Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

MIS26-P01 Room:Convention Hall Time:May 27 18:15-19:30

In situ estimation of new and regenerated production in lakes using triple oxygen isotopes as tracers

NAKAGAWA, Fumiko[1*] ; TSUNOGAI, Urumu[1] ; KOMATSU, Daisuke[1] ; OHYAMA, Takuya[1] ; MIYAUCHI, Takanori[1] ; SAKUMA, Hiroki[1] ; MINAMI, Sho[1] ; TADENUMA, Yukie[2] ; UMEDA, Makoto[3] ; TANAKA, Atsushi[4]

[1]Graduate School of Environmental Studies, Nagoya University, [2]Faculty of Science, Hokkaido University, [3]Graduate School of Engineering, Tohoku University, [4]National Institute for Environmental Studies

The gross primary production rate is an essential parameter to study biogeochemical processes in hydrosphere, having strong relations with environmental changes in lakes and oceans, such as eutrophication and global warming. Supplying rates of fixed nitrogen, especially dissolved nitrate (NO_3^-) and ammonium (NH_4^+), to each hydrospheric environment often control each gross primary production rate. As a result, the primary production is often divided into the following two categories: “new production” that uses NO_3^- supplied either from atmosphere or from aphotic layer, and “regenerated production” that uses a recycled nitrogen in the form of NH_4^+ or dissolved organic nitrogen excreted or produced during biogeochemical processes within photic layer.

All the above-mentioned parameters had been traditionally estimated based on incubations of sampled water in bottles by adding isotope-labeled compounds such as $^{13}CO_2$ or $^{14}CO_2$ for the primary production rates and/or $^{15}NO_3^-$ or $^{15}NH_4^+$ for nitrogen uptake rates. In these approaches, however, sampled water in bottles is incubated under artificial conditions that must be somewhat different from actual in-situ conditions and the results could represent different rates from the original in aquatic environments. Moreover, the estimated values based on the incubation corresponds to instantaneous uptake rates when sampling was done so that large errors could be expected for the hydrospheric environments with significant temporal variations, otherwise we must increase a number of observations using time and costs.

In this study, we determined the parameters using natural isotopes in lake-dissolved materials instead of using incubations. Most of the oxygen-containing molecules on earth show mass-dependent relative variation between $^{17}O/^{16}O$ ratios and $^{18}O/^{16}O$ ratios. On the other hand, atmospheric O_3 photochemically produced from O_2 shows an anomalous enrichment in ^{17}O, so that residual atmospheric O_2 is slightly depleted in ^{17}O in comparison with the mass-dependent relative relation. Besides, at least one of the O atoms in atmospheric NO_3^- is derived from atmospheric O_3 owing to the contribution of O atoms from O_3 during the photochemical oxidation processes of NOx in atmosphere, so that the triple oxygen isotope ratios ($\Delta\ ^{17}O$ values) of NO_3^- also deviate from the mass-dependent relative relation. Since $\Delta\ ^{17}O$ value does not vary during the general mass-dependent reactions such as decompositions, we can estimate the mixing ratio between atmospheric O_2 and photosynthetic O_2 from $\Delta\ ^{17}O$ value of O_2 and that between atmospheric NO_3^- and remineralized NO_3^- from $\Delta\ ^{17}O$ value of NO_3^-. If we determine the $\Delta\ ^{17}O$ values of both dissolved O_2 and NO_3^- in a hydrospheric environment as well as supplying rates of atmospheric O_2 and NO_3^-, we can determine both the primary production rate and NO_3^- uptake rate simultaneously. One of the priorities of this $\Delta\ ^{17}O$ method is that the estimated rate corresponds to the average value of each rate, so that the values can be a more reliable and accurate than the values estimated from the incubation methods.

In this study, we determined both gross primary production rate and new primary production (NO_3^- uptake) rate simultaneously based on the $\Delta\ ^{17}O$ value of dissolved O_2 and NO_3^- in two oligotrophic lakes (Lake Shikotsu and Lake Kuttara) and one mesotrophic lake (Lake Biwa) in Japan. The regenerated production rate was then calculated by deducing the later from the former. Water samples were collected twice (spring and summer) in a year for each lake. Both primary production rates and NO_3^- uptake rates were determined from the vertical distribution of $\Delta\ ^{17}O$ values of O_2 and NO_3^- and their difference between the seasons. We found that the f-ratios (relative use of NO_3^- among the total use of nitrogen) were lower in oligotrophic lakes than in the mesotrophic lake.

Keywords: new production, regenerated production, gross primary production, lakes, triple oxygen isotopes, hypolimnion