



TECHNICAL SUMMARY

Questions?

Contact research.dot@state.mn.us.

Technical Liaisons:

Tara Carson, MnDOT
Tara.Carson@state.mn.us

Nicklas Tiedeken, MnDOT
Nick.Tiedeken@state.mn.us

Principal Investigators:

Chris Rehmann, Iowa State University
John Gulliver, University of Minnesota

LRRB PROJECT COST:

\$214,743

MnDOT PROJECT COST (IOWA):

\$212,877



Dark grass seed roots show damage from exposure to high levels of potassium acetate.



Environmental Evaluations of Potassium Acetate Used as a Road Salt Alternative

What Was the Need?

Minnesota's winter roads have been effectively treated for decades with chloride-based mixtures for anti-icing and deicing. Salt, however, corrodes steel in vehicles and infrastructure. Additionally, chloride runoff harms the aquatic environment. For example, up to 70% of road salt applied on Minneapolis-St. Paul metropolitan area roads ends up in groundwater aquifers and nearby lakes, many of which exceed regulatory limits for chloride concentrations.

Potassium acetate-based deicers are a promising alternative. Effective at lower temperatures than road salt, potassium acetate is less corrosive to steel and generally degrades in the environment faster. Research on the environmental impacts of potassium acetate runoff into soils and bodies of water has been limited. But there is evidence that it results in a high biochemical oxygen demand (BOD), which may deprive aquatic life of needed oxygen.

The Local Road Research Board (LRRB) and MnDOT sought to explore the impacts and persistence of potassium acetate in the environment in two companion research projects.

What Was Our Goal?

The shared goal of these projects was to investigate the fate, transport and degradation of potassium acetate used as a deicer or anti-icer, and its toxicity to biota.

What Did We Do?

Research teams from the University of Minnesota and Iowa State University (ISU), in collaboration with LRRB and MnDOT, selected field sites near Duluth that represented a range of conditions. With assistance from the City of Duluth, both teams conducted field evaluations over two winters (from 2019 to 2021) to investigate potassium acetate concentrations in road runoff and the resulting impacts. They collected samples upstream from the product application and from runoff and stormwater drains of roads receiving application, roadside soil and receiving bodies of water.

The data and samples produced by each research team were shared and separately analyzed by both teams to explore a range of parameters and measurements informative to potassium acetate behavior and impacts in the environment. University of Minnesota researchers assessed the toxicity of potassium acetate, examining water fleas as aquatic indicators and roadside grasses as terrestrial indicators. In the laboratory using slurry reactors to analyze collected soil and water samples, ISU researchers examined the persistence of potassium acetate in the environment and implications for BOD levels.

Finally, both teams conducted unique modeling exercises to estimate fate and transport scenarios tracing potassium acetate from roadways to bodies of water. ISU researchers developed two models to predict the extent of potassium acetate moving into lakes and streams. The University of Minnesota team used the U.S. Environmental Protection Agency Stormwater Management Model to predict how runoff from potassium acetate application across an entire watershed would impact the receiving bodies of water.

Road salt is an effective deicer and anti-icer but creates environmental concerns in bodies of water. New research explores the environmental impacts of an alternative to road salt—potassium acetate, which is effective on ice at lower temperatures.

“This work was important in helping us understand where it makes sense to use potassium acetate for ice and snow control. It’s not a silver bullet but will help in certain circumstances.”

—Nicklas Tiedeken,
Hydrologist, MnDOT
Office of Environmental
Stewardship

“Both research teams collecting field samples resulted in more comprehensive data for which we each performed different analyses and unique modeling efforts. Our findings were consistent: Potassium is more toxic to the aquatic environment than we previously thought.”

—John Gulliver,
Resident Fellow,
University of Minnesota
Institute on the
Environment

Produced by CTC & Associates for:

Minnesota Department
of Transportation
Office of Research & Innovation
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research



The research teams collaborated on developing standard operating procedures for sampling water in winter, which local agencies and MnDOT can use for other purposes.

What Did We Learn?

The combined and individual efforts of the two research teams through fieldwork, laboratory analyses and modeling resulted in consistent, and sometimes unexpected, findings regarding the environmental consequences of using potassium acetate as a deicer and anti-icer.

ISU researchers found, unexpectedly, no observable biodegradation of potassium acetate during the study period, suggesting slow degradation in bodies of water. The University of Minnesota research team found that terrestrial and aquatic organisms were more sensitive to potassium acetate at lower levels than sodium chloride, primarily due to potassium. Observed potassium concentrations in Lake Superior generally did not reach toxic levels, but researchers concluded that smaller bodies of water are at greater risk.

Both teams used field evaluation results to model the fate and transport of potassium acetate based on specific rates and locations of road application. The ISU model predicted that effects of potassium acetate on oxygen levels in streams would be small for scenarios mimicking expected field conditions. The second model estimating how potassium acetate spreads in a lake found concentrations would be high initially and drop sharply. Researchers prepared user guides and offered future training so agencies can easily use these tools to guide decision-making on using potassium acetate.

The University of Minnesota watershed modeling predicted that even if only 25% of the roadways in the watershed were treated with a single application of potassium acetate, the potassium concentrations could reach toxic levels in some areas. The team concluded that extreme caution should be used when determining where and when to use a potassium acetate product as an alternative deicer.

What’s Next?

MnDOT and local agencies are likely to use potassium acetate for deicing or anti-icing only for temperatures below which other deicers function and only in certain locations. Sampling methods and modeling tools can aid in these decisions and be applied to examine environmental impacts of other alternative deicers. MnDOT is interested in exploring other acetate-based products for winter roads.

This Technical Summary pertains to Reports 2022-27A, “Environmental Impacts of Potassium Acetate as a Road Salt Alternative” (University of Minnesota evaluation), published July 2022, and 2022-27B, “Environmental Impacts of Potassium Acetate as a Road Salt Alternative” (Iowa State University evaluation), published June 2022. The full reports can be accessed at mndot.gov/research/reports/2022/202227A.pdf and mndot.gov/research/reports/2022/202227B.pdf. See Appendix A of Report 2022-27B for guidance to install MATLAB Runtime and run KAcStream and KAcLake. See also Transportation Research Synthesis 1706, “Field Usage of Alternative Deicers for Snow and Ice Control,” published September 2017, at mndot.gov/research/TRS/2017/TRS1706.pdf.