CONSERVATION STATION

WEEK OF RESOURCEFULNESS | CLASSROOM ACTIVITIES

ENERGY-WATER NEXUS STEM INVESTIGATIONS

Water Purity

KEY LEARNING OBJECTIVES

Students will be able to:

- **Design** and **construct** a water filtration system.
- **Engage** in teamwork to solve a problem.

OVERVIEW

This activity demonstrates methods of testing the purity of water and applying their knowledge of filtration and impurity detection to better assess how cities might improve regulating and cleaning their water. The teacher will provide several samples of water for the students to determine the pH. The teacher will lead a class discussion on how the increasing amount of carbon dioxide in the atmosphere has a direct relationship to the decreasing pH in our water reservoirs and how that impacts aquatic ecosystems and food production. Students will then be challenged to perform a water filtration activity in which they use filter papers and varying types of sediment to see which system filters water the best.

CONNECTION TO THE ENERGY-WATER NEXUS

- Continued increases in demand, growing populations, and a rapid increase in droughts are putting pressure on individuals to use water more responsibly.
- The collection and treatment of domestic sewage and wastewater is vital to public health and clean water.

NATIONAL STANDARDS

Next Generation Science Standards

- MS-ESS3-3 Earth and Human Impact
  Apply scientific principles to design a method for monitoring and minimizing a human's impact on the environment.
- MS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics
  Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

BACKGROUND

Water, despite covering 70% of the Earth's surface, is a scarce commodity. This is because only 2.5% of this water is freshwater, and just 0.3% of freshwater is found in lakes and rivers and is available for human consumption. One of our most valuable and often overlooked resources is water. We can survive for a few weeks without food, but only a few days without water. Having clean water to drink is a luxury. The water that eventually comes out of our faucets sometimes does not start off being safe to drink. In most cases, it has gone through a water treatment plant designed by engineers prior to reaching our faucets.

KEY VOCABULARY

- Commodity
- Purification
- Filtration
- Contamination

MATERIALS

- Digital balance
- Graduated cylinders (250 ml)
- Empty plastic water bottles (2 per team)
- Scissors
- Paper towels
- Cheesecloth (10 cm X 10 cm)
- Rubber bands
- Filter materials (cotton balls, coffee filters, sand, uncooked macaroni, activated carbon, aquarium gravel)
- Paper cups
- Simulated wastewater (could include coffee grounds, sand, dish soap, fertilizer, and vegetable oil)
- pH test strips

TEACHER PREPARATION

- Prepare simulated wastewater (for 1 gallon: combine 2 cups distilled vinegar, several drops of yellow food coloring, dust swept from the floor, a half-cup of soil or sand, handful of pet or human hair, and enough water to fill the gallon. Shake well.)
- Collect empty water bottles weeks in advance
- Rinse and thoroughly dry activate carbon

PROCEDURE

1. Open the lesson by showing students pictures of damage and flooding caused by Hurricane Katrina or a more recent hurricane if applicable. Lead a short discussion of how storm surges and flooding can alter the surrounding water supply and coastal zones. Water contamination from storms affects human health and the surrounding environment, and can also have a lasting impact on recreation, tourism, and the area's economy. Large quantities of pesticides and fertilizer washed down from land can cause toxic algae blooms and kill fish. Algae blooms and excess bacteria can make the drinking water supply more expensive to treat and can threaten an area's fisheries.
2. Show students the simulated waste water. Challenge them to brainstorm a list of ways that they could filter the water. Prompt students to consider filters they may have in their own homes or water bottles, classroom fish tanks, coffee filters, or examples in the kitchen (colanders and sieves). After allowing small group discussions, invite students to share their ideas with the class.
3. Next, discuss the meaning of pH, the ideal pH of drinking water, and measure the pH of the water from the drinking fountain of your school, soda, and water that a student may have brought from home.

