LTLS WP2: NEW MEASUREMENTS AND DATA GAP-FILLING

IN-SITU DENITRIFICATION AND N_2O EMISSION IN NATURAL AND SEMI-NATURAL LAND USE TYPES

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Objectives of the project:

- Measure monthly *in situ* denitrification rates in natural and semi-natural land use types.
- Assess the relative controls of the denitrification process in relation to land use management.
- Estimate annual denitrification rates for input into the terrestrial N-model to be developed under the LTLS project.

Study sites

Conwy River Catchment (C):

IG – Improved Grassland

AG – Acid Grassland

PB – Peat Bog (Migneint)

MW – Mixed Woodland

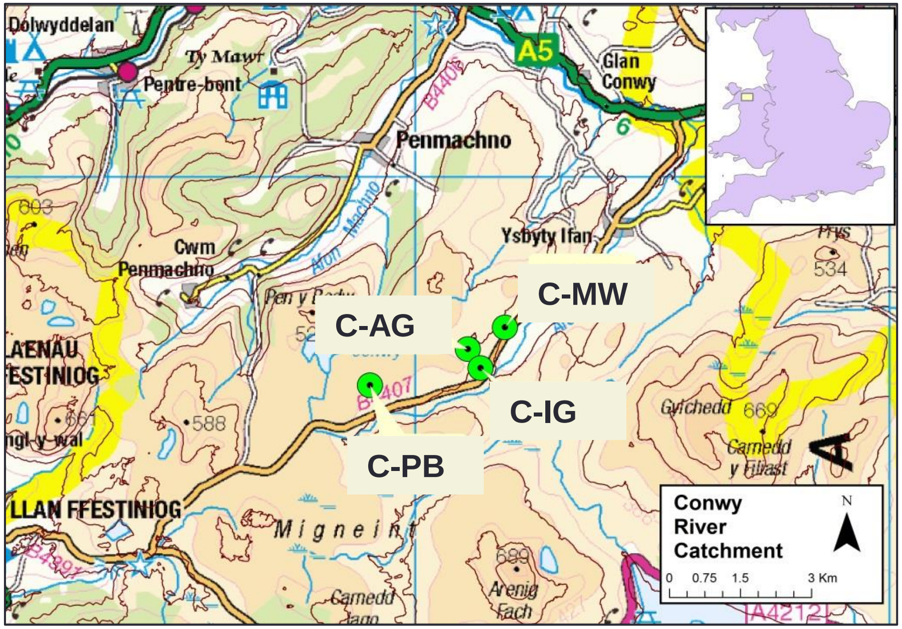
Ribble-Wyre Catchment (R):

