Got Water?

2010 Science Ambassador Workshop

Lesson Plan

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The Science Ambassador Workshop is a career workforce training for math and science teachers. The workshop is a Career Paths to Public Health (CPP) activity in the Division of Scientific Education and Professional Development, Center for Surveillance, Epidemiology, and Laboratory Services, Office of Public Health Scientific Services, Centers for Disease Control and Prevention.

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Got Water?

Summary

Natural disasters affect human population on multiple levels. They can cause immediate death, injury, destruction of property and infrastructure, and disruption of services and mechanisms that protect persons from illness. This lesson plan specifically addresses the implications of a natural disaster and its effects on water quality and a community's health.

Students will learn methods used during an emergency response to test and treat water that has been contaminated by pathogenic microorganisms. Water treatment options introduced can vary depending on the location and type of emergency involved, but have the same goal to reduce human illness and death. After completing this lesson, students will have an improved understanding of which organizations are involved in emergency response and why safe drinking water is a substantial heath concern after a natural disaster.

Learning Outcomes

After completing this lesson, students will learn how to

- identify types and sources of water contamination;
- identify common waterborne pathogens and related diseases;
- recognize public health organizations and their role in disaster response;
- explain the mechanism of different water treatment options;
- determine effective water sanitation methods for specific local cultural contexts and circumstances; and
- design and construct a simple water purification system.

Materials

- Copies of Appendix 1A, Pretest, 1 per student.
- Copies of Appendix 2A, Worksheet 1: Natural Disaster Case Studies, 1 per student, including
  - computer access, 1 computer per student or laboratory group,
  - copies of Case Studies, 1 per student, including online resources
    - Title: Earthquake: Haiti January 2010
      URL:http://www.who.int/diseasecontrol_emergencies/publications/haiti_earthquake_20100118.pdf, and
    - Title: Katrina's Aftermath: Public Health Concerns
      URL: http://www.jhsph.edu/katrina/katrina_health.html.
- Copies of Appendix 3A, Worksheet 2: Waterborne Pathogens, 1 per student, including
  - computer access, 1 computer per student or laboratory group.
- Copies of Appendix 4A, Worksheet 3: Water Purification Methods Used at Disaster Sites, 1 per student, including
  - copies of the Centers for Disease Control and Prevention (CDC) and the U.S. Agency for International Development (USAID) 2009 fact sheets about household water treatment options in developing countries, 1 per student, including online resources as follows:

  - Title: Household Water Treatment Options in Developing Countries: Boiling URL:http://www.hip.fhi360.org/file/16699/Factsheet%20on%20Boiling.pdf;
  - Title: Household Water Treatment Options in Developing Countries: Household Chlorination URL: http://www.hip.fhi360.org/file/13798/HWTS%20Options-Household%20Chlorination.pdf;
  - Title: Preventing Diarrheal Diseases in Developing Countries: Simple Methods to Remove Turbidity URL:http://www.hip.fhi360.org/file/16705/Factsheet%20on%20Options%20to%20Reduce%20Turbidity.pdf;
  - Title: Household Water Treatment Options in Developing Countries: Slow Sand Filtration URL:http://www.hip.fhi360.org/file/28135/FactSheet%20on%20Slow%20Sand%20Filtration.pdf; and
  - Title: Household Water Treatment Options in Developing Countries: Solar Disinfection (SODIS) URL:http://www.hip.fhi360.org/file/13792/HWTS%20Option-SODIS.pdf.

- Copies of Appendix 5, Rubric: Water Treatment Option Design and Experimentation, 1 per student.
- Copies of Appendix 6A, Water Treatment Option Design and Experimentation, 1 per student.

Materials

- Turbid water samples from a local pond, lake, or river in a 5-gallon container.
- Petri dishes, 2 per every 2–4 students.
- Nutrient agar, a sufficient amount to prepare 2 agar petri dishes per student laboratory group.
- Disposable bacteria spreader (L-shaped bent glass rod), 1 per student laboratory group.
- Pipettes, 1 per student or laboratory group.
- Water bottles (0.5 L), 1 per student or laboratory group.
- Gloves (latex, nitrile, or vinyl), 1 pair per student.
- Masking tape or colored labels for petri dishes.
- Colored pencils, 1 per student or laboratory group.
- Incubator set at 37°C.
- Gravel (sand and rocks of different sizes).
- Cotton fabric, 1 square yard.
- Hot plate, 1 per class.
- Bottle of unscented chlorine bleach, 1 per class.
- Beakers, 1 per student minimum, quantities and sizes vary depending on each student's design.
- Prepared slides of waterborne pathogens, such as *Cryptosporidium*, *Giardia*, and *Cyclospora*. If unavailable, use pictures of waterborne pathogens available from CDC's Public Health Image Library (PHIL), 1 per 2–4 students or 1 per class.
- Microscope (if available), 1 per 2–4 students or 1 per class.

