ROAD SALT
MOVING TOWARD THE SOLUTON

Special Report
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Cary Institute
of Ecosystem Studies

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BACKGROUND

Salt was first used in the United States to deice roads in New Hampshire, which began using granular sodium chloride on an experimental basis in 1938. By the winter of 1941-1942, a total of 5,000 tons of salt was spread on highways nationwide. Between 10 and 20 million tons of salt are used today. This massive increase in the use of road salt has caused an alarming increase in the salinity of our water. This is a cause for concern not only because of the negative impact salt has on the environment, but because of the impact it has on our drinking water.

WHAT IS ROAD SALT?

Road salt, also called rock salt, is sodium chloride, chemically abbreviated NaCl. Na is the chemical abbreviation for sodium and Cl is the abbreviation for chloride. Table salt is exactly the same chemical. The US Environmental Protection Agency has set limits on allowable levels of chloride in water but not sodium. In high concentrations both sodium and chloride can be harmful to aquatic organisms. Sodium is the primary concern for humans, as it can be harmful to people with high blood pressure.

HOW DOES ROAD SALT AFFECT HUMAN HEALTH?

The average sodium intake for most Americans is between 4000 and 6000 mg per day, most of which comes from food. A person on a sodium restricted diet will probably be limited to 1000 to 3000 mg per day. A 150 lb person drinking 2 liters (about 8 glasses) of water per day would get a total of 100 mg of sodium from his drinking water if the concentration of sodium in that water was 50 mg/L. This seems reasonable based on the average well water concentration of 48 mg/L found in a 2008 study done in Dutchess County, New York. However, the highest sodium concentration measured in that well study was 347 mg/L. A 150-lb. person would take in almost 700 mg of sodium daily if he or she drank 2 liters of water from that high sodium well. This is significant if a person is on a sodium restricted diet.

There are two things to note when looking at this information:

1. High concentrations of sodium and chloride are often found in pockets in groundwater

2. There is a legacy effect of salt in environment, which means that concentrations in surface and groundwater will increase, perhaps for decades, even if we stop using road salt today. So, the average concentration of 48 mg/L we see today could be much higher in the future.

There are additional reasons we should we be concerned about road salt. Road salt can damage metal and concrete, contaminate drinking water, damage roadside vegetation, accumulate in streams, lakes, reservoirs, and groundwater, and harm aquatic plants and animals. Trends show that, even in relatively rural areas, road salt is accumulating in our waterways. Because it can take decades for road salt to flush out of a watershed, increases in concentrations of salt may be seen even after its use has stopped. The combination of alarming increases in salt together with the time required for increases to cease indicate that it's important to address the problem now.

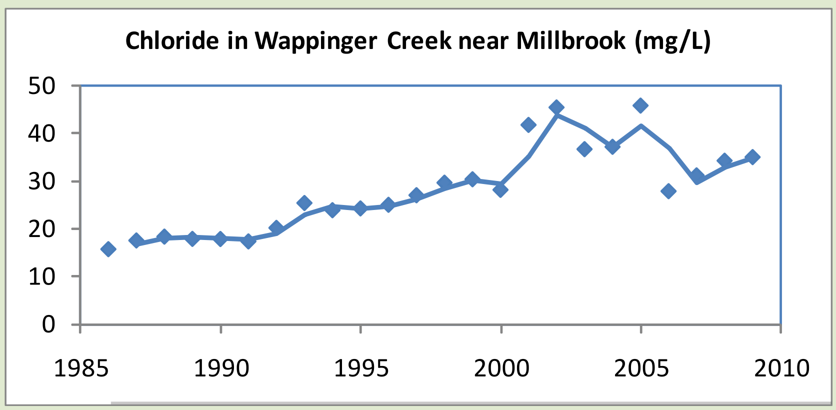
While safe roads are of utmost importance, recent research indicates that we can achieve safety while being more efficient and careful with our road salt. By combining efforts to improve efficiency in road salt use with alternative chemicals in targeted areas, we can make a difference and improve conditions for ourselves and future generations.

