Cleaning with Dirt

Learning Objectives: *Students learn that dirt can be used to trap runoff pollution, but that there are limits to what dirt can filter.*

GRADE LEVEL

5–8

SCIENCE TOPICS

Solutions and Mixtures
Techniques
Environmental Chemistry

PROCESS SKILLS

Comparing and Contrasting
Making Models
Hypothesizing

GROUP SIZE

3–4

SNEAK PEAK inside …

ACTIVITY

Students build a water filter using sand and plastic bottles.

STUDENT SUPPLIES

see next page for more supplies

20 oz. or 1-L plastic bottles
artificial pollutants (tempera, vegetable oil, sticks, rocks)
sand, tape, scissors, etc.…

ADVANCE PREPARATION

see next page for more details

Construct bottle filters
Mix up artificial pollutants, etc.…

OPTIONAL EXTRAS

DEMONSTRATIONS

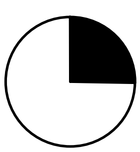
Modeling the Activity (p. D - 4)
Activity Clean Up (p. D - 4)

EXTENSIONS

Inquiry Opportunity: Build a Better Filter (p. D - 8)
Filter Acid Rain (p. D - 8)
Measure Filtration Rates (p. D - 9)

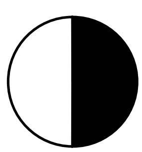
TIME REQUIRED

Advance Preparation



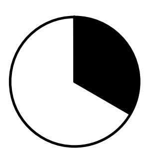
15 minutes

Set Up



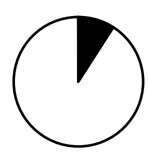
30 minutes on day one

Activity



20 minutes on day two

Clean Up



5 minutes

SUPPLIES

Item	Amount Needed
plastic bottles, 20 oz. or 1-L (e.g., soda or water bottles)	2 per group
plastic caps from plastic bottles	1 per group
drill with ⅛" bit (or small screw and screwdriver)	for teacher
scissors	1 per group
masking tape	1 roll per group
sand	2–3 cups per group
cotton balls (optional)	1 per group
pop-top squeeze bottles (e.g., water or sports drink), 16 oz. or larger	1 per group
water	2 cups per group
artificial pollutants (vegetable oil, dilute tempera paint, dirt, sticks, rocks, paper, Styrofoam)	1–2 tablespoons per pollutant per group
plastic cups	1 per pollutant per group
plastic spoons	1 or 2 per pollutant per group

For Extension or Demonstration supplies, see the corresponding section.

ADVANCE PREPARATION

Supplies Preparation

Bottle Caps:

- Drill a hole in each plastic cap with the ⅛" bit. Alternatively, use the screwdriver and small screw to make a hole in the lid (wiggle the screw loose after driving it in).
- The hole needs to be large enough to allow water to flow at an observable rate, but slow enough that the water interacts with the sand in the filter.

Water Bottles:

- Fill pop-top squeeze bottles with about 2 cups of water.
- Label these bottles "water."

Artificial Pollutants:

- If you are using tempera paint as a pollutant, add just enough paint to color some water. Use this solution as the pollutant in the activity.
- You may decide to have groups share pollutants.
- Put 1–2 tablespoons of each pollutant into plastic cups for each group.
- Add 1 or 2 plastic spoons to each cup.
- Label the plastic cups with their contents.

Filter Assembly

- Students can complete the first step of the procedure, assembling the filters, in one class period. The next day, they can complete the activity.
- Alternatively, you or a group of parent volunteers may set up the filters before the activity.

Notes and Hints

- The sand may fall through the hole when the filter is assembled. If this is the case, insert a cotton ball in the lid before adding the sand to the filter.

SETUP

For each group on Day One

- 2 plastic bottles
- scissors
- roll of tape
- lid with pre-drilled hole
- sand
- cotton ball (optional)

For each group on Day Two

- assembled filter from previous day
- water in plastic pop-top bottles
- artificial pollutants in cups with spoons

At a central location (or with the teacher)

- towels and sponges for clean up

INTRODUCING THE ACTIVITY

Let the students speculate before offering answers to any questions. The answers at right are provided for the teacher.

Choose questions that are appropriate for your classroom.

What happens in your neighborhood when it rains heavily? Have you observed a difference in areas that are paved compared to unpaved?
Perhaps students have seen gutters running full and fast directly into sewers or areas of grass and trees with water soaking into the ground (or running off in muddy streams).

