Basic kinetic study on stable isotope ratios of nitrogen compounds: a case study for groundwater in the Kathmandu Valley, Nepal

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Groundwater is a valuable source of water in developing countries where water demand is increasing with population increase. At the same time, nitrogen contamination by industrial wastewater, domestic wastewater and agricultural activities has been reported. In underground environments, it is not unusual to identify sources of contamination since the forms and the concentrations of nitrogen compounds vary at different water flow or microbial metabolism. Stable isotopic analysis is one of the effective methods to detail the variations. However, the isotope value is also greatly affected by environmental conditions, and the theoretical enforcement for describing the variation of the isotope value is needed. In this study, we aimed to quantitatively understand and identify the factors of mixing and isotopic fractionation that determine the stable isotope ratio with a case study on groundwater contamination in the Kathmandu Valley, Nepal.

The data used for the analysis was obtained from the groundwater survey of the Kathmandu Valley conducted from September 2014 to August 2018. Based on the stable isotope ratios of nitrogen and oxygen of nitrate, the contamination patterns were roughly categorized. The mixing line and the denitrification line were prepared based on the dynamic fractionation for the stable isotope ratios of nitrate nitrogen, and the spatial distribution of denitrification-related samples was examined on the map. In addition, assuming that the reactants exist sufficiently and homogeneously in the system, an equilibrium fractionation model was formulated by combining nitrification and denitrification for oxygen stable isotope ratios of nitrate and water. The range of the model parameters were determined by using the measured data from the filed survey, the influence of each process on the stable oxygen isotope ratio of nitrate was quantified.

The result showed that the nitrate in shallow groundwater partially originated from the atmospheric source through infiltration of rainwater. A characteristic of denitrification was observed, which was initiated and proceeded over the valley. Additionally, the correspondent isotopic fractionation differed at the location and the season, particularly controlled by ammonia oxidation, nitrite reduction and oxygen exchange between nitrite and water.

Keywords: groundwater , nitrogen and oxygen stable isotope ratios, nitrification, denitrification, mixing, fractionation

