Activity 5: A Percolation Revelation

Maine Geological Survey

Objectives:

To relate the rate at which water moves through various types of ground materials to the mechanical aspects of cleaning up a pollution spill situation.

Time:

This activity is designed to last for two 45 minute class periods.

Background:

As water enters and moves through a soil, it becomes available to the plant roots and animals which exist in that soil. The speed at which the water passes through the soil determines how long it is available and how much is present for use by the soil organisms. Many physical and chemical factors of the soil have a significant effect on the percolation rate, and a complete soil analysis would be necessary to isolate each of these factors. If a pollutant is introduced into the water, or spread on the surface of the soil, this pollutant will be carried into the soil with the water and thereby will reach the plants and animals. The percolation ability of a soil not only indicates the rate at which the pollutant reaches the soil organisms, but will also affect the rate at which the pollutant may be flushed or leached from the site.

A great number of human activities hold the potential for creating pollution of soils and the ground water held in those soils. Underground and aboveground storage tanks, septic systems, sludge and ash, pesticides, fertilizers, herbicides, and air pollutants, all pose threats to the soils and ground water of the country.

Materials:

Students should work in groups of two or three. Each group will need:

- Three (3) half-gallon paper milk cartons
- A nail
- Three 400 ml beakers
- A water supply
- Graduated cylinder
- Stopwatch or clock with a second hand
- Grease pencil, ruler, notebook, and pens
- Samples of dry fine gravel, sand, and topsoil, and a few drops of food coloring

Procedure:

Cut off the tops of the milk cartons, leaving about 6 inches remaining; use the nail to poke a hole in ONE CORNER of the carton bottom from the inside. Fill the cartons to a depth of one inch with the materials to be tested; one type per carton. Place each carton on top of a 400 ml beaker with the drain hole down. See Figure 1 on the student sheet. Mark the catch beakers up one inch from the bottom with the grease pencil and slowly add 250 ml of water to each carton. Have students record the data and perform the indicated calculations. See data tables.

To test pollution flushing on the three samples have students repeat steps 1-4 (see student sheet). Add several drops of a brightly colored food coloring to the 250 ml of water and add this volume to each of the samples. Allow most of the water to pass through the sample. Empty and clean the catch beakers and replace them beneath the cartons. Add clean water, 50 ml at a time, to the samples until the water draining through runs clear. Record the volume of clean water needed to flush each sample. There are no special safety precautions.

Follow-Up:

Have students research and discuss other methods of removing pollutants from a contaminated area.

Have students search newspaper files and magazine articles to determine how Exxon "cleaned up" the Valdez oil spill.

Have students explain why water holding capacity and percolation rate should be considered when sites are chosen for solid waste disposal or radioactive waste disposal.

Have students do Activities #3 (Ground Water and Development Siting) and #4 (Water, Water, Everywhere; and not a Drop to Drink!) which deal with the related aspects of building codes and site proposals for single family house construction.

Have students conduct a Household Contaminants Inventory of their own home and list all the things and the quantities involved that could become ground water/soil contaminants if used improperly.

References:

Activity developed by James H. Barden, in conjunction with the 1991 CREST intern program.

Name___________________________

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Student Sheet

Purpose:

To relate the percolation rate of a soil type to the mechanical aspects of pollution cleanup.

Materials:

Each group of students will need the following: three (3) one-half gallon cardboard milk cartons, a nail, three (3) 400 ml glass beakers, a water supply, a graduated cylinder, a stopwatch or clock with a second hand, grease pencil, ruler, samples of dry fine gravel, sand, and topsoil, food coloring. Each student will need their pens and notebook.

