Quantifying nitrogen cycling rate in streams water by using triple oxygen isotopes as tracers

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Nitrate (NO_3^-) can be an important source of information for understanding the biogeochemical cycles within the catchment area of the stream. In addition, the nitrate concentration in the stream water is important to primary production, and an excess of nitrate can lead to eutrophication in downstream areas, including receiving lakes, estuaries and oceans. However, nitrate concentration in stream water is determined through a complicated interplay of several processes within the catchment area including the deposition of atmospheric nitrate ($NO_3^-{}_{atm}$), the production of remineralized nitrate ($NO_3^-{}_{re}$) through microbial nitrification, the removal of nitrate through assimilation by plants and microbes, and the removal of nitrate through denitrification by microbes. Therefore, interpretation of the processes regulating nitrate concentration in stream water is not always straightforward.
Recent progresses in the stable isotope analysis enable us to use the stable isotopic compositions of nitrate ($\delta^{15}N$, $\delta^{18}O$, $\Delta^{17}O$) as tracers to understanding the origin of nitrate in stream water. Especially, the excess ^{17}O ($\Delta^{17}O$) tracer, in which isotopic fractionations during assimilation and denitrification have been canceled, can be a robust tracer to quantify mixing ratios of $NO_3^-{}_{atm}$ in stream water nitrate accurately. That is to say, we can quantify the absolute concentration of $NO_3^-{}_{atm}$ in the stream water by using both $\Delta^{17}O$ value and nitrate concentration ($NO_3^-{}_{total}$) in stream water.
In this study, we applied the absolute concentration of $NO_3^-{}_{atm}$ in streams as tracers to quantify nitrogen cycling rates in streams. If the supplying rate of nitrate through nitrification and the uptake rate of nitrate through either assimilation or denitrification are balanced, the nitrate concentration in the stream water is stable. The absolute concentration of $NO_3^-{}_{atm}$, however, should decrease because what produced by nitrification is $NO_3^-{}_{re}$. Therefore, we can estimate the nitrogen cycling rate (i.e., supplying rate of nitrate through nitrification and uptake rate of nitrate through assimilation) by quantifying the changes in the concentrations of $NO_3^-{}_{atm}$ and nitrate along with the stream flow. So as to verify this hypothesis, we quantified both nitrate concentrations and the stable isotopic compositions of nitrate ($\delta^{15}N$, $\delta^{18}O$, $\Delta^{17}O$) along with the stream flow at Yasu river, one of the representative inflow in Lake Biwa, to quantify nitrogen cycling rates of nitrification, denitrification, and assimilation in the stream water. We also determined the nitrogen cycling rates by using the traditional ^{15}N tracer method to verify the accuracy of the estimated values.

Keywords: nitrate, triple oxygen isotopes, stream water, nitrification, assimilation, denitrification