Biogeochemical Controls on Mercury Methylation in Arctic Tundra Soils

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Arctic tundra soils store a globally significant amount of mercury (Hg) as a result of long-distance transport and atmospheric deposition of Hg to the polar region. The greatest toxicological concern of Hg pollution is its transformation to methylmercury (MeHg), a neurotoxin that can bioaccumulate and biomagnify in Arctic ecosystems. However, our current knowledge of biogeochemical transformation of inorganic Hg to MeHg in Arctic tundra is insufficient, especially regarding the geochemical and microbial factors controlling MeHg production. In this study, we investigated the effect of different substrates (acetate and sulfate) and selective microbial inhibitors (molybdate and 2-bromoethanesulfonate) on Hg methylation in two Arctic tundra soils—collected at the Teller and Council sites near Nome, Alaska USA—with differing geochemical characteristics (e.g., dissolved organic C and sulfate concentrations). Our results indicate that increasing acetate availability had negligible influence on MeHg production, suggesting that acetate was not a limiting factor on Hg methylation in both soils. Experiments conducted with the microbial inhibitors show that sulfate-reducing bacteria are the major contributors to MeHg production in the first 15 days of incubation with the soils from Teller site. This MeHg production coincided with the depletion of sulfate, following which methanogens played a role in continued MeHg production. In contrast, methanogens and sulfate-reducing bacteria both contributed to the MeHg production in the Council soil throughout the incubation. Due to a low sulfate availability, addition of sulfate increased MeHg production by 6-fold in the Council soil, suggesting that MeHg production was stimulated by dissimilatory sulfate-reducing bacteria. Together our results indicate that sulfate-reducing bacteria and methanogens are the dominant methylators with their activities depend on geochemical factors, such as the availability of sulfate in these tundra soils.