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Mercury fate in mountain ecosystems of Colorado, United States: transformations, exposure, and impacts from climate change

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Despite decreasing mercury (Hg) emissions across the United States (U.S.), Hg deposition in the Western U.S. is increasing. Mountain ecosystems are particularly sensitive to increasing Hg inputs because they experience more rapid changes in climate and high rates of atmospheric Hg deposition, as well as having aquatic regions conducive for microbial conversion of inorganic Hg to methylmercury (MeHg). In this study, we examine the role of high elevation wetlands in Hg cycling by investigating Hg storage, transformations, and transport in alpine (~3000m) and subalpine (~2,500 m) environments in the Colorado Rocky Mountains (Fig. 1). Soil total mercury (THg) concentrations were significantly higher in alpine (61.3±25.5 ng/g) and subalpine (114.7±29.7ng/g) wetlands compared to dry soil regions (39.7±11.1ng/g, p<0.01). Concentrations of MeHg were an order of magnitude higher in subalpine (6.4±2.2ng/g) than alpine wetlands (0.6±0.5ng/g, p<0.05), and both subalpine and alpine wetlands had significantly higher concentrations than dry soil regions (0.2±0.1ng/g, p<0.05, Fig. 2). Mercury methylation rates were three orders of magnitude higher in the subalpine wetlands (0.324ng/g/day) than the alpine wetlands (0.013ng/g/day) and dry soil regions (0.006ng/g/day). Sulfate additions increased methylation rates in the subalpine wetlands by approximately 2ng/g/day. This pattern suggests that increased sulfate runoff from the weathering of pyrite in melting rock glaciers, and other ice features, may stimulate MeHg production in alpine ecosystems with continued warming. Stream THg concentrations across all sites were highest in the spring during snowmelt but were significantly higher in the subalpine (4.77±2.46ng/L) compared to the alpine (1.14±0.55ng/L, p<0.01). Stream MeHg concentrations gradually increased throughout the growing season and were an order of magnitude higher in the subalpine (0.71±0.02ng/L) than the alpine (0.006±0.01ng/L, Fig. 2). Methylmercury concentrations in overlying wetland waters within the subalpine wetland were highest during spring snowmelt, and the inlet to the wetland was significantly lower (0.09±0.07ng/L) than the outlet (0.21±0.08ng/L, Fig. 2). This suggests that MeHg is produced within subalpine wetlands and exported downstream. Overall, this study demonstrates that high elevation wetlands play a disproportionate role in storing and transforming atmospherically deposited Hg with implications for downstream ecosystems and local food webs.

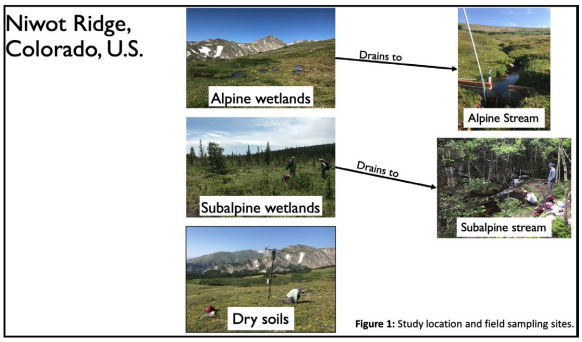

Figure 1: Study location and field sampling sites.

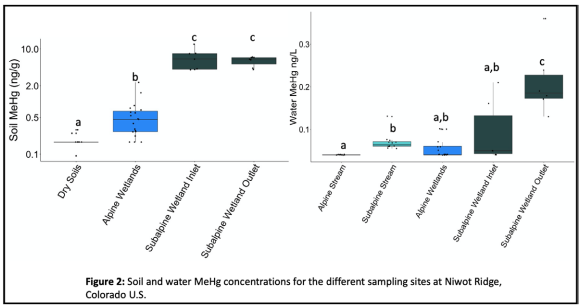

Figure 2: Soil and water MeHg concentrations for the different sampling sites at Niwot Ridge, Colorado U.S.