

safe water science.org

lessons for life



Dear Science Educator,

The purpose of these four lessons is to provide you with a set of activities to enhance your existing science curriculum. The content is meant to raise public awareness about water quality issues facing our world. Within the lessons, you will find a balance of hands-on activities, cooperative learning situations, and research opportunities for your students.

Consequences of Drinking Unsafe Water

The first lesson is an overview of how waterborne illnesses are affecting world populations and how contagious diseases can be transmitted through the sharing of contaminated water.

Treatment of Water

The second lesson teaches the student simple filtering methods through an inquiry-based activity.

Availability of Clean Water

The third lesson develops awareness of the difficulties faced by people in the developing world in obtaining water for their personal use and consumption. Students will also become aware of, and reflect upon, their personal daily water use.

Making Water Safe to Drink

The fourth lesson introduces steps used in the process of making water clean to drink, including an alternative method using the PUR Purifier of Water™ product.

For each lesson, a teacher's guide and a student activity packet have been provided for you. The teacher's guide includes the National Science Standards addressed by the lesson, specific instructions about the lesson, suggested responses to student questions, and additional resources related to the activity. Each student activity packet is meant to be copied and distributed to your students. Although the lessons were written to be taught as a unit, each lesson can be taught alone.

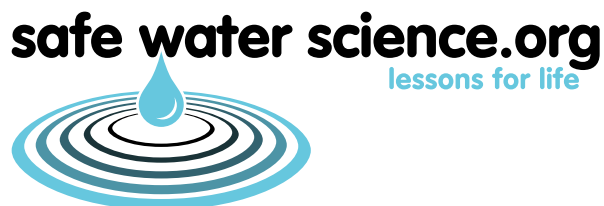
We thank you for your interest in these lessons. Our hope is that you find them useful and easy to understand and implement in your classroom. These lessons and additional content can also be found on our website, www.safewaterscience.org.

Sincerely,

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for their support of this program.**

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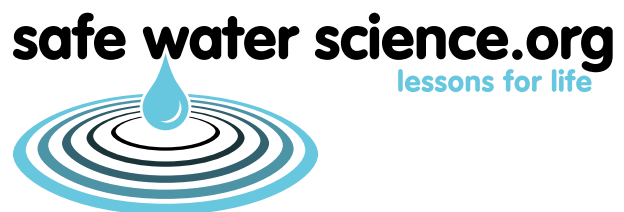
Lesson 1

Consequences of Drinking Unsafe Water

In part one, students will learn how waterborne illnesses are affecting world populations in the 21st century. They will research a waterborne illness and then share what they have learned with their classmates through a short presentation.

In part two, students will participate in a hands-on activity that demonstrates how these illnesses can be transmitted through human populations.

This lesson is most suitable for students in grades 5-8 working in a cooperative learning environment in teams of four students each. This lesson will take approximately three 50-minute class periods to complete.



National Science Content Standards: Grades 5-8



Content Standard A: Science as Inquiry

Understandings about scientific inquiry

Content Standard C: Life Science

Structure and function in living systems

Populations and ecosystems

Content Standard D: Earth and Space Science

Structure of the earth system

Content Standard F: Science in Personal and Social Perspectives

Personal Health

Populations, resources, and environments

Natural hazards

Risks and benefits



Teacher Materials

The following materials are needed by the teacher:

- 1 30-mL bottle of “Typhoid Contaminant” (1 M sodium hydroxide)
refill: purchase from science supply company or use a diluted solution of Drano*
- 1 30-mL bottle of “Typhoid Detector” (phenolphthalein, a common base indicator)
refill: purchase from science supply company*
- Store-bought distilled water*
- Small plastic cups (1 for each student)

Student Materials

For Part 1, each team of 4 students should have:

- 4 copies of the Student Activity Packet
- Access to the Internet*
- 1 piece of poster board or newsprint*
- 1 set of markers*

For Part 2, each team of 4 students should have:

- 4 copies of the Student Activity Packet
- 4 small (5oz.) plastic cups containing distilled water
(1 in every 12 cups also contains Typhoid Contaminant)
- 4 cotton swabs
- 4 pairs of safety goggles*

*Not supplied in kit



Lesson 1: Part 1

Waterborne Illnesses

The students will work within their teams to answer a set of Warm Up questions, research a waterborne illness using the internet or the material in the Appendix, make an oral presentation to teach the class about their assigned illness, and individually complete a set of Cool Down questions.

I. Warm Up



Hand out a copy of the Student Activity Packet to each student. Tell students that they will be learning about a variety of illnesses that can be caused by drinking contaminated water. To get an idea of their background knowledge, ask the class if anyone can describe an illness caused by drinking bad water.

Allow the students about 10 minutes to work together in their cooperative team on the Warm Up questions. Students should discuss answers within their teams but record their answers individually in their own words. Each team should have at least one computer with Internet access or a dictionary.

After most of the teams are finished, discuss the answers as a class. These questions are designed to get the students thinking about safe drinking water, a concept most students have never considered. A common misconception is that tap water is unsafe and bottled water is better. A glossary of Key Words is provided at the end of these teacher pages for your use.

II. Activity: Illness Research



Assign each team one of the following waterborne illnesses to research. Possible illnesses include: arsenic poisoning, ascariasis, cholera, cryptosporidiosis, diarrhea, lead poisoning, leptospirosis, schistosomiasis, typhoid, and guinea worm disease (dracunculiasis).

- If students have Internet access, the following websites contain helpful information on these illnesses:
<http://www.cdc.gov/ncidod/dpd/parasites/index.htm>
http://www.who.int/water_sanitation_health/diseases/diseasefact/en/index.html
- If students do not have access to the Internet, use the information found in the Appendix.
- After completing the Illness Research Table in the Student Activity Packet, students can create a five-minute presentation for the class on their illness. Provide them with markers and posters to create a visual aid, or have students create an overhead transparency or develop a Power Point presentation, which would be a good integration of technology. You may want to have your students take notes as each presentation is given.



III. Cool Down



Students should work individually to complete the Cool Down questions, either in class or as a homework assignment. After the questions have been completed, lead the class through a guided discussion and supplement their answers with the details below.

