

Mercury reduction in aquatic environments: Photochemical, dark abiotic, and microbial processes

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Mercury (Hg) is a global health concern due to the long-range intercontinental transport of elemental Hg (Hg(0)) in the atmosphere and microbial methylation of inorganic Hg to produce highly toxic and bioaccumulative methylmercury in aquatic environments. Biogeochemical cycling of Hg in the environmental media (air, soil, water, and sediment) involves various transport and transformation processes, among which reduction of divalent Hg (Hg(II)) to Hg(0) in aquatic environments is a critical step as it controls the air-water Hg exchange and the pool of inorganic Hg available for methylmercury production. Photochemical reaction has been extensively studied as a dominant pathway for the reduction of Hg(II) to Hg(0) in sunlit environments such as surface water. The reduction of Hg(II) in the environment with limited light penetration (e.g., aphotic water layer and sediment) can be attributed to microbial and dark chemical processes. It is well known that Hg-resistant bacteria can use the MerA pathway to reduce Hg(II), which is usually mediated by aerobic heterotrophic microbes in Hg-contaminated areas. In anaerobic zones, Hg(II) reduction can occur through the activities of some heterotrophic and chemotrophic microorganisms, e.g., the dissimilatory iron (Fe) reduction bacteria. The widely present ferrous Fe (Fe(II)) species, including aqueous Fe(II) and especially solid phase Fe(II) such as magnetite, green rusts, and mackinawite, may be a critical driving force for dark chemical reduction of Hg(II), although their exact roles in Hg redox transformation in aquatic environments warrant further investigation. We present here a comprehensive review of aquatic Hg(II) reduction by synthesizing previous information and highlighting future research needs.