Discovering the Connection:
Your Environment, Your Health

Afterschool Science Club Curriculum for Middle School Students

Unit 1: Water Quality

Developed by K-12 Specialized Information Services group,
National Library of Medicine, National Institutes of Health

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About Discovering the Connection: Your Environment, Your Health

Purpose of the Curriculum

Discovering the Connection: Your Environment, Your Health uses the Tox Town Web site (toxtown.nlm.nih.gov) developed by the National Library of Medicine (NLM) to introduce middle school students to environmental health issues in everyday life. The curriculum includes information and laboratory research and communication activities, stressing the relevance of science to informed citizenship and integrating science, society, and literacy. The curriculum is for an afterschool club, but can also be used in the science classroom. The curriculum is based on National Science Education Standards.

Teaching and Learning Approaches

The curriculum uses inquiry-based learning and problem-based learning approaches. These are student-centered approaches that promote in-depth understanding and critical thinking by fostering students' active engagement with the subject matter. Students develop content knowledge and scientific reasoning skills through collaborative work on real world problems. They explore ideas, formulate meaningful questions, collect and analyze data, and evaluate and communicate their findings.

Tox Town Web Site

Tox Town (toxtown.nlm.nih.gov) is visually engaging and is an authoritative, reliable educational Web site, dedicated to highlighting the connections among chemicals, the environment, and the public's health.

Curriculum Development Team

This effort was initiated and coordinated by the NLM K-12 Specialized Information Services group. The NLM, one of the institutes of the National Institutes of Health (NIH), has been a center of information innovation since its founding in 1836. The K-12 group develops authoritative resources for a variety of science education areas, coordinates outreach to educators and school health professionals, and conducts research into teaching and learning.

The working group for this curriculum consists of: the NLM K-12 staff; Daniel M. Levin, a professor of science education from the University of Maryland College of Education; and five teachers from Montgomery County, MD, and the District of Columbia. The teachers are Jacquelyn Geer (science), Maura Hinkle (science), Sandra Garner (language arts), Kelley Knox (social studies), and Berneatta Barnes (science).

Curriculum Overview and Suggested Use

The curriculum contains six units. Each unit introduces one environmental health topic and includes three or four 50-60 minute lessons in the following format:

- Topic introduction and information research activity using Tox Town;
- Hands-on experiment or activity reinforcing understanding, conducted with simple materials; and
- Communication and social action activity where students share their understanding of the topic with others and translate their understanding into actions.

The units can be used sequentially or individually to support the existing middle school science curriculum. They can also be used to support the science/society connection in the social science or language arts classroom. The entire curriculum was pilot-tested as an afterschool club at the Cabin John Middle School, Montgomery County, MD.

The Six Units of the Curriculum

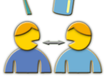
1. ***Water Quality:*** Introduces students to drinking water quality issues and the water treatment process. Includes experiments where students test school drinking water, compare it with water from other sources, and communicate the findings to the school community.
2. ***Air Quality:*** Introduces students to air quality issues and the impact of air pollution on human health. Students test air quality in several locations in and around the school.
3. ***Chemicals in Your Home:*** Informs students about potentially toxic chemicals in common products and introduces safer alternatives.
4. ***Food Safety:*** Introduces students to biological, chemical, and physical contaminants in food. Uses an experiment to teach safe food handling.
5. ***Runoff, Impervious Surfaces, and Smart Development:*** Introduces students to the relationship among runoff, water pollution, and human health. Also introduces the idea of responsible development.
6. ***The Great Debate: Bottled Water vs. Tap Water in Our School:*** Students perform research about pros and cons of different sources of drinking water, engage in a debate, and develop persuasive arguments to advocate for bottled or tap water as a primary source of drinking water in the school.

Symbols Used in This Curriculum

 – information research via Tox Town

 – lab experiment

 – hands-on activity

 – communication and social action activity

 – excerpt from student handouts in teacher directions

UNIT 1: WATER QUALITY

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Unit 1: Water Quality

Unit Overview

This unit uses the Tox Town Web site (toxtown.nlm.nih.gov) developed by the National Library of Medicine to introduce students to environmental health issues in their everyday life through *inquiry-based learning* and *problem-based learning* approaches. Inquiry-based learning is a student-centered approach that promotes in-depth understanding and critical thinking by fostering students' active engagement with the subject matter. Students explore ideas, formulate meaningful questions, collect and analyze data, and evaluate and communicate their findings. Problem-based learning is another student-centered approach, where students develop content knowledge and scientific reasoning skills through collaborative work on real world problems.

National Science Education Standards

H.F.3 Natural Resources

a. Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations.

H.F.4 Environmental Quality

a. Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.

Unit Objectives

At the end of this unit, students will be able to:

- Explain where drinking water comes from
- Discuss pollutants found in water
- Determine related risks to human health
- Explain how drinking water is treated to reduce the risks to human health

Essential Questions

How does water pollution affect human health?

What can people do to reduce water pollution and its damage to the environment and human health?

Technology Education Skills

Students will use computer resources to identify the main sources for drinking water and describe how it is treated to become safe for humans to consume.

L 1.1 Chemical Hide and Seek

L 1.1.1 Objectives, Materials, and Teacher Preparation

Objectives

Students will be able to:

- List common chemicals that can be present in drinking water
- Describe the potential human health effects of exposure to those chemicals
- Describe other (than drinking water) possible sources of exposure to these chemicals

Materials Needed for Lesson

- Several clear containers filled with water and labeled "tap," "lake," "rain," etc.
- *Chemical Hide and Seek Jigsaw Cards* (H 1.1.1)
- *Chemical Hide and Seek Chart* (H 1.1.2)
- Scissors (one for each student pair)
- Computers with Internet access

Teacher Preparation

1. Prepare copies of *Chemical Hide and Seek Jigsaw Cards* (H 1.1.1). You should have one card per two students; as there are only eight cards in the handout, some may be repeated. If you have an odd number of students, plan to assign one of the students to distribute the cards (this student will not need his or her own piece of a card). Do not print double-sided copies, as this would incorrectly cut the puzzle pieces on the other side.
2. Cut the puzzle pieces apart.
3. Prepare a copy of *Chemical Hide and Seek Chart* (H 1.1.2) for each student pair. If you have an odd number of students, one pair will have three members.
4. Ensure access to computers with Internet connection (for accessing Tox Town, toxtown.nlm.nih.gov).

L 1.1.2 Activator

Teacher Directions

1. Point to the labeled water containers and tell the students that the water in them came from different sources.
2. Ask students:
   - Would you drink water from a lake or a river? Why or why not?
   - From which containers would you drink?
   - List some words that describe good drinking water.
3. Students' descriptions are likely to include words and phrases such as no odor, no microorganisms, not too many chemicals, and no lead. To probe further, ask:
   - Which pollutants do you think can be found in the water?
   - Which chemicals?
4. Write down students' ideas on the white/black board; discuss the different types of pollutants that students mention.

