Determining the sources of anthropogenic chloride in a rapidly urbanizing watershed

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Background

- In the past century **increasing trends of chloride** in groundwater and surface water across the Great Lakes Basin have been correlated to **anthropogenic effects** in urban/built up land use with **urbanization** being attributed as the driving force.
- An understanding of the **sources of chloride** in **varying land uses** is necessary for the development of improved source water protection plans and best management practices.
- Study sites were selected (Fig.1) within the **Credit River Watershed** (CRW) according to the variation of land use across the watershed, the rate of urbanization occurring, and the Credit Valley Conservation (CVC) Authority reporting upward trends in chloride at 74% of their monitoring points. [1]
- The CRW is currently 31% urban (community/infrastructure), 34% agricultural/undifferentiated, and 35% natural/vegetated, with urban areas increasing from 13% to 15% from 2002-2013. The area experiencing the greatest urbanization is the lower watershed. [2]

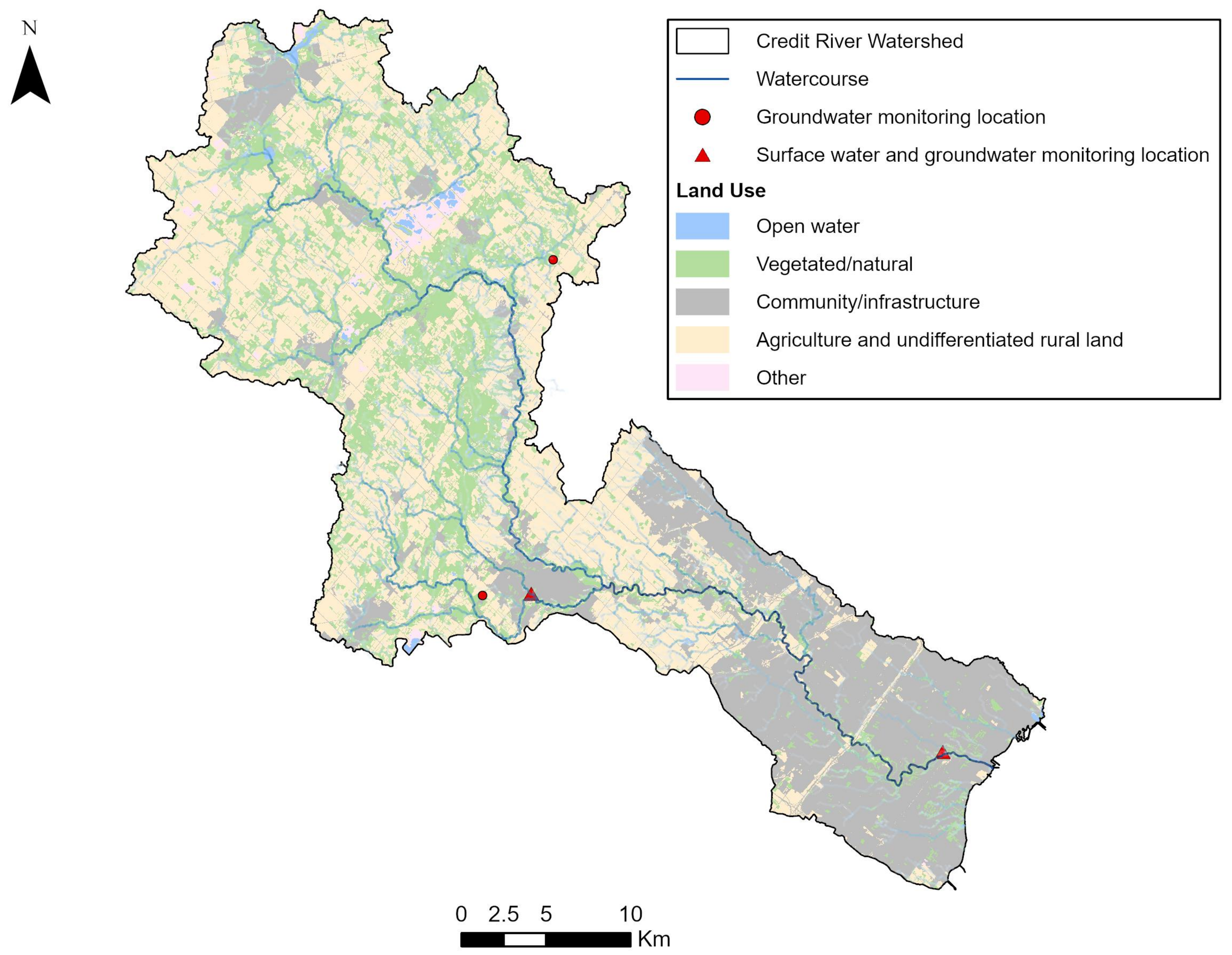


Figure 1. Land use map of the Credit River Watershed with monitoring locations.

Objectives

Determine the possible anthropogenic sources of elevated chloride in groundwater and surface water at four sites of varying land use within the Credit River Watershed.

This is be achieved by:

- Determining the various anthropogenic chloride sources at field sites with varying land uses by examining monthly geochemical trends in groundwater and surface water.
