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Tracing the source of nitrate eluted from the forest ecosystem under high deposition rate of atmospheric nitrogen

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Forest ecosystems are deficient in fixed-nitrogen in general (Vitousek and Howarth, 1991). Excess input of fixed-nitrogen, however, often produced ”nitrogen saturation” (Aber et al., 1989) in forest ecosystems. Nitrate concentrations dissolved in streams and rivers eluted from nitrogen saturated forest increased due to either increased leaching rate of nitrogen preserved in forest soils and/or increased direct drainage rate of atmospheric nitrated deposited onto forest. In order to evaluate the direct drainage of atmospheric nitrate from forest under high deposition rate of atmospheric nitrogen, we determined both concentrations and triple oxygen isotopic compositions of nitrate in the stream water eluted from the forest around Lake Ijira, Gifu Prefecture. Within Long-Term Monitoring sites of Transboundary Air Polution and Acid Deposition by the Ministry of the Environment in Japan, Lake Ijira have been characterized by the highest deposition rate of atmospheric nitrogen.

Samples were collected once in two weeks from March, 2013, to February, 2014, at two rivers, RW1 (Kamagadani river) and RW3 (Kobora river) eluted from the forest around Lake Ijira. Water samples were filtered throughout 0.45 μm membrane filter, and were stored in the refrigerator until analysis. The triple oxygen an nitrogen isotopic composition of dissolved nitrate was determined using Continuous-Flow Isotope Ratio Mass Spectrometry (CF-IRMS) system (Komatsu et al., 2008). Dissolved nitrate in the samples were chemically converted to nitrous oxide introduced into the system (Tsunogai et al,. 2010).

The triple oxygen isotopic compositions of nitrate in both rivers (RW1 and RW3) were about +1∼2 ‰, confirming the direct drainage of atmospheric nitrate from the forest. Seasonal variation in the triple oxygen isotopic composition was not significant during the observation. Calculated mixing ratios of atmospheric nitrate within total nitrate dissolved in the river water was around 5.8% at RW1 and 4.0% at RW3, respectively. RW3 catchment can be characterized by lower elution rate of atmospheric nitrate, as well as by lower elution rate of total nitrate, to the streams and rivers. In accordance with the decrease in the nitrate concentrations in 2013 from those in 2012 at both sites, the triple oxygen isotopic compositions also decreased in 2013. Therefore, both direct drainage rate of atmospheric nitrate and elution rate of remineralized nitrate in forest soils have been reduced simultaneously in the forest probably due to some kind of ”recovery” in the forest ecosystems.

Keywords: forest ecosystem, nitrogen saturation, atmospheric nitrate, triple oxygen isotopic composition, Lake Ijira