Regional variability in stream DOM characteristics across forested regions of Canada, and its implications for drinking water treatability

Julia Oriola1, David Olefeldt1, Fariba Amini2, Alyssa Bourgeois1,4, Jim Buttle3, Erin Cherlet1, Monica Emelko2, William Floyd4, David Foster5, Ryan Hutchins1, Rob Jamieson1, Mark Johnson1, Hannah McSorley4,6, Nan Qi7, Uldis Silins1, Suzanne Tank1, Lauren Thompson1, and Chris Williams1

INTRODUCTION

Rationale: Forested catchments are important sources of drinking water for communities across Canada. Dissolved organic matter (DOM) has the ability to negatively affect drinking water quality and treatability. The amount and characteristics of DOM in surface waters depend on the biogeochemical processes within the surrounding terrestrial and aquatic environments. The quality and quantity of DOM exported to lakes and streams is affected by climate, soils, geology, hydrologic connectivity and flow paths, and may change seasonally.

DOM, and in particular large molecular weight organic compounds, are known as precursors of disinfection by-products (DBPs), potentially harmful compounds formed during water disinfection. Studies observed correlations between the DBP formation potential (DBPs-FP) and SUVA as well as molecular weight distribution. Our goal is to understand the variation in DOM composition across Canada's ecotones, and what it means for drinking water treatability.

Research Questions:
1) What are the main differences in DOM chemical composition in stream water among ecotones?
2) How does climate, surficial geology, and dominant soils/ecosystems influence DOM composition among ecotones?
3) Does DOM composition influence drinking water treatability, in particular DBPs-FP?

DATA COLLECTION

• Two to six streams were sampled at each research site in 2019-2020. Each stream was sampled between two and four times under different hydrologic conditions.
• 91 samples were analyzed for general water chemistry (major ions, nutrients), DOC concentration. Indicators of DOM chemical composition determined with absorbance and fluorescence spectroscopy included SUVA (specific UV absorbance at 254 nm), S0 (slope ratio), S0/S1.05 (absorbance slope), E2/E3 (250-365 nm absorbance ratio), BIX (freshness index), HIX (humification index).
• 41 samples were analyzed using Fourier-transform ion cyclotron resonance mass spectrometry (FT-ICR-MS). The following metrics were used to differentiate between samples: aliphatic and condensed aromatic compounds, polyphenols, oxygen-rich and oxygen-poor unsaturated compounds; H/C and O/C ratios.
• Zeta potential, and true formation potential for nine DBPs, including four trihalomethanes (THMs: TCMD, BDCM, TBCM, TBM) and five haloacetic acids (HAA5s: MCAA, DCAA, TCAA, MBAA, DBAA), were measured in 72 samples.

RESULTS

DOM composition

We found large differences in stream water DOM chemical composition between ecotones. Aromaticity, as indicated by SUVA, HIX, and contribution of polyphenols and condensed aromatics, were the best differentiators. Atlantic Maritime (AM) and Pacific Maritime (PM1) had the highest aromaticity, despite not having the highest DOC concentrations; possibly related to DOM derived from podzolic soils. Montane Cordillera (MC) and Pacific Maritime (PM3) had the lowest DOC concentration and aromaticity, likely mainly microbially-derived DOM; possibly explained by shallow soils and dominance of deeper flow-paths through mineral soils.

Following the analysis, a majority of the variability in DOM composition was captured by simple DOM indices such as SUVA, but information from FT-ICR-MS provided both complementary and additional information. In addition, the study showed that DOM composition is consistent with broad differences in landscape characteristics, such as soil types, wetland abundance, and surficial geology. For example, SUVA values were highest in forested and wetland-dominated catchments, and lowest in hilly and glaciated areas.

Can we predict DBPs-FP using DOM characteristics?

DOC concentration or A200 predicted DBPs-FP, with the strongest individual predictors being DBPs-FP (R2 = 0.74). Higher SUVA is generally associated with higher DBPs-FP (R2 = 0.53). A majority of the variability in DOM composition was explained by simple DOM indices such as SUVA, but information from FT-ICR-MS provided both complementary and additional information.

SUMMARY

• Both DOM concentration and molecular composition had ecologically significant differences among ecotones. A majority of the variability in DOM composition between ecotones was captured by simple DOM indices such as SUVA, but information from FT-ICR-MS provided both complementary and additional information.
• Variability in DOM composition between ecotones is consistent with broad differences in landscape characteristics, such as soil types, wetland abundance, and surficial geology.
• DOC concentration and A200 were the best predictors for DBPs-FP, with only minor improvements to predictive capabilities by further accounting for additional aspects of DOM chemical composition.

Future work: We will further explore the effect of stream catchment characteristics (e.g., watershed size, slope) on DOM composition. We will include PARAFAC analysis to supplement our DOM characterization. Each ecozone included disturbed and undisturbed catchments, hence our analysis will reveal if there are common impacts on DOM composition in disturbed streams across ecotones.

ACKNOWLEDGEMENTS:
• We acknowledge the support of ForWater, a pan-Canadian strategic research network funded by The Natural Sciences and Engineering Research Council of Canada (NSERC), and numerous industry and academic partners (www.forwater.ca).

AFFILIATIONS:
1University of Alberta, Edmonton, AB
2University of Waterloo, Waterloo, ON
3Trant University, Peterborough, ON
4Vancouver Island University, Nanaimo, BC
5Dalhousie University, Halifax, NS
6University of British Columbia, Vancouver, BC