

Sources, transport, and fate of mercury at some representative mining sites

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Mercury contamination related to historic and to some contemporary mining comes mainly from 1) the contemporary, reckless use of mercury by artisanal miners to recover gold from ores and 2) from the historic mining of mercury itself. These mining activities often occur near waterways, either because the waterway sediments are being processed to remove placer or alluvial gold, or because of the need for water during the processing or milling of many types of ores.

For reasons that will be discussed, there is often a juxtaposition of upland mining coupled with lowland agriculture, ensuring maximum environmental impact from released contaminants. These settings are common worldwide. This makes the understanding of source, transport, environmental impacts, and fate of pollutants in these settings an important contemporary research topic. In the absence of this interesting juxtaposition, as in most contemporary artisanal alluvial mining, an understanding of sources, transport, and fate of contaminants is still important and many of the same issues pertain.

An understanding of the chemistry, geochemistry, biogeochemistry, biochemistry, and atmospheric chemistry of mercury helps with our understanding of the nature of the transport, fate, and environmental impacts of mercury. The geochemistry of mercury is the main topic of this contribution, and through a review of several examples of mercury contamination from both mercury mining and the use of mercury in artisanal gold mining, an understanding of the transport and fate of mercury, mainly in fluvial systems, can be developed.

The natural protective mechanisms present in nature which minimize the environmental impacts of mercury, as well as examples of significant environmental impacts from mercury, will be explored through the use of examples from Nevada, California, Brazil, and Guyana. It will be shown that sulfur-rich environments can fix fugitive mercury as its relatively-immobile sulfide in reducing environments of reservoirs, lakes, and soil horizons. It will also be shown that environmental impacts of mercury in other environments can arise far from the source of mercury in fluvial environments, and linkage to a specific source can be elusive.

Hydrologic control on mercury biogeochemistry in a closed river basin: The Carson River System, Nevada

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The Carson River flows in a closed basin system and the total flow of the river tends to decrease downstream due to evaporation and consumptive uses. This river system is fed primarily by the snow pack, which accumulates in the Sierra Nevada during winter and flows downward following melting in spring and summer. Water loss through evaporation in the Carson River results in a downstream buildup of conservative elements such as chloride and certain oxyanion forming elements known to interfere with the transformation of mercury within the sulfur cycle. In 1859, the Comstock Lode was discovered in western Nevada, USA and this discovery was followed by an intensive use of metallic Hg for over 50 years in the amalgamation process to extract Au and Ag from crude ores. Wastes from mining operations previously accumulated in mill tailings were dispersed throughout the Carson River drainage basin over time, in large part due to fluvial processes. Hg contamination in the Carson River system is now well documented and published Hg levels in different environmental compartments are extremely high.

In this study, hydrologic driven changes in water chemistry of the river system and their impact on the behavior and fate of Hg were examined. Obtained results show that periods of low water flow regimes correspond to high water pH values (up to 8.5), relatively high concentrations of Group VI oxyanion forming elements (e.g., Se, Mo, and W), and low Hg methylation potential in sediments. In contrast, periods of high flow regimes bring about dilution, which results in lower pH (around 7), lower oxyanion concentrations, but higher Hg methylation potential. In "Stillwater", a wetland and protected wildlife refuge fed by the Carson River water, the dry/wet cycle results in trends of methyl-Hg production and degradation that follow changes in water levels and water content of the wetland soil. Overall, the evapoconcentration of group VI elements in the terminal basins of the studied system limits the rates of Hg methylation. This limitation is likely related to: (1) the interference of group VI elements with Hg transformation by sulfate reducing bacteria, and (2) Hg speciation imposed by changes in hydrologic conditions and the resulting limited Hg-bioavailability.