1. Do you think waterborne illnesses have ever occurred in the United States? Explain.

Help students realize that before modern plumbing and water treatment facilities, people in the United States suffered from many of the waterborne illnesses they researched. For example, 8,000 people in Cincinnati died in a cholera epidemic in 1849. An interesting and kid-friendly account of this epidemic can be found at the following website: <http://www.ohiohistorycentral.org/entry.php?rec=487>.

2. In 1900, as many as 2000 cases of typhoid fever that resulted in over 350 deaths occurred in Cincinnati because citizens drank untreated water from the Ohio River. Name at least two reasons why typhoid has essentially been wiped out in the United States.

Reasons could include: advances in science that helped us understand the role of micro-organisms in transmitting disease, introduction of modern plumbing, filtration technology and construction of water treatment plants, and advances in modern medicine, especially antibiotics. One of the greatest impacts was disinfection in the form of adding chlorine to drinking water.

3. How can the world help developing countries fight against waterborne illnesses?

Help students reflect on what makes the countries that still have problems with waterborne illnesses different from developed countries like the United States. Develop the idea that these countries do not yet have water treatment technology, understanding of the spread of disease, and access to medicines that are necessary to fight against these diseases. Geographical and/or cultural barriers may also limit access to safe drinking water.

4. What are at least three challenges that must be overcome before waterborne illnesses can be prevented in these countries?

Responses could include: political instability (some of these countries are constantly ravaged by wars), development of infrastructure such as adequate roads to reach remote areas, education of the public about how diseases are spread through micro-organisms, and technology and resources needed to treat contaminated water such as plumbing or water treatment facilities.

5. In your opinion, does the United States have a responsibility to help these developing countries with their water quality issues? Explain.

Answers will vary among students. This could generate an interesting debate in your class and present a great opportunity to invite a guest speaker from the American Red Cross, World Health Organization, Peace Corps, Children's Safe Drinking Water, or another outreach organization that directly works on water issues in the developing world.

Contamination Connection

The students will work within their teams to answer a set of Warm Up questions, learn how a contagious disease – typhoid – can be transmitted through the sharing of contaminated water, and individually complete a set of Cool Down questions.

I. Warm Up



Allow the students about 10 minutes to work together in their cooperative teams on the Warm Up Questions. Because some of these terms may be unfamiliar to them, resources should be made available for their use. Students should discuss answers within their teams but record their answers individually in their own words.

After most of the teams have finished, discuss the answers as a class. A glossary of Key Words is provided at the end of these teacher pages for your use.

II. Activity: Typhoid Comes to Town



Pre-Session Preparation

For each student, fill a small plastic cup 1/3 full with store-bought distilled water (tap water may be used if it is neutral: test to see that the tap water does not turn pink when 2 drops of phenolphthalein are added).

Number each cup with a marker.

Add 2 drops of Typhoid Contaminant (1 M sodium hydroxide) to 1-3 of the cups (make 1 contaminated cup for approximately every 12 students)

Classroom Procedure

- Read the following introduction from the Student Activity Packet to the class:

“There has been a deadly outbreak of typhoid fever in your community. Many people are ill and some could die. Epidemiologists from the Centers for Disease Control (CDC) in Atlanta have been called in to find out how the disease originated and who is now a disease carrier. You and your classmates are citizens of the town and will undergo testing to find the carriers.”

Explain that epidemiologists from the CDC are often called in when an epidemic of a disease has occurred.

- Review the **Safety Note** from the Student Activity Packet.
- Randomly distribute the prepared cups of solution, making sure that the “contaminated” cups are scattered throughout the room and the students do not know which cups are contaminated. Assure the students that although they are role-playing an actual epidemic, none of the chemicals will harm them.
- Have students follow procedure steps A-D of *Typhoid Comes To Town* in the Student Activity Packet. Assign one or several procedure readers and have the class work together as the steps are read aloud.
- At student procedure step E, quickly go around the room and add two drops of the Typhoid Detector to each student’s cup. The detector is actually phenolphthalein, a common base indicator. The liquid will turn pink for any student who was contaminated during the activity and remain colorless for any student who did not become contaminated.

- At student procedure step F, quickly go around the room and add one to two drops of the Typhoid Detector to the cotton swab of each student. The swabs will turn pink for each student who was an original carrier of the disease. The students may recognize this procedure if they have ever watched crime shows such as CSI. Human blood is a mild base and is detected by phenolphthalein.

Data Analysis

Tally the number of students who were originally contaminated and the number of students contaminated after the spread of the epidemic. Write these numbers on the board so students can do the calculations of percentages. Allow students to complete the questions in the Data Analysis section.

Clean Up

Rinse the cups in a sink and keep for reuse. Dispose of the cotton swabs in a plastic bag in the trash.

III. Cool Down



Students should work individually to complete the Cool Down questions, either in class or as a homework assignment. After the questions have been completed, lead the class through a guided discussion. Question 5 requires Internet access. If your students do not have access to the Internet, make copies of the Typhoid Mary story found in the Appendix.

- 1. In real life, you cannot tell who has been infected with a contagious disease until an individual shows symptoms of being sick. If this had been a real life epidemic in your community, what immediate steps should the CDC take to stop the spread of typhoid?**

Students may suggest a quarantine of the typhoid victims or of the town itself. Antibiotics may be administered. The CDC would also work to find the original carriers of the disease so the source of the contamination is known.

- 2. What long-term steps should be taken?**

Students may suggest an investigation into the town's water purification system. Also help students understand that individual hygiene may prevent the spread of typhoid and other waterborne illnesses. Discuss with them the importance of hand-washing to prevent the spread of illnesses.

- 3. How does knowing who the original carriers are help the CDC to contain the disease?**

This information will help the epidemiologists pinpoint the exact source of the contamination so that measures may be taken to stop the spread of the disease and prevent another epidemic.

- 4. Is it ethical to quarantine people who are carriers of a contagious disease? Explain.**

Answers will vary among students. This may generate a lively debate in your class. This question leads to the final Cool Down question in which students will read about a real-life famous typhoid carrier, Typhoid Mary, who was forced into quarantine for a number of years.

- 5. Use the Internet and go to the following website or read the article provided by your teacher: <http://www.pbs.org/wgbh/nova/typhoid/about.html>. This article is a short history about a famous typhoid carrier named Typhoid Mary. Does this story change your answer to question d? Why or why not?**

Some students may change their minds about quarantine after researching the story of Typhoid Mary. Students may not come to a final decision; however, they should state clear reasons for their choices based on evidence.

