Environmental Impacts of Deicers

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2020 Michigan Winter Operations Conference
Oct. 15, 2020
Why Salt?

1. It is fairly cheap
2. It works
3. It has been proven to create safer road conditions!

What impacts do we see?

- Corrosion
- Scaling
- Damage to rebar
What impacts can NOT see?
Clear Roads QPL
(formerly known as PNS QPL)

Qualified Products List

Due to the administrative restructuring of the Pacific Northwest Snowfighters (PNS) organization, Clear Roads has assumed responsibility of the Qualified Products List. The product testing and administration of the QPL will remain essentially the same along with a few process improvements.

Mission

The mission of the Clear Roads QPL is to “strive to serve the traveling public by evaluating and establishing specifications for products used in winter maintenance that emphasize safety, environmental preservation, infrastructure protection, cost-effectiveness and performance.”

Guidance for Vendors

To begin the process of getting your product approved and listed on the QPL, please complete the Product Sample Checklist (may need to saved to your desktop prior to completing the document). Once you’ve completed the checklist, click the yellow submit button at the bottom of page 2. Keep in mind that test results from a third party lab are necessary prior to completing the checklist. Once paperwork is approved, Clear Roads will ask for product samples per the specifications.

The QPL product approval process can be expected to take at least 4 months.

Questions? Please call Patti Caswell at 503-986-3008.
What does it take to be on QPL?

- Elemental Analysis

<table>
<thead>
<tr>
<th>Element</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>5.0</td>
</tr>
<tr>
<td>Barium</td>
<td>100.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.20</td>
</tr>
<tr>
<td>Chromium</td>
<td>1.0</td>
</tr>
<tr>
<td>Copper</td>
<td>1.0</td>
</tr>
<tr>
<td>Lead</td>
<td>1.0</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.05</td>
</tr>
<tr>
<td>Selenium</td>
<td>5.0</td>
</tr>
<tr>
<td>Zinc</td>
<td>10.00</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>2500.0</td>
</tr>
<tr>
<td>Cyanide</td>
<td>0.20</td>
</tr>
</tbody>
</table>

- Other Testing Required

- Ammonia - Nitrogen
- Total Kjeldahl Nitrogen
- Nitrate and Nitrite - Nitrogen
- Biological Oxygen Demand
- Chemical Oxygen Demand
- Frictional Analysis
- Toxicity Testing
  - Rainbow Trout or Fathead Minnow Toxicity Test
  - Ceriodaphnia Dubia Reproductive and Survival Bioassay
  - Selenastrum Capricornutum Algal Growth
Where do these numbers come from?

• Your State
• The Environmental Protection Agency (EPA)
Let’s talk salt

- EPA water quality standard (*secondary drinking water standard)

250 mg/L = 250 mg Chloride

1 Liter water

*Maximum contaminant level, causes undesirable taste or odor, undesirable effects to the body, damage to equipment....
What 250 mg/L of salt looks like!

• 250 mg = about 1/10 of a teaspoon of salt

That is less than half of this add to a full 1-liter bottle.

Bagels

A bagel on average has a salt content of 490mg.
A little chemistry

NaCl

[100 g of NaCl = 39.34 g Na + 60.66 g Cl.]

MgCl$_2$

Or salt is 40% Sodium and 60% Chloride!

CaCl$_2$

Both Mag and Calcium chloride have twice as much chloride as NaCl.
What does this have to do with winter maintenance?

• Chloride (drinking water standard):
  – 250 mg/L

• Chloride (aquatic life standards):
  – 230 mg/L Chronic (longer term exposure)
  – 860 mg/L Acute (1 time exposure)
Products used by WSDOT and Application Rates

- **NaCl** (32 to 15°F)
  - Solid – 100 to 800 lbs/l-m
  - Liquid – 10 to 40 gal/l-m
  - Pre-wet – 8 to 20 gal/l-m

- **MgCl₂** (32 to -5°F) and **CaCl₂** (32 to -15°F)
  - Solid – 100 to 500 lbs/l-m
  - Liquid – 10 to 40 gal/l-m
  - Pre-wet – 8 to 20 gal/l-m

Other products?
Once applied, where do deicers go?
Let’s play a game (not really just math)

<table>
<thead>
<tr>
<th>Pounds (lbs)</th>
<th>Milligrams (mg)</th>
<th>Pond [NaCl]</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>22,680,000</td>
<td>11 mg/L</td>
</tr>
<tr>
<td>100</td>
<td>45,360,000</td>
<td>22 mg/L</td>
</tr>
<tr>
<td>250</td>
<td>113,400,000</td>
<td>57 mg/L</td>
</tr>
<tr>
<td>500</td>
<td>226,800,000</td>
<td>113 mg/L</td>
</tr>
<tr>
<td>1000</td>
<td>453,600,000</td>
<td>227 mg/L</td>
</tr>
</tbody>
</table>


https://dailyreporter.com/2010/12/07/pass-the-salt/
So where do we go from here?

