A clear solution for farmers

CATCHMENT SENSITIVE FARMING

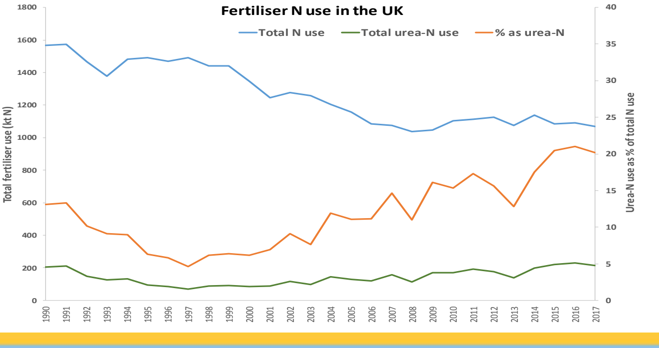
Reducing Ammonia Emissions from Urea Fertiliser Application through the Use of Urease Inhibitors

Why is ammonia a problem?

Ammonia is a key air pollutant that can affect both the environment and human health. Ammonia emissions are one of the largest contributors to acidification of soils and eutrophication of habitats and water bodies. Ammonia emissions combine with pollution from industry and transport (e.g. diesel fumes) to form very fine particulate matter ($PM_{2.5}$), which can then be transported significant distances in the air adding to background levels to which people are exposed. When inhaled particulate matter can contribute to cardiovascular and respiratory disease.

In the UK around 87 per cent of ammonia emissions come from agriculture. The application of mineral nitrogen fertilisers to land is responsible for approximately 20 per cent of emissions from agriculture but this value is very dependent on the proportion of nitrogen fertiliser that is applied as urea.

Urea and urea-based fertilisers are associated with much higher ammonia emissions than other types of nitrogen fertiliser. Total fertiliser nitrogen use declined over the period 1990 to 2008 but has remained fairly level since then. However, the proportion of fertiliser nitrogen applied as urea (straight or within urea ammonium nitrate) has been increasing since 1997 from 5 per cent to 21 per cent in 2016. Urea is the most important fertiliser globally and is used in significant quantities in the UK. Urease inhibitors represent a promising ammonia mitigation option and in Germany its use will be required for all non-injected urea-based fertilisers by 2020.



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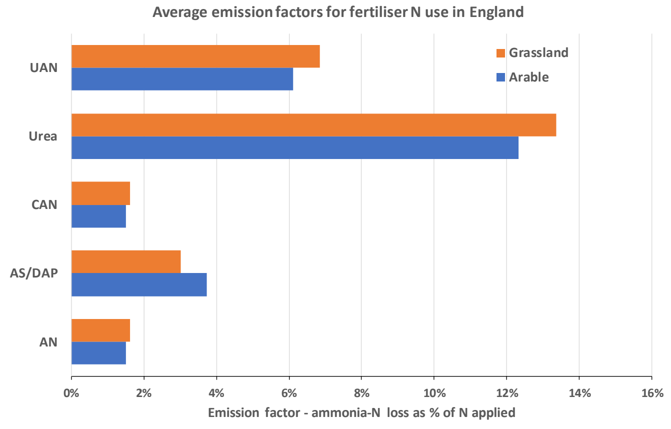


Why are ammonia emissions high from urea?

Following application, urea will rapidly break down to ammonia, facilitated by the enzyme urease which is present in soils. The conversion is associated with an increase in pH, which promotes ammonia loss. Actual losses following application can vary widely, from less than 5 per cent to more than 50 per cent of the applied nitrogen, depending on temperature, rainfall, soil type and conditions, application rate and even prill size but the average emission from urea use in England, based on application timing and location, is estimated as c.13 per cent of the applied urea nitrogen.

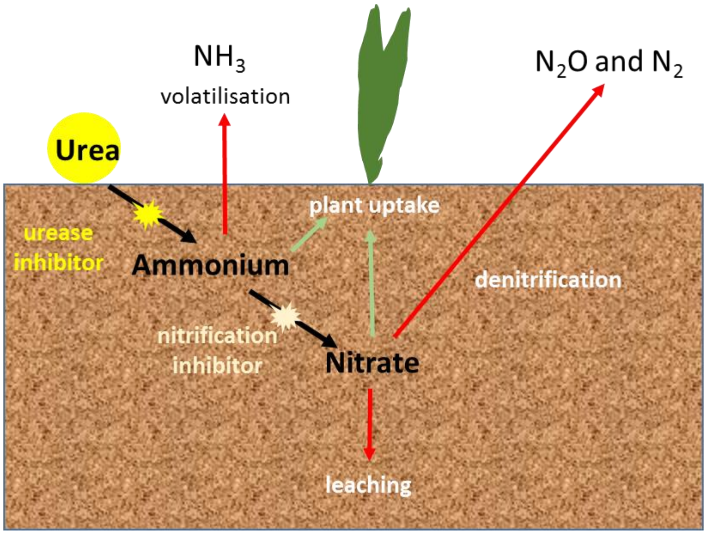
This conversion process and associated increase in pH does not occur with ammonia-based fertilisers, which consequently have much lower emission factors as shown above (although emissions from ammonium sulphate and diammonium phosphate are sensitive to soil pH and are greater when used on calcareous soils).

