

## **Science Fair Research Project 2022**

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**Title:** Ways of Water - How elements affect soil structure

**Question:**

1. How does the application of four Calcium Nitrate solution percentages and types affect the percolation of water through Sodium Chloride (NaCl) contaminated soil?
  - a. How does sodium affect the percolation of water through the soil?
  - b. How do you remove sodium contamination from the soil?

**Hypothesis:** If you contaminate the soil with Sodium causing dispersion, then applying different Calcium solution percentages and types will flocculate the soil differently. This action is due to the difference in the transfer of ions, in that the ion exchange requires the ion to replace the other ion to have more ion presence.

**Background Research:**

**Introduction**

My experiment is about how soil changes its function and structure when exposed to different chemicals. When Salt (sodium chloride powder) is added to soil, it becomes a less porous substance which slows/stops fluid from passing through it. When you add Calcium (calcium nitrate) to the soil/salt mixture, it reverses the effects making the soil porous again and allowing fluid to flow through it.

The different attributes of flocculated and dispersed soil structure affect the mechanics of soil structure. Flocculation is vital because water moves through large pores to get water to plants, and plant roots grow mainly in pore space. Dispersed clays plug soil pores and impede water movement and soil drainage.

***An example of how soils are contaminated.***

When we put salt (sodium chloride) on roads, it gets to the grass on the side of the road; sodium chloride replaces the calcium that is holding the clays together in clumps. Sodium builds up when water cannot infiltrate easily through the soil. The effect of sodium on soil structure depends on the amount of clay or silt in the soil. Hard pans are more common in clay-based soils, and concrete layers are in silty soils. The reactions in this experiment and Alberta soils are caused because there is more clay to disperse.

When the clay disperses (spreads out) and the spaces in the soil crumb structure (spaces in between dirt particles), the water can use the clay particles to expand (swelling), decreasing porosity. Once there is no space for water to get through the soil to the roots of plants or any other microorganisms beneath this "shield." The plants and microorganisms die when they do not get water!

**Role of Water**

Water plays several roles in this process. It carries the sodium chloride into the soil; it aids in the swelling of the clay, causing loss of porosity. Once the swollen clay/soil sodium chloride mixture dries, it becomes hard like a brick, preventing water from passing through. When the soil becomes hard through the dispersion process, it restricts water from penetrating the soil and limiting plant roots from accessing water. Water also plays a role in bringing the calcium to the hardened soils and releasing the salt from the soil, increasing porosity.

### ***An example of how soils are decontaminated***

To 'clean' the grass on the side of the road that is covered in salt, you need to reverse the sodium contamination process so that water can flow through the soil again. Adding calcium (calcium nitrate) to the soil/sodium mixture changes the composition by reversing the effects and increasing porosity.

### **The Chemistry of Soil Contamination**

The chemistry involved in this experiment is complex due to the many roles of soil, water, calcium nitrate, and sodium chloride.

#### **Soil**

The soil composition in Alberta is a blend of organic matter, minerals, and clay. As there is a high percentage of clay in Alberta soil, this project is especially relevant to our environment. The soil used in this experiment consisted of gardening soil from the garden center. Bentonite and Kaolinite were added to the soil to mimic the local soil conditions better. The soil mixture percentage was 12.5% clay and 87.5% soil. Calcium nitrate exists in soils and acts as an agent that maintains a typical soil crumb structure.

#### **Water**

The chemical role of water is simply to carry the chemicals through the soils and aid in the swelling of the clay particles in the soil.

### **Ion Exchange: Chemical Reactions of Calcium and Sodium Through the Contamination and Amendment Process.**

The ion exchange happens when sodium, an element that has a Mono-valent Cation, has a higher percentage of ions than calcium, so it replaces calcium in the dispersion process. During flocculation of the soil, calcium, an element that has a Di-valent Cation and has a higher percentage of ions than sodium, replaces sodium ions. Flocculation is when calcium replaces the sodium and the soil particles attract back together because calcium has a higher attraction to the negatively charged soil particles than sodium.

#### **Sodium Chloride**

Sodium chloride causes dispersion. Dispersion is when sodium has a higher percentage of calcium ions, and replaces the calcium in the clay soils, causing clay particles in soil to repel each other and disperse (spread out). The clay particles then fill the soil pores (spaces in between dirt particles), then the clay particles swell with freshwater. Once this occurs, there is no space for water to get through to any plant roots or other microorganisms.

