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LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

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$164,043

This drain along State Highway 36 was one of the roadway runoff discharge sources used in the study.

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Examining Deicing Chloride Accumulation and Transport Through a Watershed

To learn how chlorides from road salt deicers are transported in urban watersheds, researchers installed field instruments at eight sites to monitor water and chloride levels nearly continuously over three winter seasons. The results will assist in developing chloride mitigation strategies.

What Was the Need?

Road salt (sodium chloride), a road deicer used in most states that experience snow and ice, has caused chloride accumulation in the environment that has become a widespread concern. In the Twin Cities metro area, some lakes and streams show chloride levels exceeding state and federal water quality standards. A 2013 Minnesota Pollution Control Agency (MPCA) study showed that 27 percent of shallow groundwater wells in the Twin Cities metro area were above the 250 mg/L U.S. drinking water (taste) standard, and the median concentration of chlorides in urban wells was five times higher than in rural wells.

Chloride concentrations as low as 215 mg/kg in soil can be lethal to sensitive plants; chronic exposure to 210 to 240 mg/L levels in water can be lethal to some aquatic species. Of 340 lakes, wetlands and streams recently sampled by the MPCA during a chloride assessment, 39 exceeded acute (860 mg/L) or chronic (230 mg/L) levels, and another 38 were considered at risk. To address the growing problem of environmental chlorides, MnDOT needed more information about chloride retention in soil and water, chloride transport from the treated roadways through watersheds, and chloride reduction and removal strategies.

What Was Our Goal?

The goal of this project was to measure the transport and accumulation of chloride from road deicers through surface water runoff and soil infiltration in a metro area watershed. This effort included runoff directly from sources (roads and parking lots), transport in ditches and sewer networks, and retention in and release from detention ponds and wetlands. Field monitoring would generate most data, and a computer model component was included to generalize results.

What Did We Do?

For this study, which extended through three winters, researchers chose eight sites in the Lake McCarrons watershed in Roseville. At each site, researchers installed instruments to monitor water flow or depth and electrical conductivity. Water samples from each site were tested for chloride concentration, allowing the calculation of chloride content from conductivity. Readings were collected nearly continuously throughout the study and recorded by logging devices at the sites.

Sites included two road runoff locations: a highway and rural road with 30-inch pipes discharged to infiltration areas. Water discharge rates and levels as well as conductivity were monitored in the pipes. Salt usage data for these roads was collected from agencies responsible for winter maintenance. Three pond sites within the watershed were continuously monitored for water levels (and discharge) and conductivity at their inlets and outlets: a detention pond for parking lot drainage, a detention pond collecting drainage from a residential area, and a natural pond/wetland area collecting runoff from a mixed-use watershed. Pressure-sensing piezometers were used at a highway ditch to monitor changes in shallow groundwater levels.

continued

"We know now that deicer chemicals are staying in the soil and moving in the watersheds. This should change how we manage ice and snow control. The next questions are what can we do with that knowledge and what changes can we make?"

—Wayne Sandberg,
Department of Public Works Deputy Director, Washington County

"The results of this research provide us with knowledge we did not have before and will inform future research into chloride mitigation."

—William Herb,
Research Associate, University of Minnesota St. Anthony Falls Laboratory

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A V-shaped weir to measure flow was inserted into the bottom of this discharge pipe opening along County Road B. A depth monitor was mounted at the top. A conductivity monitor, located in the water beneath the weir, collected data that allowed researchers to determine chloride ion levels.

Beyond their extensive field monitoring of chloride transport, researchers also attempted to generalize and predict its movement using three hydrologic modeling programs. While some components of chloride transport were successfully modeled, the programs proved insufficient to model chloride transport through a watershed.

What Did We Learn?

Research revealed a greater infiltration of chlorides into soil and subsurface waters than was previously assumed. Investigators traced the movement of chloride, focusing on retention (the fraction of chloride retained in soil and water, not observed as runoff) and residence time (the time between road application and the appearance of chloride at the watershed outlet).

For example, less than 5 percent of chlorides were monitored as runoff from the highway ditch. More than 95 percent was retained in the ditch through infiltration, with a residence time of 172 days observed for chloride in the surface runoff in one season. Curb-and-gutter (sewered) watersheds showed shorter chloride residence times and less retention, with retention varying from 14 to 26 days and retention amounts from 37 to 66 percent.

Detention ponds retained chloride over substantial residence times (220 to 270 days), with high levels of chlorides (up to 12,000 mg/L) at the bottom but much lower levels at the surface (50 to 150 mg/L). This chloride stratification persisted throughout winter seasons and well into spring and summer. Researchers noted that winter rain-on-snow events and prolonged thaws moved surface chlorides most effectively into the watershed. Each winter, the study revealed the extensive retention and dynamic transport of chlorides in surface waters; it also showed that chlorides could be effectively traced and monitored. Analysis of chloride capture strategies found that selective capture of runoff near roadways could capture a relatively large fraction of chloride in a relatively small fraction of annual runoff.

What's Next?

This research is foundational, offering a new understanding of how deicing chlorides are infiltrated in soil and transported through watersheds in surface waters. Its results will be instructive to investigators exploring means to capture chlorides and mitigate their damaging effects.

Researchers' inability to create a comprehensive model of chloride transport through watersheds using current hydrologic modeling software also points to a need for more powerful, dedicated software tools to address the problem of environmental chloride accumulation.

This Technical Summary pertains to the LRRB-produced Report 2017-50, "Study of De-icing Salt Accumulation and Transport Through a Watershed," published December 2017. The full report can be accessed at mndot.gov/research/reports/2017/201750.pdf.