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Quantifying nitrate dynamics in hydrosphere using the natural stable isotopes as tracers

TSUNOGAI, Urumu[1*], Yukie Tadenuma[1], OHYAMA, Takuya[1], KOMATSU, Daisuke[1], NAKAGAWA, Fumiko[1], UMEDA, Makoto[2], Atsushi Tanaka[3]

[1]Earth and Planetary System Science, Faculty of Science, Hokkaido University, [2]Graduate School of Engineering, Tohoku University, [3]National Institute for Environmental Studies

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. In this conventional approach, ^{15}N labeled NO_3^- is added into bottles or mesocosms that simulate in situ conditions, which leads to the production of particulate organic-^{15}N ($PO^{15}N$) through assimilation over a known incubation period of several hours to several days. This $PO^{15}N$ is then gathered and quantified by mass spectrometry. However, these experimental procedures are generally costly, complicated, and time consuming, especially those that employ mesocosms. Furthermore, the ^{15}N tracer method has several problems with determining accurate nitrate uptake rates. For example, the usual ^{15}N tracer method does not include assimilated nitrogen released to dissolved organic-^{15}N ($DO^{15}N$) during incubation within the estimated uptake rates, which results in the rates being underestimated. Additionally, incubation itself could also result in the production of artifacts by changing the physical/chemical environments. Finally, it is difficult to simulate nitrate uptake by periphyton or microbes on the lake floor through typical incubation in bottles.

In this study, we estimated the gross nitrate uptake rate in several lakes in Japan using average $Delta^{17}O$ values of NO_3^- ($Delta^{17}O$ method) dissolved in each studied lake. Besides, we compared the results with those estimated using the traditional ^{15}N tracer method.

Based on the observation, we concluded that the $Delta^{17}O$ method overcomes the aforementioned problems inherent in the conventional ^{15}N-labelled tracer methods. Accordingly, the $Delta^{17}O$ method can be an alternative to standard techniques for the determination of accurate gross nitrate uptake rates in hydrosphere that contain detectable quantities of atmospheric nitrate within the total nitrate.

Keywords: nitrate, atmospheric deposition, assimilation, nitrification, nitrogen cycle, triple oxygen isotopes