Optional Extension

Disease Detective Game

This is a fun and engaging activity for children and adults alike. It takes about 15 minutes to complete and may be accomplished individually or in pairs. Students practice critical skills of observation and analysis of data to arrive at a conclusion.

Have your students go to <http://www.pbs.org/wgbh/nova/typhoid/detective.html> and click on the link to launch the Disease Detective game, which the site describes as follows:

You are a budding epidemiologist who has been called to a popular national park in the American Southwest to investigate a disease outbreak. Six out of eight people camping in the same area have fallen ill with a serious ailment of unknown origin. Local and state public health officials want you to trace the outbreak to its source so their agencies can implement control measures. In this Interactive, use the basic methods of field epidemiology to solve this medical mystery.

The image displays three overlapping screenshots from the 'Disease Detective' game. The top-left screenshot shows an 'ASSIGNMENT' screen with a drawing of a hospital and a text box stating: 'You've arrived at a hospital near a national park where all but two members of two food camping. Interview members involved because infected or avoided infection. doctor in charge. Talk to Dr. Jones.' The top-right screenshot shows an 'INTERVIEWS' screen with eight character portraits: Anna Smith, Sam Smith, Kelly Smith, Jane Smith, Alex Lee, and Sam Smith. The bottom screenshot shows an 'INTERVIEWS' screen for 'Sam Smith', Age: 47, with a checklist of activities and a text box describing his symptoms.

	✓	X
hiked in cave	<input checked="" type="checkbox"/>	<input type="checkbox"/>
ate restaurant food	<input type="checkbox"/>	<input type="checkbox"/>
went on ranger tour	<input type="checkbox"/>	<input type="checkbox"/>
visited petting zoo	<input type="checkbox"/>	<input type="checkbox"/>
got insect bites	<input type="checkbox"/>	<input type="checkbox"/>
visited gold mine	<input type="checkbox"/>	<input type="checkbox"/>
swam in lake	<input type="checkbox"/>	<input type="checkbox"/>
picked berries	<input type="checkbox"/>	<input type="checkbox"/>
contracted fever	<input type="checkbox"/>	<input type="checkbox"/>

Name: Sam Smith
Age: 47

I started feeling dizzy and nauseous on Sunday morning, many hours after my two older daughters and my wife Laura first showed symptoms of dizzy fever. On Saturday, I went on the ranger tour, hiked in the cave, and visited the petting zoo. I ate in the restaurant for dinner. I didn't do the other activities. Early Sunday morning I couldn't sleep because of all the itchy insect bites I was getting in my sleep, so I took a dip in the lake.

[Next Interview](#)

Fill in the table with a ✓ for yes or X for no. When the table is completely filled in, go to the next interview by clicking the link above.



Helpful Websites

<http://www.unicef.org/wes/index.html>

UNICEF website with information on water quality issues in the developing world and their efforts to improve water supplies and sanitation facilities.

<http://childinfo.org/areas/sanitation/>

UNICEF website that provides more information about how contaminated water affects the developing world. Links are provided to specific countries and regional data on efforts to improve water conditions.

<http://childinfo.org/areas/water/>

UNICEF website that offers a description and statistics about the most frequent diseases caused by poor water sanitation.

http://www.who.int/topics/drinking_water/en/

World Health Organization: this page provides links to descriptions of activities, reports, news and events, as well as contacts and cooperating partners in the various WHO programs and offices working on this topic. Also shown are links to related web sites and topics.

<http://www.ohiohistorycentral.org/entry.php?rec=487>

This website gives a short, but thorough history of 19th century cholera epidemics in Cincinnati and around Ohio. The language is kid-friendly.

<http://www.cdc.gov/ncidod/dbmd/diseaseinfo/default.htm>

At this website, you can click on the first letter of a disease and be linked to helpful information about the causes and scope of the disease. Some of the language can be very "scientific." However, basic information about particular diseases can be gleaned from the text.

<http://history1900s.about.com/od/1900s/a/typhoidmary.htm>

This website provides more detailed information about the history of Typhoid Mary. It is much longer than the website suggested to students during the Cool Down Reflection Questions, but offers much more insight into the actual case and how Mary was affected.

<http://www.peacecorps.gov/wvs/educators/enrichment/africa/lessons/bytitle.html>

This site provides many direct links to lesson plans for teachers. Many of the lessons are directly related to water quality issues in developing countries. The lessons are for teachers of all subject areas, not just science. Lots of cross-curricular opportunities can be found at this site.

Glossary of Key Words

Bacteria

any of the unicellular prokaryotic microorganisms of the class Schizomycetes, which vary in terms of morphology, oxygen and nutritional requirements, and motility, and may be free-living, saprophytic, or pathogenic in plants or animals.

Contagious

capable of being transmitted by bodily contact with an infected person, other organisms (example consumption of contaminated organisms) or object. Synonyms: catching, communicable, infectious.

Contaminated

made impure or unclean by contact or mixing. Synonyms: defiled, fouled, poisoned, polluted.

Disinfect

to cleanse so as to destroy or prevent the growth of disease-carrying micro-organisms. Synonyms: decontaminate, sterilize, sanitize, clean.

Epidemic

spreading rapidly and extensively by infection and affecting many individuals in an area or a population at the same time. Synonyms: outbreak, plague.

Epidemiology

the branch of medicine that deals with the study of the causes, distribution, and control of disease in populations.

Herbicide

a chemical substance used to destroy or inhibit the growth of plants, especially weeds.

Micro-organism

an organism of microscopic or submicroscopic size, especially a bacterium or protozoan. Synonyms: germ, microbe.

Parasite

an organism that grows, feeds, and is sheltered on or in a different organism while contributing nothing to the survival of its host.

Pesticide

a chemical used to kill pests, especially insects.

Potable

fit to drink. Synonym: drinkable.

Sanitation

formulation and application of measures designed to protect public health.

Toxic Metal (Heavy Metal)

a metal capable of causing injury or death, especially by chemical means. Synonym: poisonous metal

Virus

any of various simple submicroscopic parasites of plants, animals, and bacteria that often cause disease and that consist essentially of a core of RNA or DNA surrounded by a protein coat. Unable to replicate without a host cell, viruses are typically not considered living organisms.

