Snow, Road Salt, and the Chesapeake Bay
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We can soon expect our annual doses of wintry weather, with the inevitable snow and ice storms. On average, we can expect measurable snowfall, sleet, or freezing rain just under twenty days a year. Even a small amount of wintry weather can create headaches for commuters who drive along the 200,000 mile network of roads that connect communities across the Chesapeake Bay. It is not surprising that local and state highway agencies make Herculean efforts to quickly remove snow and ice from roads and freeways so our society can keep moving. Increasingly, they rely heavily on salt, sand, and other deicers to keep roads open and safe. This article examines what happens to the salts and other chemicals applied to the roads and what is known about their impact on the environment.

Road Salt Applications

Road salting is a pretty recent phenomenon in our region. Prior to the 1970's, sand and other abrasives were the primary weapon of choice to attack snow and ice. With the advent of new spreaders and increased road traffic, most highway agencies shifted toward heavier use of road salt in the winter. Annual road salt use has gradually increased over the last two decades, and now fluctuates between 10 and 20 million tons per year on a nationwide basis, depending on the severity of the winter. Despite the fact that much of the Chesapeake Bay watershed is situated below the traditional "snow-belt", it still accounts for much of the road salt used in the country (about a third of all road salt used in the U.S. is applied to states in the Mid-Atlantic region).

In our region, about 20 tons of road salt are applied to each mile of four lane highway, in a normal year. While exact statistics are not available for the total amount of road salt used across the Chesapeake Bay watershed, we conservatively estimate that about 2.5 million tons are applied each year. This is a lot of salt. To put this in perspective, consider that if all this salt were dissolved in a container of fresh water, it would make more than 15 billion gallons of seawater. Or to put it another way, the entire volume of the tidal Chesapeake Bay (51 billion cubic meters) typically contains about 250 million tons of chloride at any given time.

Salt Drives the Chesapeake Bay

The Chesapeake Bay is an estuary, which means that it is influenced both by the freshwater from its tributary rivers and salt water from the ocean. Indeed, it is the contrast between the two types of water that drives the circulation of the Chesapeake Bay. Ocean water has a salinity of about 35 parts of salt per thousand parts of water. Freshwater, on the other hand, has less than 50 parts of salt per million parts of water. Consequently, when the denser ocean water enters the mouth of the Bay, it tends to sink and creep along the bottom of the Bay. Fresh water is much more buoyant as it enters from the top of the Bay, and tends to travel along the top of the Bay. Throw in the tides, some wind, and the rotation of the earth, and the basic circulation of the Chesapeake Bay is created. The presence of so much salt is a major reason why the surface of the Chesapeake Bay rarely freezes over in the winter months, and can never freeze completely solid.

When the Snow Melts, Streams Get Salty

Chloride is one of the main components of road salt, and is extremely soluble in water. As a result, there is virtually no way to remove chloride once it gets into the watershed. It moves freely and easily through both surface and groundwater on its way to the Bay. Indeed, road salting is thought to be the primary source of chlorides to streams and rivers of the Bay. Consequently, once snow melts, streams tend to get salty. The highest chloride levels are recorded in melt-water runoff near salt depots, major highways, snow piles in parking lots, local streets and in urban streams, as shown below:

Salt storage areas	50,000 to 80,000 mg/l
Highway melt-water runoff	5,000 to 20,000 mg/l
Snow piles in parking lots	5,000 to 15,000 mg/l
Street melt-water runoff	2,000 to 4,000 mg/l

Urban streams in winter	1,500 to 2,500 mg/l
Normal freshwater	20 to 50 mg/l
Ocean water	25,000 to 30,000 mg/l

In addition, road salt contains many impurities. As much as 2 to 5% of road salt consists of other elements, such as phosphorus, nitrogen, copper, and even cyanide. A form of cyanide is added to road salt as an anti-caking agent (about 0.01% dry weight). Under certain conditions, it can be transformed into free cyanide, which can be very harmful to humans and aquatic life. As much as two pounds of cyanide are deposited on a mile of four-lane highway through normal road salting concentrations. Scientists have measured cyanide levels in urban streams ranging from 3 to 270 parts per billion (ppb) for short periods of time as a result of road salting (toxicity begins at 20 ppb).

