QUANTIFYING ACTUAL DENITRIFICATION IN GROUNDWATER SYSTEMS

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Aims

Nitrate is a significant issue in New Zealand's groundwater systems and waterways. It promotes growth of algae in waterways and degrades aquatic habitat and affects the water's recreational value. Elevated nitrate levels are toxic to animals and humans. Understanding the distribution and reduction rate of nitrates is critical for managing nitrogen loads in New Zealand's aquifers. GNS Science has developed a method to measure the reduction of nitrates by co-analysis of argon, neon and excess nitrogen gas which occur from either natural atmospheric input or denitrification of nitrates.

Method

Argon and neon are derived from the atmosphere, so their presence is used to quantify (or not) excess nitrogen gas which arises from reduction of nitrates during denitrification. Groundwater samples with dissolved gasses are collected in 1 litre flasks for analysis. The dissolved gases are extracted and measured, with the ratios of $Ar:N_2$ and $Ne:N_2$ indicating their origin (Figure 1); either higher $Ar:N_2$ and $Ne:N_2$ for atmospheric input or lower $Ar:N_2$ and $Ne:N_2$ ratios for excess N_2 from denitrification.

Traditional analysis of groundwater nitrates using isotopes is no longer possible once denitrification takes place as the nitrate content is often below the reliable detection limit. Dissolved gasses reveal the origin of the excess N_2 gas, providing information on denitrification pathways and quantifying denitrification efficiency. When combined with other age tracers such as SF_6, they can provide evidence for denitrification rates over time.

Results

Measurement of 'excess N_2' is the most promising method for directly measuring denitrification that has occurred in an aquifer. Current efforts to locate and characterise denitrification zones can also be confirmed by quantifying the extent of denitrification by measuring excess N_2 gas changes (Figure 2). Our initial studies show excess N_2 gas method is useful to detect denitrification and quantifies the amount that has occurred (Figure 3), even in sites with mixed redox states. This suggests the method will be useful to improve knowledge around denitrification zones and quantify levels for ongoing regulatory monitoring. To consolidate this research, we are now seeking partners to undertake small scale projects and apply the method to further studies.

Figures

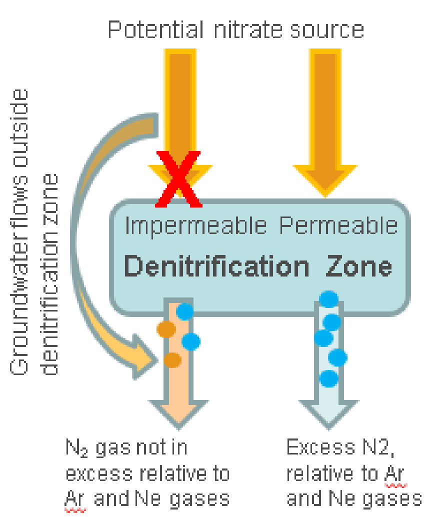

Figure 1. Determining efficiency of denitrification zones.

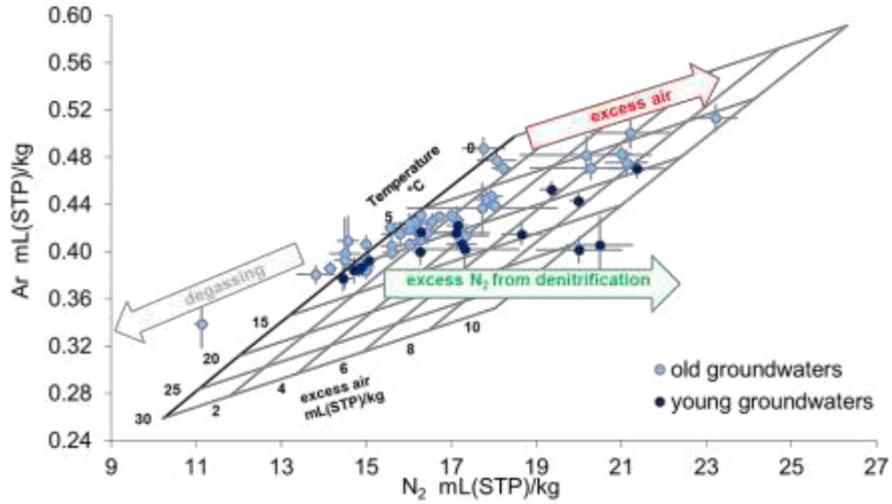

Figure 2. Excess nitrogen gas from denitrification

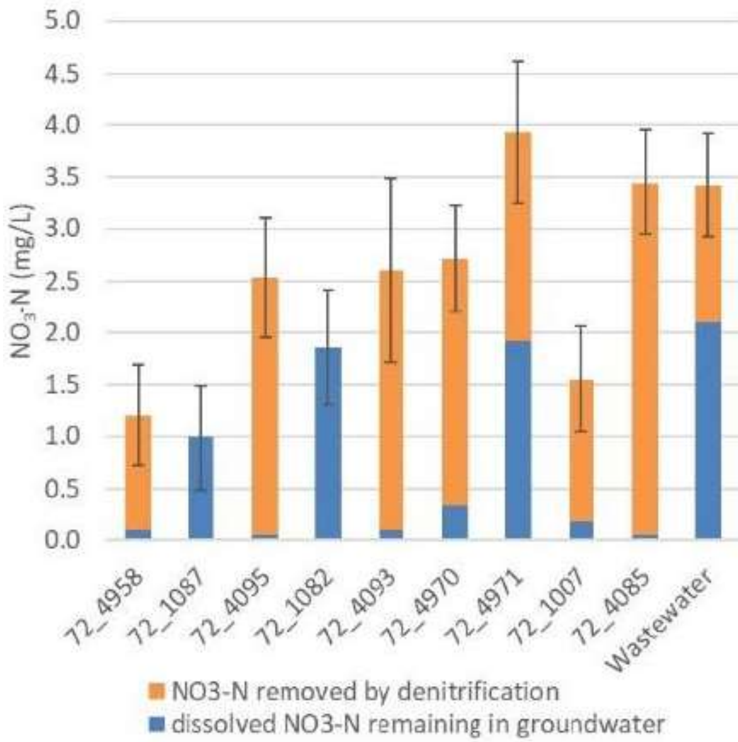

Figure 3. Proportion of concentration of nitrate in the groundwater system which has been denitrified and that which remains in the groundwater.

References

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