**Application**

This study examines how strategies to reduce ammonia emissions on dairy farms may inadvertently impact greenhouse gas (GHG) emissions. By modeling various ammonia mitigation measures on real farms, this research offers insights into balancing ammonia reduction with GHG emissions, helping dairy farmers meet two important policy targets.

**Introduction**

Under the Gothenburg Protocol and the National Emissions Ceilings Regulations (2018), the UK is required to reduce ammonia emissions by 16% by 2030, relative to 2005 levels. Agriculture is responsible for approximately 88% of ammonia emissions in the UK, with cattle alone contributing 44% of the total (DEFRA, 2024). The UK has also committed to achieving net zero greenhouse gas (GHG) emissions by 2050. To meet this target, the UK Climate Change Committee has recommended a 64% reduction in GHG emissions from the agriculture and land use sector. While reducing both ammonia and greenhouse gas (GHG) emissions reduction are key policy objectives, little research has examined the trade-offs between these two goals. The aim of this work was therefore to investigate the effects of various ammonia mitigation measures on both ammonia and GHG emissions.

**Materials and Methods**

Nine Scottish dairy farms were selected from a large dataset provided by Agrecalc. Farms were chosen to represent high, average and low emitters (based on emissions per kg fat- and protein-corrected milk (FPCM)) and included three different systems: all year-round calving (AYR) 9500 litre herd, AYR 8000 litres herd and traditional 6500 litre herd. Farms were categorised using Agrecalc’s benchmarking function, which determines the average, top 25%, and bottom 25% of emissions among all farms assessed within each system. The selected farms ranged in baseline product emissions from 1.00 - 1.35 kg CO2e/kg FPCM.

Baseline GHG emission estimates were calculated for each farm using the carbon calculator Agrecalc and ammonia emissions were calculated using a bespoke whole-farm ammonia footprinting tool. A range of ammonia mitigation measures were then modelled, including urease inhibitors, low-protein diets, slurry injection, slurry crusts and slurry covers. Assumptions were based on the UK Ammonia Inventory (Misselbrook et al., 2023), IPCC (2019) guidelines and a comprehensive literature review.

**Results**

All ammonia mitigation measures, with the exception of slurry crusts, were predicted to reduce both whole-farm ammonia and GHG emissions on average. Urease inhibitors proved the most effective, reducing ammonia emissions by 29% and GHG emissions by 1% (Table 1). Both slurry injection and floating covers were assumed to have no impact on GHG emissions. Only slurry crusts slightly increased GHG emissions on average across all farms (0.03%) due to the higher direct N2O emissions associated with manure management.

 **Table 1.** Average baseline ammonia and greenhouse gas emissions for nine farms presented alongside ammonia mitigation scenarios. Percentages in brackets represent the change from baseline.

|  |  |  |
| --- | --- | --- |
|   | Ammonia emissions (kg NH3) | GHG emissions (kg CO2e) |
| Baseline | 27,288 | 3,663,024 |
| Urease Inhibitors | 19,388(-28.65%) | 3,628,047(-1.26%) |
| Low protein diet | 25,142(-10.80%) | 3,611,579(-1.41%) |
| Slurry Injection | 25,142(-8.89%) | 3,663,024 (0.00%) |
| Slurry Crust | 26,680(-2.51%) | 3,664,039(+0.03%) |
| Floating Cover | 26,376(-3.01%) | 3,663,024(0.00%) |
| Tight Cover | 26,559(-3.46%) | 3,662,687(-0.10%) |

**Conclusions**

Overall, based on baseline emission estimates from Agrecalc, this study has demonstrated that ammonia mitigation strategies for dairy farms can be implemented without significant trade-offs for GHG emissions. These finding suggest that dairy farms can adopt measures to reduce ammonia emissions while continuing to make progress towards broader climate goals.

**References**

DEFRA, 2024. Emissions of air pollutants in the UK – Ammonia (NH3). Accredited official statistics. Department of Environmental and Rural Affairs, UK Government. <https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-ammonia-nh3>

IPCC, 2019. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change. <https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/>

Misselbrook, T.H., Gilhespy, S.L., Carswell, A.M., Cardenas, L.M., 2023. Inventory of Ammonia Emissions from UK Agriculture 2021. Inventory Submission Report. Rothamsted Research. <https://uk-air.defra.gov.uk/reports/cat09/2307061001_UK_Agriculture_Ammonia_Emission_Report_1990-2021_Final.pdf>