L 1.1.3 Activity

Teacher Directions

1. Distribute halves of the jigsaw puzzle pieces of the chemicals that can be found in water to the students (see *Chemical Hide and Seek Jigsaw Cards* [H 1.1.1]). Each student should receive one half of one of the puzzle pieces, which can be matched to the other half, received by another student. If you have an odd number of students, have one of the students distribute the pieces, and then join one of the pairs.
2. Have students walk around the room to locate their partner by finding the matching piece to their puzzle piece. If some cards have more than one copy in circulation, have students pair up with the first partner they identify.
3. Distribute a copy of *Chemical Hide and Seek Chart* (H 1.1.2) to each pair. Ask pairs to become "experts" on their chemicals by going to the Tox Town Web site (toxtown.nlm.nih.gov) and completing the *Chemical Hide and Seek Chart* (H 1.1.2) row for their chemical. Ask students to start their research on the drinking water page.

Note: Help students navigate to the Tox Town drinking water page and locate links to specific chemicals further down on that page.

4. After students have researched their chemicals, have them come together as a group and have each student pair share their findings with the class.
5. Ask students to fill out *Chemical Hide and Seek Charts* (H 1.1.2) for all eight chemicals as they listen to presentations. Consider creating and filling out a similar table on the white/black board.

L 1.1.4 Extension

Teacher Directions

If students finish researching their chemicals early, encourage them to explore Tox Town to find out what other information is available. Some possible questions for them to research are:

- What are the main water sources for urban areas?
- Which other chemicals can be found in water?

L 1.2 What's Lurking in the Water?

Part 1: How Is Drinking Water Cleaned?

L 1.2.1 Objectives, Materials, and Teacher Preparation

Objectives

Students will be able to:

- Explain the process in which water is treated to make it safe to drink
- Explain the role of chlorination in the water treatment process

Materials Needed for Lesson

- Computers with Internet access (or one computer and a projector) to show video presentation
- Headphones, if individual computers are used
- *Drinking Water Treatment Process Organizer* (H 1.2.1)

Teacher Preparation

1. Ensure individual or group computer access for viewing the video presentation. Distribute headphones if individual computers are used.
2. Prepare copies of *Drinking Water Treatment Process Organizer* (H 1.2.1)

L 1.2.2 Activator

Teacher Directions

1. Ask students why clean drinking water is necessary for human health.
2. Explain to students that drinking water comes from groundwater, wells, rivers, lakes, streams, and reservoirs. People in cities usually drink water from lakes, rivers, and reservoirs that is filtered and cleaned through water treatment plants. People in rural areas frequently drink water pumped from a private well.
3. Make sure students understand the difference between municipal drinking water and water supplied from wells. **Note: Municipal water** is a source of water (e.g., reservoir) that is supplied by a city for public use. **Well water** is groundwater that is held in the soil and in rocks. Unlike municipal water, private well water is not regulated by the Environmental Protection Agency (EPA) or, in most cases, by state laws.
4. Optional: The following links can show students images of municipal water and well water sources.

Link: Rondout Reservoir (Ecolibrary) - ecolibrary.org/page/dp4505

Link: Private Drinking Water Wells (Environmental Protection Agency) - water.epa.gov/drink/info/well/index.cfm

L 1.2.3 Activity

Teacher Directions

Note: Students may do this activity individually or complete the activity as a group for time purposes.

1. Explain to students that tap water from municipal water sources is filtered and cleaned at water treatment plants to make it safe for people to drink.

2. Distribute *Drinking Water Treatment Process Organizer* (H 1.2.1).
3. Direct students to the following Web site to view the water treatment process:

Link: Virtual Tour of a Drinking Water Plant (Environmental Protection Agency) - epa.gov/safewater/watertreatmentplant/flash/index.html

4. Students should follow these steps from *Drinking Water Treatment Process Organizer* (H 1.2.1).

> Once you are on the Web site:
>
> a. Choose language preference.
>
> b. Select skip intro.
>
> c. Then select "TOUR THE PLANT."
>
> Your task is to learn what steps are performed in a water treatment plant to make groundwater safe for humans to consume. In the spaces below, write down what happens to the groundwater at each step in the water treatment process. If you need to return to a previous section, use the map located under the video.

5. After the students complete *Drinking Water Treatment Process Organizer* (H 1.2.1), have students discuss their answers.

L 1.2.4 Extension

Teacher Directions

After students have discussed their answers from the Activity, ask students the following questions:

- How much do we need to worry about bacteria in tap water?
- What chemicals do you think can be found in your school water fountains? (Guide students to mention chlorine and to discuss whether it is a good or bad thing.)
- What is the benefit of chlorine in drinking water?

L 1.3 What's Lurking in the Water? Part 2: Lab Experiments

L 1.3.1 Objectives, Materials, and Teacher Preparation

Objectives

Students will be able to:

- Test three water sources to determine the presence of particulate matter, pH level, and level of chlorine
- Analyze data from their experiment and draw a conclusion
- Construct bar graphs for data presented in the experiment

Materials Needed for Lesson

Handouts for the Activator

- *Background Information for Water Testing Experiments* (H 1.3.1)
- *pH Scale Guide* (H 1.3.2)

Handouts Needed for the Activity (*Note:* Each of these handouts is used in all three experiments.)

- *Drinking Water Testing Lab Experiments* (H 1.3.3*)*
- *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4)
- *Drinking Water Testing Data Analysis Sheet* (H 1.3.5)
- *Lab Report and Graph Rubric* (H 1.3.6)

Experiment 1: Particulate Matter

- Funnel (one per group)
- Coffee filters (three per group)
- Graduated cylinders (three per group)
- 150 ml beakers (three per group)
- Permanent marker and masking tape (for creating labels)
- Three sources of water (distilled water, school water fountain or tap water, water filtered through a filtering pitcher) in separate labeled containers

Experiment 2: Testing the pH of Water

- pH paper or pH indicator solution
- Clean test tubes (three per group)
- Test tube rack (one per group)
- Graduated cylinders (three per group)
- Permanent marker and masking tape (for creating labels)
- Three sources of water (distilled water, school water fountain or tap water, water filtered through a filtering pitcher) in separate labeled containers

Experiment 3: Chlorine Level

- Water test kits (can be ordered from many science supply Web sites or stores) or chlorine test strips
- Clean test tubes (three per group)
- Test tube rack (one per group)
- Graduated cylinders (three per group)
- Permanent marker and masking tape (for creating labels)
- Three sources of water (distilled water, school water fountain or tap water, water filtered through a filtering pitcher) in separate labeled containers

Teacher Preparation

1. Lab kits and testing equipment may need to be ordered from a science supply company, if materials are not available.
2. Prior to starting this lab, set up lab stations and have materials for the three experiments available at each group's station.
3. Prepare copies of the handouts.

