Isotope Analysis for Source Exploration and Degradation Assessment of Nitrate

Groundwater is often heavily polluted with nitrate of unknown origin. Based on isotope analyses ($^{15}N/^{14}N$ as $\delta^{15}N$, $^{18}O/^{16}O$ as $\delta^{18}O$) nitrate sources (e.g. atmospheric deposition, mineral fertilizers, organic fertilizers, sewage) can be identified. More precise source allocation can be provided by the additional isotope analysis of boron ($^{11}B/^{10}B$ as $\delta^{11}B$).

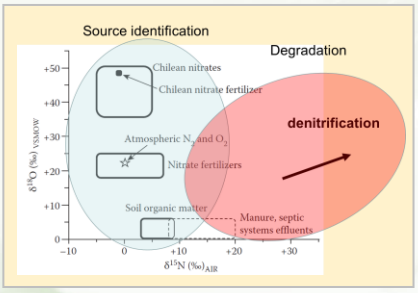
During denitrification, heavy nitrogen and oxygen isotopes (^{15}N, ^{18}O) accumulate in the residual nitrate, resulting in specific changes in $\delta^{15}N$ and $\delta^{18}O$ values. With isotope analyses of sulfate ($^{34}S/^{32}S$ as $\delta^{34}S$, $\delta^{18}O$) the degradation processes can be further evaluated. The ratio of nitrogen/argon (N_2/Ar) points to foregoing denitrification even in nitrate-free groundwater.

Sampling

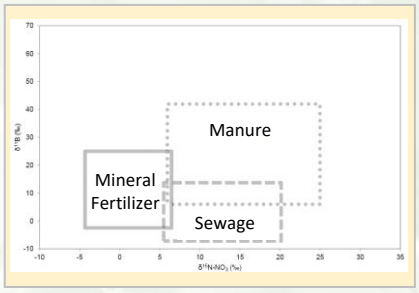
Preparation

Analysis

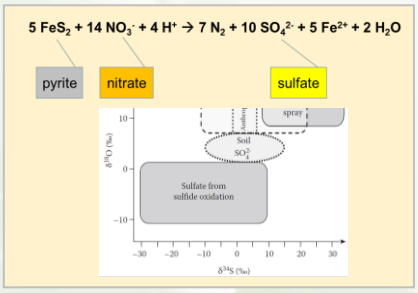
Expertise



Sources of nitrate have specific nitrogen and oxygen isotope values ($\delta^{15}N$, $\delta^{18}O$). Increasingly positive $\delta^{15}N$ and $\delta^{18}O$ values prove nitrate degradation.



Plotting isotope values of boron ($\delta^{11}B$) and nitrate-nitrogen ($\delta^{15}N$) allows for valid identification of nitrate sources.



Nitrate can be degraded by chemo-lithotrophic pyrite oxidation. The resulting sulfate exhibits particularly negative sulfur and oxygen isotope ratios ($\delta^{34}S$, $\delta^{18}O$).

Workflow

- We develop an investigation concept taking into account the site-specific framework conditions.
- We provide sampling flaks and sampling protocols.
- We perform isotope analysis of nitrate, boron and sulfate as well as the concentrations of N_2 & Ar.
- We interpret the data to evaluate nitrate sources and degradation processes.

Costs

$^{15}N/^{14}N$, $^{18}O/^{16}O$: 175 – 240 € per sample

$^{11}B/^{10}B$: 330 – 400 € per sample

$^{34}S/^{32}S$, $^{18}O/^{16}O$: 175 – 240 € per sample

N_2/Ar ratio: on request

Benefit

Differentiation of nitrate sources

Detection and quantification of nitrate degradation

Further reading

Xu S, Kang P, Sun Y (2016): A stable isotope approach and its application for identifying nitrate source and transformation process in water. Environ. Sci. Pollut. Res. 23: 1133-1148.

Widory D, Petelet-Giraud E, Négrel P, Ladouche B (2005) Tracking the source of nitrate in groundwater using coupled nitrogen and boron isotopes: a synthesis. Environ. Sci. Technol. 39: 539-548.

Hosono T, Tokunaga T, Tsushima A, Shimada J (2014) Combined use of $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ tracers to study anaerobic bacterial processes in groundwater flow systems. Water Res. 54: 284-296.

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