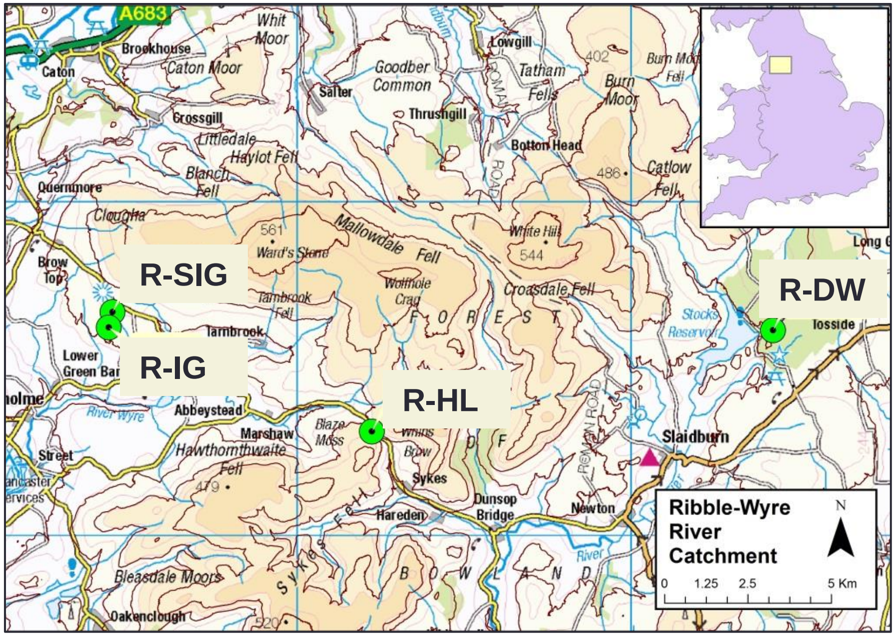
IG – Improved Grassland

SIG – Semi-Improved Grassland

HL – Heathland

DW – Deciduous Woodland





Methods: *In Situ* Denitrification

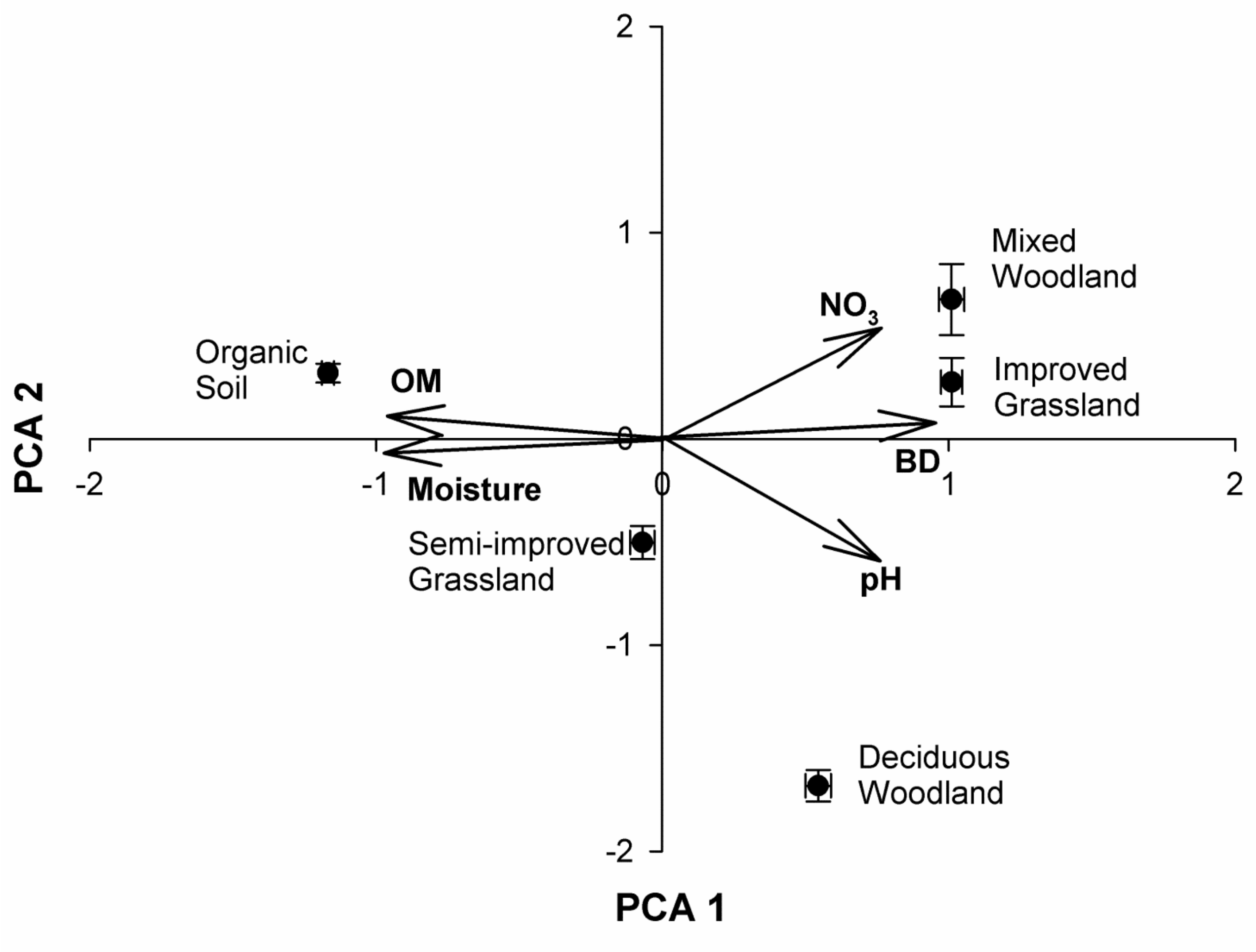
^{15}N Gas-Flux method
(Stevens & Laughlin, 1998; 2001)

- Highly enriched (98 at%) ^{15}N-labelled KNO_3^- is injected at tracer level amounts (10% of ambient NO_3^- concentration: typically 1-60 mg $^{15}N/m^2$) up to 10 cm depth and within 5% change of the soil VWC.