## **Calcium Nitrate**

Calcium nitrate causes flocculation. Flocculation is when calcium has a equal or higher amount of ions, and replaces sodium, then the soil particles attract back together. This causes the soil to form small clumps, improving soil crumb structure, and decreasing clay swelling. This process leaves the sodium to be leached (percolated) out. This process is the opposite of dispersion.

### ***An example of road salt contamination***

Road salt is sodium chloride (table salt) and comes from deposits leftover after prehistoric oceans evaporated, with huge solution mines in Northern and Central Alberta. Oftentimes, extra chemicals will be mixed in. For instance, road salt is less effective at melting ice when temperatures drop below -6 c — when it gets extremely cold, other chemicals like magnesium chloride or calcium chloride are mixed in. Another way to test contaminated soil is to use air. In labs, they blow air through the soil, and by the pressure building up, they can tell how much the soil is contaminated

## **Mechanics**

### **How to measure percolation in contaminated and amended soils.**

The amount of water per percolation time is equal to the percolation rate, or milliliters (ml) per minute (min). For example, if 200 ml of water percolates through the soil sample in 40 minutes then the percolation rate is 200 ml per 40 minutes = 5ml per minute.

### **How to Calculate the weight of Sodium Chloride Powder and Calcium Nitrate Powder.**

I decided on the percentages to use, then I converted the percentages to weight. Below is two examples of the percentages I used.

#### **Sodium chloride powder**

- $2.5\% / 100 = 0.025g$
- $1,250ml * 0.025g = 31.25 \text{ grams sodium chloride powder}$

#### **Calcium Nitrate Powder.**

- $5\% / 100 = 0.05g$
- $250ml * 0.05g = 12.5g$

## **Summary**

In summary, when soil gets contaminated by Sodium Chloride, it causes dispersion, when sodium replaces the calcium in the clay soils causing the clay particles to repel each other. The clay particles then disperse (spread out), filling the soil pores (spaces in between dirt particles). The clay particles expand with freshwater (swelling). Once this occurs there is no space for water to get through to any plant roots or other microorganisms beneath this “shield.” Then calcium nitrate replaces sodium, causing flocculation, when calcium replaces the sodium and

the soil particles attract back together because calcium has a higher attraction to the negatively charged soil particles than sodium. This causes the soil to form small clumps, improving soil crumb structure, and decreasing clay swelling. This process leaves the sodium to be leached (percolated) out.

### Definitions:

1. **Flocculation** is when calcium replaces the sodium and the soil particles attract back together because calcium has a higher attraction to the negatively charged soil particles than sodium. This causes the soil to form small clumps, improving soil crumb structure, and decreasing clay swelling. This process leaves the sodium to be leached (percolated) out.
2. **Dispersion** is when sodium replaces the calcium in the clay soils causing them to repel each other. The clay particles then disperse (spread out), filling the soil pores (spaces in between dirt particles). The clay particles expand with freshwater (swelling). Once this occurs there is no space for water to get through to any plant roots or other microorganisms beneath this "shield."
3. **Percolation** is the action of running water through something
4. **Leaching** is the process of water carrying soluble substances (substances that dissolve in water) or small particles through soil
5. **Ion Exchange** is when one ion has a higher percentage of ions than another and replaces the other, (Ca for Na, or Na for Ca)
6. A **Colloid** is any substance made up of particles larger than atoms or ordinary molecules but too small to be seen with the bare eye.
7. **Surface crusting** is a cement-like surface layer when the soil dries after the dispersion process
8. A **Cation** is a positively charged ion
9. An **Anion** is a negatively charged ion
10. **Valence** is the combining power of an element
11. **Di-valent** is having two valence
12. **Mono-valent** is having one valence
13. Soils with a high percentage of sodium in the soil are called **Sodic Soils**.

