

Compare Methods of Waste Processing

Note: The Student Resource Page and Student Worksheets can be found at the end of this lesson plan.

Essential Questions

- › Does water pass faster through some substances than through others?
- › What is the tradeoff between effectiveness and speed in water filtration?

Objectives

- › Compare the effectiveness of three different substances used to filter water.
- › Determine the tradeoff between how fast a substance filters water with how effectively it filters water.

Teacher Notes

Generally, clear water is of higher quality. In this activity, students investigate how water utilities filter dirty water to ensure clean clear water is delivered to our homes and schools.

To simulate commercial water processing, students will use different filtration methods (sand, charcoal and coffee filter). They will “process” waste from samples of dirty water. The water is “contaminated” with a household substance (diluted ketchup). The activity demonstrates that different substances filter water at different rates. The processes will be compared for amount of water processed during the class period and the quality of the resulting water. The key concept is the tradeoff between effectiveness of filtration versus water quality. More efficient filtration methods (charcoal) will result in cleaner water but take longer to process.

Tips

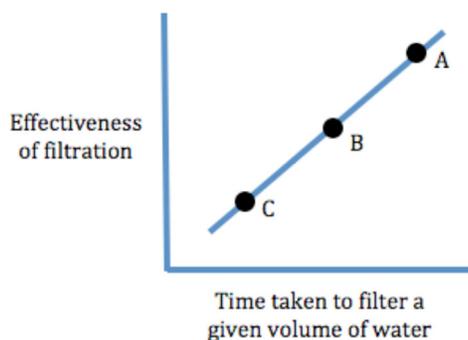
- › This activity may involve exposure to fine dust particles. Take precautions (e.g., face mask) to ensure sensitive students do not breathe in the particles.
- › To make the lesson more inquiry-based have the students decide the ratio of water to ketchup.
- › To prepare the charcoal for the activity:
 - Place a handful or so of charcoal in the large plastic bag. (Use the rubber gloves to avoid getting dirty hands.)
 - Crush the charcoal inside the plastic bag. Ensure the crushed particles are as fine as possible. Add another handful of charcoal. Continue until you have 2 cups of fine charcoal particles.
 - Add a small amount of water to the charcoal inside the bag. This prevents charcoal dust getting everywhere. Avoid breathing the dust.

Engage

1. Review some of the water Fun Facts (see Teacher Background).
2. Introduce students to key concepts (see Teacher Background) to explain why we should care about clean water and how water is filtered.
3. Conduct a straw poll to see how many students have home water filtration (such as Brita).
4. Ask the students, have they ever drunk water from a pond or lake? Did they get sick? Why then is it important to filter water? Provide a list of various diseases and explain that some are water-borne diseases caused by drinking untreated water.
5. Explain to students that many people in the world lack access to clean water due to the absence of filtration.
6. Show students the diagram of the water treatment process (EPA website) to emphasize that filtration is only one step in water treatment.

Explain (Sample Answers to Analysis Questions)

1. The coffee filter alone would be the quickest to filter the water.
2. The charcoal plus filter would take the longest to filter the water.
3. Water takes longer to percolate through closely packed particles. If the crushed charcoal particles were finer than the coarse sand, water would take longer to pass through them.
4. The coffee filter would have the least clear water, while the charcoal would have the clearest water.
5. The faster water is filtered, the less effectively it is filtered. Filters that take longer to filter water are more effective filters than those that quickly filter water. Therefore there is a tradeoff between speed of filtration and effectiveness.
6. The class used a model system to demonstrate a relationship between a substance's efficacy filtering (how much material it filters out) and how quickly water passes through the filter. In this step, students are expected to make the conceptual connection between the model system and the relationship between effectiveness and the rate of filtration. This relationship is the key learning moment of the lab. The ability to take concrete data from a model and extrapolate it to conceptualize an abstract relationship is a key scientific skill. The students should present a graph of effectiveness versus time taken to filter a given volume of water to show a positive correlation:



Useful Links

Water Treatment Process

http://water.epa.gov/learn/kids/drinkingwater/watertreatmentplant_index.cfm

Compare Methods of Waste Processing Student Resource Page

In this lab you will simulate one step in the processing of water, the removal of waste by filtration. You will compare three different methods and evaluate the efficiency and efficacy of each method.

