Road Salt

The applicability of this section will vary intensely by region. It should apply fairly well to places with cold, snowy winters, where roads are currently kept clear of ice using salt. Not all snowy areas rely on salt, even within in the United States which is generally over-reliant on it. It's as much a matter of ingrained defaults and expectations as cost and safety.

Most of my original notes and references were US-centric, especially for the nature of the problem.

What is road salt and why do we use it?

In cold regions, before and during snow and ice storms, salt is applied to parking lots, sidewalks, and driveways to melt ice and and prevent its buildup, in order to protect the safety of drivers and pedestrians. This work is performed by a mix of government employees (often from state Departments of Transportation) and contractors, private operators, city employees, and private citizens. The plow trucks they use to clear the roads of snow are equipped with salt spreaders which fling sand and salt onto the roads behind them to melt the ice, but this is a widespread practice; city sidewalk snowblowers operate in a similar fashion, and even individuals shovel salt from buckets onto their driveways, sidewalks, stairs, and footpaths. This practice, carried out annually for decades has poisoned numerous waterways, and thousands of acres of roadside land.

Road salt works by lowering the freezing point of water, keeping water liquid and making ice melt even when the temperature is below water’s normal freezing point of 32 degrees. When salt contacts and dissolves in water, it breaks into two ions, sodium and chloride, which interfere with water molecules’ ability to bond together and form ice. Both ions contaminate surface and groundwater, they are often tracked separately.

Road salt use is common and growing throughout Canada and the Northern US, Europe, Japan, China and South America. Salt was first used to deice roads in the U.S. in New Hampshire in 1938. It proved to be cheap and effective, and by the winter of 1941-1942, about 5,000 tons of salt were being spread on highways nationwide. In the following decades this use of salt as a deicer increased exponentially. As the population grew, so too did the number of vehicles and amount of impervious surfaces such as roads and parking lots receiving deicing treatment every storm. Today an estimated 20 million tons of salt is scattered on U.S. roads annually — about 123 pounds for every American. As much as 60 million metric tons (66 million tons) may be applied worldwide each year.

This annual relocation of millions of tons of salt have had a documented effect on the habitats its dumped into. Sodium chloride concentrations in freshwater have increased dramatically. This affects both surface streams, lakes, ponds etc, but also groundwater and aquifers.

The Damage

Because the ions that make up road salt don’t evaporate or break down, and plants don’t significantly filter them out of the soil, road salt accumulates in the environment after it is applied. Some environmental organizations are beginning to treat it as a forever contaminant in this context.

Road salt first contaniminates soil and surface streams near the roads and parking lots where it applied, and moves downstream with the flow of meltwater. Concentrations of sodium and chloride in surface waters have risen steadily for decades (some rivers and streams have registered salt levels at or above sea water), killing off large swaths of aquatic plants and animals, nearly sterilizing some rivers of life altogether.

As with most environmental damage, this impact has a way of cascading. The steady die-off reduces the self-purification processes of water by decreasing nutrient accumulation in aquatic plants, decreasing the denitrification rate, and reducing organic matter decomposition. Ironically this allows for an overenrichment of nutrients in the water, which favors phytoplankton, especially cyanobacteria which can tolerate the new conditions, causing toxic algae blooms. These then cause even more damage to the aquatic habitat.

For example: elevated chloride kills zooplankton, the minute animals that form critical links in aquatic food webs. Water flea populations, for instance, can drop 50 percent even where chloride levels meet water quality guidelines. Zooplankton consume algae, and are in turn eaten by aquatic insects, small fish, and other animals moving up the food chain. Absent healthy levels of zooplankton, these populations of cyanobacteria are more likely to increase, as are invasive species tolerant of high salinity.

Road salt can also be detrimental to lakes in other ways. Water polluted by road salt is denser than freshwater and therefore salt contaminated water will settle to the deepest part of the lake where it can accumulate. This chemical stratification, or the development of layers of water due to density differences, can prevent the natural mixing of lakes, which in turn can lead to a near permanent layer in the lake’s bottom waters. Often that bottom layer becomes devoid of oxygen and is unable to support aquatic insects and fish life. https://www.canr.msu.edu/news/salt_runoff_can_impair_lakes

Sodium and chloride also seep into the groundwater, contaminating wells and aquifers. And though chloride isn’t especially poisonous to humans on its own, high enough concentrations are caustic enough to damage pipes and leach lead into drinking water. And humans weren't the only ones affected: the salt which has vanished underground hides the extent of the problem – some of this pollution won’t re-enter streams and lakes until decades after the salt hit the road, meaning that the concentrations could continue to increase in surface waters independent of human activity. Even today freshwater streams are staying salty long after spring rains wash winter road salt away, indicating that road salt contamination in groundwater sources is increasing.