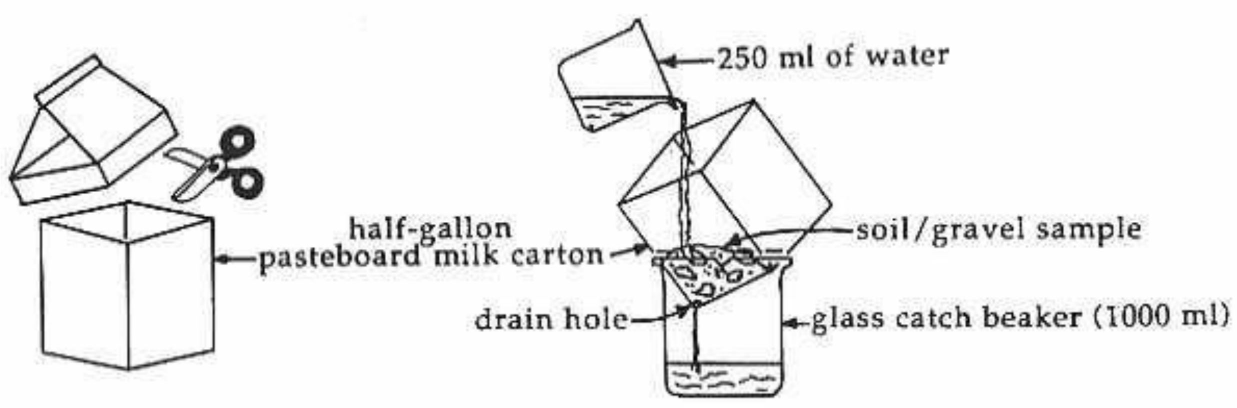

Figure 1. Experimental set-up.

PART I:

The first part of the exercise will give you some background on the rate at which water moves through different types of soil. This rate is called the percolation rate. It is important to know the percolation rate of various soil types before studying how pollutants move through the soil.

1. Cut off the top of each milk carton, leaving about 6 inches remaining.
2. Using the nail, poke a hole through one corner of each carton bottom from the inside.
3. With the carton sitting upright on the table, place approximately 1 inch of gravel in one carton, 1 inch of fine sand in the next carton, and 1 inch of topsoil in the third carton.
4. Place each carton on top of a 400 ml beaker with the drain hole pointing down. See Figure 1.
5. Mark all of the catch beakers 1 inch above the bottom with the grease pencil or marker.
6. Slowly add 250 ml of water to each sample.
7. Record the TIME at which the water was added to each carton in column one of the data table.
8. Allow the water to filter through. Record the time when the water fills the catch beaker to the one inch line in column 2 in the data table.
9. Allow the water to run until no more flows, or until it is dripping so slowly it appears to have stopped flowing. NOTE: One sample may drain so slowly that it may be necessary to leave it and check back later.
10. Measure and record the volume of the water in the catch beaker in column 3 of the data table.

DATA TABLE			
	1	2	3
	Time Water Added	Time 1” Reached	Volume Water Returned (mL)
Gravel			
Sand			
Soil			

Calculate the time required for 1 inch to fill the beaker by subtracting column 1 from column 2 and record below.

	Minutes (2-1)	Rate (inches/minute)
Gravel		
Sand		
Soil		

Calculate the percolation rate in inches/hour and record below.

Gravel: __________inches/hour

Sand: __________inches/hour

Soil: __________inches/hour

The standard percolation rate scale is as follows (in inches/hour):

Very Slow	<0.20
Slow	0.20 to 0.62
Moderate	0.63 to 2.00
Rapid	2.01 to 6.30
Very Rapid	>6.31

How do your rates compare to those of the scale?

When all of the water has seeped through, notice that all 250ml has not returned. Calculate the retained water by subtracting column 3 from 250ml. Record below.

Gravel: __________ml

Sand: __________ml

Soil: __________ml

The water not returned is a physical function of the material itself and varies among soil types. The water retained in the sample is adhering to the surfaces of the sample particles as well as being trapped in the spaces between the particles. This can be used as a measure of the water holding capacity of the soil.

PART II:

In this part you will test the three samples to see how quickly they will allow a pollutant (food coloring in the water) to be flushed out of them.

1. Follow procedures 1-4 from PART I, using new, dry samples of the three soil types.
2. Add 10-15 drops of food coloring to each of the 250 ml portions of water and slowly add one portion of "polluted" water to each soil sample.
3. Allow the water to run through completely or until it just drips. Note the color of the emerging water.
4. Empty the catch beaker into the sink, wipe it dry and replace it beneath the carton.
5. Add clean water to the sample 50 ml at a time; continue until the water runs clear.
6. When the flushing water starts to run clear, remove the carton and place it in the sink to continue draining. Record the total volume of water required to flush each sample.

Gravel: ___________ml

Sand: ___________ml

Soil: ___________ml

Questions:

1. Which sample had the fastest percolation rate? ____________________________________
2. Which sample was the easiest to clean? ____
3. Is there a relationship here? Explain.

4. Which sample had the greatest holding capacity? __________________________________
5. Was the sample in question four the hardest to clean? Explain.