1. What are actual water chloride levels?
2. And what toxicological impacts are being observed?
USGS Stream and Surface Water Chloride Concentrations from 2002-2012

https://nawqatrends.wim.usgs.gov/swtrends/
USGS Groundwater Chloride Concentration changes from 1988-2016

https://nawqatrends.wim.usgs.gov/Decadal/
Chloride numbers from the field

- USGS (Corsi et al., 2014)
  - 29% of the sites exceeded the EPA (230 mg/L)
    - by an average of more than 100 days per year from 2006 - 2011, almost double the amount of days from 1990 -1994.
  - The lowest chloride concentrations were in watersheds that had little urban land use or cities without much snowfall.

USGS (Corsi et al., 2014)

- In 16 of the streams, winter chloride concentrations increased over the study period.
- In 13 of the streams, chloride concentrations increased over the study period during non-deicing periods such as summer.
  - chloride infiltrating the groundwater system during the winter, then slowly released to the streams throughout the year.
Regional Salinization caused by WMO


- <0.5ppm w/ no roads
- 14X higher w/ roads
Lake Chloride Concentrations tied to State Road Density

- Higher state road density equals higher salt load
- No relationship found between local roads and chloride concentration.

It is not just surface water; it is ground water too…

• They found the UNEXPECTED
  – Think slow, glacial time scale..

1. Long term increases in concentration
2. High [Cl-] in summer
3. Higher [Cl-] downstream in summer

Stuart Findlay and Vicky Kelly (Cary Institute, 2018)
Stuart Findlay and Vicky Kelly (Cary Institute, 2018)

- Background < 10 mg/L
- Environmental effects (sub lethal) ~ 100 mg/L
- Lethal > 1000 mg/L

- EPA Drinking Water Std. 250 mg/L
- EPA chronic 230 mg/L
- EPA acute 860 mg/L
Summary of Reported Chloride concentrations

<table>
<thead>
<tr>
<th>Freshwater Ecosystem</th>
<th>Range due to natural sources (mg/L)</th>
<th>Range from road salt contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakes</td>
<td>0 - 10</td>
<td>6 – 1,000</td>
</tr>
<tr>
<td>River/Stream</td>
<td>1 - 20</td>
<td>10 – 7,730</td>
</tr>
<tr>
<td>Wetland/Pond</td>
<td>0 - 12</td>
<td>10 – 13,500</td>
</tr>
</tbody>
</table>

Sources of chloride
- 80% from deicing (DOT, local, private)
- 5-10% from water softeners

(Findlay and Kelly, Cary Institute, 2018; Hintz and Relyea, 2018)
The Ecological Perspective

- Salt negatively affects species across all trophic levels – biofilms to fish
- Salt impacts vary by concentration and species
- Typical impacts for species were not death, but reduction in growth and reproduction
- Community level impacts were reductions in biodiversity, and encouragement of salt tolerant species

Other documented impacts of Deicers

• Deicers can cause…
  – Mobilizations of heavy metals
  – Impacts to or death of aquatic & terrestrial species
  – Loss of native species => increase in invasive species (aquatic & terrestrial)
  – Wildlife-vehicle collisions

https://www.hoosier.aaa.com/insurance/wildlife-animal-vehicle-collisions
https://rachelcarsoncouncil.org/safe-deicing-products/
Impacts of Salt and Chloride Based Deicers
Impacts of Sand and Abrasives
BOD
(Biological/Biochemical Oxygen Demand)

• “The amount of dissolved oxygen needed by aerobic biological organisms to break down material in water at a specific temperature or a specific time.”

https://en.wikipedia.org/wiki/Biochemical_oxygen_demand
https://www.slideshare.net/jamesmacroony/biochemical-oxygen-demand
https://www.pharmaguideline.com/2013/06/determination-of-biological-oxygen.html

<table>
<thead>
<tr>
<th>BOD Standards (mg/L)</th>
<th>Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most pristine rivers</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Moderately polluted rivers</td>
<td>2 - 8</td>
</tr>
<tr>
<td>Ordinary domestic sewage</td>
<td>150 - 200</td>
</tr>
<tr>
<td>Treated sewage</td>
<td>&lt; 20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BOD Level in mg/liter</th>
<th>Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2</td>
<td>Very Good: There will not be much organic matter present in the water supply.</td>
</tr>
<tr>
<td>3 - 5</td>
<td>Fair: Moderately Clean</td>
</tr>
<tr>
<td>6 - 9</td>
<td>Poor: Somewhat Polluted - Usually indicates that organic matter present and microorganisms are decomposing that waste.</td>
</tr>
<tr>
<td>100 or more</td>
<td>Very Poor: Very Polluted - Contains organic matter.</td>
</tr>
</tbody>
</table>
Ag-based, Acetate, Formates & Glycols

Benefits
• Break down in the environ.
• Less corrosive than chlorides

Not so good
• Higher costs
• Exert a higher BOD

Reduces available oxygen for organisms in the soil and aquatic environments
Where does this leave us…

**Best Management Practices**

- Cover salt storage to minimize runoff
- Calibrate equipment to prevent over application
- Vary application rates based on precision weather forecasts
- Pre-wet materials or apply liquids before storms
- Use live-edge plows to remove more snow
- Evaluate performance after each storm
- Evaluate expectations for levels of service
Where does this leave us…

• Invent a better deicer

• Invest in a different deicing system

Heated pavements?
Resources

- www.clearroads.org
Questions?

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https://westerntransportationinstitute.org/