Lab: Soil Permeability

FOR THE TEACHER

Summary
In this lab, students will learn about the draining properties of different types of soil and how it affects the type of plants that can grow in those soils.

Grade Level
Elementary School

NGSS Alignment
This lab will help prepare your students to meet the performance expectations in the following standards:

- **2-PS1-1**: Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- **2-PS1-2**: Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Objectives
By the end of this lab, students should be able to

- Understand drainage rates or permeability of soil.
- Determine what types of plants can grow in different soils based on their draining rates.

Chemistry Topics
This lab supports students’ understanding of

- Physical Properties
- Observations
- Soil properties
- Permeability
- Water
- Plant properties

Time
Teacher Preparation: 30 minutes
Lesson: 60 minutes

Materials

- Clear plastic cups or jars of the same size (number depends on group size and number of soil samples)
- Paper towels
- ¼ cup Potting soil (per group)
- ¼ cup Sand (per group)
  - From a bag or from a beach/lake/sandbox
- Two other samples of soil (¼ cup of each per group)
  - From the schoolyard, or assign students to bring in a sample from home
- Labels
- Stop watch
- Ruler (metric)
- Tap Water
- Rubber bands (one per cup/jar)
• Dry erase marker or permanent marker (to draw a mark on the cup/jar)

Safety
• Always wear safety goggles when handling chemicals in the lab.
• Students should wash their hands thoroughly before leaving the lab.
• When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.

Teacher Notes
• 3-5 students per group is suggested.
• Each student will have their own sample to watch and record and will then share results as a group
  1. Each group will have sand and potting soil as baselines, the other samples can be different among the groups if you assigned students to bring in their own soil samples.
• For timing the experiment, use stopwatches:
  1. One per student to record how fast the first water drop falls compared to the others in their group.
  2. OR you can have the students raise their hands to report when the water drops.
  3. OR students can tell their group when their water falls first.
• You can do the experiment a second time for the same soil: have the students add another 2cm of water to see what happens and have them record their observations. Before they do the experiment a second time, ask them what they think would happen the second time.
• You can use this lesson to also discuss rain and the water cycle, saturated soils, soil pollution, and flooding.
  1. This is a video from the National Resources Conservation Service (NRCS) about soil saturation, and soil in general.
  2. This is a video about the basics of soil that is good for kids to understand what soil is made up of.
  3. This is a short video about permeability and the water cycle.
• You can expand this lesson by talking about different ecosystems like deserts and rainforests and what type of plants and animals live there and how they’ve adapted to the desert climate. Suggestions for questioning: What sort of soils do the students think would be in deserts and rainforests? For older students, you can include the tundra (cold deserts, essentially) and talk about permafrost and their soils.
• Answer key for Pre-lab Questions:
  1. Soil is: minerals, air, water, organic material.
  2. Some soils will drain water faster because they have more space in between soil particles (more air, it is easier for water, nutrients, and pollutants to flow through these spaces).
  3. Sand, or soil with more space will drain faster.
• Answer key for Analysis Questions:
  1. Answers will vary.
  2. Answers will vary.
  3. Answers will vary.
  4. Answers will vary.
  5. Nutrients and pollutants can also move through soil like air – this is important to remember as it means the pollutants can reach ground water, or can affect plants and animals (as well as humans!)
• Answer key for Conclusion Questions:
  o Drainage rates are important for farmers, people who build homes, flooding, ponds (if you have a pond that keeps drying up, for instance), pollution, losing nutrients for plants.
  o Deserts would have sandy-soils and since it doesn’t rain very often, the plants are adapted to have shallow roots and are more tolerant to less precipitation. The water
drains quickly (and evaporation is very high), so the roots are shallow to collect the water as quickly as possible.

- Two additional elementary school lab resources available in the AACT Resource Library that are focused on the chemistry of soil investigations are Settle that Soil and The pH of Soil.