Total Duration 5 hours

Procedures

Preparation

Students should be given an opportunity to review the physiology of the human digestive and excretory systems, as well as the necessity for safe drinking water. Before this lesson, students should have been learned the concepts and skills as follows:

- waterborne illness agents (e.g., viruses, bacteria, fungi, and parasites);
- bacterial cultures on nutrient agar that can be inoculated or grown; and
- general laboratory safety and the safe handling of microorganisms and water containing potentially pathogenic microorganisms.

Additonal preparation for the lesson should include the following:

- Reserve computer labs for student activities during Step 2 and Step 3.
- Access and review online resources, including
  - Engineer Your Life: Daniele Lantagne,
  - United Nation's International Children's Emergency Fund (UNICEF) Tap Project, and
  - CDC Presentation on the Importance of Water Sanitation.
- Collect turbid water from a local pond, lake, or river in a 5-gallon container.
- Prepare agar plates.
- Set up laboratory materials for water treatment activity for those systems listed in Step 5, which are based on the water treatment documents in Step 4 —
  - for slow sand filtration, use gravel (sand and rocks of varying sizes);
  - for cloth filtration, use 1-yard of cotton cloth;
  - for boiling water, use 1 hotplate;
  - for chlorination, use 1 bottle of chlorine (i.e., unscented bleach);
  - for solar disinfection, use a 0.5-L empty water bottle; and
  - use beakers (quantities and sizes vary with specific student designs).

Step 1: Introduction — Duration: 40 minutes

Preparation

View online resources as background material, focusing on videos interviewing Daniele Langagne and the UNICEF Tap Project, and then prepare pretest copies.

Materials

- Appendix 1A: Pretest.
  Description: This pretest gauges students' knowledge of the chemistry and importance of water to humans. An answer key is provided in Appendix 1B.

Resources

- Title: Engineer Your Life: Daniele Lantagne
  URL: http://www.engineeryourlife.org/cms/6167/6186.aspx?eylprofile=Video.
  Description: This video portrays an environmental engineer, Daniele Lantagne, as she visits

a class of high school students and shares accounts of her travels in low-income countries across the world. She is studying and promoting safe drinking water practices to decrease the spread of waterborne diseases.

- Title: UNICEF Tap Project
  URL: http://tap.unicefusa.org/.
  Description: This UNICEF video promotes the Tap Project to fund water, sanitation, and hygiene programs worldwide. The goal is to reduce the number of children who die from waterborne illnesses to zero. This video teaches about human populations in different geographic locales where they are affected by water and sanitation problems.

- Title: Water Resources: Managing a Scarce, Shared Resource
  URL: http://siteresources.worldbank.org/IDA/Resources/IDA-Water_Resources.pdf.
  Description: This World Bank map indicates the countries with poor water quality on the basis of a measurement termed *water poverty*.

- Title: Report: Water Crisis Hits Rich Countries
  URL:http://wwf.panda.org/?77900/report-water-crisis-hits-rich-countries.
  Description: This World Wildlife Fund website provides a link to a PDF file with information regarding the sources of pollution and waterborne illness in high-income countries, and it reviews major reservoirs of water.

- Title: Thirst for Knowledge? Take the World Water Day Quiz
  URL: http://www.cnn.com/2012/03/21/world/world-water-day-quiz/index.html.
  Description: This World Water Day Quiz by CNN reviews the global level of water conditions. It can be used as the pretest instead of the provided pretest in Appendix 1A.

Activity

1. Before watching the video clips, give a pretest to assess students' understanding of chemistry, significance of water, and water quality and quantities in the world. Then, either use the provided Appendix 1A: Pretest or the pretest titled Thirst for Knowledge? Take the World Water Day Quiz in the Resources section.

2. After completing the pretest, access the online videos listed in the Resources section, and allow students to view them. The students will learn about the importance of safe drinking water worldwide and about UNICEF, a prominent organization that aids in disaster relief.

Step 2: Natural Disasters — Duration: 50 minutes

Preparation

Develop a good understanding of the definition of a natural disaster, and also be aware of the different public health organizations that assist in recovery when natural disasters occur. Use Resources material to access information about these organizations.

Prepare copies of Worksheet 1: Natural Disaster Case Studies (Appendix 2A) and case studies listed in Materials.

Materials

- Appendix 2A: Worksheet 1: Natural Disaster Case Studies
  Description: Student worksheet about 2 international case studies regarding public health problems after a natural disaster.

- Title: Earthquake: Haiti January 2010
  URL:http://www.who.int/diseasecontrol_emergencies/publications/haiti_earthquake_20100118.pdf.
  Description: This document provides information regarding the public health conditions in Haiti after the 2010 earthquake.

- Title: Katrina's Aftermath: Public Health Concerns
  URL: http://www.jhsph.edu/katrina/katrina_health.html.
  Description: This website provides information regarding the public health conditions and concerns of New Orleans residents after Hurricane Katrina during 2005.

Resources

- Title: Natural Disaster
  URL: http://www.reference.com/browse/natural+disaster.
  Description: Reference.com website that helps to define what is a natural disaster.

- Title: Natural Disasters and Severe Weather
  URL: http://emergency.cdc.gov/disasters/.
  Description: CDC website that provides information on different natural disasters.

