Snowmelt-induced hydrologic shifts drive biogeochemical and ecological processes in hyporheic zone environments

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The hyporheic zone (HZ) is the shallow streambed region of surface water and groundwater mixing that plays a significant role in aquatic nutrient cycling and contaminant removal. Depth-resolved pore water samples were collected through the HZ in the Colorado River near Rifle, CO during periods of high, intermediate, and low river flow. These depth profiles were analyzed for geochemical and microbial changes associated with dynamics in hyporheic mixing. As the river stage receded over the summer, river water did not penetrate as deeply into the subsurface, and HZ chemistry became more anoxic and groundwater-dominated. The microbial community responds to this shifting hydrology, with differing community structures identified during each sampling period. The communities appeared to stabilize through time as groundwater began to dominate the deeper portions of the HZ depth profile with shallower microbial communities beginning to resemble those previously found at depth. Ecological modeling was performed by calculating beta-nearest taxon index (βNTI) and was used to quantify the ecological processes occurring within the HZ during these hydrological disturbances. Modeling revealed a strong deterministic pressure exerted within the HZ across all depths and times, driving communities to be more dissimilar than randomly generated community compositions. Deeper examination of these data revealed that the extent of river water mixing and organic carbon concentration were key factors in selecting for certain community structures over others. These results indicate that the mixing of distinct chemical end-members drives key redox fluctuations across HZs, with associated changes in microbial community composition. Such seasonal effects likely have implications for metal release from sediments, carbon processing, and nutrient cycling in HZ ecosystems.