Mercury transformations in mine wastes and natural habitats adjacent to abandoned mercury mines

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Abandoned Hg mines pose an environmental threat due to high Hg concentrations in waste materials. Hg mobilized during past mining activities is capable of being methylated and transported hundreds of km downstream, a process that may continue for decades into the future. To investigate the ability of Hg-laden materials to be mobilized due to bacterially-mediated transformations, activities were assessed in samples of calcine, retort ash, soil, and stream sediment surrounding abandoned Hg mines. Samples were collected from mines in Spain (Almadén), Slovenia (Idrija), Texas (Terlingua and Mariscal), Nevada (McDermitt), California (Mt. Diablo), and Alaska (Red Devil). Transformation activities were determined using radiotracers (Hines *et al*., 2000) and Hg speciation by CVAFS (Bloom and Fitzgerald, 1988; Bloom, 1989).

Results and discussion

Mine wastes, soils and sediments actively methylated and demethylated Hg, and activity data agreed with the distribution of Hg species. Calcines that are generally dry and oxic exhibited little methylation, but demethylated Hg readily. An exception was calcine material near a retort in Spain that contained very high methyl-Hg levels and methylated Hg rapidly. C-rich retort ash also methylated Hg rapidly. Calcines and soils demethylated methyl-Hg via the reductive path suggesting that bacteria express lyase genes coded by the *mer* operon genetic system. Stream sediments rapidly methylated and demethylated Hg, but the latter was via the oxidative path that may lead to a re-methylation of Hg released during demethylation. Wastes near Hg mines are subject to active bacterially-mediated transformations and thus are capable of supplying high levels of methyl-Hg to downstream environments.

References

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Overview of mercury contamination related to mercury mining and small-scale gold mining worldwide

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Areas of past and active Hg mining and small-scale (artisanal) Au mining worldwide are of environmental concern because of toxic Hg compounds in mine wastes and in surrounding sediment, water, and biota. The most significant environmental concerns of these mining activities are direct exposure of humans to elemental Hg, transference of Hg to surrounding ecosystems, and chemical and microbial conversion to bioavailable, compounds such as methyl-Hg, which are water soluble and readily transferred to biota such as fish. Methyl-Hg is the most toxic of the Hg compounds, is a human neurotoxin, and is the dominant Hg form in fish. Worldwide Hg mining produced an average of about 2,000 t/yr in the past decade and the primary Hg producing countries were Algeria, China, Kyrgyzstan, and Spain. Use of elemental Hg for separation of Au in artisanal mining results in significant loss of Hg to surrounding environments and is estimated to be about 500-800 t Hg/yr worldwide. Elemental Hg-Au amalgamation is an easy and inexpensive technique dating back to about 2700 BC. Although elemental Hg is used in artisanal mining worldwide, it is most common in developing countries, particularly those in South America, Africa, and Asia. Present estimates indicate that >10 million people in about 40 countries are involved in artisanal Au mining. Mine wastes and surrounding soils collected near Hg mines are often highly elevated in total Hg, exceeding 10,000 µg/g, and methyl-Hg concentrations exceed 1,000 ng/g in some instances. Freshwater fish collected in areas of artisanal Au mining may contain total Hg concentrations >4.0 µg/g (muscle, wet weight), significantly exceeding the 0.5 µg/g safe level recommended by the World Health Organization for human consumption of fish.