Iron Export from Permafrost Influenced Streams in the Fairbanks Area

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Introduction

Due to globally increasing temperatures, water quality is changing in Arctic aquatic networks. As permafrost thaws, it becomes a source of heavy metals to aquatic networks. Release of iron into these systems discolors the water, causing a phenomenon that has been described as "rusting" the water. This discoloration has been observed across the Arctic and Interior Alaska.

Notably, when permafrost thaws, metal mobilization occurs. Iron is the most common metal to be mobilized. In heavy concentrations, these metals can become toxic to humans and wildlife, which can jeopardize drinking water quality, as well as aquatic habitats that support fish.

This research focuses on gathering baseline data for iron concentrations and various water quality parameters, including pH, conductivity, and turbidity in the Fairbanks area.

Methods

Surface water samples were collected from six sites around the Fairbanks area from the center of the water body using a sampling pole. Water quality data was collected onsite using the In-Situ AquaTroll 500 water quality probe. Permafrost depth was checked using a steel-tipped probe in multiple locations at each site. 125 mL samples from each site were then filtered to 0.45 µm.

Samples underwent total iron, nitrate and phosphate concentration analysis within a week of collection. Total iron concentration was analyzed by using a Hach DR-300 iron colorimeter using the FerroVer method, and the nitrate and phosphate concentrations were analyzed using a Hach DR-900 colorimeter using the cadmium reduction and PhosVer 3 methods, respectively.

