

Fine-scale dissolved pore-water phosphorus and metal variability through a riffle-pool sequence of an urban stream

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Stream hyporheic zones represent critical terrestrial-aquatic interfaces (TAI), serving as mixing zones of surface and groundwaters in contact with streambed sediment. Flow through hyporheic zones involves downwelling of surface water at the head of riffles and upwelling of shallow groundwater through pools. Well-oxygenated stream water creates a redox gradient during recharge into the hyporheic zone in riffles, while pool pore-water is often anoxic. This can result in very different pore-water dissolved solute concentrations between areas in close proximity, and create conditions for phosphate and other redox-sensitive solutes to enter the surface water, potentially impairing stream water quality. These trends have been found through isolated pore-water sampling of multiple natural and flume-created riffles and pools. Extensive measurements of spatial variability of dissolved solutes within a riffle-pool sequence has not been conducted. In this study, a total of 48 mini-piezometers were installed along a single riffle-pool sequence, spanning a depth of 6 to 36 cm. Continuous temperature profiling and manual hydraulic head measurements demonstrated sustained downwelling in the riffle and moderate upwelling in the pool. The magnitude of vertical hydraulic gradient throughout both the riffle and the pool, however, varied by a factor of two on most sampling days, indicating varying water flux through the sequence. This resulted in heterogeneous dissolved solute concentrations through the riffle and pool. In some pool locations, soluble reactive phosphate was an order of magnitude higher at 36 cm depth than in the stream; however, in other pool locations SRP levels were similar to stream levels, even at depth. The coefficient of variations in pore-water concentrations of the redox-sensitive Mn (53 % pool pore-water, 188 % riffle) and Fe (191 % pool, 73 % riffle) were generally higher than other metals (ranging from 175 % for Al to 25 % for Ni) along the 40 m stream reach. In contrast, homogeneous profiles were found for the conservative Li, (coefficient of variation of < 10 %). These results demonstrate the complex interaction of cm-scale hydrological flowpaths, redox chemistry, and mineral & biological reactivity, which make generalization and prediction of TAI function in stream hyporheic zones very difficult.