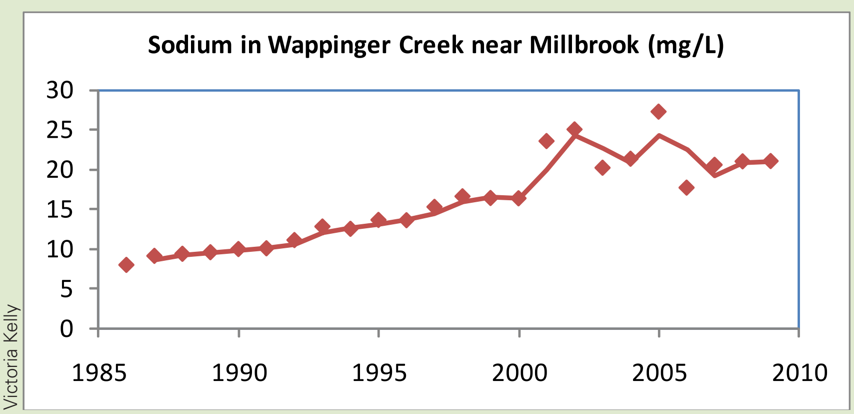
HAS THE SALT IN OUR WATER REACHED TOXIC LEVELS?

In some urban streams, salt has reached levels high enough to kill organisms. However, lower than lethal levels can affect the ability of organisms to function, which affects the overall health and function of the ecosystem. Relatively moderate levels of salt can result in decreased reproduction in amphibians, plant browning, and lower nutrient availability for plants and animals. So, ecosystem function is compromised before 'toxic' levels are reached. In addition, increased salt in streams and lakes can be associated with other indicators of human impacts, such as increased nitrogen, which causes poor conditions for fish and other aquatic animals. Moderate levels of salt in wetlands can increase unwanted invasive species and accumulating salt in lakes and ponds can alter spring mixing. Dense salty water sinks, posting a threat to fish that live in deep, cold water, which is essential for the health of a lake or pond. I

Lisa M. Dellwo

Jordan Jessup



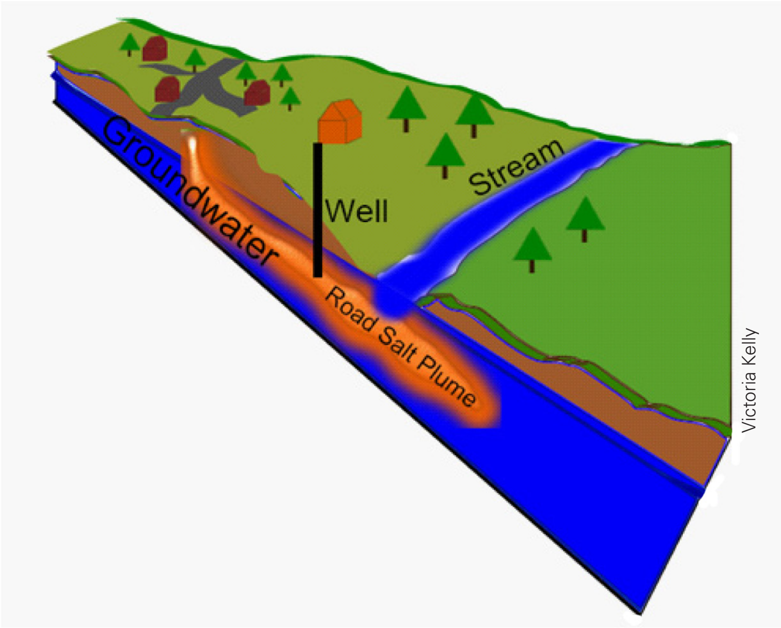


Victoria Kelly

Sodium and chloride concentrations have increased even in a relatively rural stream in southeastern N.Y.

WHAT'S HAPPENING TO OUR GROUNDWATER?

