

Quantifying nitrate dynamics in lakes using triple oxygen isotopes as tracers

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Nitrate (NO_3^-) is a key nutrient in aquatic environments that often limits primary production. Nitrate dynamics in an aquatic environment, i.e., gross uptake rate of nitrate through assimilation and gross production rate of nitrate through nitrification, are important to quantify when evaluating both the present and future state of an aquatic environment. In most studies that have been conducted to date, the gross uptake rate of nitrate has been estimated by incubation experiments using ^{15}N tracer techniques. However, these experimental procedures are generally costly and complicated. Furthermore, the ^{15}N tracer method using bottle incubations can be problematic when determining accurate nitrate uptake rates. In this study, we would like to present our results to quantify the annual average nitrate dynamics (gross uptake rate of nitrate through assimilation and gross production rate of nitrate through nitrification) together with seasonal variations in the water columns of lakes. Specifically, stable isotopic compositions of nitrate, including $\Delta^{17}\text{O}$, were determined several times during one year at the same water column of a lake studied. By using both the deposition rate of atmospheric nitrate onto the entire surface of the lake and the influx/efflux of both atmospheric and remineralized nitrate via streams, we were able to use the $\Delta^{17}\text{O}$ data to quantify the dynamics of nitrate in the lake. One of the results done in the mesotrophic Lake Biwa, the largest freshwater lake in Japan, revealed that 640 Mmol of the remineralized nitrate was fed into the water column through nitrification on an annual basis, while 810 Mmol of nitrate was simultaneously removed from the water column mostly through assimilation. Furthermore, the uptake rates of nitrate varied seasonally and showed the highest values in summer and the lowest values in winter. To explain the quantified nitrate dynamics in the lake, we found that nitrification was highly active in the epilimnion and upper thermocline.