Does the Application Method and Type of Road Salt Used Affect How it Permeates Through Soil?

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Introduction

Road salt is used to clear snow and ice from roads, but where does it go once its mission has been accomplished? With no where else to go, it runs into the soil surrounding a road or over the soil and eventually into a stream. In these places it can be harmful to both plants and animals. In the stream it can alter macroinvertebrate communities by killing the species that are more sensitive to it. Plants can also struggle to survive as the salt affects the osmotic pressures on their roots. Salt has no means of being removed from the watershed other than eventually running into the ocean, where it no longer poses a threat. As global climate change occurs, the Northeast United States could see more precipitation throughout the winter, leading to increased road salt use (Figure 1).

In this investigation different application methods and types of road salts were explored to see if there is a way to make less of an impact on the environment while still providing safe roads to drive on. Road salts are commonly applied in three ways within the Pond Brook and Indian Brook watersheds: a solution of sodium chloride, a solution of calcium chloride, and solid sodium chloride crystals.

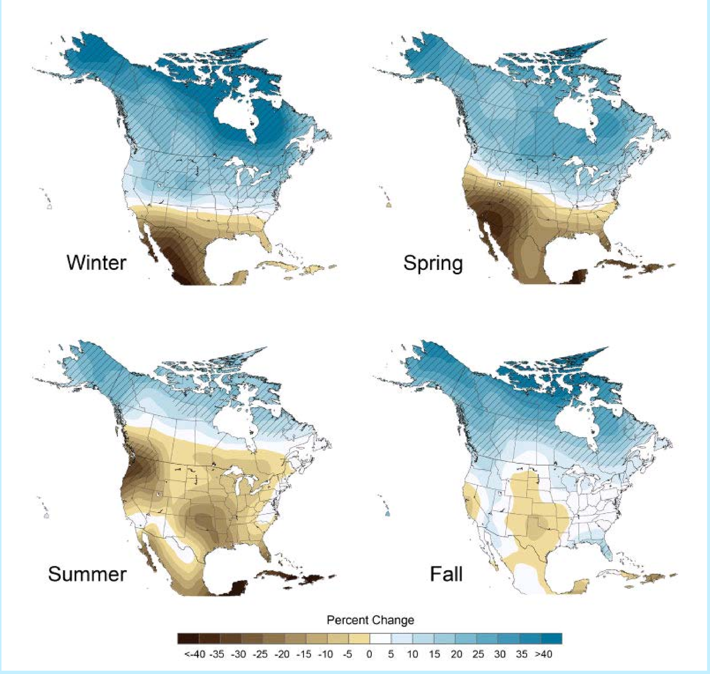


Figure 1

The above figure shows the expected percent increase in precipitation due to global climate change. An increase of 15-25 percent (blue shaded regions) is expected in the Northeast in the winter.

Methods

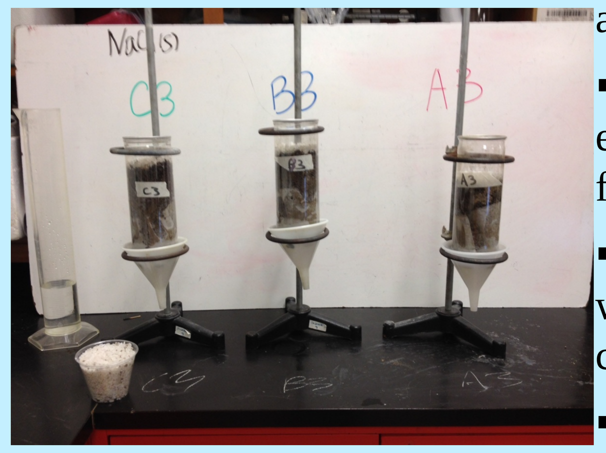


Figure 4

Figure 5

- Holes were drilled in the bottom of tennis canisters, and coffee filters were put in the bottom of each.
- Approximately 500 grams of soil were poured into each column, and the columns were then put on top of funnels in individual ring stands (Figure 4).
- Beakers were set up under the funnels to collect the water and solution that flowed through, and the conductivity of the runoff was tested (Figure 5).
- 3 different salt types were tested: 23% NaCl solution, solid NaCl, and 32% $CaCl_2$ solution.

