Winter's Coming: What Should We Do About Salt?

It's almost Winter in New England. Time to step up and confront the annual dilemma: what to do about the tons of white stuff piling up on our roads... our sidewalks… the paths to our front doors.

No, we're not talking about snow. We're talking about that other white stuff. Salt.

According to the Federal Highway Administration, 70 percent of the nation's roads are located in "snowy regions", defined as those receiving more than five inches average snowfall annually, and nearly 70 percent of the U.S. population lives in these snowy regions. A 1992 Marquette University study examining the impact of road salt on highways in New York, Illinois, Minnesota and Wisconsin found that de-icing with salt reduces accidents by 88% and injuries by 85%. But that safety comes at a cost. Vehicles and highway infrastructure can suffer significant damage from the corrosive action of road salt.

More subtle—at least at first—is the damage done to the environment.

Sodium Chloride

Road salts enter the environment through losses at salt storage and snow disposal sites and through runoff and splash from roadways. A 2001 assessment report by the Canadian government concluded that high releases of road salts were having an adverse effect on freshwater ecosystems, soil, vegetation and wildlife. Three years later Canada responded by categorizing road salt as a toxin. Nothing suggests they are less toxic in the lower 48.

In North America the most common form of salt used for deicing or pre-icing is sodium chloride ($NaCl$). Less refined than common table salt, sodium chloride road salt can contain up to 5% trace elements, including trace metals. According to a Mass Department of Transportation report, substances potentially present include phosphorus (14-26 mg/kg), sulphur (6.78-4200 mg/kg), nitrogen (6.78-4200 mg/kg), copper (0-14 mg/kg) and zinc (0.02-0.68 mg/kg) Other inorganic salts used include calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$) and potassium chloride (KCl), although cost and reduced effectiveness limits their use. Sodium ferrocyanide ($Na_4Fe(CN)_6 \cdot 10H_2O$), is commonly added to road salt as an anti-caking agent.

The freezing point of salty water is lower than that of pure water. Scattering salt on snow or ice accelerates the melting process. Dumped on top of packed layers of snow and ice in quantities sufficient to melt through to the pavement, salt thaws the bond between the ice and the road surface, making it easier for the plows to scrape the road clear. However regular road salt is only effective from near freezing to about 15 degrees Fahrenheit. Below that, crews mix in other deicers like magnesium chloride or calcium chloride, which can work down to well below zero Fahrenheit. Because salt's effectiveness depends on temperature—"At warm temperatures, a little salt melts a lot of ice. At low temperatures, a lot of salt only melts a little ice"—and because of the need for fast results, it is vulnerable to over-use. And that means everything it comes in contact with is vulnerable too.

When salt dissolves, it splits into sodium and chloride ions. These particles get carried away in melt runoff and are deposited in surface water (rivers, lakes and streams) and in ground water, where on occasion it can make its way into the municipal water supply. Because chloride ions are transported more easily than sodium, chloride is the greatest source of pollution. According to a 2009 study released by the US Geological Survey, forty percent of the urban streams tested across the northern United States had chloride levels that exceed federal guidelines for aquatic life. Elevated chloride inhibits plant growth, impairs reproduction and reduces the diversity of organisms in streams. High levels interfere with the way organisms regulate the uptake of salt into their bodies. This insult can be compounded by the use of anti-caking ferrocyanide salts, which, in solution, can photolyse to yield free cyanide ions, which are highly toxic to aquatic organisms.

Because salt affects water's density, elevated salt concentration reduces water circulation, preventing oxygen from reaching bottom layers of the water. Road salt also builds up in shallow soil, layering on to create what is essentially a salt bank. Dried salt crystals attract deer, moose and elk to busy highways, increasing the chances of fatal encounters for both animals and humans.