- The plot (area: 500 cm^2, volume: 3-4 L) is enclosed by a chamber for 20 hours. Five plots per site (40 plots/month x 18 months).

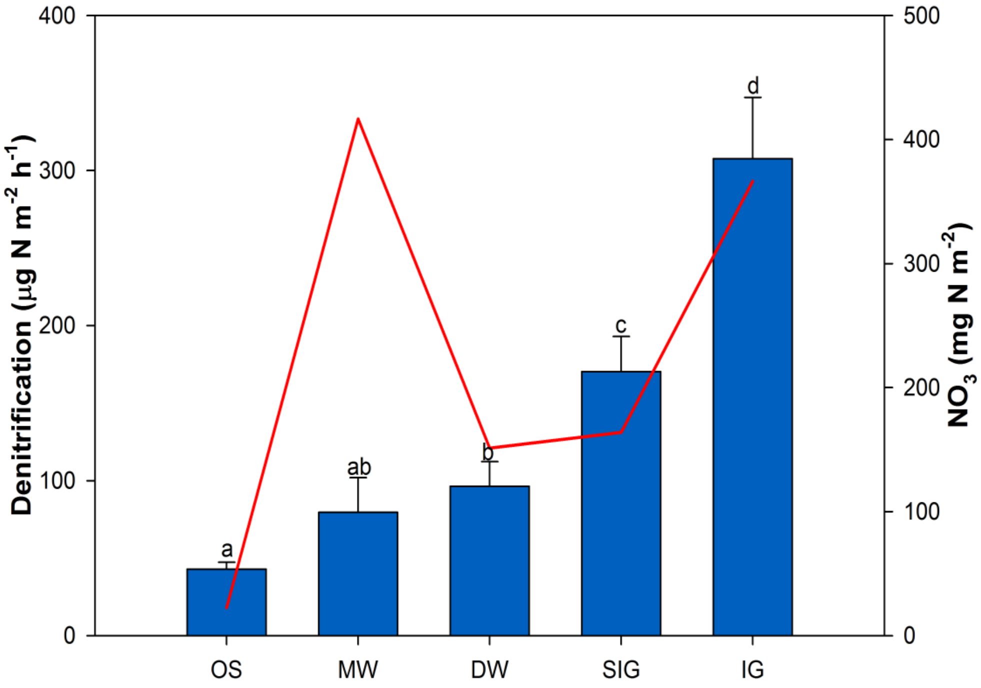
- Gas samples are collected at 0, 1, 2 and 20 hours for ^{15}N-N_2 and ^{15}N-N_2O analysis by IRMS

