Melting Accidents Away

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Abstract

The main purpose of our experiment is to find an alternative to road salt, specifically sodium chloride because it has many downfalls that harm the environment, such as turning freshwater salty, harming aquatic animals and land animals, harming plants, and harming buildings. Our question is, "Which salt, calcium chloride, magnesium chloride, potassium chloride, or sodium chloride, melts snow the fastest and harms the environment the least?" To do this, we set up 12 trays and set concrete into ¾ of it. We placed grass into the other ¼ of the tray. We placed snow on the concrete and placed salt on the snow. We put one type of salt for three trays. It took an average of 35.6 minutes for the snow to melt with calcium chloride, 51 minutes with magnesium chloride, 25 minutes with potassium chloride, and 55.6 minutes with sodium chloride. The pH level of the grass started off with a 7, and after calcium chloride, it was an average of 8, 8.3 for magnesium chloride, 11 for potassium chloride, and 12.3 for sodium chloride. This shows that potassium chloride melts snow the fastest but calcium chloride harms the environment the least.

1. Background Research

Slowly, we are destroying the Earth in many ways, from using fossil fuels to filling up our landfills. These are some examples of problems that have already started and are now becoming major issues. It is best to fix a problem when it is small, so it can be prevented from becoming a big problem. Road salt is a small problem right now, but hopefully, we can prevent it from becoming a big one.

One grain of salt is so small, yet that will slowly become a big problem. Currently, one major way we de-ice our roads is by sprinkling on rock salt, specifically sodium chloride. I heard about many drawbacks that sodium chloride has on our environment, and this will soon become a large issue, so we should start acting now. I also heard about many other salts that don't harm the environment as much but are still as effective. The question that I am investigating is, "Which salt, calcium chloride, magnesium chloride, potassium chloride, or sodium chloride, melts snow the fastest and harms the environment the least?"

Every winter, we apply about 10 million tons of road salt, sodium chloride, every year in the United States ("Road Salt Use in the United States", n.d.). The way salt works is that it melts the snow and ice by reducing the water's freezing point, which is called the freezing point depression. "In a nutshell, the salt breaks into its component ions in a small amount of liquid water. The added particles make it more difficult for the water to freeze into ice, lowering the freezing point of the water." (Helmenstine, 2019). Although we use sodium chloride to melt snow to prevent accidents, it comes with its disadvantages. For example, salt harms the environment, specifically plant and aquatic life. When the salt gets placed near soil or near a plant, there is a high solute concentration outside the plant then in the root hairs. Due to this, the water travels out of the plant and near the salt so the salt and plant can reach equilibrium, which is a process called osmosis, causing the plant to dehydrate. The lack of water makes it hard for the plant to survive. It harms aquatic life because when the salt dissolves, sodium and chloride ions are formed, which disrupts the ability for freshwater organisms to control how fluids pass in and out of their bodies. Salt also can reduce the number of eggs laid by animals and their survival rates at the larvae stage. Sodium chloride is also known to be very corrosive on cars and cause rust. That's because saltwater has more electrons, which is what enables rusting and corrosion. Sodium chloride is also known to turn fresh water salty. Research shows that 70% of salt

applied onto roads stays within the watershed of the region. It's very expensive and difficult to remove the contamination (Rastogi, 2010).

Although sodium chloride has all these drawbacks, we cannot abandon it altogether. Sodium chloride is put onto snow and ice to melt it, which can prevent many accidents and save many lives. According to the United States Department of Transportation Federal Highway Administration, 70% of people in the U.S. live in a snowy region. Every year over 1,300 people are killed and around 116,800 people are injured in accidents on snowy, slushy, or icy pavements. According to the American Highway Users Alliance, road salt can prevent up to 93% of accidents. But there are also salts that melt ice that don't have the drawbacks that sodium chloride has.

Calcium chloride is a hygroscopic compound, so it absorbs moisture and dissolves quickly into a brine. It has the lowest effective temperature, -25°F, compared to other salts. It is very corrosive towards metals but doesn't harm the environment. For example, sometimes salt can get underneath a car which causes rust. Calcium chloride can also harm pet's paws, specifically dogs. It can cause dryness and irritation to their paws and skin.

Magnesium chloride is also a hygroscopic compound. It's lowest effective temperature is 5°F. Magnesium chloride also has more water molecules, so it can quickly be diluted. Due to this, magnesium chloride has a short state of activity, so it sometimes has to be applied over and over again. Magnesium chloride is also corrosive, but not as corrosive as calcium chloride. Both calcium and magnesium chloride are corrosive towards concrete.

