Pocket fluorometers to assess the presence of disinfection by-products and cyanobacteria in northern drinking water

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Water browning in northern aquatic ecosystems

•The concentration of dissolved organic matter (DOM) is increasing in surface waters across the planet. Water browning was shown in northern lakes, particularly in systems affected by permafrost thawing[1].

•Browning changes the mixing regime in lakes, the oxygen and light availability, and the microbial assemblages. Studies hypothesize that toxic cyanobacteria could increase in response to browning[2,3].

•Adding chlorine to drinking water is effective for the removal of fecal bacteria, but it can react with DOM to generate disinfection by-products (DBPs) like trihalomethanes and haloacetic acids[4], which presence is regulated in many countries. Thereby, **browning can impact drinking water quality**.

Study objectives

Assess the concentration of DBPs in northern communities' drinking water of Northern Territories, Nunavut and Nunavik, and develop early warning tools to quantify DOM, cyanobacteria and DBPs.

Pocket fluorometers

Pocket fluorometers* are promising and accessible tools that could be used to identify critical periods along the year when **1-** DOM is rising above a threshold level in source water that is increasing the risk of DBP formation in drinking water, and **2-** phytoplankton biomass is rising enough in source water to initiate more formal testing (and adjust water treatment operations).

Pocket fluorometers also have the potential to allow a first estimation of DBP levels in drinking water by differential fluorescence (such as used with differential absorption)[5].

*Turner Designs AquaFluor® **#1** FDOM + Turbidity; **#2** Total chlorophyll-a + blue-green chlorophyll-a

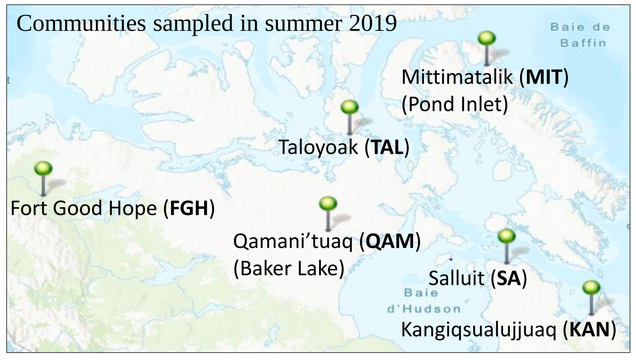
Specific objectives and methods

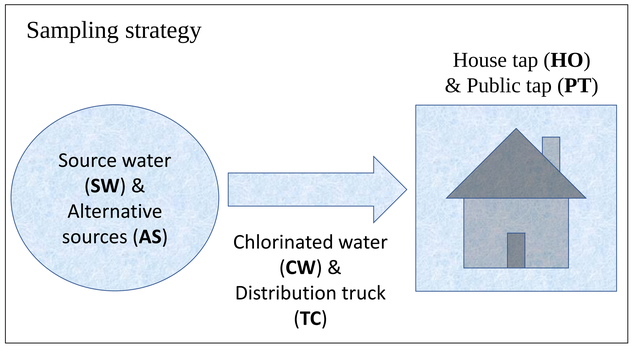
➢Is DOM quality (assessed with spectral absorption on chromophoric DOM = CDOM, and excitation-emission matrices of fluorescence) affecting the precision of pocket fluorometer #1 in estimating a_{440} or a_{250} (proxies for DBP formation[6])?

➢How reliable is pocket fluorometer #2 to quantify cyanobacteria (assessed with molecular analyses by M-A Moisan) when CDOM and turbidity increase (interference factors)?

➢To what extent is the calibration method (by the fabricant, with pure water, with fluorescent standards) affecting the precision of the fluorometers in assessing CDOM and Chla?

➢Can pocket fluorometer #1 be used as an early warning tool to monitor DBPs through differential fluorescence? To be assessed on soil leachates (CDOM gradient) exposed to a chlorination gradient.





Reference cited: [1]Wauthy et al. (2018) Limnol. Oceanogr. Lett.; [2]Pick (2015) Can. J. Fish. Aquat. Sci.; [3]Creed et al. (2018) Global Change Biology; [4]Kraus et al. (2010) Journal of Environmental Quality; [5]Beauchamp et al. (2019) Environmental Science: Water Research Technology; [6]Chen et al. (2019) Water Research.

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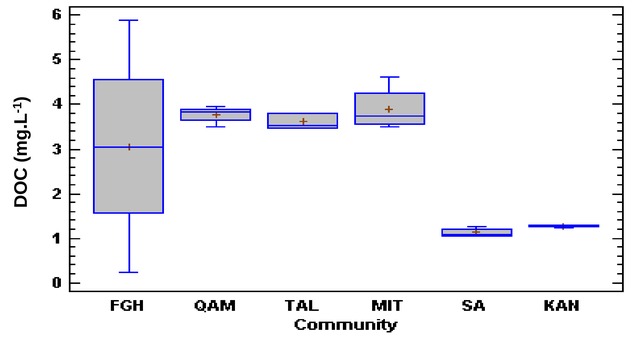
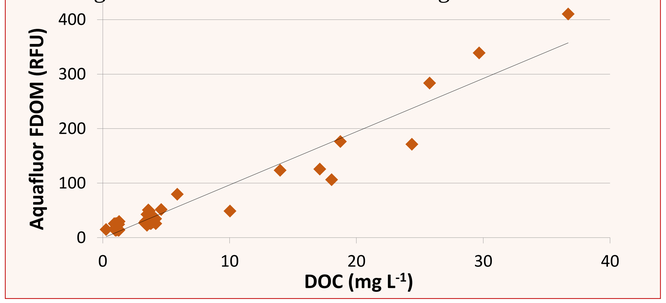
Preliminary Results

Dissolved organic matter was sufficiently high in source waters to produce relatively high levels of DBPs. It could represent a risk at certain periods of the year.

