Elucidation of nitrate dynamics in a temperate region watershed with heavy snowfall using triple oxygen isotopes as tracers

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Atmospherically deposited nitrogen to the terrestrial environment due to human activity has been increased over the last decades. It is important to elucidate the response of ecosystems towards nitrogen deposition. In this study, a triple oxygen isotope approach was used as a tracer for environmental fate of $NO_3^-{}_{atm}$ in a temperate forest with heavy snow for the years 2015 and 2016. The $\Delta^{17}O\text{-}NO_3^-$ for precipitation and throughfall in our study ranged from 22 to 32‰ and represented the seasonal variation between summer (minimum) and winter (maximum), attributed to different formation pathways of $NO_3^-{}_{atm}$ over seasons. Based on $\Delta^{17}O\text{-}NO_3^-$ in litter layer and mineral soil at 25, 55, and 90 cm depths respectively, the calculated fraction of $NO_3^-{}_{atm}$ (f_{atm}) showed that nitrification mainly occurs in the litter layer in the summer (low $\Delta^{17}O\text{-}NO_3^-$); on the other hand, high $\Delta^{17}O\text{-}NO_3^-$ was observed in the winter, indicating that nitrification does not occur in the litter layer due to the existence of snowmelt water and low temperatures. Although different f_{atm} for litter layer were observed over the seasons, f_{atm} of stream water were constant (approximately 10%) in both winter and summer. In addition, gross nitrification rates (GNR) based on f_{atm} of stream water and total NO_3^- input for this study site were lower in summer than those in winter, suggesting higher nitrification activity in winter due to higher loads of NO_3^- and NH_4^+ inputs in the latter season. Although our plots for biologically produced NO_3^- ($\delta^{15}N$ and $\delta^{18}O$) showed no clear relationship of denitrification or assimilation, enrichment of $\delta^{15}N$ in soil, ground and stream water suggest that denitrification might occur in this ecosystem.