dependent on imported and purchased fertilisers, and less exposed to price variations or supply issues.

### **2.3. Legislation**

The Clean Air Strategy for Ireland led by the Department of Communications, Climate Action and Environment (DCCA) provides an opportunity to address air pollution in Ireland. Ammonia emissions are legislated for under the National Emissions Ceilings Directive (NECD). The establishment of this Code is a requirement under the NECD. In Ireland, there is a mandatory ammonia emission target since 2010 of 116 kilotonnes (kt), ammonia emissions must be reduced to 1% below 2005 levels by 2020 (112kt) and 5% below 2005 levels from 2030 onwards (107kt). Agriculture is responsible for many of these emissions and in recent year's ammonia emissions from agriculture have been increasing. The adoption and implementation of the good practice measures outlined in this Code will reduce ammonia emissions. However, it is also important to realise that our grass-based system of farming for cattle and sheep are recognised as having a low level of ammonia emissions. Grazing systems have been shown to provide a 50% reduction in ammonia emissions in comparison to confined systems of production<sup>20</sup>.

### **2.4. What is already being done to address the problem of nitrogen losses in Ireland?**

There are synergies between Ireland's air quality legislation and water quality legislation. Ireland, unlike other Member States (MS) has adopted a whole territory approach to nitrates implementation. All farmers are obliged to abide by nutrient management planning which has many synergies with reducing ammonia due to the efficient use of animal manure. The Nitrates Action Programme (NAP) gives effect to the Nitrates Directive; in late 2017 Ireland agreed with the European Commission on its fourth NAP for the period 2018-2021. The NAP agreed includes a balanced programme of measures supporting the objectives of achieving good water quality while at the same time encouraging sustainable and efficient agricultural practices.

In line with the agreement on the latest NAP, Ireland has availed of a derogation from the 170kg livestock manure nitrogen limit as provided for in the Nitrates Directive. This derogation enables farmers to exceed the 170 kg nitrogen limit up to a maximum of 250 kg N/ha subject to compliance with specific environmental conditions. The measures in Ireland's derogation take account of the growing numbers of derogation farmers who are farming at intensive stocking rates, and also environmental objectives for water, climate change and ammonia which Ireland must achieve. For example, a new condition for derogation farms has been included, i.e. from 2018, at least 50% of slurry must be applied by 15<sup>th</sup> June and after that it must be applied by using low emission slurry spreading (LESS) equipment. The practices within this Code are additional practices that can be adopted in conjunction with actions required under the Nitrates Directive.

The Department of Agriculture, Food and the Marine (DAFM) oversee and administer the Targeted Agricultural Modernisation Schemes (TAMS). This scheme supports capital investment in several target areas which will promote, among other things, sustainability, for example, the purchase of low emissions slurry spreading equipment. Grants are also provided towards farm nutrient storage. There is also a Nutrient Management Planning Online (NMP-Online) tool which is being used by trained advisers to produce fertiliser plans for farmers. Other tools and agri-

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<sup>20</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

environmental programmes include the PastureBase Ireland, the Carbon Navigator Tool, the Agricultural Catchments Programme and the Smart Farming programme which help to reduce carbon emissions per unit of output produced and help protect our rivers.

Knowledge transfer through advisory services and training programmes continue to play an important role in information sharing and helping to reduce nutrient losses. The Department of Agriculture, Food and the Marine has trained in excess of 800 advisors to meet Farm Advisory System requirements. Furthermore, thirty Sustainability Advisors have been appointed within Teagasc and the Dairy Processors, under the Agricultural Sustainability Support and Advisory Programme (ASSAP)<sup>21,22</sup>. This programme offers a free support and advisory service and participation is voluntary. The programme is designed to work closely with the farming community across 190 priority areas of action. The advisors will work together with the Local Authorities Waters Programme (LAWPRO)<sup>23</sup> and proactively advise and work with farmers to identify pressures, protect and improve water quality, climate change and biodiversity strategies. The advisors will assess the farmers' farmyard, nutrient management plan and nutrient management practices and his/ her farmland management. The farmer and the advisor will then focus on whether improvements or actions may or may not be needed on the farm. The advice is designed to 'break the pathway' of pollution and prevent nutrients entering water.



Image Credit: National Rural Network (2018)

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<sup>21</sup> <https://www.teagasc.ie/environment/water-quality/farming-for-water-quality-assap/>

<sup>22</sup> <https://www.teagasc.ie/media/website/publications/2019/WEB-Improving-Farm-Sustainability---A5---12pp.pdf>

<sup>23</sup> <http://watersandcommunities.ie/>

### 3. A SET OF GOOD PRACTICE MEASURES TO CONTROL AND REDUCE AMMONIA EMISSIONS FROM AGRICULTURAL ACTIVITIES

The main sources of ammonia emissions from agriculture arise from the production and application of livestock manures and synthetic fertilisers. The good practice measures give guidance on reducing emissions from these key areas:

- Limiting ammonia emissions from the use of mineral fertilisers;
- Manure application and low-emission manure spreading techniques;
- Animal feeding strategies;
- Animal housing systems;
- Manure storage systems;

Ammonia is generally the largest nitrogen loss pathway on farms. There are nutrient use efficiency benefits and potential reductions in the cost of fertiliser on farms to be gained from reducing ammonia emissions. There are also environmental co-benefits and trade-offs which must be considered to air, soil, water and biodiversity associated with adopting any of these measures;

**Air:** Decreased ammonia emissions leading to less particulate matter, odour and ozone formation which lowers risks to human health (e.g., aggravated asthma and respiratory problems).

**Soil:** Improved soil condition due to improved fertiliser management to enhance and maintain plant growth.

**Water:** Reduced leaching and run-off of nutrients, decreasing eutrophication and improving surface and groundwater quality, thereby also lowering risks to human health and biodiversity.

**Biodiversity:** Positive effects on biodiversity from reduced nitrogen deposition in natural ecosystems.

### **3.1. Limiting ammonia emissions from the use of organic and inorganic fertilisers**

Ammonia emission from fertiliser applications is dependent on fertiliser type, weather and soil conditions. Organic manures, such as slurry, farmyard manure, sludge and composts are natural sources of nitrogen, which enhance soil fertility and facilitate plant growth; they may be supplemented with inorganic fertilisers if necessary. All applications of nitrogen fertilisers must be applied in accordance with the nutrient planning requirements of the Nitrates Action Programme (NAP). The aim of which is to ensure nutrients are applied under favourable soil, weather and plant growth conditions maximising their absorption in the plant thereby reducing ammonia emissions. Further information about the Nitrates Action Programme and the Directive can be found in the Appendix.

#### **The preparation and use of a Nutrient Management Plan (NMP)**

The preparation of a nutrient management plan for a farm as outlined under Ireland's whole territory approach to nitrates allows for the efficient and balanced use of fertilisers. It allows for the maximising of the return from on-farm and off-farm organic fertiliser resources, biological fertilisers and if required chemical fertilisers to balance plant needs. A key aspect of nutrient planning is determining the amount of N, P, K and other nutrients. This can vary according to the soil type, weather condition, application rate, application techniques, characteristics of the organic and mineral fertilisers used<sup>24</sup>. A summary of the NMP for farmers ensures targeted use of chemical and organic fertilisers based on accurate soil samples, waste storage capacities, stocking rates, feed usage inputs, organic fertiliser imports and exports. Following a well prepared NMP will have economic benefits as well as protecting the environment, by reducing nutrient loss to water and emissions to air.