Results

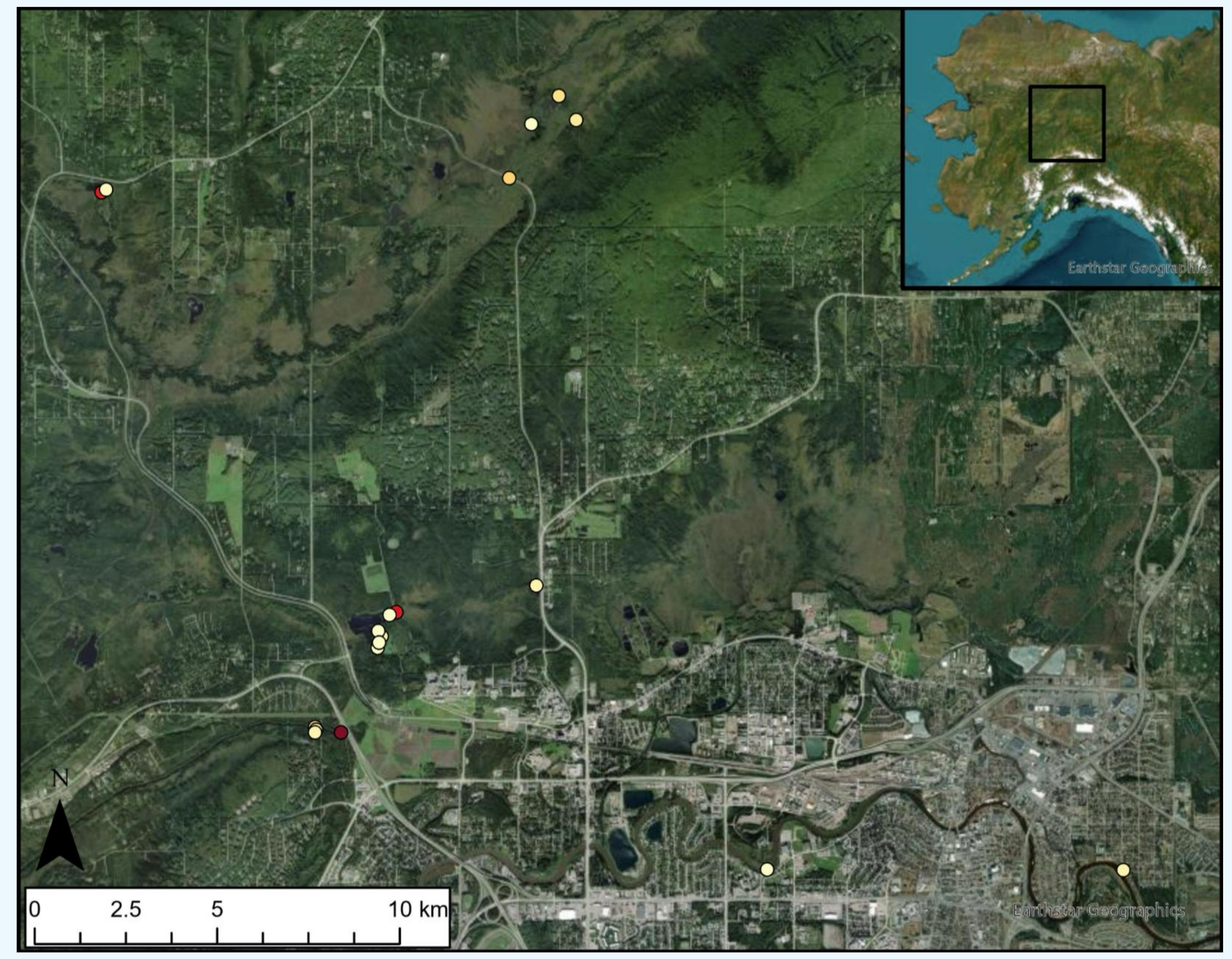

Figure 1. A. Map of sample sites, with sites marked by points. Darker points indicate higher average concentrations of iron, while lighter colors show lower concentrations of iron.

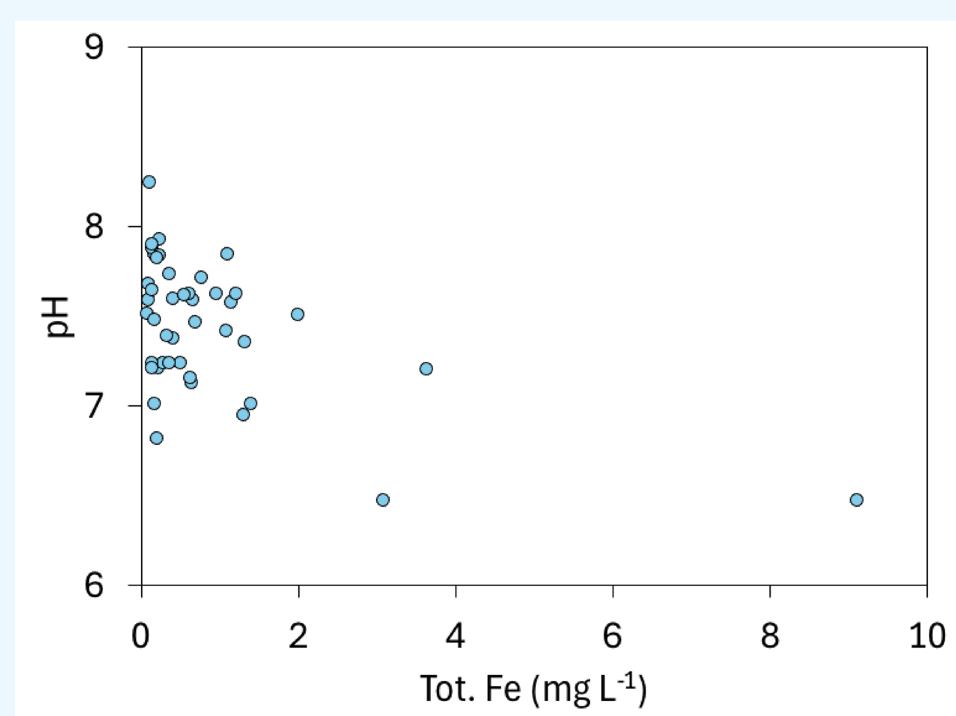

Figure 2. pH vs. iron concentrations.

