Chloride-Related Studies in Streams and Ground Water of the Twin Cities Metropolitan Area, Minnesota, 1996-98—a Summary of Published and New Results

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Extended Abstract

The transport of road de-icers containing chloride (such as sodium chloride (salt) or calcium chloride) to streams and ground water is a concern to water-resource managers because of the potentially harmful effects of chloride on human and aquatic health. The National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey collected and interpreted chloride, specific conductance, and streamflow data for streams and reviewed ground water and biological data from previous NAWQA reports, to summarize chloride-related work in TCMA (Twin Cities metropolitan area) streams and ground water. The TCMA, located in Minnesota, is part of the Upper Mississippi River Basin NAWQA study unit.

Median chloride concentrations in TCMA streams and ground water were among the greatest concentrations measured (63rd-85th percentiles, respectively) in 29 urban areas throughout the United States, based on data collected by the NAWQA Program during 1993-98 (Stark and others, 2001). Urban areas with the greatest concentrations were located in the northern United States, where snow results in the application of large quantities of de-icers. Concentrations also were great in southwestern and western United States as a result of the weathering, dissolution of chloride-rich sedimentary rocks, or the effects of natural evaporation concentration of salts.

In the northwest part of the TCMA, chloride concentrations ranged from 4.3-330 mg/L with a median concentration of 46 mg/L (milligrams per liter) in 30 water wells completed in unconfined sand and gravel aquifers just below the water table (Andrews and others, 1998). This range was greater than that found in 992 wells constructed in similar aquifers underlying non-urban areas of Minnesota and Wisconsin, where chloride concentrations ranged from 1-50 mg/L with a median of 5 mg/L (Stark and others, 1996). In the TCMA, concentrations were greatest in areas underlying older urban development and in areas with greater densities of impervious surfaces, such as roads and parking lots. Chloride concentrations were significantly greater in wells immediately downgradient of major highways (Andrews and others, 1999).

In 13 TCMA streams, chloride concentrations ranged from 13-120 mg/L during seasonally low streamflow in September 1997 (Talmage and others, 2000). Chloride concentrations correlated positively with percent impervious area (r= 0.88), indicating that runoff of road de-icers may be a primary source of chloride. Chloride and percent impervious area correlated negatively with mayfly abundance (Lee, 2001) and fish species richness and diversity (Talmage and others, 2000). Data from these sites suggest that urban lands overlying permeable sand and gravel are more vulnerable to infiltration of chloride-rich runoff of de-icers and therefore recharge streams during low streamflow conditions with chloride-rich waters. Consequently, water quality and aquatic life in streams draining permeable deposits may be more vulnerable to degradation from the application of de-icers as well as other urban pollution.

In two TCMA streams (Shingle and Nine Mile Creeks), specific conductance and streamflow was continuously monitored, and chloride samples were collected, from June 1996 - May 1998. Relations between chloride, specific conductance, and streamflow were used to calculate daily-mean concentrations, loads, and yields of chloride. Chloride concentrations were greatest from November to March when streamflow was low and de-icers were applied. During this period, concentrations generally exceeded the USEPA's (U.S. Environmental Protection Agency's) Chronic Freshwater Quality Criteria of 230 mg/L and the Secondary Maximum Contaminant Level of 250 mg/L (U.S. Environmental Protection Agency, 1996 and 1999, respectively). Concentrations approached the USEPA's Acute Freshwater Quality Criteria of 860 mg/L in small streamflow peaks resulting from snowmelt runoff. Chloride loads ranged from 1 to 36 tons per day. Peak loads occurred during November to March, when de-icers are applied to roads at rates from 1.9 to 22.2 tons per mile per application season (Chuck Johnson, Montgomery Watson Consultants, written commun., 2001), and during July to September 1997 rainfall runoff events. Chloride yields were greater in Nine Mile Creek during small snowmelt runoff peaks, whereas chloride yields were greater in Shingle Creek during streamflow recessions and baseflow. These results suggest that chloride-rich ground water recharges Shingle Creek from permeable sand and gravel. These types of deposits are limited in the Nine Mile Creek Basin.

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