It’s reached the point now that salt in the streams is year-round and the highest chloride levels typically occur during summer’s hot dry weather, when streams slow to a trickle and water levels drop in lakes and ponds. Monitoring data has revealed chloride levels during severe summer heat and drought in 2019, 2020, and 2022 that were nearly 10 times the levels recorded during wet winter months.

Once salt gets into the soil, or into a waterway, there really are no biological processes that will remove it. Salt can leave the system through transport and it can be diluted by fresher water coming in so that the levels become less concerning. However, without transport out of the system, like in an isolated lake or aquifer, the salt will continue to persist over very long time scales. Costs of chloride clean ups can run around $300,000,000, a cost that is estimated at 30-40% higher than efforts to protect drinking water in the first place.

It's also worth noting that chloride-polluted water is denser than freshwater, [which means it can become concentrated at lake bottoms](https://northernwoodlands.org/outside_story/article/road-salt-impacts). “In extreme cases, this can impede the vernal and autumnal vertical turnover of lake waters essential for distributing oxygen and nutrients to aquatic species.”

Essentially, the only real way to remove salt from the environment is to stop adding it and to flush it out with fresh water over time. This won't work in every situation though, some contaminated surface water bodies are endorheric or slow draining and lose most of their water to evaporation, which increases their salinity over time. Similarly, many underground aquifers (which are often tapped for drinking water) are basically at the bottom of their local groundwater topology, making heavy contaminants very difficult to remove.

This trapping of salinated water actually bears some resemblance to the way the salt mines (which provide the road salt) formed in the first place - after the trapped remains of prehistoric oceans evaporated.

Aside from the mass poisoning of the local biosphere, road salt causes other damage (which might be more convincing for some people):

Excessive salt use damages infrastructure and other man-made things. Salt is highly corrosive to metal and can cause rapid rusting. The undercarriage and frame of cars and trucks routinely exposed to road salt during winter driving rust out within a few years, and many smaller parts need earlier replacement than in other regions. A twenty year old car certainly isn't unheard of, but they're comparatively rare in heavy salt regions compared to elsewhere (especially in heavy salt areas with annual vehicle inspections). But this doesn't just extend to cars, any steel or iron routinely exposed to salt rusts faster, including shopping carts (which is why they're plastic-coated now).

Concrete also suffers from salt exposure; small holes, or “pitting,” form, allowing rainwater to seep in, which causes cracking and chipping. Since we build most of our roads, bridges, and buildings from steel and concrete, we are weakening them with corrosive chemicals every time we salt the roads.

Current-Day Solutions

At this point the damage is well documented, and numerous organizations have started to recognize the damage road salt is causing and are pushing for change.

Because a substantial portion of the salt being used is actually being used wastefully or incorrectly, several programs are focused on reducing the dose just by training plow drivers on when, where, and how to apply road salt effectively. For example, the NH DOT began studying alternatives in 2011 and retraining not just their own drivers but also city, town, and private operators by offering liability incentives to those who attend their course. This is generally an easy sell because it maintains the same level of safety while also reducing materials costs.

Similar programs exist attempting to educate the wider public that more salt does not equate with more melting (although the heavy application of road salt is now culturally tied to a sense of safety, so any reduction can provoke a strong response). And some towns are pushing for enforcement of no-salt areas near lakes, reservoirs, and municipal wells, though these zones are often not enforced, or are actively ignored, and obtaining the necessary buy-in can be difficult.

