In-situ determination of denitrification, assimilation, and nitrification rates in urban streams

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Fixed nitrogen, such as NO_3^-, $NH_4^+$and Org-N, controls photosynthesis (primary production) in most of the aquatic environments. In recent decades, human activities have released large amounts of fixed nitrogen into aquatic environments mainly via rivers. As a result, the primary production of rivers, and its downstream lakes and oceans has become excessively higher, leading to disturbance of the ecosystems. In order to properly evaluate the effects of human activities on ecosystems, it is essential to understand the spatiotemporal changes in nitrogen dynamics in rivers including denitrification which is a removal process of fixed nitrogen by converting it to N_2. Fixed nitrogen is often transported downstream as NO_3^-in the oxidative river water. The NO_3^-concentration in river water changes depending on the inflow from outside the river system, nitrification in the river system, and the removal processes such as denitrification and assimilation. Therefore, it is difficult to evaluate the denitrification rates only from the spatiotemporal changes in NO_3^-concentration. Previous studies have attempted to quantify the denitrification rate in river environments using culture methods. However, since the denitrification rate greatly changes due to a small change in the redox environment, it was difficult to reproduce the same environment as the on-site environment in the culture system. However, since a small difference in the redox state greatly changes the denitrification rate, it is difficult to estimate the exact denitrification rate by the culture method.

Here we propose a new tracer called “atmospheric NO_3^-concentration”, which can be calculated from both concentration and triple oxygen isotopic composition ($\Delta^{17}O$ value = $\delta^{17}O - 0.52 \times \delta^{18}O$) of dissolved NO_3^- in river water, to determine the removal rate of NO_3^-(sum of denitrification rate and assimilation rate) in the river environments. We attempt to determine the in-situ denitrification, assimilation, and nitrification ratesin the river waterindividually by tracing the atmospheric NO_3^- concentration together with totalNO_3^-concentration.
In this study, we focused on urban rivers that are significantly affected by human activities. The study was carried out at Tenpaku River (Aichi Prefecture). We selected an observation section where tributaries and other inflows were negligible, and performed observations at the entrance and exit of the section every two hours for 24 hours. The observations were held five times (August, October, December, 2018 and March and July 2019). We first estimated the NO_3^-removal rate from the difference in atmospheric NO_3^- concentration between the two sites and then estimatedthe nitrification rate from the difference in the total NO_3^-concentration between the two sitesand from the determined NO_3^-removal rate. While the denitrification rate was estimated from the NO_3^-removal rate at night, the assimilation rate was estimated from the difference between the NO_3^-removal rate at day and night.As a result, the denitrification rate, assimilation rate, and nitrification rate were estimated to be 2.4 to 4.7 mmol/m^2/h, 0.5 to 2.1 mmol/m^2 /h, and 2.1 to 5.5 mmol/m^2/h, respectively. All the rates showed seasonal changes that increased in summer and decreased in winter. Using the denitrification rate obtained in this study, we found that about 30% of loaded nitrogen that are transported from the Tenpaku River to the ocean was reduced by denitrification in the river.

Keywords: urban streams, denitrification, assimilation, nitrification, triple oxygen isotope

