

RESULTS SUMMARY

Chloride-only deicers can migrate through roadside soil to groundwater and other susceptible sources. Using agro-based additives such as beet juice in deicers may further increase deicer migration mobility.

APRIL 2026

CHLORIDE DEICER MIGRATION PATTERNS THROUGH SOIL

Need for Research

Using deicers to control snow and ice on roads is essential for safe travel and to ensure an adequate level of service. However, these deicers often make their way to roadside soil through runoff and snowplow activities where they may migrate to environmentally susceptible areas such as shallow groundwater.

To enhance deicer performance and decrease the effects of corrosion, additives such as beet juice are often employed, but it is unclear how these additives affect the migration potential of the deicer. This project evaluated the migration of solutions containing chloride and chloride with beet juice through roadside soil commonly found in the United States. The results will help inform winter maintenance decision-making to mitigate the negative environmental outcomes for groundwater and long-term soil salinity.

PROJECT DETAILS

Project Title: Determining the Migration of Chloride-Based Deicers Through Different Soil Types

Project Number: CR21-07

Project Cost: \$99,978

Report Date: January 2026

Project Chair:

Aidan Neely

Connecticut Department
of Transportation
aidan.neely@ct.gov

Investigator:

Xianming Shi

Washington State University
xms784@miami.edu

Objectives and Methodology

This project examined the migration of chloride-only deicers and deicers with agro-based additives through a common roadside soil. More complete assessments of the behavior of these deicers and their interaction with the soil would help identify locations and scenarios in which deicing procedures, such as application rates, could be revised to limit the negative impacts on the environment.

A national survey distributed to state departments of transportation determined the most used deicers and deicer additives along with the most common types of roadside soils where deicing solutions typically migrate.

In laboratory experiments, investigators compared the performance of chloride-only deicers to deicers containing beet juice as they moved through a sandy loam soil. Vertical and horizontal column testing collected outflow samples of solutions with salt, salt with beet juice, magnesium chloride and magnesium chloride with beet juice. This testing revealed the amount of each solution that migrated through the soil over a 72-hour period that could potentially leach into groundwater.

Investigators also used a machine learning model to extend analysis beyond the direct laboratory measurements for additional insight on sodium and magnesium retention.



Deicers used on roads often make their way to roadside soils where they can migrate to environmentally sensitive areas such as groundwater.

Results

Survey responses indicated that sodium and magnesium chloride are the primary salts used for anti-icing, deicing and prewetting roads; beet juice is the most common additive; and coarse to medium-grained soils like sandy loam are common along U.S. roadways.

Laboratory experiments showed that chloride from common roadway deicers migrates rapidly through sandy loam roadside soils under both vertical and horizontal flow conditions, reflecting the limited capacity of these soils to retain chloride. Sodium and magnesium ions interacted more strongly with the soil, but this retention is finite and may eventually allow migration through the soil.

The solutions containing beet juice additives altered soil interactions, reduced chloride adsorption and produced faster chloride migration compared with chloride-only solutions. The results suggest two likely conditions: Soil particle surfaces were coated by compounds in the beet juice additive, and interactions between chloride ions and the beet juice limit adsorption to soil particles.

Overall, the results indicate that roadside soils can act as a pathway for chloride movement toward shallow groundwater. Beet juice additives increased chloride mobility in the tested soil, suggesting the need for additional caution and site-specific evaluation when using agro-based additives near permeable roadside soils.

Further, soil structure and the pathways created by it influenced the flow direction of the deicer. Therefore, real-world impacts may depend on actual field conditions where soil heterogeneity, preferential flow paths and seasonal freeze-thaw cycles can vary significantly by location.

The machine learning models for predicting concentrations beyond the range of direct measurements were effective as a support tool, but not as a primary predictive model.

Benefits and Future Research

This research provides evidence that chloride migrates through common roadside soil and that the use of an agro-based additive such as beet juice can increase its migration capabilities. These findings will inform decision-makers about the risks of using deicers, especially in environmentally sensitive areas.

Winter maintenance managers should be cautious when using agro-based additives in areas with highly permeable soils or susceptible water sources, and with repeated applications. Engineers may consider these findings in roadside design and grading practices to funnel runoff away from the most environmentally sensitive areas.

“These results provide valuable initial information that could guide future research related to the migration patterns and environmental impacts of common deicer additives.”

Project Chair Aidan Neely

Connecticut Department of Transportation

aidan.neely@ct.gov