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Microbial and Organic Fine Particle Transport Dynamics in Streams – a Combined Experimental and Stochastic Modeling Approach

Jen Drummond (1,2), Rob Davies-Colley (2), Rebecca Stott (2), James Sukias (2), John Nagels (2), Alice Sharp (2,3), and Aaron Packman (1)

(1) Northwestern University, Evanston, USA, (2) National Institute of Water & Atmospheric Research (NIWA), Hamilton, New Zealand, (3) University of Waikato, Hamilton, New Zealand

Transport dynamics of microbial cells and organic fine particles are important to stream ecology and biogeochemistry. Cells and particles continuously deposit and resuspend during downstream transport owing to a variety of processes including gravitational settling, interactions with in-stream structures or biofilms at the sediment-water interface, and hyporheic exchange and filtration within underlying sediments. Deposited cells and particles are also resuspended following increases in streamflow. Fine particle retention influences biogeochemical processing of substrates and nutrients (C, N, P), while remobilization of pathogenic microbes during flood events presents a hazard to downstream uses such as water supplies and recreation. We are conducting studies to gain insights into the dynamics of fine particles and microbes in streams, with a campaign of experiments and modeling. The results improve understanding of fine sediment transport, carbon cycling, nutrient spiraling, and microbial hazards in streams. We developed a stochastic model to describe the transport and retention of fine particles and microbes in rivers that accounts for hyporheic exchange and transport through porewaters, reversible filtration within the streambed, and microbial inactivation in the water column and subsurface. This model framework is an advance over previous work in that it incorporates detailed transport and retention processes that are amenable to measurement. Solute, particle, and microbial transport were observed both locally within sediment and at the whole-stream scale. A multi-tracer whole-stream injection experiment compared the transport and retention of a conservative solute, fluorescent fine particles, and the fecal indicator bacterium Escherichia coli. Retention occurred within both the underlying sediment bed and stands of submerged macrophytes. The results demonstrate that the combination of local measurements, whole-stream tracer experiments, and advanced modeling improves the understanding of microbial and organic fine particle transport in streams.