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An Introduction to the Mechanics of Salt and Research in the Transportation Sector

Salt Management Strategy (SaMS) Training Event

May 24, 2018

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Group Leader: EcoTransportation and Alternative Systems

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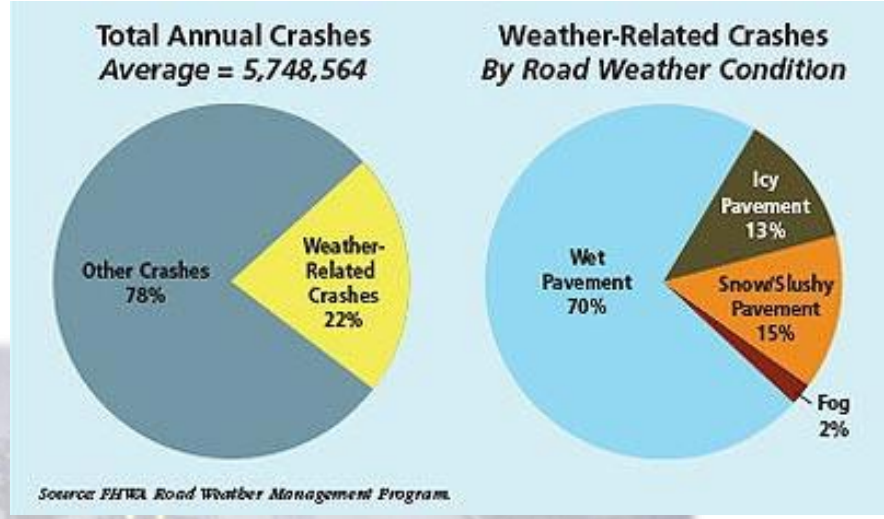
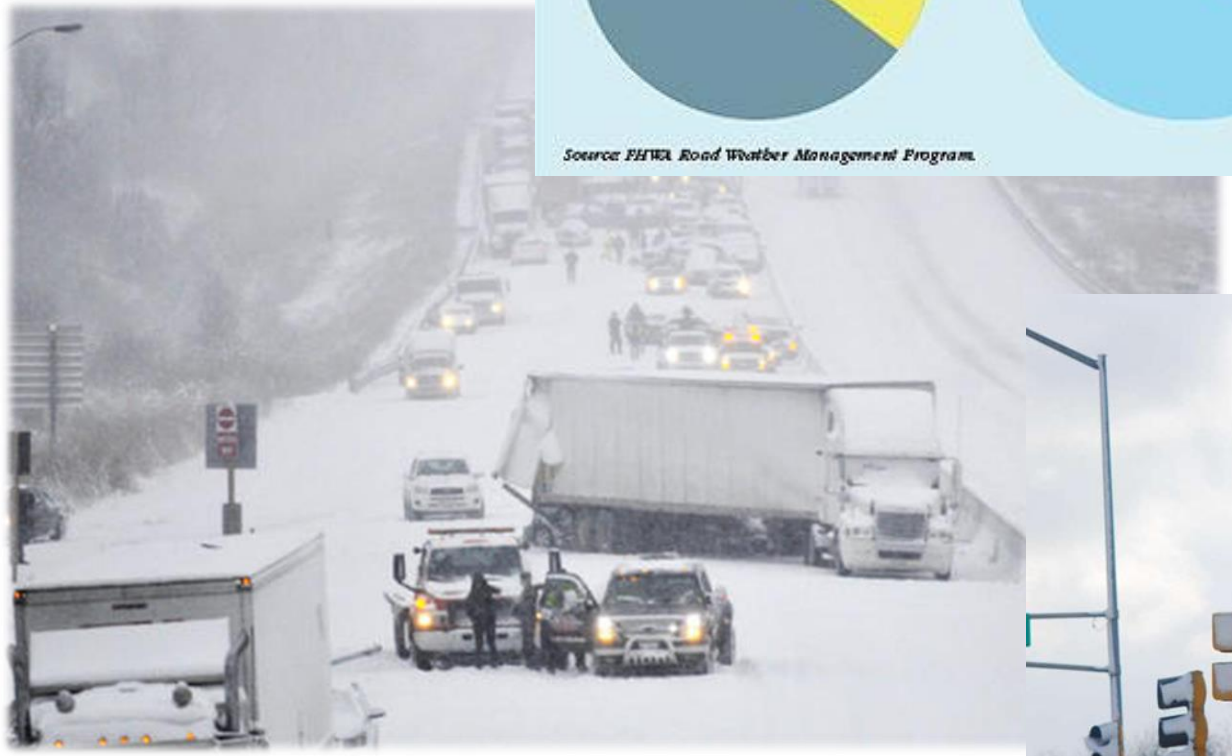
Winter-Affected Roads Impacts