Ammonia emissions arising from urea-based fertilisers in England have accounted for 30-70 per cent (average 54 per cent) of total fertiliser emissions since 1990.

What are urease inhibitors?

Urease inhibitors are compounds which block the activity of the urease enzyme, slowing the conversion of urea to ammonia. The compounds will degrade in the soil over time (depending on factors including temperature and moisture), and therefore delay, rather than completely stop the conversion process. This results in a slower release of ammonia from the urea fertiliser, which reduces ammonia emissions as there is a lower pH increase, and also more time for the fertiliser to be incorporated into the soil through e.g. infiltration prior to ammonia emission.

Plants will readily take up ammonium from the soil. However, soil microbial activity will rapidly convert ammonium to nitrate, through the process of nitrification. Nitrate is readily taken up by plants, but also subject to losses to the environment through leaching and denitrification (with emission of nitrous oxide, a potent greenhouse gas). Another group of compounds, known as nitrification inhibitors can delay this nitrification process, leading to a longer, slower conversion of ammonium to nitrate in the soil.



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What are the benefits and costs of using urease inhibitors?

Benefits

The reduction in ammonia emissions after application of urea-based fertilisers with the use of a urease inhibitor provides direct environmental benefits, but also agronomic benefits through the additional nitrogen that is available for potential crop uptake. Independent research funded by Defra and conducted at several sites in England showed ammonia emission reductions in excess of 70 per cent when the urease inhibitor NBPT was used with urea, compared to emissions from urea alone. Trials elsewhere across Europe have shown similar levels of emission reduction.

The additional nitrogen remaining in the soil can be used by the crop and the slower conversion of this nitrogen from urea to ammonium can better match crop demand, thereby improving the nitrogen use efficiency compared with urea alone. The inclusion of a nitrification inhibitor as well can further enhance nitrogen use efficiency by reducing losses of nitrate through denitrification and leaching.

In the Defra-funded study the use of the urease inhibitor increased the apparent nitrogen recovery of the applied fertiliser nitrogen compared to urea alone, comparable to that of ammonium nitrate fertiliser. The difference in crop nitrogen uptake between urea and ammonium nitrate fertiliser matched the additional ammonia loss from the urea.

Costs

The price differential between urea and other fertiliser types such as ammonium nitrate will be a major factor in a farmer's decision making process as to which product to use. Prices fluctuate considerably, but urea generally costs less per kilogramme of nitrogen than ammonium nitrate. However, as urea can be subject to high losses of nitrogen as ammonia, it is important to consider the price per kilogramme of effectively used nitrogen. The table below gives an example of the cost for urea, as taken from the AHDB website (November 2018), and for urea with an inhibitor, based on an estimate from a fertiliser supplier.

	Price per tonne product (£)	N content (%)	Price per kg N (pence)	Price per kg N after NH_3 loss (pence)
Urea	298	46	64.8	81.0
Urea + inhibitor	330	46	71.7	76.3

Per kilogramme of product, straight urea is less expensive than urea with an inhibitor. As they have the same nitrogen content, the price per kilogramme of nitrogen purchased is also less when using straight urea. However, uncertainty regarding the nitrogen use efficiency of straight urea is high, because of the likely nitrogen losses as ammonia. Price per kilogramme of nitrogen effectively used can therefore be lower for the urea with inhibitor.

In the example given in the table, an ammonia loss of 20 per cent from straight urea was assumed and a reduction in ammonia emission of 70 per cent from use of the inhibitor. Product prices will vary considerably, as will the actual ammonia loss from urea, but generally the use of urea with an inhibitor will be more cost-effective than straight urea.

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Fertiliser products containing urease inhibitors

A range of 'stabilised nitrogen' fertiliser products exist on the market which can have different mechanisms and active ingredients. The incorporation of the active ingredient may also vary from a surface coating or actively included in the melt during granule formation.

Examples on the market include urea with a urease inhibitor (e.g. Origin KAN®) and urea with urease and nitrification inhibitors (e.g. Gleadell Alzon® neo-N).

Other fertiliser products exist containing nitrification inhibitors (e.g. EuroChem ENTEC® 26, an ammonium sulphate fertiliser). These will act to reduce nitrous oxide emissions following fertiliser application, but will not reduce ammonia emissions.

Current industry estimates are that approximately 5-10 per cent of urea currently used in the UK includes a urease inhibitor, and that use of such products is increasing.

Three 'take-away' messages

1. Compared with the performance of urea fertiliser alone, there are significant crop nitrogen uptake and ammonia emission reduction benefits to using a urea fertiliser product that incorporates a urease inhibitor. The benefits will generally justify the additional cost.
2. A range of 'stabilised nitrogen' fertiliser products exist; those containing urease inhibitors will have the greatest impact on reducing ammonia emissions and therefore nitrogen losses.
3. If using urea, consider a fertiliser product with a double inhibitor (urease and nitrification) which can further improve nitrogen use efficiency and reduce ammonia and greenhouse gas emissions.

Key contacts and information

Catchment Sensitive Farming (CSF) is able to provide events, tailored advice, individual visits and grant support to farmers on air quality measures and reducing water pollution on farm.

Agriculture and Horticulture Development Board (AHDB) provides advice on nutrient management through the series of RB209 booklets.

Department for Environment, Food and Rural Affairs (Defra) published a new Code of Good Agricultural Practice for Reducing Ammonia Emissions in 2018.

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