Waterborne

transmitted in water.

Water quality

the degree to which water is suitable for different uses such as drinking, bathing, or recreation.

source: <http://education.yahoo.com/>



Acknowledgements

Many of the resources used for these lessons were provided by the following organizations:

Peace Corps: Worldwide Schools

<http://www.peacecorps.gov/wws/>

WHO: World Health Organization

<http://www.who.int/en/>

CDC: Centers for Disease Control and Prevention

<http://www.cdc.gov/education/default.html>

UNICEF: United Nations Children's Fund

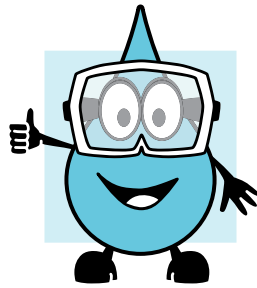
<http://www.unicef.org/>

Need help?

For assistance with chemistry and other scientific concepts, please contact Martha Brosz (martha.brosz@cincinnatiastate.edu) or Mary Repaske (mary.repaske@cincinnatiastate.edu) – Chemistry Instructors at Cincinnati State Technical and Community College.

For assistance with the structure of the lesson plans, help with materials, or classroom management techniques as they relate to the lessons, please contact Teresa Null (teresa.null@gmail.com) – Middle School Educator.



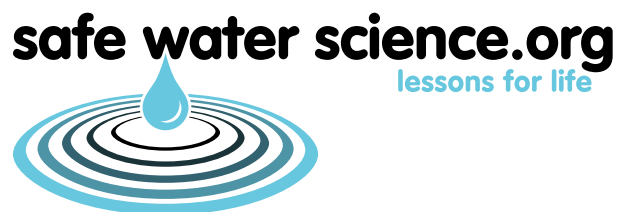


Lesson 2

Treatment of Water Teacher's Guide

In this lesson, students will investigate how water is made safe to drink in a modern water treatment facility. They will work as teams of engineers to study one step in the water treatment process: filtration. In an inquiry-based activity, they will design, build, test, and evaluate a water filter capable of being used in the process to produce clean drinking water.

This lesson is appropriate for students in grades 5-8 working in a cooperative learning environment in teams of four students each and will take approximately two 50-minute class periods to complete.



National Science Content Standards: Grades 5-8



Content Standard A: Science as Inquiry

Abilities necessary to do scientific inquiry
Understandings about scientific inquiry

Content Standard B: Physical Science

Properties and changes of properties in matter

Content Standard D: Earth and Space Science

Structure of the earth system

Content Standard E: Science and Technology

Abilities of technological design
Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

Risks and benefits

Content Standard G: History and Nature of Science

Science as a human endeavor



Teacher Materials

The following materials are needed by the teacher:

- 1 L of dirty water (mix 1 teaspoon of finely pulverized soil/dirt in 1 L of tap water in a large container)
- 2-3 drops of food coloring (red or blue)
- 1 large plastic spoon
- Scissors
- Coffee filter
- Rubber band
- 9oz. plastic cup
- 16oz. clear plastic water bottle, with bottom cut off
- 1 domed "slushie" lid (can substitute another 9oz. plastic cup, with a hole cut in the bottom)
- 1 permanent marker*
- Approximately ½ cup of aquarium pebbles, washed (refill: can be purchased at discount pet store)
- Approximately ½ cup fine aquarium sand, washed (refill: can be purchased at discount pet store)
- Approximately 2-3 tablespoons of activated granular charcoal (refill: can be purchased at discount pet store)
- 1 plastic colander for separating filter materials to reuse in future labs
- Supply of fresh tap water*

Student Materials

Each team of 4 students should have:

- 100 mL of dirty water in a plastic cup
- 1 clear 16oz. water bottle with the bottom cut off*
- 1 9oz. plastic cup (to collect filtered water)
- 1 domed "slushie" lid (can substitute another 9oz. plastic cup, with a hole cut in the bottom)
- 1 coffee filter
- 1 rubber band
- 1 sheet of plain white paper*
- Supply of paper towels for potential spills*
- 4 copies of the Student Activity Packet
- 4 pairs of safety goggles*

Access to the following filtering materials for use in their filter apparatus:

- Cheese cloth
- Cotton balls*
- Cotton cloth*
- Panty hose*
- ScotchBrite pad* (or any flat green scouring pad)
- Supply of aquarium pebbles, washed
- Supply of fine aquarium sand, washed
- Supply of activated granular charcoal

*Not supplied in kit



Lesson 2

Treatment of Water

The students will work within their teams to complete Warm Up activity, learn how to construct a water filtration device, and individually complete a set of Cool Down questions.

I. Warm Up



Hand out a copy of the Student Activity Packet to each student. Ask the students if they know where their drinking water comes from and how it is made safe to drink. As a class, have students share and discuss their responses.

Just listen to their ideas; do not correct their answers. Tell students they will discover more about their drinking water, a valuable resource, during this lesson.

You may contact your local water treatment facility for a set of brochures, usually free for educational purposes, to share with your students.

Read instructions for the Warm Up activity with the students, answer any questions, and then allow the teams to work cooperatively for 10-15 minutes on this activity. Students should discuss answers within their teams. Discuss the answers as a class. Suggested responses are as follows:

<i>Possible Contaminant</i>	<i>Stage(s) of Water Treatment</i>
Bacteria	Disinfection and Storage
Hydrogen Sulfide Gas	Aeration
Gravel	Coagulation, Sedimentation, Filtration
Viruses	Disinfection and Storage
Sewage	Aeration, Coagulation, Sedimentation, Filtration, Disinfection and Storage
Fertilizers	Aeration, Coagulation, Sedimentation, Filtration
Methane gas	Aeration
Sand	Coagulation, Sedimentation, Filtration
Leaves	Coagulation, Sedimentation, Filtration
Parasitic Worms	Coagulation, Sedimentation, Filtration, Disinfection and Storage
Pesticides	Aeration, Coagulation, Sedimentation, Filtration

II. Activity: Design And Build The Best Filter



This is a guided inquiry activity in which students will work as teams of engineers to design, build, test, and evaluate a filter for cleaning dirty water. As teacher, you will act as a facilitator, being careful not to influence the student's choice of materials to build the filter.