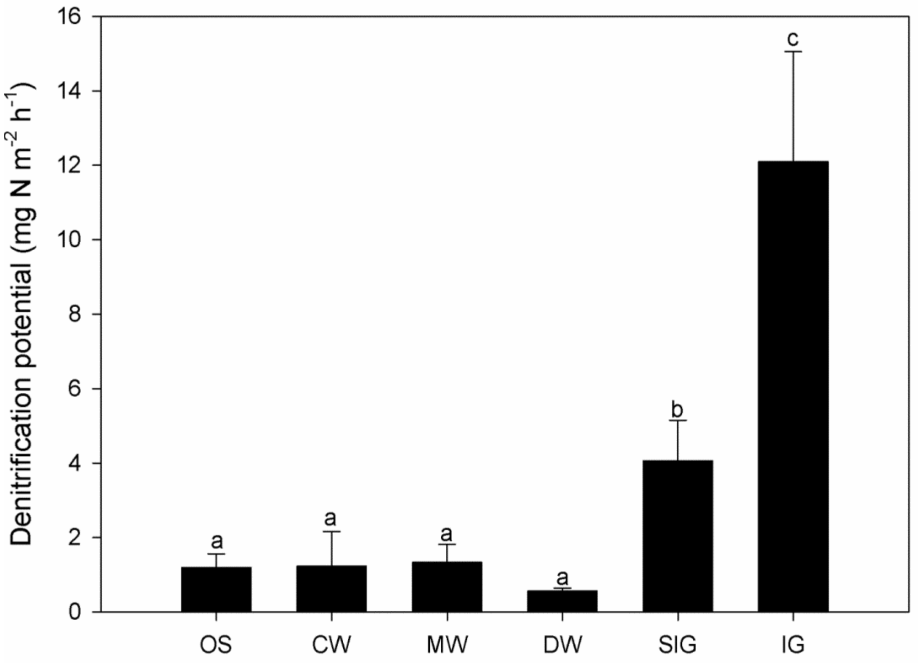
Results: PCA on Soil Properties



- PCA explains 89.7 % of the variance between samples (n=280) according to 5 environmental variables
- The samples are grouped into 5 clusters that represent distinct land use types

Results: *In situ* Denitrification

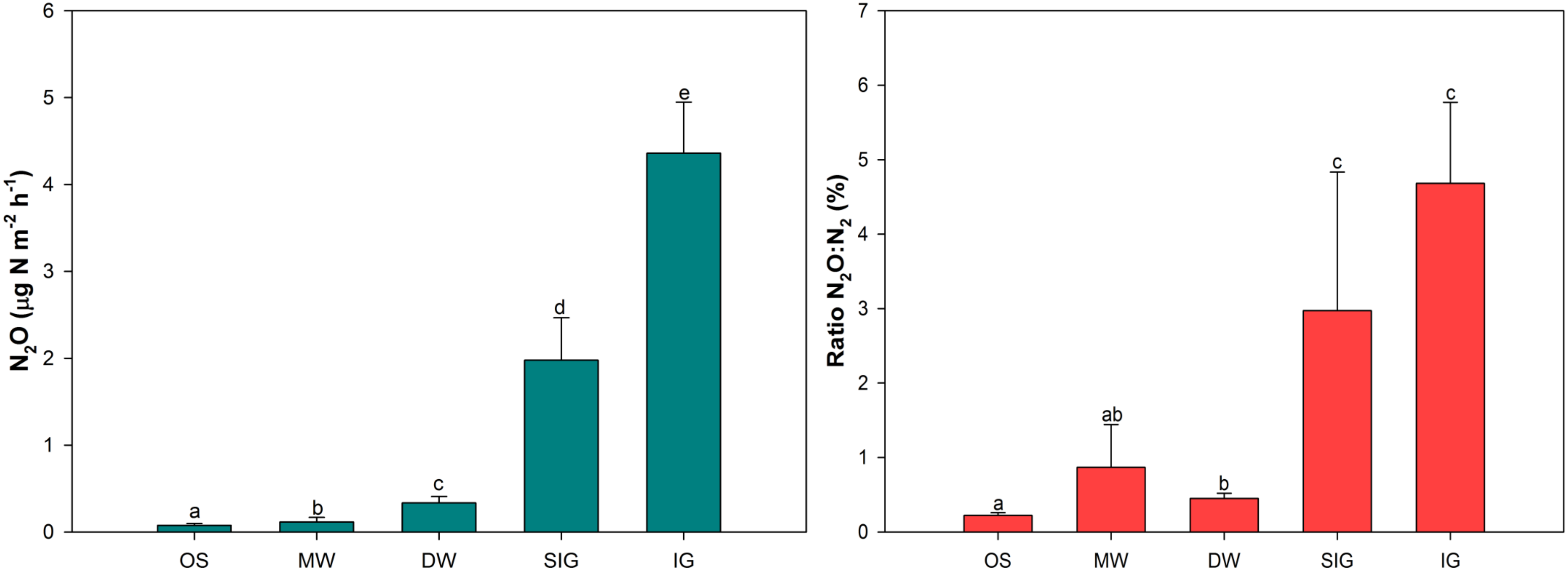




Sgouridis & Ullah. 2014. Environ. Sci: Processes & Impacts. 16: 1551-1562.