### Variables (Manipulated, Responding, Controlled):

#### Manipulated Variable

- Sodium Chloride
- Calcium Nitrate
- Water (H<sub>2</sub>O) in Soil

#### Responding Variable

- Percolation of water through the soil

#### Control

- Soil
- Type of water
- Type of plastic container
- Cheesecloth
- Containers (Plastic Tube and Sieve)

- Environment (space, light, temperature)
- Measuring cup
- Tubes
- Sieves
- Table

**Materials:**

- Soils
- Clay (Bentonite, Kaolinite)
- Freshwater
- Calcium nitrate
- Sodium chloride
- Cheesecloth
- Containers: Plastic Tubes and Sieves
- Plastic containers
- Table
- Measuring 1 cup

**Procedure:**

**Soil Containers**

*Container 1: Control - Pure Soil Mixture*

*Container 2: Soil Mixture with Sodium*

*Container 3: Soil Mixture with Sodium: 5% calcium water mix*

*Container 4: Soil Mixture with Sodium: 2.5% calcium water mix*

*Container 5: Soil mixture with Sodium: 1% calcium water mix*

*Container 6: Soil Mixtures with Sodium: Eggshells mixture*

*\*\*Container Issue: The experiment started with plastic tubes, however, the duct tape failed so we moved the soils to sieves on Day 4.*

**Set-Up**

**Day 1 Preparation Day**

1. Set up Soil containers
  - a. *Plastic Tube:*
    - a. *Cut off bottoms of tubes*
    - b. *Dust out inside with a duster*
    - c. *Place four layers of cheesecloth on the bottom of tubes evenly*
    - d. *Put an elastic band around to hold the cheesecloth*
    - e. *Trim ends to 3.5 cm from the edge of the tube all the way around*
    - f. *Duct tape edges of cheesecloth to tube*
    - g. *Duct tape from the edge of the tube around the tube*
2. *Prepare soil*
  - a. *Mix 400g (2 cups) bentonite & 200g (1 cup) kaolinite to make clay*
  - b. *Add 600g (3 cups) of clay mixture (clay is 400g (2 cups) smectite & 200g (1 cup) kaolinite) to 4200g (21 cups) of soil equaling 24 cups of soil mixture*
  - c. *The soil mixture percentage is 12.5% clay and 87.5% soil*
  - d. *Mix thoroughly for five minutes*

## Day 2

3. Add 800g (4 cups) of clay infused soil to each soil container
4. *Mix chemicals that will contaminate the soil*
  - a. *Add 31.25 grams of sodium chloride to 1420 ml of water*
  - b. *Contaminant mixture percentage is 2.5 % Sodium chloride, 97.5% water*
  - c. *Stir till sodium is dissolved*
  - d. *Pour 250 ml (1 cup) of Contaminant mixture into soil containers 2 through 6. Container one is the control.*
5. *Add 250 of water to each soil container*
6. *Heat with a space heater to dry/bake soil overnight (26 C degrees)*

## Day 3

7. *Measure how much water percolated from day 2 to day 3*
8. *Continue to dry/bake soil (26 C),*
  - a. *Add a heater to help dry out the soils.*

## Day 4

9. *The duct tape failed and soil was moved from tubes to sieves. Experiment re-setup consisted of:*
  - i. *Put two pieces of cheesecloth one way and two other pieces of cheesecloth the other way on the inside of the soil container.*
  - ii. *Put an elastic band around the soil container so that the handle and the support/hanging loop are below the elastic band to hold the cheesecloth*
  - iii. *Tie a string around the soil containers so that the handle and the support/hanging loop are below string to secure the cheesecloth*
  - iv. *Place it open side up on the plastic container. The plastic containers will collect water for measurements.*
10. *To measure percolation rate, 1 cup tap water was poured through Containers 3, 4, 5 & 6*
11. *Measure time and volume of water percolation 3, 4, 5, & 6*
  - a. *Record following information on observation chart:*
  - b. *Measure every five minutes for 30 minutes*
  - c. *Then measure every ten minutes for 30 minutes*
  - d. *Measure again, after an hour*
12. *The flocculation process included adding calcium to designated containers*
  - a. *Make calcium mixture 1 for Container 3*
    - i. *Add 12.5g of calcium to 250ml of water (5% Calcium)*
  - b. *Make calcium mixture 2 for Container 4*
    - i. *Add 6.25g of calcium to 250ml of water (2.5% Calcium)*
  - c. *Make calcium mixture 3 for Container 5*
    - i. *Add 2.5g of calcium to 250ml of water (1% Calcium)*
  - d. *Make calcium mixture 4 for Container 6*
    - i. *Mix 68 ml of 10 crushed eggshells to 200mls tap water*
13. *Add Calcium/water mix 1 (CaNO<sub>3</sub> and H<sub>2</sub>O) to Container 3*
14. *Add Calcium/water mix 2 (CaNO<sub>3</sub> and H<sub>2</sub>O) to Container 4*
15. *Add Calcium/water mix 3 (CaNO<sub>3</sub> and H<sub>2</sub>O) to Container 5*
16. *Add Calcium(eggshells)/water mix 4 to Container 6*
17. *Add water to 1, 2, 3, 4, 5, & 6*
18. *Measure time and volume of water percolation of containers 1, 2, 3, 4, 5, & 6*
  - a. *Record following information on observation chart:*
  - b. *Measure every five minutes for 30 minutes*