There are several other ways to provide traction and even melt snow and ice without pouring salt over every paved surface in society again and again during every winter storm. The downside is that within the societal/economic system where we currently operate, they're generally worse. Salt is cheap (thanks to massive industrial salt mines and established transportation infrastructure) and effective. Most of the alternatives are weaker on one or both:

- **Coarse “Winter” Sand** - Sand adds traction but doesn't

- **Option 1: Salt but different** - there are other kinds of salt and other ways to apply salt, both of which allow for the same or better results with a smaller dose, reducing the total amount of salt needed to do the same job.
  - **Salt Brine** - this is a mix of salt and water which is sprayed on roads that is used to either pre-wet solid materials that are applied from the plow trucks or to pre-treat the highways in advance of a storm event to prevent freezing or to keep the ice that does form from sticking to the road. Adding brine to salt before it is applied jump starts the melting process and helps keep the salt in place by reducing bounce and scatter. This can be regular Sodium Chloride (NaCl) or one of the following alternative salts:
  - **Calcium Chloride (CaCl)**, is the second most common deicing chemical, it is available in flake, pellet or liquid. It's safer for the environment but is three times more expensive than NaCL and so is typically reserved for use in vulnerable areas. It is effective at lower temperatures with a practical melting temperature of -20°F. In liquid form it can be used to pre-wet salt or applied directly as an anti-icing technique which can help in preventing snow and ice from bonding to the pavement and reduce the application amount needed. Several disadvantages to CaCl include a higher cost, environmental impact due to chloride, corrosive to metal, it can be difficult to handle and store, and can contribute to slippery conditions if applied incorrectly.
  - **Magnesium Chloride (MgCl2)** is available in liquid or crystal form that melts faster than rock salt; it has a practical melting temperature of 5°F. MgCl attracts moisture and can lead to slippery conditions if applied incorrectly. It is corrosive and contributes to the chloride load in our waters. is considered to be safer than NaCl but requires twice the amount to cover the same area, making it more expensive.
  - **Potassium Acetate (KA)** – has a practical melting temperature of -15°F and is biodegradable and non- corrosive. It can cause slick road conditions if applied in excess and can lower oxygen levels in the waterbody. This is a commonly used deicer in the airline industry and is relatively non corrosive.
  - **https://mm.nh.gov/files/uploads/dot/remote-docs/operational-guidelines-for-snow-removal-and-ice-control-operations.pdfLiquid Chloride Blend** - Liquid Chloride blends are used to stretch the working range of salt brine without incurring the full cost of a Liquid Magnesium Chloride product.
- **Calcium Magnesium Acetate** This is an environment-friendly alternative and is biodegradable. Calcium Magnesium Acetate is a non-corrosive formula that does little damage to the infrastructure, vegetation, fish, aquatic life, and other surroundings around it. However, it is more expensive than salt and is less effective when used in colder temperatures.
- Agricultural by-products – are mostly proprietary to the manufacturer and can be derived from sources such as corn, beet, grain, alcohol, or molasses. These products are generally not as good at melting snow and ice; though some do lower the freezing point of water through chemical means. They are less corrosive than conventional materials and in many cases act as tackifiers (meaning they're sticky) to keep salt and sand on the road surface. These attributes make the product good for anti-icing and pre-treating salt. Depending on the material they may also provide grip/traction similar to sand. They do have environmental impacts in aquatic systems due to their organic nature and can lead to biological oxygen demand, heavy metals, and nutrient enrichment by nitrogen and phosphorus.
  - **Beet Juice/Beet Molasses** - Most sources I've seen say the sugar in beet molasses lowers the freezing point of water, much like salt, (the ones that claim it can't //may// have a bias). Products/mixes with beat molassas work at lower temperatures than plain salt but the most consistent benefit is that beet juice's sticky consistency helps it (and anything it's mixed with like salt or sand) cling to roads. This means less is lost to bounce and scatter so less has to be applied. It's safer for pets and not corrosive to bridges and vehicles (one source claimed beet juice serves as a natural corrosion inhibitor - when

