Dave Reay

VANISHING act

Nitrous oxide is a powerful greenhouse gas and we produce millions of tonnes of it every year. Most comes from agriculture, but it's proved very difficult to measure. Dave Reay thinks he's found out why.

The European Community's Nitrates Directive stipulates that a litre of drinking water should contain no more than 11mg of nitrate nitrogen. There are also worries over the algal blooms and oxygen depletion that nitrogen pollution can cause in surface waters. The main source of this nitrogen is intensive agriculture and, in vulnerable areas, the UK now has limits on the amounts of nitrogen fertilisers added to farmland.

People are, however, much less aware that nitrogen fertilisers also contribute to global warming, because they increase emissions of the greenhouse gas nitrous oxide. Although nitrous oxide occurs at much lower concentrations than carbon dioxide in our atmosphere (currently about 0.32 parts per million, compared with 360 parts per million), it is about 300 times more powerful a greenhouse gas. Agriculture is the biggest man-made source of nitrous oxide, emitting 2-4 million tonnes a year globally, mainly as a result of adding nitrogen fertilisers to the soil. Soil bacteria convert some of the fertiliser nitrogen to nitrous oxide, some works its way up through the soil and escapes directly to the atmosphere, while some is carried away in drainage waters.

Scientists only poorly understand the amount and importance of greenhouse gas emissions from farmland drainage waters, and have published widely varying values for the amount of nitrous oxide released per unit of nitrate-nitrogen in water. The Intergovernmental Panel on Climate Change's so-called 'default' value says that for every tonne of nitrate-nitrogen lost in agricultural drains about 15kg is released as nitrous oxide. This value is subject to great uncertainty, which makes it difficult to gauge the true importance of greenhouse gas emissions from agricultural run-off. It is also then hard to gauge how changes in farming policy could affect the emissions.

Hunting for emissions

Keith Smith and I, of the School of Geosciences, University of Edinburgh, and Tony Edwards, of the Macaulay Institute in Aberdeen, set about examining this 'indirect' source of greenhouse gas emission, and why previous studies obtained such a wide range of results. Here in Lothian, as in much of the UK, many arable fields are drained via pipes that run under them. The pipes emerge at an outfall, pouring water into an open drainage ditch, which carries it off downstream. We found the water coming out of these pipes was invariably highly saturated with nitrous oxide. However, the water in the open ditches often didn't show any extra loading of nitrous oxide. It was apparently disappearing within only a few hundred metres of the pipes' outfall.

We put polythene tunnels, like those used for growing lettuces, over the water in sections of the open ditch. What we found was that as soon as the water entered the ditch, and was exposed to the air, the dissolved nitrous oxide was very quickly lost to the atmosphere. We also found that the water emitted nitrous oxide even more quickly in areas of high turbulence, like waterfalls and riffles.

Now you see it, now you don't

This very rapid disappearance helps to explain the widely varying results of previous studies. It seems that location is crucial when you take samples. If you miss the point at which the drains (which are often hard to spot) enter the ditches, you can easily underestimate the overall amount of nitrous oxide emitted. And, if you leave a gap of more than a few hundred metres between samples, you can completely miss large nitrous oxide emissions.

Together with other groups around the world, we are now working on a more accurate emission factor for inorganic nitrogen leaching from farmland. This should enable policy makers to better predict the effects of changes in land-use and farming practice on agricultural nitrous oxide emissions and whole-farm greenhouse gas budgets.

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