Potassium chloride has endothermic properties, and it limits ice melting because 25°F is when potassium chloride is efficient for ice melting. It can melt snow and ice as low as -12°F. It is a little corrosive but not as corrosive as the other salts. It is also safe for pets. Potassium chloride is also used to prevent low blood levels and is used as a water softener.

The purpose of this project is to find out which salt can melt snow the fastest and at the same time be environmentally friendly to nature. I noticed that there are large amounts of salt being used and that there are many drawbacks to this, such as harm to animals, plants, and turning freshwater salty. I heard about different types of road salt that do not have the same flaws as sodium chloride and are still as effective, and wanted to put them to the test.

2. Introduction

Question: Which salt, calcium chloride, magnesium chloride, potassium chloride, or sodium chloride, melts snow the fastest and harms the environment the least? Purpose: Every winter, we try to make the roads less prone to accidents by using rock salt to melt snow and ice. Doing this, we apply about 10 million tons of rock salt, sodium chloride, every year in the United States. However, like everything else, actions have consequences. There are many downfalls that rock salt has on our environment, such as turning freshwater salty, harming aquatic animals and land animals, harms plants, and harms buildings. We heard about different types of rock salt that don't harm the environment but are still as effective, and we wanted to put them to the test.

Hypothesis: If calcium chloride is applied to melt snow and ice, then it will melt the snow and ice faster than sodium, magnesium, and potassium chloride and will harm the environment the least. We believe this is because calcium chloride is a hygroscopic compound, so it absorbs moisture and dissolves quickly. It also has the lowest effective temperature, -25°F, compared to other salts.

3. Experimental Design

This section provides details of experimental design including independent variables, dependent variable, control variable, experimental groups, materials and procedures.

Independent Variable:
The type of salt, calcium chloride, magnesium chloride, potassium chloride, or sodium chloride.

Dependent Variable:
How fast the snow and ice are melted and how the grass soil pH is affected.

Control Variable:
The constants include the location, a garage, the temperature, 30° degrees Fahrenheit, the amount of snow and ice, 538 milliliters the amount of salt applied, 355milliliters, and the amount of grass, 5 x 5 x 22 centimeter block.

Experimental Groups:
1. Calcium chloride
2. Magnesium chloride
3. Potassium chloride
4. Sodium chloride

Materials:

- Twelve disposable baking trays (22 cm by 33 cm)
- Twenty-seven kilograms of All-Star Concrete Mix
- 355 milliliters of Road Runner Calcium Chloride
- 355 milliliters of Road Runner Magnesium Chloride
- 355 milliliters of Morton Potassium Chloride
- 355 milliliters of Morton Sodium Chloride
- Trowel (size and material does not affect the experiment)
- Large wooden dowel to mix with (size and material does not affect the experiment)
- Two liters of tap water
- A large bucket to mix concrete in (size and material does not affect the experiment)
- Nitrile gloves
- Black Sharpie marker to label
- Twelve 5 x 5 x 22 centimeter blocks of grass
- 538 milliliters of fresh snow
- Garage (or any other cool location)
- Stopwatch
- Journal and writing utensil

Procedures

1. Open the concrete mix and pour it into a large bucket.
2. Slowly add the 2 liters of water and stir at the same time. You may need another person's help with this.
3. Mix the concrete very thoroughly with the dowel. Continuously mix the concrete to ensure that it will not harden up.
4. You want to reach a consistency where the concrete is not sandy, but it is not very liquidy either. To ensure that it is the right consistency, you can add little amounts of water or the concrete mix.