- Title: News and Top Stories
  URL: http://www.who.int/en/.
  Description: World Health Organization (WHO) website home page for an international organization that is involved in health research, policy, and technical support for United Nations member countries.

- Title: Combatting Waterborne Diseases at the Household Level
  URL: http://www.who.int/household_water/advocacy/combating_disease/en/print.html.
  Description: WHO website with information explaining how household waterborne diseases can be handled on an international scale.

- Title: UNICEF
  URL: http://www.unicef.org/.
  Description: UNICEF is a global organization that advocates for children's health and rights on behalf of the United Nations.

Activity

Write *natural disaster* on the board and then determine students' prior knowledge regarding the history of natural disasters by initiating a discussion and allowing students to provide definitions and examples of natural disasters. After the discussion, write the definition of *natural disaster* by using the natural disaster website resource listed previously. Ensure that the following questions are addressed:

- What constitutes a natural disaster?
- What types of public health organizations respond to disasters?

Divide the class into groups of 3–4 students. Each group will get 1 of the provided case studies. If needed, abbreviate case studies to fit the class period. Each student in the group should be given a copy of the case study and a copy of Worksheet 1: Natural Disaster Case Studies (Appendix 2A).

Allow the groups 30 minutes to read and answer the questions specific to their case study, which comprise only 1 section of Worksheet 1. Then reorganize the class into new groups. Each new group will have ≥1 member from each case study group. New group members share information about their case study locations, allowing other group members to complete Worksheet 1.

Step 3: Waterborne Pathogens Duration: 45 minutes

Preparation

Schedule time in a computer laboratory for students to conduct Internet research on different waterborne pathogens and prepare copies of Worksheet 2: Waterborne Pathogens (Appendix 3A) for each student.

Prepare slides of waterborne pathogens and microbes listed on the worksheet, or if unavailable, obtain or have links available to photos of relevant pathogens listed in Worksheet 2. These photos can be obtained from CDC's PHIL.

Materials

- Appendix 3A. Worksheet 2: Waterborne Pathogens
  Description: This table of waterborne pathogens requires students to illustrate waterborne microorganisms (including viruses), determine organism classification, and the related disease and symptoms involved after infection.

- Water Recreation and Disease
  URL: http://www.who.int/water_sanitation_health/bathing/recreadis.pdf
  Description: WHO published this book by author Kathy Pond, with chapters online that discuss the history of different waterborne pathogens.

- Have a microscope available and prepare slides of waterborne pathogens, such as *Cryptosporidium*, *Giardia*, and *Cyclospora*. If a microscope is unavailable, use pictures of waterborne pathogens available from CDC's PHIL, 1 picture per each 2–4 students or 1 picture per class.

Resources

- Title: CDC Public Health Image Library
  URL: http://phil.cdc.gov/phil/home.asp.
  Description: This CDC online library contains photos, drawings, and diagrams of different pathogens, disease processes, and other topics of public health significance. The majority of this material is in the public domain and can be used at no charge. Each photo includes a

brief annotation.

- Title: Waterborne Pathogens
  URL: http://www.waterbornepathogens.org/.
  Description: This website sponsored by Montana State University and the Water Research Foundation presents information about bacterial, protozoan, and viral waterborne pathogens. Scientific data has been collected and includes information about the abundance and prevalence of pathogens in different water types, survival characteristics and persistence, and susceptibility to disinfection.

- Title: Water Recreation and Disease
  URL: http://www.who.int/water_sanitation_health/bathing/recreadis.pdf.
  Description: An in-depth discussion of the risk factors, pathogens and diseases associated with recreational water exposure.

Activity

Direct students to fill in the blanks for each pathogen on Worksheet 2, and assist students in locating the required information online.

If you have prepared slides of any of the microbes listed on the worksheet, students can use a microscope to view the slides. If slides and microscopes are unavailable, photos of the majority of pathogens listed can be obtained from CDC's PHIL.

Step 4: Water Treatment Options — Duration: 45 minutes

Preparation

Read the CDC and USAID fact sheets beforehand and be prepared to discuss options available to treat water worldwide.

Divide the class into groups of 3–4 students ahead of time and hand out copies of Worksheet 3: Water Purification Methods Used at Disaster Sites (Appendix 4A) and fact sheets about water treatment options (same fact sheet for each student in that group).

Materials

- Appendix 4A. Worksheet 3: Water Purification Methods Used at Disaster Sites
  Description: This worksheet is a chart for recording data about different water treatment options and allows for comparison of efficacy.

Resources

CDC and USAID fact sheets on water treatment options that provide details about different topics for treating and decontaming water.

- Title: Household Water Treatment Options in Developing Countries: Boiling
  URL: http://www.hip.fhi360.org/file/16699/Factsheet%20on%20Boiling.pdf.

- Title: Household Water Treatment Options in Developing Countries: Household Chlorination
  URL: http://www.hip.fhi360.org/file/13798/HWTS%20Options-Household%20Chlorination.pdf.

- Title: Preventing Diarrheal Diseases in Developing Countries: Simple Options to Remove Turbidity
  URL: http://www.hip.fhi360.org/file/16705/Factsheet%20on%20Options%20to%20Reduce%20Turbidity.pdf.

