Tracing denitrification using isotopic composition of nitrogen in soils and plants

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One of the major challenges of current research on the functioning of the continental ecosphere is to develop integrative approaches allowing scale changes. Isotopic biogeochemistry is an interested integrating tool. The basic idea is that the isotopic composition of a chemical species ($\delta^{15}N$ for nitrogen) at a definite location reflects (i) its various sources and (ii) processes which affect its concentration.
Denitrification generates an isotopic enrichment of ^{15}N and ^{18}O of the residual nitrate in soils or in waters (surface or groundwater).

However, denitrification is intermittent and occurs in hot spots. In order to get insights into this process involved at regional scale, it is important to trace the succession of denitrification in soils and test the hypothesis whether plants could integrate the signal of denitrification occurring in soils.
First results show that for a same type of soil, $\delta^{15}N$ is much higher for agricultural soils than for meadows, forest or mangrove soils. This is mostly likely due to higher gaseous losses processes occurring in agricultural soils such as denitrification.

Moreover, $\delta^{15}N$ of plants increase with increasing of $\delta^{15}N$ of soils. This confirms that the $\delta^{15}N$ of soil organic nitrogen could be an indicator of the intensity of denitrification

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Physical and geochemical processes during groundwater replenishment with highly treated wastewater

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Decreasing availability of ground and surface water resources in conjunction with increasing water demands has motivated the exploration of unconventional new water sources in Australia and other places. Among possible solutions recycling of municipal wastewater through advanced tertiary treatment techniques presents a promising option to augment existing drinking water supplies. During this treatment process reverse osmosis (RO) plays a critical role in the removal of undesired solutes and results in low ionic strength product water. The purified, desalinated water can be stored underground for protection against evaporation loss and introduce, where required, an additional aquifer treatment step for the removal of trace pollutants (e.g., pharmaceuticals, disinfectant-byproducts). As the recycled low ionic strength water is typically in chemical disequilibrium with the native aquifer conditions, the injection into aquifers often triggers a complex range of coupled physical and geochemical processes that can strongly affect the quality of the groundwater in the recharged aquifer. In this study we present field observations and a model-based interpretation of the data collected during a large-scale groundwater replenishment trial using highly treated waste water in Perth, Western Australia. The trial injection was conducted between November 2010 and December 2012 to clarify the technical feasibility and societal acceptance of a large-scale implementation of this approach. The first phase of the modelling study was dedicated to obtaining an accurate understanding and description of the injectant and temperature propagation within the highly heterogeneous sedimentary aquifer.

The calibrated conservative transport model was then subsequently used to identify and quantify the geochemical reactions that were induced by the injection. In agreement with earlier laboratory results from respirometer tests (e.g., [1,2]) the simulation results show that pyrite oxidation acts as the major driver for reaction-induced concentration changes within the aquifer. Pyrite oxidation showed to cause a rapid removal of oxygen and also the removal of the nitrate contained in the injectant. The acidity produced by the pyrite oxidation showed to be partially buffered by the alkalinity contained in the injected water but also by a range of mineral reactions, including Fe-carbonate and feldspar dissolution. Understanding the nature and longevity of the mineral buffering mechanisms is cruicial for the design of future large-scale implementations of groundwater replenishment.

[1] Descourvieres *et al. (*2010a) *Appl. Geochem* **25**, 261–275.
[2] Descourvieres *et al.* (2010b) *Env. Sci. Technol.*, **44**, 6698-6705.

DOI:10.1180/minmag.2013.077.5.19