Mercury contamination from mine and natural sources in Harley Gulch, downstream from the Abbott and Turkey Run Mercury Mines, Lake County, California

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The Abbott and Turkey Run Mercury (Hg) mine area in central California has released Hg tailings into the Harley Gulch watershed since 1862. Harley Gulch flows into Cache Creek, which is a significant source of Hg into San Francisco Bay Delta. Thermal mine water effluent emanating from the Turkey Run adit flows into the upper part of the watershed. Despite remediation efforts, Hg tailings and enriched sediment remain in the Harley Gulch wetlands and in the creek downstream from the mine area. Water, sediment, and biota have been sampled from below the mine area to 15 km downstream to the confluence with Cache Creek in order to assess the impact of Hg on water quality and biota. Two previously unrecognized natural sources of Hg in the watershed are connate groundwater with elevated levels of Hg, and biogenic sediment composed of phytoplankton that accumulates in the upper part of the watershed during the dry season. The connate groundwater source contains isotopically-heavy MgCa-Cl-CO_3-SO_4 water that has elevated concentrations of Ba, W, Ti, and Hg. This water first enters Harley Gulch in the central part of the wetland immediately downstream from the mine area and continues to contribute water downstream for a distance of 1.5 km. It is both chemically and isotopically distinct from the thermal mine water effluent from the Turkey Run adit. The biogenic source consists of blooms of phytoplankton that accumulate to a thickness of up to 0.2 m. Phytoplankton have a large bioaccumulation factor of Hg and monomethyl mercury (MMeHg) that results in a high concentrations of Hg and MMeHg (Hg: 5-25 μg/g, MMeHg 5.2 ng/g) in the biogenic sediment. The tan biogenic sediment at the surface consists of living diatoms and below it is a layer of black reduced biogenic sediment consisting of diatom fragments with micron- to submicron-sized FeS, HgS, and barite grains. Sulfate-reducing bacteria reduce sulfate to sulfide in the pore waters of the biogenic sediment that reacts with dissolved Fe to form FeS. Hg released from the diatoms into the pore fluid reacts with sulfide to form micron- to submicron-sized particles of HgS. The decrease in sulfate concentration resulting from sulfate reduction results in precipitation of barite. The resulting biogenic sediment is composed primarily of diatoms with a minor component of $CaCO_3$ and clay and is transported downstream during periods of high flow. Composites of aquatic invertebrates collected from the upper two sites of the Harley Gulch wetland included larval damselflies (Coenagrionidae), adult predaceous diving beetles (Dytiscidae), and larval water scavenger beetles (Hydrophilidae). The percentage MMeHg was low in all samples, the concentrations of MMeHg (113 - 604 ng/g, wet mass) were moderate, and the total Hg concentrations were extremely high (1,240 – 9,940 ng/g). The concentration of both MMeHg and Hg were lower at downstream sites in 2011 in both damselflies and diving beetles compared with the wetlands and the area where connate groundwater enters the creek in the upper part of the watershed. As with these biological taxa, concentrations of both Hg and MMeHg in water and sediment were lower at the downstream sites.