- Safety
  - 1,836 fatalities annually, on average (2005-2014)
- Mobility with heavy snow (highway)
  - Average speed ⬇: 5 – 64%
  - Average volume ⬇ 40-44%
  - Average Capacity ⬇ 12-27%
- DOT budgets
  - 20% of total budget
  - $2.3 B annual nationally
- Public expectations





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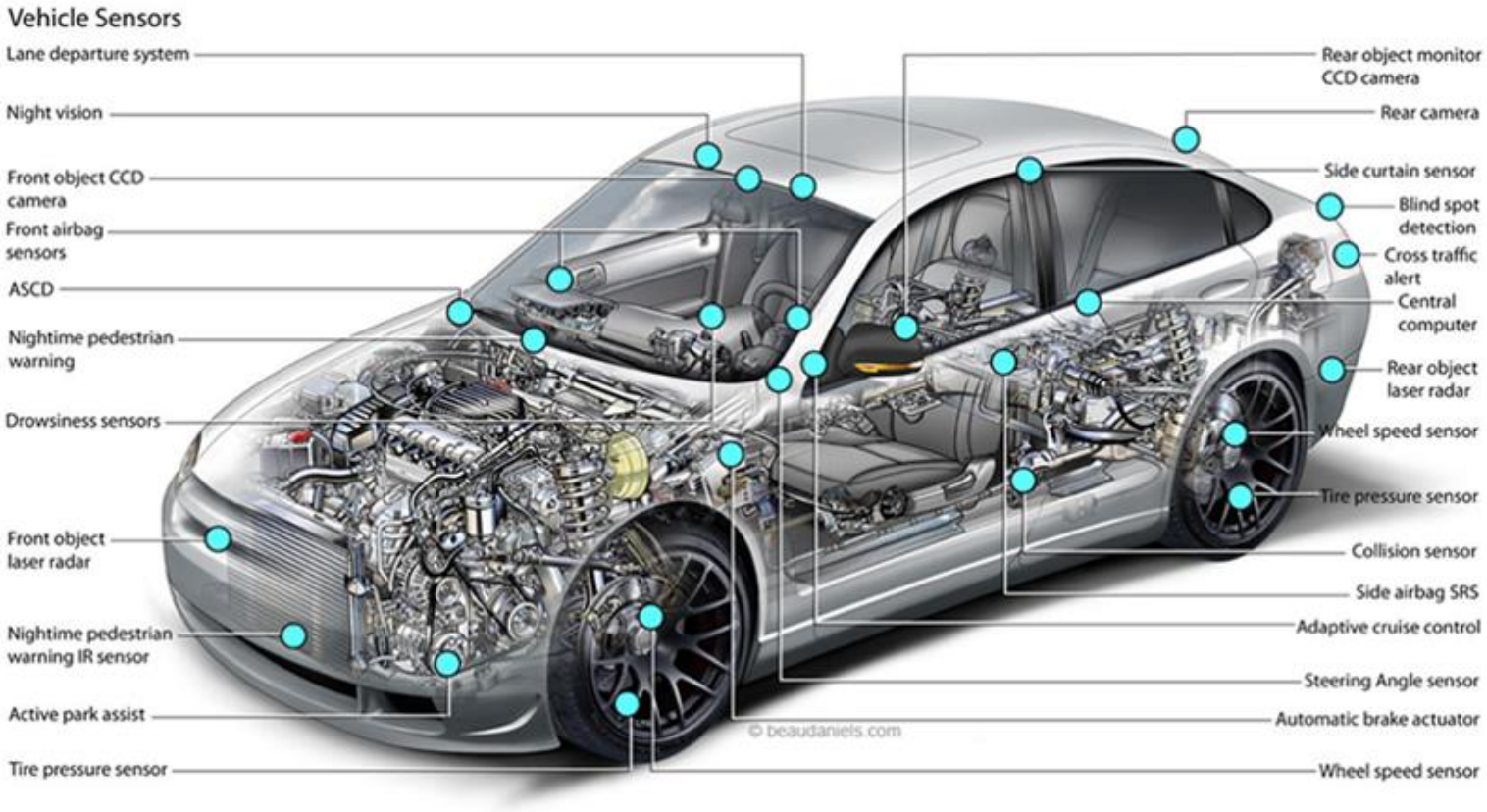
Better Vehicles

