Bedrock Nitrogen Impacts on Terrestrial and Aquatic Ecosystems

RANDY A. DAHLGREN

University of California, Davis, CA USA
(radahlgren@ucdavis.edu)

While the occurrence of nitrogen in bedrock has long been recognized, there is a paucity of information concerning the environmental and ecological significance of nitrogen released from bedrock. Rocks of sedimentary origin contain >99% of the global fixed N. Nitrogen in bedrock occurs as organic N and/or ammonium substituted in silcate minerals. Nitrogen is ubiquitous in rocks of sedimentary origin with fine-textured shales and mudstones (600 - 800 mg/kg) containing higher concentrations than sandstones (200 - 350 mg/kg) and carbonates (200 - 400 mg/kg). The source of nitrogen in bedrock is from incorporation of organic materials deposited with sediments. Organic nitrogen contained in sediments may be released as ammonium upon diagenesis and incorporated into silicate minerals (e.g., mica, feldspars). Nitrogen is stable in bedrock upon low-grade metamorphism but is increasingly released with higher grade metamorphism.

Nitrogen released from bedrock has been implicated in soil acidification, stimulating forest productivity and carbon storage, enhancing aquatic ecosystem productivity, contributing to terrestrial ecosystem nitrogen saturation and nitrate leaching to surface waters, and elevating groundwater nitrate concentrations. The limited information available for release of nitrogen by chemical weathering in temperate forests indicates rates on the order of 3 – 5 kg/ha/yr. In a study in northern California, N from bedrock increased above-ground tree biomass by 40% and soil carbon storage by 60% in the upper 30 cm of soil. Release of ammonium from silicate minerals has the potential to induce strong soil acidification upon nitrification of ammonium to nitrate thereby inhibiting forest regeneration. In groundwater, nitrogen may occur as ammonium under anaerobic conditions or nitrate under aerobic conditions. High groundwater nitrate concentrations have been documented in N-rich shale aquifers. In volcanic systems, hydrothermal mobilization of nitrogen from underlying sedimentary rocks has been shown to stimulate primary productivity of aquatic ecosystems leading to enhanced growth of fish. While further research is necessary to establish the global importance of bedrock nitrogen, current knowledge suggests that bedrock nitrogen has the potential to strongly impact terrestrial and aquatic ecosystems.