Students will be studying only one of the five stages of the treatment process: filtration. The other stages will be examined in lesson 4. If you choose to do this activity as a demonstration and not an inquiry-based lesson, see Advance Preparation, section E, page 5.



Pre-Session Preparation

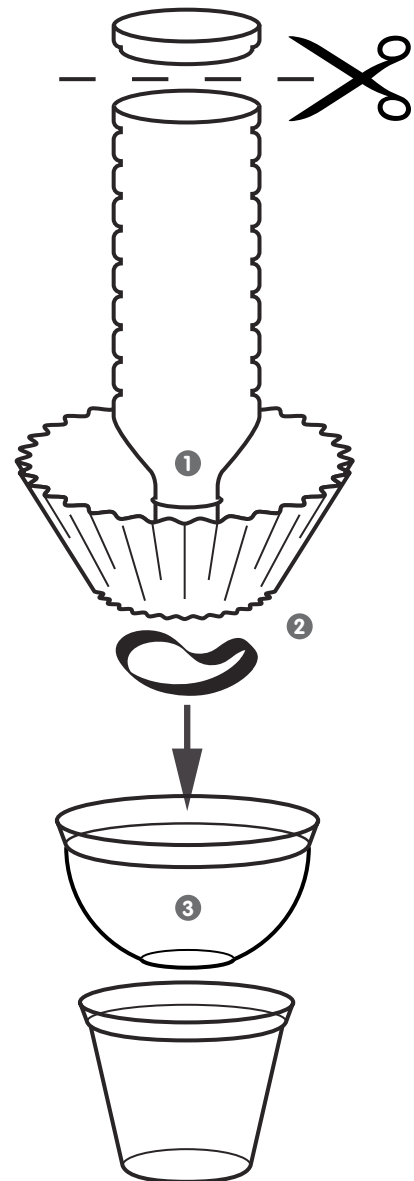
- A. Prepare enough dirty water for each class (see Teacher Materials). To make the dirty water visible during the filtering process, add 2-3 drops of red or blue food coloring to the container of dirty water.
- B. Prepare the water bottles that will hold the filters (one for each team of 4 students, one for the sample filter apparatus, and one for an "ideal" filter prepared by teacher): remove the lids, and cut the bottom off of each clear 16-oz water bottle. On each bottle, draw a line with a permanent marker 8 cm from the opening of the neck of the bottle. Students will fill the bottle with their choice of filtration materials up to this mark.
- C. Prepare **two** sample filter apparatus as examples for the students. Do not add the filtration materials to the first, so as not to bias the student's choices. Use the second to create the "ideal" filter (see step E below).

1. Take one of the prepared water bottles and cover the neck opening with a small piece of coffee filter.
2. Secure the coffee filter to the bottle neck with a rubber band.
3. Insert the neck of the bottle (now covered with a coffee filter and rubber band) through the hole in the "slushie lid" so that it stands upright. Place the whole structure into the clear 9oz. plastic cup.

- D. Set up a station in your classroom where student teams will collect the materials they need: cheese cloth, activated charcoal, sand, and pebbles, etc. You may include additional materials, or have students bring materials of their choosing from home.
- E. Build and test an "ideal" filter capable of removing the contaminants from your dirty water. You will use this filter as an example of an "ideal" filter at the end of the lesson, after the students have completed their filters.

1. Fill the inverted bottle 7 cm high with a mixture of equal amounts of fine aquarium sand and aquarium pebbles. Add another 1 cm of activated granular charcoal to the top of the sand and pebble mixture.
2. Be sure to test the operation of this "ideal" filter before demonstrating it to the students. To test, slowly add 100 mL of the dirty water to the filter, covering the entire surface of the charcoal.
3. Observe as the particulate matter and food coloring are filtered from the water. It is not necessary to filter the entire 100 mL of dirty water to determine that the filter is capable of producing clear water. Note: you must use "washed sand" to produce clear water.

- F. Prepare a large container in which students may dispose of their wet materials at the end of class.



Student Lab Roles

This lesson provides a good opportunity for students to assume roles within the team. Possible roles could be as follows:



Team Coach

- Keep the team on task at all times.
- Make sure that others are performing their roles and that safety guidelines are followed.
- Be the main assistant to the Equipment Manager in performing lab procedures.
- Make sure that lab clean up is complete by assigning tasks to all team members.
- Motivate the team to do a good job

Data Manager

- Record all observations and data as the lab is being performed. Other team members will record data later on their own papers.
- Record any data that are to be reported by teams on the board, overhead, or marker board, etc.
- Watch the clock for the team for all timed observations.

Equipment Manager

- Be responsible for obtaining all materials for the lab.
- Perform most of the lab procedures for the team. If more than one person is needed to perform the procedures, assign tasks to the other group members with the Team Coach as primary assistant.
- Work with the Team Coach to make sure that the group is observing all safety guidelines.

Procedure Manager

- Read and interpret the procedures and other instructions for the team.
- Direct all team questions to the teacher during the lab.
- If one team member is absent, also act as Team Coach.

Classroom Procedure

- A. Show the class the liter of dirty water you prepared. Ask the group if they would be willing to drink this water.
- B. Ask them what steps they think are necessary to make this water safe to drink. They may refer to the Warm Up questions they completed together. Students may suggest getting rid of the dirt, some may suggest filtering, and some may even suggest that there are bacteria in the water that need to be killed.
- C. Read together the introduction to the Design & Build The Best Filter section of the Student Activity Packet. Discuss with the students their roles as engineers and answer any questions they may have. Depending on your time constraints, you could have each team create an engineering company name and logo to display at their lab stations.
- D. Discuss the required and optional materials used for construction of the filters. At this time, show the students the sample filter apparatus you prepared. Be sure not to influence their choice of optional materials.
- E. As a class, discuss student procedure step 1, and allow the teams 10-15 minutes to design their filters. After each team's design is complete, approve the procedure by signing each team member's Student Activity Packet. Only sign if ALL students in a team have the design diagram and explanation completed to your satisfaction.

