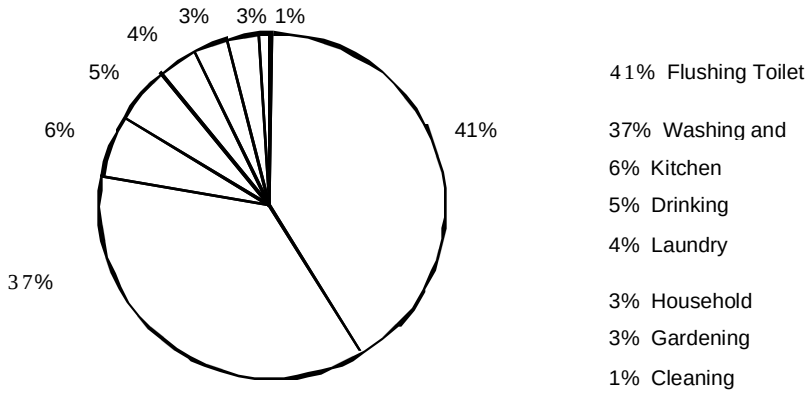
Water Pollution and Waste Water Treatment Plants: Build A Filter

Student Activity Sheet

Name_____ Date_____ Class_____

The water cycle is nature's way of providing a continuous supply of clean, pure water. The water cycle is the processes that removes water from the sea and lakes, evaporates it, and precipitates it back to the Earth again. Water is a renewable resource that means that it can be used but it can't be used up. This makes it sound as though we have plenty of water on Earth, but this is not exactly the case. Although we do have enormous water reserves, not much of it is drinkable. The majority of the water on Earth is saltwater. ***Potable*** or drinkable water is one of the most important resources required by living organisms on Earth. Since freshwater is so limited and all living beings require it, it is very important that we treat and recycle water that has already been used. Water that has been used is called ***wastewater***. It is also important to treat wastewater so that disease is not spread and pollutants do not enter the environment.

The amount of water used in the United States has doubled every 25 years since 1900. People now use more water than ever. To ensure enough water for the future we must protect our water supply now. The graph below shows you how water is most commonly used in the United States so that you can begin to understand how freshwater becomes wastewater.



The U.S. has more homes with faucets and flush toilets than any other country in the world. Every American uses an average of 70 gallons of water a day in their home. It takes about 3 gallons of

water to flush a toilet. It takes 30-40 gallons to take a bath and each minute under the shower takes at least 5 gallons. It takes up to 10 gallons of water to wash dishes, and up to 30 gallons to run an automatic washing machine.

Legislation requires that wastewater from homes and businesses must be treated before it is reused or discharged into rivers or the ocean. Many communities possess wastewater treatment facilities which process wastewater. Wastewater treatment in most communities involves a two step process. During ***primary treatment,*** solid materials in the wastewater are removed by several types of filtration and the water is then ***disinfected*** and discharged. ***Microorganisms*** and minute solid particles are removed by ***aeration*** and ***sedimentation*** during ***secondary treatment***. The resulting water is then disinfected with chlorine or some other chemical. Water that has been treated by secondary methods should be clear (no ***turbidity***), have no odor, have ***neutral pH*** and should be free of ***pathogens***.

Objectives:

- Design and test the effectiveness of a wastewater filter.
- Compare your filter to others in the class to determine the best overall filter.

Materials per team:

Plastic soda bottle with the bottom cut off	200 ml Wastewater
Water measuring container	Filter material (additional materials needed)
Plastic cups	Water
Scissors (Teacher Supplied)	pH paper
Labels	Plastic spoons

Procedure:

Stage 1

1. Form groups of three to four students. Gather the materials that you'll need.
2. Select the filter material you will use and determine the placement of each the filter materials in the bottle.
3. Assemble your filter with the bottle oriented nozzle down. Make a diagram, using the supplied bottle outline, of the layers of material in your filter.
4. Obtain 200 ml of wastewater in a plastic cup and enough water in another cup to wet your filter materials.

5. Carefully wet the filter by running enough tap water through the filter so that any dry components will no longer soak up water
6. Hold the filter over an empty cup and pour all of the wastewater into the filter.
7. After all the groups have finished filtering wastewater, determine which group created the best filter in each of the following categories:
   - Turbidity/Water clarity - compare equal amounts of all samples over white paper.
   - Odor -test to determine the filtrate sample with the least odor.
   - pH - students should conduct a pH test on each sampling using pH paper. Note: For this activity the ideal pH for water is 7.0.
   - Presence of Soap - test samples by stirring them with a spoon and looking for suds.
8. After determining which filters worked the best in each or all categories, take your filter diagrams and discuss what factors were involved in creating the best filter (s). Discuss both the materials and the placement of the materials in the filter.
9. Regroup with your team to discuss changes to be made in your filter.