L 1.3.2 Activator

Teacher Directions

1. Divide the students into groups.
2. Distribute *Background Information for Water Testing Experiments* (H 1.3.1). Explain that the students are about to test drinking water from several sources, and this handout introduces some concepts about drinking water sources and regulation. Have students volunteer to read the handout, or have students follow along as you read it aloud.
3. Explain to students that the allowable amount measuring unit for chlorine, **ppm**, stands for **parts per million.** The total allowable chlorine amount is 4 ppm.
4. Distribute copies of *pH Scale Guide* (H 1.3.2) and discuss the pH scale's explanation with them:

> The pH scale is used to measure how acidic or basic a liquid is. The scale goes from values 0 to 14. Pure water is and always should be 7, right in the middle. The National Secondary Water Regulations accept drinking water pH readings of 6.5 to 8.5 as safe to consume. Substances with a pH between 0 and less than 7 are acids. Substances with a pH greater than 7 and up to 14 are bases.

Note: Please discuss with students the difference between an acid and a base. Discuss with students the example of a pH scale and the pH reading of common examples of acids and bases.

Acid - A solution that has an excess of H+ ions and a pH reading that is less than 7 on a pH scale.

Base - A solution that has an excess of OH- ions and has a pH reading that is greater than 7 on a pH scale.

5. Explain that the pH reading for water should be between 6.5 and 8.5.
6. Explain that drinking water should have no evidence of particulate matter.

Note: Use the following link for information on drinking water standards: Drinking Water Contaminants (Environmental Protection Agency): http://water.epa.gov/drink/contaminants/index.cfm#List

L 1.3.3 Activity

Teacher Directions

1. Distribute the following handouts:
   - *Drinking Water Testing Lab Experiments* (H 1.3.3)
   - *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4)
   - *Drinking Water Testing Data Analysis Sheet* (H 1.3.5)
   - *Lab Report and Graph Rubric* (H 1.3.6)
2. Ask students to look at the Materials Needed for Lab section in *Drinking Water Testing Lab Experiments* (H 1.3.3).
3. Go over the materials assembled at the lab stations (see Teacher Preparation section), explaining which set of materials is needed for each of the three experiments. Refer to lists of materials in the Materials Needed for Lesson section of this lesson, or Materials Needed for Lab section on *Drinking Water Testing Lab Experiments* (H 1.3.3).
4. Go over the testable question and ask students to come up with their hypotheses, using the format provided on *Drinking Water Testing Lab Experiments* (H 1.3.3) (see below). Discuss how the data supporting or not supporting the hypotheses can be related to drinking water safety.

Testable Question: Do 1) distilled water, 2) water from the school water fountain or tap, and 3) water filtered through a filtering pitcher have acceptable levels of particulate matter and chlorine, and acceptable pH readings that would make them safe to drink?

Hypothesis for particulate matter test (If, then form): If we test our three samples for particulate matter, **then** the greatest amount of particulate matter will be in ______________________________ and the lowest amount of particulate matter will be in ______________________________.

Hypothesis for pH test (If, then form): If we test our three samples for pH, **then** the highest reading will be in ______________________________ and the lowest will be in ______________________________.

Hypothesis for chlorine test (If, then form): If we test our three samples for chlorine, **then** the highest reading will be in ______________________________ and the lowest will be in ______________________________.

5. After discussing the testable question and hypotheses, students will proceed to complete their lab experiments.
6. Read over student procedures in *Drinking Water Testing Lab Experiments* (H 1.3.3) with students.

Experiment 1: Particulate Matter (Read all of the instructions before you begin testing your water sample)

1. Obtain (1) funnel, (3) 150 ml beakers for your water samples, (3) filters, and (3) graduated cylinders.
2. Using a permanent marker and masking tape, label each beaker, graduated cylinder, and filter with the name of one of the water sources. Make sure you label the filters on their edges.
3. Fill each graduated cylinder with 150 ml of water from one of the water sources.
4. Examine each sheet of filter paper for any particles or dirt and record their presence or absence in the appropriate box of the Particulate Matter Test table in *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4).
5. If particles are present, record their number in appropriate boxes.
6. Fold the first sheet of filter paper in half and then in half again.
7. Place the folded filter paper sheet in a funnel so that it forms a cone shape.
8. Place the funnel over a beaker with the same label as the filter paper.
9. Take a graduated cylinder containing water from the source that is indicated on the beaker.
10. Pour the water very slowly from the graduated cylinder through the filter into the beaker. Work in small portions, allowing all of the water to filter through before adding more.
11. After all of the water has filtered through, carefully examine the filter paper. Is there any residue left on the paper? If so, how many particles are now on the filter paper? Did the paper change color after the water sample was filtered through?
12. Record your data in the Particulate Matter Test table *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4).
13. Repeat steps 6-12 for the two remaining water samples.
14. To get the total amount of particulate matter from the water samples, subtract the amount of particles or dirt observed before pouring the water through the filter paper from the amount of particles or dirt on the filter paper, after pouring the water through the filter paper.
15. Clean materials used and move on to Experiment 2: Testing the pH of Water.

Experiment 2: Testing the pH of Water (Read all of the instructions before you begin testing your water sample.)

1. Obtain (3) test tubes and a test tube rack for water samples.
2. Using a permanent marker and masking tape, label each test tube with the name of one of the water sources.
3. Fill each test tube with 10 ml of water from the corresponding water source.
4. Take the first test tube.

If using pH indicator solution:

5. Add 1 ml of pH indicator solution to the test tube. Gently mix the pH indicator solution together with the water sample for about 10 seconds.
6. After 10 seconds, hold the test tube against the white area of the pH color chart.

If using pH paper:

5. Insert the bottom part of the pH test strip into the test tube for about 10 seconds.
6. Remove the strip and let it dry for 10 seconds.

7. Match the sample color to a color standard. Record the pH in the pH Test table on *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4).
8. Repeat steps 4-7 for the two remaining water samples.
9. Rinse test tubes and move on to Experiment 3: Chlorine Level.

Experiment 3: Chlorine Level (Read all of the instructions before you begin testing your water sample.)

1. Using a permanent marker and masking tape, label each test tube with the name of one of the water sources.

2A. If using a chlorine test kit, follow the procedures that are included, or complete the following steps:

Note: To test for chlorine, the water must first be demineralized to remove any potential ions that could interfere with the reaction.

1. Remove the cap of the demineralizer bottle and fill the bottle with water from one of the three water sources.
2. Recap. Close the spout. Shake the bottle vigorously for 30 seconds.
3. Open the spout. Invert the bottle and gently squeeze it to release the demineralized water into the corresponding test tube.
4. Collect 10 ml of demineralized water into the test tube.
5. Discard the rest of the water.
6. Hold the bottle of hypochlorite solution vertically over the test tube.
7. Add one drop of hypochlorite solution.
8. Cap the test tube and gently mix (turn the tube upside down to mix).
9. Add one chlorine DPD test tab to the sample. (The sample will have a strong chlorine smell; DO NOT taste it.)
10. Cap the test tube again and mix until the tablet disintegrates.
11. Match the color of the water sample to a ppm reading on a color chart provided with the test kit. (If high levels of chlorine are present, the sample will turn PINK.)