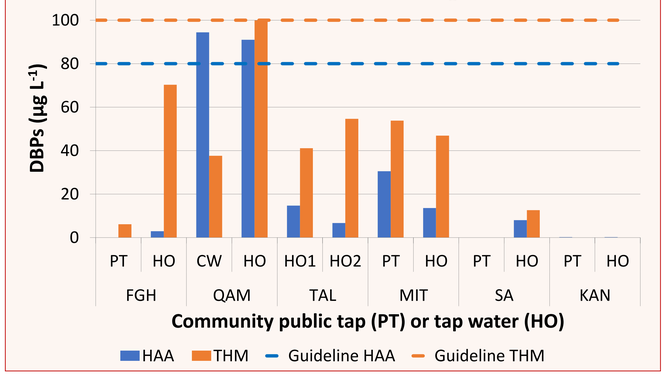
➢**DOM range** – Dissolved organic carbon (DOC) was relatively low in sampled waters (< 6 mg L^{-1}) and did not vary much from source to tap (box plots), except in FGH where DOC was higher in source water (5.9 mg L^{-1}).



➢**FDOM Aquafluor readings** – A significant correlation was found between pocket fluorometer readings (FDOM, in relative fluorescence units, or RFU) and DOC (r = 0.963, p < 0.0001), including a dataset from FGH with much higher concentrations.

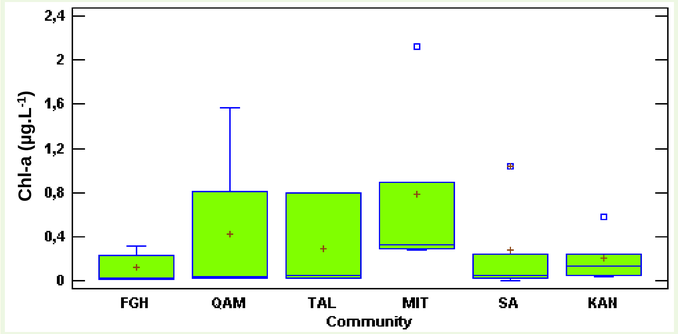


➢**DBPs in drinking water** – In QAM, haloacetic acids (HAA) and trihalomethanes (THM) were near or above Health Canada guidelines for tap water (CW or second HO shown when PT unavailable). In the other communities, DBPs were under the guidelines, and even undetectable in SA and KAN (likely linked to lower DOM and chlorination dose). Proportionally more THM than HAA were found in FGH drinking water.

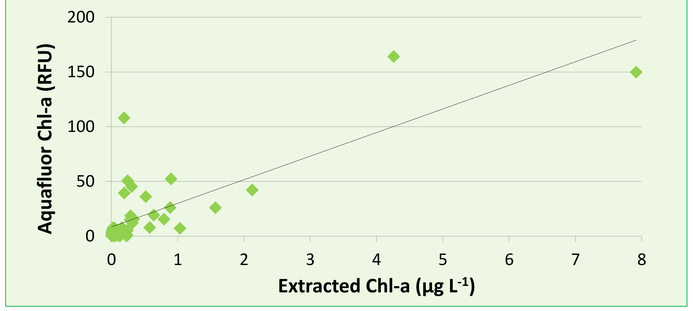


The risk associated to elevated phytoplankton biomass was low in source waters, at least on sampled dates; this needs to be monitored seasonally.

➢**Biomass range** – Chlorophyll-a concentration (extracted) was generally low in sampled water (< 1 µg L^{-1}). Source and raw waters had the highest concentrations (up to 2.1 µg L^{-1} in MIT). Degradation pigment pheophytin-a was proportionally elevated (median 44% of Chl-a, max 173%), potentially caused by the sometime long filtration delay (needs to be shortened).



➢**Chl-a Aquafluor readings** – The blue-green Chl-a signal was always null on pocket fluorometer. The biomass range was not wide enough to properly test the Aquafluor potential for Chl-a estimations. It will be challenging to test this on natural samples since source waters are chosen as pure and free of algal blooms. We can rather test this with laboratory cultures of cyanobacteria and other phytoplanktonic groups.



Work ahead

- Establish contacts with other communities, to generalize the algorithms linking fluorescent indicators to laboratory results.
- Receive water at different periods of the year to quantify seasonal variations.
- Explore the influence of DOM optical characteristics (matrix fluorescence and absorption spectra) on the quantity and type of DBPs present in drinking water.
- Make an experiment to test the interference by CDOM on Chl-a estimations by the pocket fluorometer, and by turbidity (algal cells or inorganic particles) on CDOM estimations.
- Make an experiment on permafrost leachates (DOM gradient) exposed to chlorination, to test the potential of differential fluorescence in estimating DBP concentration.