Geospatial Estimates of Road Salt Usage Across a Gradient of Urbanizing Watersheds in Southern Ontario

Introduction
Chloride (Cl) salts, while an effective de-icing agent, have significant environmental consequences to local aquatic ecosystems. Cl has been recognized as a pollutant of concern in Canada by the Government of Canada’s Council of Ministers of the Environment, especially in urban areas. Negative ecological effects to many aquatic organisms include impaired reproduction, growth and mortality. Cl salt usage is determined by temperature, while recorded precipitation is often not accurate enough for application of Cl salt. Determining accumulated Cl levels requires accurate estimates of road salt. Despite this, Cl salt usage in Ontario is considerably higher than in other jurisdictions (Lauriault, Fournier & Laflamme, 2002). Urbanization (high density Municipal & Regional) and climatic conditions (Figure 1) drive increased Cl salt usage and pollution. Urbanization refers to the increased concentration of people and activities within city limits (higher population density). Regional refers to cities and their surrounding areas (region). Municipal refers to cities and towns within these areas (municipality). Climatic conditions include precipitation and temperature. Salt is used during cold weather to melt and prevent accumulation of snow and ice. High density urbanization, cold weather and frequent winter precipitation increase use of salt. Ontario experienced an average of approximately 1.18 metres of ice, snow and slush in 2007. 1.18 m of ice and snow fell in 2009, 2013 and 2015 (WMO, 2016). The City of Toronto and the Province of Ontario have jointly developed an application for road salt usage that is called Road Weather Information System (RWIS). The RWIS application records road conditions, including snow and ice accumulation, and then provides an estimate of how much road salt was used. RWIS was developed based upon a cross-section of roadways with less than 60% of the traffic volume of the province. This project addresses all the roadways in the province of Ontario, with the exception of the greater Golden Horseshoe (Figures 1a & 1b) home to 8.7 million people, about 25% of Canada’s population. A variety of urbanizing environments are represented here. Subwatersheds include: 1. Toronto 2. Hamilton Harbour 3. Lake Simcoe

Study Sites
Preliminary map of 9 watersheds of concern (Figures 1a & 1b) in the greater Golden Horseshoe home to 8.7 million people, about 25% of Canada’s population. A variety of urbanizing environments are represented here. Subwatersheds include: 1. Toronto 2. Hamilton Harbour 3. Lake Simcoe

1st Geospatial shapefiles are used: • Land Information Ontario (LIO) • Toronto • Peel • York • Regional & Municipal • Ontario Ministry of Transportation (MTO) • road salt application area polygon vectors • Ontario Municipal & Administrative boundaries vectors

2nd Road salt application data from various sources are used (Figure 2b): • Environment Canada annual road salt application data for solid (fanes) & liquid (lites) for NaCl, MgCl2, CaCl2 (the 3 most commonly used salts) for 2006-12 based on submissions from multiple jurisdictional levels • MTO daily distribution data for all patrol yards impacted for 2006-15 for pure salt, mixed sand/salt, & a various liquid applications • MTO Municipal annual summary on quantities/types of liquids used & chemical compositions • Operator & managerial inputs

3rd Direct, uniform allocation of each layer of salt distribution data to the calculated lane-lengths for the appropriate jurisdiction level (i.e. provincial, regional, or municipal)

4th While still under development, statistical analysis to ascertain relationships between salt or total solids distributed & various predictive factors: • Urbanization (high impact of where & how much de-icing agent is used) • Weather (total snow, total precipitation, & temperatures (k), maximum, minimum, & mean) retrieved from nearby Environment Canada weather stations data • Limited to timeframes with available salt data & where snow/freeze rain was present • MTO provided a distribution decision matrix based around temperature to aid in analysis

5th Outputs: • Ongoing development with model for 2016-2018 data to better estimate the impact of where & how much de-icing agent is used

6th Synthesis of all my data to map salt distribution layers (Figures 3b, 3d) & create new salt distribution model for 2016-2018 data to better estimate the impact of where & how much de-icing agent is used

7th Results: • The Lake Simcoe area subwatersheds of concern were considered first with available & provided data • Regional & Municipal will comprise subsequent steps: all 3 will be summed • Same processes will then be executed for Toronto & Hamilton

Next Steps
1. Re-examine input & output data for 2016-2018 data to better estimate the impact of where & how much de-icing agent is used

2. Further refinement of the processes has occurred. Further refinement of the processes has occurred.

3. Multiple refined layers and gis layers are represented here. Subwatersheds of concern (Figure 2b) will be evaluated for improved road salt data inputs/outputs (ovals based around temperature to aid in analysis)

4. Multiple refinements in relating specific subwatersheds to weather

5. Very limited relationship between general weather & salt distribution, instead, actual road condition data may be relevant

6. A case study of specific subwatersheds’ relationship between salt data & RWIS (Road Weather Information System) data is suggested

7. Sample regressions of salt data for Lovers Creek (Figures 3c, 3d) to determine relationship between salt data & RWIS (Road Weather Information System) data

ACKNOWLEDGMENTS

Gregory Giberson1, Claire Oswald1
1 Department of Geography and Environmental Studies, Ryerson University, Toronto, Ontario

REFERENCES
Gregory Giberson
Jeff Underhill (MTO), Chris Weller (Department of Earth and Environmental Sciences, University of Waterloo), Lisa Trudel (Environment Canada), Funding provided by Environment Canada.