AP BIOLOGY SCIENCE PROJECT

How Does Run off from Salted Roads Affect the Heuchera Plant?

By Steve Chou and Dan Dunkley

\*1

4/23/01

**Introduction:**

# **BACKGROUND**

On January 23, while vacationing with his family in Boston, Massachusetts, Dan noticed the overwhelming amount of salt used on streets and sidewalks to prevent ice from forming. He pondered how the salt would affect the environment when it is washed into the environment.

Millions of people throughout the world live in environments that reach temperatures below freezing and ice on roads and sidewalks is a common occurrence. Very often, the counter by simply applying rock salt to these surfaces to lower the freezing point of the water and prevent ice from forming. The problem with this is that the salt is dissolved into the water and taken away as runoff. This necessitates frequent re-salting of the surfaces. In fact, many apply salt daily to ensure safe roads. This large amount of salt buildup introduced into the ecosystem can play a major role in determining the success of plant life.

Turgor pressure is essential to plant life as it ensures ample water throughout the plant, which is needed to complete photosynthesis, as well as making the cells in the plant rigid, which is necessary for the plant to support itself. Plants draw the water into the root system by maintaining a hypertonic solution within the root system. This means that the solute concentration within the plant is significantly higher within the plant than that of the water. Water, by nature, seeks equilibrium. Through the use of osmosis, water is transferred from the soil surrounding the plant’s root system to within the plant. However, when the water surrounding the root system has a high salt concentration, this upsets the balance needed to maintain osmosis flowing into the roots.

As the salt concentration of the soil surrounding the root system rises, less water from the soil is drawn into the plant, as the difference in solute concentration is not as drastic. This decrease in water transfer decreases the turgor pressure within the plant. This results in some loss of rigidity within the plant cells, causing the leaves to droop and decreasing surface area of the leaves. Because the leaves will also be lower to the ground, they will often be in the shadows of healthier plants and will also be more susceptible to predators.

If the salt concentration outside the roots is equal to the solute concentration inside, it creates an isotonic situation where water will neither leave nor enter the root system. This causes a problem, as water pressure is essential in maintaining ideal turgor pressure. The plant will no longer be able to maintain rigidity in it’s cells and the stems and leaves will no longer be able to support their own weight. This drooping decreases exposure to sunlight as it lowers surface area of the leaves. The leaves will now be closer to the ground, which will often put them in the shadows of competition for sunlight. This also puts the leaves in jeopardy of being eaten by primary consumers.

As salt concentration in the soil surpasses the concentration within the root system, a hypotonic situation arises where water within the plant is actually drawn out of the plant. This makes plant life impossible, as photosynthesis is no longer possible with this absence of water. Without photosynthesis, the plant cannot create energy and cannot live.

## **SAND**

Sand is sometimes used on roads at risk of freezing because it can both increase traction of tires by providing a rougher surface. However, sand actually inhibits the process of deicing by salt or other deicing chemicals (Salt Institute).

# **SALT**

Salt is an ideal deicing agent for many reasons. Most importantly it effectively reduces the freezing point of water, which will prevent ice from forming. This is because when the salt is dissolved into the water, it chemically bonds to the H2O molecules. . This bond requires more energy loss to form into ice crystals. (Oregon State University). As salt scattered onto roads melts the surface ice, it forms “brine,” or a strong saline solution (Salt Institute). This brine then sinks down into cracks in the ice and snow and the high salt concentration prevents water from freezing and bonding to the pavement. This, in effect, will break up the ice and snow on roads quickly and prevent more from forming as long as ample salt is present. Salt also reduces work required to return roads to safe conditions.

Furthermore, salt significantly reduces manpower needed to maintain safe roads. If deicing agents weren’t available, roads would need to be cleared manually very frequently. The snowplows used to clear the ice would wear the roads out quickly, raising costs, in addition to creating traffic problems.

Many alternatives to salt have been found have major drawbacks. Salt is also ideal because it is safer to handle than alternatives. Salt is relatively benign to humans, as it is even an essential part of our diet. Alternatives can be dangerous to human road workers to implement. They can also have more drastic effects on the environment. Some are also significantly more expensive and damaging to roadways or nearby structures.

**SALT IMPURITIES**

Salt from different regions generally have different impurities. We used California solar salt, which is one of the most pure and free from additives. Solar salt is created from being dried in a kiln, ensuring purity through evaporation. The chemical makeup of California solar salt, according to Martina Moran of the Salt Institute, is:

**99.75% NaCl (dry basis)**

**Impurities:**

**0.01% water insoluble**

**0.17% CaSO4**

**0.018%MgSO4**

**0.013% MgCl2**

**0.03% Sodium Sulfate**

We do not believe that these low levels of impurities would significantly affect our data as we kept the type and brand of salt consistent throughout the experiment. However, the salts with more impurities are used in various other regions of America. One such example is Kansas rock salt, which consists of:

**95.8-97.4% NaCl (dry basis**

**Impurities:**

**0.015% iron oxide**

**2.2-3.5% CaSO4 (much of which is insoluble)**

**0.004-0.09% MgSO4**

**.20-0.26% MgCl2**

Another type of salt commonly used for deicing roads is gulf coast rock salt, which consists of:

**99.01-99.26% NaCl (dry basis)**

**Impurities:**

**0.54-0.75% water insoluble**

**0.17-0.24% CaSO4**

**.004-.012% CaCl2**

**.002-0.011% MgCl2**

Although these impurities remain throughout the rock salt, they play very little impact on our experiment, as their numbers are so insignificant.