- Tires
- Traction control
- Anti-lock brakes
- Stability Control



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Mechanical Removal

- Plowing

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Dissolved Salt Application

- ‘Anti-icing’ or ‘pre-treatment’
  - Weakens bond to pavement
- Brine applied before event

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Granular Material Application

- Deicers
  - NaCl
  - $CaCl_2$
  - $MgCl_2$
  - Calcium Magnesium Acetate (CMA)
  - Blends
- Aggregates – mechanical traction improvement
- Pre-wetting (typically brine)

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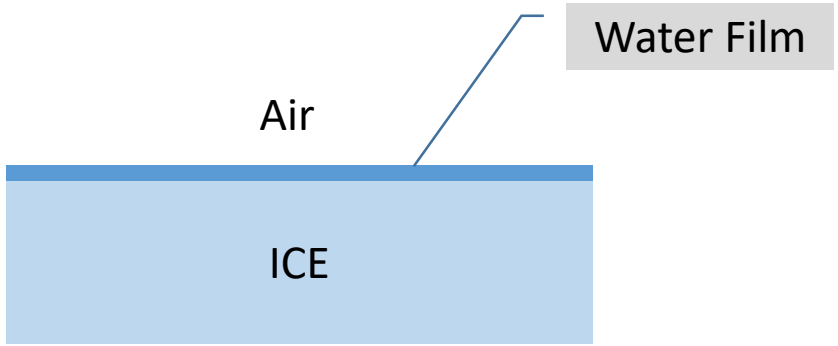
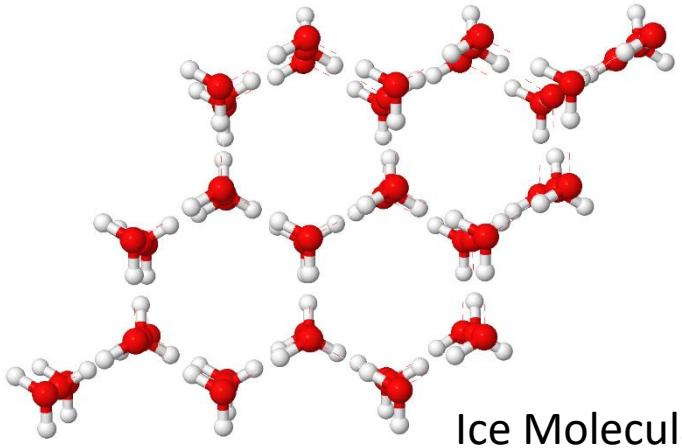
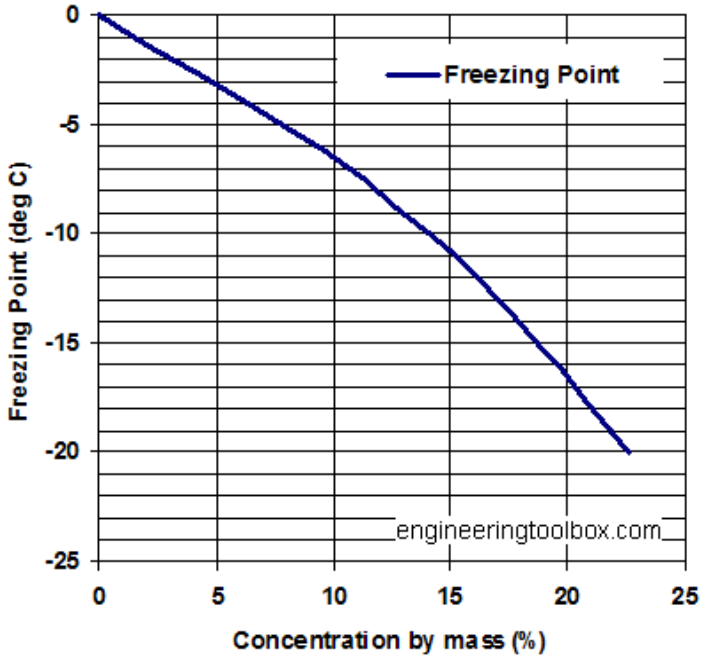
Salt Deicing