- c. *Then measure every ten minutes for 30 minutes*
- d. *Measure again, after an hour*

**Observations:**

Contaminated Soil Observations (Containers 3-6)

1. At 5 minutes containers 3 and 5 percolated between 150 - 152 ml of water and 4 and 6 percolated between 129 and 132 ml of water. 3 & 5 seemed to be percolation water faster than 4 & 6.
2. At 10 minutes containers 3, 4, and 5 percolated at different rates between 170-177 ml of water, and container 6 was lower at 136ml percolation of water.
3. At 15 minutes containers 3 through 6 started to show ore variation. There is a 52ml difference between containers 5 and 6. Container 5 at 192 ml is percolating much faster than container six at 140mls of water.
4. \*\*\*Container six stayed in the forties the whole time after the 15-minute mark
5. At 20 minutes the container seems to be percolating the fastest as it is the highest with 200ml. It increased only in small increments for the rest of the contamination test.
6. there was a 20ml difference between containers 3 and 5 (container 3 at 180 and container 5 at 200). And there was a 12ml difference between containers 4 and 5 (container 4 at 188 and container 5 at 200)
7. Changes in water percolation seem to be smaller after 25 minutes. At 25 minutes, container 4 stayed the same and containers 3 and 5 both percolated 2ml.
8. At 30 minutes container 4 percolated 4ml, container 3 percolated 3ml, and container 5 percolated 2 ml
9. At 40 minutes containers 3 and 4 both percolated between 185 - 192 ml of water, and container 5 percolated 207ml
10. At 50 minutes container 3 percolated an additional 13ml bringing it to 203 ml, which was a large percolation at a later time, more than the other containers.
11. At 60 minutes container 4 stayed the same and containers 3 and five both gained 1ml, container 6 remains the same.
12. At 120 minutes container 5 gained 1 ml, container 4 gained 3ml, and container 3 gained 8ml, container 6 remains the same.

Percolated soil observations: In the percolation rate of Flocculated soils, these are three observations.

1. Container 2 only went up by one the last five times and by two the fourth-fifth time
2. Containers 1,3,4,5,6 all had similar numbers at the same times
3. Container 2 never made it past 200ml, while containers 1 and 6 past 200ml at the five-minute mark, and containers 3, 4, 5, all passed 200ml on the 10-minute mark
  - a. At five minutes containers 1 and six already passed the 200ml point. Container 4 and container 5 percolated between 190ml-192ml. Container 6 has the same percolation rate as the control.
  - b. At 10 minutes all containers other than container 2 are higher than 200ml. Containers 4 to 6 have a higher percolation rate than the control. Containers 4-6 percolated between 212ml-214ml. Containers 1and 3 percolated between 208ml-210ml.
  - c. At 15 minutes container 2 was at 185ml, and container 6 was at 229, so there is a 44ml difference. Containers 1, 3, 2, and 5 percolated between 211ml-214ml.

Container 1 and container 3 so far have had very similar results. Container 6 has a higher percolation rate than the control.

- d. At 20 minutes containers 3-6 are higher than the control. Container 1 and container 5 percolated between 213ml-216ml. Container 3 and container 4 percolated between 222ml-224ml.
- e. At 25 minutes container 5 percolation increased by 10ml. Containers 3-6 percolated between 224ml-226ml.
- f. At 30 minutes container 1 percolation increased by 11ml. Container 6 has stayed at 229ml for 4 (including this one) measurements. Containers 3-5 percolated between 225ml-227ml. Containers 1 and 6 percolated between 227ml-229ml.
- g. At 40 minutes all containers other than container 2 percolated between 225ml and 230ml. Containers 1`-6 are all percolating in small increments.
- h. At 50 minutes container 6 has 35ml more percolated water than container 2, seeing as container 2 is at 195ml, and container 6 is at 230ml. Containers 1, 3, and 6 percolated between 230ml-230ml.
- i. At 60 minutes containers 1-6 other than container 2, percolated between 227ml-230ml. Container 5 has percolated at 227ml for four (including this one) measures. Containers 1`-6 are all percolating in small increments.
- j. At 120 minutes Containers 3 and 6 percolated between 236ml-237ml. Container 6 percolation increased by 7ml. Container 3 percolation increased by 6ml.

