AFTER 1: 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

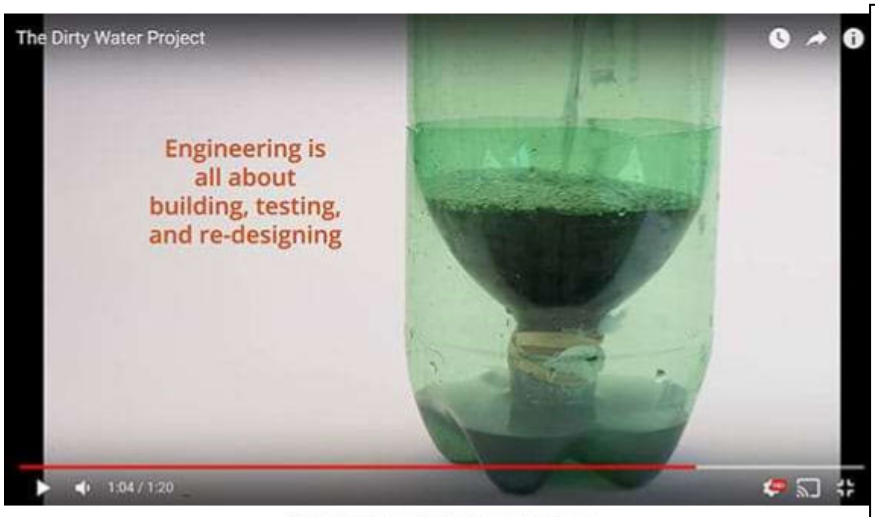
Required: 90 minutes (Add 15 minutes at the beginning of class to make the "polluted water".)

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



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.

Standards (NGSS).

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 student 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 used 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 takes longer with 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

Have some 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 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

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

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.

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, let 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.

References

- Cole, Joanna and Relf, Pat. The Magic School Bus - WetAll Over: A Book About the Water Cycle. New York, NY: Scholastic Inc.,1996 (ISBN 0-590-50833-4).
- Glencoe Science: An Introduction to the Life, Earth and Physical Sciences. Student Edition. Blacklick, OH: Glencoe/McGraw-Hill, 2002.
- Hassard, jack. Science as Inquiry - Active Learning, Project-Based, Web-Assisted and Active Assessment Strategies to Enhance Student learning.Tucson, AZ: Good Year Books, 1999. (ISBN 0-673-57731-7)
- Lucas, Eileen. Water: A Resource in Crisis. Chicago, IL: Children's Press, Inc., 1991.

- Prentice Hall Science. Ecology Earth's Natural Resources Activity Book. NJ: Prentice Hall, Inc. 1993.
- Spurling Jennett, Pamela. Investigations in Science - Ecology. Westminster, CA: Creative Teaching Press, Inc., 1995. Stille, Darlene. The New True Book - Water Pollution. Chicago, IL: Childrens Press, Inc., 1991.

Contributors

Amy Kolenbrander; Jessica Todd; Malinda Schaefer Zarske; Janet Yowell

Supporting Program

Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder

Acknowledgements

The contents of this digital library curriculum were developed under grants from the Fund for the Improvement of Postsecondary Education (FIPSE), U.S. Department of Education and National Science Foundation (GK-12 grant no. 0338326). However, these contents do not necessarily represent the policies of the Department of Education or National Science Foundation, and you should not assume endorsement by the federal government.

Last modified: March 14,2018