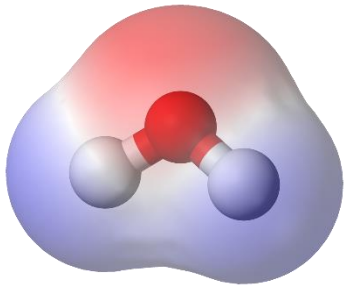




Ice Molecular Matrix

- Dissolution
  - Cl^-
  - Na^+ (Mg^+, Ca^+)
- Attraction to polar water molecules





Water Molecule

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Deicing Agents Comparison

- Byproducts
  - Beer
  - “Beet Heet” juice

Product	Cost Relative to Road Salt	Freezing Point Depression (degrees C per unit weight)	Effective Lower Limit (degrees F)	Corrosive?	Aquatic Toxicity	Other Environmental Impacts
Road Salt or Rock Salt (NaCl)	$1.00	1	20	Yes	Moderate	Roadside tree damage
Potassium Chloride (KCl)	$1.60	0.78	12	Yes	Very	K fertilization
Magnesium Chloride ($MgCl_2$)	$2.40	0.29	5	Yes	Very	Mg addition to soil
Calcium Chloride ($CaCl_2$)	$5.70	0.53	-25	Very	Moderate	Ca addition to soil
CMA- Calcium Magnesium Acetate ($C_8H_{12}CaMgO_8$)	$19.30	0.30	0	No	Indirect	Decreased aquatic oxygen
Potassium Acetate (CH_3CO_2K)	$26.30	0.60	-15	No	Indirect	Decreased aquatic oxygen
Urea (CH_4N_2O)	$1.80	0.97	15	No	Indirect	N fertilization
Sand	$0.60	0	-	No	indirect	Sedimentation

http://www.mde.state.md.us/programs/Marylander/Documents/cary_report_road_salt_2010.pdf

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Salt Application - Associated Problems

Environmental Impact

Impact on Constructed Systems

Indirect Impact

Water Quality

ELSEVIER

Science of The Total Environment
Volume 508, 1 March 2015, Pages 488-497

River chloride trends in snow-affected urban watersheds: increasing concentrations outpace urban growth rate and are common among all seasons

Steven R. Corsi [a], Laura A. De Cicco [a], Michelle A. Lutz [a], Robert M. Hirsch [b]

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Highlights

- Chloride trends in northern U.S. urban streams are computed.
- The rate of chloride concentration increase outpaced urbanization from 1990 to 2011.
- The greatest chloride concentration increase was during the winter.
- Increasing chloride concentration trends were observed in all seasons.
- Chronic water quality criteria for chloride were exceeded for extended durations.

Influence of Modern Stormwater Management Practices on Transport of Road Salt to Surface Waters

Joel W. Snodgrass[*†‡], Joel Moore[†], Steven M. Lev[†], Ryan E. Casey[†], David R. Ownby[†], Robert F. Flora[†], and Grant Izzo[†]

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- *On study findings:* “We know that surface water salt levels have been rising steadily for at least the past 30 years in Baltimore’s reservoirs and we know little about the effectiveness in reducing inputs of salt to surface waters.”
- “Current stormwater management practices don’t completely stop chemicals from reaching streams and we have seen chemical contamination year round.”
- “People may end up drinking water containing sodium levels that exceed those recommended for people on low sodium diets.”
- “Municipal water supplies may also become contaminated and require treatment to lower sodium and chloride levels before distribution.”
- “Some counties are already reimbursing people for the costs associated with replacing contaminated water wells.”
- *On the wildlife impact:* “You’re basically putting these animals in a desert, because they can’t regulate the salt in their bodies and get enough water to balance it out.”
- “If salt levels continue to increase in freshwater areas, many fish and amphibians will stop breeding and eventually die because their bodies cannot adjust to the change.”