- Title: Household Water Treatment Options in Developing Countries: Slow Sand Filtration
  URL: http://www.hip.fhi360.org/file/28135/FactSheet%20on%20Slow%20Sand%20Filtration.pdf.

- Title: Household Water Treatment Options in Developing Countries: Solar Disinfection (SODIS)
  URL: http://www.hip.fhi360.org/file/13792/HWTS%20Option-SODIS.pdf.

Activity

After giving each student Worksheet 3A and the fact sheet for their group, allow the group 30 minutes to read and discuss their treatment option fact sheet and to answer the question, "How Does It Work?". During this step, students will fill in only **1** box (for their specific treatment option) in the first row of Worksheet 3A.

The class will then be reorganized into different groups, and students can share information regarding other water treatment options so that the entire class can complete the remaining boxes in the first row of this worksheet to introduce different methods for water decontamination.

Step 5: Water Treatment Efficacy — Duration: 90 minutes

Preparation

If you are unfamiliar with this information, review the description of the spread-plate technique at http://www2.hendrix.edu/biology/CellWeb/Techniques/microspread.html (source: Hendrix College, Conway, Arkansas) or at the majority of microbiology text websites.

Also, complete the following preparatory activities:

- Collect approximately 5 gallons of water from a local water source (lake, river, or pond) before the students begin the experiment or do as a class, if time permits (this water is to be used as the contaminated water sample; therefore, determine the bacteria count in this sample beforehand with low-count samples seeded with soil or a baker's yeast suspension).
- Prepare nutrient agar plates so that each student team has ≥2 plates.
- Assemble materials that can be used to construct water treatment option devices, such as Bunsen burners, ring stands, funnels, cloth for filters, and chlorine bleach.
- Set up and stabilize an incubator at 37°C (optional).

This activity involves the experimental culture of microorganisms and will require incubation periods outside of the class time noted. Divide the class into groups of 3–4 students.

Materials

- Appendix 4A. Worksheet 3: Water Purification Methods Used in Disaster Sites Description: This worksheet is a chart for recording data about different water treatment options and allows for comparison of efficacy of each option.

- Laboratory supplies and equipment, including 5 gallons of turbid water, nutrient agar plates, Bunsen burners, ring stands, funnels, cloth for filters, and chlorine bleach.

Activity

1. Provide each group with the water treatment option information documents from Step 4. Instruct students to design an experiment that will test the effectiveness of their selected water treatment option by using 1 variable (see the following possible ideas).

2. Follow the protocol for water treatment efficacy test by using bacterial growth specimens.

    2.1. Each student laboratory group should develop a written protocol for their experiment. Guide students through development and organization of the protocol according to the standard scientific method. Write the the steps on the board as follows: observation, hypothesis, experimental procedure, data, analysis, and conclusion. Instruct students to design a device to model the type of water treatment option their group is assigned. Instruct students to include a detailed materials list, procedure to test for the presence of microorganisms before and after treating the sample contaminated water, and a data table for students to record their results.

    2.2. Provide each student laboratory group with a single plastic bottle to collect a sample of contaminated water from the 5-gallon container. Instruct students to collect materials from the main laboratory bench necessary to build their purification system, which will depend on the method they are assigned. Guide students to build a rudimentary structure through which their sample water will be passed through on the basis of the documents from Step 4. The apparatus should be illustrated and described in their laboratory report. Help students organize their laboratory set up with a single 50 mL-sample of untreated water sample (control) set aside and a single 50-mL sample of treated water.

    2.3. Provide students with the common laboratory materials needed for bacterial growth, including 2 petri dishes (labeled pretreatment and posttreatment) prepoured with nutrient agar, a 500 mL sample of the contaminated water, glass flask (to be used for the treatment, e.g., boil the sample), disposable bacteria spreader (L-shaped bent glass rod), and 2 beakers to collect water before treatment and water after treatment. Help students prepare 2 petri dishes with nutrient agar and plate a sample of each sample of water (untreated and treated) Turn on the class incubator for the incubation period of the prepared plates. The incubator should be set at 37^{o}C.

    2.4. Instruct all student laboratory groups that they will record the number of colonies at increments of 24 hours for a duration of a minimum 72 hours of 2 water samples,

including 1 water sample of untreated water (control) and 1 water sample that has been treated with the apparatus. Explain to students that the number of bacterial colonies will be their dependent variable.

2.5. Instruct all student laboratory groups that independent variables for this water purification experiment can include the following:

- chlorination with concentration of chlorine (i.e., unscented bleach) as a variable;
- chlorination with chlorine (i.e., unscented bleach) concentration constant and duration of purification (wait time) as a variable;
- solar disinfection with amount of sun or shade or the duration (number of days) as a variable;
- cloth filtration with the number of layers of cloth as a variable;
- sand and gravel filter with arrangement of materials as a variable; and
- boiling with time as a variable.

Rubric

After the experiment, discuss data collected from each student laboratory group and instruct students to note efficacy of the varying water treatment options on Worksheet 3A. Use the provided Rubric for Water Treatment Options (Appendix 5) to assess the experimental design and efficacy test.