- In situ Denitrification (DNT) significantly influenced by land use type ($p<0.05$) :
  OS = MW = DW < SIG < IG
- The trend is confirmed by a laboratory study of Denitrification Potential (DP) in the same land use types. DP was on average 20 times higher than DNT.
- DNT follows a gradient of nitrate availability between land use types. Positive correlation between DNT and soil nitrate ($r= 0.43$, $p<0.01$; $r= 0.54$ without MW)

Results: N_2O Emission

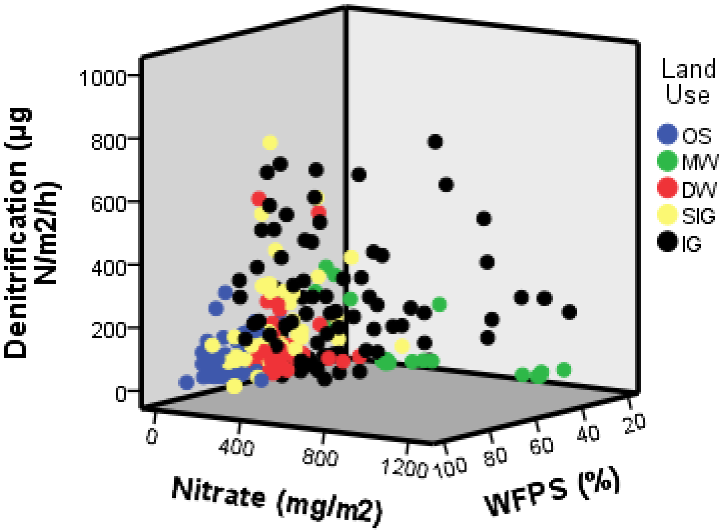


- ➢ N_2O emission from Denitrification followed a similar trend to DNT ($r= 0.58$, $p<0.01$) :
  OS < MW < DW < SIG < IG

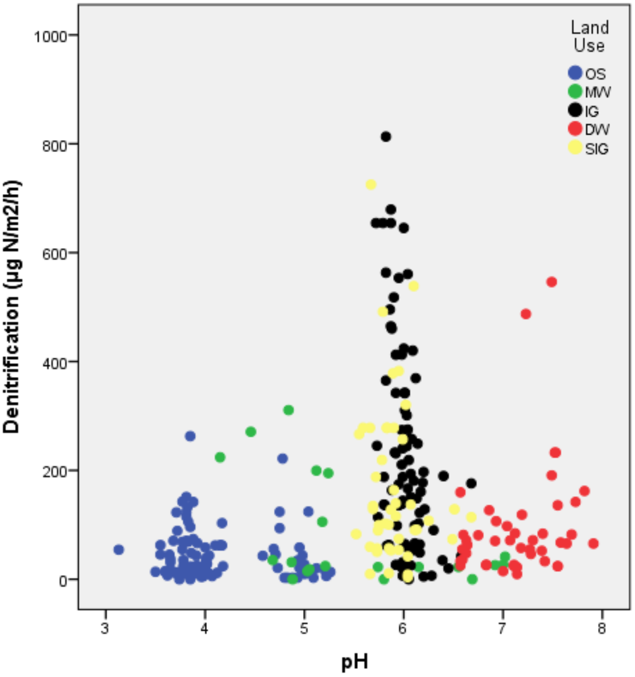
- ➢ The ratio of N_2O:N_2 was significantly higher in the nitrate rich land use types ($p<0.05$) ranging between 0.2 and 4 % across organic to grassland soils respectively.

