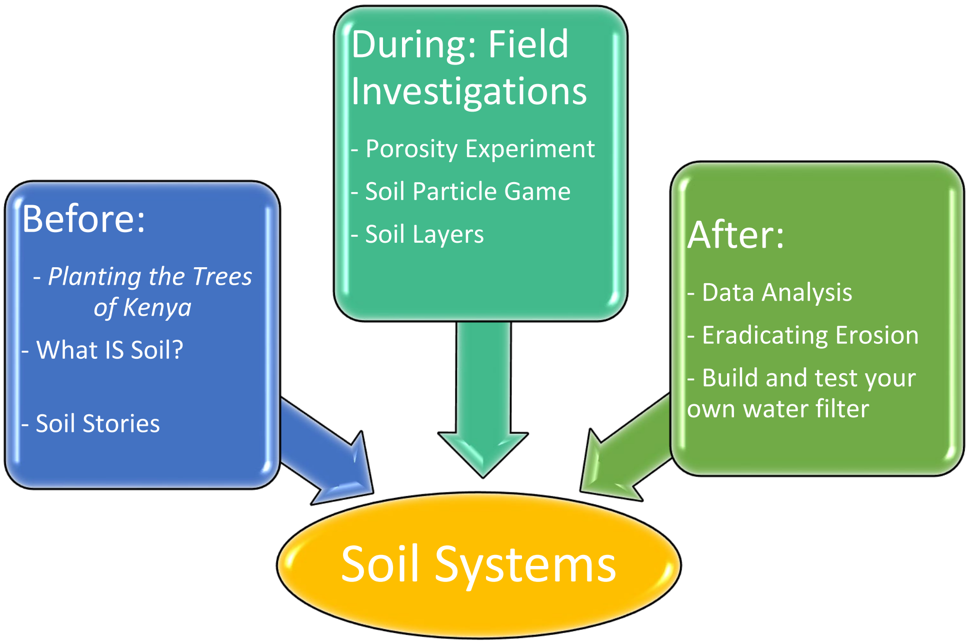
SCOOP ON SOILS



Your students will be visiting Blandy to engage in a field investigation focused on soil and soil systems.

To enhance classroom connections with the field experience, we have developed this lesson cluster. **Field investigations** are more meaningful to students when they are integrated into their curriculum. This lesson cluster can be used to: introduce soil concepts, increase depth of knowledge by synthesizing a variety of components in a systems approach, and develop student collaboration and cooperation with an action project. **Before-visit activities** increase student awareness of the process of science, understanding of soil, and create literacy connections with historical conservation figures. With the **after-visit activities**, students synthesize concepts gathered in the field as they plan and execute an action or community science project.

BEFORE 1: *Planting the Trees of Kenya*

Standards Addressed: English (2024) 3.C.1, 3.RV.1, 3.RI.1

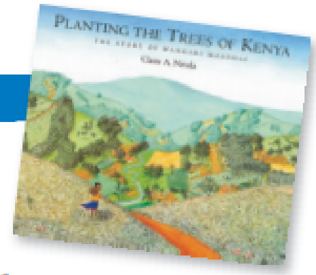
Lesson Preparation: ***Planting the Trees of Kenya: The Story of Wangari Maathai*** by Claire A. Nivola (Lexile: AD870L)

Instructional Strategy:

1. Use the RIF Guide for Educators (Figure 1) for your class to read and comprehend the book. To think more deeply about soil, add these questions:
    a. Why did the soil blow away in the “devil wind”? and
    b. What did Wangari mean when she said the soil needs its “cloth of green”?
2. If time allows, use the extension activities to further explore the text (Figure 2).

Planting the Trees of Kenya

The Story of Wangari Maathai



A RIF GUIDE FOR EDUCATORS

Themes: Heroic Women, Perseverance, Environment, Education

Grade Level: 3rd to 5th grade

Book Brief: A Kenyan woman fights to save her country, one tree at a time.

Author and Illustrator: Claire A. Nivola

Content Connections: Math, Science, Social Studies

TIME TO READ!

BEFORE WE READ, LET'S LOOK AT...

The Cover: Have students predict what the text is about based on the title and front cover illustrations. Have them make predictions about the text's genre and the author's purpose. Who is Wangari Maathai?

The Pictures: Flip through the pages in the text. Ask your students what they notice about the illustrations. How does the land change throughout the book? What effect might that have on the people of Kenya?

