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The impact of ammonia emissions from agriculture on biodiversity

Summary

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As levels of other air pollutants have declined, ammonia emissions in the UK have been rising since 2013, with significant implications for biodiversity and human health. The agricultural sector is the biggest contributor to ammonia pollution, producing 82 per cent of all UK ammonia emissions in 2016. The aim of this study is to provide an overview of the existing evidence in three main areas:

- The impacts of ammonia emissions from agriculture on biodiversity in the UK.
- The interventions available to reduce ammonia emissions from agriculture and their effectiveness.
- The costs of the interventions, and how these compare to the costs of inaction on ammonia emissions, both in terms of impacts on biodiversity and wider impacts (e.g. on human health).

Impact of ammonia on biodiversity

Ammonia itself and the nitrogen deposition resulting from ammonia emissions negatively affect biodiversity. Ammonia is one of the main sources of nitrogen pollution, alongside nitrogen oxides. A major effect of ammonia pollution on biodiversity is the impact of nitrogen accumulation on plant species diversity and composition within affected habitats. Common, fast-growing species adapted to high nutrient availability thrive in a nitrogen-rich environment and out-compete species which are more sensitive, smaller or rarer. Ammonia pollution also impacts species composition through soil acidification, direct toxic damage to leaves and by altering the susceptibility of plants to frost, drought and pathogens (including insect pests and invasive species). At its most serious, if changes in species composition and extinctions are large, it may be that remaining vegetation and other species no longer fit the criteria for that habitat type, and certain sensitive and iconic habitats may be lost.

Certain species and habitats are particularly susceptible to ammonia pollution. Bog and peatland habitats are made up of sensitive lichen and mosses which can be damaged by even low concentrations of ammonia. Grasslands, heathlands and forests are also vulnerable. However, much of the wider evidence on biodiversity impacts relates to all nitrogen pollution, rather than just ammonia.

There is far less evidence on the impact of ammonia, and nitrogen more generally, on animal species and the wider ecosystem. However, animal species depend on plants as a food source; therefore herbivorous animals are susceptible to the effects of ammonia pollution. There is a negative correlation between flower-visiting insects, such as bees and butterflies, and nitrogen pollution. Ammonia affects freshwater ecosystems through direct agricultural run-off leading to eutrophication (accumulation of nutrients, leading to algal growth and oxygen depletion) and also has toxic effects on aquatic animals that often have thin and permeable skin surfaces.

Quantifying the economic impact of ammonia emissions on biodiversity is challenging and the methods used are subject to debate. Available estimates suggest that loss of biodiversity due to ammonia emissions could have impacts in the UK which can be valued, conservatively, at between £0.20 and £4 per kg of ammonia. Combining this with the monetised health impacts, our conservative estimate of the total costs from both health and biodiversity impacts of ammonia in the UK is £2.50 per kg of ammonia (though the range of possible values is from £2 to £56 per kg). This conservative estimate, combined with projected emission data, suggests that if no action is taken to reduce ammonia emissions, the negative impacts on the UK in 2020 could be equivalent to costs of over £700m per year. However, there are significant uncertainties in these values.[1] The range of possible costs, based on the estimates in the literature and best available projections for emissions, are between £580m and £16.5bn per year.

Reducing ammonia emissions

Ammonia emissions can be reduced by managing the production, storage and spreading of manure. Some of the most established ways to do this are summarised in Table 1. Figure 1 provides an overview of the cost-effectiveness, acceptability and strength of evidence for a range of specific interventions. Based on our estimates above, the impacts of ammonia can be conservatively costed at £2.50 per kg, which is equivalent to £1 of damage being caused by every 0.4kg of ammonia emitted. On this basis, any intervention which exceeds this threshold – to the right of the line in Figure 1 – could

1 See report section 2.5 for the full data and caveats. The £700m figure comes with a range between £580 million and £16.5 billion (based on variation within the published literature and exact methodology used). £700m was calculated by combining an estimate of £2 per kg for health impacts (*based on the Watkiss (2008) and Dickens et al. (2013) estimates which are most relevant to the UK context, use the UK standard values for a value of life years lost (VOLY) and do not include additional costs e.g. related to crop damage*) with an estimate of £0.42 for impacts on biodiversity (*based on the most comprehensive and recent analysis in the UK context, by Jones et al. (2018)*) to arrive at a conservative estimate of the total costs from both health and biodiversity impacts of £2.50 per kg of NH_3. Combining this with projected emission data, we can produce an indicative estimate of overall cost equivalents to the UK of ammonia emissions. If no action is taken to reduce emissions, the costs are estimated to be over £700m per year.

