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17 years of biogeochemical data from a remote tropical montane forest in Ecuador: Tracing changes in the N cycle under environmental change

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Water-bound N cycling in temperate terrestrial ecosystems of the Northern Hemisphere is today mainly inorganic because of anthropogenic release of reactive N to the environment. In little-industrialized and remote areas, in contrast, a larger part of N cycling occurs as dissolved organic N (DON). Since 1998, we intensively study the biogeochemical cycle of a north Andean tropical montane forest in Ecuador. The resulting data set offers the unique opportunity to assess the effects of environmental change on a remote ecosystem.

Rainfall, throughfall, stemflow, litter leachate, soil solution in 0.15 and 0.30 m soil depth, and stream water were sampled in weekly resolution and analyzed for total N, NO_3-N, NH_4-N, DON, total organic C, PO_4-P, total dissolved phosphorus, Cl, K, Ca, Mg, and Na. Furthermore, ecological time-series data from other disciplines (e.g., climate or phenological data) is available for the study site, resulting in over 500 ecosystem variables by now. The data set was aggregated to monthly means and analyzed for temporal trends with the non-parametric Seasonal Mann-Kendall test.

Our results show that the N cycle changed markedly during the study period along with increasing N deposition and reduced soil moisture. The DON concentrations and the fractional contribution of DON to total N significantly decreased in rainfall, throughfall, and soil solutions. This turn toward inorganic N was most pronounced in rainfall and became weaker along the flow path of water through the system until it disappeared in stream water. Decreasing organic contributions to N cycling were not only caused by increasing inorganic N input but also by reduced DON production and/or enhanced DON decomposition. Such an accelerated DON decomposition might be attributable to less waterlogging and higher nutrient availability, which both were observed at our study site. Significantly increasing NO_3-N concentrations and NO_3-N/NH_4-N concentration ratios in throughfall and litter leachate below the thick organic layers indicated increasing nitrification. In mineral soil solutions, in contrast, NH_4-N concentrations increased and NO_3-N/NH_4-N concentration ratios decreased significantly, suggesting increasing net ammonification. Our results demonstrate that the remote tropical montane forests on the rim of the Amazon basin experienced a pronounced change of the N cycle in only one decade. This change likely parallels a similar change that followed industrialization in the temperate zone of the Northern Hemisphere more than a century ago.