What substances might a heavy rainfall wash off a busy street? A household lawn? A commercial parking lot? Are they all pollutants?
Gasoline, oil, anti-freeze, hydraulic fluid, fertilizers, pesticides, silt, sand.

What are some ways to limit the amount of polluted runoff entering rivers and lakes?
Allow students to brainstorm ways and use any ideas related to filtering to introduce the activity. Point out that other valid ideas are just as valuable.

In this activity students will learn that dirt can be used to trap runoff pollution. Students also learn that there are limits to what dirt can filter.

TEACHER DEMONSTRATION

Modeling the Procedure
You may want to demonstrate how to assemble the filter from the plastic bottles and sand.

After-Activity Cleanup
As students clean up, collect the used sand into a large aquarium. During the discussion, refer to the sand and compare how dirty the sand became. Even if students' water does not appear "clean," the sand will appear to be "dirty."

Also, use this to demonstrate what will happen after a heavy rain. Pour water on top of the sand in the aquarium. Some pollutants (oil, paint, Styrofoam) will rise into the water layer. Explain that the pollutants are not completely trapped in the soil but will leach out and become runoff to pollute a new area.

CLASSROOM ACTIVITY

Have students follow the Scientific Procedure on page D - 12, working in groups of 2–3. Below are suggestions to help the teacher facilitate the activity.

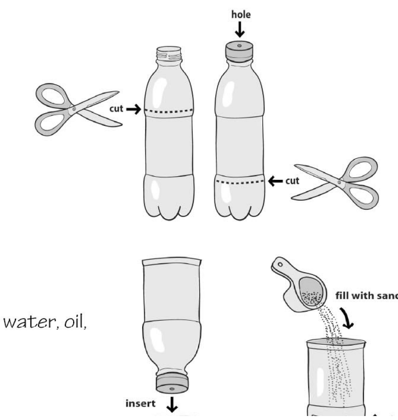
NOTES

This handout is on p. D - 12.

Cleaning With Dirt

SCIENTIFIC PROCEDURE

1. Prepare the plastic bottles.
   - Cut the bottom off one bottle, and the top off the other.
   - Put the cap with the drilled hole on the bottle with no bottom.
2. Build the filtration column.
   - Insert the bottle with the cap upside down into the other bottle.
   - Tape the bottles together.
   - Fill the column with sand.
3. To prepare some dirty water, mix some water, oil, paint, rocks, sticks, and dirt.
   - Record your recipe.



Running Suggestions

- Monitor students as they cut the bottles as directed and assemble them into filtration columns. It is important that the bottles are taped together securely BEFORE the sand is added.
- The filters will be top heavy and may tip over. Encourage students to be careful and not bump the table. Also, students may try using tape to secure the bottom of their filter column to the table.

Ongoing Assessment

- Students can prepare their dirty water according to a specific recipe, or they can each make up their own mixture. Encourage students to record their recipe for dirty water.

It is vitally important that students carefully observe and record their observations of the dirty water. Students should also carefully observe the water after it is filtered. They can compare and contrast the water when it was "dirty" and when it is "clean."

You may want to instruct students to write their answers and draw pictures on a separate piece of paper so they will have more space to write.

Safety and Disposal Information

- As students clean up, they should return their sand to a large container. If you are doing the Teacher Demonstration, collect the sand into a large aquarium.

CAUTION: Do not allow students to pour their sand down the drain.

CAUTION: Do not allow students to drink their filtered water. Even though it may look clean, it is not safe for drinking.

CLASSROOM DISCUSSION

Ask for student observations and explanations. Let the students guide the discussion and present their hypotheses before discussing explanations.

Choose questions that are appropriate for your classroom.

What mixture did you use to create your dirty water?
Answers will vary.

What did your water look like before you poured it in the filter?
The oil floated on the water. The paint mixed with the water. Dirt and sticks were floating in the water.

What happened when you filtered your water?
All the solids stayed on top of the sand. The oil stayed in the sand. The paint took longer to go through the sand, so it stayed in the sand. The paint came out of the sand later.

What did the water look like after you filtered it? Is your water clean?
It looks clear, cloudy, etc. It's definitely cleaner but not quite drinking water.