- Further differentiating the anthropogenic sources of chloride at each site through evaluation of field parameters and isotopic analysis.
- Supporting the source characterization of chloride contamination at each site using geospatial evaluation of past and present land uses.

Methods

- **Four research sites of varying land use** were selected throughout the CRW.
- **PGMN wells** were sampled at the **Georgetown** (2 wells) and **Warwick** (1 well) locations.
- Pre-existing infrastructure for groundwater (3 wells), surface water (1), and riparian zone (2 in stream piezometers) was sampled at **Cedarvale Park in Region of Halton** with 1 more in-stream piezometer installed in May 2022.
- A new research site was established at the **Mississauga Golf Club (MGCC)** in May 2022. Infrastructure was installed for groundwater (2 wells), surface water (4), shallow groundwater (6 piezometers), and riparian (2 in stream piezometers) monitoring.
- Levelogger LTCs are used for continuous monitoring of groundwater and surface water level, temperature, and conductivity.

Samples were collected for analysis of:

- Field parameters (temperature, EC, DO, pH, ORP)
- Anions + δ^2H and $\delta^{18}O$; every month
- Cations; every third month
- Artificial sweeteners; January 2023
- ^3H and He, I, and $\delta^{37}Cl$; sampled sporadically

Figure 2. (1) Wells drilled at MGCC, **(2)** drive point piezometers installed in stream at MGCC, **(3)** site map of MGCC infrastructure.

Figure 4. Field photos of monitoring points; **(A+B)** Cedarvale monitoring points in and adjacent to Silver Creek, **(C)** Georgetown PGMN wells, **(D)** Warwick Shallow PGMN well.

