Modeling Coupled Organic Matter and Nitrogen Cycling in River Corridors Across the Columbia River Basin

Xingyuan Chen,[1*] Kyongho Son,[1] Pin Shuai,[1] Yilin Fang,[1] Peishi Jiang,[1] Jesus Gomez-Velez,[2] Maruti Mudunuru,[1] and Glenn Hammond[1]

[1]Pacific Northwest National Laboratory, Richland, WA
[2]Vanderbilt University, Nashville, TN

Contact: Xingyuan.Chen@pnnl.gov
Project Lead Principal Investigator (PI): Tim Scheibe
BER Program: ESS
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Project Website: https://www.pnnl.gov/projects/river-corridor

Project Abstract: *This element of the PNNL SFA seeks to quantify the cumulative impacts of river corridor hydrologic exchange flows (HEFs), dissolved organic matter (DOM) chemistry, and microbial activity on biogeochemical cycling, water quality, and contaminant mobility across the Columbia River Basin (CRB) under both baseline and disturbance conditions.* River corridors play important roles in organic matter and nitrogen cycling and removal of excess nutrients. At basin scales, the incorporation of hydrologic connectivity and molecular information on microbiome structure (i.e., species composition and distribution of enzyme-encoding genes), microbial expression, and metabolomes will greatly improve a river corridor model (RCM) in capturing distinct water quality signatures in connection to variations in land use, hydrogeology, climate, and disturbances. We have developed an RCM that resolves reactions occurring in both the water columns and in the river corridors as impacted by the hydrologic exchange flows (HEFs). Applying this RCM to the Columbia River Basin (CRB), we found that the physical properties influencing HEFs and land use are the primary controls of the spatial variability in river corridor denitrification. We have also developed integrated watershed models leveraging the IDEAS-Watersheds software ecosystem to understand terrestrial inputs to river corridors through both surface and subsurface pathways under baseline and disturbance conditions. Machine learning methods have been applied to integrate data from USGS river gauges and remote sensing to improve model parameterization and calibration. Next, we will enhance the mechanistic foundation of the RCM by linking dynamic river flow processes and heterogeneous terrestrial inputs with variable temperatures and reaction kinetics (informed by molecular properties) to investigate water, energy, and solute fluxes across the river-groundwater interface under both baseline and post-fire conditions. Stream and riverbed temperature regimes simulated by the model can also be used to map thermal refugia for resilient aquatic habitat. Our approach can be generalized beyond CRB and applied to other basins facing environmental disturbances and water challenges of national significance.