Filtration

Main Concept

Soils can filter and clean water. The ability of a soil to filter water is largely dependent upon particle size and how fast the water flows through the soil.

EDUCATIONAL GOALS

- **Demonstrate how soils can clean water.**
- **Understand what properties influence the filtering of water.**
- **Understand why it is important to be aware of the chemicals that are spread on the ground and how some of them can contaminate ground water.**
- **Demonstrate that sand particles do not filter chemicals from water as well as silt and clay particles.**
- **Recognize that water flows through sandy soil faster than it does through clayey soil.**
- **Predict the outcome if colored water flows through a loamy soil (a soil that contains a mixture of sand, silt, and clay).**

Demonstration is suitable for Kindergarten through College. Activity is suitable for 5th - 8th Grade.

Materials & Preparation

1 Stack of Bottle Filters with Sandy Soil
1 Stack of Bottle Filters with Clayey Soil
1 Stack of Bottle Filters with Loamy Soil (Optional)
1 Stand to Secure the Bottle Filters
1 Gallon of Colored Water (Red will be used in the documentation; food coloring recommended)
1 Measuring Cup
4 to 7 Clear Plastic Cups

Background Information

The relative proportions of sand, silt, clay, and organic matter influences how fast water moves through soil and how well water is cleaned. The longer it takes for water to flow through soil the more time it has to interact with the soil and the cleaner the water becomes. In sandy soils water flows more quickly because of the larger spaces between soil particles. The shorter time the water has to interact with the soil particles combined with the smaller surface area than clayey soils, results in water that is not as clean. Water generally flows more slowly through soils with more silt and clay because the spaces between the individual soil particles are smaller. Clay particles and organic matter also have charges that attract some chemicals and keep them from moving through the soil. The results of this experiment will vary over time based upon which holes the water passes through and how much water has been poured through the filters.

Explanation

If red water is poured quickly through a sandy soil the water generally will end up red in the bottom bottle. If red water is poured very slowly through a soil high in silt and clay, it generally will still take a long time to infiltrate into and through the soil and the water will usually come out clear. If the soil is intermediate in texture, the water will come out pink or a lighter shade of red.

Over time, a soil high in silt and clay will eventually become saturated with color. If red food coloring is used, water that is pink will make it through the soil first. Over more time the filtrate will gradually become darker red.

Answers to Student Handout

1. If more filters are added to the stack, it will take longer for the water to filter to the bottom. There will be more soil to hold water against gravity as well as additional surface area to interact with the water. The soil will hold more coloring and clean the water better.
2. If there are fewer filters, it will take less time for the water to filter to the bottom. There will be less soil to hold water against gravity, as well as less surface area to interact with the water. The soil will hold less coloring and the water will not be cleaned well.
3. If the water is added more slowly it will have more time to interact with the soil and will be cleaned better.
4. If the water is added more quickly it will have less time to interact with the soil and will not be cleaned as well.
5. If the water going into the soil is red and the water coming out is pink some of the coloring was extracted from the water, but not all. This is called preferential absorption.

Further Investigations

Now that the experiment is finished ask your students "What does this mean to me and why is this important?" Answers can range from "I should be careful not to spill bad chemicals on the ground" to "If I use chemicals I should read and follow the directions on the label".

Some other topics that relate to soil filtration are:

-Some chemicals need to be applied well before a rain because they need to have contact with plants for a while to work.
-Some chemicals need to seep down into the soil to be effective and rainfall or irrigation is required to incorporate the chemical into the soil.
-The addition of chemicals to soil can improve the overall health of the soil, plants, and people.
-Plants grow better if the proper amounts of nutrients are added.

How to Make a Bottle Filter (Teacher Preparation)

Materials: 5 Empty Plastic (16-20 oz) Bottles, Cheesecloth, Rubber Bands, 1 1/2 Cup of Each Type of Soil (Sandy, Clayey, and/or Loamy), Permanent Marker

Step 1:
Remove the bottoms from 4 plastic bottles.

With the 5th bottle, measure and mark where 1/4 to 1/2 cup of water reaches in the bottle. Cut off the top of the 5th bottle now.

Step 2:
Cover the lid end of all of the bottles with cheesecloth and attach with a rubber band.

Step 3:
Fill 3 of the 4 bottles without bottoms with 1/2 cup of soil each. Be sure to only use one type of soil in each stack of bottle filters .

Step 4:
Mount the bottles as follows (From Top to Bottom).

-Bottle with no bottom and no soil,
-Bottles with no bottom with soil x3
-Bottle with no top.

*To assist in the bottles snapping together, small vertical slits can be cut into the bottom of the bottle.

Name:_____

Student Procedures:

First, create the comparison standards:

a. Fill a plastic cup with 1 cup of colored water from the gallon jug.
b. Fill a second cup with 1/2 cup of water from the gallon jug and 1/2 cup of clean clear water.
c. Fill a third cup with 1/4 cup of water from the gallon jug and 3/4 cup of clean clear water.
d. Fill a fourth cup with 1/8 cup of water from the gallon jug and 7/8 cup of clean clear water.

You will use the solutions to compare the color coming from the bottle filters.

Ask your teacher what type of soil is in each stack of bottle filters. Record the information below.

What type of soil is in each stack of bottle filters?		
Stack 1	Stack 2	Stack 3

Now, you are ready to begin the experiment!

Begin by pouring 1/4 cup of colored water into the top of each bottle filter.
Now, record your observations below.

Observation 1 (1/4 Cup of Water)		
Filter 1	Filter 2	Filter 3

Try adding an additional 1/4 cup of colored water to each bottle filter now.
Again, record your observations.

Observation 2 (1/2 Cup of Water)		
Filter 1	Filter 2	Filter 3

Continue until the bottle at the base of each stack of bottle filters is filled to the line drawn on the bottle. Record your observations.

Observation 3 (To the Line)		
Filter 1	Filter 2	Filter 3

Compare the solution in the base of the stack of bottle filters to that of the comparison standards that you made. Estimate the amount of color that was removed by each stack of filters.

How much color was removed?		
Filter 1	Filter 2	Filter 3

Questions:

1. What will happen if more filters are added to the stack?

2. What will happen if fewer filters are used?

3. What will happen if the water is added more slowly (1 teaspoon at a time)?

4. What will happen if the water is added more quickly (1/2 cup at a time)?

5. If the water that comes out of the soil does not match the color that went in, what might be the reason for this?

6. Was the amount of time it took for the water to filter through each stack of bottle filters the same? Why or why not?