   Teacher note: pH is a scale that identifies how acidic or basic a water-based solution is. The ideal pH of drinking water is 7 but a range of 6.5–8 is acceptable.
4. Share with students that there are many reasons why water-based solutions are measured and need to be kept in an acceptable range. And there are unfortunately many threats to maintaining a healthy pH. Lead a short discussion on how the Great Barrier Reef is under threat from a range of pressures including deteriorating water quality due to pollution from adjacent land use, rising water temperatures and increasing ocean acidification. Ocean acidification is occurring because excess carbon dioxide (CO2) in the atmosphere is being absorbed at the surface of the ocean at an increasing rate. This excess CO2 results in more hydrogen ions, which increases the acidity of the ocean. This lowers the overall pH of the water and changes the livable environment for species.
5. Describe that Coral Reefs act as natural filters, but they can be impacted by pollutants and toxins and cannot do their jobs efficiently. Some design solutions for water filtration of reef systems involve engineering filters to mimic the coral reef system. Today, we will explore how different materials could mirror and act as these critical filters!
6. Present the various types of filter material the students may use in this design challenge. The materials list suggests cotton balls, coffee filters, sand, cheesecloth, uncooked macaroni, activated carbon, and aquarium gravel.
7. In small groups of three, challenge students to determine which filter materials would provide the purest filtered water and may even look a bit like existing coral reefs. Clearly communicate to students that the water filtration devices they are about to make will remove some impurities, but they will not make the water safe to drink.
8. Students will work in groups of three to complete the Build and Test Your Filter student handout. After students have built and tested different designs, discuss the filter materials used in different groups and results achieved. Allow each group to design and build a modified filter based on the class data.
9. To close the activity after testing and modifying their designs, have students answer the summary questions on their handout.
   - What was the goal of the design challenge?
   - How can the lack of a water filtration system affect aquatic ecosystems and food production?
   - Did your team's design work as well as expected? Explain.
   - Is the water you filtered clean enough for plant, animal or human consumption?
     Do NOT drink the water!
   - What would you change to further improve the design? How could your design be modified to help purify contaminated water after storms?

EXTENSION

Have students relate this obstacle to their own lives. How does water get to your homes? What filtering processes are used every day to make sure that your water is safe to drink? If you were an engineer, what additional methods would you use to make the water safe?

If possible, take a field trip to a wastewater processing plant. Talk to the engineers and technicians about the processes that they use to filter and clean the water. What happens to the water after it is cleaned?

SOURCES

https://www.noaa.gov/education/resource-collections/ocean-coasts-education-resources/ocean-acidification

https://www.epa.gov/ground-water-and-drinking-water

https://www.usgs.gov/special-topic/water-science-school/science/wastewater-treatment-water-use?qt-science_center_objects=0#qt-science_center_objects

BUILD AND TEST A FILTER

As a team, you will act as engineers to design a filter. You will then build, test, and evaluate how effective it could be to filter pollutants and toxins.

1. Remove labels from two water bottles. Recycle one cap and place the other cap securely on the other water bottle.
2. Use scissors to remove the bottoms of both water bottles.
3. Place selected filtration materials over the opening of the water bottle without a cap and secure with a rubber band.
4. Place the water bottle with the cap upside down on the table. Place the other water bottle with the filtration materials upside down securely in the bottle sitting on the table. Both bottles will be upside down.
5. Fill the top bottle to within 1.5 inches of its top with filter materials selected by the group. Document the amounts and sequence of filter materials used.
6. Measure and record the pH of the simulated wastewater.
7. Slowly pour 200 ml of simulated wastewater through each filtration device prototype.
8. Measure and record the pH, color, and odor of the filtered water.
9. Repeat steps 3–8 with different filtration materials.
10. Wait for teacher directions to compare the results (color, odor, pH) among other groups.

Test	Filter Material(s) used	pH	Color	Odor
1				
2				

Summary Questions

1. What was the goal of the design challenge?

2. How can the lack of a water filtration system affect aquatic ecosystems and food production?

3. Did your team's design work as well as expected? Explain.

4. Is the water you filtered clean enough for plant, animal or human consumption? How do you know? Are there things in water we may need other tools to see closer? Do NOT drink the water!

5. What would you change to further improve the design? How could your design be modified to help purify contaminated water after storms?