**Results:**

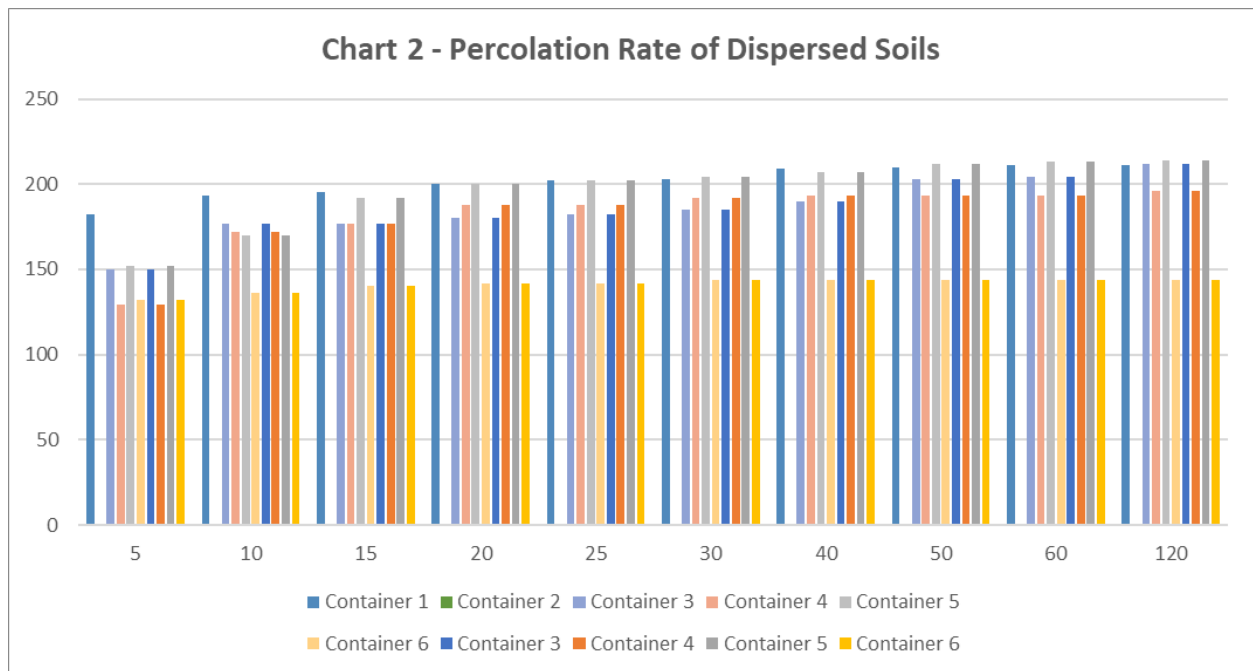
Chart 1 - Water percolation through initial soil mixtures

	Container 1	Container 2	Container 3	Container 4	Container 5	Container 6
24 hours	230	200	130	154	172	180

Chart 2 - Percolation rate of Dispersed Soils

	Container 1	Container 2	Container 3	Container 4	Container 5	Container 6
5:11 (5 min)	182	0	150ml	129ml	152ml	132ml
5:16 (10 min)	193	0	177ml	172ml	170ml	136ml
5:21 (15 min)	195	0	177ml	177ml	192ml	140ml
5:26 (20 min)	200	0	180ml	188ml	200ml	142ml
5:31 (25 min)	202	0	182ml	188ml	202ml	142ml