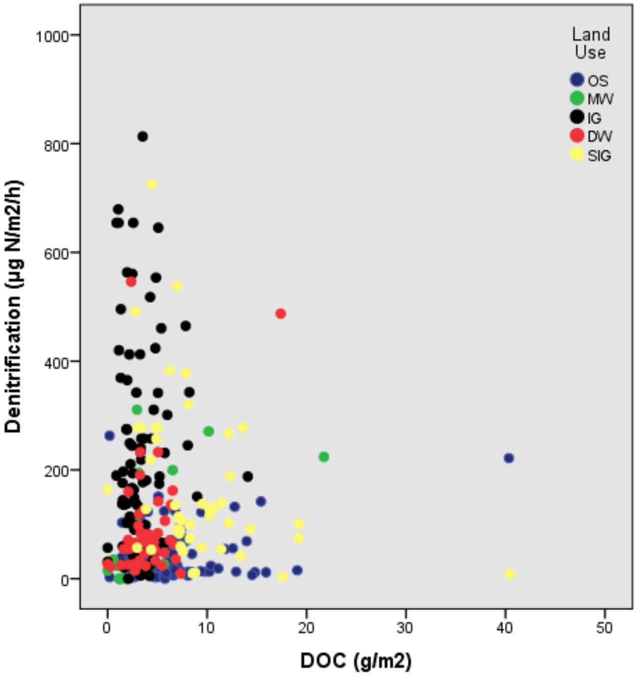
- ➢ The positive correlation between N_2O:N_2 and soil nitrate ($r= 0.47$, $p<0.01$) indicates a higher potential for N_2O emission from nitrate rich soils, whilst low soil water content ($r= -0.47$, $p<0.01$) can exacerbate this effect (e.g. MW).

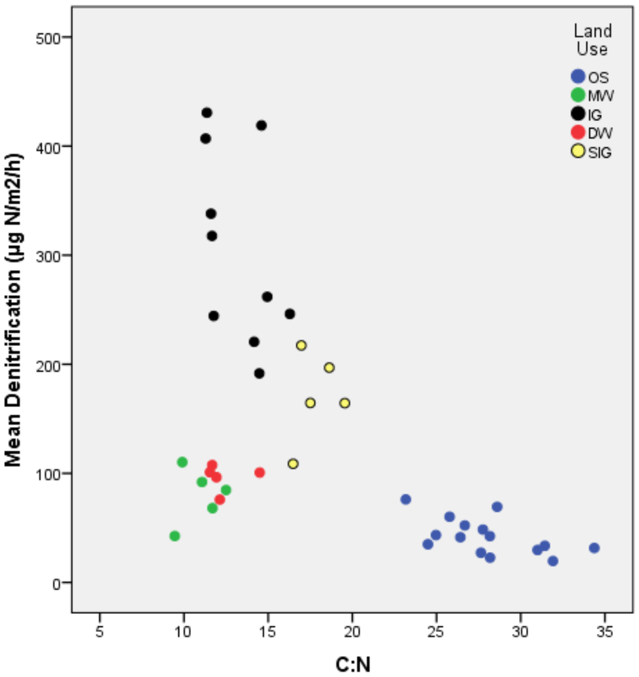
Results: Denitrification Controls



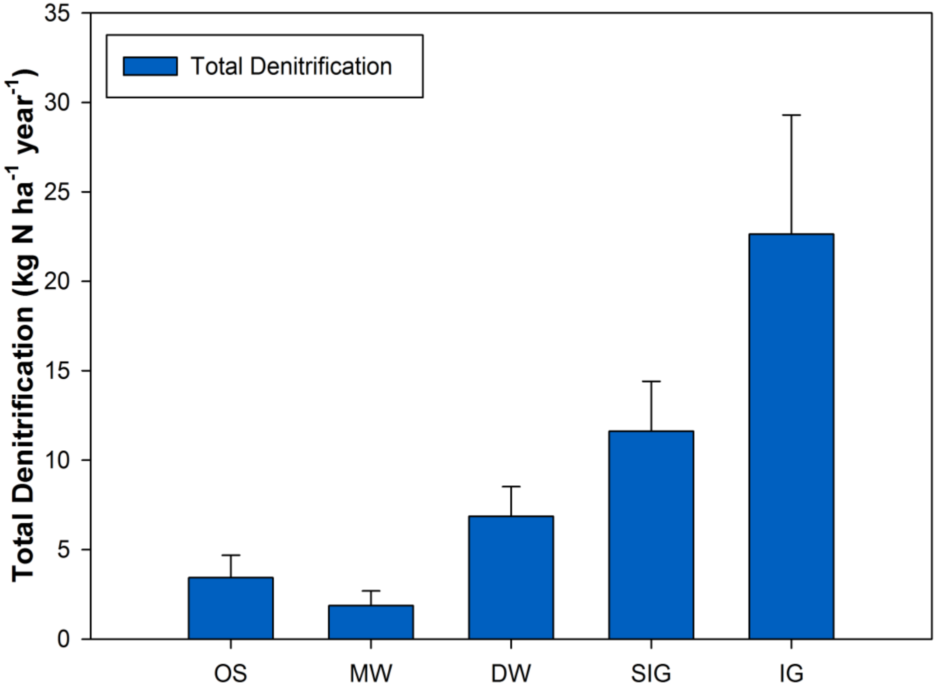
- ➢ Denitrification optimum at WFPS 60 – 70% (SIG, IG, DW)
- ➢ Optimum pH around 6 (SIG, IG) (r= 0.31, p<0.01)
- ➢ No significant effect of carbon availability to denitrification in these land use types (r= -0.07, p>0.05)
- ➢ Optimum C:N ratio between 10 and 20 (all LUs but OS)