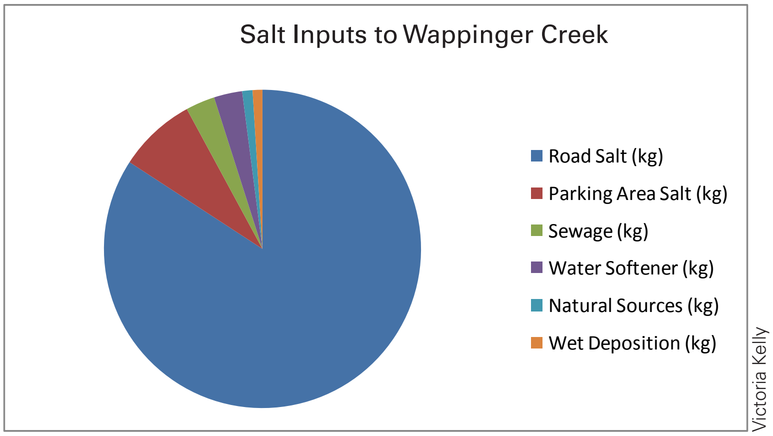
Groundwater feeds wells, where many communities obtain drinking water. The US EPA suggests that 20 mg/L of sodium in drinking water is a safe concentration to strive for. In a study done in Dutchess County, New York in 2008, the average sodium concentration of 125 wells was 48 mg/L and 48% of the wells had concentrations greater than 20 mg/L. Other studies show that high concentrations of sodium occur most commonly in shallow wells, in wells that are near point sources such as salt storage facilities, and in wells that are downhill from heavily salted roads. Additionally, we know that salt accumulates in the ground, possibly in pockets of groundwater. We also know that there is a legacy effect of road salt in our groundwater and that it will take decades before the concentrations reach a steady level.



DON'T WATER SOFTENERS & SEWAGE ADD TO THE PROBLEM?

Although water softeners and sewage can be important point sources of salt, studies show that, in regions where road salt is used, 60 to more than 90% of the salt in water comes from road salt. So to make a difference, we must reduce amount of road salt we use while still maintaining the safety of our roads.

More than 95% of the salt in the relatively rural Wappinger Creek near Millbrook, N.Y. is from deicing salt



THE ECONOMICS

THERE ARE 3 LEVELS OF COST TO CONSIDER WHEN ESTIMATING THE COST OF ROAD SALT:

- The direct cost of the salt itself together with the labor cost of distributing it.
- The indirect costs including corrosion and the associated cost to repair or replace equipment, bridges, concrete, reinforcing steel, and vehicles.
- The long-term cost of mitigation and/or remediation of removing salt from surface and ground water.

While the use of salt defrays the cost of car accidents and lost productivity as a result of impassable roads, roads can be sufficiently deiced by implementing efficiency standards and thus using less salt. Increasing efficiency and reducing salt use is a win-win endeavor both economically and environmentally.

Joy Fera

Victoria Kelly

Bridges are especially imperiled by the use of salt.

THE SOLUTION

While some communities have switched to alternative deicers, none of the currently available alternatives is without problems (see pros & cons of alternatives table on page 10). When the cost of switching wholesale is prohibitive, there are many ways to improve the efficiency of salt use that are relatively inexpensive and could save money in the long term. Reducing salt used by both public and private users is attainable. The first step for road departments and private contractors is to establish a management plan. In 2004, Environment Canada created a code of Best Management Practices for road salt. This move, together with an education and voluntary compliance program, resulted in a 20% decline in salt use.

A ROAD SALT MANAGEMENT PLAN:

- Set goals, including the amount of salt currently used and a targeted reduction amount.
- Have a timeline to meet those goals.
- Do cost benefit analyses to determine the cost of salt compared with cost of the salt-cutting measures, e.g., retrofitting trucks, training, etc (see below).
- Have an implementation plan.
- Do recordkeeping to ensure that the plan is working. Carefully kept records of how much salt is applied, where, and when can help defray liability costs.
- Do an annual review to consider new technology, alternatives, and new information.