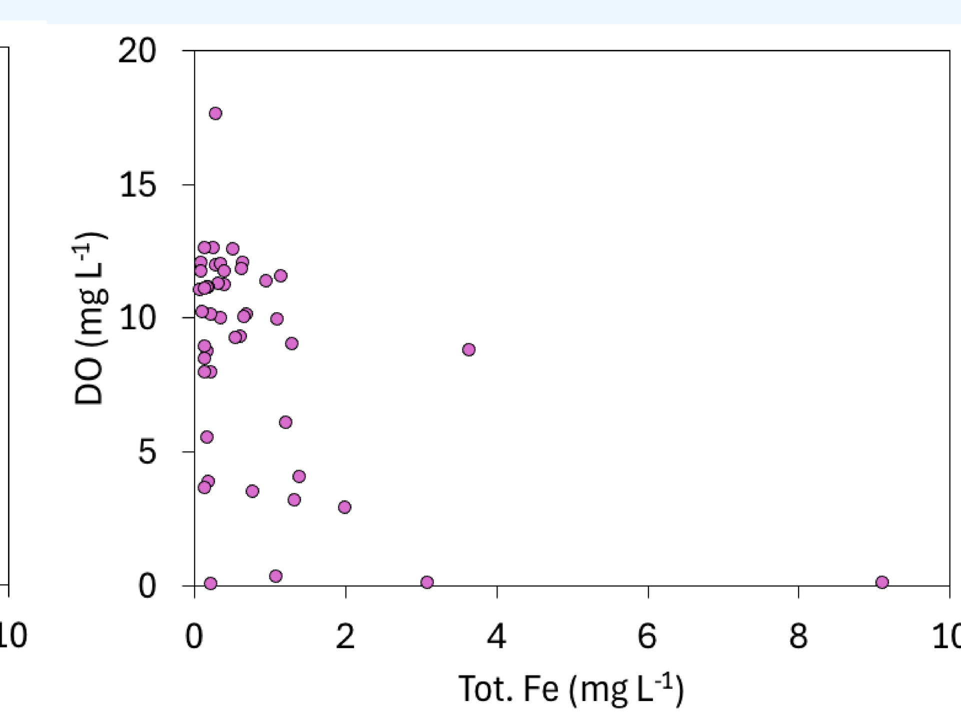

Figure 3. Dissolved oxygen (DO) vs. iron concentrations.

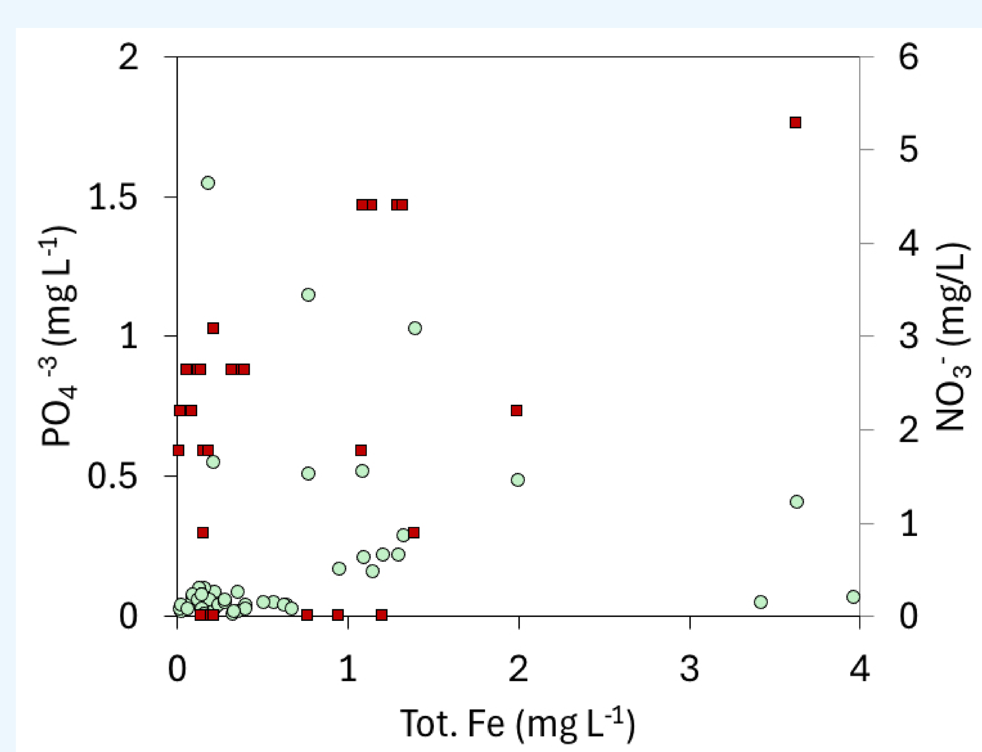

Figure 4. Total Fe concentrations vs. nutrient (PO_4^{3-} and NO_3^-) concentrations.

Iron export in the water at the Peat Ponds and Cripple Creek sites. Iron can be seen forming on the rocks, and in the rust-colored water.

Conclusions

Iron concentrations are variable across sites (Fig. 1). At the Cripple Creek and Peat Ponds sites, permafrost was found within the first meter under the soil column. The higher concentrations of iron may be attributed to the permafrost mobilizing metals into the water.

pH seems to have a relationship with iron (Fig. 2). Lower pH values correspond to higher iron concentrations. DO concentrations show a similar trend (Fig. 3). These results may be caused by iron readily bonding with oxygen, thus depleting dissolved oxygen and causing a lower pH.

Phosphate and nitrate concentrations were low across sites, with little relationship to iron concentrations. (Fig. 4)

Conductivity and turbidity does not have an evident relationship with iron concentration. More data is needed to determine if there is a relationship between iron concentration and these water quality parameters.

Future Directions

Over the coming seasons and years, I will be collecting more data for this project to determine iron speciation and seasonal trends.

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References

1. O'Donnell, J. A. *et al.* Metal mobilization from thawing permafrost to aquatic ecosystems is driving rusting of Arctic streams. *Commun Earth Environ* 5, 1–10 (2024).