Taking reliable representative soil samples is vitally important<sup>25</sup> and getting them analysed by an accredited laboratory (e.g., an Irish National Accreditation Board accredited laboratory). Organic manures can also be analysed to determine their nutrient value.

The nutrient requirements for a farm can be calculated and interpreted with the help of an approved agricultural advisor/ consultant, who can also prepare the NMP. The amount of fertiliser applied is determined by a soil fertility report and the crop requirement, helping to maintain and enhance soil fertility and reduce losses to the environment. A large proportion of soils in Ireland are sub-optimal in terms of pH, P and K; therefore, optimising soil fertility will allow nitrogen fertiliser rates to be reduced<sup>26</sup>, increasing nutrient use efficiency. The application of lime (which is a natural and cost-effective soil conditioner) based on soil sample results will increase the efficacy of applied nitrogen. Also, maintaining soil at Index 3 for phosphorus (P) and potassium (K) will further increase the efficacy of fertilizer nitrogen.

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<sup>24</sup> EIP-AGRI Focus Group –Nutrient recycling. Mini-paper – On Farm Tools for accurate fertilisation. [https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/2\\_mp\\_on\\_farm\\_tools\\_final.pdf](https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/2_mp_on_farm_tools_final.pdf)

<sup>25</sup> <https://www.teagasc.ie/crops/soil--soil-fertility/soil-analysis/soil-sampling/>

<sup>26</sup> <https://www.teagasc.ie/crops/soil--soil-fertility/soil-analysis/soil-results/>

It is important that the fertiliser spreading equipment is properly calibrated. This will ensure an accurate and even spread of inorganic compounds and avoid overlapping while spreading. There is also the additional benefit of a cost saving due to the reduced purchase and application of additional fertiliser.

Other practices that can be considered in Nutrient Management Planning include:

- *Use of a slurry hydrometer* - The nutrient content of cattle slurry is known to be highly variable. A slurry hydrometer is a useful decision support tool for nutrient management. The slurry hydrometer estimates the slurry dry matter content<sup>27</sup>. It can permit an on-the-spot estimate of nutrient concentrations in slurry. It will help to adjust slurry application rates on the move and to achieve better utilisation of available nutrients.
- *Role of Biological N fixation* - The potential to grow alternative crops or grow mixed swards that supply nutrients, e.g. clover which acts as a nitrogen supply. Clover maintains high quality pasture with a low nitrogen fertiliser input and a well-established clover sward can fix nitrogen but requires careful management.
- *Role of precision technology* - the use of precision technology including variable rate technology and GPS precision techniques help with the accurate and even spread of fertilisers. Other examples of precision technology that can enhance the accuracy of nutrient management planning include:
  - On site measurement of organic fertiliser composition to improve manure and nutrient management, e.g. slurry hydrometer, Near Infrared Spectroscopy (NIRS) technology<sup>28</sup>.
  - A soil scan for site-specific fertilisation. Differences in hydraulic conditions, acidity and soil fertility can occur within a field. A soil scan can give information on the soil conditions within the field in order to adapt the fertilisation rates. The fertiliser use and other inputs can be adjusted based on this information.
  - Uniform application of fertilisers by using a GPS-systems or variable rate technology for spreading organic and inorganic fertilisers.
  - Correct application of fertilisers based on results of NIRS. The farmer can also choose how much nitrogen (or another nutrient) he/she wants to apply per hectare. The dosage system regulates the dosage on the spreader automatically.

### Limiting ammonia emissions from nitrogen fertilisers

Fertilisers should be applied to the soil during favourable conditions and at times of optimum plant growth. This maximises the adsorption of ammonium ions into the clay component of the soil, the organic matter and in plant uptake<sup>29</sup>, thereby ammonia emissions.

*Calcium Ammonium Nitrate (C.A.N. 26-27% N)* is the most widely used straight nitrogen source presently used in Ireland. It should be applied in cool but moist conditions and avoid application when rainfall is expected to minimise nitrogen loss to air and water.

<sup>27</sup> <https://www.teagasc.ie/media/website/publications/2010/6094.pdf>

<sup>28</sup> EIP-AGRI Focus Group –Nutrient recycling. Mini-paper – On Farm Tools for accurate fertilisation. [https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/2\\_mp\\_on\\_farm\\_tools\\_final.pdf](https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/2_mp_on_farm_tools_final.pdf)

<sup>29</sup> Department of Environment, Food & Rural Affairs (2018). Code of Good Agricultural Practice (COGAP) for reducing Ammonia Emissions.

*Urea (46% N):* Irish research has shown that maximum ammonia loss rates in Irish grassland are generally reached within 24-48 hours after application<sup>30</sup>. Ammonia losses from urea fertiliser can be reduced by rapid incorporation of the fertiliser into the soil, i.e. <4 hours after application. If possible, it should be applied when the soil is moist (not wet), or when rainfall is expected, and the weather is cold. Do not spread urea soon after the application of lime as this can lead to increased losses of nitrogen.

*Using protected nitrogen products:* Ammonia loss from urea is reduced when urea is protected by a urease inhibitor, i.e. protected urea. A *urease inhibitor* is an active ingredient which is coated or incorporated into the fertiliser granule to protect against ammonia loss, forming protected or stabilised urea. In Teagasc trials, the active ingredient known as nBTPT (N-(*n*-butyl) thiosphosphoric triamide) has been found to reduce ammonia losses from urea to levels comparable to CAN, and allowed urea perform equally as well as CAN in terms of grass growth, and also reduce greenhouse gases (GHG) compared with CAN<sup>31</sup>.

Care should also be taken when spreading fertilisers. Urea is a less dense fertiliser compared to CAN 27%. It has a density of 0.75kg/l compared to CAN 1.0kg/l which can affect the spread at application and the evenness of application across the spread width. Urea and the urea plus urease inhibitor have limitations due to spread width and compatibility issues which do need careful management.