A Cost Benefit Analysis

The town of East Fishkill, New York retrofitted trucks with applicator regulators in 2009. To the right is the cost benefit analysis of this expenditure. Note that the total snowfall in the winter of 2008-2009 was less than snowfall in winter 2009-2010.

Total cost savings $243,810, and a reduction of 4,483 tons of salt

The cost to retrofit the trucks with application regulators was $140,000. ***The total return on their investment was $103,810. in the first year.***

Winter 2008-2009

$744,590 cost to purchase 10,637 tons of salt.

Winter 2009-2010

$500,780 cost to puchase 7,174 tons of salt.

TEN WAYS TO IMPROVE APPLICATION EFFICIENCY

1. Road Weather Information Systems (RWIS)

Many state departments of transportation have real-time information about road and weather conditions available on their web sites. The data often includes road surface temperatures, air temperatures, and the weather forecast. Knowing this information will help you determine when to apply deicers and what deicers to use. An informal RWIS can consist of information gathered from citizens in your service area.

2. Calibrate your equipment

Calibration allows you to measure the exact amount of material you apply, which will allow you to more accurately use your deicers. You can calibrate your equipment even if you don't have a regulator. The tendency is to use less material in calibrated spreaders. Calibration procedures should be part of training, and are also readily available in online manuals (see reference #14).

3. Don't overfill

Only put the amount of salt in your truck that you need for your route. Studies have shown that 20% less salt is used if the exact amount of salt is loaded. Drivers tend to use what they load, which can often be more than is needed.

4. Temperature sensors

Retrofit trucks with on-board air and pavement temperature sensors or purchase handheld temperature sensors. Knowing the surface temperature of the road is important in determining what steps to take to keep a road clear of ice. If the surface and air temperatures are above freezing and the forecast calls for increasing temperatures, plowing or sanding may suffice to maintain an ice-free surface.

5. Retrofit trucks with applicator regulators

While this can be an expensive step, it's important to do a cost-benefit analysis. Determine how much less salt you'd use if you purchase regulators for your trucks and the cost of that salt. You may discover that the regulators pay for themselves in an acceptable number of years.

Photo of a truck retrofited with salt reducing equipment

Richard Witt

There are several manufacturers of road deicing equipment. The control units are installed in the cab of the truck which regulates the dispersal of the sand or chemical in the spreader.

6. Pre-wet the salt

A Canadian study recently revealed that pre-wetting salt before roadway application reduced the amount of salt infiltrating aquifers by 5%. Pre-wetting salt allows it to stick better to the road, which minimizes spray and kick-up of salt grains.

7. Anti-ice

The key to successfully maintaining ice-free surfaces is to create a brine layer between pavement and precipitation to prevent ice from forming and make it easier to remove if it does form. So what we call deicers should technically be called anti-icers. If the forecast is certain, it may be possible to pre-salt surfaces to create a brine layer before the precipitation begins. New technology is being used in Westchester County, New York and other communities in the northeast US, in which a brine solution is used in tanks instead of salt crystals. The result is 25 percent less salt needed. (See reference #6)

8. Reduce the salt content of your sand

5% Salt/ 95% Sand

If you're using sand, only use as much salt as you need to keep the sand from freezing. Approximately 5% salt by volume should be sufficient. Keeping your sand pile dry will keep it from freezing.

9. Alternative deicers (see page 10)

Target these more expensive alternatives for vulnerable areas. Consult local conservation and planning boards to identify vulnerable areas. Examples might include roads near municipal water supplies, wetlands, reservoirs or other important water bodies, on bridges, where residences occur downhill from salted roads, and other low-lying areas.

10. Training

Require drivers to attend regular training or add a salt efficiency module to existing training.

Pamela Freeman

Salt storage improvements: Make sure all of your salt piles are completely covered.

