The contribution of source materials to the dissolved organic matter of Smith Lake

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Background

With the disproportionate effect of climate change on high-latitude environments, it is increasingly important to study these regions. Carbon cycling in high-latitude freshwater environments is expected to respond to changes in hydrologic connectivity, vegetation structure, and permafrost thaw. These changes will alter the supply of dissolved organic matter (DOM), a major component of the C cycle, to lakes and rivers. The goal of this project is to investigate the extent to which organic material sourced from vegetation found in and around a small sub-Arctic lake, Smith Lake, affects the amount of dissolved organic carbon (DOC) available for microbes to decompose into greenhouse gasses (carbon dioxide and methane). Smith Lake is hydrologically connected to the surrounding landscape, and because of this, it is an ideal location to study the impacts of terrestrially sourced DOM on the carbon cycle of the lake, as its hydrologic connectivity allows for many sources of DOM to be supplied to the lake.

Materials and Methods

To study the biolability of a potential DOM sources to Smith Lake, I collected source materials, then dried and leached them in one liter of 0.001 M sodium bicarbonate solution. After the material had been leached in the solution for 24 hours, I filtered each leachate using a 0.2 um membrane filter to remove particulate matter and any microbial community found in the sample. I inoculated each filtered leachate with 10mL of Smith Lake water, collected at the same site, filtered through a 1.2 um glass fiber filter. On days 0, 2, 7, 14 and 28 days I filtered a subsample to 0.2 um into three 40 mL vials and acidified them using HCl to prevent further microbial activity. These samples were analyzed using a Shimadzu total organic carbon analyzer to evaluate the concentration of non-purgeable organic carbon(NPOC) at each of the five times in the incubation, providing the rate at which DOM is metabolized by the microbial community in the lake.

Samples were collected on 11May23 at the site(Smith_1). On this date, green-up had not fully commenced, and the samples that were collected were in-lake sediment(Smith_1 ake sed)), spruce detritus(Smith_1 spruce), tussock grass(Smith_1 tuss grass), and mossed spruce detritus(Smith_1 moss spruce).

On 24May23, once green-up had occurred, more samples were collected, both at Smith_1, and a region of the lake previously identified to be a thermokarst region(Smith_2). At Smith_1, more tussock grass(Smith_1 tuss grass green) and in-lake sediment (Smith_1 lake sed green) were collected. At Smith_2, tussock grass(Smith_2 tuss grass), border soil(Smith_2 soil), and in-lake sediment(Smith_2 soil) were collected.

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Results

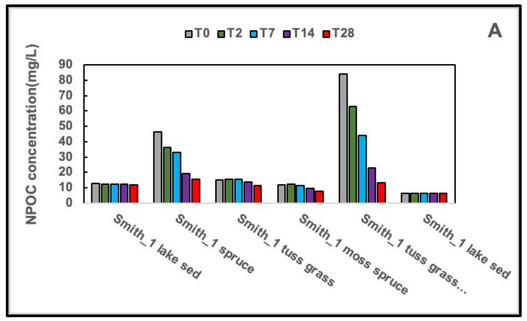

Figure A: Smith_1 mg/L NPOC throughout incubation.

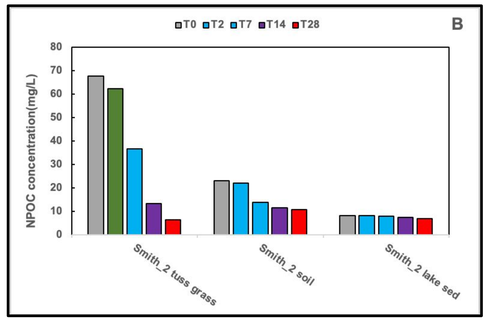

Figure B: Smith_2 mg/L NPOC throughout incubation.

