How Thirsty Is the Ground?

Key Concepts

1. Different soils have different permeabilities which can be determined by percolation tests.
2. The use of areas is related to the type of soil and its permeability.
3. Types of soils and their permeabilities can help explain how wetlands are formed.

Background

Wetlands are usually found in low-lying areas because runoff and groundwater can collect there. An area lying at the bottom of a slope receives rainwater that has not soaked into the higher ground. Why doesn't the rainwater runoff simply soak into the ground at the bottom of the slope?

Many wetlands are formed because the soil in an area has become saturated for long periods of time, or because the type of soil there was impermeable or poorly drained. For example, clay soils that become saturated form an impermeable layer called a **hardpan**. A hardpan causes water to remain standing on the surface, which eventually creates a wetland. A high water table can saturate soils enough to hold surface water, too.

"How Thirsty Is the Ground?" looks at the **permeability** of the soil, using a simple **percolation** test. This is a test to find out if the ground is saturated with water, or if the makeup of the soil will allow water to **infiltrate** (penetrate the surface) or **percolate** (move down through it). Permeability is the rate at which water poured onto the surface percolates through the ground. Soil at many building sites is tested for permeability to determine if a septic system is a feasible form of sewage treatment. This process is sometimes called a "perc" test. In general, the slower the percolation rate, the less permeable the ground; soil that drains quickly is usually not wetland soil, though sand is often an exception.

Sandy soil often percolates quickly, but if the water table is high, as in a wetland, the percolation rate may be much slower. Organic topsoil or humus (e.g. in a forest or mulched garden) is full of spaces which can absorb water, allowing the soil to percolate fairly quickly. A grassy lawn contains grass root channels that will allow the water to move through the soil, but the percolation rate will be a bit slower than in sand. Saturated soil, as in a wetland, will percolate very slowly or not at all. Soils with a high clay content may not percolate even if they are not saturated--the clay content may hold water at the surface for long enough to classify the spot as a wetland. Very compacted soil, such as on a heavily traveled path or playground, will also have a very slow percolation rate or even be impermeable. Another impermeable surface is pavement--rainwater washes right off it. Impermeable surfaces can have a great impact because they increase runoff and erosion.

Materials

Part 1: Done as a demonstration in class

- small bag of plain clay cat litter
- 3 beakers, glasses or jars of the same size
- 3 small cups
- blender
- sand
- measuring cup
- water
- mixing bowl

Part 2:

For each group of 4 students:

- stopwatches or students with watches
- rulers
- coffee can (with both lids removed)
- 16 oz. size empty soda bottle
- permanent marker (for marking in. or cm. on sides of cans)

For the class:

- jug of water, 2 gallon or larger
- coffee can with bottom intact

Teaching Hints

First in the lab, then in the field, "How Thirsty Is the Ground?" examines percolation rates for various soil types.

Part 1: Classroom demonstration- comparison of percolation rates in some "home-made" soil compositions.

Procedure

1. Finely grind unscented clay litter in a blender. You will need 2 cups ground litter. This amount allows for the possibility of error by providing you with enough ground litter to do this experiment twice (the litter from the first trial cannot be reused in the second).

2. Mix the litter **well** with **moist** sand (just enough moisture for the sand to stick together when squeezed) in these volumes:

   a. 3/4 c. sand + 1/4 c. clay

   b. 1/2 c. sand + 1/2 c. clay (List mixtures on the chalk board)

   c. 1/4 c. sand + 3/4 c. clay

   Place each of the mixtures in one of the glasses. Do not pack the mixture down; jiggle the containers to settle the "soil".

3. Measure and pour 1/2 cup of water into each of the small cups. Ask students to predict which mixture will percolate the water the fastest.

4. Let students pour the water into each of the glasses of "soil" at exactly the same time. Watch how long it takes for all of the water to "disappear" or percolate down into the mixture. You may want to have volunteers time the percolation in each of the three glasses. It takes about 5 minutes to see which percolates fastest; about 20 for all of the water to percolate.

5. Ask students which percolated more slowly. Ask: **What seems to be the relationship between amount of clay and percolation rate?** (Mixture #1 percolates fastest, #3 percolates slowest. The more clay, the slower the percolation. Sand particles are fairly large and irregularly shaped, so there are lots of large spaces (pores) between them into which the water can trickle. On the other hand, the clay particles are finer and lie close together, so there are smaller spaces into which the water can soak. As the clay particles absorb water, they expand and fill the space even more.)

