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Nitrate discharge from an N-rich forest in central Japan: A preliminary isotopic diagnose of rainfall events

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Tracing nitrate (NO3-) losses from highly polluted forests is directed to understanding ecosystem N cycles in response to anthropogenic N inputs. Stable isotopes of NO3- (d15N, d18O and D17O) are well-suited tools to differentiate atmospheric-deposited and soil-derived NO3- leached into streams of forested catchments, thus provide diagnostic evidences on the plant-soil N status and forest N saturation. However, our understanding of the mechanisms that regulate the temporal and hydrological variability of stream NO3- isotopes is rather limited. It has not been well characterized how the source and flux of stream NO3- will change across rain events, and how stream NO3- isotopes record the response of short-term soil NO3- dynamics to rainfall and/or direct hydrological losses of soil NO3-.

A high-temporal resolution collection and flow monitoring of the headwater stream was conducted across two rainfall events in 2011 in an N-rich forest of Karasawayama, the northern Kanto district of Japan. All samples were analyzed for NO3- concentration ([NO3-]) and part of samples has been analyzed for stable isotopes (d15N, d18O and D17O). Using the flow rate and [NO3-] of regular flows, annual NO3- discharge was estimated. In the same way, total NO3- discharge in the whole event was calculated using event-based flow and event-based [NO3-]. Then using D17O of stream NO3-, atmospheric-derived NO3- (atm-NO3-) can be differentiated in annual and event NO3- discharge. According the differences of soil-derived NO3- and atm-NO3- in regular and event discharges, it can be quantified how much soil NO3- was washed out by the rain event.

The D17O of stream NO3- ranged between 0.8-1.5 permil, showing no substantial difference between event-based and regular flows. On average, 5.0-5.8% of stream NO3- was derived directly from precipitation. Annually, 3.0-4.0 kg-N in total 60?80kg-N discharge was directly from precipitation. This annual discharge did not include influences from rain events. Actually, in a rain event, ca.95% of NO3- is soil-derived, in which only 18?30% was discharged in the regular pathway, 70-82% of soil NO3- was flushed out by rain water. For regular flow, d15N and d18O of stream NO3- co-varied with a slope closing to 1:1 and did not change with [NO3-], suggesting little influence from denitrification and the mixing of atm-NO3-. However, according to the event of September, the temporal variations of D17O and fatm were weak and the fatm was actually low, simple atm-NO3- mixing could not explain the d18O fluctuations (by 4-12 permil). Altered soil nitrification/denitrification dynamics, not the mixing of atm-NO3- (fatm), were suspected fluctuating the d18O but keeping a low D17O signal of stream NO3- during the rain event.

Keywords: N saturation, N deposition, Nitrate leaching, Stable isotopes, 17O anomaly, Rainfall event