Prior Knowledge: Find out what your students know about Kenya. Show them Kenya on a map and point out its proximity to the equator. Explain that the climate tends to be wet and hot—ideal for growing many plants. Compare your area's climate with that of Kenya.

Vocabulary: sacred, homestead, plantation, export, silt

Purpose for Reading: Choose the purpose that best fits your class: "Let's read today to find out how the choices people make can affect their environment." "As we read, think about how the people of Kenya found themselves growing poorer even though they were working the same land they always had." "As we learn about Wangari Maathai, think about the difference just one person can make."

WHILE WE READ

MONITORING COMPREHENSION

- What caused the changes in Kenya while Wangari was away at college?
- What effect would the changes in the land have on the animals? How would this affect the people?
- How do you think Wangari felt when she returned to Kenya?
- What does Wangari mean when she says that good soldiers should have guns in their right hands and trees in their left?
- What would have happened if Wangari hadn't come back to Kenya?

LET'S THINK ABOUT

Our Purpose: Revisit the purpose: "How can choices people make affect the environment?" "Why did the Kenyan people become poorer while still farming?" "How was just one woman able to have such an effect on an entire country?" Have students look for evidence in the text to support their answers.

Extending Our Thinking: "What makes the fig tree sacred?" Point out that many cultures have traditionally considered certain plants or animals sacred because of all the things they provide for us. Is there any plant, animal or aspect of nature most people in the US today still hold sacred? Have we lost respect for nature? This would make a good think-pair-share activity.

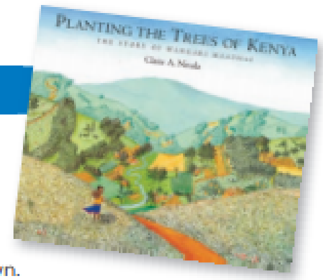
NOTE TO EDUCATORS

- Extension Activities for Educators also available.
- Vocabulary Scaffolding Sheet also available.

FIGURE 1. GUIDE FOR EDUCATORS

Planting the Trees of Kenya

The Story of Wangari Maathai



RIF EXTENSION ACTIVITIES FOR EDUCATORS

THINK-TAC-TOE ACTIVITY OPTIONS

- Individual students can choose an activity to complete.
- Educators can assign an activity for an individual, pairs or groups.
- Student pairs or cooperative groups can work together on a choice of their own.

TREES, PLEASE As the people of Kenya learned, trees are *important*! What do trees do for us every day? Using the book and your own research, make a brochure, poster or PowerPoint explaining why trees are so important for the planet. *Science/Informative Writing*	**FIND YOUR FOOTPRINT** Find out your family's ecological *footprint*, which measures how much land and water you use each year. With a parent or guardian's help, go to **www.myfootprint.org** and find your family's footprint. How big is it? Think of 5-10 ways to make it smaller. (Website is available in Spanish, Chinese, Russian and French.) *Science/Math*	**THE POWER OF ONE** Wangari made a huge difference in the world even though she was just one person. Can you think of any other people who have changed the world like Wangari? Choose one and make a children's book of your own to tell the story of that person's life. Be sure your book has lots of colorful pictures! *Word Smart/Art Smart* *Social Studies*
PEACE OUT Wangari Maathai won a Nobel Peace Prize in 2004. Research to find out who else has won a Nobel Peace Prize. Pick one winner and make a chart or graphic organizer comparing that person with Wangari. What traits do they have in common that helped them make such a difference in the world? *Social Studies*	**DEAR DIARY** Wangari was put in jail for trying to save her country. Pretend you are Wangari. Write a journal entry for your first night in jail. What's it like? Are you scared? Angry? Are the other prisoners nice? Do you wish you'd stayed in America? *Word Smart/Creative Writing*	**GO WEST, YOUNG PEOPLE!** Some of the most famous trees in the world are the giant redwood, or sequoia, trees in California. What makes these trees so special? Make a colorful tourism brochure to encourage people to come see them. Include information about their location, height, age and other fun facts. Be sure to include pictures and a map! *Science/Geography*
BOLDLY GOING There's only one Earth, and when it's gone, it's gone. Imagine you live in 2250. We've used up the whole planet! You and your crew are on a spaceship searching for a new place for humans to live. Write a story or draw a comic about your journey. Do you find a new planet? What's it like? Are there aliens living there? *Science/Creative Writing*	**DON'T PAVE PARADISE!** Oh no! The giant company PollutoCorp wants to tear down your favorite park or forest to build a parking lot! Write a letter to the editor explaining why PollutoCorp should leave your trees alone. Include reasons and concrete details to support your argument. *Science/Persuasive Writing*	**TAIGA, TAIGA** Many people think the Amazon Rainforest is the largest forest in the world. Actually, it's the Taiga Forest. Make a graphic organizer comparing the two. Include information on size, location, climate, tree type and kinds of animals that live in each forest. What percent of Earth's woodlands does each forest represent? *Science/Geography/Math*