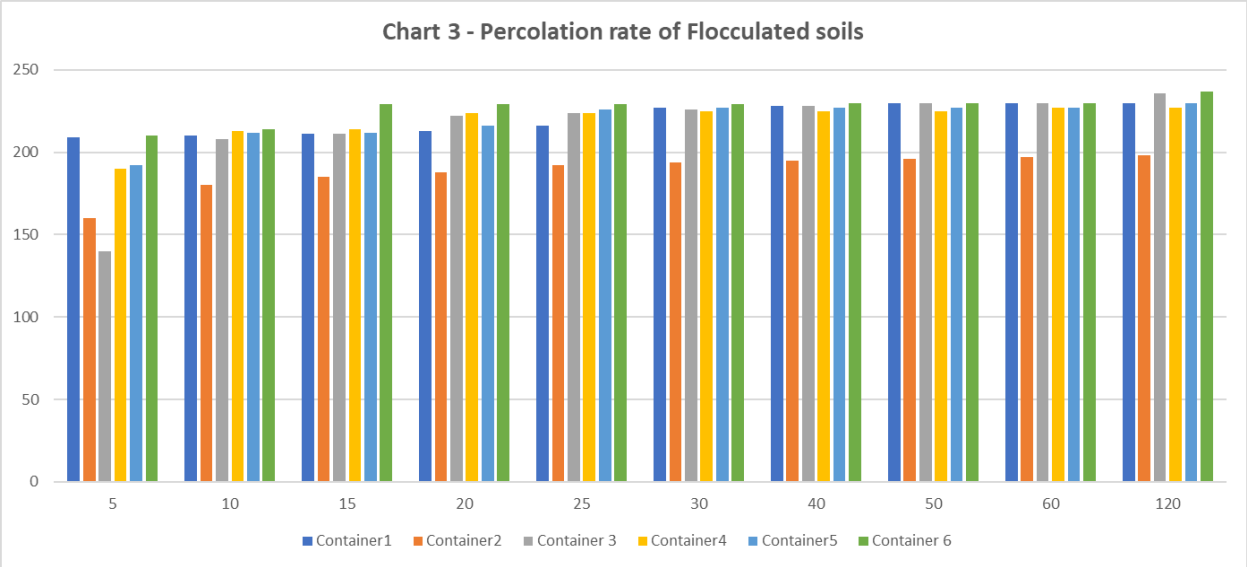
<b>5:36 (30 min)</b>	<b>203</b>	<b>0</b>	<b>185ml</b>	<b>192ml</b>	<b>204ml</b>	<b>144ml</b>
<b>5:46 (40 min)</b>	<b>209</b>	<b>0</b>	<b>190ml</b>	<b>193ml</b>	<b>207ml</b>	<b>144ml</b>
<b>5:56 (50 min)</b>	<b>210</b>	<b>0</b>	<b>203ml</b>	<b>193ml</b>	<b>212ml</b>	<b>144ml</b>
<b>6:06 (60 min)</b>	<b>211</b>	<b>0</b>	<b>204ml</b>	<b>193ml</b>	<b>213ml</b>	<b>144ml</b>
<b>7:06 (120 min)</b>	<b>211</b>	<b>0</b>	<b>212ml</b>	<b>196ml</b>	<b>214ml</b>	<b>144ml</b>



**Chart 3 - Percolation rate of Flocculated soils**

	<b>Container 1</b>	<b>Container 2</b>	<b>Container 3</b>	<b>Container 4</b>	<b>Container 5</b>	<b>Container 6</b>
<b>7:55 (5 min) 1</b>	<b>209ml</b>	<b>160ml</b>	<b>140ml</b>	<b>190ml</b>	<b>192ml</b>	<b>210ml</b>
<b>8:00 (10 min) 2</b>	<b>210ml</b>	<b>180ml</b>	<b>208ml</b>	<b>213ml</b>	<b>212ml</b>	<b>214ml</b>
<b>8:05 (15 min) 3</b>	<b>211ml</b>	<b>185ml</b>	<b>211ml</b>	<b>214ml</b>	<b>212ml</b>	<b>229ml</b>

min) 3						
8:10 (20 min) 4	213ml	188ml	222ml	224ml	216ml	229ml
8:15 (25 min) 5	216ml	192ml	224ml	224ml	226ml	229ml
8:20 (30 min) 6	227ml	194ml	226ml	225ml	227ml	229ml
8:30 (40 min) 7	228ml	195ml	228ml	225ml	227ml	230ml
8:40 (50 min) 8	230ml	196ml	230ml	225ml	227ml	230ml
8:50 (60 min) 9	230ml	197ml	230ml	227ml	227ml	230ml
9:50 (120 min) 10	230ml	198ml	236ml	227ml	230ml	237ml



*The Sodium contaminated the soil making it more difficult for the water to permeate and percolate through the soil. Then, the addition of the calcium allows the water to permeate and percolate through the water.*

**Below are the results of the contaminated soil percolation rates:**

- Container 3 (5% Ca) at 5 min measured a percolation rate of 150ml, at 10 min measured 177ml, and at 15 min measured 177ml. At 20 min measured a percolation rate of 180ml, at 25 min measured 182ml, and at 30 min measured 185ml. At 40 min container 3

measured a percolation rate of 190ml, at 50 min measured 203ml, and at 60 min measured 204ml. At 120 min measured a percolation rate of 212ml.

