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Occurrence and controls on N_2O accumulation in the lower Namoi alluvial aquifer, Australia

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The lower Namoi alluvial aquifer (LNAA) in northwest Australia supports a multibillion-dollar agricultural sector focused around cotton growing established in the 1960s. Investigations into N_2O emissions from the LNAA and possible perturbations from agriculture and natural processes are lacking. To determine groundwater N_2O concentrations and production processes in the LNAA, we sampled groundwater from 23 bores (8.4 – 33.6 m depth) in the lower Namoi catchment. To the best of our knowledge, this is the first study to quantify N_2O in groundwater at a catchment scale in Australia.

Dissolved N_2O-N concentrations ranged from 1.2 – 11.9 μg L^{-1}, and NO_3-N concentrations ranged from <0.02 – 5.1 mg L^{-1}. N_2O-N and NO_3-N concentrations were weakly, yet positively, correlated (r^2 = 0.2, p = 0.01). The highest concentrations measured in groundwater were beneath intensely cropped farms (N_2O-N ranging from 1.9 – 11.9 μg L^{-1}; and NO_3-N ranging from 1.3 – 5.1 mg L^{-1}). An exception to this occurred along a groundwater transect within cropped farmland, where both N_2O-N and NO_3-N concentrations were lower (1.2 – 2.0 μg $L^{-1}$and 0.02 – 0.3 mg L^{-1}, respectively). Spatially, this groundwater transect is located where the Great Artesian Basin (GAB), the largest artesian basin in the world, discharges into the LNAA (Iverach *et al*. 2017). Here, GAB input causes the groundwater to have low dissolved oxygen (0.2 – 0.4 mg L^{-1}) and warmer temperatures (23 – 26 ºC), which promotes the reduction of NO_3^- to gaseous N_2O and N_2via denitrification.

Mean emission factors for indirect N_2O emissions (EF_{5g}; N_2O-N / NO_3-N) from groundwater bores located on-farm (EF_{5g} = 0.2%) were lower than IPCC default EF_{5g} (EF_{5g} = 0.25%), while estimates from riparian zone groundwater (EF_{5g} = 3.0%) were higher. Importantly, EF_{5g} values from groundwater affected by GAB discharge (EF_{5g} = 3.4%) were also significantly greater than the IPCC default EF_{5g}, despite being located beneath intensely cropped farmland and having low N_2O-N contents.

The proximity of GAB discharge to major basement faults (FrogTech 2006) suggests these geological features may act as principal conduits for GAB input into the LNAA. By extension, this highlights a fundamental geological control on N_2O emissions and nitrogen cycling – a concept that has been largely ignored in the literature.

References

FrogTech (2006). OZ SEEBASE^{TM} Proterozoic Basins Study, Report to Geoscience Australia by FrogTech Pty Ltd.

Iverach, C. P., Cendón, D. I., Meredith, K. T., Wilcken, K. M., Hankin, S. I., Andersen, M. S., & Kelly, B. F. (2017). A multi-tracer approach to constraining artesian groundwater discharge into an alluvial aquifer. *Hydrology and Earth System Sciences*, 21(11), 5953.