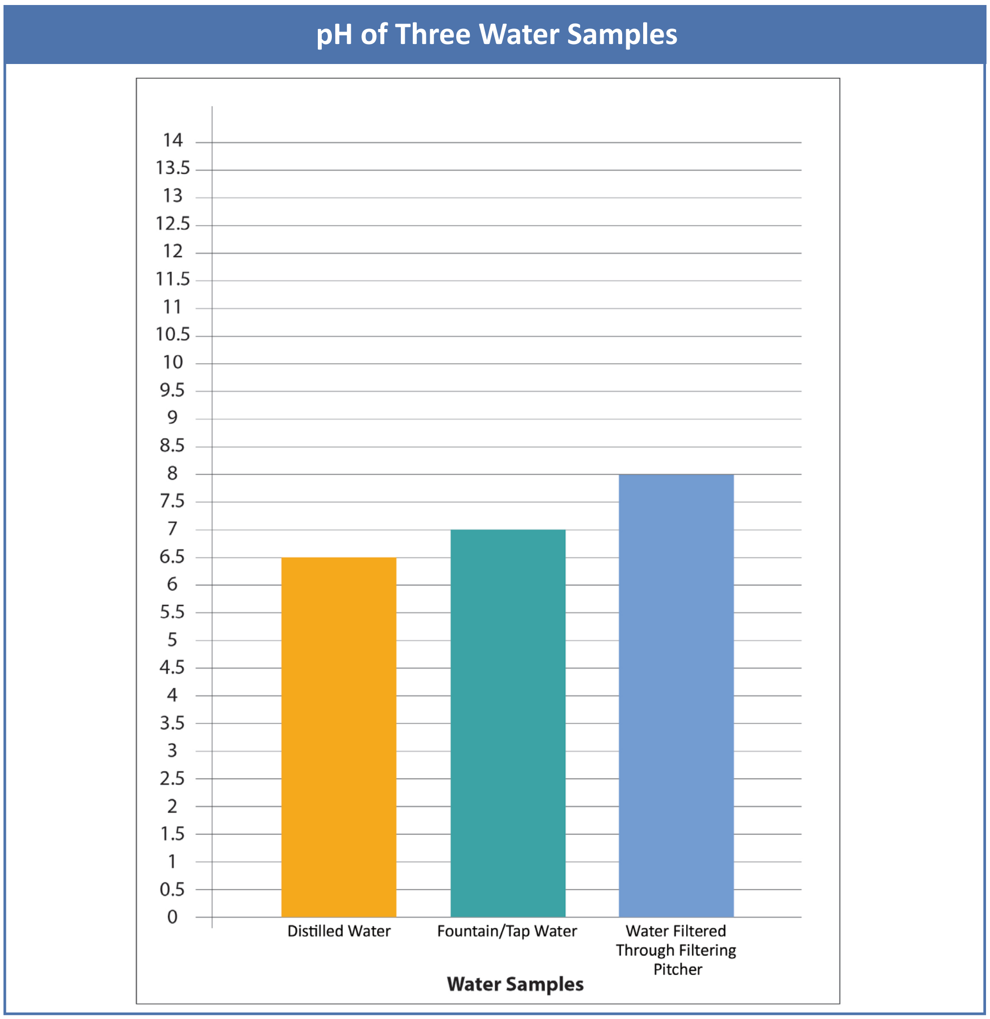
2B. If using chlorine test strips:

1. Insert the bottom part of the chlorine test strip into the test tube for about 10 seconds.
2. Remove the test strip and let it dry for 10 seconds.
3. Match the color of the test strip to a ppm reading on a color chart provided with the test strip. (If high levels of chlorine are present, the sample will turn PINK.)

3. Record your data on *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4).
4. Repeat steps for each water sample.
5. Rinse test tubes and move on to your *Drinking Water Testing Data Analysis Sheet* (H 1.3.5)

7. Tell students that they will be creating **three** graphs on *Drinking Water Testing Data Analysis Sheet* (H 1.3.5) to display the results of their tests. Each graph will show the data collected from the three water sources during one of the tests.
8. Ask students to complete the Conclusion section of *Drinking Water Testing Data Analysis Sheet* (H 1.3.5). Explain that their conclusion should summarize how their results did or did not support their hypotheses.
9. Ask students to complete *Lab Report and Graph Rubric* (H 1.3.6).

Note: Below is an example of how students should represent their graph.



L 1.4 Is It All a Matter of Taste?

L 1.4.1 Objectives, Materials, and Teacher Preparation

Objectives

Students will be able to:

- Explain how to communicate their findings about the school's water quality to their school community
- Describe how to determine the correct amount of particulate matter acceptable in drinking water
- Determine an appropriate "grade" for their school's drinking water

Materials Needed for Lesson

- Student results from *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4) and *Drinking Water Testing Data Analysis Sheet* (H 1.3.5)
- The materials needed for this activity depend upon how one's school broadcasts information. In the case of morning announcements over a public address system, one would need only a computer word processing program and/or some blank paper and writing utensils. If the school has a television studio, students may have the option of creating storyboards and producing their own short video public service announcements (PSAs) for broadcast.
- *Is It All a Matter of Taste? Public Service Activities* (H 1.4.1)
- Computers with Internet access

Teacher Preparation

1. Prepare copies of *Is It All a Matter of Taste? Public Service Activities* (H 1.4.1)
2. Make sure students have their results and conclusion from *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4) and *Drinking Water Testing Data Analysis Sheet* (H 1.3.5).
3. Ensure access for computers with Internet connection (for accessing Tox Town, toxtown.nlm.nih.gov).

L 1.4.2 Activator

Teacher Directions

Prior to completing the communication activity, have a discussion with your students about the findings from their experiments. Discuss the following questions with the students:

- Are chlorine levels in our fountain water safe? What can we say about particulate matter in the water?
- Were there differences in chlorine and particulate matter levels among the school fountains that we tested? If yes, why do you think this was the case? Which fountain would you rather drink from and why?
- Can we say that our water is safe in general?
- What other chemicals or pollutants might you want to test for?

L 1.4.3 Activity

Teacher Directions

Note: Students can work individually or in groups.

1. Ensure that students have their results from *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4) and *Drinking Water Testing Data Analysis Sheet* (H 1.3.5).
2. Distribute *Is It All a Matter of Taste? Public Service Activities* (H 1.4.1). Review the directions (see the box below).
3. Remind students to use their experiments' results to support their arguments from *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4) and *Drinking Water Testing Data Analysis Sheet* (H 1.3.5).

Directions: Now that you've completed your lab experiments, it is your job to communicate the findings to your school community. Using one of the scenarios below or your own original idea, spread the word to your school community about the drinking water quality within your school. For this activity, use the results from your experiment on *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4) and *Drinking Water Testing Data Analysis Sheet* (H 1.3.5) to support your argument.

1. Create PSAs for the morning announcements or school news show(s) that broadcast the importance of having "good" drinking water and discuss the quality of water in the school water fountain or tap.

   ***Teacher Note:* Consult your media specialist or administrator to determine the protocols for submitting PSAs.**

2. Imagine that the level of chlorine in the school water fountain or tap is too high. Voice your concern by writing a letter to your PTSA, school board, local newspapers, and/or public representatives. The letter should contain documentation of what constitutes healthy drinking water, the method and data of the students' water fountain or tap content investigation, your concerns, and suggestions on how to improve your school's water.

