Activity: Water Filter

In this activity, youth will learn about the importance of having clean water. Youth will apply the engineering design process to design, build, and construct a water filter that will remove all the contaminants from a bucket of dirty water.

Grade Level	Grades 6 - 8
Activity Level	Intermediate
Activity Time	One hour 20 minutes to one hour 35 minutes
Preparation time	15 minutes
Grouping	2-3 per team
Key Scientific and Engineering Terms	Filter
Career Connections	Environmental engineer

Learning Targets

- I can explain the importance of having clean drinking water.
- I can explain the negative and positive impacts humans have on aquatic environments.
- I can explain the benefits of water filtration and the positive impact it has on the environment.
- I can apply the engineering design process to design a water filter.

Connections to NGSS

This activity connects to the following Next Generation Science Standards performance expectations:

- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- **MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Materials

Per individual:

- **Key Facts About Water** handout

Per team:

- Scratch paper and pencils
- Plastic soda or water bottles (2-liter bottles and 16-ounce bottles both work)
- Gravel
- Sand
- Sponges
- Coffee filters
- Paper clips
- Straws
- Cotton balls
- Rubber bands
- Tape (electrical or duct)
- Panty hose
- Clay or putty
- Cotton batting
- Paper cups
- Cheesecloth, mesh, or some other fabric with large porous holes
- Scissors

Per class:

- A glass of water

To make the dirty water:

- A large bucket filled with water
- Food coloring (to represent chemicals)
- Raisins or dried beans (to represent animal/human waste)
- Potting soil (to represent the earth)
- Baking soda (to represent road salt)
- Vegetable oil (to represent motor oil)
- Torn pieces of paper & Styrofoam (to represent litter)
- Cooking oil

For cleanup:

- Tablecloths
- Paper towels
- Bags for disposal

Introduction (10-15 minutes)

1. **Introduce the activity**. Explain to youth that they will be **environmental engineers** and will use their engineering skills to construct a water filter that will purify dirty water. Ask youth:

   - What do you think environmental engineers do?

   Possible answers: Environmental engineers apply science and engineering principles to improve the natural environment so that our water, air, and land are healthier. They try to solve environmental problems such as air pollution and waste disposal.

2. **Discuss where water comes from and how it becomes contaminated.** Show youth the glass of water and ask:

   - Where did this water come from?

   Tip: Youth may give answers about the water's immediate source (e.g., the faucet, the water fountain, a bottle)—ask probing questions to encourage them to think about the fact that the water originally came from a

body of water such as a lake, river, or reservoir. The source may be nearby or hundreds of miles away. See *Resources* for a link to a website with information about where California's drinking water comes from.

- How do you know that it's safe to drink?
- What are some ways that water can get contaminated? What are some possible contaminants?

Possible answers: Water can pick up trash from cities, chemicals from factories, motor oil from roads, fertilizers and animal waste from farms, and animal waste from the mountains.

- How does water get cleaned before it gets to your faucet?

Possible answer: Water that is used for drinking in most parts of the United States goes through a process of being filtered, purified, and tested for contaminants before it goes into the water delivery system.

- We filter water to make it drinkable, but why do you think we need to filter wastewater before it is released into the environment?

Possible answers: Filtering wastewater before it is released into the environment helps keep the oceans and rivers clean. This helps keep wildlife and the environment healthy.

3. **Discuss facts about water and sanitation around the world.** Distribute the **Key Facts About Water** handout and have youth take turns reading each fact aloud to the rest of the group. Lead a discussion with youth using the following questions:

- After hearing all the key facts about water, what stood out to you and why?
- Do you think rainwater or water from a lake or river is immediately drinkable? Why or why not?

Possible answers: No, because water from a lake or river has dirt and other environmental contaminants such as bacteria, chemical pollutants, and trash, all of which need to be removed before it can be used for drinking.

4. **Make dirty water**. Stand in front of the class and mix up the dirty water. Start with a clean bucket of water and gradually introduce a new contaminant. Each new material represents a new contaminant.

- Food coloring (to represent chemicals)
- Raisins or dried beans (to represent animal/human waste)
- Potting soil (to represent the earth)
- Baking soda (to represent road salt)
- Vegetable oil (to represent motor oil)
- Torn pieces of paper & Styrofoam (to represent litter)

5. **Introduce filtering materials**. Remind youth that they will be building water filters. Introduce them to the various materials they can use in their filters. Ask:

- What does a *filter* do?

Possible answers: A *filter* removes pollutants or other materials from a substance. For example, air filters might filter dust out of the air.

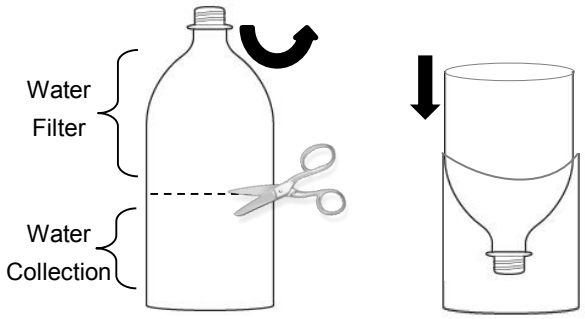
- Think about the contaminants you are trying to remove from the water. Which materials will work better to remove which contaminants?

Water Filter

Brainstorm (10 minutes):

1. **Optional: Assemble the water filter container**. Split the group into teams of two or three. Give each team an empty plastic bottle and a pair of scissors. You can either show youth how to create a water filter container, or have them create their own designs.

   If you are showing youth how to make water filter containers, have them cut off the bottom 1/3 of the bottle. The top half will be the water filter and the bottom half will be the water collection container. Flip the top half upside down and insert it into the bottom half of the bottle. (See diagram below.)