5. Carefully pour the concrete into one of the baking trays. Only pour the concrete into ¾ of the tray. Make sure that the thickness of the concrete is even. The exact thickness will not affect the experiment, but it is requested to keep it around the same thickness.
6. Use the trowel to smooth the concrete out.
7. Repeat steps 5 and 6 to the rest of the trays.
8. Repeat steps 1 to 4 if more concrete is needed.
9. Take 29 milliliters of calcium chloride and spread it out evenly on the snow for 3 trays. Label the tray with the marker.
10. Take 29 milliliters of magnesium chloride and spread it out evenly on the snow for 3 trays. Label the tray with the marker.
11. Take 29 milliliters of potassium chloride and spread it out evenly on the snow for 3 trays. Label the tray with the marker.
12. Take 29 milliliters of sodium chloride and spread it out evenly on the snow for 3 trays. Label the tray with the marker.
13. Let it dry for a minimum of 36 hours.
14. Take one of the sections of grass and place it in the empty area of the tray. Repeat this for the other trays.
15. Measure the pH level of the soil with the pH strip. Record it in your journal.
16. Place the trays into an electric cooler. Do not stack them on top of each other. If needed, use racks that fit your cooler.
17. Take 2 cups of snow and spread it out evenly on the concrete slabs for each tray. Label the tray with the marker.
18. Start recording with the stopwatch. Record in your journal the time it took for the snow to melt from each salt.
19. Look at the grass from each of the trays. Measure the pH level of the soil with the pH strip. Record in your journal the pH level.

4. Analysis

Tables 1-4 show the average time for the snow to melt, potassium chloride took the fastest time to melt, which is 30 minutes less than the amount of time it took for sodium chloride, which is the salt that is currently being used on our roads. In fact, sodium chloride took the longest time to melt the snow. The sodium chloride also changed the pH of the grass the most, by increasing the pH from 7 to an average of 12.3. Calcium chloride increased the pH level the least, going from 7 to an average of 8. This was followed closely by magnesium chloride, increasing the pH level from 7 to an average of 8.3. This could mean that potassium chloride melts snow the fastest but calcium chloride harms the environment the least. Figures 1-4 shows the melting time for those options.

Table 1. Melting time and pH level with Calcium Chloride

Trials	Time Snow was Melted in	pH of Soil
Trial 1	30 minutes	8
Trial 2	30 minutes	8
Trial 3	47 minutes	8
Average	35.6 minutes	8

Table 2. Melting time and pH level with Magnesium Chloride

Trials	Time Snow was Melted in	pH of Soil
Trial 1	48 minutes	8
Trial 2	50 minutes	9
Trial 3	55 minutes	9
Average	51 minutes	8.3

Table 3. Melting time and pH level with Potassium Chloride

Trials	Time Snow was Melted in	pH of Soil
Trial 1	20 minutes	10
Trial 2	25 minutes	11
Trial 3	30 minutes	12
Average	25 minutes	11

Table 4. Melting time and pH level with Sodium Chloride

Trials	Time Snow was Melted in	pH of Soil
Trial 1	52 minutes	11
Trial 2	55 minutes	12
Trial 3	60 minutes	14
Average	55.6 minutes	12.3