6. Ask: **Did anything surprising happen in #2 or #3 after a few minutes?** (They may notice that the water seemed to stop percolating. A thin layer of "solid" clay often forms at the top and blocks the water (the clay is almost

impermeable) This occurs because the clay absorbs water quickly at the top and expands, making it harder for the water to pass through. Even after all of the water soaks into the "soil", it may only reach partway down the glass (by contrast, the water in #1 usually travels all the way to the "bedrock" at the bottom of the glass). This impermeable layer is called a **hardpan** and occurs many times in clay soils that become saturated. A hardpan causes water to remain standing on the surface, eventually creating a wetland.)

7. Just for fun, pour another 1/4 cup of water on each of the mixtures and see what happens to a saturated wetland when it rains.

Part 2: Percolation at or near a wetland site

In Part 2, students use a marked, open-ended can to test the permeability of soils in a variety of locations. The can is pushed into the soil and a measured amount of water is added to the can. The time for the water to percolate into the soil is recorded.

Procedure

Before going to the wetland:

1. Divide the class into groups of four students.

2. Have each group prepare one of the coffee cans with both lids removed. Beginning at the bottom of the can, two students use the permanent marker and ruler to make marks every 2 inches or every 5 centimeters on the inside and outside of the can.

3. While the can is being marked, the other two members of each group mark a soda bottle. First, they pour 2 in. or 5 cm of water into the can with bottom. Next, they pour this amount into one of the pop bottles and mark the level with the permanent marker. The group will use the bottle in the field to pour measured amounts of water into their marked "percolate can".

   Have the speedier groups make a few extra cans to have on hand in case water percolates slowly in some area and groups need to move on to the next site while letting the slow percolate can sit.

4. Students will have specific roles to play at each sampling site: "can sinker/level measurer", "pourer", "timer", and "recorder". Have students choose their specific roles for the first site and design a rotation scheme so that roles are rotated at each site.

At the Wetland:

Each group performs at least three different tests at three different sites. Groups share and compile data back in the classroom.

1. Have groups test the permeability of the ground in these six different spots.

    a. ground that is bare and compacted (path or play area)

    b. a grassy area that gets little use

    c. a forest area where there is leaf litter (brush litter away), or a landscaped area (under bushes) near the school

    d. a muddy spot or wetland area

    e. a paved area

    f. sandy area, if available, or use a sand box or small pile of purchased sand.

2. Review instructions and procedures given on student worksheet and discuss each column on the data chart. Go over the calculations. You may also wish to practice the coordination of pouring and timing, stressing that the groups need to be consistent. Make sure that students know that they must perform their tests on level ground.

3. At the compacted site, after students perform their can tests, have them pour some water directly onto the ground and ask them to describe what happens. If a gully forms as the soil washes away, they will have witnessed **erosion**.

4. Students obviously will be unable to get a can pushed into a paved surface, and the water will likely wash right off. This is a good demonstration of **runoff**.

5. After completing the tests, have the students compare their results and relate percolation rates to soil type or surface conditions. Percolation rate should be expressed as inches or centimeters per hour.

Key Words

infiltrate - to pass a liquid through small spaces, in this case in the soil

percolate - to drain or seep through a porous material

permeability - in this case, the rate at which water moves through soil

rate - measured change occurring within a fixed time period

Answer Key

Text Questions

1. Predictions will vary. One would expect that the sandy area will percolate the fastest, then the forest/landscaped site, the grassy area, the muddy, the compacted, and finally the paved area (which will not allow water to permeate at all).

6. The water moves downward, filling in the small spaces between the soil particles.

Analysis and Interpretation

1., 2., 3. Results of these tests will, of course, depend upon the soil types sampled. The main point to be made is that the makeup of wetland soils is <u>different</u> from the makeup of upland soils because of their composition and the presence of water--this is part of the reason why wetlands are so special.

4. This question calls for an opinion. Accuracy would be increased by conducting the tests several times, at different times of the year.

5. Answers will vary depending upon experimental results. Normally, a high rate of water flow out of the can would mean porous soils. With this apparatus, a high rate of flow on pavement occurs because the can cannot penetrate the surface, letting the water flow out of the can-pavement joint.

6. Although site four was chosen as the wetland site, answers may vary depending upon experimental results.

7. Answers will vary depending upon experimental results. It would be expected that water would have penetrated into the ground. Wetlands act like a sponge. Even when saturated, they can take in more water if some is released first.

8. a. Answers will vary depending upon experimental results. Water usually beads on the ground surrounding the compacted soil site.

   b. This question calls for an opinion. Most students will think the water will either quickly runoff or form puddles.

   c. Answers will vary. Most students will think that water will enter the garden or sandy soil more readily.

   d. Answers will vary. “Better” is a qualitative opinion. Again, make the point that wetlands act as a sponge to slow runoff from areas with poor infiltration.

How Thirsty Is the Ground?

Measuring Percolation Rates of Different Soil Types

We've seen that wetlands help filter silt and pollutants from water and help prevent soil erosion. But, what causes wetlands?