Image Credit: Teagasc (2019)

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<sup>30</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

<sup>31</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

## Where to get more information

- You can get information about the Nitrates Action Programme and the Nitrates Directive from:
  - The Department of Agriculture, Food and the Marine:  
<https://www.agriculture.gov.ie/farmerschemespayments/crosscompliance/nitrates/>
  - Department of Communications, Climate Action & Environment:  
<https://www.dccae.gov.ie/en-ie/environment/Pages/default.aspx>
- You can get guidance and technical advice from:
  - Teagasc (Agriculture and Food Development Authority):  
<https://www.teagasc.ie/crops/soil--soil-fertility>  
<https://www.teagasc.ie/environment/water-quality/farming-for-water-quality-assap/>
  - The Fertilizer association of Ireland:  
<https://www.fertilizer-assoc.ie/plant-nutrients/nitrogen/>
  - The Agricultural Consultants Association: <http://aca.ie/>
  - Nutrient Management Planning (NMP) Online:  
<https://www.teagasc.ie/environment/soil/nmp/>
- Protecting your health and safety while working on the farm is crucial. Health and Safety saves lives, and farmers are urged not to take unnecessary risks and to follow the necessary precautions to ensure their own safety and others. More information about safe farming practices can be gotten from:
  - The Health and Safety Authority: <https://www.hsa.ie/eng/>
  - Teagasc: <https://www.teagasc.ie/rural-economy/farm-management/farm-health--safety/>
- Relevant training and courses are provided by:
  - Teagasc (Agriculture and Food Development Authority) (Teagasc ConnectED):  
<https://www.teagasc.ie/about/our-organisation/connected/>
  - The Fertilizer association of Ireland: <https://www.fertilizer-assoc.ie>



### 3.2. Manure application

Animal slurries account for approximately 80% of organic fertilisers in Ireland<sup>32</sup>, and ammonia emissions occur from the land application of slurry and manures. The exposure of slurry or manure to warm, windy and sunny conditions at the time of application promotes ammonia loss, therefore the timing of application and slurry management are important factors to consider. Also, reducing nitrogen losses at application means that more nutrients are available for crop uptake and losses to the environment are minimised. It is also essential to check that machinery used for spreading the manure is in good working order and set at the proper application rate.

#### Timing of application of manures

Manure needs to be applied at a time when crop demand is high in spring. Where soil conditions allow, aim to have 70% applied by the end of April<sup>33</sup>. Early slurry applications result in better nitrogen uptake, less ammonia emissions, and reduced fertiliser nitrogen requirement.

The application of fertiliser should be done under the right temperature and moisture conditions. The optimum temperature of the soil should be between 6 and 8 degrees to reduce ammonia loss. Application in dull, cool, overcast or misty conditions will result in lower ammonia losses compared to application in warm, dry, sunny weather.

It is also important to ensure that enough slurry storage capacity is available on the farm to ensure that slurry can be spread at the correct times.

#### Incorporation of manures into the soil (slurry, farmyard manure, sludges, compost)

Where organic fertilisers are applied to tillage land prior to or during the cultivation process, soil incorporation will reduce ammonia emissions. This is because the length of time that the manure is exposed to the air is reduced. Immediate incorporation (or at least within 3-6 hours of application) is recommended<sup>34</sup>. When manure is incorporated immediately after spreading, the risk of nutrient run-off is also reduced. The most effective reduction in emissions is achieved by incorporation within a couple of minutes of spreading, achieving a 70-90% reduction; a 45-65% reduction is achieved if incorporation is within 4 hours, and 30% reduction with incorporation after 24 hours<sup>35, 36</sup>.

The appropriate application method may depend on the soil type/crop type and time of year. Incorporation of slurry using disc or tine cultivation is as effective as ploughing in reducing emissions and maximising nitrogen usage.

<sup>32</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

<sup>33</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

<sup>34</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

<sup>35</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2015). United Nations Economic Commission for Europe Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. ECE/EB.AIR/129.

[http://www.unece.org/fileadmin/DAM/env/documents/2015/AIR/EB/ECE\\_EB.AIR\\_129\\_ENG.pdf](http://www.unece.org/fileadmin/DAM/env/documents/2015/AIR/EB/ECE_EB.AIR_129_ENG.pdf)

<sup>36</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

## Use low emission slurry spreading (LESS) techniques to reduce ammonia emissions

The use of LESS equipment such as a dribble-bar, trailing shoe/hose or injection can reduce ammonia emissions compared to a splashplate by decreasing the surface area of manure in contact with the air.

Low emission slurry spreading techniques such as trailing shoe, place the slurry in bands or lines on the soil or crop, rather than the entire surface as with a conventional splashplate method. Slurry applied with a low emission method has been shown to reduce ammonia losses compared to splashplate application. Low emission slurry spreading techniques combined with adequate application timing help to decrease ammonia emissions and consequently increase the nitrogen fertiliser replacement economic value (NFRV) (Table 1)<sup>37</sup>. For example, a  $\geq 25\%$  reduction in ammonia losses for a trailing shoe technique compared to splashplate<sup>38</sup>, have been shown to occur.

Table 1: Grass contamination, ammonia reduction and NFRV of cattle slurry according to application timing and method<sup>39, 40, 41</sup>.

	Low Emission Spreading Equipment				
	Splashplate	Trailing hose	Trailing shoe	Shallow Injector	Deep Injector
Grass contamination	Moderate	Low	Low	Moderate	High
Relative ammonia reduction	0%	30-35%	30-60%	70-80%	90%
NFRV (Spring)	30%	*	40%	*	*
NFRV (Summer)	15%	*	25%	*	*

Application close to the soil also reduces odour emissions and reduces grass contamination (as shown in Table 1). Using LESS technology also has an agronomic benefit, with a consistent application of slurry and an added advantage of reduced slurry run-off.

<sup>37</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

<sup>38</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

<sup>39</sup> Teagasc (2016). Major & Micro Nutrient Advice for Productive Agricultural Crops.

<sup>40</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions.

<http://www.unece.org/index.php?id=41358>

<sup>41</sup> Department for Environment, Food & Rural Affairs (2018). Code of Good Agricultural Practice (COGAP) for reducing Ammonia Emissions.

## Where to get more information

- You can get information about low emission spreading technologies and grants available from:
  - The Department of Agriculture, Food and the Marine:  
<https://www.agriculture.gov.ie/farmerschemespayments/tams/lowemissionslurryspreadingequipmentscheme/>
- You can get guidance and technical advice from:
  - Teagasc (Agriculture and Food Development Authority):  
<https://www.teagasc.ie/environment/climate-change/>
  - The Agricultural Consultants Association: <http://aca.ie/>
  - Nutrient Management Planning (NMP) Online:  
<https://www.teagasc.ie/environment/soil/nmp/>
- Protecting your health and safety while working on the farm is crucial. Health and Safety saves lives, and farmers are urged not to take unnecessary risks and to follow the necessary precautions to ensure their own safety and others. More information about safe farming practices can be gotten from:
  - The Health and Safety Authority: <https://www.hsa.ie/eng/>
  - Teagasc: <https://www.teagasc.ie/rural-economy/farm-management/farm-health--safety/>
- Relevant training and courses are provided by:
  - Teagasc (Agriculture and Food Development Authority) (Teagasc ConnectED):  
<https://www.teagasc.ie/about/our-organisation/connected/>
  - The Fertilizer association of Ireland: <https://www.fertilizer-assoc.ie>



Image Credit: DAFM (2019)

### 3.3. Animal feeding strategies

Animal feeding strategies help to decrease ammonia emissions from both the manure at housing and storage as well as following the application of the manure to land<sup>42,43</sup>. There is a lot of research currently being conducted regarding feeding strategies and their role in reducing emissions.

Animals absorb nitrogen from protein within the diet which is used to support animal function and growth, and to produce meat and milk. Any excess nitrogen (55% to 95%) is excreted primarily in the urine and the dung<sup>44</sup> which leads to ammonia emissions. The ratio of nitrogen excreted in the urine and dung depends on the animal species, the protein content of the animal feed and the production level of the animal<sup>45</sup> (e.g. young, growing cattle).