If the activity cannot be completed in one class period, stop at this point. If you want students to bring in additional materials from home, include this in their homework assignments for the day.
- F. After all teams have had their filter designs approved, allow the teams 25-30 minutes to build, test, and evaluate their filters (student procedures step 2-4). Only a small amount of filtered water (approximately ½ to 1 cm) needs to be collected before students may evaluate the effectiveness of their filters.
- G. When all teams are finished, direct them in proper cleaning and disposal of the lab materials. Be sure to have students rinse and dry the water bottles and cups for the next class.

Evaluation of Results

Any team that did not use activated granular charcoal in their filter will have food coloring come through in the filtered water. The idea is not to have all teams build the perfect filter, but rather to learn and draw good conclusions from the various team results as to what materials work best. Evaluation for grades should not be based on how clear the filtered water came out, but on how well a student demonstrates his/her learning based on written observations and responses in the Student Activity Packet.

Cleanup

Separate the wet pebbles and charcoal from the fine sand by putting the wet materials into a colander/strainer and allowing the water and sand to pass through the colander. Decant the water from the sand, and spread out the materials to dry. The materials can then be used again.

III. Cool Down

Students should work individually to complete the Cool Down questions, either in class or as a homework assignment. After the questions have been completed, lead the class through a guided discussion.



- 1. Will your filter help improve the quality of water available to citizens in the developing world? Explain.**

Answers will vary. Students are expected to reflect on their lab results and what they learned in the Warm Up activity.

- 2. Would you drink the water that passed through your filter? Why or why not?**

Answers will vary. Many students would not choose to drink the water without some kind of disinfection process due to the risk of being exposed to harmful microorganisms.

- 3. In addition to your filter, what other treatment processes may be required to make drinking water safe?**

Students should realize that although the filtered water looks clean, it may contain harmful microorganisms. Because of this, the water should be disinfected using a chemical treatment such as chlorine or should be boiled.

- 4. Whose responsibility is it to make sure that your personal drinking water is safe? Explain.**

Most students of this age have not thought about who is responsible for ensuring safe drinking water for their community. Many will realize that the government is responsible; however they should realize their personal role in this process by becoming an informed and educated citizen.

- 5. Whose responsibility is it to make sure that people in developing countries have safe drinking water? Explain.**

Again, answers will vary. Students may suggest that it is the responsibility of the government of the developing country. However, some may feel a personal responsibility to reach out to those who are less fortunate. It is a goal of this curriculum to help direct young people to be more involved in this important and worthy endeavor.

Optional Extension



Water Treatment

Visit a water treatment plant or have a professional from your local water treatment facility come and speak to your class. Contact your local water treatment facility for free materials or to obtain more ideas for teaching about the water treatment process.

Visit the following USEPA website for many games and activities related to water quality:

http://www.epa.gov/safewater/kids/kids_4-8.html.

Helpful Websites

http://www.epa.gov/safewater/kids/kids_4-8.html

This website contains links to many games, printable activities, and other lessons about water quality, with many activities geared toward high school and elementary school students.

<http://www.epa.gov/safewater/kids/gamesandactivities.html>

At this website, kids can participate in interactive on-line learning games about all aspects of water quality. For example, in one interactive game, kids control the water cycle while they learn about it.

http://www.epa.gov/safewater/kids/flash/flash_filtration.html

This is the direct link to a water filtration activity kids can do at home. The animated video shows the steps outlined in the Warm Up questions and includes explanations of materials and vocabulary.

<http://www.epa.gov/safewater/kids/watertreatmentplant/index.html>

This website has the water treatment diagram included in the Student Activity Packet. Students can click on different parts of the diagram to learn more about each stage of the process.

<http://www.flowthefilm.com/>

Irena Salina's award-winning documentary investigation into what experts label the most important political and environmental issue of the 21st Century - The World Water Crisis. Salina builds a case against the growing privatization of the world's dwindling fresh water supply with an unflinching focus on politics, pollution, human rights, and the emergence of a domineering world water cartel.

Glossary of Key Words

Aeration

the process of supplying with air or exposing to the circulation of air. Synonyms: airing, ventilation, breathing.

Bacteria

any of the unicellular prokaryotic microorganisms of the class Schizomycetes, which vary in terms of morphology, oxygen and nutritional requirements, and motility, and may be free-living, saprophytic, or pathogenic in plants or animals.

Chlorination

the process of treating or combining with chlorine or a chlorine compound. Most often the purpose is to disinfect of harmful microorganisms.

Coagulation

the transformation of a liquid into a soft, semisolid, or solid mass. Synonyms: clotting, congealing, curdling

Developing country

a developing country has a relatively low standard of living, an undeveloped industrial base, and a relatively low Human Development Index score (HDI). In developing countries, there is low per capita income, widespread poverty, and low capital formation. Some examples are Algeria, Botswana, Armenia, Azerbaijan, Guatemala, Brazil, and Paraguay. (<http://en.wikipedia.org/wiki/developing-country>)

Disinfect

to cleanse so as to destroy or prevent the growth of disease-carrying micro-organisms. Synonyms: decontaminate, sterilize, sanitize, clean.

Fertilizer

any of a large number of natural and synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its capacity to support plant growth.

Filtration

the act of passing a gas or liquid through a porous material in order to separate the fluid from suspended particulate matter.

Pesticide

a chemical used to kill pests, especially insects.

Sedimentation

the act or process of depositing sediments.

Virus

any of various simple submicroscopic parasites of plants, animals, and bacteria that often cause disease and that consist essentially of a core of RNA or DNA surrounded by a protein coat. Unable to replicate without a host cell, viruses are typically not considered a living organism.

resource: <http://education.yahoo.com/>

Acknowledgements

Many of the resources used for these lessons were provided through websites sponsored by the US Environmental Protection Agency: <http://www.epa.gov/ow/>.

Need help?

For assistance with chemistry and other scientific concepts, please contact Martha Brosz (martha.brosz@cincinnati.state.edu) or Mary Repaske (mary.repaske@cincinnati.state.edu) – Chemistry Instructors at Cincinnati State Technical and Community College.

For assistance with the structure of the lesson plans, help with materials, or classroom management techniques as they relate to the lessons, please contact Teresa Null (teresa.null@gmail.com) – Middle School Educator.





