Are melting alpine glaciers a source of legacy contaminants to downstream environments?

A high-frequency analysis of proglacial water chemistry in the Canadian Rockies.

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Introduction

Glaciers are retreating worldwide in response to anthropogenic climate warming (1).

Legacy contaminants and weathering products release with glacial meltwater (2).

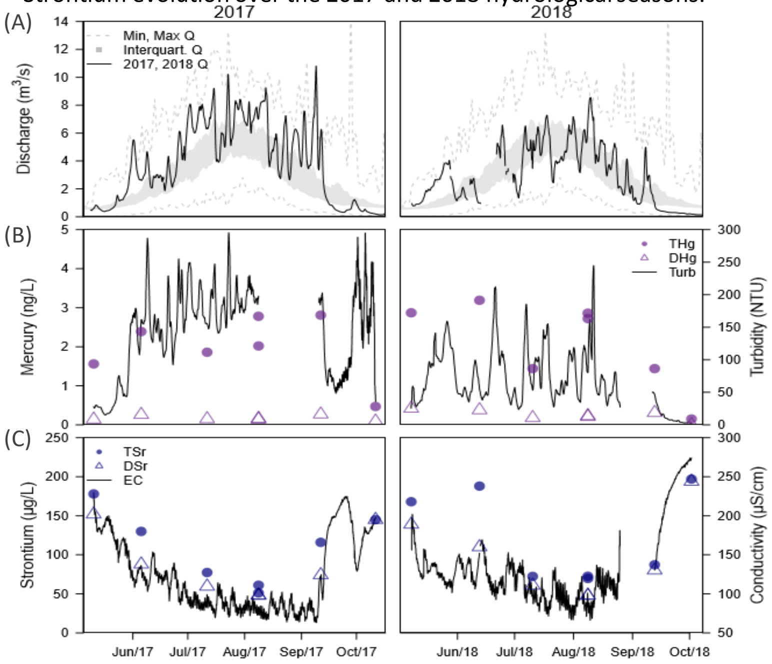
We investigated the chemical composition of proglacial water at Athabasca Glacier, Canada.

We modeled annual flux, and yield of legacy contaminants and weathering products at a high temporal resolution using a discharge gauge and sondes (turbidity and conductivity).

Site Description and Methods

- Proglacial Sunwapta River (29.3 km^2; 63% glacial coverage) flows from Athabasca Glacier, Canada.
- Hourly Discharge: Water Survey of Canada gauge station 07AA007.
- Sondes monitored 15-min conductivity, turbidity, pH, dissolved oxygen, temperature.
- Grab sampled monthly; clean-hands dirty-hands.
- Trace elements: ICP-MS. Mercury: Tekran 2600. Ions: ion chromatography.
- Principal component analysis on down-sampled chemical, sonde, and discharge data.
- Turbidity & conductivity modeled annual trace element flux & yield at a high temporal resolution.

Fig 1. (A) Discharge, (B) Turbidity and Mercury, (C) Conductivity and Strontium evolution over the 2017 and 2018 hydrological seasons.



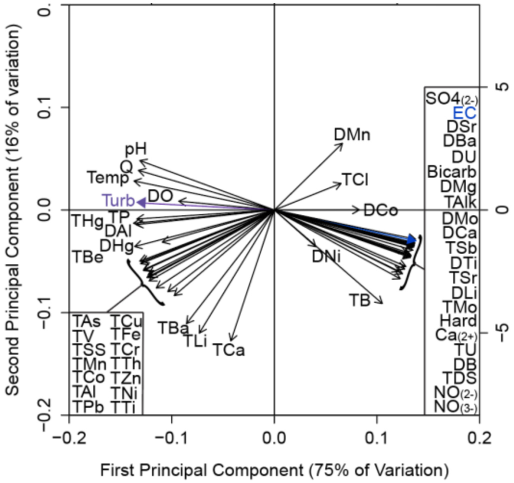


Fig 2. Principal component analysis: grab sample chemistry and sonde parameters formed two distinct groupings. Negative 1stPC loadings: Turbidity and Englacial Melt associated species; Positive 1stPC loadings: electrical conductivity and subglacial melt associated species.

Results and Discussion

Contaminant concentrations were below Canadian Water Quality Guidelines and mainly in a less bioavailable particulate phase (75-100%). Mercury <3.2ng/L; arsenic, cadmium, chromium, lead, uranium < 2 µg/L.

Sunwapta River chemical **flux and yield was dominated by carbonate** associated elements – modeled robustly by conductivity – originating from subglacial melt and erosion of carbonate bedrock.

Yields of legacy contaminant trace elements – modeled by turbidity – **were low**, associated with dust deposition, and englacial melt.

Mercury yield was comparable to other small glaciated, wetland, urban, forested, and agricultural catchments (3-9); unlike in temperate settings, yield was dominated by particulate phases.

The application of continuous conductivity and turbidity monitoring should be investigated further for its application to en-, and subglacial meltwater chemistry modeling at high temporal resolution.

Table 1. Mean annual concertation, flux, and yield of select chemical parameters, and the modeling parameter used to estimate annual flux and yield.

Chemical Species	Mean concentration (mg/L)	Modeling Parameter	Flux (Gg/yr)	Yield Annual (Mg/km^2/yr)
TSS	63	Turbidity	4.0	138
TDS	95	Conductivity	3.4	117
	(µg/L)		(Mg/yr)	(kg/km^2/yr)
TAl	638	Turbidity	36	1231
TSr	0.22	Conductivity	3.9	133
	(ng/L)		(kg/yr)	(g/km^2/yr)
TCr	868	Turbidity	47	1597
TPb	680	Turbidity	37	1255
TU	350	Conductivity	13	431
TAs	125	Turbidity	7.7	263
THg	2.2	Turbidity	0.10	3.53

Acknowledgement

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