Students will likely notice that the dirt was not able to filter everything. Some may even assert that the dirt did nothing to improve the purity of the water. At this point, direct students' attention to the aquarium where they dumped their sand after filtering. Pour water into the aquarium and stir the sand. All of the trapped pollutants will appear. From this, students should see that dirt can act as a filter, but it is limited in its capability.

EXPLANATION

This background information is for teachers. Modify and communicate to students as necessary.

Students create their own mixture of dirty water, and then pour it through a sand filter. Students then observe what materials the dirt filter could and could not clean from the water.

Chemistry of Filtration

All kinds of things can float and dissolve in water. To remove them and produce cleaner water, people use **filters**. Filters work in two ways. First, they physically block the passage of large items (e.g., sticks and pieces of plastic) by trapping them inside or on the surface of the filter. Second, they chemically attract many smaller items (e.g., small drops of oil floating in the water, floating bits of clay, etc.) and prevent them from passing through.

Filters use substances like sand, dirt, and charcoal to clean water because these substances are chemically similar to and therefore attract many common pollutants. For example, sand is an excellent filter for oily water because the oil is more attracted to the sand than it is to the water. Water pours through the sand quickly, but it takes longer for the oil because the sand slows it down.

In the same way, a famous person takes longer to cross a room full of people they know than it takes a stranger to cross the same room. The number of interactions might be the same, but the length of each interaction is different.

For more information on how substances are chemically similar, see the Explanation of **Salting Out**.

Water Cycle

Usually, rainwater soaks into the ground. This water evaporates, is taken up by plants, or becomes **groundwater**. Groundwater is water that is held underground in dirt or rocks. As dirty water soaks into the soil, the soil traps **pollutants**. This means that the soil is acting as a water filter. This process takes time, so the water needs to move through the ground slowly. Plants, rocks, and other natural barriers trap surface water and slow it down enough to be filtered.

Sometimes water cannot get to the ground easily. Buildings, roads, and houses are all considered **impervious cover** and block water from getting to the ground. The water then accumulates on the roofs, gutters, and pavement. In these places it can collect even more pollutants. The water collects from these places and then gains enough volume that it moves across the impervious cover quickly, becoming **urban runoff**. When and if this urban runoff eventually reaches the ground, it is sometimes moving too quickly to be filtered by the ground. This type of pollution is called **non-point source pollution** because the pollution is collected from many sources and cannot be identified as coming from one place.

EXTENSIONS

Extension A: Inquiry Opportunity—Build a Better Filter

Try changing variables in this experiment. For example:

- Filter Length—Investigate whether a longer column results in even cleaner water. Stack multiple inverted bottles filled with sand and run the dirty water through a longer filter.
- Number of Filtrations—Investigate whether multiple trials will result in cleaner water. Pour the filtered water through the sand repeatedly to see if the water becomes cleaner.
- Filter Material—Investigate which material makes the best filter. Try any of the following items instead of sand: dirt, potting soil, shredded paper, rice, kitty litter, charcoal, or gravel.

> For more information about experimental design, see the section **Science Inquiry** in the beginning of the Guide.

Extension B: Neutralizing Acid Rain

Make fake "**acid rain**" and watch the filter neutralize it. This can be an extra teacher demonstration or an activity for student groups.

> This extension requires students to have previous experience with acid-base indicators. The activity **Of Cabbages and Kings** is a good precursor activity.

Extra Supplies

- lemon juice—1 tsp. per group
- cabbage juice indicator (prepare as in **Of Cabbages and Kings**)—1 cup per group
- substitute for sand in the filtration column
  Either—a mixture of half sand and half garden lime (which is powdered limestone)
  OR—¼- to ½-inch diameter marble chips or crushed limestone
  Marble is a common landscape material and is usually available as rocks with 1- to 3-inch diameter. You or an energetic team can crush these rocks with a hammer to a diameter of ¼- to ½-inch diameter.

> **CAUTION: If you choose to use a hammer and break up landscape marble rocks, wrap the rocks in old towels to prevent stray projectiles. Wear goggles when crushing marble rocks.**

Extra Instructions

- Mix the 1 cup of cabbage juice and 1 teaspoon of lemon juice together to make "acid rain." Make sure students know the red color of the juice shows the acid (lemon juice) in the water.
- Lemon juice is the only pollutant needed.

- Pour the acid rain solution through the column. Students should see the solution change color from pink (acid) to purple (neutral) or blue (basic) at the bottom.
- It may be helpful to pour one batch of acid rain through the sand filter to show that normal sand does not remove the acid from acid rain.