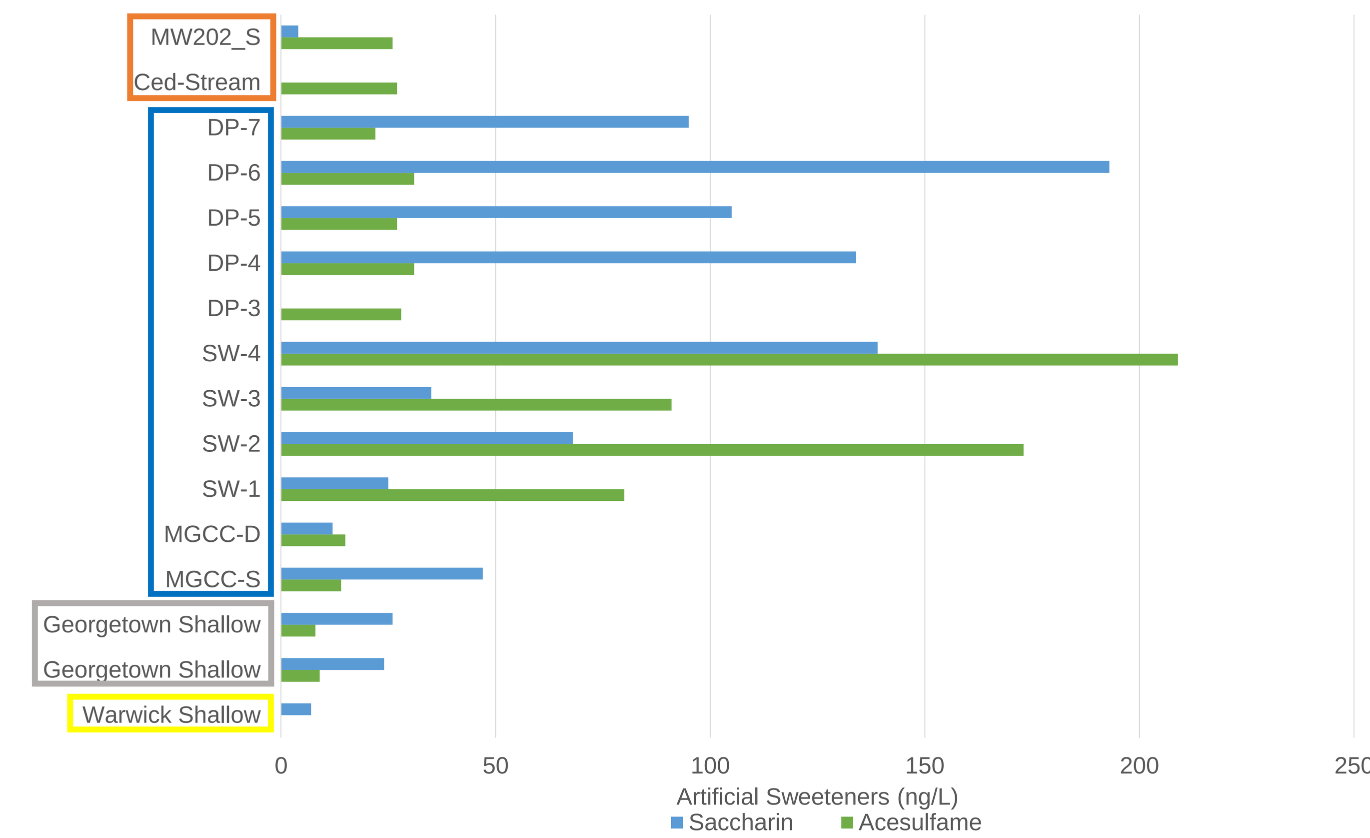