Impacts– Natural Environment

- Water
- Soil
- Air
- Plants
- Animals

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Impacts – Constructed Environment

- Bridges
- Pavement
- Crops
- Water supplies
- Spalling
  - Thaw freeze
  - Salt crystallization

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Impacts - Vehicles

- Chassis corrosion
- Sensor obstruction

Indirect Impacts

- Supply
- Transport
- Storage
- Cost

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Winter Road Maintenance – Research and Innovations

Connected Vehicle Applications

Safety Mobility Environment

- Corridor traffic signal coordination
- Smart Parking
- Curve Warning
- Collision Prevention
- Queue warning
- Truck roll-over protection
- Eco-Driving
- Truck Platooning
- Driver notification of at-risk pedestrian nearby
- Cyclist notification of the approach of a quiet vehicle

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Transportation Infrastructure – Smarter

- Sensing
  - Roadside
  - In-road
  - Drones (UAS)
- Adaptively
  - Lighting (power, nuisance lighting, alerts.
  - Controls (traffic signals)

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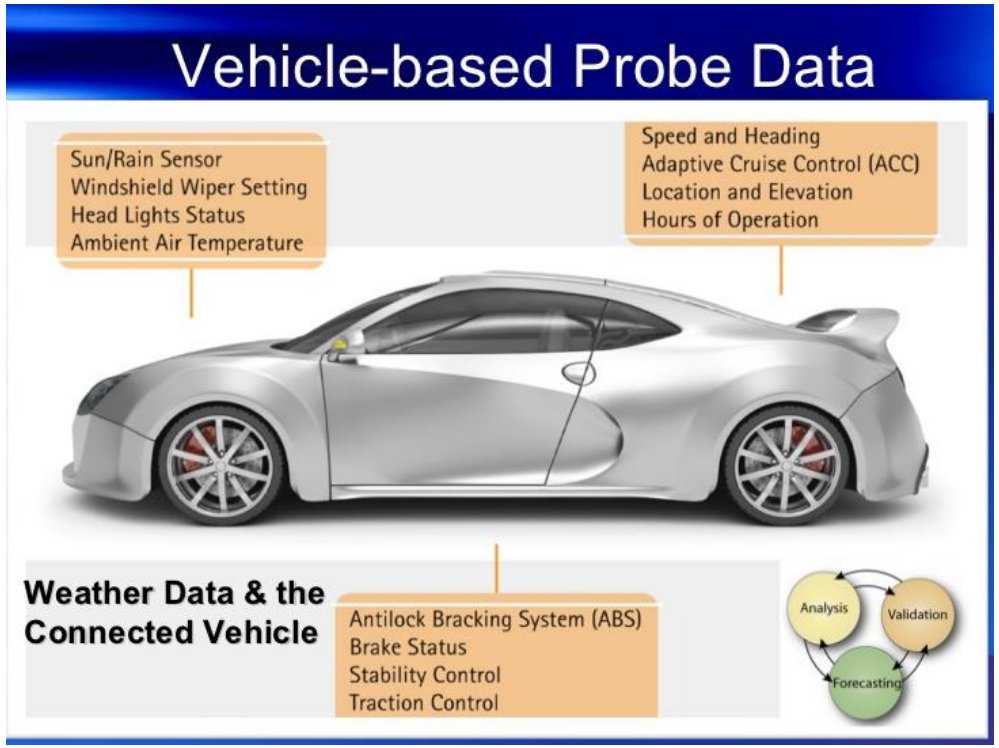
Vehicles as Mobile Probes

- Direct measurement of environmental conditions
  - Temp
  - Dew point
  - Light intensity
  - Barometric pressure?
  - Pavement temp
- Vehicle system activity
  - Windshield wipers (e.g. precipitation)
  - Headlights
  - Tire macro-slip
    - Antilock brakes, Traction Control, Stability Control

Yields inference of road weather



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Connected Vehicle-Enhanced-MDSS

- Use of Connected Vehicle network and data allows more effective and efficient deployment of pre-treatment, treatment, and plowing operations
- Local weather information from Connected Vehicle network
  - From vehicles as probes:
    - Temperature, barometric pressure, precipitation sensors, head lights
    - Activation of ABS, Stability control, traction control
  - From roadside equipment:
    - Pavement conditions, weather, etc.
- From on-board equipment in snowplows
  - Application rates
  - Tractions
  - GPS location, time

