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Book of Abstracts from the UC Davis Postdoctoral Scholars Association 2026 Postdoctoral Research Symposium

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Publication Date

2026-04-24

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Arctic Rusting Streams and Rivers Show Spatial and Temporal Variability in Dissolved Metal Concentrations from Acid Rock Drainage

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***Keywords*:** Water Quality, Metals, Acid Rock Drainage, Arctic, Streams

***Abstract*:**

Streams and rivers in Arctic Alaska are turning orange due to acid rock drainage that mobilizes metals from sulfide minerals below thawing permafrost. However, the spatial and temporal variability of chemical signatures from acid rock drainage, and the relative contributions of point versus diffuse sources remain poorly understood. Here, we performed repeat synoptic samplings of hillside seeps, tributaries, and mainstem sites in the Nakolikurok Creek watershed in the Brooks Range, Alaska, USA, during June, July, and twice in August 2024 to understand how acid rock drainage chemical signatures varied spatially and temporally. Seeps and impaired tributaries showed distinct chemistry from unimpaired sites. Hillside seep chemistry was highly temporally variable; for example, SO_4^{2-} concentrations in a single seep varied from 5960-13,700 mg/L. A subwatershed leverage (relative chemical influence) analysis indicated that tributaries contributed -13-6465% of dissolved iron and -8-151% total iron to the outlet of Nakolikurok Creek, suggesting that some tributaries dilute Fe while others disproportionately enrich downstream concentrations. Sulfate, a conservative tracer of acid rock drainage, was strongly related to continuous specific conductance (R^2=0.96), with specific conductivity and sulfate concentration peaking in late July. These findings demonstrate that acid rock drainage influences Arctic river chemistry through highly dynamic source contributions.

***Funding Acknowledgements**: This work was supported by the National Parks Foundation.*

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