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Persistent science challenges in legacy mine land sites: Results from a multi-scale geochemical study in Tomichi Creek, Colorado, USA

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Despite considerable progress in remediating legacy mine land (LML) sites in the western U.S., many continue to negatively impact watershed ecosystems. In addition to financial and regulatory constraints, scientific challenges remain making it difficult to identify sites where remediation efforts could be most beneficial. In collaboration with land managers, we work to identify and evaluate persistent LML impacts using multi-scale geochemical techniques. The Tomichi Creek Mining District (Colorado), where primary commodities were Pb, Ag, Zn, Cu, and Au, was mined from 1880s-1950s. Tomichi Creek underwent remediation (completed 2016) coordinated by USEPA, USFS, and Trout Unlimited, including excavation of the mill property and wetlands, moving waste rock away from the stream, regrading slopes, and encapsulating waste. Post-remediation, Pb and Cd, though reduced, remain elevated nearing aquatic life standards (ALS) with evidence of impacted fish populations.

In 2021, we collected stream water, groundwater (piezometers installed immediately adjacent to the stream), and stream bank sediment. We performed an in-stream synoptic tracer study along a ~4-km stretch of Tomichi Creek starting just above the Akron Mine. Stream bank sediments collected adjacent to piezometers show elevated Pb, Zn, and Cd, with highest concentrations adjacent to the mine/mill (8,600 mg/kg Pb; 6,250 mg/kg Zn; 50 mg/kg Cd), decreasing downstream (3,900 mg/kg Pb; 3,800 mg/kg Zn; 24 Cd mg/kg). Dissolved groundwater Pb and Zn concentrations are highest (24-128 µg/L Pb and 374-7,800 µg/L Zn) approximately 600 m downstream of the Akron Mine/Mill. Stream water Pb concentrations also increase abruptly from <1 to 3.4 µg/L (chronic ALS ~1.8 µg/L), remaining elevated downstream. Zinc increases from 5 to 16 µg/L, and steadily increases downstream (up to 72 µg/L; chronic ALS ~93 µg/L). Cadmium is greatest in groundwater at the same site (28 µg/L) and stream water concentrations steadily increase downstream (0.39 µg/L; chronic ALS ~0.58 µg/L). Differences in concentrations between raw (unfiltered) and dissolved (filtered <0.45 µm) in stream and groundwater suggests a fraction of trace elements are transported downstream via suspended sediment/colloidal material. Work is ongoing to improve understanding of the residual sources and geochemical processes contributing to trace element mobilization to assess long-term impacts to ecosystem health.