Salt can radically alter entire ecosystems. In the June 2001 issue of *Wetlands*, researchers reported that high salt concentrations in the groundwater, attributed to deicing salts, were having a significant impact on Kampoosa Bog, a 1,350-acre wetland in Berkshire County. Owned by the Marian Fathers of the Immaculate Conception, who placed the property in a conservation restriction some thirty years ago, and designated an Area of Critical Environmental Concern by the Commonwealth in 1995, the 12,000-year-

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old Kampoosa Bog (an old Indian word meaning "dangerous place") is the largest and most diverse calcareous *(calcium-rich)* fen in the state. The site is comprised of old growth forest of hemlock, beech and hickory trees, red maple swamp areas and calcareous basin fen surrounding open water area. Possibly introduced in the course of some Tennessee Gas Pipeline Company pipeline work more than twenty years ago, giant reed *(Phragmites australis)*, a salt-tolerant invasive species, established a foothold in a portion of the wetlands adjacent to the Massachusetts Turnpike. Forming dense colonies, it's continued to spread across Kampoosa.

The natural chemistry of Kampoosa has been greatly altered by road salt runoff from the Pike, and in question is whether the run-off has facilitated aggressive growth by the invasive species. The salt run-off may have compromised less tolerant native, and in many cases rare, species, allowing giant reed to easily move in.


PHOTO: Z22, WIKIMEDIA COMMONS

Roadway With Salt Residue

Before the advent of the automobile, people used ashes, sand or sawdust to keep their walkway slip-free. To improve travel in wintertime, wheels on horse carts and coaches were replaced with ski-like runners, which were better able to handle snowy conditions. Sure-footed horses made their way through the snow to Grandmother's house pulling sleighs. (No surprise that the Thanksgiving-bound horse and sleigh that made it though the wide-and-drifting snow was a literary creation of a Massachusetts native, abolitionist Lydia Maria Child.) Enterprising inventors were issued the first patents for snowplows in the 1840s, but several years passed before the plow designs were put to use. One of the first mentions of snowplow—a plow attached to a cart pulled by a team of horses through the snow-clogged streets—came from Milwaukee in 1862. Over the next several years, horse-drawn plows gained popularity and came into use in many other Northeastern cities. In a few cities salt was used to do what plows could not, but residents strongly protested salting not just because it damaged pedestrians' shoes and clothing but also because it ruined the streets for sleighing.

The invention of the automobile changed all that. By 1925, more than 17 million cars were registered, vastly increasing public demand for, and reliance on, streets that were safe and easy to navigate. Salt was first used on American roadways for snow and ice control in the 1930s, and in 1941 New Hampshire became the first state to formally adopt the process. By the late 1940s and early 1950s, highway departments were adopting a "bare pavement" policy for establishing winter roadway standards.

By the end of the decade, however, damages to salt-intolerant roadside sugar maples in New England and reports of contaminated drinking wells were beginning to raise concerns about the "more is better" approach to road salting. In the sixties research began on alternative deicing chemical use, improved operational procedures, including pavement heating, to reduce environmental salt exposure. In 1967 the Salt Institute, an Alexandria Virginia based non-profit industry trade institute, launched its Sensible Salting program. The evolving program, which continues to influence municipal planning, emphasizes storm-response planning, personal training, equipment maintenance, spreader calibration, storage and environmental awareness to minimize the harmful impact of salt on the environment.

For years now Rajib Basu Mallick, professor of civil and environmental engineering at Worcester Polytechnic Institute, has been looking at ways to harvest solar energy to clear snowy roadways. Funded in part by grants from the National Science Foundation, Mallick first looked at embedding fluid-filled tubes in the pavement to collect solar energy. He now believes that would only be practical in places like parking lots, where the collected energy could not only clear snow and ice but be diverted to nearby buildings to provide heat and lights. For roadways Mallick is now putting his money on special geotextile fabrics, which could be embedded in the pavement, collecting and dispensing energy as desired. (Mallick's work in heat spreading technologies could benefit summer pavements, too, where high surface temperatures can reduce the life of the pavement.)