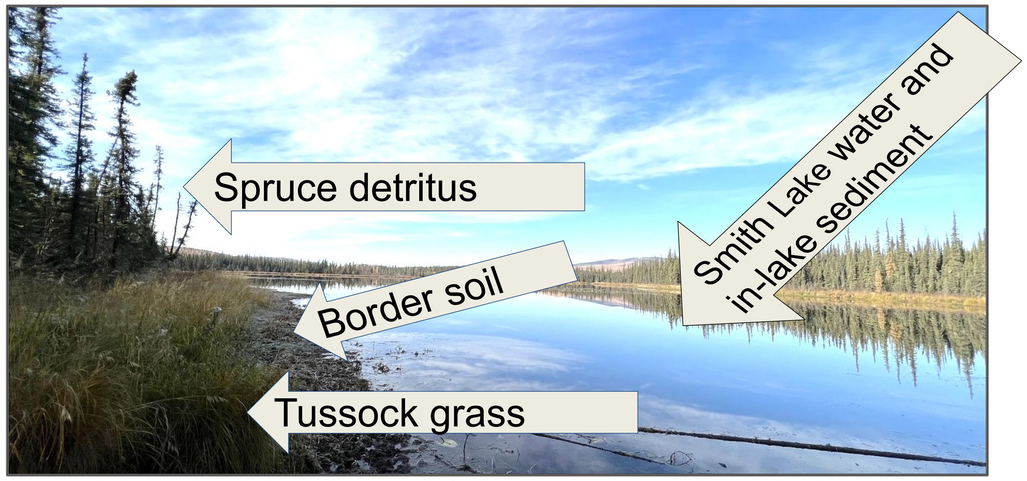

Image A: Smith Lake from Smith_1 with arrows indicating endmember sources included in this study.

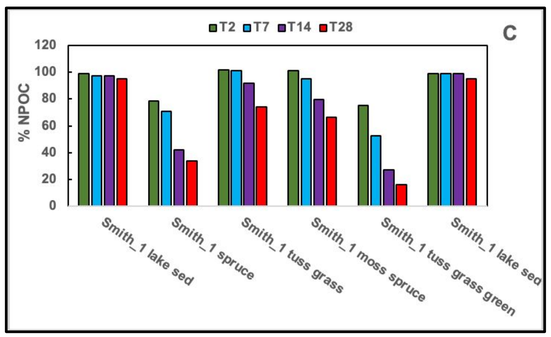

Figure C: Smith_1 % of remaining NPOC throughout incubation relative to % at T0.

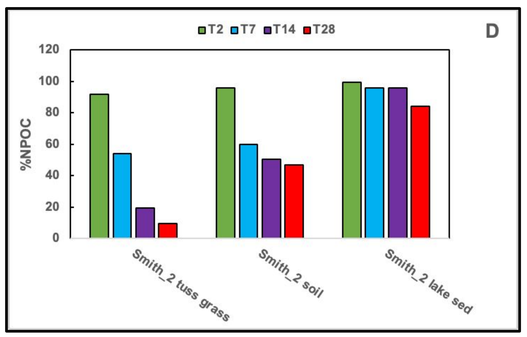

Figure D: Smith_2 % of remaining NPOC throughout incubation relative to % at T0.

Conclusions

The analysis of a lake sediment leachate at Smith_1 showed low percent loss of DOC, ~5% both before and after green-up. This is likely due to the labile organic matter having already been leached out of the material by the lake water. This conclusion is supported by the fact that the lake border soil sample shows a significantly higher percent loss (53%) of DOC compared to the sediment leachate.

Lake sediment leached from a suspected thermokarst region of the lake had notably high BDOC, ~16%, although still relatively low compared to the other source material leachates. This could be the result of an altered biogeochemistry of the region of the lake. More analysis is needed to determine whether this result is due to recent thermokarst activity contributed biolabile DOM to the lake sediment.

The tussock grass was much more labile after green-up. The 3-4x increase in the rate of consumption of DOC shows that DOM derived from tussock grass in the growing stage would contribute greatly to a high lake productivity in an area where it was introduced to the water.

The results from the two spruce detritus samples show that the sample containing moss was roughly twice as labile as the sample that contained no moss. The relatively high lability of spruce detritus is significant, as there is much of this detritus that accumulates on the ice around the perimeter of the lake during the winter. This detritus is then introduced into the lake water in the spring when the ice melts, introducing a highly labile DOM source to the lake. This indicates that spruce detritus could be playing a significant role in the spring productivity of the near shore regions of the lake.

Cumulatively, these results support the conclusion that fresh sources of DOM are rapidly metabolized when they enter Smith Lake's aquatic environment.

Future Directions: I am currently running an incubation of Smith Lake water to provide more context for my results. In addition to this, I plan to also plan to investigate the lability of these organic sources at different times of the year. Lastly, I would like to investigate Smith lake lignin concentrations to determine the extent to which terrestrial sourced DOM is found in the lake at different times of the year.