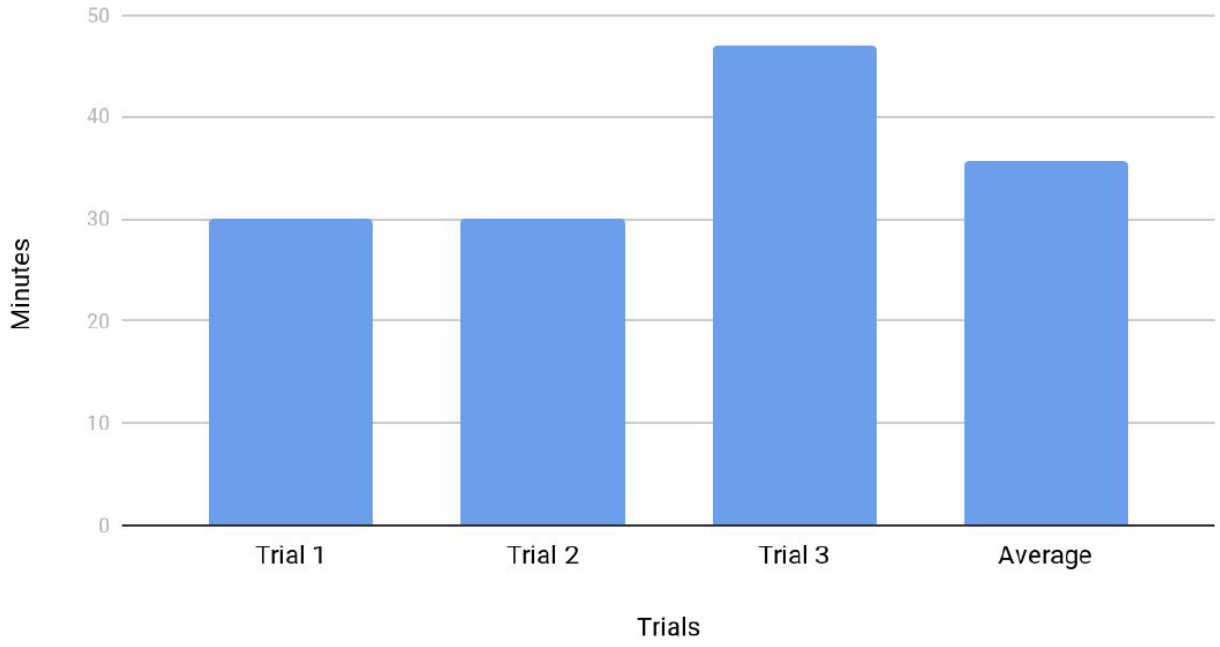

Figure 1. Timing for snow to melt with calcium chloride

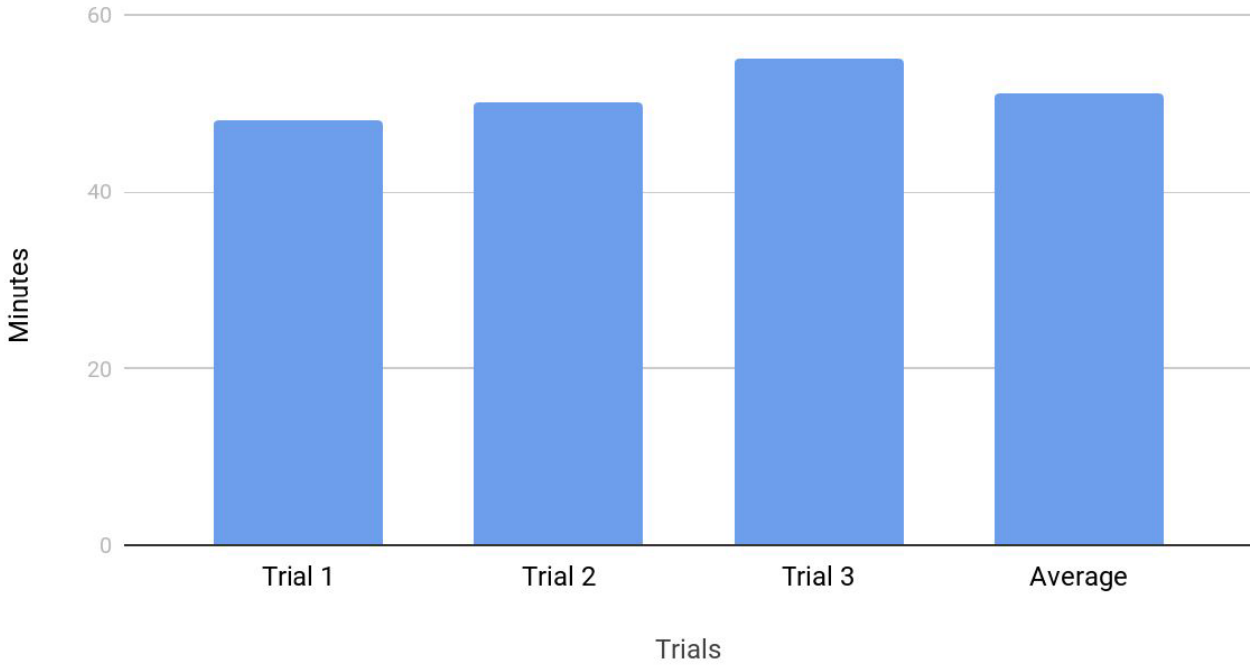

Figure 2. Timing for snow to melt with magnesium chloride

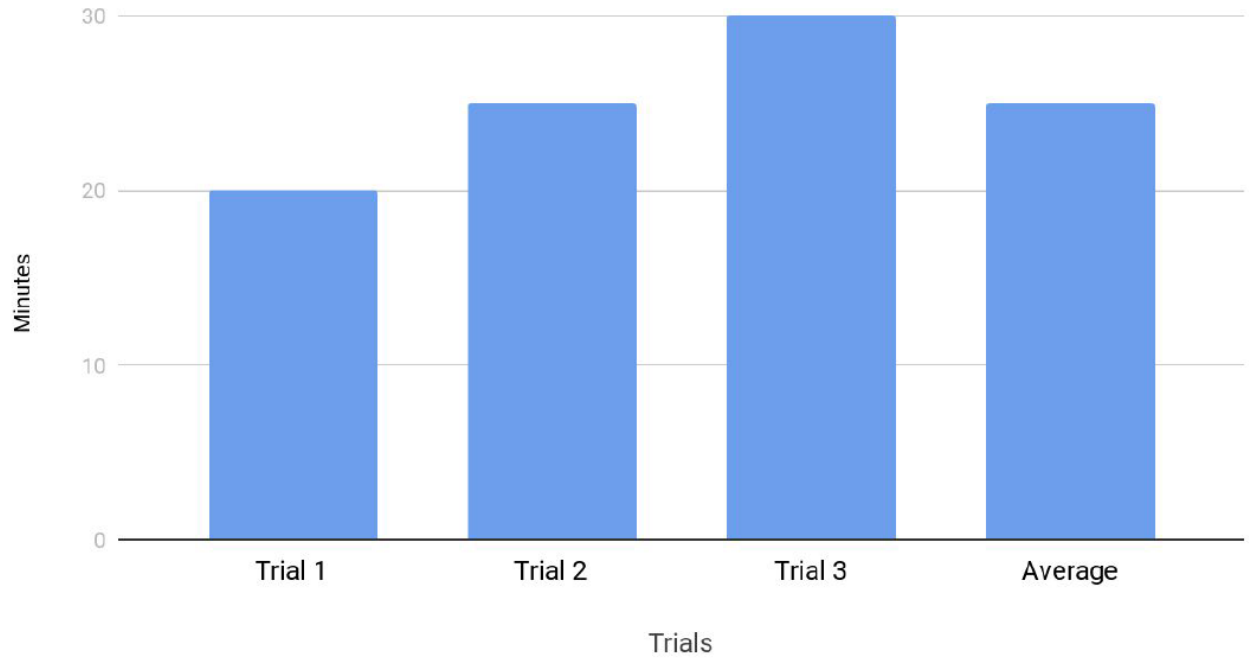

Figure 3. Timing for snow to melt with potassium chloride

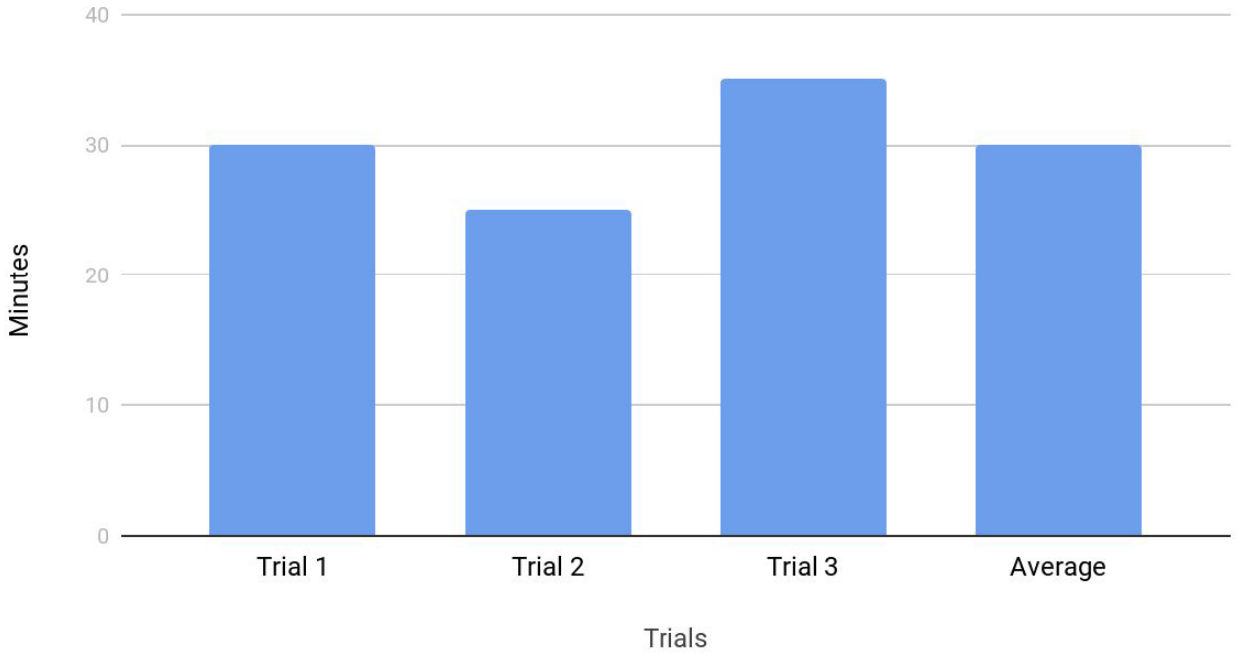

Figure 4. Timing for snow to melt with sodium chloride

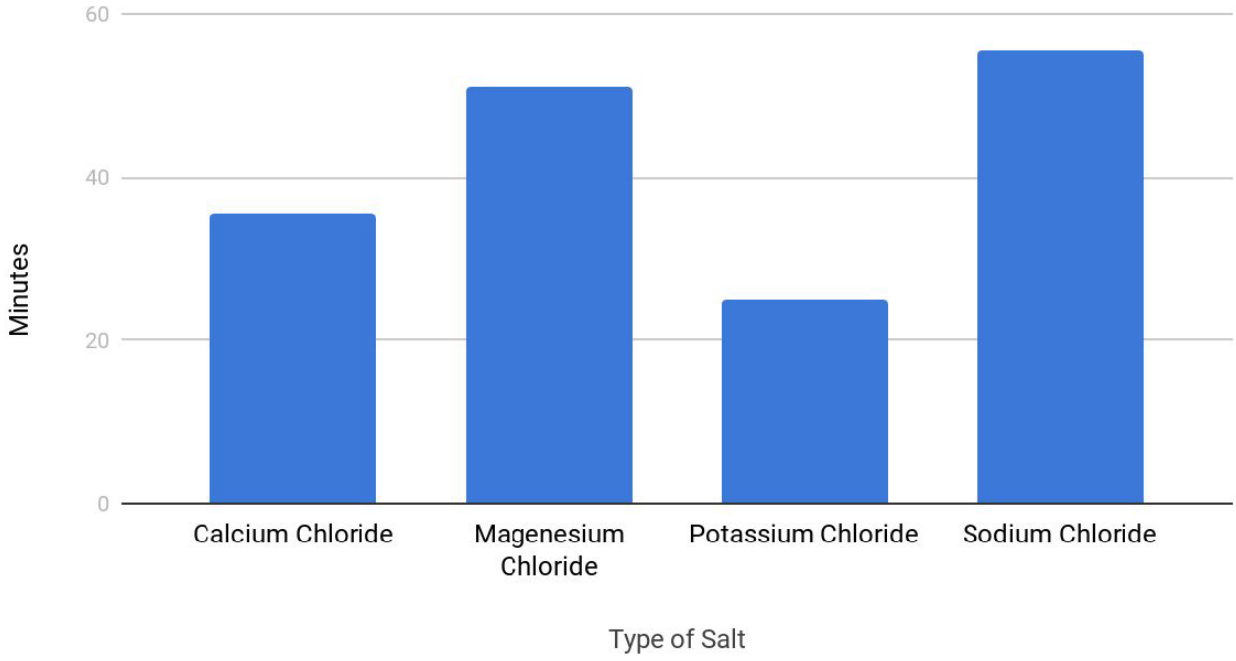

Figure 5. Average time of snow melting for each salt

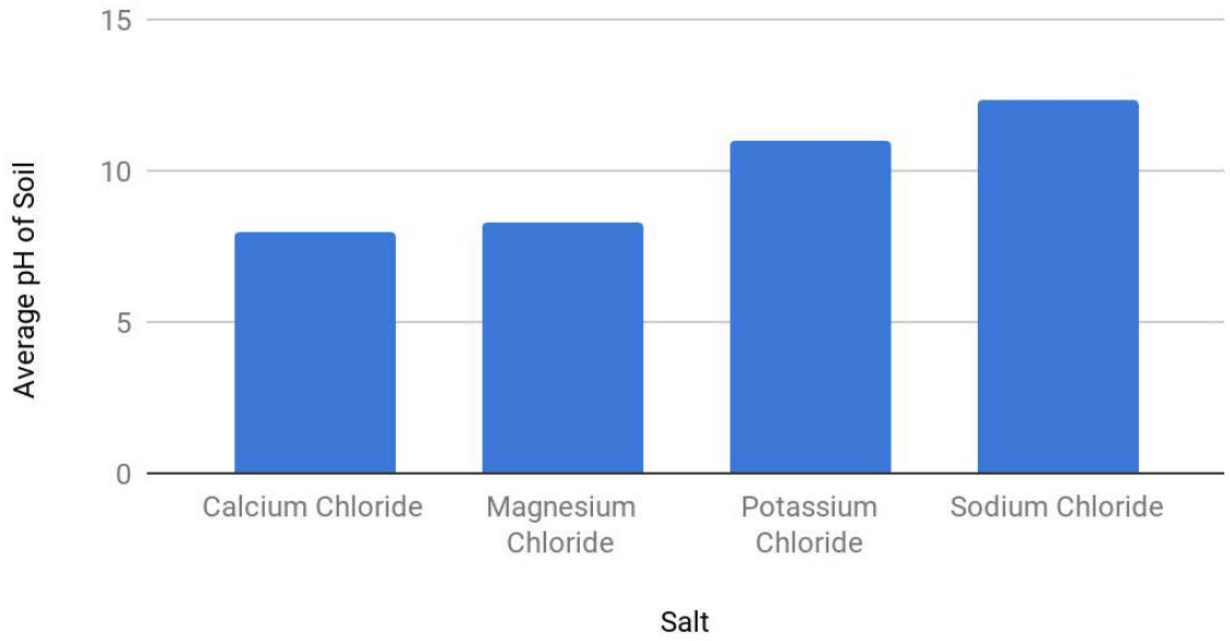

Figure 6. Average pH of soil with each salt

Figures 5-6 depicts the average melting times and average pH levels.

Experimental Errors
Random errors and gross errors are recorded and are shown below:

Random Errors:
1. The color of the pH strip could have been interpreted incorrectly.
2. The surrounding temperature could have changed slightly.

Gross Errors:
1. The amount of salt may not have been consistent throughout the experiment. (This is a gross error because a human could've made the amounts of salt inconsistent throughout the experiment).
2. The amount of snow may not have been consistent throughout the experiment.