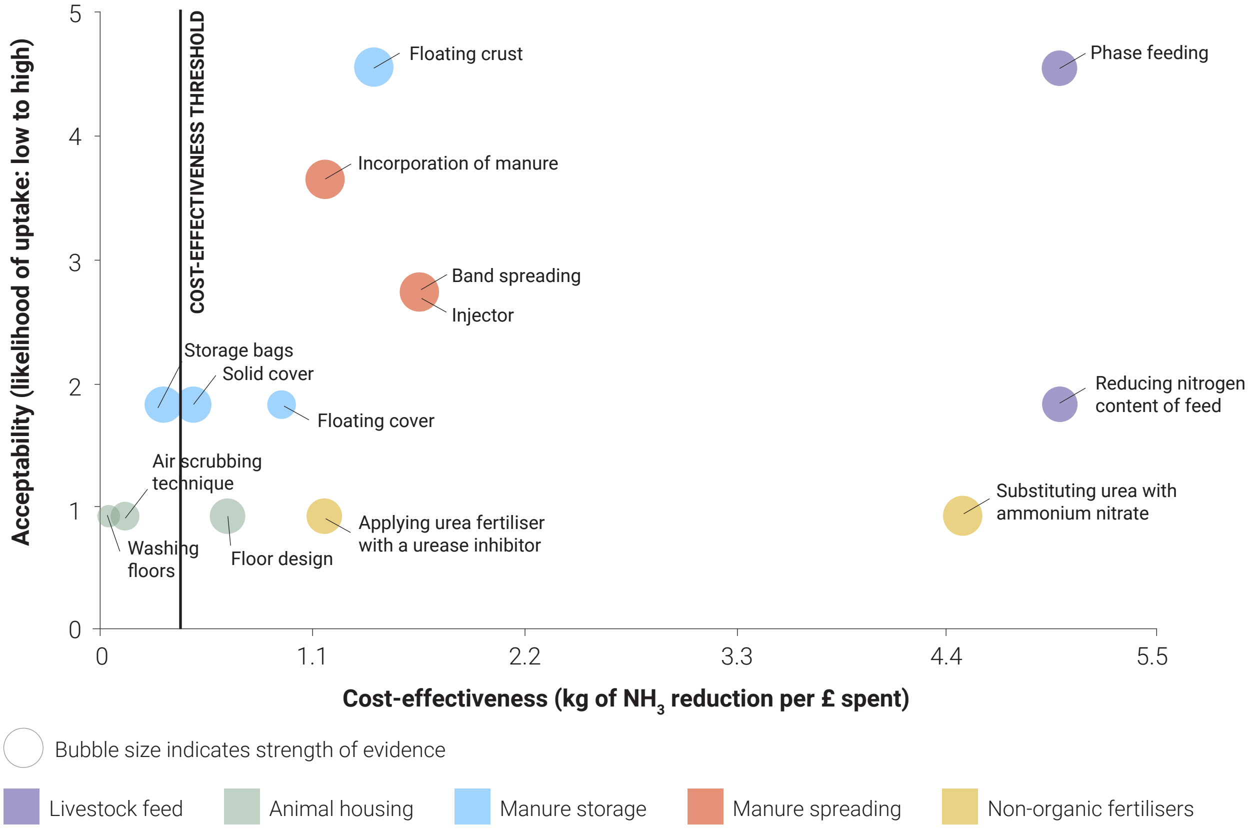
be considered cost-effective, which would include the majority of interventions. However, the whole ammonia lifecycle needs to be taken into account. If emissions are reduced immediately after manure production (e.g. through collection), but then not reduced in later stages (e.g. in storage or in spreading), then the emissions benefits at earlier stages are negated. Therefore, interventions need to be used in combination, spanning the whole lifecycle of manure production, storage and application. This also highlights the benefits of feed-based approaches which reduce the amount of ammonia produced in manure in the first place. It is also important to consider the interplay of ammonia emissions with those of other polluting gases, which might be negatively affected by some interventions, or by ammonia reductions generally. For example, excess nitrogen, whilst reducing species richness, can increase the volume of plant matter overall, which has benefits for carbon sequestration.

From a policy perspective, a mix of regulation, incentives and education are likely to be necessary to support the implementation of interventions. Evidence from the Netherlands and Denmark suggests that for interventions with a high level of acceptability to the agricultural sector, regulatory approaches can be introduced fairly quickly to support compliance. Where there are high upfront costs for farms, or a lower level of acceptability or knowledge, there may be more need for incentives and education, alongside voluntary actions in the first instance, before regulation can be effectively introduced. It may also be that different approaches are needed across different farm types or sizes. Wider education and awareness-raising may also be needed to help build understanding of the importance and costs of ammonia reduction amongst the public and in the retail sector, so that the full cost of these measures are not placed solely on the agricultural sector and/or government subsidies.

Table 1. Summary of categories of interventions to reduce ammonia emissions

Method	Description	Reduction in ammonia emissions	Limitations	Implementation cost (£/kg of ammonia)
Livestock feed	Reducing the amount of excess protein in livestock diets	10% to 60%	Higher feeding costs to farmers and potential for imbalanced nitrogen levels in the farm as the full use of grass production is not guaranteed	-2.3 to 2.3
Animal housing	Designing animal housing to better contain manure and reduce emissions	10% to 90%	High investment costs to refurbish or replace existing buildings	1 to 27
Manure storage	Storing manure for spreading as fertiliser in ways that reduce emissions	30% to 100%	Difficult to mix covered slurry; different covers are suitable for different quantities	0.4 to 3
Manure spreading	Methods for spreading manure as fertiliser that reduce emissions	0% to 99%	Effectiveness varies	-0.6 to 2.3
Non-organic fertilisers	Using manufactured fertilisers in ways that reduce emissions	40% to 90%	Ammonia emissions from organic fertilisers in the UK only account for a small proportion (c.10%) of ammonia emissions	-0.6 to 2.3

Figure 1. Bubble diagram showing strength of evidence, cost effectiveness and acceptability for a range of interventions to reduce ammonia emissions



Source: RAND Europe analysis. Cost-effectiveness and strength of evidence from Bittman et al. (2014). Acceptability based on likelihood of uptake from low (1) to high (5) as set out in Newell Price et al. (2011).

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