Explanation

Marble and limestone are made from calcium carbonate ($CaCO_3$). The calcium carbonate reacts with acid in water, producing hydrogen carbonate (H_2CO_3) and a neutral salt. Thus, the marble or limestone is able to **neutralize** the acid rain.
Most acid rain in the U.S. falls in the Northeast. There, engineers are lining lakes with limestone rock to help counter the effects of acid rain. Unfortunately, this is not a complete solution. The hydrogen carbonate (H_2CO_3) will further break down to produce water (H_2O) and carbon dioxide gas (CO_2). Carbon dioxide gas is known as an agent in global warming.

Another topic for discussion is the difference between a **physical change** and a **chemical change**. In the main activity, the filtration is a physical change. Even though there interactions between different chemicals, no new substances are being created when the polluted water travels through the filter. In this extension, there is a chemical change as the cabbage juice is neutralized from an acid.

Extension C: Measure Flow Rate

During the activity, students may notice that the water moves through the filters at different rates. Here is a way to quantify that difference.

Extra Supplies

- timer or a clock with a second hand

Extra Instructions

- Use a timer or a clock with a second hand to time 30 seconds.
- While students are doing the filtration, they should count the number of drops that come out of the filter in 30 seconds.
- After the activity, organize the filtered water in order from fastest filtration (most drops in 30 seconds) to slowest (fewest drops in 30 seconds).
- Observe the water. Do slow filters lead to cleaner water?

Explanation

Even though slower flow rates usually lead to cleaner water, this may not be the case due to different recipes of dirty water. Use this as an opportunity to discuss the importance of controlling variables.

For more information on experimental design, see the section **Science Inquiry** at the beginning of the Guide.

CROSS-CURRICULAR CONNECTIONS

ENVIRONMENTAL SCIENCE

Pond Study
Ponds and vernal pools are filled with runoff water. The quality of the runoff water plays an important part in the life of the pond. Use the resources listed to study a local pond.

Environmental Impacts
Research the impact of buildings, parking lots, and roads on runoff. Research ways to reduce groundwater pollution.

MATHEMATICS

Measure Impervious Cover
Find a scale map (or aerial photo) of the school grounds. On this map mark the areas that have impervious cover. Calculate the area of impervious cover and the total area of the school grounds. Then find out what percentage of the school grounds has impervious cover. Advanced students could make their own scale map of the school for calculations.

Find scale maps (or aerial photos) of your local area, a farming area, and a large city. Repeat the same calculations to find the percentage of impervious cover in these areas. Compare the calculations

RESOURCES

Web – http://pbskids.org/zoom/activities/sci/waterfilter.html
Web site gives directions on making a water filter similar to the one modeled here. Kids are encouraged to write in to the site and share their results.

Web – http://www.metro-region.org/
Metro is the regional government for the 3 counties and 25 cities in the Portland metropolitan area. At the bottom right is a link "for kids and schools" which describes lessons and videotapes available for teachers.

Web – http://www.epa.gov/npdes/pubs/nps_urban-facts_final.pdf
The Environmental Protection Agency has good information about urban runoff.

Morrison, Gordon, *Pond*
Reading level: 3rd grade to 6th grade
Uses attractive ink drawings to describe the life cycle of a pond. Includes factual text about the animals and plants that live in a healthy pond.

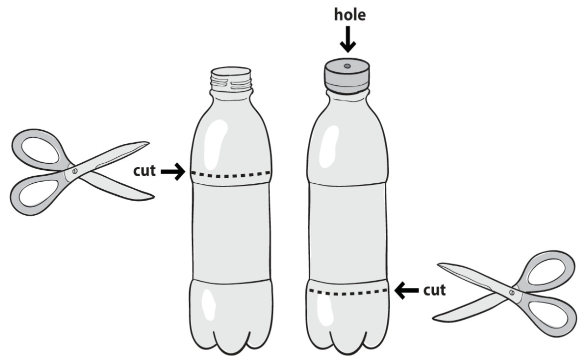
Josephs, David, *Lakes, Ponds, and Temporary Pools (Exploring Ecosystems)*
Reading level: 5th grade to 8th grade
This activity book allows students to study a local pond. Includes detailed information about ponds and how sensitive they are to environmental factors. Also includes dichotomous keys to identify organisms living in the pond.

