

## **Controls on hyporheic nitrate retention – Discriminating among transport, reaction-rate, and substrate limitation.**

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The transport and fate of nitrogen in stream networks is critical to understanding watershed exports of nitrogen. Nitrate ( $\text{NO}_3^-$ ) retention, and denitrification in particular, is known to be dependent upon a variety of factors: geochemical conditions (chiefly RedOx potential), substrate (largely availability of  $\text{NO}_3^-$  and dissolved organic carbon (DOC)), and transport of nitrate and DOC to favorable locations for denitrification. We will examine the controls of nitrate retention in the hyporheic zones of streams in Oregon and Wyoming: 4 forested stream reaches, 4 agricultural streams, and 4 urban streams. Each reach will be the subject of  $^{15}\text{NO}_3^-$  injections in partnership with the Lotic Interbiome Nitrogen eXperiment II (LINX II) project which is using nitrogen-15 ( $^{15}\text{N}$ ) techniques to study uptake and retention. Collaborating with LINX II allows synergistic and cost-effective examination of stream and hyporheic nitrogen cycling. The objectives of our research are to examine the factors controlling nitrate retention and denitrification in hyporheic zones of small streams and to quantify the fraction of nitrate retention in these streams due to hyporheic exchange. We will test the following hypotheses: (1) hyporheic denitrification in headwater, forested streams will be low because of substrate and rate limitations, yet biotic assimilation will be high, relative to agricultural and urban streams, because of inorganic N-limitation; (2) hyporheic denitrification will be greatest in mid-network locations where surrounding land use is predominantly agricultural, however, total loss of  $\text{NO}_3^-$  will be transport-limited and biotic assimilation will be reduced because nitrogen is less limiting; and (3) potential rate of denitrification in the hyporheic zone will be high in the urban stream reaches, but total nitrate retention in the hyporheic zone will be low because both denitrification and biotic assimilation will be severely transport-limited.

Elevation surveys of the longitudinal profiles of the stream reaches will be used to quantify channel morphology and provide a base for groundwater flow and reactive transport simulations. We have successfully used this technique to model groundwater flow and calculate hyporheic residence time distributions [e.g., *Kasahara and Wondzell, 2003; Wondzell et al., 2003*]. We will use tracer tests based on new understanding of their use for measuring residence time distributions in the hyporheic zone [*Gooseff et al., 2003; Haggerty et al., 2000; Haggerty et al., 2002*].

We will couple our work to the LINX II NSF project by installing a sampling well and piezometer network in the hyporheic zone of 12 LINX II experimental reaches in Oregon and Wyoming. The sampling wells will provide access to hyporheic water,

from which we will obtain samples for measurement of  $^{15}\text{NO}_3^-$ ,  $^{15}\text{N}_{2(\text{g})}$ , and  $^{15}\text{N}_2\text{O}_{(\text{g})}$  as well as DO, DOC and other physical and geochemical parameters, which will be used to quantify biotic assimilation, denitrification, and groundwater flow in the hyporheic zone. We will have access to LINX II stream data on these and other (e.g.,  $^{15}\text{NH}_4^+$ ) N-species. The work will build upon, and enhance the current LINX II project. The LINX II project will benefit from quantification of nitrogen cycling in the hyporheic zone of 12 of its sites and will gain a method to refine models of nitrogen dynamics.

Three of the experimental reaches are on OSU campus, which allows us to use Oak Creek as a hands-on, active-learning laboratory in 3 courses with a combined annual enrollment of more than 300 students. Through these courses, undergraduate and graduate research projects, and the participation of undergraduates in our field work, a large number of students will gain field experience in hydrology at experience-appropriate levels. The USU research team will continue to interact with middle school and high school students through the Teton Science School, demonstrating field activities and facilitating hands-on field experience for these students. Together, the OSU and USU research teams will develop a web site with our data and project-related science activities and dissemination of results for K-12 students and teachers, and will promote learning about surface water hydrology and water quality in local schools through the NSF-sponsored GLOBE program.

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