Elucidating Coupled Solute Transport, Transformation, and Ecosystem Processes in River Corridors using Stream Tracers

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Project Abstract: Metabolically active transient storage zones in stream ecosystems, most notably the hyporheic zone, are ecological and biogeochemical hotspots that exert control over geochemical and metabolic processing and regulate the distribution and transformation of matter and energy in river systems. Multiple natural and anthropogenic factors, including channel morphology, dynamic hydrology, and modifications to nutrient regimes, drive changes in the solute transport dynamics and reactivity of transient storage zones over time and space, which should, in turn, influence rates of whole-stream ecosystem functions such as metabolism and both assimilatory and dissimilatory nutrient transformations. However, there remains uncertainty about the coupling between solute transport, transient storage, and stream ecosystem function within streams, and the relative importance and organization of these coupled processes across systems and watershed scales. Additionally, we lack understanding about the relative importance and organization of these coupled processes across systems and watershed scales. Improving the representation of these coupled processes in both our conceptual and numerical models is essential to developing a more robust predictive understanding of functioning within river corridors. Here, we present insights gained from stream tracer experiments employed across a range of lotic systems to evaluate transient storage and aerobic respiration in relation to varied spatio-temporal patterns in stream structural controls and ecosystem processes. We also summarize new forward modeling capability and uncertainty-aware model-based interpretation approaches that leverage results from the stream tracer experiments. We identify challenges, opportunities, and new experimental approaches for expanding our process understanding across systems and scales and linking this understanding to reach-scale simulations of transport and transformation.