- Container 4 (2.5% Ca) at 5 min measured a percolation rate of 129ml, at 10 min measured 172ml, and at 15 min measured 177ml. At 20 min measured a percolation rate of 188ml, at 25 min measured 188ml, and at 30 min measured 192ml. At 40 min container 4 measured a percolation rate of 193ml, at 50 min measured 193ml, and at 60 min measured 193ml. At 120 min measured a percolation rate of 196ml.
- Container 5 (1% Ca) at 5 min measured a percolation rate of 152ml, at 10 min measured 170ml, and at 15 min measured 192ml. At 20 min measured a percolation rate of 200ml, at 25 min measured 202ml, and at 30 min measured 204ml. At 40 min container 5 measured a percolation rate of 207ml, at 50 min measured 212ml, and at 60 min measured 213ml. At 120 min measured a percolation rate of 214ml.
- Container 6 (1% Ca) at 5 min measured a percolation rate of 132ml, at 10 min measured 136ml, and at 15 min measured 140ml. At 20 min measured a percolation rate of 142ml, at 25 min measured 142ml, and at 30 min measured 144ml. At 40 min container 6 measured a percolation rate of 144ml, at 50 min measured 144ml, and at 60 min measured 144ml. At 120 min measured a percolation rate of 144ml.

**Below are the results of the flocculated soil percolation rates:**

- Container 1 (control) at 5 min measured a percolation rate of 209ml, at 10 min measured 210ml, and at 15 min measured 211ml. At 20 min measured a percolation rate of 213ml, at 25 min measured 216ml, and at 30 min measured 227ml. At 40 min container 6 measured a percolation rate of 228ml, at 50 min measured 230ml, and at 60 min measured 230ml. At 120 min measured a percolation rate of 230ml.
- *Container 2 (contaminated control) at 5 min measured a percolation rate of 160ml, at 10 min measured 180ml, and at 15 min measured 185ml. At 20 min measured a percolation rate of 188ml, at 25 min measured 192ml, and at 30 min measured 194ml. At 40 min container 6 measured a percolation rate of 195ml, at 50 min measured 196ml, and at 60 min measured 197ml. At 120 min measured a percolation rate of 198ml.*
- *Container 3 (5% Ca) at 5 min measured a percolation rate of 140ml, at 10 min measured 208ml, and at 15 min measured 211ml. At 20 min measured a percolation rate of 222ml, at 25 min measured 224ml, and at 30 min measured 226ml. At 40 min container 3 measured a percolation rate of 228ml, at 50 min measured 230ml, and at 60 min measured 230ml. At 120 min measured a percolation rate of 236ml.*
- *Container 4 (2.5% Ca) at 5 min measured a percolation rate of 190ml, at 10 min measured 213ml, and at 15 min measured 214ml. At 20 min measured a percolation rate of 224ml, at 25 min measured 224ml, and at 30 min measured 225ml. At 40 min container 4 measured a percolation rate of 225ml, at 50 min measured 225ml, and at 60 min measured 227ml. At 120 min measured a percolation rate of 227ml.*
- *Container 5 (1% Ca) at 5 min measured a percolation rate of 192ml, at 10 min measured 212ml, and at 15 min measured 212ml. At 20 min measured a percolation rate of 216ml, at 25 min measured 226ml, and at 30 min measured 227ml. At 40 min container 5 measured a percolation rate of 227ml, at 50 min measured 227ml, and at 60 min measured 227ml. At 120 min measured a percolation rate of 230ml.*
- *Container 6 (eggshell mixture) at 5 min measured a percolation rate of 132ml, at 10 min measured 136ml, and at 15 min measured 140ml. At 20 min measured a percolation rate of 142ml, at 25 min measured 142ml, and at 30 min measured 144ml. At 40 min container 6 measured a percolation rate of 144ml, at 50 min measured 144ml, and at 60 min measured 144ml. At 120 min measured a percolation rate of 144ml.*

**Analysis:**

Contamination Event: The sodium caused a chemical reaction that affected how particles interacted at a molecular level. The experiment showed that when I added Sodium to the clay soil mixture, the rate of water percolation decreased. The chemical reaction was an ion exchange where the sodium ions outnumbered the calcium ions and replaced them, causing dispersion.