There are a number of livestock feeding strategies that can reduce ammonia emissions from livestock production systems. These strategies include:

- Extended grazing;
- Maintaining the quality of crude protein when making silage;
- Use of low-crude protein animal feeds;
- Managing nitrogen applications for grazing to maintain grass crude protein (CP) at acceptable levels.

Improved grassland management and feed budgeting are also important to ensure efficient feed usage on farms.

#### Extended grazing

Grass is an important source of low-cost and high-quality feed for ruminants. Increasing the grazing season reduces the volume of manure present to emit ammonia and other greenhouse gases during storage. It also reduces the direct and indirect emissions associated with land spreading<sup>46</sup>. It is important to follow good agricultural practices to avoid damaging the soil structure and poaching, which can result in run-off and loss of nutrients to waterbodies.

As grass is the cheapest form of feed for Irish farmers, extended grazing would reduce the dependence on concentrate feeds. Also, Irish grasslands can grow up to 10-15t of dry matter per hectare, significantly reducing the dependence on concentrate feeds, many of which are imported and reducing ammonia loss by a factor of about 10.

It is important to consider the protein content of grass if supplementing with concentrates. Grass has been shown to contain a high protein content and the grass protein content may be

<sup>42</sup> Draft guidance document for preventing and abating ammonia emissions from agricultural sources, submitted by the Co-chairs of the Task Force on Reactive Nitrogen. WGSR-49. Informal document no. 21

<sup>43</sup> Oenema, O., Velthof, G. Kilmont, Z. and Winiwarter, W. 2012. Emissions from agriculture and their control potentials. TSAP Report #3, Version 2.1. International Institute for Applied Systems Analysis (IIASA).

<sup>44</sup> Oenema, O. and Tamminga, S. 2005. Nitrogen in global animal production and management options for improving nitrogen use efficiency. *Sci. China Ser. C.-Life Sci.* (2005) 48(Suppl 2): 871.

<sup>45</sup> Oenema, O. and Tamminga, S. 2005. Nitrogen in global animal production and management options for improving nitrogen use efficiency. *Sci. China Ser. C.-Life Sci.* (2005) 48(Suppl 2): 871.

<sup>46</sup> Schulte, R. and Donnellan T. (2012). A Marginal Abatement Cost Curve for Irish Agriculture. Teagasc.

in excess of the animal's requirements. Young, growing cattle and lactating cows need most protein. Young stock need 13-15% crude protein (CP) in the diet, lactating cows 14-17%, depending on yield and finishing cattle need 11-12% CP<sup>47</sup>. For this reason, crude protein analysis of grass fed to livestock can be beneficial in determining the optimal nutrient requirements.

In addition, grass measuring is an important aid to efficient grass management, for example, using tools such as plate meters and management programmes (e.g., PastureBase or AgriNet). Some of the benefits of grass measurement include<sup>48</sup>:

- Identifying grass surpluses or deficits
- More control over grass quality
- Improved use of fertilisers and meal feeding (less wastage)

A feed budget can help to determine the feed requirement on an annual basis, so the farmer is only growing the required amount of grass necessary, therefore enhancing nitrogen use efficiency.

Delaying fertiliser application after cutting allows the grass to recover and reduces ammonia emissions. Research has shown that a two-week delay in nitrogen fertilisation reduced total ammonia emissions from cut and fertilised grassland by 15%<sup>49</sup>.



Image Credit: Teagasc (2019)

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<sup>47</sup> [https://www.teagasc.ie/media/website/animals/dairy/Whats\\_in\\_Grass\\_Todays\\_Farm\\_May2014.pdf](https://www.teagasc.ie/media/website/animals/dairy/Whats_in_Grass_Todays_Farm_May2014.pdf)

<sup>48</sup> <https://www.teagasc.ie/media/website/publications/2011/LiquidMilkProceedings2011.pdf>

<sup>49</sup> Draft guidance document for preventing and abating ammonia emissions from agricultural sources, submitted by the Co-chairs of the Task Force on Reactive Nitrogen. WGSR-49. Informal document no. 21

## Maintaining the quality of crude protein when making silage

Silage quality is fundamental to good animal performance, reducing winter feed costs and increasing profitability during the housing period. Grass silage is the basis of most winter-feeding systems and satisfactory animal performance is dependent on the intake of good quality silage<sup>50</sup>. The level of meal fed on farm is determined by silage quality. The composition of silage is determined by the composition of the grass samples, sward type, harvest date, harvest number, wilting period, weather conditions, additive treatment and ensiling method. Silage made under poor conditions could result in silage with a low dry matter, low digestibility (energy value), low crude protein, high ammonia levels and high acidity. This results in low feed intake and poor animal performance.

Crude protein levels are a direct reflection of the quality of grass at the time of harvest. Typical values range from 9-15%<sup>51</sup>. Young leafy grass produces high protein silage, while older stemmy grass produces low protein silage<sup>52</sup>. Protein levels in grass can also be much higher earlier in the silage season than in mid-season. Ensiling the grass as fast as possible after cutting can help to maintain a high quality of crude protein. Ammonia is released from the breakdown of protein in the grass during preservation, reducing feed quality and palatability. High nitrate levels in grass at ensiling contribute to elevated ammonia.

Farmers should aim to have a silage protein content of 12-14%. When the protein content of grass silage drops below this level (12-14%), cattle will require an additional source of protein in their diets. A crude protein of <10% may impede rumen microbial growth<sup>53</sup>.

Maintaining the quality of crude protein when making silage, potentially limits the amount of crude protein needed in concentrates, which would be an economic benefit to a farm business.

A silage test can be used to determine the protein and energy content of silage, which will determine the amount of supplementary feed needed. This is particularly important for feed and fodder planning.

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<sup>50</sup> <https://www.teagasc.ie/publications/2017/silage-analysis---why-its-important-and-what-it-all-means.php>

<sup>51</sup> <https://www.teagasc.ie/media/website/publications/2016/Teagasc-Quality-Grass-Silage-Guide.pdf>

<sup>52</sup> <https://www.teagasc.ie/publications/2017/silage-analysis---why-its-important-and-what-it-all-means.php>

<sup>53</sup> <https://www.teagasc.ie/media/website/publications/2016/Teagasc-Quality-Grass-Silage-Guide.pdf>



Image Credit: Teagasc (2019)

### Use of low-crude protein animal feed

Using low-crude protein animal feed reduces nitrogen excretion in urine and it avoids the unnecessary and inefficient use of dietary crude protein. The feeding of low-crude protein animal feed has been shown to be one of the most cost-effective and strategic ways to reduce ammonia emissions.

The protein in any feed can be divided into the quantity (Crude Protein %) and quality of the protein (degradability). The crude protein of grass varies typically from 16-28%, depending on the sward type, growth stage, fertiliser regime and time of the year; it will typically be at the highest in spring/ early summer when nitrogen fertiliser is being applied at reasonably high levels to maximise grass growth. Occasionally, protein levels in grass dip as low as 11-12%, This can happen during a period of stress on the grass plant e.g., a drought<sup>54</sup>. The protein content in herbage can be managed through various techniques such as balanced nitrogen fertilisation and grazing/ harvesting the grass at a later growing stage.