# **OUR PLANT**

When choosing the plant to test, we wanted one that could be commonly found in colder climates that would be subject to icy road conditions. We went to Navlet’s nursery in Fremont, California and spoke with Phil Morgan, the manager and a specialist in botany. He suggested the Northern Fire Huechera (Huechera Sanguinea) as a plant that could sustain life in very cold climates. He also noted that they were generally fairly hardy and would be a good indicator as to whether or not the salt concentration in runoff would significantly affect the environment.

We ultimately settled upon his recommendation of Northern Fire. This particular plant can thrive in USDA hardiness zones ranging anywhere from 4-10. (Bobna) This range includes much of the United States and Canada, which encompasses some very cold regions.

The Northern Fire Heuchera grows to a height of 24”. It has large green marbled foliage with double raspberry-red flowers. They thrive in light shade with moist, well-drained soil. We opted to test younger Heuchera of around 4cm in height. This was ideal because much of the runoff of the salt would occur in late winter and spring, when the plants would still be sprouting. This size plant best modeled the effects salt would have on the environment in a more natural setting.

**Hypothesis:**

The runoff from salted roads will have a negative impact on the surrounding plant life.

**Prediction:**

If salt has a negative impact on the environment, then plants, which are exposed to high concentrations of salt, will display negative results such as decreased growth and death.

**Procedure:**

We put each set of 6 plants together in one planter box. All of the planter boxes were identical, as they were 48" long, 8" wide, and 10" deep, with two holes in the bottom for drainage. We put about 1 and 1/3 cubic feet of soil in each planter, as we filled them with soil to about four inches from the top. The soil we used was Nursery Man's Gardener’s Gold. It contains all natural ingredients, including fir bark, worm castings, topsoil, redwood, peat moss, perlite, chicken manure, bat guano, kelp meal, oyster shell, and dolomite lime (because it did not give specific amounts of the ingredients, we recommend using this same brand to exactly replicate the experiment.) We selected this soil because it was all natural and contained no chemicals, which might have upset our data. The planters themselves were placed outdoors in direct sunlight. The daily high temperatures ranged from 53 degrees Fahrenheit to 76 degrees Fahrenheit over the course of the experiment and the planters were always left outside. They were all placed close together and they all received the same amount of sunlight, as there were no nearby objects that would put some plants in shadows but not others. They were all watered daily at around 4:00 PM, as this would be when the sun would melt the most snow and runoff would likely be at it's highest.

The concentrations of the saltwater we used were 0%, 2%, 4%, 6%, and 8%, and the concentration of the sand was 8%. We decided that it would take approximately 16 cups of water to properly saturate each of the 6 planters, each holding a set of six plants that would be tested at the same concentration level. We calculated that to achieve these percentages, we would have to have 2.56 ounces of pure salt in the 128 ounces of 2% salt water. For 4%, we used 5.12 ounces. The 6% salt water needed 7.68 ounces of salt and the 8% needed 10.24 ounces of salt. When measuring the salt, we used water displacement to ensure accurate water percentages. To accomplish this, we would fill a 40 ounce graduated cylinder to the 20ounce mark. We would then add salt until the water level reached the appropriate level, depending on the concentration we were going for. For example, to measure out the 2% concentration of salt, we filled the graduated cylinder to the twenty-ounce mark with pure water and then added salt until the water level reached 22.56. We would then add these 22.56 ounces to 105.44 more ounces of pure water to have a total of 2.56 ounces of salt 125.44 ounces of water. We would then stir until all of the salt was completely dissolved in the water. Finally, we would pour this water in the appropriate planter, being sure to pour evenly across the whole surface of the planter. For the sand, we would follow the same procedure as the highest concentration of salt, but the sand would not dissolve because it is not polar. For the control (0% salt), we just poured 16 cups of water evenly across the entire surface.

We took measurements of the lenght of the longest stem of each plant and the largest leaf of each plant (measuring from the point where the stem meets the leaf to the tip of the leaf) just before watering.

# **Journal**

**3/7** - Dan did pre-project research. Found the website of the National Salt Institute as well as writing emails requesting information to both National Salt Institute and UC Berkeley

**3/8** - Steve continued with Dan’s research, finding essential articles within the Salt Institute’s website

**3/20** - Both Steve and Dan drew up the preliminary details on the subject.

**3/24** - Visited nursery and met with botanist to find a suitable plant

**3/26** - Researched Huechera plant to assess its validity within our topic

**3/30** - Went back to nursery and purchased 36 Huechera plants

**4/1-4/7** - Dan cared for the plants and recorded the data

**4/8-4/15** - Steve cared for the plants and recorded the data

**4/19** **- Present** - Both Steve and Dan worked on write up together.

# **Bibliography**

1. http://www.seps.org/oracle/oracle.archive/Expert/Toco/Physical\_Science.Chemistry/1999.10/000937507522.24483

2. http://www.homearts.com/affil/gardb/zomemap.htm

3. http://www.bobna.com/products/heuchera.htm

4. http://www.saltinstitute.org/snowfighting/12-prewet.html

5. http://www.pca.state.mn.us/publications/mnenvironment/fall2000/salt.html

6. http://www.nas.edu/trb/publications/sr235.html

7. http://www.ec.gc.ca/cceb1/eng/public/road\_salts.html

8. http://www.fhwa.dot.gov/reports/mopeap/eapcov.htm

9. In addition to these web links, we have email correspondence with a public transportation expert at the University of California at Berkeley as well as a specialist from the Salt Institute