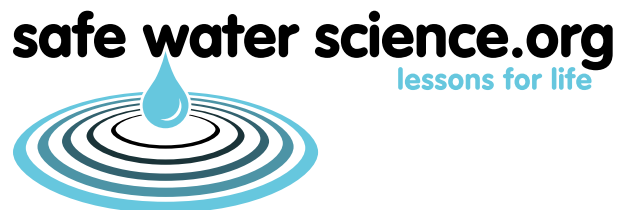
Lesson 3

Availability of Clean Water Teacher's Guide

In part one, students will learn about the difficulties many people in the developing world face each day in obtaining water for their personal use and consumption. Through a water hauling activity, students will experience the physical hardship involved in carrying water from a distant source.

In part two, students will determine how much water they personally use each day.

This lesson is most suitable for students in grades 5-8 working in a cooperative learning environment in teams of four students each. This lesson will take approximately one or two 50-minute class periods to complete.



National Science Content Standards: Grades 5-8



Content Standard A: Science as Inquiry

Abilities necessary to do scientific inquiry

Understandings about scientific inquiry

Content Standard F: Science in Personal and Social Perspectives

Personal Health

Populations, resources, and environments

Natural hazards

Risks and benefits



Teacher Materials

The following materials are needed by the teacher:

- 1 large bucket containing 2.5 gallons of dirty water prepared by mixing $\frac{1}{4}$ cup of finely ground soil/dirt in 2.5 gallons of tap water.

Student Materials

For Part 1, each team of 4 students should have:

- Access to the Internet*
- Calculator*
- 4 copies of the Student Activity Packet

For Part 2, each team of 4 students should have:

- Calculator*
- 4 copies of the Student Activity Packet

*Not supplied in kit



Lesson 3: Part 1

Local Water Sources

The students will work within their teams to write a set of definitions in the Warm Up activity, observe a “Water Haul” demonstration, and individually complete a set of Cool Down questions.

I. Warm Up



Hand out a copy of the Student Activity Packet to each student. Allow the students about 10 minutes to work together in their cooperative teams on the Warm Up activity. Students should discuss answers within their teams but record their answers individually in their own words. Each team should have at least one computer with Internet access or a dictionary.

After most of the teams are finished, discuss the answers as a class. A glossary of Key Words is provided at the end of these teacher pages for your use.

II. Activity: Water Haul



Classroom Procedure

Prepare 2.5 gallons of dirty water for each class (see Teacher Materials), and select two or more students to serve as water carriers.

- Select a route over which the students will carry the 2.5 gal-containing bucket of dirty water. Possible routes are: 10-15 loops around the perimeter of your classroom, 3-4 times up and down a long hallway outside your classroom, or a route of your choosing.
- Monitor the water carriers as they haul the water over the route. Change carriers, if you choose.
- During and after the water haul activity, have the water carriers describe their experiences. Students should discuss these experiences within their teams and individually answer the questions in the procedure section of the Student Activity Packet. To answer one of these questions, student will need you to provide them with the name of a local site approximately 1.9 miles (or 3 km) from your school.

III. Cool Down



Students should work individually to complete the Cool Down questions, either in class or as a homework assignment. After the questions have been completed, lead the class through a guided discussion.

1. How could you carry this water more easily?

Answers will vary. Possible answers include: carry the bucket on their head, suspend the bucket from a pole across their shoulders, use a cart with wheels, use an animal, etc.

2. If the water supply in your community is turned off, where could you get water for your personal use?

Answers will vary. Possible answers include: buy bottled water at the grocery store, go to a friend's house in another community, get water from a river, lake, or pond, etc.



Lesson 3: Part 2

Personal Water Use

The students will work within their teams to answer a set of Warm Up questions, determine the amount of water they personally use in a 24-hour period, and individually complete a set of Cool Down questions.

I. Warm Up



Hand out a copy of the Student Activity Packet to each student. Allow the students about 5 minutes to work together in their cooperative teams on the Warm Up activity. Students should discuss answers within their teams but record their answers individually in their own words.

After most of the teams are finished, discuss the answers as a class.

II. Activity: Calculating Personal Water Use



Have the students tally the number of times they perform over a 24-hour period each of the activities listed on the Daily Personal Water Use table in the Student Activity Packet (student procedure step A). Assign this activity as a homework assignment at least 24 hours before the students will be doing their calculations in class.

Classroom Procedure

- Have the students individually perform the calculations indicated on the table and determine the total amount of water they use in a 24-hour period in both gallons and liters (student procedure steps B and C).
- Have the students discuss within their teams the questions in student procedure step D, and then individually answer the questions in their own words.

III. Cool Down



Students should work individually to complete the Cool Down questions, either in class or as a homework assignment. After the questions have been completed, lead the class through a guided discussion.

1. **If you had to carry to your house the amount of water you personally use every day and could only carry 5 gallons of water on each trip, how many trips would you have to make?**

Answers will vary.

2. **If you had to carry this amount of water a distance of 3.75 miles, how would you reduce the amount you personally use each day?**

Answers will vary. Possible answers include: cutting off running water while washing dishes, brushing teeth, or washing hands; taking shorter showers; washing linens, towels, and clothing less often, etc.



Glossary of Key Words

Access

The ability or right to make use of.

Developed country

A developed country has a relatively high standard of living and is advanced in industrial capability, technological sophistication, and economic productivity. Some examples are the United States and most of Europe.

Developing country

A developing country has a relatively low standard of living, an undeveloped industrial base, and a relatively low Human Development Index score (HDI). In developing countries, there is low per capita income, widespread poverty, and low capital formation. Examples are: Algeria, Botswana, Armenia, Azerbaijan, Guatemala, Brazil, Paraguay (source: http://en.wikipedia.org/wiki/Developing_country).

Hygiene

Conditions and practices that serve to promote health.

Purify

To become clean or pure.

Synonym: clean.