The PDI system is a protein nutrition system utilised in Ireland and is based on a French system. A central principle of the PDI system which is used for ruminant dietary formulation is the balancing of energy and protein in the rumen; formulating diets using this system results in improved efficiency of utilisation of feed nitrogen and reduced nitrogen losses. Using effective monitoring tools, such as milk urea testing, enables good management of nitrogen fertilisation at grazing while also ensuring there is not excess nitrogen in the diet.

The net costs of livestock feeding strategies depend on how the diet is manipulated and the changes in the animal's performance.

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<sup>54</sup> [https://www.teagasc.ie/media/website/animals/dairy/Whats\\_in\\_Grass\\_Todays\\_Farm\\_May2014.pdf](https://www.teagasc.ie/media/website/animals/dairy/Whats_in_Grass_Todays_Farm_May2014.pdf)

Important points to note regarding choosing low protein animal feeds:

- Consider getting advice from a qualified ruminant nutritionist to formulate rations for livestock, taking into account the breed type, gender, stage of production and quality of feed available on farm.
- Consider analysing home-grown forage for crude protein content so that this can be considered in Total Mixed Rations (TMR), e.g., protein content of grass.
- Establish the protein requirements of your animals and adjust the diet as necessary.
- Care must be taken to ensure that crude protein is not reduced below a level where animal wellbeing and performance will be affected.

*Dairy Cows & Cattle:* It is important to consider the protein content of grass if supplementing with concentrates, as the grass may contain a high protein content. In this case, a crude protein analysis of grass being fed to livestock may be beneficial. It has been suggested that reducing the crude protein in dairy cow diets by 3-4% will significantly reduce the nitrogen excretion in urine by 45%<sup>55</sup>. Conducting a milk urea test will show where there is excess protein in the diet, excess protein in the diet is broken down into urea and excreted in the urine (see *Section 3.6* for more information about the milk urea test).

*Pigs:* More accurate matching of the diet to specific requirements of the different growth and production stages is necessary when feeding pigs. In pig diets, diet formulation with regards to amino acids is important. There is scope to manipulate the diet to reduce ammonia and odour emissions. It may be possible to reduce ammonia by up to 30% along with odour. Every 1% decrease in crude protein reduces ammonia by 10%<sup>56,57</sup>. Efficiency of nitrogen utilisation varies from 56% for weanling to 66% for finisher to 70% for a breeding sow. Almost half of nitrogen excretion can be attributed to poor amino acid balance in the diet. It is important to formulate the feed to match the specific nutritional requirements.

*Poultry:* The potential for reducing N excretion through feeding is more limited for poultry than pigs, because the conversion efficiency currently achieved is already great and the variability within a flock of birds is also high. A crude protein reduction of 1% to 2% (10-20 g/kg of feed) can be achieved depending on whether it is a broiler, layer or turkey and its age<sup>58</sup>. There is evidence that significant ammonia reductions of up to 35% are possible through changing poultry diets<sup>59</sup>.

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<sup>55</sup> 'The importance of research and innovation in the Dairy Sector' Dr. Keith Agnew, AFBI Stakeholder Day, 1<sup>st</sup> June 2017.

<sup>56</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

<sup>57</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2015). United Nations Economic Commission for Europe Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. ECE/EB.AIR/129. [http://www.unece.org/fileadmin/DAM/env/documents/2015/AIR/EB/ECE\\_EB.AIR\\_129\\_ENG.pdf](http://www.unece.org/fileadmin/DAM/env/documents/2015/AIR/EB/ECE_EB.AIR_129_ENG.pdf)

<sup>58</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

<sup>59</sup> Making Ammonia Visible. An Annex to "Delivering Our Future, Valuing Our Soils: A Sustainable Agricultural Land Management Strategy for Northern Ireland". Produced by the Expert Working Group on Sustainable Agricultural Land Management in N. Ireland. December 2017.



## Where to get more information

- You can get information about animal health and welfare from:
  - The Department of Agriculture, Food and the Marine: <https://www.agriculture.gov.ie>
  
- You can get guidance and technical advice from:
  - Teagasc (Agriculture and Food Development Authority): <https://www.teagasc.ie/search/?q=animal+feeding+strategies>
  - Agricultural Consultants Association: <http://aca.ie/>
  - Irish Grassland Association: <https://www.irishgrassland.com/>
  - PastureBase Ireland: <https://www.teagasc.ie/crops/grassland/pasturebase-ireland/>
  
- Protecting your health and safety while working on the farm is crucial. Health and Safety saves lives, and farmers are urged not to take unnecessary risks and to follow the necessary precautions to ensure their own safety and others. More information about safe farming practices can be gotten from:
  - The Health and Safety Authority: <https://www.hsa.ie/eng/>
  - Teagasc: <https://www.teagasc.ie/rural-economy/farm-management/farm-health--safety/>
  
- Relevant training and courses are provided by:
  - Teagasc (Agriculture and Food Development Authority) (Teagasc ConnectED): <https://www.teagasc.ie/about/our-organisation/connected/>
  - The Fertilizer association of Ireland: <https://www.fertilizer-assoc.ie>

### 3.4. Animal housing

Different animals require different housing systems and environmental conditions for their health and welfare. This section will look at management of animal housing to reduce ammonia emissions for cattle, dairy, pig and poultry housing systems. All these practices will further improve animal welfare and hygiene and have additional environmental benefits for air, soil, water and biodiversity.

For animal housing, reducing ammonia emissions is based on one or more of the following principles<sup>60,61,62,63</sup>;

- Decreasing the surface area fouled by manure;
- Adsorption of urine (e.g. by straw);
- Rapid removal of urine;
- Rapid separation of faeces and urine;
- Decreasing the movement of air over the manure;
- Reducing the temperature of the manure and of the surface area;
- Removing (scrubbing) ammonia from exhaust air through scrubbers;

#### Farm Cleanliness

The areas of dirty yards in a farmyard should be minimised, by brushing, scraping and washing livestock and handling areas. Maintaining clean farmyards and housing areas reduces ammonia emissions and the amount of soiled water produced in a farmyard.

Regular cleaning of hard standing and collecting areas and regular manure/excreta removal can reduce ammonia emissions by up to 49%<sup>64</sup>.

#### Cattle Housing

The tendency to increase the time that cattle are housed increases the amount of manure that must be managed compared to that deposited on fields. Not surprisingly, this increases ammonia emissions from animal houses, manure storage and manure spreading hot spots.

The following steps can help to reduce ammonia emissions from cattle housing;

- Regular cleaning of sheds and yards, for example, with automatic scrappers and regular washing down of collection yards. Keeping passageways and yards used by livestock as

<sup>60</sup> Draft guidance document for preventing and abating ammonia emissions from agricultural sources, submitted by the Co-chairs of the Task Force on Reactive Nitrogen. WGSR-49. Informal document no. 21.

<sup>61</sup> Oenema, O. (2016). Principles of overall nitrogen management, background document. Prepared for the DG En/TFRN workshop, Brussels, October 11-12, 2016. Wageningen University.

