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Feedbacks between element availability, (diel) cycling and assimilatory uptake in a biologically productive spring-fed river

Marie J. Kurz (1,2), Matthew J. Cohen (2), Jonathan B. Martin (2), Rachel L. Nifong (2,3)

(1) Helmholtz Centre for Environmental Research - UFZ, Leipzig, Germany, (2) University of Florida, Gainesville FL, United States, (3) Appalachian Laboratory, University of Maryland Center for Environmental Science, Frostburg MD, United States

The metabolism of submerged aquatic vegetation directly and indirectly controls the cycling of solutes in streams at diel (24-hour) frequencies. Photosynthesis and respiration induce diel variation in dissolved oxygen (DO) concentrations and pH which, in turn, mediate elemental concentrations via a host of geochemical reactions. Plant metabolism also directly exerts control on water composition via assimilatory uptake, creating diel variation in major nutrients. Trace elements can be essential micronutrients, suggesting their assimilatory uptake could also contribute to diel variation in element concentrations in streams. If diel element variation is indicative of metabolic processing, assessing the magnitude and timing of this diel variation relative to other inorganic controls could be used to estimate the ecosystem demand for those elements, infer ecosystem function, and predict how stream ecosystems may respond to changes in environmental element availability.

We evaluated the relationship between the elemental requirements of submerged vegetation and the availability and cycling of elements in streams by comparing spatial and diel variation in stream chemistry with measurements of tissue stoichiometry from submerged vascular plants and algae in the Ichetucknee River ($Q = 8\ m^3/s$) , a highly productive spring-fed system in north-central Florida. Diel variations were observed in the concentrations of soluble reactive phosphorus (SRP), Ca, Mg, K, Mn, Fe, V, Cr, Co, Cu, Sr, Ba, and U. Autotrophic assimilation, estimated using the measured stoichiometry and calculations of primary production from diel DO variation, accounted for a significant portion of the in-stream diel variation of some elements, including approximately 100% for K and >30% for Fe and Mn. However, the exact timing of assimilation of these elements remains uncertain relative to the other inorganic controls. Correcting the observed SRP diel signal for the effect of calcite co-precipitation revealed both the magnitude of the two major P retention pathways (66% geochemical, 34% assimilatory) and the timing of assimilatory P uptake (asynchronous with N uptake). Variations in measured tissue stoichiometry between major vegetation types, and between sampling sites, suggests that elemental availability may affect the productivity and relative abundance of invasive algae and submerged macrophytes. Conversely, changes in species abundance could lead to corresponding changes in in-stream element cycling, illustrating the reciprocal interactions between solute dynamics in streams and the elemental requirements of submerged aquatic vegetation.