  -Colchester uses solid NaCl and 23% NaCl solution, and Essex uses $CaCl_2$ solution in addition to those two. Pond Brook and Indian Brook are in these two towns.

  -36.65g of solid NaCl were applied to the columns, and 250 ml of the 32% $CaCl_2$ and 23% NaCl solutions were used.
- 250 ml. of distilled water were poured through each column, and initial conductivity measurements were taken. 250 ml equates to 1 ¼ inches of precipitation.
- 250 ml. of the 23% NaCl solution were poured into three different columns and the conductivity of the runoff was collected in 15 second increments.
- The same procedure was done for the solid NaCl and 32% $CaCl_2$ solution, and then distilled water was run through each column in increments of 250 ml until the soil returned to its initial conductivity, or 4L (20 in. precipitation) of distilled water had been run through.

Results

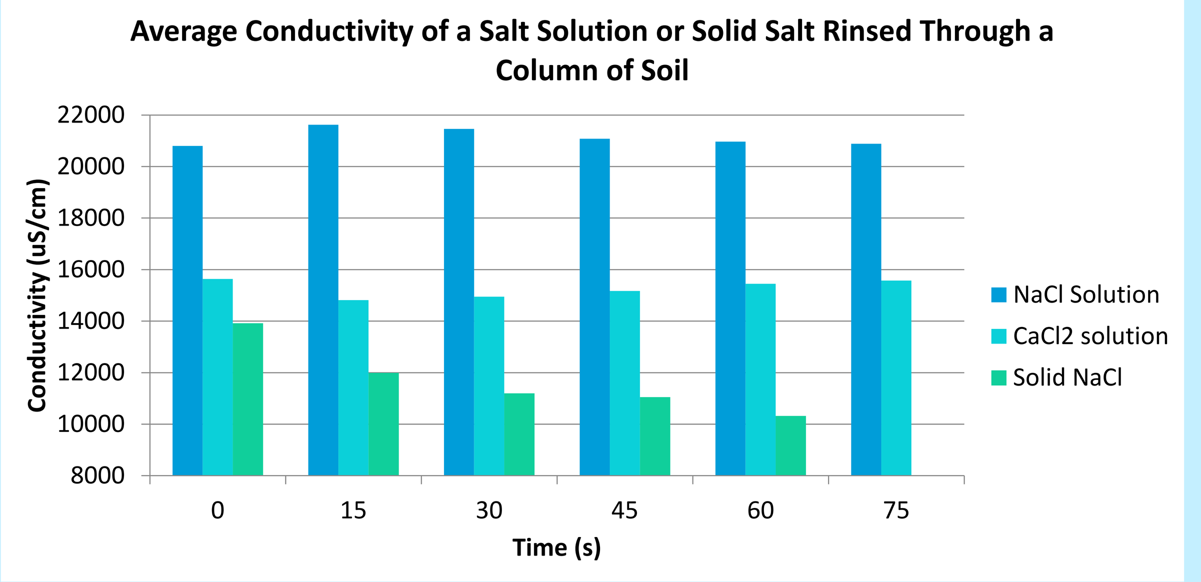


Figure 7

The graph to the left shows the average conductivities of the substrates in 15 second intervals as a salt or salt solution moves through each column. Upon initial application the conductivity of the solutions' trials stays relatively the same, while the conductivity of the solid NaCl trial dropped slightly over time. This means that for the dissolved salts a constant amount move s through the soil as it runs into it. Conversely, the solid salt seems to move through the soil less as time progresses. No data was collected for the 75s mark of solid NaCl