   ***Teacher Note:* Consult a language arts teacher for additional guidance on this activity. If the test levels were indeed too high, secure an administrator's approval prior to mailing any correspondence.**

3. Create a PowerPoint or other software presentation that can be shared during study halls, science classes, and/or other appropriate venue(s).

   ***Teacher Note:* Consult your staff development teacher for guidance on this activity, and secure an administrator's approval prior to distributing any information.**

L 1.4.4 Extension

Teacher Directions

1. After students complete their PSAs, ask students how they think their findings may benefit others outside their school community.
2. Ask students to discuss the possible positive and negative effects of publicizing the data they found during their experiments.

Helpful Web Sites for Teachers

1. **Rondout Reservoir (Ecolibrary)** – provides an image of a reservoir that supplies municipal drinking water for public use
ecolibrary.org/page/dp4505
2. **Private Drinking Water Wells (Environmental Protection Agency)** – provides an image of a private drinking water well
water.epa.gov/drink/info/well/index.cfm
3. **Drinking Water Contaminants (Environmental Protection Agency)** – provides list of contaminants and the allowable amounts in drinking water
http://water.epa.gov/drink/contaminants/index.cfm#List

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Student Handouts

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H 1.1.1 Chemical Hide and Seek Jigsaw Cards

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Arsenic

Bisphenol A (BPA)

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Chlorine

Gasoline

INTENTIONALLY LEFT BLANK

Lead

Mercury

INTENTIONALLY LEFT BLANK

Methanol

Persistent Organic Pollutants (POPs)

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H 1.1.2 Chemical Hide and Seek Chart

Name(s): ______________________________ Date: ______________

Chemical Name	How is this chemical used?	Where is it found? (How can you be exposed?)	How can this chemical affect human health?
Arsenic			
Bisphenol A (BPA)			
Chlorine			
Gasoline			
Lead			
Mercury			
Methanol			
Persistent Organic Pollutants (POPs)			

H 1.2.1 Drinking Water Treatment Process Organizer 

Name(s): ______________________________ Date: ______________

Directions:

Access the following link: Virtual Tour of a Drinking Water Plant
epa.gov/safewater/watertreatmentplant/flash/index.html

Once you are on the Web site:

A. Choose language preference.

B. Select skip intro.

C. Then select "TOUR THE PLANT."

Your task is to learn what steps are performed in a water treatment plant to make groundwater safe for humans to consume. In the spaces below, write down what happens to the groundwater at each step in the water treatment process. If you need to return to a previous section, use the map located under the video.

Water Treatment Process
Step 1: Pretreatment/Screening
Step 2: Coagulation and Flocculation
Step 3: Sedimentation
Step 4: Filtration
Step 5: Disinfection

H 1.3.1 Background Information for Water Testing Experiments

Name(s): ______________________________ Date: ______________

Your task:

You are about to investigate the quality of the water that students and teachers drink at your school and compare it with drinking water from other sources.

Before you begin, there are several things you should know about where drinking water comes from and how it's regulated.

Water sources:

Drinking water can come from either municipal or private water sources. These water sources are regulated differently. Municipal water must meet the quality standards set by the Environmental Protection Agency (EPA). Approximately 15 percent of Americans rely on their own private drinking water supplies (private wells). These supplies are not subject to EPA standards, although some state and local governments set rules to protect well users.

Unlike public municipal drinking water systems serving many people, wells do not have experts regularly checking the water's source and its quality before it is sent to the tap. These households must take special precautions to ensure the protection and maintenance of their drinking water supplies. (Source: http://water.epa.gov/drink/info/well/index.cfm)

Pollutants in your experiments:

EPA sets standards or guidelines for maximum allowable levels for numerous contaminants in the drinking water. In our experiments, we will focus on two: particulate matter and chlorine.

pH:

We will also measure the pH level of drinking water. Please, refer to *pH Scale Guide* (H 1.3.2) for information about water pH and its regulation. pH is important to regulate because having it too high or too low is bad for human health. For example, high pH levels in the water can break down the lead solder in pipes, which can lead to the water being unhealthy for you to drink.

Chlorine in drinking water:

Some chemicals are added to municipal water to make it safe to drink. Chlorine is a chemical added to municipal water as a treatment technique to kill unwanted bacteria that can cause you to get sick. When added to water during the water treatment process, chlorine helps produce water that is safe for people to drink. At the same time, you don't want too much chlorine in the drinking water. EPA standards state that the total allowable amount for chlorine in drinking water is 4 ppm (parts per million). Although chlorine is used for making sure your water is safe to drink, it is important to know that the pH levels in water can change based on the amount of chlorine present in the water.

Particulate matter in drinking water:

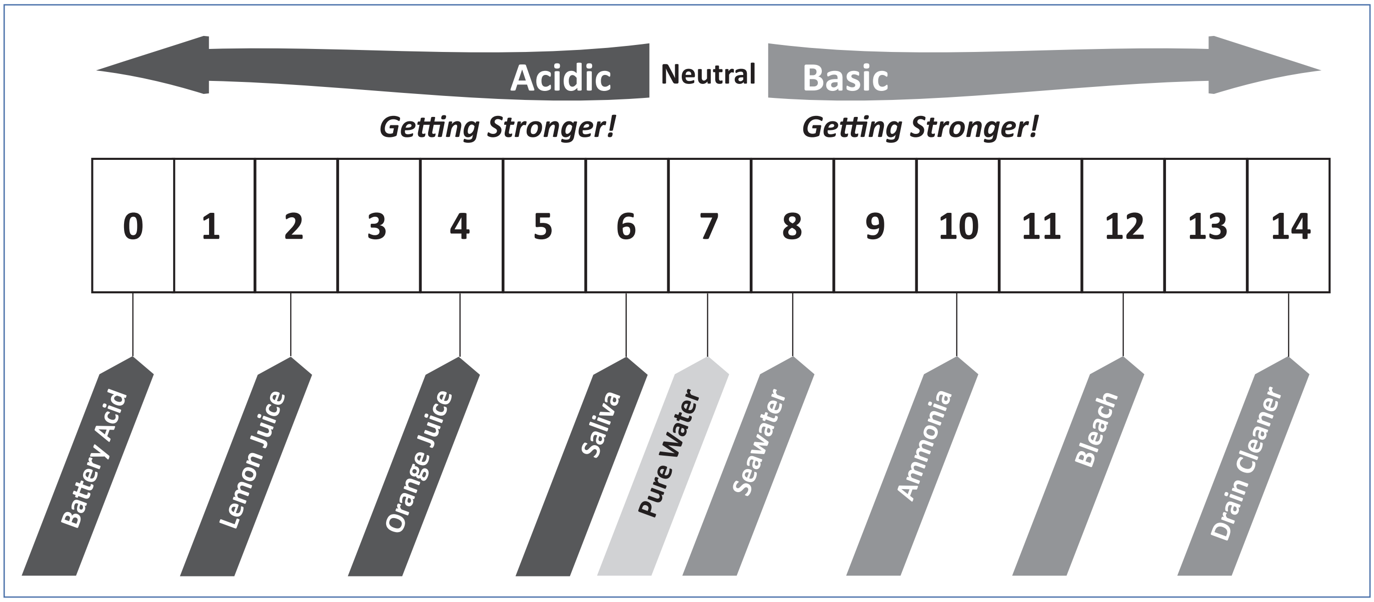
Particulate matter includes tiny particles found in the water, such as dust, dirt, and soot. It is important for drinking water to be free of particulate matter, which can cause drinking water to be unsafe for humans to consume.