Melting Snow Packs: Not Exactly Pure as the Driven Snow

Fresh snow is beautiful and relatively pure. In a short time however, the snow pack gets grey and dirty in urban areas, particularly along the roadside. Road slush, salt spray, airborne pollutants, street dirt, and trash all accumulate in the snow pack over days and weeks. When the snow pack melts, it releases many pollutants to the stream, including sediments, nutrients, zinc, copper, lead and hydrocarbons and chloride. During the melt, pollutant concentrations in storm water runoff are among the highest seen all year.

Impacts of Road Salt on the Environment

Generally, the presence of chlorides in our drinking water is not a major public health concern. Our tongues can generally detect saltiness or brackishness in drinking water when chloride levels exceed 250 mg/l. Water utilities routinely report a peak in complaints about the taste of drinking water during winter melt events. However, since we only get about 2% of our daily salt intake from drinking water, the extra sodium and chloride are not usually a major problem. We get about 98% of the salt from the foods we eat, so it makes more sense to pass on the french fries, rather than a glass of water.

The impacts of chloride and melt-water pollution on aquatic life, however, can be much more severe. A growing body of research has lead Canada to recently designate road salt as an environmental toxin, and look for ways to reduce its use without compromising road safety. So, what are the impacts associated with chlorides in the environment?

To start with, chloride can be harmful to many forms of aquatic life at concentrations of about 1000 mg/l. Chloride levels above this level are not uncommon in many small streams and wetlands, at least for short periods of time in the winter. A growing body of research has documented the strong impacts of chlorides on stream, lake, and wetland ecosystems in the snow-belt states, but few studies have examined these impacts in the Mid-Atlantic states.

Melting roads create an artificial “salt lick” that attracts both birds and mammals. In the past, natural salt licks were often considered the best hunting grounds since wildlife crave salt in their diet. Wildlife biologists have recently observed that deer, elk, moose, and other mammals lick salt from road-sides where they often become road-kills. The same effect is seen for small birds, such as finches, whose cravings for roadside salt have earned them the dubious nickname “grill birds” in northern regions of the country.

Salting the Earth

When the Romans finally defeated Carthage in the Punic Wars, they did not just settle for plundering and razing the city, and killing or enslaving its inhabitants. To ensure that Carthage could never again become a rival, they reputedly salted the fields of Carthage so crops could not grow. Whether (and how) the Romans salted the earth is still a matter of debate among archaeologists, but it is very clear that high salt levels can be very harmful to plants.

High salt levels are frequently measured in roadside soils. The saltiest soils occur within a few feet from the blacktop, but the influence of salt can extend as far as 100 feet from a major highway and 50 feet from a two-lane road (salt is transported by spray from fast moving cars and trucks). High salt levels are usually observed in lawn soils within five or ten feet of sidewalks and driveways that are salted. Many species of trees, shrubs, and ground covers are extremely sensitive to high soil chloride levels, and may be killed, dieback or fail to germinate under these conditions (see the list in *Low Salt Diet* section). Indeed, highway researchers report that as many as ten percent of trees found along road corridors have been harmed by road salt.

On the other hand, some plant species flourish in soils with high chloride levels. Two notable examples are cattails and *Phragmites*, two hardy wetland plants that have become ubiquitous in roadside swales and wetlands. Indeed, *Phragmites* is an invasive plant that prefers brackish water. A researcher has claimed that *Phragmites* has migrated from the east coast to the Midwest by following the salty soils of the New York thruway system.

Excessive road salt also damages human infrastructure, including concrete bridges, decks, and parking structures, as well as causing corrosion of metal surfaces (such as the undersides of older cars). The Transportation Research Board estimates that the national cost of these damages exceeds four billion dollars each year.

Towards a Low Salt Diet

The road salting that keeps us moving in the winter clearly has a large economic and environmental cost. To date, no cost-effective alternative to road salting has emerged, although research efforts are continuing to evaluate some promising candidates. Highway agencies have begun to take the salt problem seriously, and are working hard to develop new technology to reduce its environmental impact. Examples include the construction of salt domes to safely store salt, use of calibrated spreaders to apply the right dose, improved driver training; more sophisticated forecasting methods to treat roads at the proper time, and the designation of low salt application zones near environmentally sensitive areas. Homeowners can also make better choices in how they use deicing chemicals, and a series of practical tips are given in the *Low Salt Diet* section below.

