

Would You Like Salt On That? Improving Winter Driving Conditions with Road Salt

Outcomes:

1. Identify some positive and negative effects and intended and unintended consequences of using salt on highways. (113-1)
2. Describe how our understanding of the properties of solutions has resulted in better road de-icing technologies (111-1)
3. Provide examples of how road de-icing technologies have affected our lives, our communities, and our environment (112-7)
4. Make an informed decision about the use of road salt as our main road de-icing chemical taking into account the environmental, social, and economics advantages and disadvantages (113-9)

Introduction

Our winter months provide us with the opportunity for many enjoyable activities, such as snowmobiling, skiing, skating, and tobogganing. However, winter also brings the great danger of slippery road conditions. Canada uses about 4.9 million tonnes of de-icing materials each year. Of these, 4.75 million tonnes of this is sodium chloride (rock salt), 0.11 million tonnes is calcium chloride, and the rest is made up of potassium chloride and magnesium chloride. At the local level, road crews in Newfoundland and Labrador use around 200,000 tonnes of sodium chloride and 800 tonnes of calcium chloride each winter.

Safe driving in the winter requires good traction between the automobile's tires and the road. Good traction will decrease the amount of skidding and slipping when driving or stopping. Slippery road conditions are created when moisture from fog, rain, or snowfall freeze onto the road. Also, when cars and trucks drive over snow it becomes compacted and bonds to the road making it very hard for plows to remove.

Using Salt to De-Ice Roads

To prevent freezing of moisture and compaction of snow on roads, salt (sodium chloride) is often used because it lowers the freezing point of water. When the addition of one substance to another causes the freezing point to lower, this is referred to as a **freezing point depression**. Freezing point depression is a **colligative property** of solvents. A colligative property is one which depends on the number of particles dissolved in the solute (not the type of particle). For example, as the number of salt particles dissolved in water increases, the water's freezing point decreases to its lowest possible temperature of -9°C . The lowest freezing point of -9°C is reached when the water has become saturated with sodium chloride (i.e., when the water can not dissolve anymore solid salt). Since salt can only lower the freezing point of water to a maximum of -9°C , it will not melt ice or snow if the outside temperature is less than -9°C . For temperatures colder than -9°C , a substitute is used.

Sodium chloride is not the only chemical used for de-icing roads, nor is it necessarily the best at melting ice. Sodium chloride, which has the

chemical formula NaCl, dissolves into two types of particles: one sodium (Na) particle and one chloride (Cl) particle per sodium chloride unit that dissolves. A compound that yields more particles when put into water would lower the freezing point of water more than salt. For example, calcium chloride, CaCl_2 , dissolves into three particles; one of calcium (Ca) and two of chloride (Cl). Because there are more particles dissolved in the water, calcium chloride lowers the freezing point of water more than sodium chloride.

The following table provides a list of some other chemicals that are used to de-ice roads. Note that each chemical has different advantages and disadvantages to its use.

Applying salt at the beginning of a storm prevents the precipitation from freezing and creates an immediate brine (saltwater) solution. As a result, snow build up can be more easily plowed and, depending on road and weather conditions, a new application of salt may be applied.

Name	Lowest Practical Temperature	Advantage	Disadvantage
Sodium Chloride	-9°C	keeps road surfaces dry	damages concrete and vegetation causes metals to rust
Calcium Chloride	-29°C	melts ice faster than salt	attracts moisture, surfaces slippery below -18°C
Magnesium Chloride	-15°C	melts ice faster than salt	attracts moisture
Potassium Acetate	-9°C	biodegradable	corrosive
Ammonium Sulfate	-7°C	fertilizer	damages concrete

Figure 1: Some chemicals used to melt ice.

* Further research into these chemicals will give a more detailed account of their negative affects on the environment.