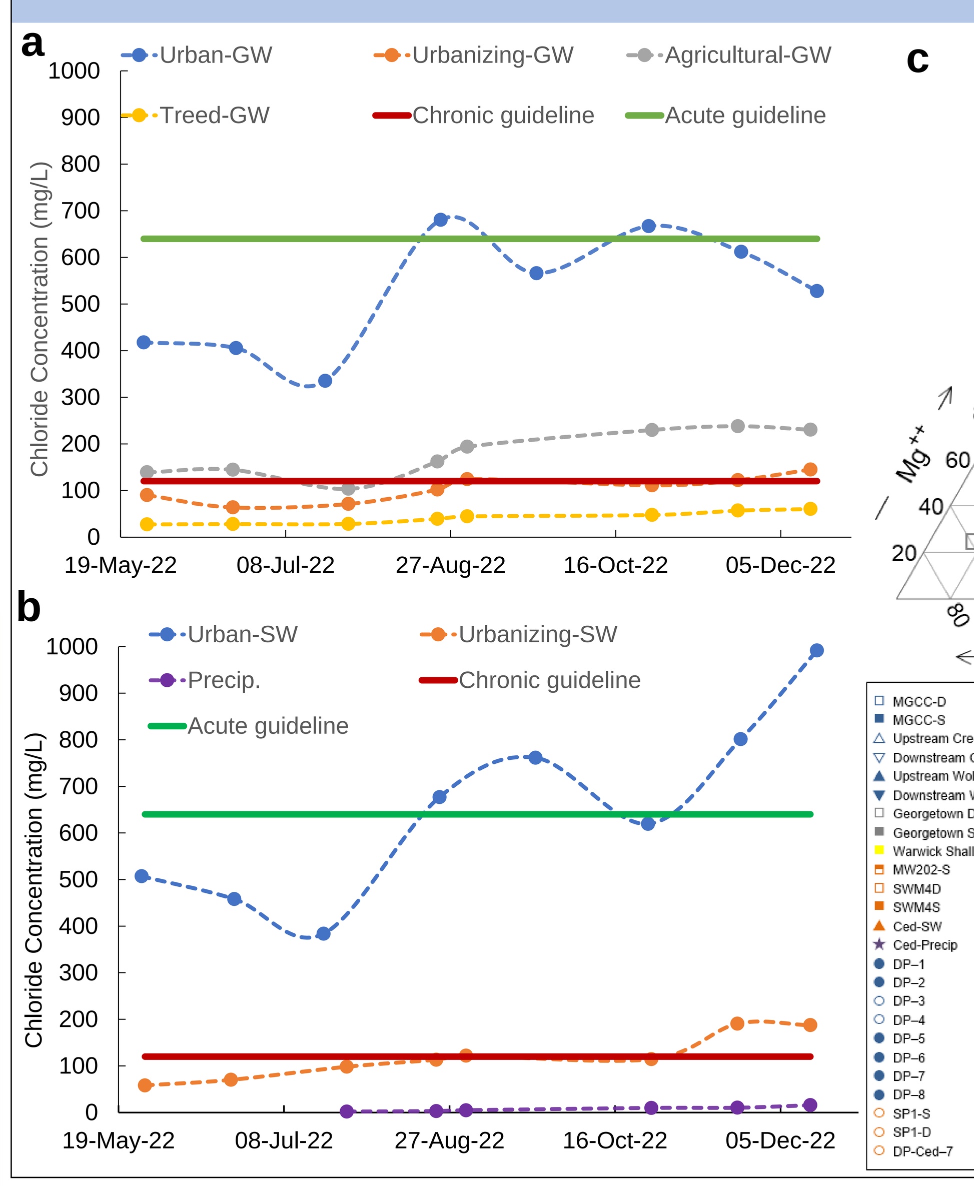


