

Arsenic mobilization in mine-impacted sediments

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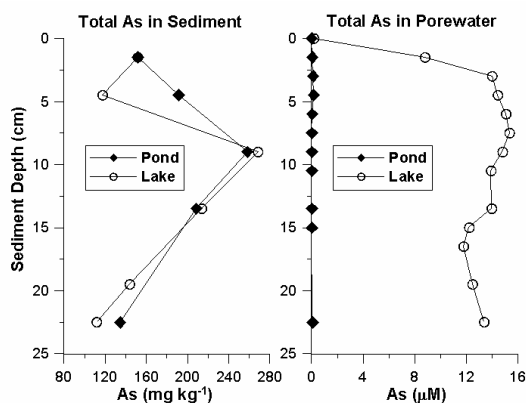
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Introduction

Lake Coeur d'Alene (CDA) and the floodplain along the CDA River, Idaho, USA are major collecting areas for metal(loids) produced during regional mining activities. Sediment geochemical properties and porewater concentrations from the lake and a nearby pond were monitored to determine the variables controlling aqueous metal(loid) concentrations. Total metals were determined by sediment digestion and aqueous concentrations were determined from porewater collected in dialysis samplers. X-ray absorption spectroscopy (XAS) was used to speciate Fe, S, and As in the solid phase.

Results

Maximum lake- and pond-sediment concentrations of As were 268 and 258 mg kg⁻¹, respectively, while maximum As in the lake porewater was 15.37 and in the pond 0.184 μM (figure below). The magnitude of the difference in available As (aqueous) in these same-source sediments indicates the importance of identifying the geochemical processes controlling As solubility.



Conclusion

Oxic conditions at the sediment-water interface in the lake promote the formation of iron oxyhydroxides and scavenging by these oxides prevents As diffusion into the overlying water column. Burial and reductive dissolution of these oxides releases As to the sediment porewater. The deficiency of sulfides in these sediments promotes high aqueous concentrations. In contrast, the anoxic interface in the pond limits oxyhydroxide formation, the subsequent scavenging of As, and negligible aqueous As concentrations.

Reductive mechanisms of arsenic mobilization from contaminated sediments

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Significant questions remain concerning the mechanism of arsenic mobilization, both in natural settings and at contaminated sites, such as the Coakley Superfund site (North Hampton, NH). During monitored natural attenuation of organic and inorganic wastes at Coakley, excessive groundwater arsenic levels have persisted. This study examines the mechanisms of arsenic mobilization at the Coakley site using field data paired with laboratory based flow experiments.

Field data tracing arsenic and other metals at the site over the past decade suggest that arsenic contamination results from reductive release from an underlying glaciomarine clay layer, where arsenic is associated with ferric species. Various pathways for iron and arsenic reduction exist. In addition to direct reduction by iron-reducing bacteria, sulfide produced by sulfate-reducing bacteria has also been tied to arsenic release [1]. Furthermore, stoichiometric analysis of site data suggests that the reduction is driven by oxidative degradation of benzene and other organic contaminants. Past studies link oxidation of organics to arsenic mobilization.[2]

Flow experiments incorporating Coakley sediments were used to evaluate abiotic and dissimilatory redox processes responsible for the arsenic mobilization. Experiments explored the roles of iron- and sulfate-reducing bacteria in consuming organic wastes and the role of sulfide as an intermediate. Stimulation of bacteria in the sediments with benzene confirmed the correlation between organic waste and increased iron reduction and arsenic mobilization. A study of the effects of sulfate concentrations also suggested that sulfate-reducing bacteria may play a major role in the mobilization of metals, as the addition of sulfate to the system was associated with increased release of iron and arsenic.

References

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