ALTERNATIVE DEICERS

These are chemicals or abrasives that can be used in place of, or to reduce salt. They should be considered for use in vulnerable areas (bridges, wetlands, other low-lying areas, roads near well fields or other public water supplies, etc.). Currently there is no perfect alternative to road salt, but research is ongoing, so stay tuned (see the resource list).

Product	Cost Relative to Road Salt	Freezing Point Depression (degrees C per unit weight)	Effective Lower Limit (degrees F)	Corrosive?	Aquatic Toxicity	Other Environmental Impacts
Road Salt or Rock Salt ($NaCl$)	$1.00	1	20	Yes	Moderate	Roadside tree damage
Potassium Chloride (KCl)	$1.60	0.78	12	Yes	Very	K fertilization
Magnesium Chloride ($MgCl_2$)	$2.40	0.29	5	Yes	Very	Mg addition to soil
Calcium Chloride ($CaCl_2$)	$5.70	0.53	-25	Very	Moderate	Ca addition to soil
CMA- Calcium Magnesium Acetate ($C_8H_{12}CaMgO_8$)	$19.30	0.30	0	No	Indirect	Increased BOD
Potassium Acetate (CH_3CO_2K)	$26.30	0.60	-15	No	Indirect	Increased BOD
Urea (CH_4N_2O)	$1.80	0.97	15	No	Indirect	N fertilization
Sand	$0.60	0	-	No	indirect	Sedimentation

Private contractors

As much as 40% of salt use in some areas is from private users. Salt is not only used on public roads, but on parking lots and internal roads of commercial and industrial establishments, schools, churches and other nonprofit institutions, apartment complexes and other residences, and by individual home and small business owners. Education about ways to improve efficiency among private contractors can go a long way toward reducing salt loadings to the environment. Highway superintendents should share educational materials and training and maintain open lines of communication with private salt users. Remember that the end result is cleaner surface water and groundwater, so it's for the public good. And, there's the added benefit of direct cost savings in using less salt. Also, some insurance companies may reduce liability rates if workers are trained in efficiently maintaining ice-free travelling surfaces. Municipalities can offer a certification program for sidewalk & parking lot contractors. Minnesota is the first state to offer this, but it should extend to other states.

Public awareness campaign

Every year at the onset of winter inform drivers about snow ordinances and safe driving habits in written communications or workshops.

APPLICATION TIPS FOR HOMEOWNERS

Adding too much salt to an icy surface is a waste of money and can only increase damage to concrete, metal, drinking water and vegetation. It is a good rule of thumb to use deicers sparingly. Deciding how much to use depends on the deicer. A successful rate for rock salt is about a handful per square yard. If using calcium chloride, the amount needed is less—about a handful for every 3 square yards. Here are some precautionary steps you can take to decrease the amount of deicer you'll need.

- Shovel the snow early and often. If the temperature drops after a snowstorm, the snow can turn icy and be harder to remove.
- The more scraping and removal of ice that you can do, the less deicer you will need to use. Deicers work best on a thin layer of ice.
- After you remove all of the snow and ice, sprinkle salt sparingly.
- As the sun comes out or the temperature rises, the deicer will make a slushy mixture of water and ice. Remove this before the temperature drops again and you should have an ice-free surface until the next storm.

Chemical deicers on the market today

New products are introduced every year with catchy names that often promise magic or wizardry (e.g. Magic Salt® and Blizzard Wizard®). These products are usually new, proprietary mixtures of the same chemical deicers that have been used for years. Chemical deicers are typically chloride salts of sodium, calcium, potassium or magnesium (see table on opposite page). There are also non-chloride chemicals including calcium magnesium acetate, potassium acetate, and urea. And some new products on the market use liquid byproducts from the food or beverage industry such as beer waste and beet juice. Many of the products are 60-90% sodium chloride (rock salt) with the balance made up of one or more of the other products.

