Implications of alpine warming on biogeochemical cycling in Green Lakes Valley, Colorado Front Range, USA

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Alpine ecosystems are particularly susceptible to disturbance due to their short growing seasons, sparse vegetation and thin soils. Atmospheric nitrogen deposition and warming temperatures currently affect Green Lakes Valley (GLV) within the Colorado Front Range. Research conducted within the alpine links chronic nitrogen inputs to a suite of ecological impacts, resulting in increased nitrate export. According to NADP records at the site, the atmospheric flux of nitrogen has decreased by 0.56 kg ha-1 yr-1 since 2000, due to a decrease in precipitation. Concurrent with this decrease, alpine nitrate yields have continued to increase; by 32% relative to the previous decade (1990-1999). In order to determine the source(s) of the sustained nitrate increases we utilized long term datasets to construct a mass balance model for four stream segments (glacier to subalpine) for nitrogen and weathering product constituents. We also compared geochemical fingerprints of various solute sources (glacial meltwater, thawing permafrost, snow, and stream water) to alpine stream water to determine if sources had changed over time. Long term trends indicate that in addition to increases in nitrate; sulfate, calcium, and silica have also increased over the same period. The geochemical composition of thawing permafrost (as indicated by rock glacial meltwater) suggests it is the source of these weathering products. Mass balance results indicate the high ammonium loads within glacial meltwater are rapidly nitrified, contributing approximately 0.45 kg yr-1 to the NO3- flux within the upper reaches of the watershed. The sustained export of these solutes during dry, summer months is likely facilitated by thawing cryosphere providing hydraulic connectivity late into the growing season. In a neighboring catchment, lacking permafrost and glacial features, there were no long term weathering or nitrogen solute trends; providing further evidence that the changes in alpine chemistry in GLV are likely due to cryospheric thaw exposing soils to biological and geochemical processes. These findings suggest that efforts to reduce nitrogen deposition loads may not improve water quality, as melting cryosphere associated with climate change may affect alpine nitrate concentrations as much, or more than atmospheric deposition trends.

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