Just Passing Through

Purpose

To develop an understanding of some of the relationships between soils of different types and water

Overview

Students will time the flow of water through soils with different properties and measure the amount of water held in these soils. They will also experiment with the filtering ability of soils by testing the pH of the water before and after it passes through the soil and observing changes to the clarity of the water and to the characteristics of the soil.

Student Outcomes

Students will be able to identify the physical and chemical changes that occur as water passes through soil. Students will be able to design experiments that test soil and water properties.

Science Concepts

Earth and Space Science

Soil consists of weathered rocks and decomposed organic material.

Soils have properties including color, texture, structure, and density.

Water circulates through soil changing its properties.

Scientific Inquiry Abilities

Identify answerable questions.

Design and conduct an investigation.

Use appropriate mathematics to analyze data.

Develop descriptions and explanations using evidence.

Communicate procedures and explanations.

Time

One class period for initial activity

2-3 class periods for *Further Investigations*

Level

All

Materials and Tools

(for each team of 3 - 4 students)

2 - 3 clear 2-liter bottles*

4 - 6 500-mL beakers* or similar size clear containers to pour and catch water for the demonstration, more as needed for the class activity. The number of beakers will be dependent on the number of student groups.

Soils samples (Bring in 1.2 L samples of different types of soil from around the school or from home. Possibilities include top soil (A horizons), subsoils (B horizons), potting soil, sand, soils that are compacted, soils with grass growing on top, soils with clearly different textures).

Fine window screen or other fine mesh that does not absorb or react with water (1 mm or less mesh size)

Strong tape

Scissors

Water

Laboratory ring stands with rings, if available (enough to hold the number of plastic bottles to be used). Another approach is to rest the bottles in the top of the beaker (this method does not use the laboratory ring stands). With the soil weight, the bottles will be relatively stable setting in the beakers.

pH paper, pen, or meter

Work Sheet

GLOBE Science Notebooks

For Further Investigations:
Distilled water, salt, vinegar, baking soda
Plastic wrap to cover bottles
Conductivity meter
NPK kit
Growing sod or mulch
Alkalinity kit
*You can use 1-liter bottles and either 400 or 250 mL beakers. The size of the beakers will be dependent on the diameter of the bottles. The bottle with the screen should not descend too deep into the beaker so that it impacts the reading of the volume of water. The smaller size bottle has the advantage of requiring less soil. Regardless of which size bottle is used, it is important that the amount of soil, water and size of the beakers and bottles used in comparative experiments are the same.

Prerequisites

None

Background

What happens to water when it passes through soil depends on many things such as the size of the soil particles (texture and particle size distribution), how the particles are arranged (structure), how tightly they are packed (bulk density), and the attraction between the soil particles and the water. Some types of soil let water flow in quickly (infiltrate), then hold the water inside the soil (water holding capacity). This might give plants a better chance of using some of that water. Other types of soil may let the water go completely through in just a few seconds. Still other soils may keep the water from getting in at all. None of these soil types is better than the other - they are simply good for different reasons. Which soil property would you look for if you wanted to plant a garden? Build a driveway or a playground? What happens if the soil is full of water and a heavy rain falls on it? How can you change the way your soil holds water? What happens to the soil when organic matter is added, when plants are growing on top of it, when it is compacted, or when it is plowed?

Water in soil is also a key to the transfer of nutrients from the soil to growing plants. Most plants do not eat solid food (although a few do digest insects!) Instead, they take in water through their roots and use the nutrients the water has obtained from the soil. How nutritious is soil? That depends on how the soil was formed, what it was formed from, and how it has been managed. Farmers and gardeners often add *nutrients* or fertilizer to soil so that it will be better for their plants.

Preparation

- Discuss with students some of the general characteristics of soils or do *Soil in My Backyard* or the *Soil Characterization Protocols*.
- Bring in samples of different types of soil from school or from home.
- Collect a number of clear plastic 2 liter bottles with straight sides. Remove the label and lid and cut off the bottom and the top so that the end will fit into a 500 mL beaker or other clear container. Note that some of the curve of the top part of the bottle should be kept so that the bottle will fit into the beaker.
- Cut a circle of a fine mesh window screen or nylon net about 3 cm larger than the opening made in the top of the bottle. Using strong tape, secure the mesh circle around the end of the bottle where the top was cut off.