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RIF Reading Is Fundamental

FIGURE 2. EXTENSION ACTIVITIES

SCOOP ON SOILS

BEFORE 2: **What IS Soil?**

Background for teachers: https://extension.illinois.edu/soil/soil-basics provides a good overview of soil concepts.
Standards addressed: Science (2018) 3.1, 3.6, 3.8
Instructional Strategy:

1. Ask students to bring in soil samples from their houses. (You can also collect soil from a couple different locations and bring it to class if students are unable to bring soil in. Reuse milk or yogurt containers to bring soil to school.)
2. Cover tables with paper or plastic tablecloths.
3. Instruct students to pour out their soil and carefully and closely examine the soil using hand lenses, table magnifiers, and /or microscopes.
4. Students record their soil observations by writing, drawing, and/or labeling.
5. **First**, have students investigate soil visually. Invite students to look at the soil and find the following things:
    a. The largest piece of soil they can see.
    b. The smallest piece of soil they can see.
    c. Any materials they recognize.
    d. Different colors they see.
6. **Second**, have students investigate soil by smell. Students will often have the assumption that soil smells “bad”. Soil should smell rich. Give students a second chance to smell the soil to react to their senses rather than their expectations. Invite students to scoop up a handful of soil with both hands and ask them how the soil smells:
    a. Does the soil smell sour? Rich? Good? Alive?

    Encourage students to use adjectives and descriptive language to explain why they describe the soil as smelling in a specific way.
7. **Third**, have students investigate soil by feel. Have students take a pinch of soil and rub it between their fingers.
    a. Is the soil smooth? Rough? Gritty? All of the above?
8. **Finally**, have students investigate soil structure. Invite students to grab a handful of soil and pack it into a ball in their hands. Hold the ball in an open palm and see if it stays together.
    a. Does it break when you tap on the top of the ball of soil?
    b. Is the soil blocky? Is it loose? Does it stay fluffy or does it compact easily?

    NOTE: The soil must be slightly moist for this investigation to work. If the soil is too dry, the soil particles will simply fall through students’ hands.

9. As a class, share observations. As students share, introduce vocabulary such as those defined below. These terms will be used at Blandy when discussing soils and soil layers.

  - **Organic matter**: anything that came from a recently living organism (dead leaves, insect wings, etc.) Another definition is materials of biological origin that are capable of being decayed.
  - **Inorganic matter**: minerals (non-living) substance such as sand or rocks.
  - **Topsoil, subsoil, and bedrock**: the three basic layers of soil
  - **Humus**: dark organic matter that forms as soil microorganisms decompose the plant and animal matter.
  - **Erosion**: movement, from one place to another, of pieces of rock or portions of the soil by wind, water, or ice.
  - **Soil conservation and renewal**: naturally occurring and human efforts to preserve soil resources
- **Review** with students that soil is composed of air, water, minerals, and organic matter and that soil structure depends on the percentage of each of these components.

10**. Safety:** Be sure students wash their hands and tables after handling soil.

SCOOP ON SOILS

BEFORE 3: **Soil Stories** (adapted from Project Learning Tree):

Materials: (1 per team):

- Soil Percolation student page
- metal can with both ends removed
- measuring cup (8 oz)
- stopwatch that keeps time to the second
- 20-penny nail
- flat wooden board OR thick work gloves (to press can into ground)
- ruler
- paper/pencil
- container with water