What You Can Do: Put your sidewalk and driveway on a low salt diet

Keeping ice and snow off your driveway and sidewalks is important for safety. The following tips can help you choose the best deicing product for your home and the environment.

1. *Buy early.* Make sure to buy your deicing product well before the big storm hits, otherwise you will be looking at empty shelves, and have few, if any, environmental choices to make at the store.

2. *Check the label.* The table below provides a summary of the pros and cons of main ingredients of common deicing products. Check the package closely to see what you're buying. I recommend using calcium chloride over sodium chloride (rock salt).

Check the Label for:	Works Down to:	Cost	Environmental Risks
Calcium Magnesium Acetate (CMA)	22 to 25 degrees F	20 times more than rock salt	Less toxic
Calcium Chloride	-25 degrees F	3 times more than rock salt	Uses lower doses No cyanide Chloride impact
NaCl: Sodium Chloride, also known as rock salt	15 degrees F	About 5 bucks for a 50 lb bag	Contains cyanide Chloride impact
Urea	20 to 25 degrees F	5 times more than rock salt	Needless nutrients Less corrosion
Sand	No melting effect	About 3 bucks for a 50 lb bag	Accumulates in streets and streams

3. *Avoid kitty litter and ashes.* Although these products are environmentally friendly, they don't work. While they provide some traction, they do not melt snow and ice. Also, they tend to get really gooey and messy

when it warms up, which often causes tracking on the floors of your home. If traction is what you want, then stick with sand, which is much cheaper and easier to sweep up.

4. *Shovel early and often.* When it comes to snow removal, there is no substitute for muscle and elbow grease. Deicers work best when there is only a thin layer of snow or ice that must be melted. So get out the snow shovel and move as much snow as you can during the storm if possible. A flat hoe can also help to scrape ice off the surface before any deicers are applied.

5. *Know your salt-risk zone.* You wouldn't want to kill your favorite tree, shrub, or grass, so check out the plants that grow within five or ten feet of your driveway and sidewalk (and the road, for that matter). The table below summarizes some of the salt-sensitive plants that might be at risk. If you have a salt-sensitive tree, shrub, or grass in this zone, you should avoid any deicing product that contains chlorides (rock last and calcium chloride), or use very small doses. You may want to use CMA as a safer alternative, or stick with sand for traction.

Landscaping Areas	**Species at Risk from Salting**
Deciduous Trees	Tulip Poplar, Green Ash, Hickory, Red Maple, Sugar Maple
Conifers	Balsam Fir, White Pine, Hemlock, Norway Spruce
Shrubs	Dogwood, Redbud, Hawthorn, Rose, Spirea
Grasses	Kentucky Bluegrass, Red Fescue

6. *Avoid products that contain urea.* Some folks recommend the use of urea as a safer alternative, reasoning that it does not contain chlorides and, as a form of nitrogen, will help fertilize your yard when it washes off. In reality, urea-based deicing products are a poor choice. To begin with, urea is fairly expensive and performs poorly when temperatures drop below 20 degrees F. More to the point, the application rate for urea during a *single* deicing is ten times greater than that needed to fertilize the same area of your yard. Of course, very little of the urea will actually get to your lawn, but will end up washing into the street and storm drain. Given that nitrogen is a major problem in the Bay, it doesn't make sense to use nitrogen-based products for deicing.

7. *Apply salt early, but sparingly.* As Mom always told you, a little salt goes a long way. The recommended application rate for rock salt is about a handful per square yard treated (after you have scraped as much ice and snow as you can). Throwing any more salt down won't speed up the melting process. Even less salt is needed if you are using calcium chloride (about a handful for every three square yards treated – or about the area of a single bed). If you have a choice, pick calcium chloride over sodium chloride. Calcium chloride works at much lower temperatures and is applied at a much lower rate.

Links

National Snow and Ice Data Center: www.nsidc.org
Salt Institute: www.saltinstitute.org