Wetlands are usually found in low-lying areas because runoff and groundwater can collect there. The bottom of a slope receives rainwater that has not soaked into the higher ground. Why doesn't the rainwater runoff simply soak into the ground at the bottom of the slope?

Many wetlands are formed because the type of soil at the bottom doesn't let the water soak into it. We say these soils are impermeable or poorly drained. In this activity, you'll be looking at the **permeability** of the soil, using a simple **percolation** test. This is a test to find out if the ground is saturated with water. It also tells if the makeup of the soil will allow water to move down through it (percolate).

1. Before you begin, look over the data chart to become aware of the types of data you must gather. As a group **predict** how quickly you think the **same amount** of water will percolate into the soil at each site.

Predict: Which will percolate the fastest?

Which will take the longest?

Will any not penetrate at all? Why?

Then, on the **left** side of the page, number the sites on the chart according to your predictions. Label the fastest #1 and so on. Begin your testing at the site you predicted as the longest.

2. Go to your first site. Choose a flat, level spot; clear away leaves, etc. The "can sinker" should twist a can into the soil or tap it lightly with his/her shoe to force it down to the 2 in. (5 cm) mark on the side of the can. If the ground is hard do not bend the can. Instead, sink it as far as you can or hold it firmly on the surface.

3. Make sure the "pourer" has the bottle filled with water to the mark on the bottle. Get "timer" ready and begin timing as the "pourer" pours. The "recorder" records **START TIME** on your chart. (For example, with a digital wrist watch, "twelve-o-three and six seconds" is written as 12:03:06. With a stop watch, start with 00:00:00.)

4. The "level measurer" determines the level of the water inside the can after all of the water is poured in. The "level measurer" tells the "recorder" who will mark **Beginning Water Level** on the chart.

5. When all the water has "disappeared," stop timing and record the **Finish Time**. Record the **Ending Water Level**. If all the water has drained out, the level will be "0". If after 5 minutes, the water level has not changed much, get another can and move on to another site. Send someone back frequently to check the level. If all of the water has not drained after 30 minutes, stop timing. Record the Finish Time, and measure and record the Ending Water Level.

6. Record the **# in. or cm drained** (subtract Beginning and Ending Levels)

   Where did the water go? Be specific.

7. Now move to the next site. Change jobs (timer, pourer, etc.). Use the same procedure that you used at the first site. Fill your soda bottle to the mark with water from the jug and conduct your next perc test. Record your results.

8. Complete the tests at all of the sites assigned by your teacher.

Analysis and Interpretation

1. After doing all tests, complete your chart by performing the necessary calculations. You may need to obtain values from other groups for tests that you didn't conduct. Here's how to make the calculations:

   Total Perc Time = Finish time Ð Start time = # minutes. (Round to the nearest half minute.)

   Average Perc Time = add values from other teams and divide by the number of values.

   Average Percolation Rate = number of in. or cm drained per minute

$$= \frac{\text{\# in. or cm drained}}{\text{Average Perc Time}}$$

   If your time measurement is in seconds, here's how to change it to minutes:

Convert seconds to minutes: $\frac{\text{\# in. or cm}}{\text{sec}} \times \frac{\text{60 sec}}{\text{min}} = \frac{\text{in. or cm}}{\text{min.}}$

If the Average Perc Time was more than one minute, then convert the rate to hours in the following way:

$$\frac{\text{\# in. or cm}}{\text{min}} \times \frac{\text{60 sec}}{\text{hour}} = \frac{\text{in. or cm}}{\text{hour.}}$$

2. On the right side of the page, number the sites according to the actual percolation rate. Label the fastest #1.

3. Your predictions are on the left side of the page. How do your predictions compare with your results?

4. a. Do you think that your results are accurate?

   b. Why or why not? (think about the condition of the ground)

5. a. Were you able to calculate the percolation rate for the bare or paved areas?

   b. If the water ran out quickly, what can you say about infiltration and the percolation rate?

6. Which area represents a wetland?

7. Even though it was already saturated, did some of the water still penetrate into the ground?

8. a. At the compacted site, what happened to the ground around the can?

   b. What do you think will happen on the compacted ground when it rains?

8. c. Compare this to what you predict would happen in the garden or sandy area.

d. Which kind of area do you think is better to have and why?

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Measuring Percolation Rate

SITE	Beg. Water Level	End. Water Level	#in or cm Drained	Start Time	End Time	Total Perc Time min or sec	Avg. Perc Time min or sec	Avg. perc Rate cm/m in or cm/hr
Bare and compacted								
Grassy, not used								
Forest or Garden								
Muddy (Wetland)								
Paved								
Sandy								