mixed with salt it makes a brine that is 75% less corrosive than salt itself. The downsides is that it's less effective than salt on its own, and pouring sugar and organic nutrients into the environment can also cause problems in rivers, lakes, and streams.
  - **Cheese/Pickle Brine** - These seem to be a way to source brines cheaply from local industrial/agricultural byproducts, although cheese brine appears to have an even lower freezing temperature than normal salt brines.
  - **Fermented Grape Skin Compounds** (this can apparently also be done using sugar beet leaves, peony leaves, or other agricultural byproducts. The claim is that by fermenting these byproducts they break down the agricultural waste, and through the work of bacteria, it ends up as a liquid mixture of chemicals, which can be mixed into the salt brine at a certain ratio to improve its effectiveness and reduce the harm it causes. I've seen other listings that include vinegar as icemelt, (probably because it contains acetic acid) so this may be similar to that. They also claim the grape skin or sugar beet leaf solution appears not to pose the same risk as beet juice, but they're not sure why yet. This is currently another way to reduce salt, it doesn't look like they've tested it as a full replacement yet.
  - **Brewery/Distillery Byproducts** Producing whiskey, wine, beer, bourbon, vodka, rum, and other alcoholic beverages results in an organic waste product — distiller's "mash," and spent brewer's grains — which possess chemical properties (probably alcohol, though https://www.sciencedirect.com/science/article/pii/S2666517424000105brewery effluent contains a high proportion of sodium) that makes ice melt at lower temperatures. It looks like these have been tested and can be used to help road salt adhere to roads and melt more efficiently at lower temperatures.
  - **Pickle juice** - this appears to still be a salt brine, just sourced as a byproduct to lower the cost.
- **Permeable Paved Surfaces** - Another solution is to change the infrastructure rather than the deicing practices. These pavements are usually constructed with asphalt or pavers and feature a porous structure that drains water into systems below the roadway rather than allowing it to pool on road surfaces where it freezes and requires an application of road salt. This can work, but the permeable pavements are typically more expensive than conventional asphalt, require care by contractors during construction, and require maintenance to keep pores from clogging with decaying leaves and other organic material. These pavements also don't offer the strength of impermeable pavements and are better-suited for residential streets, parking lots and other applications not used by commercial trucks and equipment. It also looks like they might be best on level ground or shallow grades, and a poor choice for hills. The upside is that they're not just useful in wintertime, reducing the amount of impermeable surfaces is an important part of improving our cities through https://www.wired.com/story/los-angeles-just-proved-how-spongy-a-city-can-be/sponge city tactics, reducing both floods and water waste while refilling important aquifers.

Things individuals can do to help:

- Use less. More salt doesn't automatically equal more safe.
- Remove snow and ice manually. The more you remove, the less salt will need to be applied.
- Sweep up any excess salt visible on a dry sidewalk.
- Do not apply salt below 15°F – most salt products will not work below that temperature.

Solarpunk Alternatives

The simplest answer to this problem is to change the circumstances, but that requires some of the biggest changes: if a solarpunk society can move at a slower pace, accept a snow day or two during and after bad weather, much of the excess labor and resources necessary to keep roads clear and derivable even during severe blizzards can be reduced and the immediate effectiveness of the alternatives is less important. Even in winter, the weather changes frequently, and ice on pavement often melts or sublimates on its own once the sun is on it.

But this requires an entire cultural shift. In the present, many people are dependent on cars (and thus the road network) for everything from buying supplies to seeking emergency medical attention. When you need to get to the hospital, or when your job won't accept a raging blizzard as an excuse for being late, you need the roads to be clear because you have no choice but to drive on them. This constant rush means the natural world has to conform to our schedules - sidewalks can't be slippery for a day or even a few hours because people have to use them *right now*. Roads have to be clear at all times because there's no alternative, and opting out for safety isn't an option for far too many people.

This might be different in a solarpunk setting where the pace of life is hopefully gentler. An emphasis on trains and other public transit options (such as airships, ropeways, and trams) would mean that many people would have options besides driving. And an acceptance that weather exists and can derail our plans and schedules would mean that many of those who still rely on cars could safely wait for it to pass without losing their livelihoods. Fewer cars on the road mean fewer accidents and less risk for those who have to drive in bad conditions. Society could safely reconsider the number of autoroads and bike paths which need to be maintained to bare-pavement conditions, especially during winter storms. In fact, the expectation that roads will take a few days to fully clear would likely inform peoples' decisions on where to live and how to prepare themselves. In the recent past, rural areas often expected to be isolated during winter storms, and people often adapted their personal vehicles to meet the conditions.

This might even extend to accepting that not all roads even have to be plowed at all, and might be seasonal, open for regular use during summer and fall, and restricted to suitable vehicles (such as snowmobiles, including a variety of ski-and-tracked truck-format vehicles), skiers, snowshoe-rs, etc during the winter.

Even in solarpunk cities, where driving would hopefully be less of a common concern, people would need to accept that they can be safe in the winter without salt crunching underfoot and that's not easy. This is a fairly recent expectation, and it's driven by a mix of things including legal liability (a bag of salt is a lot cheaper than a personal injury lawsuit) and the present day need to hustle, even in bad weather, that demands that people go out during an ice storm and woe betide anyone who hasn't salted their sidewalk enough. Education is a big piece here, informing people on how salt works on ice, that a heap of dry salt isn't changing anything but the local wetlands, and the consequences of overusing road salt.