

Nitrification and denitrification in Lake Biwa sediment viewed from natural stable isotopes

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Nitrogen compounds in natural environment have various oxidation numbers, and they convert their forms by chemical and biochemical processes occurring according to various redox status. Among these processes, nitrification and denitrification that are biochemical processes by microbes play roles as a natural purification for large loads of nitrogen and as emission of nitrous oxide, which is one of the greenhouse gases, and occurrences of those processes are closely linked to redox condition. Therefore, we will make some reference to eutrophication, conservation of ecosystems, and the history of redox status and evolution of organisms in the earth by information of nitrification and denitrification in natural environment.

Stable isotope ratio of a material provides information about the substrate and process that the compound was produced and consumed. We can get such information about nitrification and denitrification by using multiple stable isotopes of nitrogen compounds such as ammonium, nitrate, and nitrous oxide. In denitrification, nitrogen and oxygen isotope ratios of nitrate increased together during reduction, and ratio of an enrichment factor of stable isotope ratio for nitrogen and oxygen shows a certain extent (the ratio of enrichment factor is about 1 in sea water (Sigman *et al.* 2005) and about 0.5 in fresh water (Lehmann *et al.* 2003).

Some recent studies suggested that denitrification would occur in Lake Biwa (Yamada *et al.* 1997, Ogawa *et al.* 2001), but definitive evidence of denitrification had not been obtained. Thus, we studied how nitrification and denitrification occur in a monomictic lake with moderate dissolved oxygen concentration.

We sampled core sediment at the point of 90m depth in north basin of Lake Biwa on September 2004 and October 2006. We measured oxygen concentration and redox status by using microsensors. Then, we sliced the core sample by 5mm or 10mm and extracted with 2M KCl solution. We measured concentrations of ammonium, nitrate, and nitrite in the extractions. We also measured nitrogen and oxygen stable isotope ratio of nitrate by denitrifier method.

Dissolved oxygen concentration was not depleted in water column, and in the sediment, it was depleted in 7mm of the depth on September 2004 and 2mm on October 2005. Isotope ratios of nitrate in the sediments were also different between sampling years. On September 2004, both nitrogen and oxygen isotope ratio increased simultaneously in deeper sediment with decrease of nitrate concentration. The enrichment factor of nitrogen was about -1 and this small enrichment factor corresponded with that in sedimentary denitrification reported by Brandes and Devol (1997). Although the ratio of enrichment factors for nitrogen and oxygen was about 5 because of relatively large oxygen isotopic fractionation in the sediment, the concurrent increase of nitrate isotope ratios indicates that nitrate reduced by denitrification in the sediment in Lake Biwa.

In Lake Biwa, a monomictic lake with moderate dissolved oxygen, oxygen diffusion to sediment would control nitrification and denitrification in sediment. We will discuss mechanisms of nitrification and denitrification in sediment based on the difference between years.