USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Soil Quality Fact Sheet

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 water flows through soil.

Educational Goals

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

Materials & Preparation

√ 1 Stack of bottle filters filled with sandy soil

√ 1 Stack of bottle filters filled with clayey Soil

√ 1 Stack of bottle filters filled with Loamy Soil *(Optional)*

√ 1 Stand to secure bottle filters

√ 1 Gallon of Green colored water *(Green will be used in this demonstration; food coloring recommended)*

√ 1 Graduated Measuring cup

√ 4-7 Clear plastic cups

Background

The relative proportions of sand, silt, clay, and organic matter influence 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. Water moves slowly through clayey soils because the spaces between the individual clay particles are very small. Clay particles and organic matter have charges that attract some chemicals and keep them from moving through the soil. Water flows faster through sandy soils because of the large spaces between sand grains. The shorter time the water has to interact with the soil particles combined with the smaller surface area results in water that is not as clean as the water that flows through the clayey 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 green water is poured quickly through a sandy soil, the water generally will end up green in the bottom bottle. If green water is poured very slowly through a soil high in silt and clay, it generally will 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 light green.

Over time, a soil high in silt and clay will eventually become saturated with color. If green food coloring is used, light yellow water will make it through the soil first. Over time the water that makes it through the filter will gradually become more green.

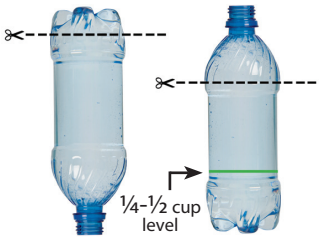
How to Make a Stack of Bottle Filters *(Instructor Preparation)*

Materials

- √ 5 empty plastic (16 – 20 oz) bottles
- √ Cheesecloth
- √ Rubber bands
- √ 1+1/2 cup of a type of soil (sandy, clayey, or loamy)
- √ permanent marker

STEP 1

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



STEP 2

- Cover lid end of all bottles with cheesecloth and attach with a rubber band.

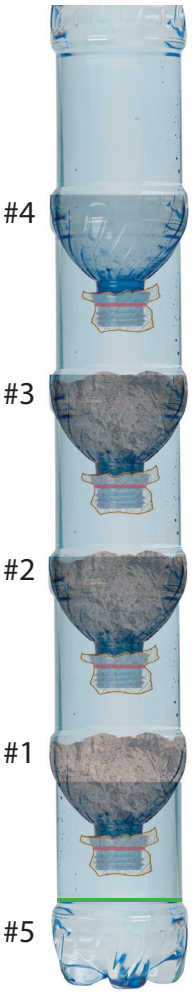
STEP 3

- Fill 3 of the 4 bottles without bottoms with 1/2 cup of sandy, clayey or loamy soil. Be sure to use only one type of soil in each stack of bottle filters.

STEP 4

- Mount 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.

* Small vertical slits may be cut into the bottom of the bottles to improve fit.



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 fewer filters are used, it will take less time for 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 as well.

3 If water is added more slowly, it will have more time to interact with the soil and will be cleaned better.

4 If water is added more quickly, it will have less time to interact with the soil and will not be cleaned as well.

5 If water going into the soil is green and water coming out is yellow, some of the coloring was extracted from the water, but not all of it. This is called preferential absorption.

6 Answers will vary.

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."

Other topics related to soil filtration are:

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

Name:_____

Create the comparison standards:

Step 1. Fill first cup with 1 cup of colored water from gallon jug.

Step 2. Fill second cup with 1/2 cup of colored water from gallon jug and 1/2 cup of clean, clear water.

Step 3. Fill third cup with 1/4 cup of colored water from gallon jug and 3/4 cup of clean, clear water.

Step 4. Fill fourth cup with 1/8 cup of colored water from gallon jug and 7/8 cup of clean, clear water.

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

Step 5. Ask your instructor what type of soil (sand, silt, or clay) 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

Begin the experiment:

Pour 1/4 cup of colored water into the top of each bottle filter and 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. 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.

Over >

Observation 3 (to the line)		
Filter 1	Filter 2	Filter 3

Compare solution in the base of the stack of bottle filters to that of the comparison standards you made.

Estimate amount of color removed by each stack of filters.

How much color was removed? (some, none, or all)		
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 water is added more slowly (1 teaspoon at a time)?

_____

_____

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

_____

_____

5. If the water color 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?

_____

_____

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Illinois NRCS contributed to this fact sheet.

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