Standards addressed: Science (2018) 3.1, 3.6, 3.8; Math (2023) 3.MG.1

Instructional Strategy

1. Read the mystery below to your students and lead a discussion about it by helping students identify key questions: What is a "perk test"? How would it prevent someone from building a house? To discover the answer, students will work in teams to perform a percolation (perk) test on soil in different areas of school grounds.
2. Group students into teams of four. Distribute the student page "Soil Percolation Test" and let students get to work! Some potential scenarios: water does not disappear completely during class period—ask students why they think this is the case? (Soil may already be saturated, soil may be compacted at ground surface, or there may be a hardpan layer near the surface, etc.)
3. Allow teams to finish summarizing their data before leading a class discussion about their results. Guide students toward the understanding that dense or compacted soil has fewer air passages so that water percolates (drains) through it more slowly, while porous soils drain water very quickly.
4. Ask students why it is important that soils drain near houses. (For houses not on a sewer system, soils need to be able to drain wastewater from sinks, showers, toilets, and washing machines. Soils also need to drain rainwater to prevent flooding.)
5. Ask students why it might be a problem if the soil drains *too* quickly (These soils may not properly filter out impurities which may result in groundwater contamination.)
6. Ask students if they have a solution to the mystery. Perhaps one solution they might suggest is that the house be connected to a sewer system because the soil does not drain properly for a septic system. This is a common problem in rural areas where the soil contains large amounts of clay.
7. Explain to students that when a property fails the perk test, the land owner may be given permission to install an alternative system, called a "mound system." However, this system is very expensive and may not be appropriate depending on the property. Ask students to consider other alternatives for Petra and Rocky instead of building their house on this property.

SCOOP ON SOILS

Soil Mystery Story

One misty morning, the phone rang. Petra slowly rose from her bed and answered, “Hello? Who’s calling so early!?” The man on the line was a lawyer from the city, calling to tell Petra that her grandfather who had passed a few weeks ago, left several acres of land to Petra in his will. Petra sprung to her feet and ran to her best friend Rocky and told him the news. Rocky and Petra had been dreaming of building their own house one day, and it seemed their deepest wishes were about to come true!

Petra and Rocky drove to the countryside to see the property, and it seemed perfect: had some trees for shade, lush grasses, even a creek nearby. They were so excited that they began the process to build immediately: they came to find out they would need to do a percolation or “perk” test. When they finally received the results, all their excitement faded into dismay… Their soil had failed the perk test! So, the house cannot be built. But… why? What’s wrong with the soil?

Student Page

Soil Percolation Test

For Part B

Getting Ready

1. Within your team, choose a person for each role:

- **Equipment Monitor**–collects equipment, keeps track of it, and returns it in good condition.
- **Time Keeper**–uses a watch that tells time to the second.
- **Recorder**–makes a data chart and records data for each experiment.
- **Facilitator**–reads directions and helps everything get done.

2. Have the Equipment Monitor collect the necessary equipment from the instructor. Have the Facilitator read the instructions out loud to the team and make sure everyone understands.

Team Instructions

1. Choose five outdoor locations where there is a small patch of ground. Predict which location's soil will drain water the most quickly and which will be the slowest. Have the Recorder keep track of these predictions.

2. At each location, have the Recorder write a description of the location. Have one person push one end of the can 1" (2.5cm) into the ground. (It may be easier to rest a board on top of the can and firmly tap on the board with a hammer to push in the can.) Pour 1 cup (240 ml) of water into the can. Have the Time Keeper measure to the second how long it takes for the water to completely disappear. The Recorder records this time.

3. At each site, have one person in your team use a thumb to push a nail into the soil as far as it will go using moderate force. Then the student should measure the nail's height. Record this number.

Note: Try to use the same amount of force to push in the nail at each site. Do not use excessive force.

4. Discuss the following and record your group's answers:

a. Rank your sites by how long it took for the water to disappear (percolate).
b. How does this ranking compare with your prediction from step 1?
c. Is there a relationship between nail heights and the time it took for the water to disappear?
d. What does the data tell you about the soil's ability to filter water?
e. What assumptions can you make about the differences in soil you tested?
f. Why would a percolation test be important before someone builds a house?

SCOOP ON SOILS

DURING: Field Investigation

Standards addressed: Science (2018) 3.1, 3.6, 3.8; **Math (2023)** 3.CE.1, 3.MG.1, 3.MG.3, 3.PS.1. ; **English (2024)** 3.C.1, 3.RV.1

During your field investigation at Blandy, your students will engage in several indoor and outdoor lessons where they explore soil components and systems acting as soil scientists and soil conservationists.

Below is an overview of the "standard" program activities to assist you with integrating this field experience into the classroom experiences. Field investigations may change due to weather, volume of students, or through communication with Blandy educators.

