Riparian nitrogen dynamics in a tropical rainforest catchment

Richard L. Brereton and William H. McDowell
Department of Natural Resources and the Environment, University of New Hampshire, Durham, NH

Introduction

Riparian processes can exert strong controls on N dynamics and cause decreased N flux from groundwater into streams. In a first-order catchment in the Luquillo CZO, groundwater N concentrations show that N transformations across the upslope-riparian margin and the hyporheic-stream margin create distinct zones of groundwater chemistry dominated by different N species. The mechanisms causing this pattern in N dynamics and ultimate N removal are not yet understood.

We propose to explore several competing hypotheses explaining the observed pattern:
1) Denitrification accounts for the drawdown of NO3- from upslope to riparian wells.
2) Mineralization of DON accounts for the high riparian NH4+ concentrations.
3) Dissimilatory nitrate reduction to ammonium (DNRA) converts upslope NO3- to NH4+.
4) Coupled nitrification-denitrification in the hyporheic zone accounts for the removal of NH4+ across the riparian-stream margin.

Study Site Characteristics

The well field covers the riparian zone and adjacent steep slopes above a 1st-order tributary of the Rio Icacos. Palms (Prestoea anomioides) dominate the riparian zone, while colorado dominates the upslope forest. Soils are Oxisols clayey underlain by a reddened gravel layer of variable thickness. Wells were installed from 1998 to 2020, and are between 180 and 210 cm in depth. In upslope wells, NO3-N dominates, while NH4+ dominates in riparian wells (Fig. 3). In stream water, NO3- and DON are the dominant species. TDN is greater in riparian wells, suggesting that a N source other than uplope groundwater is contributing.

Methods and Preliminary Results

In-situ sensors have been deployed to characterize spatial and temporal variability of factors affecting N transformations such as redox potential and oxygenation. Time series data were acquired inside wells with a Hydrolab MS5 sondes equipped with ORP, DO, and NO3- instrumentation. Sediment depth profiles were determined in-situ using a modified Unisense microelectrode unit (MM3).

Sediment depth profiles (Fig. 4) show fine-scale (mm) differences in dissolved oxygen below the benthic surface. [DO] decreased over 50% from the water column to a depth of 3mm and remained constant to 10mm, indicating relative homogeneity of oxygen status in the hyporheic zone. Anoxia was not observed.

Well time series data show variability in ORP, DO, and NO3- over hours to days. Both time series shown below are from wells in the topographic break between upslope and riparian zones. In well I-10 (Fig. 4), redox conditions do not strongly track DO, indicating that aeration alone does not control redox. Oxidizing and reducing conditions were both observed within the time series. Well I-9 (Fig. 5) showed stable, strongly oxidizing conditions and fluctuating NO3- concentrations. Dilution did not appear to account for nitrate variability.

Research Questions and Needs

1) What is the driver of variable redox and oxygen conditions across the upslope-riparian margin and the hyporheic-hyporheic margin? We will continue to characterize temporal and spatial variability of redox and dissolved oxygen conditions in distinct groundwater zones.
2) What role do weathering products play in controlling redox conditions and other factors affecting N transformations? We will determine the spatial variability of dissolved weathering products (Fe, DIC) in groundwater at the site.
3) Do all N species come from the same source? A multiple stable isotope approach will allow us to determine the variable sources of different N species. We will characterize N15 (and O18 where applicable) signatures of NO3-, NH4+, and DON in groundwater from all wells and from the stream.

Figure 4. Depth profile of dissolved oxygen in stream sediment. Jan. 2011

Figure 5. Time series of oxidation-reduction potential and dissolved oxygen in upslope well I-10, March 2010.

Figure 6. Time series of oxidation-reduction potential and [NO3-] in upslope well I-9, Feb.-March 2011.

Literature cited

Brockcamp, R.A. Soil survey of Humacao area of eastern Puerto Rico. NRCS. 1977


For further information
Please contact Richard Brereton at rich.brereton@unh.edu
A pdf of this poster can be obtained by request.