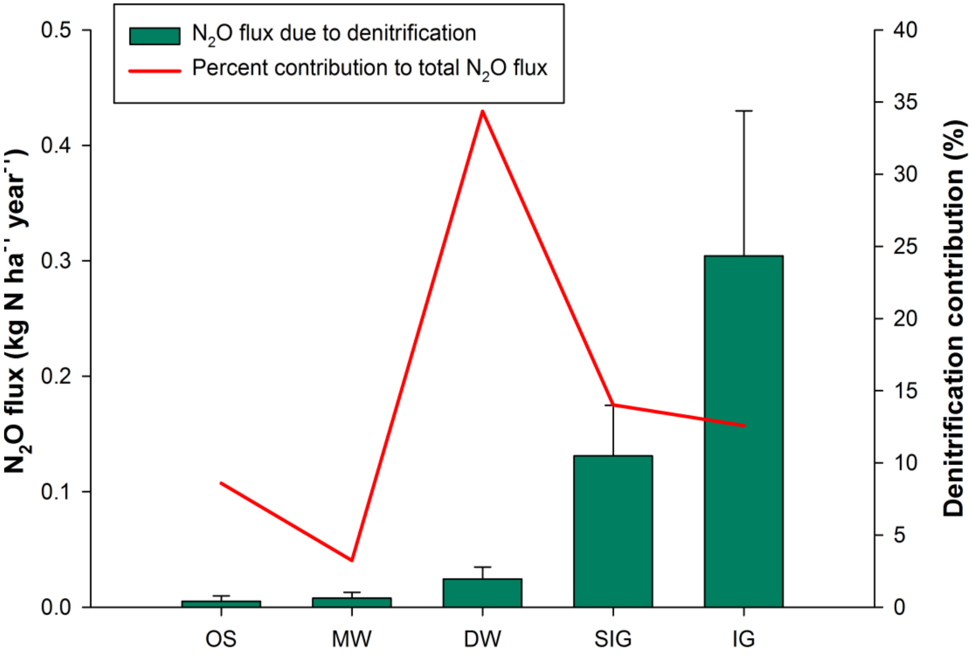






Annual Denitrification and N_2O fluxes





- Annual Denitrification range: 1.9 – 22.6 kg N ha^{-1} $year^{-1}$
- Annual N_2O flux range: 0.005 – 0.3 kg N ha^{-1} $year^{-1}$
- The relative amount of N_2O contributed by denitrification varied across the sites, ranging from 0.2 to 75%
- The largest contribution of N_2O due to denitrification was observed in the DW, while the lowest in the MW.

Conclusions

- The ^{15}N-Gas Flux method can be successfully applied in a variety of land use types for high temporal and spatial resolution measurement of *in situ* denitrification

- The method allows the simultaneous quantification of N_2 and N_2O fluxes due to denitrification and thus the ratio of N_2O/N_2 and also the source apportionment for N_2O can be estimated more accurately

- Denitrification and N_2O emission rates across the natural and semi-natural land use types in this study appear to follow a nitrate availability gradient, which is influenced by both natural variability and land use management:

  Organic soils ≤ Forest soils <Semi-improved <Improved grassland

- The relative importance of other controlling factors (e.g. organic carbon, moisture, bulk density and pH), as these are influenced by the relative degree of land management within each land use type, exert additional controls on denitrification rates

- Land management practices can have significant impacts on the biogeochemical controls of denitrification, and thus need consideration when modelling denitrification across large spatio-temporal scales and/or predicting the response of denitrification to land use change

Acknowledgements

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