Physical, Biological and Resource Supply as Key Factors Driving Nutrient Uptake Along a Fluvial Network

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Project Abstract: Nutrient impairment has led to damages to US surface and groundwater systems in excess of 100 billion dollars per year. Therefore, there is a strong need to develop methods to predict the transport, uptake, and export of nutrients along fluvial networks. We present results that are based on a data-driven mechanistic understanding of three factors that largely control nutrient uptake and export: 1) interactions between transport-related processes (mass transfer to metabolically active zones), 2) resource supply dynamics (nutrient concentration, Stoichiometric constraints, etc.), and 3) biological controls (microbial community structure and function). Our results were generated from column experiments conducted along the Jemez River-Rio Grande continuum which spans four orders of magnitude in mean annual discharge, more than 2000 m in altitude, and more than 500 km of stream longitude. Two resource supply injections were performed on each of the columns, i.e., a nitrate only addition, followed by a stoichiometrically 'balanced' 106Carbon:16Nitrogen:1Phosphorus addition. We quantified NO3-N uptake kinetics while constraining three variables: stream order, sediment type and type of injection(N vs stoichiometrically 'balanced' C:N:P) throughout the river continuum. We observed increases in NO3-Nuptake velocity for the Stoichiometrically 'balanced' injection relative to concentrations during the Nitrate only injection, except for the 1stand one of the 7thOrder sites (downstream of a Wastewater Treatment Plant). Higher NO3-N uptake velocities were also observed in the Native sediment compared to the sterile sediments. We also observed that limitation and co-limitation in biological NO3-N across the two-injection experiments varied with stream order. Lastly, the Michaelis-Menten asymptotic decay pattern was observed for NO3-N uptake kinetics. While our results shows that stoichiometric imbalances limits nutrient uptake in lotic systems, ongoing work with our partners at the Pacific Northwest National Laboratory (PNNL) is seeking to identify how the type of microbial communities sampled from each of the columns control the observed uptake results.