FOR THE STUDENT

Lesson

Soil Permeability

Background
Soil is made up of minerals (from rocks), air, water, and organic material (dead plants and animals). Pore space is where the air and water can flow through the soil. The bigger the particles, the larger the space between the particles, and the more air and water can flow through the soil at a very fast rate. In very sandy soils water and nutrients necessary for plants to survive flow too quickly for the plants’ roots to collect it. Soil samples with very small particles, like clay, have smaller spaces between each particle; water, air, and plant roots have a harder time finding the necessary space they need. These soils may cause flooding or puddles because the water is unable to infiltrate or enter the soil.

If soil has a lot of clay particles, water will flow through slowly. If soil has a lot of sand particles, water will flow through very quickly. This picture depicts a sandy soil because the space between each particle is very large.

Soils that have a good mix of sand, silt, and clay, are better for plants because the water will drain and not puddle on top of the soil, but it will not drain too quickly. Plants that live in areas with this type of soil get the water and nutrients they need to survive.

Pre-lab Questions
1. What is soil?
2. Why do some soils drain water faster than others?
3. Which of your soil samples do you think will drain the fastest? Why?

Objective
What are the drainage rates of sand and different soils in your neighborhood?
**Safety**
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow the teacher’s instructions for cleanup of materials and disposal of chemicals.

**Procedure**
1. You will need one plastic cup per group member. Each group member will be responsible for testing a different soil type. Label your cup with the type of soil or where it’s from.
2. Using a ruler, mark 1cm, 2cm, 3cm on your cup with a marker (for example the 1cm line will be marked 1cm above the bottom of the cup; 2cm line will be marked 2cm above the bottom of the cup, etc.) See photo.
3. Each group member will need an additional cup for water.
4. Using a ruler, measure 2cm from the bottom of the cup, and label your water cup with a 2cm line.
5. Fill the water cup with water up to the 2cm line.
6. Lay the paper towel over the top of your soil cup and push the towel in so that it is about ¼ inch or so in the cup. The paper towel should give a little and shouldn’t be too tight.
7. Put the rubber band around the outside of the cup to hold the paper towel in place. See photo.
8. Gently pour ¼ cup of your soil sample onto the paper towel.
9. Get your water cup ready to pour into your soil cup.
10. **Everyone in your group should add the water at the exact same moment.** Use your stopwatch to write down when your first water droplet reached the bottom of the cup. (OR raise one finger if yours was first, two if yours was second, etc. so your group knows which type of soil had the first drop of water).
11. In the data table below, put an ‘x’ in the column that had the soil that drained the first.
12. Use your stopwatch for the one minute observation.
13. Have one person in your group be the timekeeper so you know when you will need to check your cups to record your other observations below (after 1 minute, 2 minutes, 5 minutes and 10 minutes).
14. Record all of your observations in the data table below.

**Data**
Write down what your other samples were in the last two columns before you begin.

Example: Sample 1: Soccer Field at school

<table>
<thead>
<tr>
<th></th>
<th>Sand</th>
<th>Potting Soil</th>
<th>Sample 1:</th>
<th>Sample 2:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Which soil drained first?

<table>
<thead>
<tr>
<th>How much water was in the cup after 1 minute?</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much water was in the cup after 2 minutes?</td>
</tr>
<tr>
<td>How much water was in the cup after 5 minutes?</td>
</tr>
<tr>
<td>How much water was in the cup after 10 minutes?</td>
</tr>
</tbody>
</table>

**Analysis**

1. Which soil drained first? Which soil drained last?
2. Was there a noticeable difference among the different samples after one minute?
3. At what time was there the biggest difference among the samples?
4. Was all the water drained after 10 minutes from all the samples?
5. What else can move through soil like water?

**Conclusion**

Why do you think it’s important to know the drainage rate for soil? Who might this information be useful for?

What sort of soil do you think a desert would have? Think about the plants that live in a desert: do these plants need a lot of water? From what you learned about the drain rates of your soil samples today, do you think desert soils have fast or slow drainage rates?