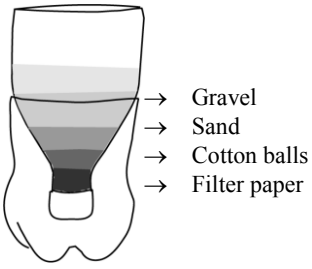
2. **Brainstorm and sketch**: Have youth look at the different materials they can use for their filters and discuss in their teams which ones they want to use.

   Tip: You may want to limit the materials that youth can use in their filters, e.g. one piece of sponge, 15 cotton balls, etc.)

3. Give each team scratch paper and a pencil to sketch their design for their filter. Have teams clearly label each layer. As youth are brainstorming, ask them the following questions:

   - Why are you using that particular material in your filter? Which "contaminants" do you think will be caught by it?
   - Why are you placing a particular material as the top layer/middle layer/bottom layer? Do you think the end result (how well the water was filtered) would change if the order of the materials was switched?

Example:



4. **Review water filters designs**. Once teams have finished their sketch have them check in with you and explain their design before beginning to build.

Water Filter

Build (30 minutes)

Build water filters. Give teams about 30 minutes to build their filters. As teams are building, engage youth by asking questions about their designs such as:

- Have you made any changes to your original design? Why?
- Do you think engineers get it right the first time?

Test and Present (10 minutes)

1. **Design a procedure to test the water filter.** Begin by asking the class to do a pair-share. Ask youth:

   - How can we tell if the water got clean?
   - What tests can we do to check the purity of water?

   Possible answers: Youth can do a visual test to see how clear the water got. They can do a smell test, comparing the smell of the water before and after filtration. They can do a touch test to compare the texture of the filtered water with the dirty water.

   Have the whole group decide on the tests they will use to determine how well the filters work.

2. **Test water filters.** Have teams test their water filters one at a time in front of the group and discuss the results, asking:

   - What do you see? Which contaminants were removed and which contaminants are still in the water?
   - Did certain materials work better for cleanup than others? Why do you think that is?
   - Which test was a better indicator of how clean the water got?
   - What other tests could we do to check the purity of the water?

Redesign and Retest (15 to 20 minutes)

1. **Redesign water filters.** Have teams redesign their filters based on what they learned during the testing phase.
2. **Test water filters.** Test the water filters once again and discuss the results. Ask youth:

   - Do you think your final water filter produced drinkable water? If it's not, what still needs to happen to make it drinkable?
   - What contaminants were easier to remove, natural or manmade?

Reflection and Discussion (5-10 minutes)

Lead a think-pair-share with youth to debrief the activity. For each question, give youth 30 seconds to think about the answer on their own, 2 minutes to discuss in pairs, and then have pairs share out their answers with the large group. This process will give all youth the opportunity to voice their thoughts about the activity.

The timings above are suggested guidelines. Feel free to adjust them based on your group's needs and the nature of the questions you are asking them to reflect on. Some possible discussion questions include:

- Imagine you no longer had running water in your house. How would your life be different?
- Why is it important that engineers and scientists are working in the area of water filtration?
- How can we conserve (protect and save) clean water for future use?
- Why is it important for people in rural areas to have access to water filters?

  Possible answers: People in rural areas may not have access to clean filtered water, and may be getting water from lakes or rivers. Water from these sources can have contaminants that make people sick.

Science and Engineering Connections

Filters

A *filter* is a device that is used to separate components of a mixture. In the case of a water filter, pollutants and debris are removed to improve the quality of the water. Clean water is clear, free of bacteria, oils, and other harmful contaminants. High quality water is clean and safe to drink.

Some other examples of filters that show up in our everyday life are oil filters, which separate contaminants from engine oil to keep cars running smoothly, and air filters, which are fibrous materials that trap mold, bacteria, and other contaminants to keep the air in buildings clean. *Environmental engineers* are involved in the design of such filters to ensure that harmful chemicals are not released into our drinking water supply or the air we breathe in. Water filtration can happen in a large facility that is run by a city. In a rural area a filter could be a small device that an individual uses.

Handout – Key Facts About Water

Adapted from **www.wateraid.org**

- **884 million people** in the world do not have access to safe water. This is roughly **one in eight** people around the world.
- Based on current trends over the next 20 years humans will use **40% more water** than they do now. (UN Environment Program (UNEP))
- 97.5% of the earth's water is saltwater. **If the world's water fit into a bucket, only one teaspoonful would be drinkable.**
- The average **European** uses **53 gallons of water** every day. **North Americans** use **106 gallons.**
- The average person in the developing world uses 2.6 gallons of water every day for their drinking, washing and cooking. (Water Supply and Sanitation Collaborative Council (WSSCC))
- **40 billion working hours** are spent carrying water each year in Africa. (Cosgrove and Rijsberman 1998)
- Households in rural Africa spend an average of **26% of their time fetching water**, and it is generally women who are burdened with the task. (DFID)
- The weight of water that women in Africa and Asia carry on their heads is commonly **45lbs.**
- The simple act of **washing hands** with soap and water can reduce diarrheal diseases by over 40%. (British Medical Journal)
- Water-related disease is the **second biggest killer of children worldwide**, after acute respiratory infections like tuberculosis.
- The **integrated approach** of providing water, sanitation and hygiene reduces the number of deaths caused by diarrheal diseases by an average of **65%**. (WHO)
- At any one time, half of the developing world's hospital beds are occupied by patients suffering from water-related diseases. (UN)
- **1.8 million children** die every year as a result of diseases caused by unclean water and poor sanitation. This amounts to around **5000 deaths a day**.
- **443 million school days are lost** each year due to water-related diseases.
- **11% more students** attend school when sanitation is available. (DFID)

*Unless otherwise stated, figures were taken from the Human Development report 2006.