Poughkeepsie Journal.com
Since 1785 | New York's Oldest Newspaper

Originally published:November 8, 2009

EcoFocus: Salt makes roads safe but can pollute water

Written by William H. Schlesinger and Stuart Findlay

With winter right around the corner, many municipalities are oiling up their snowplows in preparation for the first storm. As part of that effort, each year about a million tons of road salt are applied to roads in New York state. What happens to all that salt?

Road salt, rock salt or sodium chloride, which chemists know as NaCl, is the same stuff that is in your salt shaker at home. It lowers the freezing point of water, and it is effective at melting the snow and ice from roadways in temperatures as low as 20 degrees Fahrenheit. When water runs off of treated roads, dissolved road salt washes into nearby ponds and rivers. Near Millbrook, more than 90 percent of the sodium chloride in Wappinger Creek is from road salt.

Salt occurs naturally in the environment. It is generally nontoxic, and high concentrations are not found outside of areas containing geologic salt deposits. Indeed, salt is used widely to preserve and flavor food and to regenerate home water softeners. In most cases, drinking water is only a small source of the total daily salt intake by the public, even in areas where water is derived from wells.

Like most chemicals, too much salt is toxic. And humans are inadvertently increasing the salinity of freshwater resources through routine road salt application. If salt continues to accumulate at its present rate, in our region many surface and well waters will be unhealthy for humans and wildlife by the end of this century.

In Dutchess County, chloride concentrations are the highest in streams that pass through densely populated areas. Groundwaters refresh very slowly. This means that they are slow to increase in salt, but also slow to flush salt when new inputs stop.

Approximately 20 percent of the wells in Dutchess County now have salt concentrations restricting their use by residents with high blood pressure.

Some organisms are already suffering from salt inputs. Excess salinity has been shown to impede the survival of spotted salamanders and wood frogs living in roadside ponds.

Current efforts to preserve vernal pools in woodlands are potentially compromised by salt, which can travel up to 200 yards from the edge of roads. Road salt has detrimental effects on the growth of roadside maple trees, and the spray from road salt produces an obvious "burn" on the foliage of many conifers, such as white pines.

A recent workshop for elected officials and highway maintenance personnel held at the Cary Institute concluded while excessive salt is not a crisis in Dutchess County, the trends are worrisome. Village, town and county officials could opt to reduce salt usage, improve efficiency of application, or consider substitutes to avoid a future environmental issue.

Here are several classes of alternatives. Already some municipalities use a mix of sand to reduce the total amount of salt applied. And, for some types of storms, a small amount of calcium chloride can be applied to reduce the overall rock salt needed - saving money.

Various acetate salts are less corrosive but may have other environmental effects and are generally more expensive for widespread application. They can be employed in areas where sensitive ecosystems are nearby. Urea is another alternative; it is non-corrosive but has significant odor.

The most important player in winter driving is, of course, you and me. We want to be safe on the road, and we want to know that emergency vehicles can travel rapidly.

But, maybe we shouldn't expect to drive at 55 mph on all roads all winter. Fewer tax dollars would be spent on salt, our cars and bridges would last longer, and roadside ponds would be alive with the sound of spring peepers.

Everyone gains when we slow down, and perhaps even stop to enjoy the woods on a snowy evening.

William H. Schlesinger *is president of the Cary Institute of Ecosystem Studies in Millbrook and a member of the National Academy of Sciences.Stuart Findlay is a aquatic ecologist at the Cary Institute of Ecosystem Studies.*

PoughkeepsieJournal.com
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Originally published: Sunday, December 23, 2007

Ecofocus: Salt nixes ice - at a price

Written by Vicky Kelly

Winter has descended upon us with its snow and ice. With it has come the familiar sight of snowplows and deicing trucks. Across the Northeastern United States, each year more than 10 million tons of sodium chloride are applied to roadways. Homeowners also rely on salt to prevent falls on walkways and driveways. While useful for stabilizing slippery surfaces, salt use comes at a cost to the environment.

Once applied, salt makes its way into natural areas. From there, it enters freshwater bodies such as wetlands, ponds, lakes, reservoirs, streams and rivers. Rivers have always carried small amounts of sodium and chloride, derived from the breakdown of rocks and maritime rainfall, but human activities are intensifying their salt loads.