Objectives

- > Compare the effectiveness of three different substances used to filter water.
- > Determine the tradeoff between how fast a substance filters water with how effectively it filters water.

Materials

- > 2 L plastic soda bottle
- > 4 coffee filters
- > 4 cups of multi-purpose sand
- > Bottle of ketchup
- > Craft knife
- > Large beaker or measuring bowl, big enough to accommodate the soda bottle
- > Large plastic freezer bag
- > Measuring jug (500 mL capacity or more)
- > Rubber band
- > Rubber gloves
- > Small bag of charcoal (barbecue charcoal from hardware store)
- > Tap water (2 or 3 liters in a container)
- > Timer (with second hand) or a stopwatch
- > Waste bin for used filters and filter material
- > Wooden spoon

Procedures

A. Make the test apparatus

1. Use the craft knife to cut the soda bottle in half.
2. Wrap the coffee filter around the neck of the bottle and use the rubber band to secure the filter.
3. Place the top half (inverted) of the soda bottle in the measuring beaker.
4. Support the soft drink bottle so that its neck is above the bottom of the beaker.

B. Make the "dirty" water

5. Mix the bottle of ketchup with the tap water, with a ratio of 4 parts water to 1 part ketchup. Ensure you have a total 1.5 liters for the three tests.
6. Stir the mixture with the wooden spoon.

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C. Test the filtration rates

7. Use the measuring jug to measure 500 mL of the dirty water.
8. Gently pour the water into the inverted soda bottle.
9. Start the timer.
10. In the worksheet provided, record the time taken for all the water to pass through the filter into the measuring beaker.
11. Observe the clarity of the water and make notes accordingly
12. Remove the filter and clean the apparatus.
13. Secure a clean filter to the top of the soda bottle.
14. Add 2 cups of the sand to the inverted bottle and place it in the measuring beaker. Pour 2 liters of clean tap water through the sand to clean it.
15. Repeat steps 7 through 13.
16. Place a handful or so of charcoal in the large plastic bag. (Use the rubber gloves to avoid getting dirty hands.)
17. Crush the charcoal inside the plastic bag. Ensure the crushed particles are as fine as possible. Add another handful of charcoal. Continue until you have 2 cups of fine charcoal particles.
18. Add a small amount of water to the charcoal inside the bag. This prevents charcoal dust getting everywhere. Avoid breathing the dust.
19. Place the charcoal particles in the inverted bottle. Use the wooden spoon to remove any pieces of charcoal remaining in the bag.
20. Pour 2 liters of clean tap water through the charcoal to clean it.
21. Repeat steps 7 through 13.
22. If time allows repeat the above procedure with a new layer of sand on top of the layer of charcoal.

Analysis

1. Which set up was the quickest to filter 500 mL of water?
2. Which set up took the longest to filter 500 mL of water?
3. Why do you think one set up took longer than another?
4. Describe the differences in the water after it was run through the different filters.
5. What can you conclude about how fast water is filtered compared with how effectively it is filtered?
6. Illustrate the relationship between efficiency and time taken to filter a given volume of water, showing three materials A, B, C.

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Phosphate levels: Low phosphate detergent

Material	Efficiency	Time Taken
A	High	Long
B	Medium	Medium
C	Low	Short

(In this lab you used a model to illustrate the conceptual relationship between filtering efficiency and filtering rate. You do not need actual data. You are expected to understand how the model shows a relationship between the two variables. Such understanding is a key skill in science. Simply draw a graph that would result from a correlation between how quickly a material filters water versus how efficiently the material filters water.)

Compare Methods of Waste Processing Student Worksheet

Set up	Time taken to filter 500 mL (min, sec)	Observed water clarity
Coffee filter only		
Coffee filter plus sand		
Coffee filter plus charcoal		
Coffee filter plus charcoal and sand*		

*Optional if time allows