H 1.3.2 pH Scale Guide

Name(s): ______________________________ Date: ______________

The pH scale is used to measure how acidic or basic a liquid is. The scale goes from values 0 to 14. Pure water is and always should be 7, right in the middle. The National Secondary Water Regulations accept drinking water pH readings of 6.5 to 8.5 as safe to consume. Substances with a pH between 0 and less than 7 are acids. Substances with a pH greater than 7 and up to 14 are bases.

Below is an example of a pH scale and the pH reading of common examples of acids and bases.



H 1.3.3 Drinking Water Testing Lab Experiments

Name(s): ______________________________ Date: ______________

Testable Question: Do 1) distilled water, 2) water from the school water fountain or tap, and 3) water filtered through a filtering pitcher have acceptable levels of particulate matter and chlorine, and acceptable pH readings that would make them safe to drink?

Hypothesis for particulate matter test (If, then form): If we test our three samples for particulate matter, **then** the greatest amount of particulate matter will be in ______________________________ ______________________________ and the lowest amount of particulate matter will be in ______________________________.

Hypothesis for pH test (If, then form): If we test our three samples for pH, **then** the highest reading will be in ______________________________ and the lowest will be in ______________________________.

Hypothesis for chlorine test (If, then form): If we test our three samples for chlorine, **then** the highest reading will be in ______________________________ and the lowest will be in ______________________________.

Materials Needed for Lab

Experiment 1: Particulate Matter

- Funnel (one per group)
- Coffee filters (three per group)
- Graduated cylinders (three per group)
- 150 ml beakers (three per group)
- Permanent marker and labels (to label beakers)
- Three sources of water (distilled water, school water fountain or tap water, water filtered through a filtering pitcher) in separate labeled containers

Experiment 2: Testing the pH of Water

- pH paper or pH indicator solution
- Clean test tubes (three per group)
- Test tube rack (one per group)
- Graduated cylinders (three per group)
- Permanent marker and labels
- Three sources of water (distilled water, school water fountain or tap water, water filtered through a filtering pitcher) in separate labeled containers

Experiment 3: Chlorine Level

- Water test kits (can be ordered from many science supply Web sites or stores) or chlorine test strips
- Clean test tubes (three per group)
- Test tube rack (one per group)
- Graduated cylinders (three per group)
- Permanent marker and labels
- Three sources of water (distilled water, school water fountain or tap water, water filtered through a filtering pitcher) in separate labeled containers

Experiment 1: Particulate Matter
(Read all of the instructions before you begin testing your water sample.)

1= Distilled Water

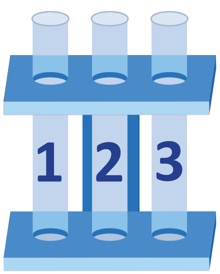
2= Fountain or Tap Water

3= Water Filtered Through a Filtering Pitcher

1. Obtain (1) funnel, (3) 150 ml beakers for your water samples, (3) filters, and (3) graduated cylinders.
2. Using a permanent marker and masking tape, label each beaker, graduated cylinder, and filter with the name of one of the water sources. Make sure you label the filters on their edges.
3. Fill each graduated cylinder with 150 ml of water from one of the water sources.
4. Examine each sheet of filter paper for any particles or dirt and record their presence or absence in the appropriate box of the Particulate Matter Test table in *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4).
5. If particles are present, record their number in appropriate boxes.

6. Fold the first sheet of filter paper in half and then in half again.
7. Place the folded filter paper sheet in a funnel so that it forms a cone shape.
8. Place the funnel over a beaker with the same label as the filter paper.
9. Take a graduated cylinder containing water from the source that is indicated on the beaker.
10. Pour the water very slowly from the graduated cylinder through the filter into the beaker. Work in small portions, allowing all of the water to filter through before adding more.
11. After all of the water has filtered through, carefully examine the filter paper. Is there any residue left on the paper? If so, how many particles are now on the filter paper? Did the paper change color after the water sample was filtered through?
12. Record your data in the Particulate Matter Test table *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4).
13. Repeat steps 6-12 for the two remaining water samples.
14. To get the total amount of particulate matter from the water samples, subtract the amount of particles or dirt observed before pouring the water through the filter paper from the amount of particles or dirt on the filter paper, after pouring the water through the filter paper.
15. Clean materials used and move on to Experiment 2: Testing the pH of Water.

Experiment 2: Testing the pH of Water
(Read all of the instructions before you begin testing your water sample.)



1= Distilled Water

2= Fountain or Tap Water

3= Water Filtered Through a Filtering Pitcher

1. Obtain (3) test tubes and a test tube rack for water samples.
2. Using a permanent marker and masking tape, label each test tube with the name of one of the water sources.
3. Fill each test tube with 10 ml of water from the corresponding water source.
4. Take the first test tube.

If using pH indicator solution:

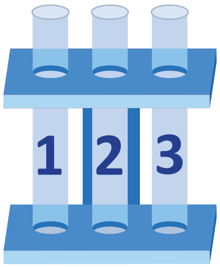
5. Add 1 ml of pH indicator solution to the test tube. Gently mix the pH indicator solution together with the water sample for about 10 seconds.
6. After 10 seconds, hold the test tube against the white area of the pH color chart.

If using pH paper:

5. Insert the bottom part of the pH test strip into the test tube for about 10 seconds.
6. Remove the strip and let it dry for 10 seconds.

7. Match the sample color to a color standard. Record the pH in the pH Test table on *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4).
8. Repeat steps 4-7 for the two remaining water samples.
9. Rinse test tubes and move on to Experiment 3: Chlorine Level.

Experiment 3: Chlorine Level
(Read all of the instructions before you begin testing your water sample.)



1= Distilled Water

2= Fountain or Tap Water

3= Water Filtered Through a Filtering Pitcher

1. Using a permanent marker and masking tape, label each test tube with the name of one of the water sources.

2A. If using a chlorine test kit, follow the procedures that are included, or complete the following steps:

   1. To test for chlorine, the water must first be demineralized to remove any potential ions that could interfere with the reaction.
   2. Remove the cap of the demineralizer bottle and fill the bottle with water from one of the three water sources.
   3. Recap. Close the spout. Shake the bottle vigorously for 30 seconds.
   4. Open the spout. Invert the bottle and gently squeeze it to release the demineralized water into the corresponding test tube.
   5. Collect 10 ml of demineralized water into the test tube.
   6. Discard the rest of the water.
   7. Hold the bottle of hypochlorite solution vertically over the test tube.
   8. Add one drop of hypochlorite solution.
   9. Cap the test tube and gently mix (turn the tube upside down to mix).
   10. Add one chlorine DPD test tab to the sample. (The sample will have a strong chlorine smell; DO NOT taste it.)
   11. Cap the test tube again and mix until the tablet disintegrates.
   12. Match the color of the water sample to a ppm reading on a color chart provided with the test kit. (If high levels of chlorine are present, the sample will turn PINK.)