Conclusion

Conclusion Summary — Duration: 30 minutes

Set up the computer laboratory for the research and concluding portion of this lesson. Students will use the UNICEF Tap Project to identify countries that are affected by contaminated waters, water-related illnesses, and death. Provide students with empty water bottles and instruct students to create a label by using construction paper and tape for the water bottle that represents the location of an area affected by water sanitation concerns. Direct students to include the name of the country and data about water sanitation concerns in that country.

Assessment

Use the Posttest: What Have We Learned About Safe Drinking Water in Our World? (Appendix 6A).

Modifications and Extensions

Modification 1: Fundraiser for UNICEF Tap Project

Help the class organize a school fundraiser by raising awareness and selling the water bottles they created for donations to be sent to the UNICEF Tap Project. Help students locate other clubs at school or work with other area schools involved in community service to collaborate and extend the influence of the awareness-building fundraiser.

Extension 1: Water Treatment Designs

Students can create their own experiment to design a new type of water treatment solution.

Extension 2: Recreational Water Illnesses

Create an additional activity that requires students to plan and execute a study regarding recreational water illnesses that affect their local community.

Resources

- Title:Recreational Water Illnesses (RWIs)
  URL: http://www.cdc.gov/healthywater/swimming/rwi/.
  Description: This CDC website summarizes water contamination concerns associated with recreational areas.

Extension 3: Field Trip to a Water Treatment Facility

Consider arranging field trips to local water treatment facilities.

Extension 4: Killing Microbes

Expand on the processes and mechanisms involved in removing or killing bacteria (e.g., sunlight). Refer students to microbiology texts that discuss factors that kill microbes or websites that can help them develop meaningful experiments.

Resources

- Title: Learn How to Disinfect Contaminated Water
  URL: http://www.sciencebuddies.org/science-fair-projects/project_ideas/MicroBio_p025.shtml.
  Description: This Science Buddies microbiology project explores how to help students investigate the inexpensive disinfecting properties of sunlight.

- Title: Solar Disinfection of Drinking Water
  URL: http://www.wpi.edu/Pubs/ETD/Available/etd-0423103-124244/unrestricted/rojko.pdf.
  Description: This master's degree thesis provides a detailed description of methodology to determine whether solar disinfection is effective in inactivating *Escherichia coli* in water.

Science Education Standards

National Science Education Standards

Science as Inquiry, Content Standard A

As a result of activities in grades 9–12, all students should develop the following:

- abilities necessary to do scientific inquiry, and
- understandings about scientific inquiry.

Life Science, Content Standard C

As a result of their activities in grades 9–12, all students should develop understandings of the following:

- interdependence of organisms, and
- behavior of organisms.

Science and Technology, Content Standard E

As a result of activities in grades 9–12, all students should develop the following:

- abilities of technologic design, and
- understandings about science and technology.

Science in Personal and Social Perspectives, Content Standard F

As a result of activities in grades 9–12, all students should develop understanding of the following:

- personal and community health;
- environmental quality;
- natural resources;
- natural and human-induced hazards; and
- science and technology in society.

Appendices
Supplemental Documents
Appendix 1A: Pretest

Name: _____ Date: _____

Directions: Answer the following questions to the best of your ability.

1. What is the chemical formula for water?
2. What percentage of earth is covered with water?
3. What is a reservoir for water on earth?
4. What percentage of the human body is composed of water?
5. Which of the following organs contain the most amount of water in a human: brain, lungs, bone, or blood?
6. How much water do humans need to replace each day?
7. Name 1 country that has poor or limited water quality for use by the human population.
8. Name 1 reason countries have poor or limited water quality.
9. Name a waterborne illness and the pathogen that causes it.
10. How can a community solve poor water quality concerns?
11. Name 3 ways that contaminated water can be made safe to drink.
12. Name 3 ways that water can be contaminated.

Appendix 1B: Answer Key to Pretest

Name: _____ Date: _____

1. What is the chemical formula for water?
   Answer: H_2O.

2. What percentage of earth is covered with water.
   Answer: Approximately 67%.

3. What is a reservoir for water on earth?
   Answer: Answers may vary, but can include the following: lake, pond, river, ocean, or groundwater.

4. What percentage of the human body is composed of water?
   Answer: Approximately 60%, but varies with age and sex.

5. Which of the following organs contain the most amount of water in a human: brain, lungs, bone, or blood?
   Answer: Lungs. The brain is composed of 70% water; lungs are approximately 90% water; bone is 22% water; and blood is 83% water; water helps to digest food, transport waste, and control body temperature.

6. How much water do humans need to replace each day?
   Answer: 2.4 liters.

7. Name 1 country that has poor or limited water quality for use by the human population.
   Answer: Answers may vary. Refer to The World Bank website that identifies countries at a severe level of water poverty according to their index (e.g., India and sub-Saharan Africa, including Nigeria, Sudan, and Ethiopia). (URL: http://siteresources.worldbank.org/IDA/Resources/IDA-Water_Resources.pdf.)