3. The amount of grass may not have been consistent throughout the experiment.

5. Conclusion
My hypothesis states, "If calcium chloride is applied to melt snow and ice, then it will melt the snow and ice faster than sodium, magnesium, and potassium chloride and will change the pH level the least." I made two claims in the hypothesis. I accept the part of our hypothesis where it states that calcium chloride will have the pH level the least. However, the potassium chloride melted the snow the fastest, so I reject our hypothesis in that matter. There are many consequences to using road salt, specifically sodium chloride, to melt snow on our roads. It causes freshwater to turn salty, harming aquatic animals, land animals, harms plants and is corrosive to metal and concrete. I found out there are other salts that can melt salt and decided to compare them to each other.

According to the data, potassium chloride took the fastest time to melt, which is 30 minutes less than the amount of time it took for sodium chloride, which is the salt that is currently being used on our roads. In fact, sodium chloride took the longest time to melt the snow. The sodium chloride also changed the pH of

the grass the most, by increasing the pH from 7 to an average of 12.3. Calcium chloride increased the pH level the least, going from 7 to an average of 8. This could mean that potassium chloride melts snow the fastest but calcium chloride harms the environment the least.

There are a few implications that can be found out from our project. The experiment has shown that calcium chloride changed the pH level of the grass the least, so maybe calcium chloride can be used as road salt around areas that grow agriculture, such as farms or areas where land quality is important, and fresh water bodies so the environment doesn't get harmed with the salt. The experiment has shown that sodium chloride took the most time to melt the snow, with an average of 55 minutes while potassium chloride took the least amount of time, with an average of 25 minutes. Since potassium chloride melts snow the fastest, potassium chloride can be used around suburban and urban roads, so the salt will melt faster. Maybe a combination of potassium and calcium chloride could be used so it can melt the snow more efficiently and harm the environment less. This will not only help the environment but will also potentially reduce accidents on the road and save more lives.

If I were to redo our experiment, we could do more trials to have more data and to reduce the margin of error. For example, the calcium chloride changed the pH level the least with an average of increasing the pH level by 1, but the magnesium chloride increased the pH level with an average of 1.3. This could've easily changed if more trials were to be done. Some next steps and follow up experiments that I could do are adding more elements, such as testing water quality, seeing the effect of animals with different salts in their environment, plant effects with different salts in their environment, and seeing the effect on metals and concrete to see how corrosive each salt is.

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Biography

Arita Zaman currently is a high school freshman at Novi High School. During the time of this project, she was an 8th grade student at Huda School, located in Franklin, Michigan. She hopes to pursue a career in the field of computer science, in our ever so developing and technologically lead world.