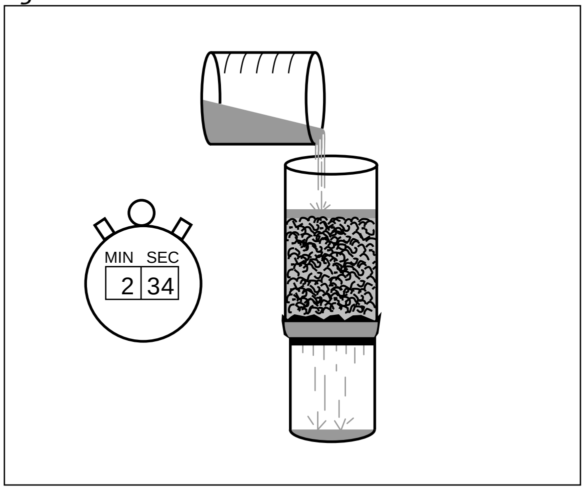
Place the bottle, mesh side down, on a beaker or set it in a ring stand and place a catchment beaker under it.

What To Do and How To Do It

Class Investigation

1. Observe the properties of the soil samples that will be used. Use your GLOBE Science Notebooks to record information about the soil samples which you observe. Also record where each sample was found and the depth at which it was found. If you have done the soil characterization protocols, you can also record the moisture status, structure, color, consistence, texture, and presence of rocks, roots and carbonates.
2. Choose one soil (a sandy loam works best) to use as a demonstration and place 1.2 L of the soil in one of the 2 liter bottles.
3. Pour 300 mL of water into 500 mL beaker or other clear container for pouring. Measure the pH of the water. Also, notice the clarity of the water.
4. Ask the students "*What will happen if you pour the water onto this soil*"? Ask students to explain why they think the soil will behave this way when water is poured onto it. Some possible questions to ask are:
   - *How much water will flow out the bottom of the container?*
   - *How fast will the water pass through the soil?*
   - *Will the pH of the water change, and if so, how?*
   - *What will the water look like when it comes out the bottom?*
5. Record the class hypotheses on the board and ask the students to record the hypotheses in their GLOBE Science Notebooks.
6. Pour the water onto the soil and begin timing. Ask students to describe what is happening as you pour the water:
   - Is all the water staying on top?
   - Where is it going?
   - Do you see air bubbles at the top of the water?
   - Does the water coming out of the soil look the same as the water going in?
   - What is happening to the soil structure, especially at the soil surface?
7. Record the class observations on the board and have the students record the information in their GLOBE Science Notebooks. Also record how long it takes for the water to pass through the soil.
8. Ask students to compare their hypotheses and the results of the experiment.
9. Have students record their own conclusions in their GLOBE Science Notebooks about how the water and soil interacted.
10. Once the water has stopped dripping from the bottom of the bottle, measure the amount of water that moved out of the soil into the beaker. Ask students:
    - What happened to the water that is missing?
11. Notice the clarity of the water.
    - Is it more or less clear than before it passed through the soil?
12. Test the pH of the water in the beaker that has flowed through the soil, record the results, and compare the results with the pH of the water that was poured into the soil. Compare with the student hypotheses.
    - Did the pH change?
    - If so, what might have caused this change?
13. Using the bottle of saturated soil, ask students what will happen if you pour another 300 mL of water into the soil. Record the class hypotheses on the board.
    - How much water will stay in the soil?
    - How fast will it move through?
    - Will the pH change?
    - How clear will the water be?
14. Pour the water back through the soil, observe the results, and compare with the hypotheses.
15. Have students record their questions, hypotheses, observations and conclusions in their GLOBE Science Notebooks.

Figure SOIL-PA-2



Group Investigations

Experimenting with different soils

1. Review the properties of the various soil samples that were brought in.
2. Ask students if they think water would pass through all of the types of soils in the same amount of time and if all the soils would hold the same amount of water.
3. Discuss which soils they think might be different and how.
4. Have each group of students select one of the various soils.
5. Have each group repeat steps 2 - 15 above on their own soil. Instead of writing hypotheses and observations on the board, the students will record the experiment in their GLOBE Science Notebooks.
6. Have each group report on the results of their experiment to the class. Reports should include questions, hypotheses, and observations regarding the following variables, as well as their conclusions about the variables and how they affected the results of their experiment.
   - soil characteristics
   - original water pH and clarity
   - amount of time for the water to pass through the soil
   - the amount of water which passed through the soil
   - changes in water pH and clarity
   - results of the saturation test.

Note: The information collected in the students' GLOBE Science Notebooks will be used to prepare their papers and reports.