* **Soil Experiment:** Students conduct an experiment to examine how water moves through different sized particles at different rates.
* **Soil Horizons or Layers:** Students use observation and vocabulary skills to examine soil samples and their different soil layers. Students understand that soil is a natural resource to be conserved.
* **Particle Game:** Students engage in a kinesthetic game, acting as soil particles for the main soil types (sand, silt, clay) and explore how the process of soil erosion shapes our world. Students learn the major soil components.

SCOOP ON SOILS

AFTER 1: Data Analysis for Porosity Experiment

Background: Each student group collected data during their porosity experiment. Students can apply the data cycle as they make conclusions about the experiment, discuss experimental design and flaws in their investigation process. What does the data tell us?

Standards Addressed: Math (2023): 3.PS.1, 3.NS.3

Instructional Strategy:

1. Recap and review the soil porosity experiment conducted at Blandy.
2. **Ask:** What can we do with our data from our experiment at Blandy? Solicit responses to move students to begin discussing analysis of their data. Ask students to generate ideas on HOW to analyze the data. They can write ideas on post-its, consider each idea, tally up the most frequent responses, and decide on the best way to analyze the data.
3. In the Virginia math SOL, students study bar graphs so this may be the path they choose to display their data. If so, you can find the mean (average) of the time in seconds for the water moving through the soil AND for the amount of water left in the soil.
4. Students can create graphs on large paper or create the graphs using an appropriate math digital platform.
5. Alternative: Groups input their respective data into this Google Sheets class example datasheet to visualize results.
    a. https://docs.google.com/spreadsheets/d/1t_-ssSsLBMi71mWTTD05jf7Y8lp1qHEgpx2WS0Ac-S8/copy
    b. It will ask you to make a copy to open the file, do so. Each student or group will have their own copy.
    c. Each group will enter their data into light green boxes.
    d. Datasheet automatically calculates the averages at the bottom.
    e. Graphs should automatically update with new data inputs.

AFTER 2: Eradicating Erosion in the Schoolyard

Background: Your field investigations at Blandy can be a launch into an action project in your schoolyard! Below are some general ideas and an example of an action plan. We leave this open-ended so you and your students can drive the inquiry and project goals.

Standards Addressed: Will vary with project. Activity can pull from many content areas.

Instructional Strategy:

Hook: What evidence of soil erosion did you observe during the field investigations at Blandy?

Student Work:

1. Outside, student groups find and take notes on erosion in the schoolyard. Possible places to explore are the playground, near the parking lots, front entrance, etc.
2. Once students have made their observations, discuss: Are any of the erosion areas large enough that something should be done to lesson or stop the erosion? As a class, brainstorm ideas then vote on one to pursue. What can be done to reduce or stop the erosion?
3. Class develops a plan for erosion control around their school.

Sample plan:

- Scenario: Over time, a path formed between two buildings on a school's campus. The grass has been worn down and now every time it rains, the path becomes a mud pit, erosion is occurring, washing soil down to a nearby stream.
- Students investigate the path and the erosion that is occurring, taking field notes and taking photographs or drawing what they see.
- In the classroom, students research the impact of the erosion on the stream closest to their school and research ways to mitigate (reduce or stop) the erosion. Either in groups or individually, students come up with a plan to reduce or stop the erosion. In this example, a solution might be to put in a walkway (stone tiles or something similar), seed the area with grass or moss, and then put up a temporary barrier to allow the plants to establish.
- If possible, bring in a soil scientist or expert to discuss soil, erosion, and soil management.
- Students vote on a potential solution and then write a persuasive letter to the school administration for their plan.

SCOOP ON SOILS

AFTER 3: Build and Test your own Water Filters

Standards Addressed: Science (2018) 3.1 and 3.8

Instructional Strategy: For the full lesson and videos, see https://www.teachengineering.org/activities/view/cub_environ_lesson06_activity2