<sup>62</sup> Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution (2014). Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/ EB.AIR/ 120. [https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE\\_EB.AIR\\_120\\_ENG.pdf](https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf)

<sup>63</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

<sup>64</sup> Cited by Rachel Carolan in 'Making Ammonia Visible' An Annex to 'delivering our future, valuing our soils: a sustainable agricultural land management strategy for Northern Ireland. Produced by the Expert Working Group on Sustainable Agricultural Land Management in N. Ireland. Dec. 2017.

clean as possible.

- Adsorption of urine, for example, straw can be used to soak up urine and keep floors dry, preventing the pooling of urine<sup>65</sup>.
- Housing design to facilitate separation of faeces and urine; this can reduce both emissions during housing and emissions at spreading time. Design floors to drain effectively so urine and slurry do not pool.
- Decreasing the movement of air over the manure; a moderate reduction in emissions can be achieved in houses with automatically controlled natural ventilation due to decreased temperature and reduced air velocities above the manure.

## Dairy Housing

The following practices can help to reduce ammonia emissions from dairy housing;

- Regular cleaning or washing down of dairy collection yards;
- Keeping passageways and yards used by livestock as clean as possible can help to lower ammonia emissions;
- Scraping of buildings at least twice a day<sup>66</sup>, for example using automatic scrapers.

## Pig Housing

These techniques can be considered for reducing ammonia emissions from pig housing, particularly when refurbishing or constructing new buildings. Ensuring that any changes are compatible with the existing housing system and allow for adequate ventilation:

- Reducing the area where manure is gathered;
- Partly slatted floors emit less ammonia, allowing the manure to fall more rapidly into the pit below the pen.
- Increase the frequency of slurry (manure) removal;
- Keep bedding clean and dry because wet material emits more ammonia;
- Reducing the ventilation rate taking into account the minimum levels required for animal welfare and health reasons;
- Reducing air flow over the surface of the manure;
- Air cleaning systems (such as wet acid scrubber; two-stage or three stage air cleaning system; bioscrubber (or biotrickling filter). These devices are fitted to the outlets of mechanically ventilated pig houses and some systems can reduce ammonia emissions in exhaust air by up to 90%<sup>67</sup>.

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<sup>65</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

<sup>66</sup> Department for Environment, Food & Rural Affairs (2018). Code of Good Agricultural Practice (COGAP) for reducing Ammonia Emissions.

<sup>67</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

## Poultry Housing

Poultry manure and litter should be kept as dry as possible because wet material emits more ammonia. Other practices that can reduce ammonia emissions from poultry housing include:

- Reducing the surface area where manure is gathered;
- Removing the manure frequently to an external slurry store (e.g. removal of manure on a belt removal system);
- Drying the manure;
- Air cleaning system, e.g. using acid scrubbers or bio-trickling filters. A multistage scrubber is recommended because of the co-benefits of reducing ammonia and other particulate emissions, including phosphorus, which is an important plant nutrient.

## Where to get more information

You can get information about animal health and welfare from:

- The Department of Agriculture, Food and the Marine:  
<https://www.agriculture.gov.ie/animalhealthwelfare/animalwelfare/>  
<https://www.agriculture.gov.ie/farmerschemespayments/tams/>

You can get guidance and technical advice from:

- Teagasc (Agriculture and Food Development Authority):  
<https://www.teagasc.ie/rural-economy/farm-management/farm-buildings/animal-housing/>  
<https://www.teagasc.ie/animals/beef/animal-health/animal-welfare-and-health/>
- Agricultural Consultants Association: <http://aca.ie/>

Protecting your health and safety while working on the farm is crucial. Health and Safety saves lives, and farmers are urged not to take unnecessary risks and to follow the necessary precautions to ensure their own safety and others. More information about safe farming practices can be gotten from:

- The Health and Safety Authority: <https://www.hsa.ie/eng/>
- Teagasc: <https://www.teagasc.ie/rural-economy/farm-management/farm-health--safety/>

Relevant training and courses are provided by:

- Teagasc (Agriculture and Food Development Authority) (Teagasc ConnectED):  
<https://www.teagasc.ie/about/our-organisation/connected/>
- The Fertilizer association of Ireland: <https://www.fertilizer-assoc.ie>

### 3.5. Manure storage

Ammonia emissions from manure storage systems can be reduced by the appropriate design and management of the manure/ slurry storage systems. One or more of the following factors may be considered<sup>68,69</sup>;

- Decreasing the surface area where emissions arise from, e.g., covering the storage area;
- Decreasing the time over which emissions can take place, i.e., frequent removal or slurry/ manure;
- Decreasing the amount of ammonia emitted from the manure/ slurry, e.g., lowering the pH.

Maintaining storage facilities in good condition is important to ensure the containment of slurry and prevent pollution to the environment.

#### HEALTH & SAFETY SAVES LIVES: SLURRY

*Gas Poisoning from slurry gases and drowning in slurry or water, caused 20 (10%) of farm deaths between 2006 and 2015<sup>70</sup>*

**Please do not take unnecessary risks while working on the farm.  
Please adhere to all health and safety practices.**

**For solid manures:** It is important to minimise the movement of air over the manure to reduce ammonia emissions. For example, In the case of poultry manure and litter it is important to keep these dry. When poultry manure/ litter is wet it releases ammonia into the air.

**For slurry or other liquid manure types:** Cattle slurries for example, normally build up a natural crust of floating organic material. The crust should cover the whole area of the slurry store/ tank, to be efficient in reducing ammonia emissions. Crusts will only form if the slurry dry matter (DM) is high enough (>7%) and agitation should be avoided until spreading, as this will break the crust<sup>71</sup>. For outside stores, the store/ tank should be filled from below the surface of the crust to prevent it from breaking up. Natural crusts do not protect the manure from rainfall, so an impermeable cover or certain types of semi-permeable covers would be more effective. The addition of adding chopped straw or Light Expanded Clay Aggregate (LECA) pellets to non-crusting slurry may aid the formation of a crust. These fibres rise to the surface and act as a barrier, reducing the interaction between the movement of air and the nitrogen in the slurry.

If slurry does not form a natural crust, putting a cover over the store will reduce the ammonia lost to the air. It will also help retain valuable nutrients within the slurry. Covering the slurry

<sup>68</sup> Draft guidance document for preventing and abating ammonia emissions from agricultural sources, submitted by the Co-chairs of the Task Force on Reactive Nitrogen. WGSR-49. Informal document no. 21

<sup>69</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

<sup>70</sup>

[https://www.hsa.ie/eng/Publications\\_and\\_Forms/Publications/Agriculture\\_and\\_Forestry/Farm\\_Safety\\_Code\\_of\\_Practice\\_Risk\\_Assessment\\_Document.pdf](https://www.hsa.ie/eng/Publications_and_Forms/Publications/Agriculture_and_Forestry/Farm_Safety_Code_of_Practice_Risk_Assessment_Document.pdf)

<sup>71</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

store reduces the dilution of the slurry by rainfall, decreasing the volume of slurry to be spread and potentially allowing savings to be made on slurry spreading costs. Also, if LESS techniques are used for slurry application emissions are reduced even further. **It is important to seek professional advice if adding a cover to an existing tank.**

### Farm yard manure storage

Cover solid manure heaps – Limits the amount of ammonia that can escape to the atmosphere.

