Nitrogen and Carbon Dynamics of Groundwater at the Coastal Margin

Barbara Nowicki, James McKenna, and Art Gold

National Science Foundation Grant, 1999-2002

Project Summary

Groundwater is frequently cited as the single largest contributor of N to coastal receiving waters, yet attempts to quantify N delivery to coastal waters are hampered by a lack of understanding of factors regulating N and C cycling in coastal aquifers. Previous work suggests that factors which control the presence and bioavailability of subsurface organic carbon regulate nitrogen cycling in aquifer systems. Research conducted in riparian transition zones demonstrates that certain combinations of hydrology, vegetation and geomorphology can generate enriched pools of labile C that enhance groundwater N cycling and removal. This proposal tests the hypothesis that the coastal margin also contains transition zones enriched in labile organic carbon and that these zones can markedly affect groundwater N dynamics in coastal aquifers.

The coastal fringe is characterized by dynamic changes in hydrology, sediment deposition and inputs of labile C. Labile C can enter the subsurface of the coastal fringe from plant/soil interactions, buried soil horizons, shoreline processes and from storm-driven deposition of organic detritus. Water table dynamics in coastal groundwater undergo marked fluctuations driven by tidal and seasonal cycles and create opportunities for NO_3 laden groundwater to interact routinely with deposits of labile C that occur at multiple depths in the aquifer.

This study focuses on three coastal settings (low energy, back lagoon basin, fringing salt marsh, and salt tolerant shrub border) in the salt ponds of Rhode Island to examine how temporal and spatial processes affect N and C cycling, groundwater N removal rates and N_2O efflux at the coastal margin.

Both ambient geochemical profiles and experimental dosing studies will be used to examine groundwater Na and C cycling in coastal aquifers. The significance of these processes in N and C loading to coastal marine ecosystems will be evaluated. The strength of the proposed approach is that studies will be done in-situ, with minimal disturbance to soil structure, using multiple, complimentary techniques. Vertical ambient geochemical profiles and carbon stoichiometry will be used to infer denitrification activity. Transect sampling will be used to quantify denitrification rates through direct N_2 and N_2O production measurements using Argon gas as a conservative tracer in both ambient and NO_3^- amended groundwater. Finally, NO_3 removal rates will also be evaluated in situ dosing studies employing $^{15}NO_3$ and two conservative tracers. In submerged and sub-tidal areas, measurements from in-situ benthic chambers will be used to complement results from well-sampling transects. Groundwater N and C cycling will be examined at different temporal (i.e., seasonal vs. tidal) and spatial (i.e., landscape vs. ecosystem) scales.

The proposed research will increase our mechanistic understanding of the structure and function of the coastal margin and provide information on groundwater N and C dynamics essential to water quality management in the coastal zone.