VOCABULARY

acid rain:	clouds or rain droplets containing pollutants, such as sulfuric and nitric acid, which make them acidic
chemical change:	when substances change their properties <u>and</u> their molecules change; examples include burning, rusting, forming a new material, creating gas bubbles, creating light
filter:	a device, usually containing sand, charcoal, dirt, or some other porous material, that traps the contaminants in water when water passes through
groundwater:	water that is held underground
impervious cover:	material that blocks water from getting to the ground; pavement, buildings, roads, and sidewalks are examples
neutralize:	to make chemically neutral (i.e., bring to a pH of 7); to make inert and less dangerous
non-point source pollution:	pollution that accumulates from multiple sources
physical change:	when substances change their properties <u>without</u> any changes to their molecules; examples include melting, freezing, boiling, creating or separating a mixture, cutting, denting, or scratching
pollutant:	an agent that can potentially harm or contaminate a resource
urban runoff:	excess water, often contaminated with pollutants, that tends to dump in streams and rivers before being filtered through the ground

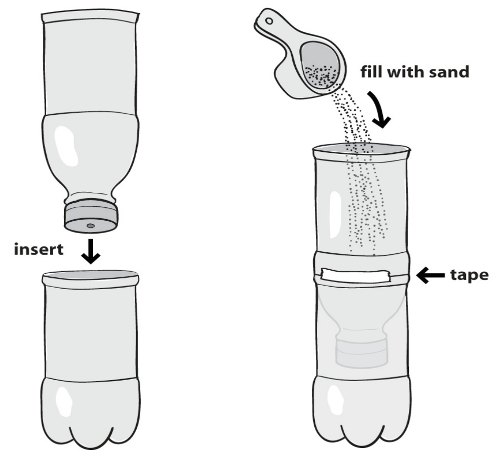
Cleaning with Dirt

SCIENTIFIC PROCEDURE



1. Prepare the plastic bottles.
    - Cut the bottom off one bottle and the top off the other.
    - Put the cap with the drilled hole on the bottle with no bottom.

2. Build the filtration column.
    - Insert the bottle with the cap upside down into the other bottle.
    - Tape the bottles together.
    - Fill the column with sand.



3. To prepare some dirty water, mix water, oil, paint, rocks, sticks, and dirt.
    - Record your recipe for dirty water.
    - What does your dirty water look like?

4. Pour your dirty water into the column, and watch it run through. When the dirty water has made it to the bottom, pour a cup of clean water on top of the column to chase out the dirty water.
    - Which ingredients are still in your water?
    - Which ingredients stayed in the sand?
    - Did some ingredients travel more slowly?

5. Clean up your area.
    - Follow your teachers instructions.

This worksheet is available online at **www.omsi.edu/k8chemistry**.

Cleaning with Dirt

Recommended group size: 2–3

Number of Students: ☐ Number of Groups: ☐

Supplies	Amount Needed	Supplies on Hand	Supplies Needed
plastic bottles, 20 oz. or 1-L (e.g., soda or water bottles)	2 per group		
plastic caps from plastic bottles	1 per group		
drill with ⅛" bit (or small screw and screwdriver)	for teacher		
scissors	1 per group		
masking tape	1 roll per group		
sand	2–3 cups per group		
cotton balls (optional)	1 per group		
pop-top squeeze bottles (e.g., water or sports drink), 16 oz. or larger	1 per group		
water	2 cups per group		
artificial pollutants (vegetable oil, dilute tempera paint, dirt, sticks, rocks, paper, Styrofoam)	1–2 tablespoons per pollutant per group		
plastic cups	1 per pollutant per group		
plastic spoons	1 or 2 per pollutant per group		
Extension A			
extra bottles for filters	amount varies		
extra sand for filters	amount varies		
other filter materials: dirt, potting soil, shredded paper, rice, kitty litter, charcoal, or gravel.	amount varies		

Supply Worksheet continues on next page.

Supplies	Amount Needed	Supplies on Hand	Supplies Needed
Extension B			
red cabbage	1 head per class		
knife, blender, or food processor	1 per class		
strainer	1 per class		
lemon juice	1 tsp per group		
crushed marble chips or crushed limestone	2–3 cups per group		
garden lime	1–2 cups per group		
hammers	1 per person crushing marble		
goggles	1 pair per person crushing marble		
Extension C			
timer or clock with a second hand	1 per group		
Teacher Demonstration			
After-Activity Clean Up			
large aquarium			
pitcher of water			