Real-Time Conductivity Monitoring Provides Estimates of Chloride Levels in Minnesota Watershed

Aqua TROLL® 200 Instrument aids road salt reduction efforts

Application

Monitoring deicing chemical levels can help researchers, city governments, and regulatory agencies understand runoff impacts on surface water, groundwater, and surrounding environments.

Data can be used to develop short- and long-term improvements, such as identifying and implementing alternative means of applying deicing chemicals.

Minnesota creek classified as impaired

In 1998, the Minnesota Pollution Control Agency (MPCA) listed Shingle Creek as an impaired water, under Section 303(d) of the federal Clean Water Act.

The creek is impaired for aquatic life due to excessive levels of chloride, low dissolved oxygen levels, and biotic integrity. Bass Creek and Eagle Creek form the headwaters of Shingle Creek, which flows into its confluence with the Mississippi River in Minneapolis.

The river is approximately 11 miles (17.7 km) long and drops approximately 66 feet (20 m) from its source to its mouth. Shingle Creek is described as a highly disturbed system that is used extensively for stormwater conveyance from a densely urbanized watershed.
**Main culprit identified**

The U.S. Geological Survey (USGS) discovered high levels of chloride during an intensive study of the creek as part of the National Assessment of Water Quality (NAWQA) program conducted from 1996 to 1998.

Previously, chloride was not monitored regularly in Minnesota streams, but the USGS study promoted further investigation, and elevated chloride levels were found in many streams. Though not harmful to humans, extreme levels of chloride can disrupt metabolic processes in fish and other aquatic life, and can be harmful to aquatic vegetation. In addition, studies have shown correlation between road salt runoff and elevated chloride levels in aquifers.

To determine what should be done to reduce chloride in the creek, the Shingle Creek Watershed Commission partnered with the MPCA to complete a Total Maximum Daily Load (TMDL) study. Begun in 2002, the TMDL investigated potential sources of chloride, how chloride entered the creek, and how much chloride needed to be reduced to attain acceptable levels.

According to the U.S. Environmental Protection Agency (USEPA), freshwater aquatic organisms should not be affected unacceptably if:

1. **Chronic exposure**—Four-day average concentration of dissolved chloride, when associated with sodium, does not exceed 230 mg/L more than once every three years.

2. **Acute exposure**—One-hour average concentration does not exceed 860 mg/L more than once every three years on the average.

According to the Shingle Creek Chloride TMDL Report, one of the main goals of the Shingle Creek TMDL was to determine the spatial extent, severity, and duration of chloride exceedances in the watershed. To define the extent of chloride exceedances, both grab samples and logged conductivity data were collected at numerous sites throughout the watershed. Conductivity can act as a surrogate measure for chloride because specific conductance and chloride are directly related (Figure 1).

"Chloride-conductance relationships vary depending on the stream’s location," explains James Fallon, Chief of the Hydrologic Networks and Data Division of the USGS in Minnesota. "We collect accurate chloride and conductivity data and then determine whether or not we have a good correlation. With a good correlation, conductivity measurements can be used to estimate chloride concentrations."
“By using conductivity as a surrogate for chloride and developing chloride-conductivity relationships, more robust data sets can be developed to increase the accuracy of load estimations and to decrease some manual data collection,” explains Fallon. “In addition, the chronic standard is based on a four-day exposure to chloride concentrations. Grab sampling has limitations, unless it occurs daily and even then, valuable data may be lost. By continuously logging specific conductance, the four-day average is more easily calculated and both the severity and duration of exceedance can be identified.”

**Study finalized**

The final Shingle Creek Chloride TMDL study found that most of the chloride in Shingle Creek comes from road salt applied to icy roads. City, county, and state road maintenance authorities apply road salt to several highways and roadways crisscrossing the Shingle Creek watershed, a 44-mi² area (114 km²). The study estimated that 85 percent of the chloride in Shingle Creek comes from road authorities. To meet state and federal water quality standards in Shingle Creek, the TMDL concluded that a reduction of approximately 71 percent in chloride levels is needed to achieve water quality standards and to avoid future water quality impairments. The nine cities in the watershed, Hennepin County, and the Minnesota Department of Transportation developed an implementation plan to work toward that goal. Due to safety and transportation concerns, road salt application will continue. However, new technologies are being tested, for example, using equipment to “prewet” the road salt before application. The prewetting process reduces road salt use and makes the road salt stick better to the pavement.

**Reduction strategies evaluated**

Chloride reduction will occur mainly through the implementation of best management practices by road maintenance authorities. The USGS will continuously monitor discharge, temperature, specific conductance, and gage height. This data will help the MPCA evaluate how well reduction strategies are working.

At the USGS gaging station on Queen Avenue in Minneapolis, Minnesota, the USGS installed an In-Situ® Aqua TROLL® 200 Instrument to monitor temperature and specific conductance. The instrument is connected to a Sutron Data Collection Platform via its native SDI-12 output, which logs the data every 15 minutes and transmits data to a USGS web site hourly.

Fallon says, “Although the use of a product by the USGS does not represent an endorsement, our field technicians find the Aqua TROLL 200 easy to maintain, program, and calibrate. The stage data provided by the Aqua TROLL are useful as a back-up recorder to our primary transducer.”

Specific conductance data from this monitoring site are used by the Shingle Creek Watershed District, county and state agencies, and water resources professionals to estimate and assess real-time chloride concentrations in the stream. Real-time specific conductance data is critical to the timely collection of snowmelt containing peak chloride concentrations. Data will be used to assess trends in chloride concentrations and to evaluate the effectiveness of best management practices adopted by the watershed for the chloride TMDL (December 2006).

“The peak chloride level on December 27, 2008 is (provisionally) the greatest conductance that the USGS has recorded at Shingle Creek (greater values have been recorded by the Watershed District elsewhere in the basin),” says Fallon. “We checked calibration of the sensor on December 29, 2008 when the stream conductance was around 4,000 μS/cm, and found that the instrument drift to be near zero after cleaning.”

**Disclaimer**

The use of brand names by the U.S. Geological Survey is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

**References**

1. Minnesota Pollution Control Agency. September 2006. Shingle Creek TMDL: Chloride. Wq-iw8.02a