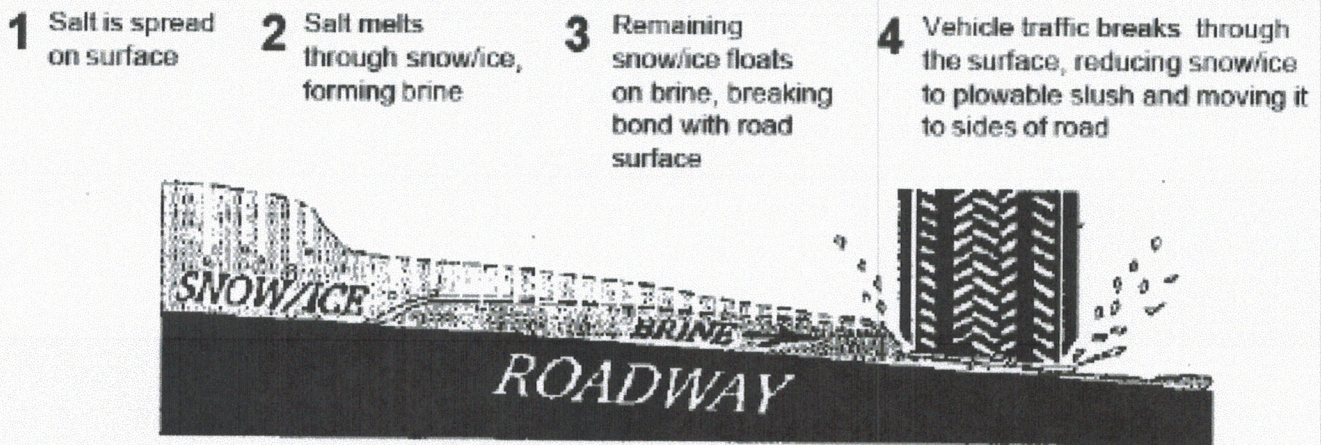


Figure 2: How Salt aids in Ice Removal (Source: <http://www.highways.gov.sk.ca/technical-backgrounder/>)

Problems with using Salt to De-Ice Roads

Although road salt is very important to help keep our roads and highways safe during the winter months, using too much can have a negative impact on our environment and structures. Some of the problems associated with using salt for de-icing roads are described below.

1. Surface and Groundwater

When salt is spread on the ground it will dissolve in the water that is present in the soil. As a result the groundwater will become salty and this saltwater may then end up in streams, ponds and even in our drinking water supplies. When salt water gets into freshwater ecosystems, it will affect the aquatic life in a negative way and may even kill off some of the living organisms. If communities use the aquatic ecosystem as a source of drinking water, it will affect the quality of our drinking water and may cause it to become dangerous for humans to drink.

2. Impacts on Soil

The sodium part of salt can react with minerals in soil which causes it to become harder. In some cases, the soil is so hard packed that water will not percolate through it easily. Also, because the soil is so hard, it is difficult for plant roots to push their way into the soil. Since plants use some of the minerals in soil for nutrients, this will decrease the soil's fertility and its ability of plants to grow there.

3. Vegetation

High concentrations of salt in soil, groundwater and salt spray from vehicles can damage the trees, grasses and shrubs present along the roadside. As a result, some plants will die off and other, **salt tolerant** plants may move into the area. You may notice that the vegetation along newly constructed roads is different than that along older roads. The vegetation along the side of older roads may have been damaged by salt or may be better able to withstand the salt concentration.

