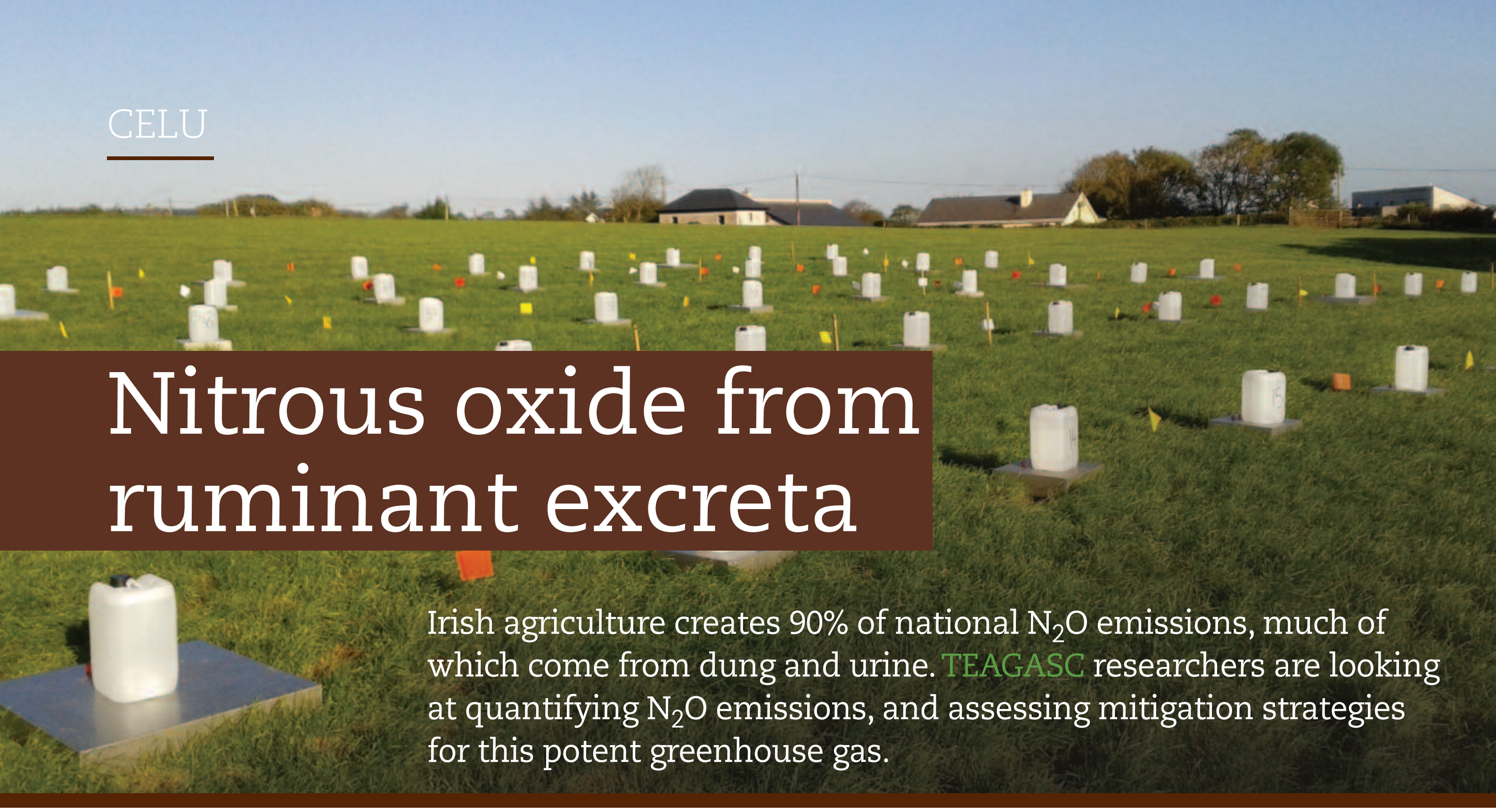

Nitrous oxide from ruminant excreta

Irish agriculture creates 90% of national N_2O emissions, much of which come from dung and urine. TEAGASC researchers are looking at quantifying N_2O 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 (N_2O). As much as 41% of N_2O 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 N_2O emissions. Therefore, accurate accounting and targeted mitigation of N_2O from excreta at pasture is urgently required.

