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Geomorphic controls on respiration in two headwater streams in Oregon (USA)

R. González-Pinzón and R. Haggerty

College of Earth, Oceanic and Atmospheric Sciences, Oregon State University, Corvallis (OR), United States (gonzaric@geo.oregonstate.edu)

Stream metabolism is a key component of nutrient and organic matter cycling. To date, determining rates of metabolism is accomplished with techniques that are not spatially representative, mainly because of the limited sample volume of the methods. The lack of a robust technique to estimate stream metabolism has restricted the development of methods for upscaling biological processes that mediate nutrients processing. Recognizing that the interaction between stream geomorphology units and flow is one important control on the rate of stream metabolism, we combined the spatially extensive resazurin– resorufin (Raz-Rru) approach (Haggerty et al., 2008) with detailed topo-bathymetric data to investigate how stream metabolism scales with geomorphology.

The Raz-Rru approach uses the irreversible reduction of Raz to strongly fluorescent Rru, in the presence of aerobic respiration, to estimate metabolic activity. We injected Raz and a conservative tracer for 48 hours in two streams at the H.J. Andrews LTER (OR, USA), and measured main channel and hyporheic breakthrough curves at downstream locations. We also estimated ecosystem respiration using the two-station diel technique and compared these independent results with the transformation of Raz for the same sub-reaches. Sampling points were defined to differentiate characteristic geomorphic units (e.g., pool-riffle, pool-cascade), bed materials (i.e. alluvium vs. bedrock channels) and type of transient storage (i.e. pure hyporheic exchange, pure surface transient storage and a combination of both). Results show that hyporheic exchange mainly controlled stream metabolism and that wood debris were hotspots for in-stream metabolism. We propose here the use of zeroth and first order moments of Raz, Rru and a conservative tracer as an alternative, rather simple, approach to analyze stream metabolism and spatial heterogeneity of in-stream biological processes. This approach can be used independently or coupled with more complex dynamic solute transport models to investigate biologically mediated transformations in stream ecosystems. As opposed to traditional stream metabolism techniques where limited volumes restrict upscaling results (e.g., respiration chambers), or where highly heterogeneous processes are assumed to be uniform over significant distances (e.g., atmospheric-dissolved oxygen equilibrium), the Raz-Rru approach provides the possibility of estimating biological processes at different temporal and spatial scales without overcomplicating sampling strategies.