### Covered external slurry storage

Covering an external store can reduce the amount of ammonia released into the atmosphere. It also reduces the dilution of the slurry by rainfall, decreasing the volume of slurry to be spread and potentially allowing savings to be made on slurry spreading costs.

Examples of covers include:

- plastic, canvas, geotextile material applied over earthen bank lagoons or
- other external stores such as above-ground circular stores or air tight lids over circular above-ground slurry stores.

To decide on the type of cover, the percentage of dry matter in the manure needs to be considered as well as the expected amount of precipitation<sup>72</sup>. It is important to seek professional advice if adding a cover to an existing tank.

- *Retrofitting to existing stores*: Air tight lids are an effective measure to reduce emissions from slurry stores.
- *Tight lid, roof or tent structures*: can be built on concrete or steel tanks or silos. They can reduce ammonia emissions by 80%. It is important to check that the store is structurally sound to support the weight of the lid or roof<sup>73</sup>.
- *Floating sheeting*: can be applied to 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. They can reduce ammonia emissions in storage by 60%<sup>74</sup>, and some types will prevent water entering the store.
- *Floating LECA (light expanded clay aggregate) balls or hexa-covers*: are suitable for non-crusting pig manures or digestate. They can reduce ammonia emissions in storage by 60%<sup>75</sup>, and some types will prevent water entering the store.

<sup>72</sup> Sarteel, M. and Tostivint, C. (2013). Closing the mineral cycles at farm level. Good practices to reduce nutrient loss in the Brittany Region (France). Part of the project 'Resource Efficiency in Practice – Closing Mineral Cycles Funded by the EC., No. 070372/2013/665122/ETU/B.1

<sup>73</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

<sup>74</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

<sup>75</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

- *Slurry or digestate storage bags*: These can be installed within existing storage tanks or lagoons as an alternative to installing covers. They may not be suitable in all locations and require secondary containment, e.g. a bund to prevent leakages, spillages and ensure no pollution. Ammonia emissions can be reduced in storage by up to 100%<sup>76</sup>.

Covering external stores means that there is the potential for higher nitrogen recovery, but this is dependent on appropriate land application methods i.e., the use of LESS technologies and incorporation of the manure.

Due to the higher nutrient content of the manure, manure nutrient levels need to be calculated to match crop requirements, otherwise application of the same quantity of manure would result in higher nutrient levels and potential environmental and economic losses.

### Slurry/ manure amendments:

#### Amendment of poultry litter with Aluminium sulphate (Alum) & drying poultry manure

The addition of Alum has been found to reduce ammonia emissions from poultry houses, both by reducing its production in the litter and by reducing ventilation needs<sup>77</sup>. A reduction in pH may also persist in the litter during land spreading, further reducing ammonia loss. The pH reduction may also reduce pathogen numbers. This is suitable for all poultry houses producing dry litter (broilers/breeders/ turkeys).

Regular addition of Alum can decrease ammonia emissions by up to 70%<sup>78</sup>. This results in lower ammonia levels in the poultry houses and Alum also reduces particulate matter (PM<sub>2,5</sub>)<sup>79</sup>. Alum additions to poultry litter also precipitates phosphorus into a form which is not water soluble. This greatly reduces phosphorus runoff from fields fertilized with poultry litter, as well as phosphorus leaching.

Ammonia emissions from battery deep-pit or channel systems can be lowered by reducing moisture content or the manure by ventilating the manure pit.

**It is important to note that research is on-going into the effects of slurry/ manure amendments, such as Alum on soil chemistry and soil properties.**

**It is very important to seek the professional advice of an agricultural adviser/ consultant prior to choosing a slurry amendment product. This ensures that you pick the most appropriate product and that the product is safe and approved for use.**

<sup>76</sup> UNECE (2015) Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. <http://www.unece.org/index.php?id=41358>

<sup>77</sup> Draft guidance document for preventing and abating ammonia emissions from agricultural sources, submitted by the Co-chairs of the Task Force on Reactive Nitrogen. WGSR-49. Informal document no. 21

<sup>78</sup> Draft guidance document for preventing and abating ammonia emissions from agricultural sources, submitted by the Co-chairs of the Task Force on Reactive Nitrogen. WGSR-49. Informal document no. 21

<sup>79</sup> Draft guidance document for preventing and abating ammonia emissions from agricultural sources, submitted by the Co-chairs of the Task Force on Reactive Nitrogen. WGSR-49. Informal document no. 21

## Addition of amendments to cattle/ pig slurry

The addition of amendments to slurry to lower the pH can reduce ammonia emissions during storage.

A reduction in nitrogen losses during the storage period will result in more nitrogen in the slurry during application. There may be an impact of increased emissions after land spreading and this still needs to be investigated. There is a need to be careful during application and ensure that it is applied in the optimum conditions and using LESS technology to minimise losses.

**It is important to note that research is on-going into the effect of slurry/ manure amendments on soil chemistry and soil properties.**

**It is very important to seek the professional advice of an agricultural adviser/ consultant prior to choosing a slurry amendment product. This ensures that you pick the most appropriate product and that the product is safe and approved for use.**

## Where to get more information

- You can get information about manure storage from:
  - The Department of Agriculture, Food and the Marine: <https://www.agriculture.gov.ie>
- You can get guidance and technical advice from:
  - Teagasc (Agriculture and Food Development Authority):  
<https://www.teagasc.ie/rural-economy/farm-management/farm-buildings/silage--slurry/>
  - The Agricultural Consultants Association: <http://aca.ie/>
- Protecting your health and safety while working on the farm is crucial. Health and Safety saves lives, and farmers are urged not to take unnecessary risks and to follow the necessary precautions to ensure their own safety and others. More information about safe farming practices can be gotten from:
  - The Health and Safety Authority: <https://www.hsa.ie/eng/>
  - Teagasc: <https://www.teagasc.ie/rural-economy/farm-management/farm-health--safety/>
- Relevant training and courses are provided by:
  - Teagasc (Agriculture and Food Development Authority) (Teagasc ConnectED):  
<https://www.teagasc.ie/about/our-organisation/connected/>
  - The Fertilizer association of Ireland: <https://www.fertilizer-assoc.ie>