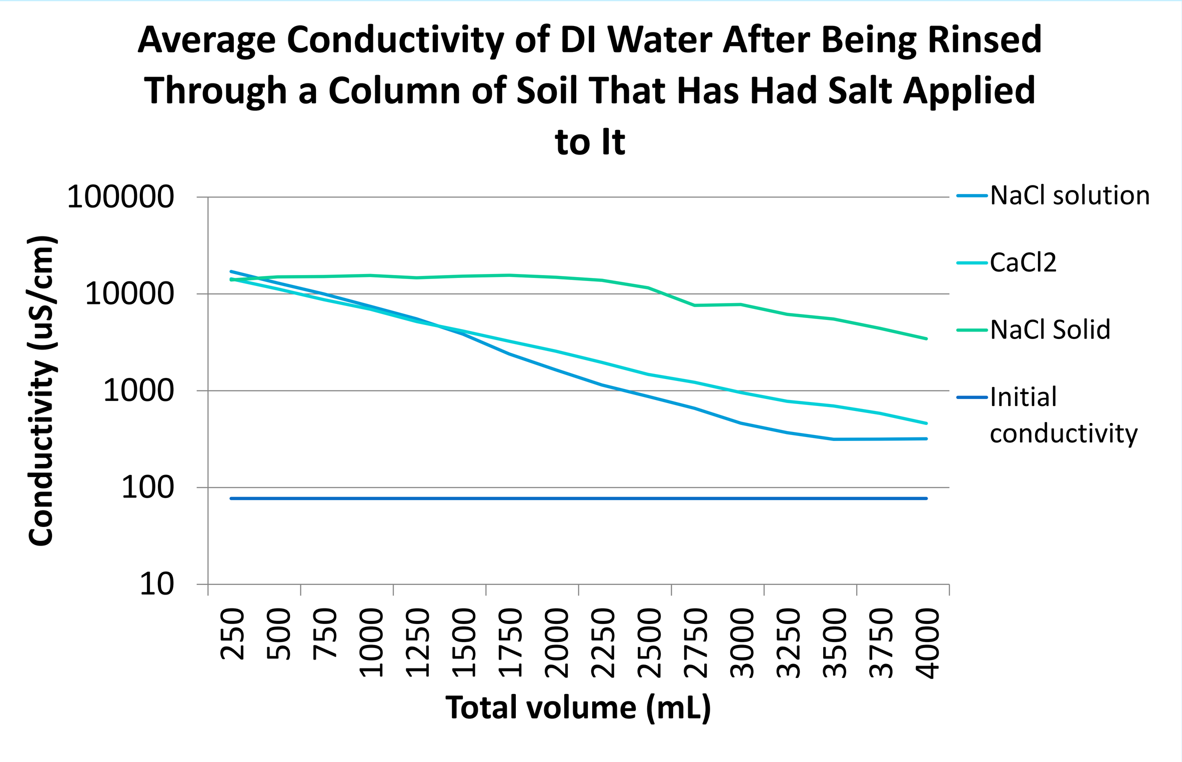


Figure 8

The graph to the left shows the decreasing trend of the salt leaving the soil, shown through the falling conductivity levels. None of the samples returned to their initial conductivity even after the equivalent of 20 in. of precipitation was applied. The conductivity of the solution collected from the column s with solid NaCl do not start to decrease until salt crystals are no longer visible, at about 2500mL.This graph is in log scale.