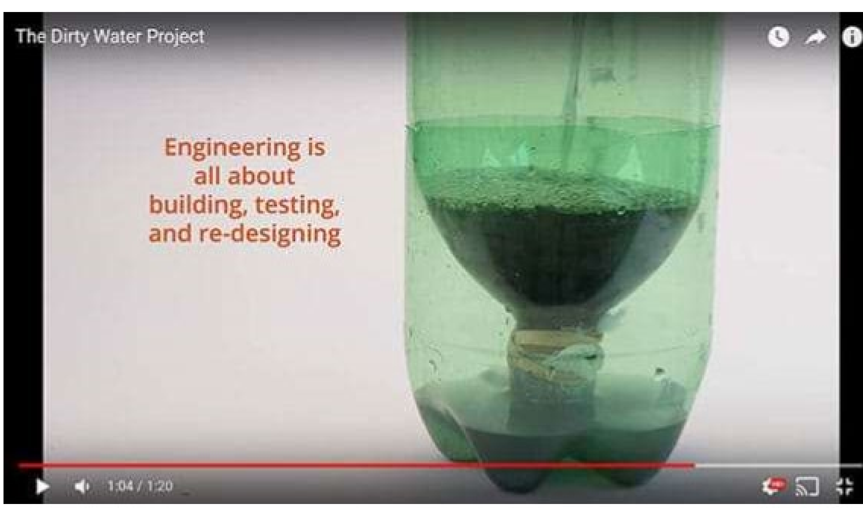
Hands-on Activity: The Dirty Water Project: Design-Build-Test Your Own Water Filters

Contributed by: Integrated Teaching and Learning Program, College of Engineering. University of Colorado Boulder

Quick Look
Grades: 3-5
Required: 90 minutes (Add 15 minutes at the beginning of class to make the “polluted water”.)
Expendable Cost: US $3.00
Subject Areas: Science and Technology

Summary

In this hands-on activity, students investigate different methods-aeration and filtering-for removing pollutants from water. Working in teams they design build and test their own water filters, -essentially conducting their own “dirty water projects”. A guiding data collection sheet is provided. This engineering curriculum meets Next Generation Science Standards (NGSS).



Students design their own water filters.

Engineering Connection

Civil, chemical, and environmental engineers work together to make existing water treatment systems better and to develop new water treatment systems. Some engineers design state of the art seawater treatment technologies that process ocean water cost effectively for safe domestic use.

SCOOP ON SOILS

Design-Build-Test Your Own Water Filters (cont.)

Learning Objectives

~ After this activity, students will be able to:
  Use sight and smell to identify pollutants in a water sample,
  Explore what types of pollutants are removed from water by aeration and filtration.
  Design, build and test a water filtration system.
  Explain the role of engineers in water treatment systems.

Educational Standards

NGSS: Next Generation Science Standards – Science International Technology and Engineering Educators Association- Technology Colorado - Science

Materials List

Each group needs:

- ~ Data Collection Sheet, one per student
- ~ 2-liter plastic bottle cut in half horizontally, as shown in Figure 1: Ask students to bring empty bottles from home or get from local recycling center near you; wash before use;
- ~ 3-inch square of mesh, such as fine nylon screen or fine cheese-doth
- ~ 1 rubberband
- ~ 1 spoon or other stirring utensil; a chopstick works well

To share among all groups:

- ~ filter materials, such as filter paper or large coffee filter (at least 6" diameter),
- ~ 6 cottonballs
- ~ 6 cups soil
- ~ 6 cups sand
- ~ 1 dozen large and small pebbles (total).
- ~ 6 cup activated charcoal (such as used for potting plants and In aquariums)
- ~ Aquarium aerator or a mechanical stirrer (pumps for fish tank work well.
- ~ Measuring cups
- ~ Large plastic jugs-1 gallon size, such as plastic gallon milk jugs with lids; for mixing/Storing "polluted water" (recipe follows)
- ~ "Polluted water" made by mixing the following items in amounts at the teacher's discretion: water (enough to fill the jugs/jars -16 full), green liquid food coloring & soil, organic matter such as grass clippings and orange rinds, dishwashing detergent, vinegar, baking soda, salt, pepper, pieces of polystyrene foam (foam peanuts), small pieces of newspaper, and your own ideas for other items.

Introduction/Motivation

Due to its incredible chemical properties. Water is considered a universal solvent. It can mix with organic natural or synthetic (human-made) substances. Some of these products easily breakdown while others break down very slowly, or perhaps never. Water naturally cleans itself via filtering through the ground and evaporation the water cycle.