2B. If using chlorine test strips:

   1. Insert the bottom part of the chlorine test strip into the test tube for about 10 seconds.
   2. Remove the test strip and let it dry for 10 seconds.
   3. Match the color of the test strip to a ppm reading on a color chart provided with the test strip. (If high levels of chlorine are present, the sample will turn PINK.)

3. Record your data on *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4).
4. Repeat steps for each water sample.
5. Rinse test tubes and move on to your *Drinking Water Testing Data Analysis Sheet* (H 1.3.5)

H 1.3.4 Drinking Water Testing Lab Results Recording Sheet

Name(s): ______________________________ Date: ______________

Particulate Matter Test

Directions:

Answer the following questions for each sample test. Put the word "yes" or "no" depending on the result from the water sample. To get the total amount of particulate matter from the water samples, subtract the amount of particles or dirt observed before pouring the water through the filter paper from the amount of particles or dirt on the filter paper, after pouring the water through the filter paper.

	Water Source		
	Distilled Water	Fountain or Tap Water	Water Filtered Through Filtering Pitcher
Are particles or dirt present on the filter paper before pouring water sample through filter paper? **(Y/N)**			
Are there any particles or dirt present on the filter after pouring water sample through filter paper? **(Y/N)**			
Did the filter paper change color after pouring water sample through filter paper? **(Y/N)**			
# of particles or dirt on filter paper before pouring water sample through filter paper			
# of particles or dirt on filter paper after pouring water sample through filter paper			
Total # of particles in drinking water sample			

pH Test

pH Testing	
Distilled Water	
Fountain or Tap Water	
Water Filtered Through Filtering Pitcher	

Chlorine Test

Chlorine Test (ppm)	
Distilled Water	
Fountain or Tap Water	
Water Filtered Through Filtering Pitcher	

H 1.3.5 Drinking Water Testing Data Analysis Sheet

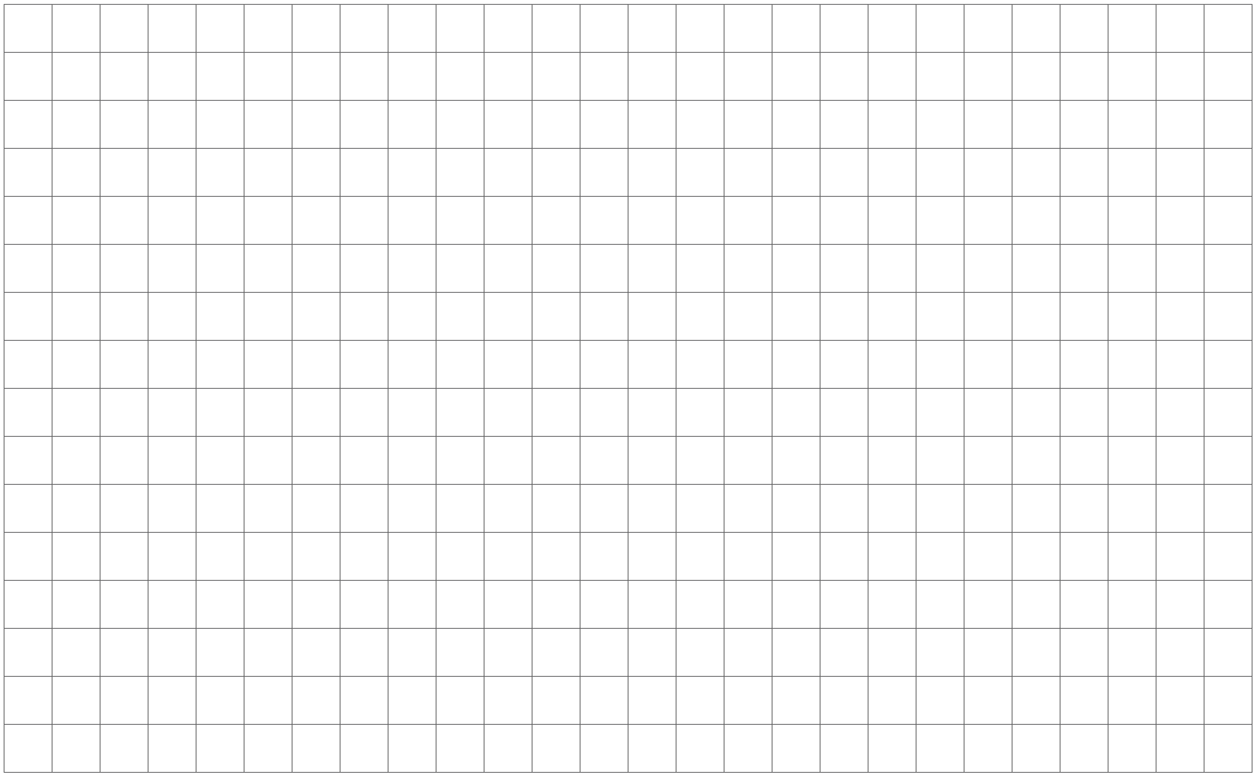
Name(s): ______________________________ Date: ______________

Data Analysis

Directions:

Construct three graphs illustrating your results from each test.

Particulate Matter Test Results Graph



pH Test Results Graph

Chlorine Test Results Graph

Conclusion

Write a conclusion about your experiment and your results. Use the space provided below.

H 1.3.6 Lab Report and Graph Rubric

Name(s): ______________________________ Date: ______________

Lab Report Rubric	
Are your data tables complete?	___yes ___ no
Is your conclusion written in paragraph form?	___yes ___ no
Does the first sentence tell what the experiment is about?	___yes ___ no
Does the second sentence state the hypotheses (hypotheses can be more than one sentence)?	___yes ___ no
Does your conclusion explain how your data support or do not support each of your hypotheses?	___yes ___ no
Did you use accurate scientific vocabulary?	___yes ___ no
Total	**_______/6**

Graph Rubric	
Do your graphs have labels on the axes?	___yes ___ no
Do your labels include units of measurement, if appropriate?	___yes ___ no
Are your data correctly plotted?	___yes ___ no
If a key was needed, was it constructed correctly?	___yes ___ no
Are your independent variables on the x-axis and your dependent variables on the y-axis?	___yes ___ no
Total	**_______/5**

H 1.4.1 Is It All a Matter of Taste? Public Service Activities

Name(s): ______________________________ Date: ______________

Now that you've completed your lab experiments, it is your job to communicate the findings to your school community. Using one of the scenarios below or your own original idea, spread the word to your school community about the drinking water quality within your school. For this activity, use the results from your experiment on *Drinking Water Testing Lab Results Recording Sheet* (H 1.3.4) and *Drinking Water Testing Data Analysis Sheet* (H 1.3.5) to support your argument.

