

Nitrous oxide from ruminant excreta

Irish agriculture creates 90% of national N₂O emissions, much of which come from dung and urine. **TEAGASC** researchers are looking at quantifying N₂O emissions, and assessing mitigation strategies for this potent greenhouse gas.

The pasture-based livestock systems dominating Irish agriculture are inherently 'leaky' in their nitrogen (N) use efficiency, with less than 30% of applied N recovered in final products – meat and dairy. Ruminant livestock excrete 70-95% of their N intake onto pasture as dung and urine.

These excreta patches, in particular urine, are an important source of the potent greenhouse gas (GHG) nitrous oxide (N₂O). As much as 41% of N₂O produced from Irish agriculture comes from urine and dung deposited by grazing animals. However, there is large uncertainty around this figure.

Ireland has committed to reducing national GHG emissions by 20% by 2020 under the EU Energy and Climate Package. Achieving these targets and realising the opportunities for growth identified in the Food Wise 2025 report pose a significant challenge for Irish agriculture, which accounts for 90% of national N₂O emissions. Therefore, accurate accounting and targeted mitigation of N₂O from excreta at pasture is urgently required.

Aims

The aims of this research were:

- to quantify N₂O emissions from urine and dung deposited to pasture by grazing animals;
- to examine the interactive effects of synthetic N fertiliser applied to urine and dung patches in pasture; and,
- to assess potential mitigation of N₂O emissions from urine patches by manipulating urine composition.

Developing nitrous oxide emission factors for excreta deposited on pasture

Currently, Ireland uses the Intergovernmental Panel on Climate Change (IPCC) default emission factor (EF) of 2% to estimate excreta-derived N₂O, meaning that 2% of N in the excreta patches is estimated to be lost as N₂O.

However, N₂O can vary greatly depending on the type of excreta (dung or urine), soil type and timing of application. During a recent project, N₂O was measured from urine and dung in spring, summer and autumn on well-drained, moderately drained and imperfectly

drained pasture soils. Measurements took place for 12 months following excreta application using a recognised static chamber method.

The average N₂O EF was 0.31% and 1.18% for cattle dung and urine, respectively. N₂O loss was driven by rainfall, temperature and soil moisture, with highest N₂O EFs in autumn and from the imperfectly drained soil (**Figure 1**). These N₂O EFs are lower than the current default value used in Ireland's national GHG inventory and highlight that N₂O emissions from animal excreta deposited on pasture by grazing animals in Ireland may be overestimated.

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Interactive effects of synthetic N fertiliser with excreta deposited on pasture

In intensively managed grazing systems, mineral fertiliser is typically spread shortly after grazing to promote regrowth between rotational grazing cycles. Consequently, annually, up to approximately one-fifth of this fertiliser is applied to urine patches.

However, in the national GHG inventory, N₂O emissions from these N sources are calculated separately and then added together. An experiment was conducted to investigate the effect on N₂O and associated N₂O EF of fertilising existing urine patches using a variety of synthetic fertilisers, and to examine the effect of how emissions from these areas of overlapping N loading are calculated in the national GHG inventory.

N sources applied separately and measured N₂O losses added together were called 'disaggregated' and 're-aggregated', respectively, versus N sources applied together called 'aggregated'. Application of fertiliser to urine patches did not significantly increase

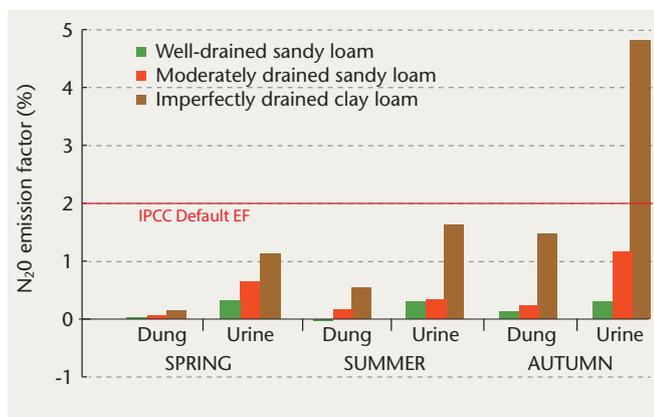


FIGURE 1: Direct nitrous oxide emission factors for different excreta sources, over three seasons and applied to three different soils.

either the N₂O emissions or the N₂O EF in comparison to urine and fertiliser applied separately. However, there was a consistent trend for 20% underestimation of N₂O loss calculated this way, suggesting uncertainty in the national GHG inventory.

Mitigation of nitrous oxide emissions from urine

Previous laboratory studies shed light on the potential of mitigating N₂O losses from urine patches by changing urine composition through dietary amendments (incremental additions of hippuric acid (HA) and/or benzoic acid (BA)). This experiment investigated the effect of elevating concentration of these minor urine constituents on N₂O emission *in situ* under soil conditions conducive to denitrification. However, manipulation of ruminant urine by adding HA and/or BA was found to have no effect on N₂O emissions. Although promising results were observed in the laboratory studies, these acids were not effective at mitigating N₂O loss *in situ* (Figure 2).

Conclusions and future research

Country-specific N₂O EFs for ruminant excreta will feed directly into the refinement of Ireland's national GHG inventory. This will, in future, allow disaggregation of EFs between types of excreta, soil type and timing of deposition. More research is needed into areas of overlapping fertiliser and excreta N loading and mitigation options for urine-derived N₂O. Although manipulation of HA and BA concentration in urine had no mitigating effect, other urine manipulations, such as reducing N content or inclusion of novel inhibitory products, might prove successful.

Acknowledgements

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Further reading

Krol, D.J., Minet, E., Forrestal, P.J., Lanigan, G.J., Mathieu, O. and Richards K.G. (2017). 'The interactive effects of various nitrogen fertiliser formulations applied to urine patches on nitrous oxide

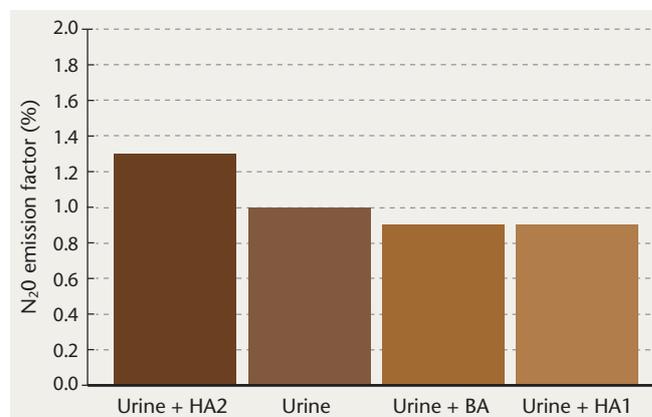


FIGURE 2: Direct nitrous oxide emission factors from urine with and without amendments.

emissions in grassland.' *The Irish Journal of Food and Agricultural Science*, 56: 54-64.

Krol, D.J., Carolan, R., Minet, E., McGeough, K.L., Watson, C.J., Forrestal, P.J. *et al.* (2016). 'Improving and disaggregating N₂O emission factors for ruminant excreta on temperate pasture soils.' *Science of the Total Environment*, 568: 327-338.

Krol, D.J., Forrestal, P.J., Lanigan, G.J. and Richards K.G. (2015). 'In situ N₂O emissions are not mitigated by hippuric and benzoic acids under denitrifying conditions.' *Science of the Total Environment*, 511: 362-368.

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