7. Review all results with the class. Have the class determine the soil characteristics, such as different size of particles, space between the particles, organic material which may hold water, etc. associated with the fastest and slowest infiltration, retention of water in the soil, and changes in pH and clarity.
8. Based on the comparison of their hypotheses with the experimental results, record conclusions about how the water and soil interact and how diverse soils behave differently in their GLOBE Science Notebooks.
9. Ask the students to explore how what they have learned from their experiment may be used in real life circumstances to understand what might occur in their local watershed and land use questions in their community. They might explore questions such as:
   - *What might happen if the soil in an area is tightly compacted and there is an extended heavy rain?*

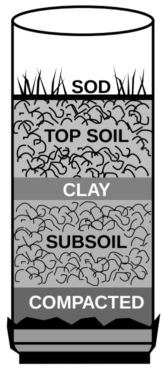
Further Investigations

1. Challenge students to come up with strategies for building a soil column in a 2 liter clear, plastic bottle which will SLOW or SPEED UP the rate of water flow through a soil.

   Brainstorm ideas for accomplishing the task. Hint: soil may be sifted and the particle sizes layered. Students may also add clay, sand or mulch. Soils may be compacted. Have students record their method and measure and record the 'soil recipe' they use. Hint: The rate of flow may be very slow for loams or clayey soils. Teachers may want to have students build their soil column one day, then have a student come in before class the next day and start the water flow.

   Record the results for the rates of water flow. Which strategies worked best?

Figure SOIL-PA-3: Experimental Soil Column



Ask students to determine whether the same strategies work for moving water through the soil slowly and for holding water in the soil.

2. Build a soil column similar to the soil profile at one of your soil characterization sample sites (use the samples for each of the horizons in the same order they are found in the profile). Observe how the water-soil interaction occurs in a simulated profile.

More Advanced

Based on the observations and results of their experimentation, have students design experiments to test other hypotheses they may have developed. Some possible ideas include:

1. Have students hypothesize about how soil can affect other aspects of the chemistry of water. Take a reading of NPK using the Soil NPK kit with the soil alone, and with a water sample. Repeat the water measurement after it has passed through the soil.
2. Have students experiment with adding salt to the water and testing the conductivity or salinity of the water before and after it goes through the soil.
3. Add vinegar or baking soda to the water and test the pH and alkalinity before and after water is added to the soil.
4. Ask the students to hypothesize about the effect of evaporation on the amount of water the soil will hold. What are the factors that control evaporation? Use some soil of the same type in two bottles and saturate both with water. Leave one bottle open on top and cover the other bottle securely with plastic wrap or other cover. Place both in a sunny window. The weight of the soil in each of the bottles will be a function of how much water it holds over time. Students can graph the difference in weight over time for the covered and uncovered bottles.
5. Place a mulch or growing sod over the soil in the bottle. How does this affect the rate at which water infiltrates the soil? How does it affect the clarity of the water that comes out the bottom? How is this related to erosion in the real world?
6. Ask students what changes may occur if the soil remains saturated with water over long periods of time. Place a soil sample in a bottle which has not had the bottom removed, then saturate it. Can they detect changes in structure, color, smell? How long does it take for changes to take place?

Have students examine soil moisture data for five GLOBE sites which have approximately the same amount of precipitation over a six month period. Graph the monthly soil moisture for each site. How do the graphs differ? What other GLOBE data can students find that might explain the variation?

Student Assessment

Students should know the scientific method and how to use it to set up an experiment as well as understand the scientific content relating to soil moisture. They should also be able to demonstrate higher order thinking skills such as drawing conclusions from experimental observations and they should be able to justify their conclusions with evidence. These can be assessed by using a portfolio assessment of their GLOBE Science Notebooks, class participation in discussions and the contribution of questions, hypotheses, observations and conclusions. The quality of their presentations are another mechanism for assessing their progress. It is also a good idea to have the students prepare a written report or a paper on their experiment. The experimental work should be done in groups as should the presentations and the reports so that their ability to work cooperatively in groups can also be assessed.

Note: This activity works nicely when done in conjunction with the soil moisture protocol. The activity can begin in the classroom before going out to set up the sampling strategy or take a soil moisture measurement. Additional observations and recording of flow rate, volume of water, pH, water clarity, etc. can be taken when returning to the classroom. (For some soils, it may take some time before all the water flows through the soil columns.) The activity also places both the soil moisture and soil characterization protocols in a conceptual context for the students. They will understand why the information and data they collect are important for developing hypotheses, designing experiments to test the hypotheses, interpreting observations, and making conclusions. They will also develop an understanding of the potential research significance of the soil moisture and characterization data.