8. Name 1 reason countries have poor or limited water quality.
   Answer: Answers may vary. Refer to the World Wildlife Fund document titled, Report: Water Crisis Hits Rich Countries (e.g., reduced water quantity, sanitation problems, poor infrastructure, and dense population with lower per capita water resources). (URL:http://wwf.panda.org/?77900/report-water-crisis-hits-rich-countries.)

9. Name a waterborne illness and the pathogen that causes it.
   Answer: Answers may vary (e.g., *Shigella dysenteriae* causes Shigellosis; *Salmonella typhi* causes typhoid fever; *or Escherichia coli* causes diarrhea and abdominal cramps).

10. How can a community solve poor water quality concerns?

Answer: Answers may vary (e.g., regulate industry to prevent dumping, educate persons about safe drinking water practices, or contact nongovernmental oragnizations for support and supplies).

11. Name 3 ways that contaminated water can be made safe to drink.
    Answer: Answers may vary (e.g., boiling, filtration, chlorination, and solar disinfection).

12. Name 3 ways that water can be contaminated.
    Answer: Answers may vary (e.g., cross-contamination with sewage, industrial dumping upriver, rainwater runoff, and contamination by animals or humans).

Appendix 2A
Worksheet 1: Natural Disaster Case Studies

Name: _____ Date: _____

Directions: Use the resources provided to investigate recent natural disasters.

Case Study 1:
Location: Haiti Date: _____ Cause: _____

What response organizations were involved?

What were the public health concerns and major disease risks?

What was the source of local drinking water?

What sanitation concerns were prominent during the postdisaster period?

What water treatment methods were in use beforehand (prior knowledge of locals)?

Resource:
http://www.who.int/diseasecontrol_emergencies/publications/haiti_earthquake_20100118.pdf.

Case Study 2:
Location: New Orleans Date: _____ Cause: _____

What response organizations were involved?

What were the public health concerns and major disease risks?

What was the source of local drinking water?

What sanitation concerns were prominent during the postdisaster period?

What water treatment methods were in use beforehand (prior knowledge of locals)?

Resource: http://www.jhsph.edu/katrina/katrina_health.html.

Appendix 2B: Answer Key
Worksheet 1: Natural Disaster Case Studies

Name: _____ Date: _____

Case Study 1:
Location: Haiti Date: __ **Answer:** January 10, 2010_ Cause: _**Answer**: Earthquake

What response organizations were involved?
Answer: To name a few - World Health Organization, Centers for Disease Control and Prevention, Doctors without Borders, and the International Red Cross .

What were the public health concerns and major disease risks?
Answer: Answers may vary. Immediate health risks included wounds and injuries, water, sanitation, foodborne and hygiene-related diseases, disease associated with overcrowding, vaccine-preventable disease and routine vaccination coverage, and vectorborne and zoonotic diseases.

What was the source of local drinking water?
Answer: During 2009, approximately 45% of the human population lacked access to safe drinking water. Unsafe water sources include unprotected wells, unprotected springs, rivers, bottled water, and carts with drums.

What sanitation concerns were prominent during the postdisaster period?
Answer: Increased risk for disease associated with water, sanitation, and hygiene, as well as foodborne-related diseases because of reduced access to safe drinking water and sanitation systems. *Salmonella typhi* (which causes typhoid fever), hepatitis A and hepatitis E can be present and have epidemic potential.

What water treatment methods were in use beforehand (prior knowledge of locals)?
Answer: Chlorine is the most widely available and easily used method in Haiti.

Resource:
http://www.who.int/diseasecontrol_emergencies/publications/haiti_earthquake_20100118.pdf.

Case Study 2:
Location: New Orleans Date: **Answer:** August 29, 2005. Cause: **Answer:** Hurricane.

What response organizations were involved?
Answer: To name a few - Federal Emergency Management Agenc, Centers for Disease Control and Prevention, Red Cross, and the National Guard.

What were the public health concerns and major disease risks?
Answer: Answers may vary. Public health concerns included contaminated drinking water, West Nile virus, mental health, and toxic contaminants.

What was the source of local drinking water?
Answer: Water was pumped from the Mississippi River.

What sanitation concerns were prominent during the postdisaster period?

Answer: Lack of safe drinking water, poor sanitation, and the limited space available in certain emergency shelters created conditions for spreading communicable diseases, such as cholera, *Escherichia coli*, and noroviruses.

What water treatment methods were in use beforehand (prior knowledge of locals):
Answer: Water was pumped from the Mississippi River and underwent a 7-step purification process that included coagulation, flocculation, sedimentation, disinfection, pH adjustment, fluoridation, and filtration (sand and anthracite).

Resource: http://www.jhsph.edu/katrina/katrina_health.html.

Appendix 3A

Worksheet 2: Waterborne Pathogens

Name: _____ Date: _____

Directions: Research the pathogens and complete the table. Useful websites include: http://phil.cdc.gov/phil/home.asp and http://www.waterbornepathogens.org/.