Decontamination Event: The calcium and eggshells caused another chemical reaction that affected how particles interact at a molecular level. The experiment showed that when I added calcium to the clay/soil mixture the rate of water percolation increased. The chemical reaction was an ion exchange where calcium ions outnumbered the sodium ions and replaced them causing flocculation. The addition of the eggshell as a natural element was particularly interesting and successful. This experiment showed that the calcium inside an eggshell (approx. 2 grams of calcium per egg) was able to interact similarly to the calcium nitrate.

**Conclusion:**

My hypothesis, If you contaminate soil with Sodium causing dispersion then applying different Calcium solution percentages and types will flocculate the soil differently. This is due to the difference in the transfer of ions, in that the ion exchange requires the ion replacing the other ion to have more ion presence, was correct. My hypothesis was correct because the percolation rate of container 5 was almost the same as the control, which shows the contaminated dirt was successfully flocculated by the Calcium treatment, accounting for unseen variables at the start of the experiment.

Soil dispersion hardens soil and blocks water infiltration, making it difficult for plants to establish and grow. The significant implications associated with decreased infiltration due to sodium-induced dispersion include reduced plant available water and increased runoff and soil erosion.

**Interesting Points:**

The eggshell treatment of the contaminated soils was not only as effective as the calcium nitrate, but the experiment also showed that it was more effective than the pure chemical

- *Seeing as Beaker 6 (eggshells) end product was 237 and the rest of the flocculated containers results are: for container 3 the end product was 236, for container 4 end product was 227, and for container 5 end product was 230*

Beakers 3, 4, and 6 were higher than the control

- This may be because there are already low amounts of sodium in regular soil, so when we wetted it and dried it with the rest, it may have dispersed a little bit and was never flocculated, so when we ran the percolation tests, container one may have had some contamination.

**Sources of Error:**

1. The duct tape failed and soil was moved from tubes to sieves. Experiment re-setup consisted of:
  - a. *Put two pieces of cheesecloth one way and two other pieces of cheesecloth the other way on the inside of the soil container.*
  - b. *Put an elastic band around the soil container so that the handle and the support/hanging loop are below the elastic band to hold the cheesecloth*
  - c. *Tie a string around the soil containers so that the handle and the support/hanging loop are below string to secure the cheesecloth*
  - d. *Place it open side up on the plastic container. The plastic containers will collect water for measurements*
  - e.
2. *Cured soils turned out to be higher than the control, so I inference that there was a small amount of sodium in the soil, seeing as the soil has natural sodium in it, had dispersed when I added the water and dried it.*
3. *The water I added was not freshwater, as current dispersion requires, but tap water that may have had chemicals in the water that affected the experiment.*

### **New Research Questions:**

*Other research questions related to dispersion and flocculation include:*

1. Why does sodium cause a problem in soils?
2. How does soil react to Sodium?
3. How do you remove sodium?
4. How does sodium affect the Percolation of water through soil?
5. What are the soil properties where salt can contaminate the soil?
6. In what ways are the plants beneath the dispersion affected by the dispersion

*An Innovation related to dispersion and flocculation:*

- A machine could be built to test contamination of soil using air (Another way to test contaminated soil is to use air. In labs, they blow air through the soil, and by the pressure building up, they can tell how much the soil is contaminated), and try to improve it over ones in labs currently

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### **Cliff White Credentials:**

- Graduated in 1961 from Calgary institute of technology (SAIT) (diploma in chemistry)
- Department of public health 1961-1963 (air and water monitoring)
- International nickel Thompson Manitoba 1963-1964 (Metallurgical chemist)
- Hinton Pulp and Power 1964-1969 (Processes Chemist) (designed pulp mill wastewater treatment system)
- Beak and environmental consultants 1969-1980 (vice-president) (prairies northern division)
- Turbo chemicals 1980-1982 (Canadian manager) (Oil field stimulation chemicals)
- Amraigo International 1982-1986 (Oil fields stimulation chemicals)
- Bondell Chemicals 1986-1989 (Oil Fields stimulation chemicals)
- Canadian chemical technology 1989-2019 (vice-president to owner) (oil field stimulation chemicals)
- Mud Master/Optifrac limited 2019-current (Consultant and chemical development).