At one time, communities disposed of their waste and garbage directly into lakes, streams and oceans. Now, most countries require that unclean (contaminated, polluted) water be treated before it is permitted to be released into natural bodies of water like lakes, rivers and oceans. Generally, three different ways are used to treat raw sewage (waste) water before it is released. First, the liquid is given time to settle and then is exposed to oxygen by stirring or bubbling air through it (aeration). This helps many harmful organic pollutants react with oxygen and change into carbon dioxide and water. Second, the liquid is filtered to remove the particulate matter. Third, it is treated chemically with chlorine or ozone to kill any remaining harmful components such as bacteria.
Environmental, chemical, and civil engineers work together to improve existing water treatment systems and design new ones to ensure that we have clean water both now and in the future. Today, let's imagine that we are engineers working for the Clean Water Environmental Engineering Company. The company has been asked to design a new water filtration system for a small community with a polluted water supply. We are going to focus on the second step in the water treatment process, filtering. First, we are going to look at different types of filter material to determine which ones work well. Then each group in the company will design a filtering system to clean the polluted water. The best filtering system will be used in the small community.

Procedure:
Before the Activity

1. Prepare the "polluted water" supply and let it ripen in a sunny spot for a day or two. Alternatively, do this as a class demonstration so that students know exactly what is in the water. If you have students create the "polluted water" supply, have them write down the ingredients and their sight and smell (not taste) observations about the solution as it changes.
2. Place the aerator/mixer in one sample of "polluted water" and let it sit overnight before Part 1. You will probably need to aerate a large sample of water for a day or so before Part 2, depending on how many groups choose to use aerated water for their best filter. Note: Aeration, the process of adding air to water, is often part of the water purification process in order to help many harmful organic pollutants react with oxygen and change into non-threatening carbon dioxide and water.
3. Be sure to mix the solution thoroughly before preparing the student samples.

4. Prepare the 2-liter bottles: cut them in half horizontally. Place a square of mesh over the bottle opening and secure it with the rubber band. If you use cheese cloth, you will need to replace it before Part 2.
5. Make copies of the Data Collection Worksheet, one per person.
6. Make a transparency or large chart of the class data section for use in Part 1.
7. Review the water cycle with the class. Pay special attention to where the water can be purified. See the following book for a great description: The Magic School Bus — Wet All Over: A Book about the Water Cycle by Joanna Cole and Pat Relf (New York, NY: Scholastic Books, Inc., 1996).

With the Students
Part 1

1. Divide the class into groups of three, distribute an activity sheet to each group.
2. Remind the students that they are now working for the Clean Water Environmental Engineering Company and have been asked to design a new water filtration system for a small community with a polluted water supply. First, the company is going to look at different types of filter material to determine which ones work well. Then each group in the company will design a filtering system to clean up the polluted water.
3. Give the following supplies to each group: a pre-cut 2-liter bottle, a (100-200 ml) sample of the "polluted water" in a beaker or cup, one type of "filter" (one group will not get a filter in order to test the mesh only), and a spoon.

4. Ask each group to look at a picture of the "polluted water”. Ask them to describe in words what it looks and smells like. Remind them to gently stir the solution and record their sight and smell observations on the worksheet. Remind students not to taste the solution.
5. Ask students to write down on their worksheets the predictions for what they think their particular filter material will do.
6. Ask students to set up their filters by placing the filter material Into the Inverted 2-liter bottle as shown in Figure 2. Note: Place the filter in the end of the bottle while the neck, so it functions like a funnel; Use the other half of the bottle as, a stand. Prompt students to draw sketches of the setup on their activity.
7. Ask students to gently stir the "polluted water" and then slowly pour it into the filter. Make sure the group with the filter paper is careful to not pour liquid above the top of the filter.
8. Direct students to observe what happens during the filtration. Expect some filtrations to take longer than others. Remind students to record on their worksheets their observations and draw pictures of the filtered water.
9. After all groups have collected data, share the results as a class by filling in the information

on the transparency or chart made earlier. Have students record team results in the class data section on the activity sheets.

10. As a class look at the aerated sample. Discuss what aeration is and how it works, (refer to the aeration explanation in the Before the Activity section).
11. Ask students to work in their engineering design groups to design the best water filtration system given the filter material options and their choice of aerated or non-aerated water. Have them fill in the worksheet to record and explain their design choices. Permit them to use as many of the filtering materials as they want.
12. Collect all supplies and dispose of used items properly. Rinse the 2-liter bottles.

Part 2.