Research Sites

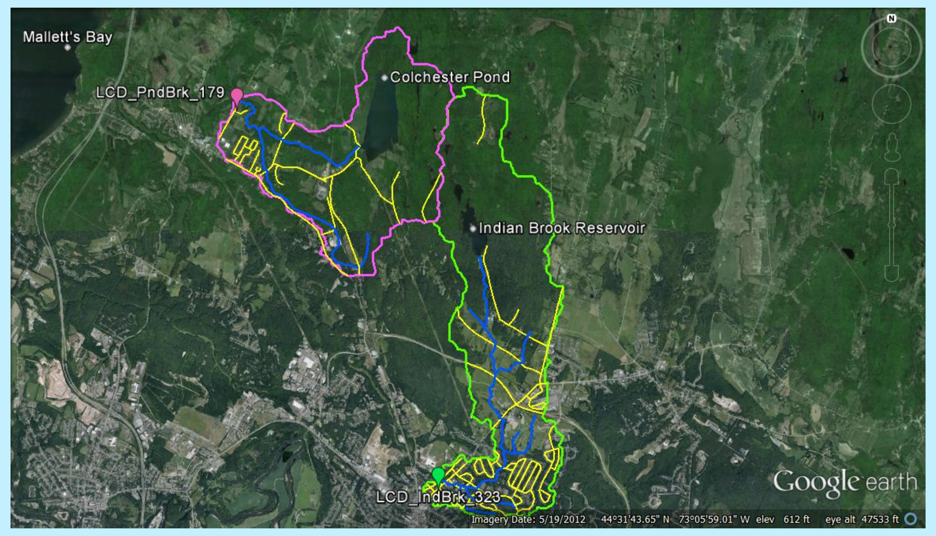


Figure 2 A map showing the roads within each watershed.

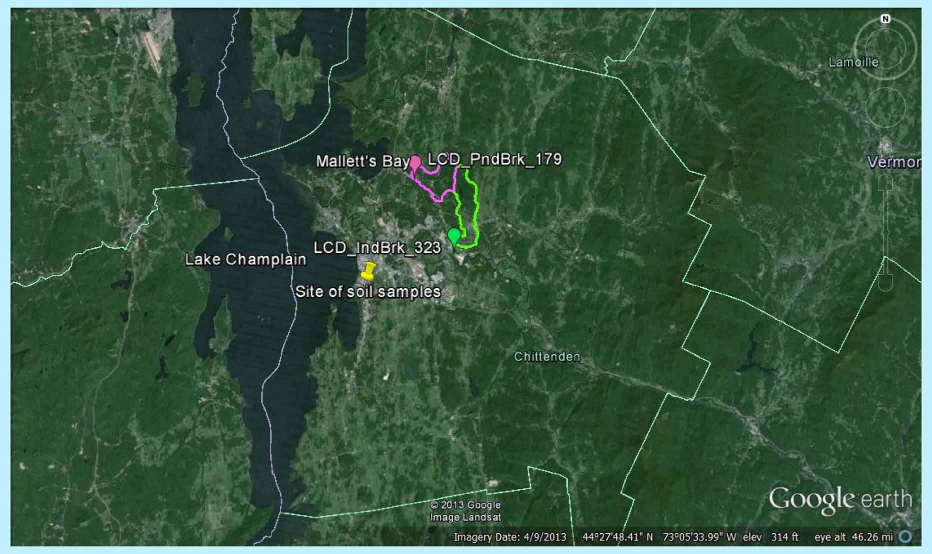


Figure 3 A map showing the locations of the two watersheds relative to the site where the test soil was collected.

The two sites examined were Indian Brook in Essex and Pond Brook in Colchester. The sampling site at Pond Brook is surrounded by agricultural fields and has much more forested land within its catchment than Indian Brook. Indian Brook is a much more urban site with many more road miles in its catchment than Pond Brook. Clay loam soil from a neighboring watershed was used in this experiment, as it is similar in composition to the soils found in the watershed (figure 2).

Discussion

The data collected supports the hypothesis that application methods and road salt type do change the rate at which the salt permeates through the soil. It indicates that if the salt is already in solution, it flows through the soil faster than if it is in solid form. All three salt types had relatively similar conductivities initially, however the conductivity of the solid NaCl remained elevated longer than that of the NaCl and $CaCl_2$ solutions. The NaCl solution ended at an average conductivity of 319.33 uS/cm, the $CaCl_2$ solution ended at 460.33 uS/cm, and the solid Na ended at 3,447.33 uS/cm. The NaCl solution started at the highest conductivity and eventually reached the lowest, crossing $CaCl_2$'s curve after 1.5 liters of deionized water had been applied. NaCl solution ran through the column the fastest of the three, and solid NaCl stayed the longest.