We all know too much road salt can corrode cars. So it should come as little surprise that excess sodium can be a problem in freshwater systems, where plant and animals are not adapted to saline conditions. Road salt can also pollute drinking water. When it enters reservoirs and groundwater systems, sodium and chloride concentrations become elevated.

In an effort to understand how road salt affects natural areas, an Institute study examined a small rural watershed near Millbrook. By measuring the total amount of salt going into the watershed, and comparing that to the amount of salt flowing out of the watershed, we gained a better understanding of the fate of deicers.

The New York State Department of Transportation provided estimates on the amount of salt used on Dutchess County roads. Using a housing inventory, we estimated household salt use, including water-softeners. Institute long-term monitoring data on sodium and chloride were essential to input and output calculations.

In the study area, 91 percent of the sodium chloride originates from deicers, 4 percent is from household use, 3 percent is from water softeners, and 2 percent is from rain and rock weathering. Thus 98 percent of the salt entering our streams comes from humans.

Each winter, Dutchess County road crews apply an average of 14 tons of road salt per lane-mile. The efficiency of road maintenance has improved since road salting began, so some municipalities use less salt per lane mile than 20-30 years ago. But there are more roads, so total road salt use has increased.

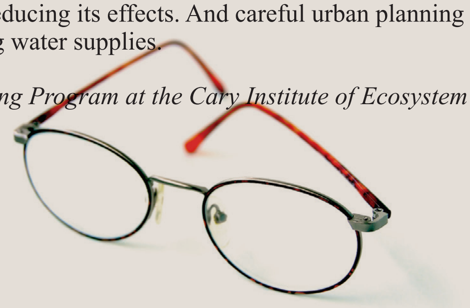
Watershed concentrations rising

Since the Institute began taking measurements in 1986, salt concentrations have been increasing in our small watershed. Yet no new roads have been built. By measuring inputs and outputs, we discovered salt application has a legacy effect. Once applied, it is stored in the soil and ground water for decades. Even if we stopped using salt today, it could persist in our streams, reservoirs and groundwater for some time to come.

Excessive salt, or salinity, can have detrimental effects on the natural environment and human health. Excessive sodium raises human blood pressure. The salt content of some rivers in New England has reached toxic levels for some species of fish and mollusks and it is known to be detrimental to roadside sugar maple trees. Excessive salt also promotes the deterioration of cars and bridges.

Clearly, salt is a convenient and inexpensive way to clear the roads of ice, but it has inadvertent environmental costs borne by all of us. Judicious and efficient salt use is a first step to reducing its effects. And careful urban planning can reduce the long-term effects of salt on our natural areas and our drinking water supplies.

***Vicky Kelly** manages the Long-term Environmental Monitoring Program at the Cary Institute of Ecosystem Studies in Millbrook.*



RESOURCES

Organizations

United States

Transportation Resource Board of the National Academies **www.trb.org**

US Federal Highway Administration **http://environment.fhwa.dot.gov**

American Association of State Highway and Transportation Officials **www.transportation.org/aashto**

Minnesota Pollution Control Agency Road Salt Education Program **www.pca.state.mn.us/programs/roadsalt.html**

Fortin Consulting, Inc Road Salt Training (Minnesota) **www.fortinconsulting.com/roadsalt.html**

Maine Road Salt Risk Assessment Project. Margaret Chase Smith Policy Center, University of Maine. **http://mcspolicycenter.umaine.edu/?q=RoadSalt_Background**

Cornell Local Roads Program: Workshops on snow and ice control **www.clrp.cornell.edu**

Canada

Environment Canada **www.environment-canada.ca**

Transportation Association of Canada **www.tac-atc.ca/english**

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About Us

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The Cary Institute is dedicated to connecting its findings to learners of all ages. To find out more about our educational offerings, public programs, and free scientific seminars, visit **www.caryinstitute.org.**

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