Name of pathogen	Illustration	Classification (V/P/B)*	Pathophysiology: disease and symptoms
Entamoeba histolytica			
Coxsackie virus A or B			
Yersinia enterocolitica			
Vibrio cholera			
Giardia lamblia			
Noroviruses			
Shigella dysenteriae			
Salmonella typhi			
Toxoplasma gondii			
Poliovirus			
Escherichia coli			
Campylobacter spp.			

Cryptosporidium			

*** V/P/B: virus, protozoa, or bacteria.**

Appendix 3B: Answer Key
Worksheet 2: Waterborne Pathogens

Name: _____ Date: _____

Directions: Research the pathogens and complete the table. Useful websites can include: http://phil.cdc.gov/phil/home.asp and http://www.waterbornepathogens.org/.

Name of pathogen	Illustration	Classification (V/P/B)*	Pathophysiology: disease and symptoms
Entamoeba histolytica		**Answer:** Protozoa	**Answer:** Amebic dysentery; bloody diarrhea, weight loss, fatigue, or intestinal lesions.
Coxsackievirus A or B		**Answer:** Enterovirus	**Answer:** High fever, muscle ache, sore throat, nausea, or blisters on throat
Yersinia enterocolitica		**Answer:** Bacteria (rod-shaped bacteria)	**Answer:** Yersiniosis; fever, abdominal pain, or diarrhea
Vibrio cholerae		**Answer:** Bacteria (kommabacillus)	**Answer:** Cholera; diarrhea resulting in severe dehydration and possible death within hours
Giardia lamblia		**Answer:** Protozoa	**Answer:** Giardiasis; diarrhea, abdominal cramps, nausea, vomiting, or fatigue.
Noroviruses		**Answer:** Virus (norovirus caliciviridae)	**Answer:** Acute gastroenteritis; diarrhea, vomiting, or stomach pain
Shigella dysenteriae		**Answer:** Bacteria	**Answer:** Shigella; diarrhea, blood, mucus, or pus in stool, fever, nausea, vomiting, or stomach cramps
Salmonella typhi		**Answer:** Bacteria	**Answer:** Typhoid fever; sustained high fever, weakness, stomach pain, headache, or rash
Toxoplasma gondii		**Answer:** Protozoa	**Answer:** Toxoplasmosis; swollen lymph nodes, muscle aches, and pains
Poliovirus		**Answer:** Virus	**Answer:** Poliomelitis; fever, sore throat, nausea, constipation, aches, or loss of reflexes
Escherichia coli		**Answer:** Bacteria	**Answer:** Food poisoning; sever cramps, watery diarrhea, or vomiting
Campylobacter jejuni		**Answer:** Bacteria	**Answer:** Gastroentritis and food poisoning; abdominal pain, diarrhea, fever, or malaise

*** V/P/B = virus, protozoa, or bacteria.**

Appendix 4A:
Worksheet 3: Water Purification Methods Used at Disaster Sites

Name: _____ Date: _____

Directions: Complete the table. For question 2, record the number of colonies on your plate before and after treatment.

Question	Type of water purification system									
	Boiling		Chlorination		Cloth filtration		Slow sand filtration		Solar disinfection	
1. How does the purification system work?										
2. How effective is the purification system? (Record number of colonies on your plates before and after treatment.)	Before	After	Before	After	Before	After	Before	After	Before	After
3. What are the limitations of the purification system?										
4. Where in the world is the purification system used?										

Resources
Boiling: http://www.hip.fhi360.org/file/16699/Factsheet%20on%20Boiling.pdf.
Household chlorination: http://www.hip.fhi360.org/file/13798/HWTS%20Options-Household%20Chlorination.pdf.

Cloth filtration: http://www.hip.fhi360.org/file/16705/Factsheet%20on%20Options%20to%20Reduce%20Turbidity.pdf.
Slow sand filtration: http://www.hip.fhi360.org/file/28135/FactSheet%20on%20Slow%20Sand%20Filtration.pdf.
Solar disinfection: http://www.hip.fhi360.org/file/13792/HWTS%20Option-SODIS.pdf.

Appendix 4B: Answer Key
Worksheet 3: Water Purification Methods Used at Disaster Sites

Name: _____ Date: _____

Directions: Complete the table. For question 2, record the number of colonies on your plate before and after treatment.

Question	Type of water purification system									
	Boiling		Chlorination		Cloth filtration		Slow sand filtration		Solar disinfection	
1. How does the purification system work?	**Answer:** Boiling for 1 minute at 212°F is effective at inactivating protozoa and certain bacteria causing diarrheal disease.		**Answer:** ~~One cap of solution~~1/8th teaspoon household bleach per gallon of water can inactivate the majority of bacteria and viruses causing diarrheal disease.		**Answer:** A cloth can filter parasites from the water.		**Answer:** Layers of sand and gravel are used to filter protozoa and the majority of bacteria.		**Answer:** Water bottles placed in the sun result in UV-induced DNA alteration, thermal inactivation, and photooxidative destruction of organisms.	
2. How effective is the purification system? (Record number of colonies on your plates before and after treatment.)	Before	After	Before	After	Before	After	Before	After	Before	After
3. What are the limitations of the purification system?	**Answer:** Answer can include lack of residual protection, incomplete treatment, and substantial risk for burn injuries.		**Answer:** Answer can include limited protection against parasites and carcinogenic effects.		**Answer:** Answer can include variations in ability to filter and protection against smaller organisms.		**Answer:** Answer can include limited removal of viruses, recontamination, routine cleaning, and difficult to transport.		**Answer:** Answer can include the need for pretreatment, ability to only treat limited volumes of water, and availability of plastic bottles.	

