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Investigation of persistent environmental impacts of legacy mining in a remediated mountain watershed

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Although progress has been made in remediating legacy mine sites in the western U.S., restoring watersheds for optimal ecological health remains challenging in part because of a lack of understanding of the mobility and bioavailability of metal(loid)s associated with solid phases (e.g., streambed sediments, colloids). To address this issue, we are investigating processes affecting solid-phase residence and bioavailability of metal(loids) in a remediated watershed with persistent environmental impacts.

The Akron Mine, Tomichi Creek Mining District, Colorado, was active from the 1880s-1950s with primary commodities Pb, Ag, Zn, Cu, and Au. Despite recent (2016) extensive mine-waste reclamation work, trout populations in Tomichi Creek remain impaired downstream from historic mining. High density water sampling of this circumneutral stream segment at baseflow in 2021 showed persistent elevated concentrations of dissolved (<0.45 μm) Pb (2 μg/L) adjacent to mine/mill locations that steadily increase downstream (3.4 μg/L), exceeding EPA-established chronic aquatic life standards (ALS ~1.8 μg/L). To a lesser extent, Zn and Cd also increase downstream (72 μg/L and 0.4 μg/L, respectively) nearing, but not exceeding chronic ALSs (93 and 0.58 μg/L, respectively). Significantly higher total (unfiltered) Pb, Zn, and Cd stream water concentrations, relative to the dissolved phase, suggested that suspended sediment may be a source of metal(loid)s. A 2023 follow-up investigation used multiple filter pore sizes and ultrafiltration (10 kDa). Results show the aqueous Pb is predominantly colloidal (<0.09 μg/L in ultrafiltered samples) and likely associated with Fe. Conversely, the majority of aqueous Cd appears truly dissolved. Streambed sediments contain elevated Pb, Zn, and Cd throughout the stream reach with the highest concentrations in the fine-grained fraction (<64 μm). Concentrations in this fraction were highest upstream near milling sites and decreased downstream (concentration ranges: 2100-3600 mg/kg Pb, 1700-3800 mg/kg Zn, 7-19 mg/kg Cd). Mineralogical characterization of streambed and suspended sediments is underway to assess the residence of metals of concern, and the determination of metal concentrations in benthic invertebrates is being undertaken to elucidate metal uptake. These data should better identify processes controlling metal transfer to fish and aid in restoring ecological health to impacted watersheds.