Figure 5. Results of artificial sweeteners samples collected in January 2023 across sites of varying land uses follows; Blue – Urban, Orange – Urbanizing, Grey – Agricultural or open space, Yellow – Treed/Natural. Greater Saccharin indicates landfill leachate; greater acesulfame indicates wastewater.

Preliminary Results



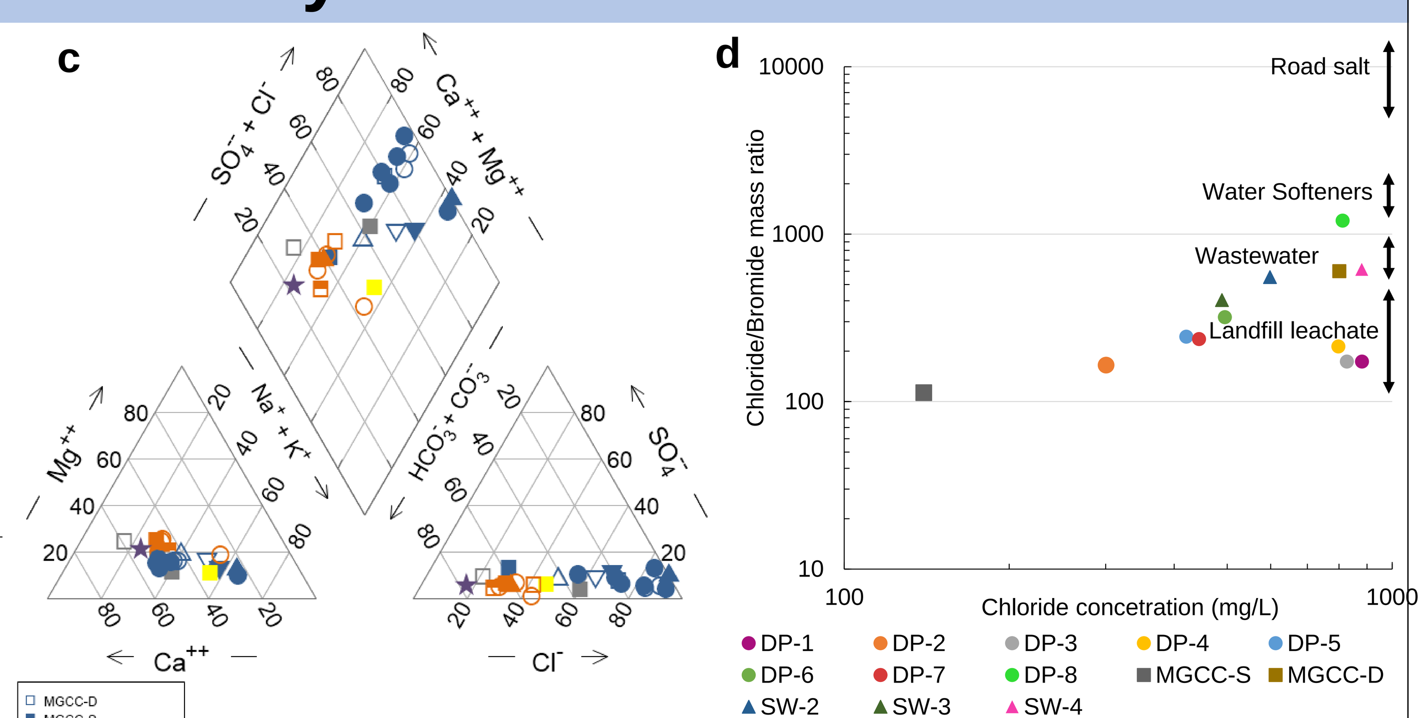


Figure 3. (a) Average chloride concentrations of GW (wells and land piezometer) samples taken from varying land uses from May-December 2022. **(b)** Average chloride concentrations of SW (surface water monitoring points and in stream piezometers) samples taken from various land uses from May-Dec. 2022. **(c)** Piper plot displaying the dominate anions and cations of GW (squares), SW (triangles), shallow GW (filled in circle), in riparian piezometers (circles), and precipitation (star) samples collected in October 2022 across varying land use infrastructure that follows the same colour legend as Fig. 2(a&b). **(d)** Average chloride bromide ratios for GW, SW, shallow GW, and riparian samples taken from the MGCC site from May-Dec. 2022.

Summary

- **Chloride concentrations in GW and SW at the urban site (MGCC) are the highest**, surpassing the acute guideline (120 mg/L) frequently and intermittently surpass the chronic guideline (640 mg/L). (Fig. 3a,b)
- GW chloride concentrations the agricultural and GW and SW chloride concentrations at the urbanizing field sites rose then surpassed the acute guideline.
- SW samples from Wolfedale Creek, a channelized stream (Fig. 2.3), (SW-2 and SW-4) Cl/Br ratio plot in the wastewater range (Fig. 3d) and display high (>50 ng/L) levels of acesulfame (Fig.. 5), strongly suggesting **wastewater** is entering the site there.
- GW samples, specifically shallow GW samples from MGCC (DP-7, 6, 5, 4) and SW-4, Cl/Br ratio plot in the landfill leachate range (Fig. 3d) and have elevated saccharin concentrations further indicating **landfill leachate** influence possibly originating upstream Wolfedale.
- From Fig. 3c. the dominant water type at MGCC is calcium chloride with some samples moving into the mixed type and the sodium chloride water type. This is expected due to the mixed chloride sources observed.
- At the rest of the sites, samples are magnesium bicarbonate water type common to the precipitation or have no dominate ions.

Acknowledgements

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[1] Integrated Watershed Monitoring Program Technical Report: Status and Trend Analysis of Stream Water Chemistry , Credit Valley Conservation; January 4, 2022.
[2] Integrated Watershed Monitoring Program Technical Report: Status and Trend Analysis of Land Cover and Land Use, Credit Valley Conservation; January 4, 2022.