Assessing groundwater denitrification under two contrasting land uses in South-East Ireland

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Introduction Denitrification is focused upon as the dominant nitrate attenuation process in groundwater zones. A major concern for the implication of denitrification is that this process does not only serve as a natural pathway for excess NO_3^- attenuation but its intermediate product N_2O is a potent greenhouse gas (IPCC, 2007). The implementation of the Nitrates Directive and the Kyoto Protocol in Ireland has identified the considerable need for robust scientific data on the fate and transport of nitrogen (N) in agricultural systems. The aim of present work was to investigate the denitrification capacity and $N_2/(N_2O+N_2)$ ratio within the shallow groundwater zone.

Materials and methods A groundwater monitoring network was established in Johnstown Castle (JC) grazed grassland and Oak Park (OP) tillage farm (100 km far from JC). The aquifer geology in the shallow groundwater was sand and gravel intermixed with clay and sand, and dense gravel with clay bend in Johnstown and Oak Park, respectively. Seven piezometers (5 cm ID) and 2 m screen sections were installed 3.5 to 5.5 m below ground level. Groundwater was sampled monthly using a bladder pump following the USEPA low flow sampling procedures (*In situ* Inc. USA). DO, pH, temperature, turbidity, electrical conductivity and redox potential were measured during sampling using a multiparameter probe. Groundwater samples were transported at 4°C to the laboratory and analysed, using standard methods, for NO_3^-, NO_2^-, NH_4^+-N, TOC, Total N, Na, K, Ca, Mg, Fe, Zn, SO_4^{2-}, and Cl^-. Dissolved groundwater N_2O was analysed by degassing groundwater in sealed serum bottle (160ml) using high purity He (water: He=3:1) and the headspace gas was analyzed on a Varian gas chromatograph (Reay *et al.*, 2003). The quantity of groundwater N_2 was estimated from N_2/Ar ratios, measured using Membrane Inlet Mass Spectrometer.

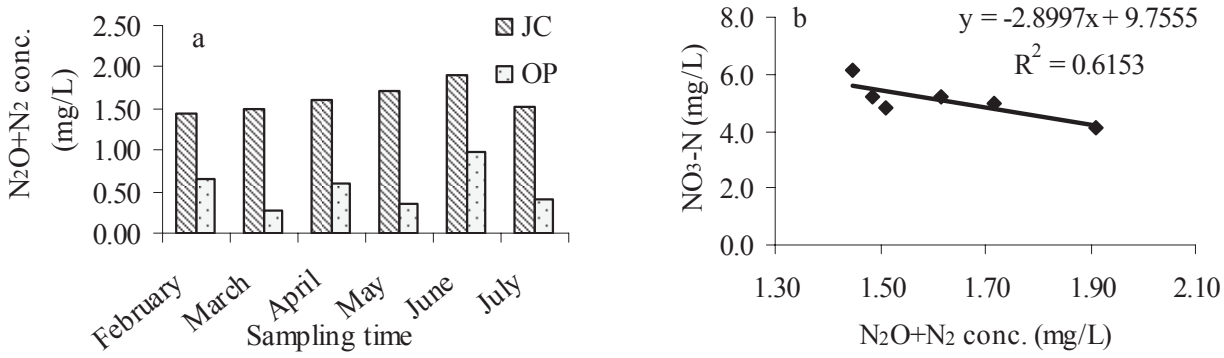

Figure 1 Mean monthly N_2O+N_2 conc. over the sampling period in Johnstown Castle (JC) and Oak Park (OP) (a); and correlation between dissolved N_2O+N_2 and NO_3 –N concentrations (b).

Results Total denitrification was higher in JC than in OP (Fig. 1a). High temporal variation of total denitrification were observed in both land uses systems, giving the highest and lowest concentrations of dissolved N_2O+N_2 in June and February, respectively in JC. In contrast, OP showed the highest and lowest deninitrification in June and March, respectively. The estimated loss of NO_3-N by denitrification was 24.30 and 4.80% in JC and OP, respectively. The $N_2/(N_2O+N_2)$ ratio ranged from 0.96 to 0.99 in JC and 0.59 to 0.98 in OP. The NO_3-N concentrations over the whole period showed a strong negative correlation with the total denitrification indicating the transformation NO_3-N to N_2O-N and N_2 (Fig. 1b).

Conclusion Grazed grassland showed a higher NO_3^- removal capacity through denitrification process than the tillage farming system. A higher percentage of denitrification in the tillage site is N_2O rather than N_2, which could be indirectly contributing to greenhouse gas emissions upon discharge to surface water. Groundwater denitrification appeared to be an important mechanism in reducing NO_3^- in groundwater zone.

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References

IPCC, 2007. Climate Change 2007. The physical science basis. Contribution of working group 1 to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK & New York, USA.

Reay, D. S., Smith, K. A., Edwards, C. A., 2003. Nitrous oxide emissions from agricultural drainage waters. Global Change Biology 9, 195-203.