CLEAR ROADS
research for winter highway maintenance

RESEARCH BRIEF

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RANKING DEICER TOXICITY

RESULTS SUMMARY

Researchers ranked the toxicity of eight deicing chemicals based on their impacts on aquatic organisms. While these rankings generally followed conventional wisdom about the relative toxicity of sodium, calcium, magnesium, and potassium, corrosion inhibitors also had notable impacts.

PROJECT DETAILS

Project Title: Determining the Aquatic Toxicity of Deicing Materials

Project Number: No. CR11-02

Project Cost: $85,098.26

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Winter maintenance agencies must balance traveler safety with the need to minimize environmental impacts. Deicing chemicals can enter waterways and affect the organisms living there. Laboratory tests of the impacts of commonly used deicing chemicals on representative aquatic fish, insects and plants provide valuable information about the overall toxicity of these chemicals, which can help winter maintenance agencies make appropriate deicer usage decisions based on local needs and conditions.

Need for Research

Winter maintenance agencies in many states are receiving concerns from residents about the toxicity of the deicing chemicals they use. Conventional wisdom ranks the toxicity of deicers by the deicer's cation component (the positively charged metal ion in the compound), with potassium considered the most toxic, followed by magnesium, calcium and sodium.

The limited published research on deicer toxicity generally supports these rankings. This body of research is not comprehensive, however, particularly considering that new deicing products with a variety of corrosion inhibitors are constantly under development. These inhibitors, and their interactions with deicing salts, can impact the deicers' effects on receiving waterways or the surrounding environment. Research must therefore be updated regularly.

Objectives and Methodology

This project sought to evaluate and rank the toxicity of several deicing chemicals.

Researchers selected eight chemicals for evaluation from several chemical product and corrosion inhibitor categories established by the Pacific Northwest Snowfighters association. These chemicals are:

- Sodium chloride brine with **Watershed Cl** inhibitor (category A1) and **Beet 55** inhibitor (category A3)
- Magnesium chloride-based **FreezGard Cl Plus** and **MeltDown Apex** (both category 1)
- Calcium chloride-based **Road Guard Plus** and **Boost** (both category 2)
- Potassium acetate-based **CF7** (experimental category)
- Glycerol-based **Apogee** (not categorized)

CONTINUED

All road deicing chemicals can have negative impacts on the waterways they eventually flow into. In this study, researchers ranked the toxicity of eight deicers based on their impacts on three representative aquatic organisms.

Researchers conducted laboratory tests on the impact of various concentrations of these chemicals on representative aquatic organisms: a fish (fathead minnow), a crustacean (water flea), and algae. Using standard test procedures defined by the U.S. Environmental Protection Agency, researchers calculated seven toxicological endpoints (chemical concentrations that produce a predefined impact) for each chemical on each tested organism:

- **NOEC** (no observed effect concentration): the highest chemical concentration that had no significant impact on the organism, with endpoints calculated for acute (short-term) survival, chronic (long-term) survival, and chronic reproduction or growth.
- **LC50** (lethal concentration 50), the test concentration that resulted in mortality of 50 percent of the organism's population, with endpoints calculated for both acute and chronic survival.
- **IC25** (inhibition concentration 25), the test concentration that reduced growth or reproduction of the organism by 25 percent.
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Researchers ranked each combination of endpoint and organism from 1 to 8, and summed those to produce an overall ranking for the eight products.

Results

Of the eight products tested, CF7 ranked as most toxic overall, while sodium chloride brine with Watershed Cl inhibitor ranked as least toxic. Researchers designed this study to match real-world conditions as closely as possible, and they expect that the results will correlate closely with these deicers' actual environmental impacts.

In general, this project confirmed the traditional toxicity rankings of the four cations. Inhibitors also impacted toxicity, most notably in the case of Beet 55. Agricultural by-product–based inhibitors are widely considered to have minimal environmental impact, but this project found Beet 55 to be significantly more toxic than expected to the tested organisms.

Both short- and long-term chemical impacts are important, as either the acute killing of organisms or a longer-term reduction in growth or reproduction will have serious impacts on the health of a body of water. The specific characteristics of the affected bodies of water may warrant giving more attention to certain components.

For example, the acute NOEC and LC50 components are indicators of short-term toxicity and may be best suited to waterways such as rivers and streams, where chemicals will be diluted quickly. The chronic NOEC and LC50 components may be more applicable to lakes where chemicals would remain for a longer period, or climates with longer storms.

Benefits and Further Research

This research provides winter maintenance agencies with valuable information to help them select deicing chemicals that minimize environmental impact, and to demonstrate to the public that they are balancing environmental concerns with the need to protect traveler safety.

Possible future research directions include developing models to clarify how a chemical's application rate translates to its concentration when it reaches an aquatic environment, evaluating the effect of the chemistry of a body of water on deicer toxicity, and measuring how long inhibitors take to decay in the environment and how they are affected by their journey from roadway to water.

> "We hope all agencies will use this research to make the best choice for their specific needs, taking into account both the health of the environment and the safety of the traveling public."

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