Interactions of Elemental Mercury with Microbial Biomass

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Introduction: The disposal of mercury (Hg) containing wastes has contaminated large areas of sediment and groundwater in the United States. When released into the environment, Hg undergoes redox transformations that strongly affect its solubility and sorption characteristics. Dissolved gaseous elemental mercury [Hg(0)] is mobile in groundwater, while oxidized mercuric mercury [Hg(II)] readily sorbs onto mineral surfaces and NOM. Furthermore Hg(II) is the substrate for methylation, and uptake of Hg(II) by anaerobic methylating bacteria leads to the production of neurotoxic methylmercury [MeHg]. Currently the redox interactions between Hg(0) and microbial biomass are poorly understood. In this study, we conducted laboratory experiments to determine if subsurface microorganisms can oxidize Hg(0) to Hg(II) under anoxic conditions.

Materials and Methods: Mercury oxidation experiments were carried out with the obligate anaerobic bacteria *Geothrix fermentans* H5 and *Desulfovibrio desulfuricans* ND132 and the facultative anaerobic bacteria *Shewanella oneidensis* MR-1 and *Cupriavidus metallidurans* AE104. To demonstrate the formation of Hg(II), we performed ethylation experiments and X-ray absorption near edge structure (XANES) spectroscopy on Hg(0)-reacted cell. Finally, samples from experiments conducted with the methylating bacterium strain ND132 were analyzed for the production of MeHg.

Results and Discussion: All four bacterial strains reacted with dissolved gaseous Hg(0) to form non-purgeable Hg. Derivatization of non-purgeable Hg to diethylmercury and the Hg L_{III}-edge position of the XANES spectra demonstrated that the Hg(0)-reacted bacterial samples had formed oxidized Hg(II). XANES analysis also revealed that cell-associated Hg(II) was covalently bound to bacterial functional groups, most likely to thiol moieties. Experiments with metabolically active and heat-inactivated cells indicated that both live and dead cells oxidized Hg(0) to Hg(II). MeHg analyses showed that live cells of *D. desulfuricans* ND132 produced large quantities of methylmercury. The results of this work demonstrate a previously unrecognized pathway in the mercury cycle, whereby anaerobic bacteria produce MeHg when provided with dissolved Hg(0) as their sole Hg source.