Stage 2

1. Repeat Steps 2-5 from Stage 1, but redesign the filter so that the speed of filtration as well as the other properties tested before can be judged. Make sure that you use the knowledge gained from the discussion to try to improve your filter.
2. When the teacher tells you to begin, pour 200 ml. of wastewater through the new filter and stop filtering when the teacher tells you to stop.
3. Check the filtrate for pH, turbidity, odor, soap presence and also determine which group filtered the most water in the set amount of time.
4. Answer the Discussion questions.

Discussion Questions:

1. Which filter worked the best overall? Why?

2. Were there any key materials for filtering out a particular pollutant?

3. How is this activity realistic? How is this activity unrealistic? What are the limitations of the activity?

4. Which is more important, the speed of filtration or the quality of filtration?

5. What other pollutants might be found in normal wastewater? Could you construct a filter that could eliminate these pollutants?

6. The Law of Conservation of Matter (Mass) states that matter can neither be created nor destroyed. How does this Law relate to wastewater treatment?

7. In a real-world situation, what would and/or should be done with the solid waste that is left in the filter?

8. How does nature purify water?

9. Discuss qualitative versus quantitative testing. Which was used in this activity? Which is more accurate?

10. Try to design, on paper, the best possible wastewater treatment system that you can imagine and is technologically possible today.

Vocabulary

Potable water: Water that is suitable for drinking.

Wastewater: Water that has been used by humans and is no longer fit for drinking.

Primary water treatment: Wastewater is subjected to filtration that removes solids and is followed by disinfection.

Disinfection: The addition of some material, such as chlorine, which kills harmful bacteria and one-celled organisms.

Secondary water treatment: Following the removal of the solid wastes by filtration (primary treatment), the water is processed by aeration and sedimentation, followed by disinfection.

Microorganism: Bacteria and one-celled organisms that may be beneficial or harmful to humans.

Aeration: The addition of air to wastewater to speed the growth of helpful microorganisms and aid in the removal of organic matter, nitrates, and phosphates (from fertilizer).

Sedimentation: The settling out of small solids from slowly moving or still water. These solids can then be collected.

Turbidity: Cloudiness or opaqueness.

Neutral pH: When a substance is neither acid nor base and measures 7 on the pH scale.

Pathogens: Disease-carrying microorganisms.

How Does a Wastewater Treatment Plant Work?

The process of wastewater treatment can be broken down into two major stages.

Stage 1: Primary Treatment

Bar Screens: The bars are between 3/4 of an inch and 3 inches apart. The screens allow the water to flow through, but traps trash (such as rags, cans, sticks, etc.). The trash is collected and then disposed of.

Grit Chambers: Large tanks that slow down the flow of water. This allows sand, pebbles, coins, and other heavy solids to settle to the bottom to be removed later.

Primary Sedimentation Tanks: In these tanks, the flow of wastewater is again slowed to allow small, heavy particles to settle to the bottom and light objects to rise to the top. The material that sinks to the bottom is called **sludge** and the material that floats to the top is called **scum.** These waste materials are collected and disposed of properly.

Disinfection: A disinfectant such as chlorine is added to the wastewater to kill disease-causing organisms if the water is to be discharged. This step is skipped if the water is to go to Secondary Treatment.

Stage 2: Secondary Treatment

Aeration Tanks: Air is supplied to the wastewater to help speed the growth of helpful microorganisms. These microorganisms help to remove much of the organic matter and nitrates and phosphates.

Secondary Sedimentation Tanks: The flow is slowed and clumps of microorganisms and solid waste form and settle to the bottom. These clumps are referred to as **secondary sludge.**

Disinfection: Same as in Primary Treatment Disinfection.

Student Filter Diagram

Stage 1

Group Name_____ Student Name_____

Draw and label all the layers of filter material in this diagram.

Comments:

Turbidity/Clarity

pH

Odor

Soap Presence

Student Filter Diagram

Stage 2

Group Name_____ Student Name_____

Draw and label all the layers of filter material in this diagram.

Comments:

Turbidity/Clarity

pH

Odor

Soap Presence

Teacher Strategies

Students often hear about pollution and its effects on the environment yet many fail to realize what challenges exist in the cleaning up of our environment. In this activity, the students are given the chance to apply their problem solving skills to the issue of wastewater treatment. They are asked to design a simple filter to clean a sample of wastewater. From this experience, your students will gain a small scale appreciation for the large scale problem of wastewater filtration and the difficulties present in finding an easy solution to the problem.

Note: This activity has been written with the assumption that the students have very little or no prior knowledge of the ways in which wastewater may be filtered. The activity may be altered if the students have previous knowledge of wastewater filtration or basic chemistry.

Prior Preparation:

If possible, have your students bring in the majority of the filter materials so that there is more variety. Students feel a greater sense of "ownership" for the filter if they bring in the majority of the materials themselves. Tell your students to use their imaginations as the materials in the kit are only meant as a starting ground.

