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Science for Environment Policy

Nitrification inhibitors — climate change mitigation tool recommended by the IPCC – may be less effective than previously thought

Nitrification inhibitors are thought to mitigate climate change by reducing emissions of nitrous oxide — a potent greenhouse gas — from land. However, they may not be as effective as once thought, a new study suggests. The researchers found that, while inhibitors decrease emissions of nitrous oxide, they can increase emissions of ammonia — which is later converted to nitrous oxide. They recommend these effects are considered when evaluating inhibitors as a mitigation technology.

Nitrous oxide (N_2O) is important in medicine and engineering, but is also a potent greenhouse gas. Its global warming potential could be up to 310 times that of CO_2 (over a 100-year time scale). Globally, over half of anthropogenic nitrous oxide emissions come from agriculture — making it an important sector to target in reduction efforts.

One possible way to reduce agricultural nitrous oxide emissions is to use nitrification inhibitors, chemicals that slow the nitrification of fertilisers to cut nitrous oxide emissions. They also reduce leaching, whereby nitrate is transported to water bodies and can be converted to nitrous oxide. These inhibitors are recommended as a climate change mitigation tool by the IPCC and used in a range of agricultural systems.

However, the inhibitors may have a downside. They can increase the storage of ammonium (also a nitrogen-based compound, NH_4^+) in soil, which increases emissions of ammonia (NH_3) — a threat to the environment in itself and an indirect contributor to nitrous oxide emissions. Studies suggest that nitrification inhibitors could significantly increase emissions of ammonia from fertilisers and manure.

However, most studies haven't considered these effects, focusing only on direct N_2O emissions, and an understanding of the overall effect of nitrification inhibitors on nitrous oxide emissions is lacking. This paper aimed to address this knowledge gap by reviewing studies that look at both the direct and indirect impacts of the inhibitors.

The researchers performed an extensive search of several databases, including Web of Science, Scopus and Google Scholar. Only studies that simultaneously analysed nitrous oxide and ammonia emissions (and in the same location) were included; this resulted in 18 observations, in pasture and cropping systems (respectively: farmland grazed by livestock and land for growing crops) across Brazil, China, New Zealand, Spain and the UK.

Analysis of the findings showed that nitrification inhibitors consistently decreased direct nitrous oxide emissions from fertilisers (both urea and ammonia-based) and animal waste (slurry and urine). Applications of the inhibitors at fertiliser rates between 97 and 625 kilograms nitrogen per hectare (kg N/ha) reduced nitrous oxide emissions by 0.2–4.5 kg N/ha (8–57%). However, ammonia emissions *increased* in all but three cases (by 0.2–18.7 kg N/ha, equivalent to 3–65%). This is because the conversion of NH_4^+ to nitrate (NO_3^-) was suppressed, which increased the storage of NH_4^+ in soil. The ammonia released to the atmosphere will return to the land, and be converted by soil microbes to NO_3^- as part of the natural process of nitrification, during which nitrous oxide is produced. The NO_3^- can subsequently be converted to nitrous oxide through denitrification, another part of natural cycles in soil.

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Nitrification inhibitors — climate change mitigation tool recommended by the IPCC – may be less effective than previously thought *(continued)*

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According to the IPCC, around 1% (but potentially as much as 5%) of ammonia is converted to nitrous oxide. An increase of ammonia release from fertilisers and manures of 65% could, therefore, have important implications for nitrous oxide emissions.

Overall, the results suggest that when considering all N_2O production pathways, nitrification inhibitors may be less effective than previously thought. Although they do reduce emissions of nitrous oxide, both directly and indirectly (by reducing leaching of nitrate), they also *increase* nitrous oxide emissions indirectly by increasing emissions of ammonia — effects that have generally not been considered when evaluating the inhibitors.

The benefits of nitrification inhibitors may be negated or even outweighed by the associated increase in ammonia emissions, and it is important that these effects are considered in future evaluations. To alleviate this problem, the researchers suggest ammonia mitigation measures, such as urease inhibitors, could be used alongside nitrification inhibitors. Urease inhibitors limit the breakdown of urea, a process that results in ammonia. They can function for up to two weeks, reduce ammonia loss by up to 90% and be produced from natural sources[1,2].

1. https://www.ipni.net/publication/nss.nsf/0/EA265C5FE184D4F285257C8300753585/$FILE/NSS-25%20Urease%20Inhibitors.pdf

2. http://www.sciencedirect.com/science/article/pii/S2090123214001088