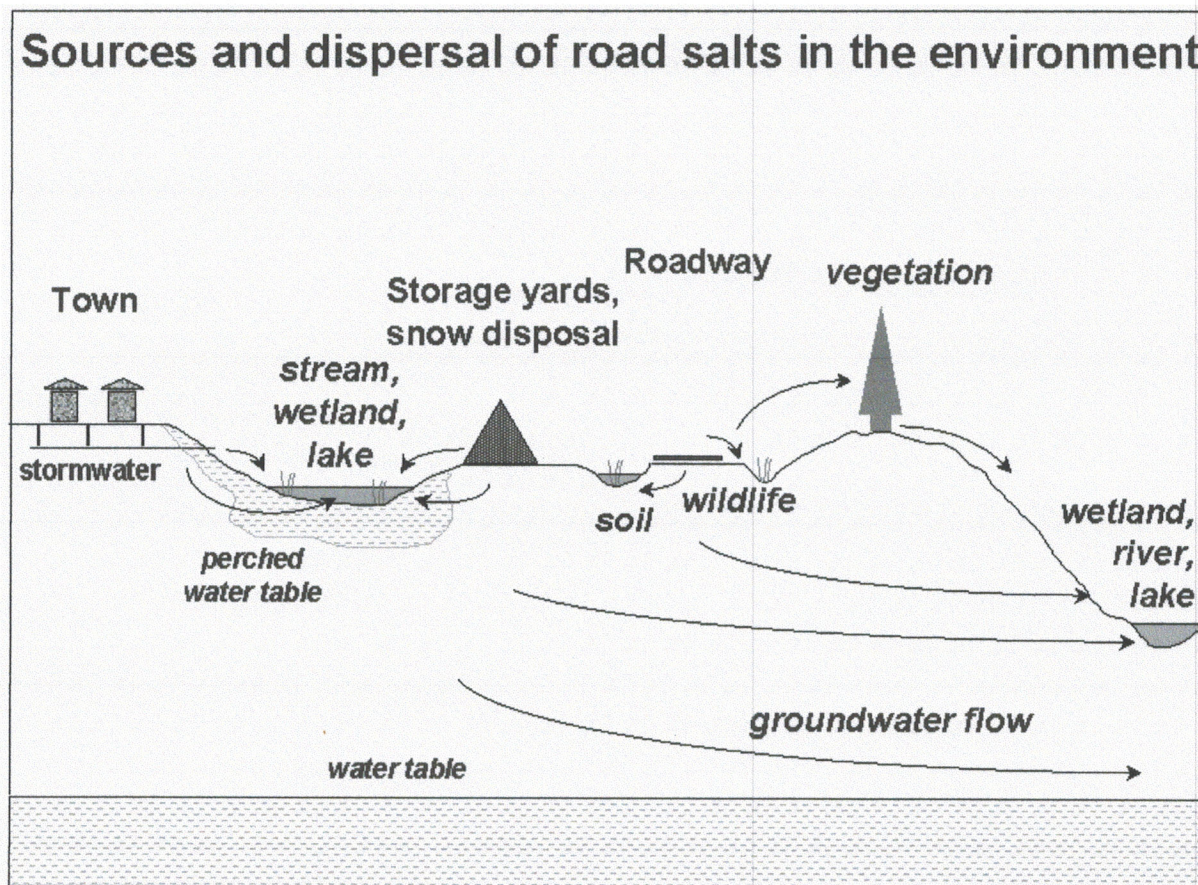


Figure 3: Sources and Dispersal of Road Salts in the Environment

(Source: http://www.ec.gc.ca/EnviroZine/english/issues/14/email_story_e.cfm?page=feature1)

4. Wildlife

Animals, like humans, need a certain amount of salt in their diet to keep them healthy. During the winter plants, which are animals' main source of salt, are not easily available. As a result, animals become "starved" for salt. The roadside provides a readily available and easily accessible source of salt. The salt is not a danger to the animals. However, having animals on or near the roads increases the chance of an animal-vehicle collision.

5. Corrosion of Vehicles and other Structures

Have you ever had the chance to compare the condition of an older car from Labrador with one from the island portion of the province? Road salt (and sea salt) dramatically speeds up the process

of rusting. Salt also causes damage to our concrete bridges. Scientists are working to producing better rust resistant paints for vehicles as well as developing salt-resistant concrete.

Reducing the Negative Effects of Salt

In addition to trying to develop paints that slow down the rusting process and salt-resistant concrete, there are several other things that can be done to reduce the negative effects of salt.

1. Anti-icing

To further improve the safety of the roads and reduce the amount of salt used hi-tech Road Weather Information Systems (RWIS) have been set up across our province. These are automatic weather stations that are located near the highway and have sensors on the surface of and under the pavement. The system records the atmospheric conditions, such as relative humidity, wind speed, air temperature, and the temperature and wetness of the road. This information is used by department of highway officials to predict road conditions over a 24 hour period. By using this system, the maintenance crews will know, in advance, if roads will become slippery and will be able to apply salt before this happens. This process, called “anti-icing”, has reduced the amount of salt used by 20 – 30% as well as reducing weather-related accidents by 10 – 15% in some countries.

2. Pre-wetting

Another method used to reduce the amount of salt spread on our roads is to “pre-wet” it. Wetting provides moisture to make a brine, which is then applied to the road, resulting in faster melting action. Also, wet salt has a lower tendency to bounce or be blown off the road by traffic. A savings of 20 to 30% in lost or wasted salt is possible using this method.

Conclusion

Salt has long been the chemical of choice for de-icing our roads. Scientists are continually studying modifications of salt-based de-icing, such as:

- i) combining salt with other chemicals
- ii) mixing salt with sand in different amounts
- iii) pre-wetting the salt before it is applied to the road
- iv) ensuring that it is spread on the road in such a way as to maximize its effectiveness and minimize its environmental affects.

While there are some problems associated with using salt to de-ice roads, because of its low cost, abundance and relatively low environmental impact salt is widely used today, and probably will continue to be used into the future.

Questions

1. List and briefly describe the five problems created by using road salt (sodium chloride) on our roads.
2. Explain, with the aid of a diagram, how salt works to create a safer road to drive on.
3. When 10 grams of sodium chloride, NaCl, dissolves in 100 grams of water, the freezing point of the water goes down to -5.9°C . When 10 grams of table sugar, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, dissolves in 100 grams of water, the freezing point only goes down to -0.56°C . How do you account for this difference?
4. The Department of Transportation use mostly sand on the roads in Labrador. Why? Are the driving conditions in Labrador different from those in places that use salt? Explain your answer.
5. What is the purpose and advantages of Road Weather Information Systems?
6. What are two advantages of pre-wetting the salt before it is put on the road?