1. Have students sort into their Part 1 groups.
2. Give each team a prepared 2-liter bottle, 100-200 mL of the "polluted water" in a beaker or cup (aerated or non-aerated, whichever they chose) and a spoon.
3. Distribute the filter materials as needed. Note: It helps If teams each send a designated "materials" person from collect their supplies from a central classroom location.
4. Ask students to fabricate their groups' water filter systems and draw pictures of them on their worksheets.
5. Direct students to gently stir the polluted water supply and then slowly pour an amount into the filter. For teams that use filter paper, remind them to be careful not to pour the liquid above the top of the filter.
6. Alert students to carefully observe and record on their worksheets what happens during the filtration process. Note: Some filtration systems take longer than others do. Ole "polluie.t water." so students should not worry if some filtration systems take longer than other systems. Also, have teams draw pictures on their worksheets of the filtered water.
7. Direct students to record their results and answer the worksheet discussion questions comparing answers with team members.
8. After all the groups are finished, label and line up the filtered samples. Ask each team to present its filter to the Hs (aka Clean Water Environmental Engineering Company). Conclude with a class vote and discussion about which water is the cleanest and give reasoning and/or evidence.

Safety Issues

Remind students to only make and smell observations of the "polluted water" solution and never taste a solution, even if it looks clean.

Troubleshooting Tips

Design-Build-Test Your Own Water Filters (cont.)

Have paper towels, rags, or sponges on hand In-case of spills. Consider any student allergies before making the dirty water sample. Advise students to fold the filter paper so it fits into the bottle top and suggest they pre-wet the paper so that it sticks to the sides of the "funnel. An eyedropper is useful for pre-wetting the filter paper. Remember to dispose of the waste from this experiment properly! Typically, the "polluted water" solution can be poured down the drain. However, if any contaminating chemicals were used, dispose of using responsible disposal methods.

Assessment

Pre-Activity

- Picture Draw: Ask each student to draw a picture of his/her group's "polluted water" In the space provided on the Data Collection Worksheet.
- Prediction: Ask students to write down a prediction for what they think their particular filter materials will do in the space provided on the worksheet
- Recorded Observations: Ask students to stir the solution and record their observations on their worksheets.
- Picture Drawing: Ask each student to draw a picture of his/her best water filter in the space provided on the worksheet.

Activity Embedded Assessment: Parts 1 and 2

- Recorded Observations: Students observe and record what happens during the filtration process.
- Picture Drawing: Have each student draw a picture of the filtered water in the space provided on the worksheet.

Post Activity Assessment:

- Data Recording: After all groups have collected data, share the results as a class by filling in the information on the transparency or chart made earlier. Have students record all team results in the Class Data Section on the worksheet.
- Clean Water Environmental Engineering Company Design Project: Ask students to work in their engineering design groups to design the best water filter system given the filter material options and their choice of aerated or non- aerated water. Have them record and explain their choices on the worksheet.
- Worksheet Questions: Have students answer the worksheet discussion questions, comparing answers with a team member. Collect and review student worksheets to assess their engagement, comprehension and mastery of the subject matter.
- Engineering Presentations: Ask each team to present its filter system design to the class, explaining their logic. Examine the filtered solutions. Conclude with a class vote and discussion about which water is the cleanest and why.

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Activity Extensions

1. Provide students with pH paper and a pH guide so they can determine the pH of the solution during different stages of the process: plain water, "polluted water" before treatment, after aeration, after filtering with one filter, and after using their final filter. Discuss how the different components in the solution affect the pH. How would the pH of the solution affect the rest of the environment? (Refer to pH table.)
2. Ask students to measure the volume before and after filtration. Younger students can describe it as more or less or use measuring spoons/cups. Older students can use labeled beakers or graduated cylinders.
3. Experiment with some simple chemical treatments. For example, add chlorine to a water sample as a class demo or with older students. Remember to wear protective equipment when handling chemicals!
4. Ask students: Does the order of the filter layers matter? Why or why not?
5. Direct students to filter their samples more than once, keeping a small sample after each filtration for comparison purposes. Does the water get (visually) cleaner on subsequent filtrations? Why or why not?

Activity Scaling

For younger students, conduct the activity as a demo with fewer filter choices. Demonstrate each filter type individually and then ask students to predict what will happen when both filter types are used together. Ask students to draw pictures of the results.
For older students, the teams work more independently so more time is spent on the design portion of the project. Ask students to make their own suggestions for filter materials and other ways to treat the "polluted water." Have students bring in some materials from home to test as filters and have each team test its own items after you have modeled the filtration procedure.

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