While Mallick's work continues in the lab, low-tech methods endure. Salting before a storm, especially if sand or gravel is added, can keep snow from binding to the pavement. But as anyone who's had the misfortunate to travel behind a highway salt truck can testify, dry salt bounces. Irritation and car finish scratches aside, bounced salt is also wasted salt. The addition of liquid to make a brine can mitigate the "bounce effect," reducing the amount of salt needed to clear roadways. And pre-wetting the pavement with brine can reduce the amount of snow accumulating, making it easier to plow. A number of states have been experimenting with brines—in Minnesota they like sugarcane molasses; Illinois and Michigan go for beet juice; while Wisconsin is awash in cheese brine. For the most part, these agricultural by-products would be discarded and, thus, can be utilized at minimal expense. They are not without their own environmental concerns, however. For example, beet juice runoff can also deplete oxygen in waterways.

The Newton Department of Public Works is responsible for sanding and plowing more than 300 miles of streets, 15 municipal parking lots and approximately 87 miles of sidewalk each winter. After the winter of 2013-14, then-Commissioner David Turocy told the Board of Aldermen's Public Facilities Committee that while the City was "going in the direction" of using brine as a pre-storm pavement treatment, the decision had been made to wait for the state and municipalities like Lexington to "iron out" problems like establishing the optimal brine/salt ratio. (According to Turocy, Lexington, which uses both brine and a calibrated salting spreader, reduced their salting costs by forty percent.) According to a compliance report filed with the EPA this past April, Newton was still not doing any prewetting as part of roadway treatment. Ninety-six percent of Newton's winter pavement treatment is done with plain sodium chloride, while two percent is done with the additives magnesium chloride (when the temperature falls between 10 and 20 degrees) and two percent with sand (when temperatures are expected to remain below 10 degrees), applied at a rate of 200 – 400 pounds per lane mile. Low salt areas around designated bodies of water are treated with half the rate of salt used in other areas.

In the absence of specific guidance from the City, Newton residents are left on their own to consider what the eco-friendly alternatives are for their own sidewalks and paths. Safe (or safer) melts are sold in home quantities, although they typically command a premium price. Sand and kitty litter can provide extra traction, although they can also be tracked inside with predictable results. Auburndale resident Aimee Lambert remembers that her mother used to spread bird seed on her walkways, keeping them from being slippery, making them safe for pets' paws and feeding the birds all at the same time. "I grew up in Vermont where it was hard to get to bird feeders once the snow started mounting," she explains. Lambert has used birdseed on her own walks, but not on ones that are shared. "I live on a corner lot on Auburndale Ave. where there are lots of pedestrians, and I worry it wouldn't provide enough traction. So we remove snow as much as possible and put down salt as little as possible." Now she's wondering if she can do a little more by doing even less. "This discussion has made me reconsider," she says, "maybe I'll switch to sand this year."

Snow shoveling ordinances aside, sometimes it seems like doing nothing is the best choice for the environment, and for people. "I feel that leaving some snow, about 3 inches, on the curb is safer because it stays on top of the black ice that forms at night from the melting nearby high mounts," says Helena Froehlich, artistic director of CreationDance, the First Unitarian Society in Newton's Sacred Dance Company in residence. Froehlich, who is also an EMF Balancing Technique instructor, explains, "I slip less on snow than on ice." ■

Margaret Doris

New Geology Field Trip

Eric Olson

Senior Lecturer in Ecology at Brandeis University

Professor of Geology Dr. Chris Hepburn (Emeritus, Boston College) shared his knowledge of local geology on a Newton Conservators walk.

On Saturday, October 24, the car-pool tour of Newton-Needham area rocks included a stop in Webster Conservation Area near Beacon St. Here, Chris notes the contact between the Roxbury Conglomerate, which is the Commonwealth's State Rock and an ancient river channel filled with sandstone.

Roxbury Conglomerate Rock at Webster Conservation Area

Other rock types seen on the tour: basaltic lava flow, welded volcanic tuff, and the Cambridge Argillite (a kind of slate). We came away with a mental picture of the setting and age of formation of this area of New England, about 585 million years ago and 60 degrees south of the equator, before the evolution of land plants. Think archipelago of volcanic islands in a cold sea, land surfaces looked like Mars, river channel sometimes carried ice.

Geologists can help make the past visible. ■