Land-use and topographic characteristics control nitrate concentration in river water of Lake Kitaura Basin, Japan

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Nitrogen (N) concentration in rivers of the Lake Kitaura Basin (LKB) (5.6 mg-N L^{-1} in average in FY2015) is higher than that of the neighboring Lake Nishiura Basin (2.9 mg-N L^{-1}). Under the intensive agricultural practices in LKB, inflow of N originated from soil-amended chemical fertilizers and manures via surface runoff and groundwater discharge can be considered as the main cause of the higher N concentration. In the present study, we analyzed the relationship between N concentration, stable N and oxygen (O) isotope ratios of nitrate (δ^{15}N-・ δ^{18}O-NO_3^-) in river water, and watershed land-use and topographic characteristics in the two main rivers of LKB (Hokota and Tomoe Rivers). From April 2016 to July 2017, river water samples have been sampled monthly at 6 and 7 tributaries of Hokota and Tomoe Rivers, respectively, under low-flow condition and analyzed for the water quality parameters including N concentration and δ^{15}N-・ δ^{18}O-NO_3^-. Excluding one station where a strong influence from point sources was suspected, principal component analysis showed that log-transformed nitrate concentration (ln[NO_3^-]) has close positive relations with areal percentage of dry field (DF) and concentrations of Ca^{2+}, Mg^{2+} and SO_4^{2-}, and also has negative relations with such parameters as topographic wetness index (TWI). In the non-irrigation period (October 2016 April 2017), significant negative correlations between ln[NO_3^-] and δ^{15}N-・ δ^{18}O-NO_3^-, as well as a significant positive correlation between δ^{15}N- NO_3^- and δ^{18}O-NO_3^-, were recognized. Nitrogen and O isotopic fractionation factors ($^{15}\varepsilon$ and $^{18}\varepsilon$, respectively), corresponding to the slopes of the linear regression curves for ln[NO_3^-] and δ^{15}N-・ δ^{18}O-NO_3^-, were calculated to be 2.4‰ and 1.5‰, both of which were lower than the reported values for denitrification and algal assimilation processes. However, the ratio of the two fractionation factors ($^{15}\varepsilon$: $^{18}\varepsilon$) was 1: 0.63 and comparable to the reported values. Furthermore, multiple regression analysis found that ln[NO_3^-] can be explained by a function containing DF and TWI as explanatory parameters (R^2 = 0.98). In conclusion, fertilizers amended into dry fields are suggested to be the main source of nitrate in rivers of LKB, whereas denitrification and algal uptake in riparian zone and runoff process would play an important role in reducing nitrate concentration in river water.

Keywords: land use, nitrate, stable isotope ratio, topographic wetness index