4. Where in the world is the purification system used?	**Answer:** Boiling is used in areas with fuel supply, cultural traditions of boiling, and where water can be stored safely after boiling.	**Answer:** Chlorination is used in areas with a supply chain for solution and low turbidity water.	**Answer:** Cloth filtration is used in areas witih high cholera transmission.	**Answer:** Sand filtration is used in areas where funding, education, locally available sand, and transportation are available.	**Answer:** Solar disinfection is used in areas with the availability of bottles and community motivation and training is available.

Resources
Boiling: http://www.hip.fhi360.org/file/16699/Factsheet%20on%20Boiling.pdf.
Household chlorination: http://www.hip.fhi360.org/file/13798/HWTS%20Options-Household%20Chlorination.pdf.
Cloth filtration: http://www.hip.fhi360.org/file/16705/Factsheet%20on%20Options%20to%20Reduce%20Turbidity.pdf.
Slow sand filtration: http://www.hip.fhi360.org/file/28135/FactSheet%20on%20Slow%20Sand%20Filtration.pdf.
Solar disinfection: http://www.hip.fhi360.org/file/13792/HWTS%20Option-SODIS.pdf.

Appendix 5
Rubric: Water Treatment Option (WTO) Design and Experimentation

Name: _____ Date: _____

Criteria	1 Emerging	2 Needs improvement	3 Good	4 Very good	5 Excellent
Hypothesis and experiment: What is the focus on the efficacy of WTO?					
Experiment: What is the accuracy of WTO apparatus?					
Analysis and conclusion: What is the ability to discuss the purpose of the experiment through the outcome, including understanding of the material and presentation?					
What is the quality of communication with the laboratory write up (e.g., spelling or grammar)?					
Was WTO submitted on time?					

Appendix 6A
Posttest: What Have We Learned About Safe Drinking Water in Our World?

Name: _____ Date: _____

Directions: Complete the following questions by using the knowledge you have gained during your unit of study about water safety and treatment options.

1. What types of disasters can result in a compromised water supply for a community?

2. If a natural disaster hit my neighborhood and affected the water, what can I do to make sure my family has safe drinking water?

3. On the basis of the experiments we conducted, describe a water treatment system you can build from common household products that can effectively treat your water.

4. Certain waterborne pathogens cause similar symptoms, list 3 symptoms.

5. Pathogens are listed in multiple biologic classification categories, list 3 categories.

6. Consider the different water treatment options that we researched and tested, which would you use to treat the following and why?
   a. Sediment:

   b. Animal parasites:

   c. Bacteria:

7. Which places on earth are more susceptible to water crises? Why?

8. Write a slogan to inform the public about the concerns of water safety and a simple solution that can be supported and followed by persons in the majority of the world.

   Slogan:

   Solution:

Appendix 6B: Answer Key
Posttest: What Have We Learned About Safe Drinking Water in Our World?

Name: _____ Date: _____

Directions: Complete the following questions by using the knowledge you have gained during your unit of study about water safety and treatment options.

1. What types of disasters can result in a compromised water supply for a community?
   Answer: Natural disasters, including hurricanes, tsunamis, and earthquakes.

2. If a natural disaster hit my neighborhood and affected the water, what can I do to make sure my family has safe drinking water?
   Answer: Answers may vary. Answers should include ≥1 specific water treatment option.

3. On the basis of the the experiments we conducted, describe a water treatment system you can build from common household products that can effectively treat your water.
   Answer: Answers may vary.

4. Certain waterborne pathogens cause similar symptoms, list 3 symptoms.
   Answer: Answers may vary. Answers can include diarrhea, vomiting, stomach cramping, fever, and chills.

5. Pathogens are listed in multiple biologic classification categories, list 3 categories.
   Answer: Answers may vary. Answers can include protozoa, fungi, bacteria, and viruses.

6. Consider the different water treatment options that we researched and tested, which would you use to treat the following and why?
   a. Sediment: **Answer:** Answers may vary on the basis of student results, but should include cloth or slow sand filtration.

   b. Animal parasites: **Answer:** Answers may vary on the basis of student results, but should include boiling, cloth filtration, slow sand filtration, or solar disinfection.

   c. Bacteria: **Answer:** Answers may vary on the basis of student results, but should include cholorination, slow sand filtration, or solar disinfection.

7. Which places on earth are more susceptible to water crises? Why?
   Answer: Answers may vary. Answers might include low-income areas with limited water supply and limited access to clean water and filtration systems.

8. Write a slogan to inform the public about the concerns of water safety and a simple solution that can be supported and followed by persons in the majority of the world.

   Slogan:
   Answer: Answers may vary.
   Solution:
   Answer: Answers may vary.