Aims

The aims of this research were:

- to quantify N_2O 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 N_2O 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 N_2O, meaning that 2% of N in the excreta patches is estimated to be lost as N_2O.

However, N_2O can vary greatly depending on the type of excreta (dung or urine), soil type and timing of application. During a recent project, N_2O 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 N_2O EF was 0.31% and 1.18% for cattle dung and urine, respectively. N_2O loss was driven by rainfall, temperature and soil moisture, with highest N_2O EFs in autumn and from the imperfectly drained soil (**Figure 1**). These N_2O EFs are lower than the current default value used in Ireland's national GHG inventory and highlight that N_2O emissions from animal excreta deposited on pasture by grazing animals in Ireland may be overestimated.

Ireland has committed to reducing national GHG emissions by 20% by 2020 under the EU Energy and Climate Package.

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, N_2O emissions from these N sources are calculated separately and then added together. An experiment was conducted to investigate the effect on N_2O and associated N_2O 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 N_2O 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

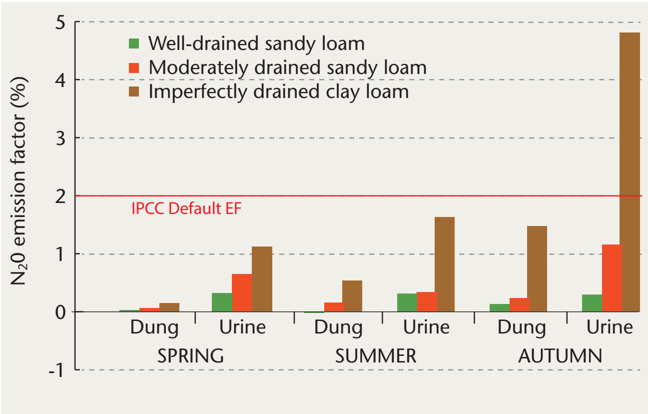

FIGURE 1: Direct nitrous oxide emission factors for different excreta sources, over three seasons and applied to three different soils.

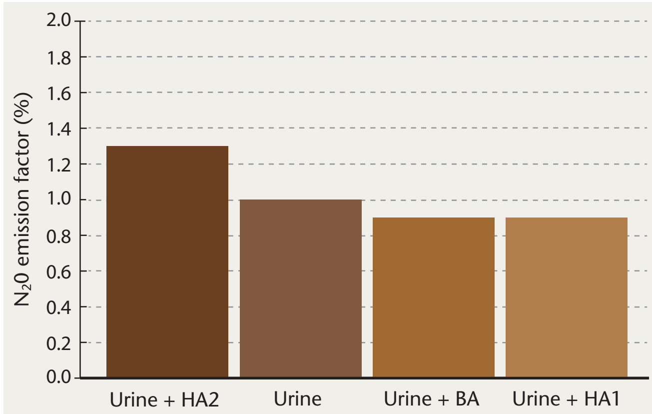

FIGURE 2: Direct nitrous oxide emission factors from urine with and without amendments.

either the N_2O emissions or the N_2O EF in comparison to urine and fertiliser applied separately. However, there was a consistent trend for 20% underestimation of N_2O 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 N_2O 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 N_2O 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 N_2O emissions. Although promising results were observed in the laboratory studies, these acids were not effective at mitigating N_2O loss *in situ* (**Figure 2**).

Conclusions and future research

Country-specific N_2O 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 N_2O. 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

This research was funded by the Department of Agriculture, Food and the Marine (RSF10/RD/SC/716 and 11S138).

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 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 N_2O 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* N_2O emissions are not mitigated by hippuric and benzoic acids under denitrifying conditions.' *Science of the Total Environment*, 511: 362-368.

Authors

Dominika Krol
Research Officer, Teagasc Crops, Environment and Land Use Research Programme, Johnstown Castle, Co. Wexford
Correspondence: dominika.krol@teagasc.ie

Patrick Forrestal
Research Officer, Teagasc Crops, Environment and Land Use Research Programme, Johnstown Castle, Co. Wexford

Gary Lanigan
Principal Research Officer, Teagasc Crops, Environment and Land Use Research Programme, Johnstown Castle, Co. Wexford

Karl Richards
Principal Research Officer and Head of Environment, Soils and Land Use Department, Teagasc Crops, Environment and Land Use Research Programme, Johnstown Castle, Co. Wexford