It is necessary for you to prepare the 'wastewater' before this activity. The recipe follows, but feel free to adapt it. If you don't add the acid or base to your wastewater then your students won't really need to use the pH paper to test the filtrate.

Wastewater Recipe

- 2500 ml Water (**Teacher Provided**).
- 35 ml Concentrated Liquid Laundry Detergent - any brand will do, but those with strong perfumes will help with the smell test.
- 5 ml Alcohol Based Extract - (lemon, mint, almond, etc.)- avoid oil based extracts because they are broken down by detergent.
- Potting soil or regular dirt or even mud.
- Sand.
- Gummy Worms, squashed jello, Slime, or anything else that the students would find gross, yet cool (**Teacher Provided**).
- Optional - NaOH or HCl to adjust pH. For example, add 2.5 ml of 6M NaOH to the water to raise the pH to 8.0 (**Teacher Provided**).
- Container to hold enough wastewater for your class (**Teacher Provided**).

Preactivity Discussion:

1. Ask the students to describe, in general, where wastewater goes, and what happens to it along the way. Go over the steps water goes through in an actual wastewater treatment plant (information sheet included).
2. Motivate the students by introducing the following activity as a contest to try to design the best possible wastewater filter.

Instructional Hints and Hazards:

Before students begin the design of the filter, make sure that you show them the ingredients of the wastewater that they will be filtering. Explain that procedure steps for Stage 1 and Stage 2 represent the two steps that wastewater goes through in an actual wastewater treatment plant and is not meant to simulate what actually happens in each stage. Making a diagram of the filter will help students to compare their filter against other teams as well as against their second filter. Wetting the filter materials before adding the wastewater will help assure that a large volume of the wastewater will not be absorbed by the filter materials.

Organization is the key to the testing of the filtrate (step 7). One method that has worked successfully is assigning a group of 3 students to do one test, such as pH, on all filtrate samples. This will require labeling each of the cups with the group's name.

Adding a competitive spirit to this activity adds to the motivation of the students. You may be successful with rewarding points for each of the four categories in Stage 1 and the five categories in Stage 2. Award 3 points for first place, 2 points for second, and 1 point for third place teams. The overall winners are then calculated and rewarded with bonus points with a special privilege, etc., as their prize. Students should work in cooperative groups or teams to create the best possible water filter. The answers to the discussion questions will depend upon the materials used for the filters.

Approximate Time Required: One class period.

Target Audience: Science.

Extensions:

Grades 4-6

1. Allow students to be more creative and design a filtration system using any equipment available in your lab. Because this is a very open ended assignment you may want to discuss this as a class or have each team hand in a design proposal sheet or a lab procedure for your approval before actually constructing the filter. Students will often want to try a distillation method of filtration. To enhance this you may want to add salt to the water to see if the students can separate it.
2. Students may try to add alum to the water as a pretreatment method. The alum will increase the settling of particles in the wastewater.
3. This activity can be done by testing only the clarity, presence of soap and speed of filtration.
4. Visit a local sewage treatment plant.

Grades 9-12

1. Students can perform the activity as indicated but also include distillation of water to remove dissolved mineral or salts such as NaCl. Teacher may demonstrate distillation. Teacher should prepare a 0.63M (3.5%) NaCl solution that is to be distilled. A distillation apparatus should be set up. This set up requires a condenser, rubber tubing, Bunsen-burner, one-hole stopper to fit flask outfitted with glass tubing, flask, NaCl solution, cold water supply, and beaker to collect distillate. A salt solution should be tasted by students before distillation. After distillation the students should taste the distillate to prove the effectiveness of distillation in removal of dissolved salts.

   Questions

   1.) How could distillation be used to increase U.S. supply of potable water?

   2.) Investigate communities/countries that must distill sea water to increase potable water supplies? What are the costs of distillation?

   3.) Does distillation remove all dissolved minerals and salts from water? Explain.
2. Potable water varies a great deal in pH and "hardness." Have student's research dissolved minerals and salts that may be present in their drinking water supplies to determine their effects on pH, hardness, taste, ability to dissolve soaps and detergents used for cleaning. Have student's research EPA regulations regarding these minerals and salts.

   Questions:

   a.) What effects does water pH and "hardness" have on taste, ability to dissolve soaps and detergents?

   b.) Is your local water supply regularly tested for dissolved minerals and salts? What are the levels? Do they exceed EPA guidelines?

   c.) What are some of the possible taste/ health effects of some of these substances?

References:

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291 Promenade Street
Providence, RI 02908

Massachusetts Water Resource Authority
Charlestown Navy Yard
100 First Avenue
Boston, MA 02129

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Published by U.R.I. Fisheries Center
Kingston, RI 02881