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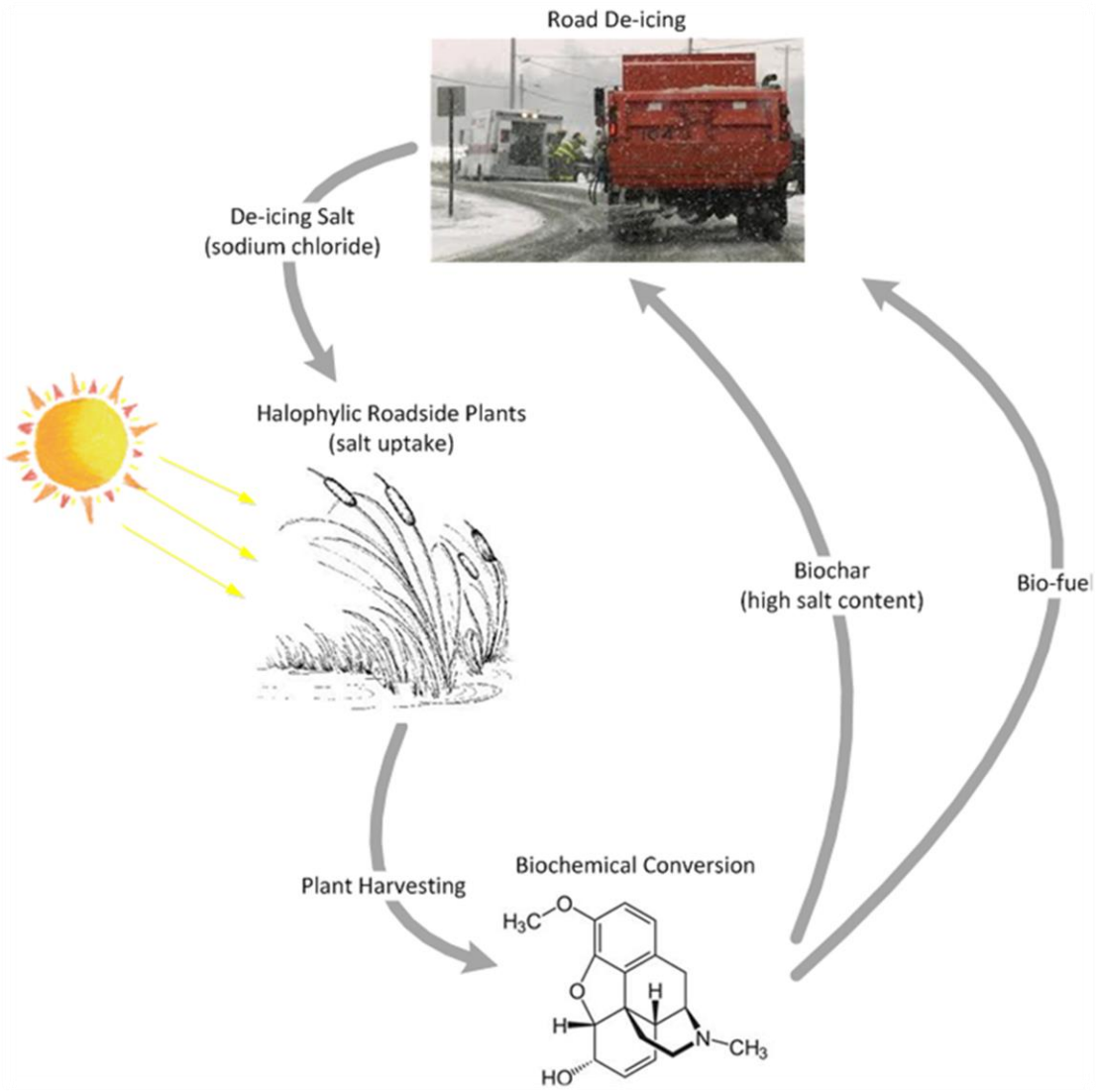
Biochar for Recycling of Applied Road Salt



- Salt recovered at roadside
- Biomass harvest
- Biofuel production
- Salt-rich biochar applied as part of winter maintenance

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Field Evaluation of Selected Cultivars

- 7 different plant species
- Randomized complete block design
- 1 species planted twice in each block
- 3 separate plots (each serves as a replication
- Each divided into 8 subplots
- Salt application
- Plant harvest
  - Chemical analysis
  - Pyrolysis – biochar production

Presentation End

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