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Microbiome structure influenced by metal-oxide precipitation in hyporheic zones receiving acid mine drainage

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Streams impacted by historic mining are characterized by acidic pH, unique microbial communities, and abundant metal-oxide precipitation, all of which can influence or be influenced by groundwater-surface water exchange in the hyporheic zone. In this study, we investigated how metal-oxide precipitates and hyporheic mixing mediate the structure and composition of microbial communities in two streams – Mineral Creek and Cement Creek – receiving acid-rock and mine drainage near Silverton, Colorado, USA. Previous work found that the hydrology and geochemistry differed in the hyporheic zones of these two streams. A large hyporheic zone at Mineral Creek facilitated the precipitation of metal particles and colloids in hyporheic porewaters. A small hyporheic zone at Cement Creek, limited by the presence of a low-permeability, iron-oxyhydroxide layer known as ferricrete, led to the formation of geochemical gradients and high dissolved-metal concentrations. To determine how these two different hyporheic systems influence microbiome structure and composition, we installed well clusters in each stream at three depths to sample porewaters and sediments for 16S rRNA gene sequencing. Results indicated that the ferricrete in Cement Creek caused distinct hydrogeochemical conditions to develop above and below the ferricrete, which in turn separated abundant, iron-oxidizing bacteria (*Gallionella sp.*) in the shallow streambed from rare, low-abundance bacteria in the deep streambed. In comparison, metal precipitates and colloids that formed in the hyporheic zone at Mineral Creek allowed for a diverse phylogenetic community to develop in the porewaters that consisted of nonmotile, nutrient-cycling bacteria. Based on this site comparison, we posit that systems with large, well-mixed hyporheic zones harbor and transport diverse microorganisms attached to particles/colloids through hyporheic pore spaces, which contributes to nutrient cycling and overall stream health. In acid mine drainage streams where metal oxides clog pore spaces and inhibit hyporheic exchange, iron-oxidizing bacteria dominate and phylogenetic diversity is low. The abundance of these iron-oxidizing bacteria can contribute to additional clogging of hyporheic pore spaces and the accumulation of toxic metals in the hyporheic zone. In summary, the geochemical conditions created by hyporheic mixing mediate the structure of the microbiome and the cycling of metals in streams receiving acid mine drainage.