1. Create public service announcements (PSAs) for the morning announcements or school news show(s) that broadcast the importance of having "good" drinking water, and discuss the quality of water in the school water fountain or tap.
2. Imagine that the level of chlorine in the school water fountain or tap is too high. Voice your concern by writing a letter to your PTSA, school board, local newspapers, and/or public representatives. The letter should contain documentation of what constitutes healthy drinking water, the method and data of the students' water fountain or tap content investigation, your concerns, and suggestions on how to improve your school's water.
3. Create a PowerPoint or other software presentation that can be shared during study halls, science classes, and/or other appropriate venue(s).

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UNIT 1 GLOSSARY

The following vocabulary is featured in Unit 1 of the Tox Town curriculum.

acid—A solution that has an excess of H^+ ions and a pH reading that is less than 7 on a pH scale.

alkaline—A term describing a material or chemical that is capable of neutralizing an acid (turning red litmus paper blue). Alkaline materials are also referred to as hydroxides or bases. Examples of alkaline products are ammonia and lye.

arsenic—Arsenic is most commonly a brittle, gray metalloid that is highly poisonous. There are also other forms and colors. Repeated exposure can damage the liver and kidneys and cause stomach problems and skin darkening. It is used mainly in wood preservatives.

bacteria—Bacteria is the plural for bacterium, which is any one-celled organism. Bacteria are usually associated with the cause of diseases.

base—A solution that has an excess of OH^- ions and has a pH reading that is greater than 7 on a pH scale.

bisphenol A (BPA)—Bisphenol A or "BPA" is a chemical that has been used since the 1960s to make lightweight, hard plastics (also known as polycarbonate plastics) and epoxy resins. More than a billion pounds of BPA are produced in the United States every year. The National Toxicology Program (NTP) has "some concern" for hazardous BPA effects.

chemical—A chemical can be anything that is related to or produced by chemistry. It is something that is manufactured or man-made.

chlorine—Chlorine is a naturally occurring element that can be either a gas or a liquid. As a gas, chlorine has a yellow-green color and a strong, irritating odor similar to bleach. Chlorine gas can be released if household bleach mixes with ammonia or other cleaning products. Chlorine is mainly used to bleach paper and cloth and to make pesticides, chemicals, rubber, and solvents. It is used to kill bacteria in drinking water and swimming pool water. It is also used in the sanitation process for industrial waste and sewage and as a disinfectant and fungicide.

demineralize—To demineralize is the act of removing minerals. It usually refers to removing minerals from water.

dependent variable—The dependent variable is the variable that is affected by a manipulation of the independent variable. It is usually the result part of an experiment that is measured and analyzed.

environment—Environment refers to the surroundings of something living.

environmental health—Environmental health is the field of science that studies how the environment influences human health and disease. "Environment," in this context, means things in the natural environment like air, water, and soil and also all the physical, chemical, biological, and social features of our surroundings.

gasoline—Gasoline is a clear or pale brown, highly flammable liquid with a strong odor. It is manufactured from petroleum and contains more than 150 other chemicals, including benzene and toluene and sometimes lead. Gasoline is used as a fuel for internal combustion engines in cars, some trucks, lawn mowers, motorized equipment, and other vehicles. It can also be used as a solvent.

independent variable—In a lab or science experiment, the independent variable is manipulated to cause a change in something else.

lead—Lead is a heavy, soft, bluish-gray metal that occurs naturally in the rocks and soil of the earth's crust. It is also produced from burning fossil fuels, mining, and manufacturing. Lead is used to produce batteries, ammunition, pipes, tank linings, solder, casting metals, building construction materials, roofing, scientific electronic equipment, military tracking systems, medical devices, and products to shield x-rays and nuclear radiation. It is used in ceramic glazes and crystal glassware. Some cosmetics and health care products from outside the United States contain lead. The part of the body most sensitive to lead exposure is the central nervous system, especially in children, who are more vulnerable to lead poisoning than adults.

mercury—Mercury is a metal that occurs naturally in the environment. Mercury is used in some thermometers, barometers, vapor and fluorescent lamps, mirror coatings, dental fillings, batteries, pharmaceuticals, and agricultural chemicals. Energy efficient compact fluorescent light (CFL) bulbs contain small amounts of mercury.

methanol—Methanol (a.k.a. methyl alcohol and wood alcohol) is a highly toxic colorless liquid that may explode when exposed to flames. Methanol occurs naturally in wood and volcanic gases and is a product of decaying organic material such as vegetation. It is also emitted from gasoline and diesel engines and from burning trash and plastics. Methanol is a solvent that is used in gasoline, antifreeze, paints, paint thinners, inks, resins, adhesives, dyes, and plastics and in some cleaning products, insulation products, pesticide products, car windshield washer compounds, copy machine fluids, and some pesticides.

microorganism—A microorganism is any organism so small that it can be seen only with the aid of a microscope.

particulate matter— Particulate matter (PM) is the term for tiny particles found in the air. These particles can include dust, dirt, soot, smoke, and liquid droplets. Some particulate matter is large and dark enough to be seen, such as soot and smoke. Other particulate matter is so fine that it can be detected only with a microscope that examines air, unless it gets past our nose's filter and into our lungs, where it may cause many health issues.

persistent organic pollutants (POPs)—Persistent organic pollutants are a group of organic or carbon-based chemicals that are highly toxic and ever-present in the environment. POPs are deliberately used as pesticides or generated unintentionally as by-products of industrial or combustion processes. POPs circulate regionally and around the world in the atmosphere and oceans by wind and water, and they travel easily from one location to other distant parts of the world. Because they are absorbed by all living things, they move up the food chain; they are found in greatest concentrations in predatory birds, fish, mammals, and humans.

pH—The pH test measures the amount of H+, hydrogen ion, present in a substance. The pH is a number, an "index," that helps us identify a substance as acid, neutral, or alkaline. Substances can exhibit a pH ranging from 0 (zero) for very strong acids like HCl (hydrochloric acid) to 14 for very strong bases like NaOH (sodium hydroxide). Pure water contains equal numbers of H+ ions and OH- ions, and it is considered, therefore, neutral. The pH of pure, de-ionized water is 7. Natural waters have a pH value from 6.5 to 8.2. Most aquatic life has adapted to a specific acidity, and even a slight change in pH can wipe out a whole population.

pollute/pollutants—To pollute is to make any part of an environment unfit or harmful to any living thing. A pollutant is anything that pollutes (or causes harm) to the environment.

residue—A residue is anything that is left over after a part is removed, usually as the result of a chemical process.

sanitize—To sanitize is to make clean or more acceptable in terms of health. A sanitary environment would be one that is hygienic or free of germs.

solvent—A solvent is a liquid that is capable of dissolving another substance.

toxic—Toxic is a term used to describe the ability of a substance to cause harm to any living organism (plants and/or animals) or the environment.

toxins—A toxin is a poison of any kind. Toxins are capable of causing poisoning when introduced into any living thing, and they can be produced by plants, animals, or any other means.

variable—A variable is something that is capable of change or being changed. In the scientific process, changing the independent variable should cause a change or an effect on the dependent variable(s).