In the average salt season (November-April) 13.25 inches of liquid precipitation falls. In the non-salt season months (May-October) an average of 20.11 inches of liquid precipitation falls for an annual average precipitation of 33.36 inches(Figure 6a-b). According to the data, it takes more than 20 inches of liquid precipitation to return soil to its normal salt level. With 4 liters of water applied, representing almost two-thirds of a years liquid precipitation, salt levels were still a much higher than what they had been before the salt was applied.

Essex applies an average of 335.33 g/sq ft of solid NaCl to their roads over the course of a season. Colchester is likely similar. In the experiment there was an equivalent of 746.44g/ sq ft, 1171.08 g/sq ft, and 1,629.33 g/sq ft of solid NaCl, NaCl solution, and $CaCl_2$ solution, respectively. Although these numbers are much larger than the actual value, it seems reasonable that they could represent the approximate amount of salt that reaches roadside soil, given that the salt applied to the road does not run into an equivalent area of soil; the area is likely smaller making the salt more concentrated. Also, the statistic takes into account only the solid NaCl, not the solutions applied to the roads. Given the amount of precipitation and salts used, our data suggests that a buildup of salts in the soil could occur over a large period of time.

Figure 6a

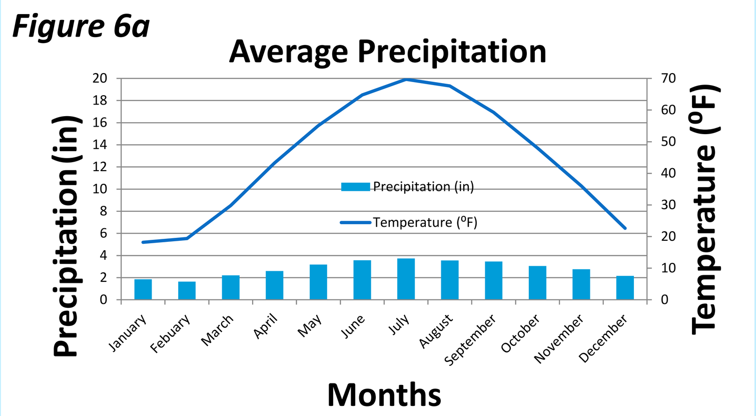
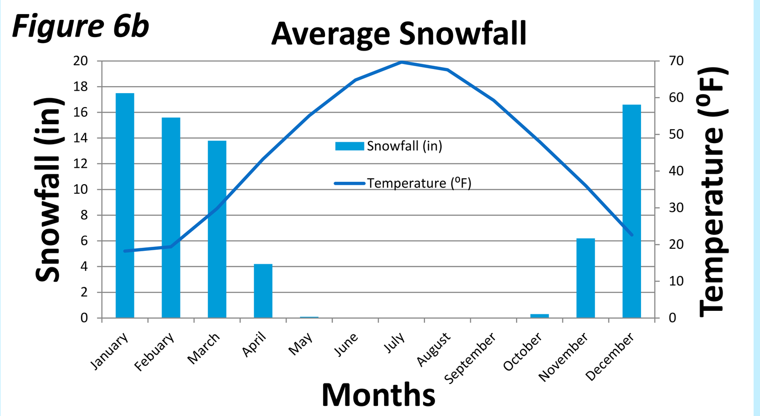


Figure 6b



Recommendation

Towns should take the environmental impacts of salt distribution and type into account when making decisions about snow removal. This is especially important considering how long the salt stays in the soil after application. Brine solutions appear to not persist in the soil for as long as crystals do. The data also indicates that crystals could cause salt levels in the stream to remain elevated for longer than the brines would. That being said, in an actual winter there would be multiple applications of salt The data suggests that the use of brine would cause spikes in stream salinity levels versus the use of solid salt which would lead to a more constant high salinity level throughout the winter. Further study is necessary to make a definitive statement citing one salt type and application method as the best. Research should include the effect of different salts on macroinvertebrate and plant life, as well as whether it is better for the salt to move rapidly through the soil or to travel at a slower rate. It could be important to collect soil samples near roads and stream samples year round, particularly before and after salt season.

References

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Acknowledgements

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