### 3.6. Additional measures to prevent and abate ammonia emissions

- **Capturing ammonia by planting trees** can be an effective mitigation measure in capturing ammonia deposition near livestock units. Trees with rapid growth and high leaf area index are ideal for shelterbelts established to recapture nitrogen.
- **Incorporating fertiliser into the soil** to minimise loss to the air.
- **Analysis of slurry and organic manure to determine its nutrient content:** The nutrient content of cattle slurry is known to be highly variable. A slurry hydrometer is a useful decision support tool for nutrient management and permits an on-the-spot estimate of nutrient concentrations in slurry. Samples of organic manure can also be sent to an accredited laboratory to determine its nutrient content.
- **Inclusion of legumes and reduction of N fertiliser in grasslands**
- **Protein analysis of grass on the farm:** grass has been shown to have high protein content and this should be taken into account when feeding concentrates to livestock, optimising the diet and minimising excess crude protein in the diet.
- **Conduct milk urea analysis:** excess nitrogen is taken up in the diet and can be detected using milk urea analysis. Milk urea analysis could be used to optimise the level of protein in the diet; it reflects the level of protein in the diet. Milk urea levels are usually higher during the indoor period, this is due to the greater amount of crude protein (20-25 %) in good quality pasture. Milk urea is a by-product formed from the breakdown of dietary protein. Excess protein in the diet, which is not used by the cow, is broken down into urea and passed in the urine. Research in the Netherlands has found that ammonia emissions rise exponentially with increasing milk urea (MU) concentrations<sup>80</sup>. A MU levels <20 mg may be indicative of insufficient protein in the cows' diet and levels >35 mg could be considered excessive and may impact on reproduction. Outside the range of 20-35 mg it is advisable to have the diet checked for protein content. Balancing the diet for protein and energy intake is essential to ensure that cows produce milk with good constituents.
- Participation in **Knowledge Transfer Groups** and **training courses** for continued professional development, knowledge exchange and to enhance environmental awareness.

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<sup>80</sup> Van Duinkerken, G. and Sebek, L.B.J. (2007) Milk urea as an indicator for ammonia emission reduction from dairy barns by feeding measures. In: *Ammonia Emissions in Agriculture*. Wageningen Academic Publishers, Netherlands.

## **4. APPENDIX**

### **4.1. Legislative information**

Agricultural activities account for over 99% of the national ammonia (NH<sub>3</sub>) emissions. Under the National Emissions Ceiling Directive (NECD), Ireland has had a mandatory ceiling for ammonia since 2010 of 116kt, ammonia emissions must be reduced by 1% below 2005 levels by 2020 (112kt) and 5% below 2005 levels from 2030 (107kt) onwards.

Ireland is a Party to the Convention on Long Range Transboundary Air Pollution (CLRTAP) under which certain transboundary air pollutants including ammonia are controlled. As a member of the EU, implementation of the Gothenburg protocol (a daughter protocol of the CLRTAP) is achieved through limits set out in the National Emissions Ceilings Directive 2001/81/EC (NECD). The National Emissions Ceiling Directive controls a range of emissions to the air which include sulphur dioxide, nitrous oxides, fine particulate matter, volatile organic carbon (VOC) and ammonia. Member states must implement measures to ensure that reduction targets for these air pollutants are met. The establishment of a National Advisory Code for the Control and Reduction of Ammonia Emissions is a requirement under the NECD. The Clean Air Strategy for Ireland led by the Department of Communications, Climate Action and Environment (DCCAE) provides an opportunity to address air pollution in Ireland.

In order to avoid potential fines and negative reputational damage on Ireland's green image for breaching ammonia ceilings, ammonia emissions must be significantly reduced.

Measures within the Common Agricultural Policy (CAP) such as cross compliance measures and green direct payments also support these environmental objectives. The Rural Development Programme (RDP) (2014-2020) measures (part of CAP) provide investment funding for environmental protection measures, e.g. the Green Low-Carbon, Agri-Environment Scheme (GLAS). The scheme is green as it preserves traditional hay meadows and low-input pastures; low-carbon as it retains the carbon stocks in soil through margins, habitat preservation and practices such as minimum tillage; and, agri-environment as it promotes agricultural actions, which introduce or continue to apply agricultural production methods compatible with the protection of the environment, water quality, the landscape and its features, endangered species of flora and fauna and climate change mitigation.

Additional pieces of legislation that indirectly and directly address nitrogen losses to the environment include the Water Framework Directive (Directive 2000/60/EC) and the Nitrates Directive (Directive (91/676/EEC). These water protection measures ensure the protection of healthy rivers, lakes and estuaries while also preserving biodiversity. The objective of this legislation is to restore and protect water quality, by implementing measures that achieve ongoing improvements in the environmental status of water bodies from source to sea. There is a correlation between the level of nitrate in rivers and high nitrogen application to the soil<sup>81</sup>. There is scope to improve resource efficiency and reduce the loss of nutrients and environmental impacts, without impacting on productivity/ yields.

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<sup>81</sup> Commission Staff Working Document. Agriculture and Sustainable Water Management in the EU. Brussels, 28.4.2017, SWD(2017) 153 final.

## 4.2. **Relevant links for further information**

### **Financial Support/ Guidance**

Under Structural improvements (TAMS)<sup>82</sup>, the following schemes are provided for in the 2014-2020 Rural Development Programme (RDP) of Ireland –The European Agricultural Fund for Rural Development: Europe investing in rural areas:

- Pig and Poultry Scheme;
- Young Farmer Capital Investment Scheme;
- Dairy Equipment Scheme;
- Low Emission Slurry Spreading Equipment Scheme;
- Animal Welfare, Safety and Nutrient Storage Scheme;
- Organic Capital Investment Scheme.

More information can be found on

<https://www.agriculture.gov.ie/farmerschemespayments/tams/>

### **Technical Support/ Guidance**

- The Department of Agriculture, Food and the Marine: <https://www.agriculture.gov.ie>
- Teagasc (Agriculture and Food Development Authority): <https://www.teagasc.ie/>
- Department of Communications, Climate Action & Environment: <https://www.dccae.gov.ie>
- The Health and Safety Authority: <https://www.hsa.ie/eng/>
- Agricultural Consultants Association: <http://aca.ie/>
- Best Available Techniques (BAT) for pig and poultry production: [http://eippcb.jrc.ec.europa.eu/reference/BREF/IRPP/JRC107189\\_IRPP\\_Bref\\_2017\\_published.pdf](http://eippcb.jrc.ec.europa.eu/reference/BREF/IRPP/JRC107189_IRPP_Bref_2017_published.pdf)
- The Fertilizer association of Ireland: <https://www.fertilizer-assoc.ie/plant-nutrients/nitrogen/>
- DG Environment – Nitrates Directive: [http://ec.europa.eu/environment/water/water-nitrates/index\\_en.html](http://ec.europa.eu/environment/water/water-nitrates/index_en.html)
- EU Climate Action: [https://ec.europa.eu/clima/index\\_en](https://ec.europa.eu/clima/index_en)
- Irish Grassland Association: <https://www.irishgrassland.com/>
- Smart Farming: <https://smartfarming.ie/>
- PastureBase Ireland: <https://www.teagasc.ie/crops/grassland/pasturebase-ireland/>
- NMP Online: <https://www.teagasc.ie/environment/soil/nmp/>

### **Continued Professional Development**

- Teagasc (Agriculture and Food Development Authority) (Teagasc ConnectED): <https://www.teagasc.ie/about/our-organisation/connected/>
- The Fertilizer association of Ireland: <https://www.fertilizer-assoc.ie>

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<sup>82</sup> Department of Agriculture, Food and the Marine (2015). Schemes and Services 2014-2020. <https://www.agriculture.gov.ie/media/migration/publications/2015/SchemesServices050216.pdf>