Sewage

Liquid and solid waste carried off in sewers or drains.

source: <http://education.yahoo.com/>



Acknowledgements

Many of the resources used for these lessons were provided by the following organizations:

Peace Corps: Worldwide Schools

<http://www.peacecorps.gov/wws/>

WHO: World Health Organization

<http://www.who.int/en/>

CDC: Centers for Disease Control and Prevention

<http://www.cdc.gov/education/default.html>

UNICEF: United Nations Children's Fund

<http://www.unicef.org/>

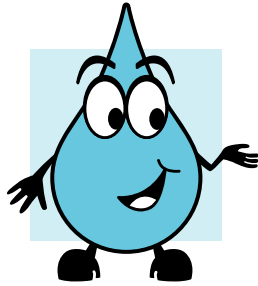
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Lesson 4

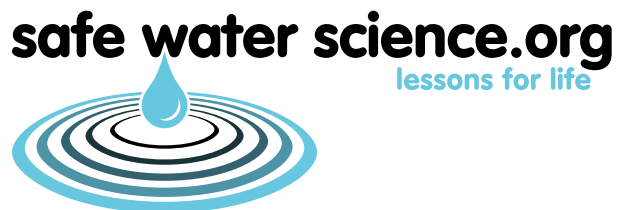


Making Water Safe to Drink Teacher's Guide

In part one, students will learn how to begin to purify dirty water by removing dissolved gases and large particles using aeration, coagulation, and sedimentation: the first steps of the water treatment process.

In part two, will learn about and observe a demonstration of how PUR Purifier of Water™ can be used as a method for making contaminated water good to drink. Students will relate the PUR Purifier of Water™ method of treating water to the steps used in a modern water treatment plant. Students will reflect on how PUR Purifier of Water™ could be used as a method for helping people in developing countries obtain clean drinking water.

This lesson will take approximately one 50-minute class period to complete and is appropriate for grades 6-8.



National Science Content Standards: Grades 5-8



Content Standard A: Science as Inquiry

Abilities necessary to do scientific inquiry
Understandings about scientific inquiry

Content Standard B: Physical Science

Properties and changes of properties in matter

Content Standard D: Earth and Space Science

Structure of the earth system

Content Standard E: Science and Technology

Abilities of technological design
Understandings about Science and Technology

Content Standard F: Science in Personal and Social Perspectives

Personal Health
Risks and Benefits
Science and Technology in Society



Teacher Materials

For Part 1, the following materials and quantities are needed by the teacher:

- 1 large bucket containing about 2 liters of dirty water (prepared by adding approximately 1 tablespoon of finely pulverized soil/dirt to a clear 2-liter pop bottle filled with tap water).

For Part 2, the following materials and quantities are needed by the teacher:

- 1 large bucket containing 10 liters (2.5 gallons) of dirty water (prepared by adding approximately 1/4 cup of finely pulverized soil/dirt to the large bucket filled with tap water; *new dirty water is needed for Part Two*).
- 1 sachet of PUR Purifier of Water
- 1 large stirring spoon
- 1 large jar or beaker for collecting the filtrate (at least 1 L in size)
- Paper towels or clean cloth for filtering
- 1 Small Dixie cup per student for drinking clean water

Student Materials

For Part 1, each team of 4 students should have:

- 2 clear 9-oz. plastic cups (one containing dirty water, one empty for collecting the filtered water)
- Coffee filter
- 1 small plastic spoon for stirring
- 1/8 tsp. of lime powder (calcium hydroxide) in a 2-oz. plastic cup
- 1/8 tsp. of alum (aluminum sulfate) in a 2-oz. plastic cup
- 4 copies of the Student Activity Packet

For Part 2, each team of 4 students should have:

- 4 copies of the Student Activity Packet



Lesson 4: Part 1

The First Steps of Water Treatment

The students will work within their teams to answer a set of Warm Up questions, perform the first three steps of water purification, and individually complete a set of Cool Down questions.

I. Warm Up



Hand out a Student Activity Packet to each student. Allow the students about 10 minutes to work together in their cooperative teams on the Warm Up activity. Students should discuss answers within their teams but record their answers individually in their own words.

A copy of the Treatment of Water diagram from Lesson 2 or the Glossary of Key Words from this lesson will be helpful to student teams when answering Warm Up question 4.

II. Activity: Aeration, Coagulation, Sedimentation, and Filtration

Pre-Session Preparation

- Prepare 2 liters of dirty water for each class (see Teacher Materials)
- Label 8 2-oz. plastic cups "Alum" and 8 2-oz. plastic cups "Lime"
- Measure 1/8 tsp. of lime powder (calcium hydroxide) in each of the eight labeled
- Measure 1/8 tsp. of alum (aluminum sulfate) in each of the eight labeled cups.

Classroom Procedures

- Review the lab procedures with the students.
- Prepare a station where student teams may obtain alum, lime, dirty water, and other lab materials.
- Allow 10 to 15 minutes for students to work through the lab procedures.
- Clean Up; if a cloth was used for filtering, wash it with soap and water, and let dry. Dispose of the floc in the toilet or at the base of a bush or tree, away from animals and children. The floc does not contain anything that was not originally in the soil (dirt, bacteria, and the components of PUR are already present in soil).

III. Cool Down



Students should work individually to complete the Cool Down questions, either in class or as a homework assignment. After the questions have been completed, lead the class through a guided discussion.

1. What steps in the water treatment process were not done?

Filtration and Disinfection were not included in this activity.

2. Do you think your treated water is safe to drink? Why or why not?

Answers will vary. Because the disinfection stage of water treatment did not occur in this activity, harmful microorganisms may still be present, even though the water may appear clean.



Lesson 4: Part 2

Making Water Safe to Drink with PUR Purifier of Water™

The students will work within their teams to answer a set of Warm Up questions. The students will then observe how dirty water can be turned into safe drinking water using PUR Purifier of Water. Students will individually complete a set of Cool Down questions and consider how they may become agents of change in the global struggle to provide safe drinking water to all people.

I. Warm Up



Hand out a Student Activity Packet to each student. Allow the students about 10 minutes to work together in their cooperative teams on the Warm Up activity. Students should discuss answers within their teams but record their answers individually in their own words.

II. Activity: Making Water Safe to Drink with PUR Purifier of Water

Pre-Session Preparation

Prepare 10 liters (2.5 gallons) of dirty water for each class (see Teacher Materials). You will use the 10 liters of dirty water to demonstrate how PUR Purifier of Water makes the water safe to drink.

Classroom Procedure



- Have students record observations of the dirty water (student procedure step A).
- Add 1 packet of PUR Purifier of Water to the dirty water.
- Select a student volunteer(s) and have the volunteer stir the water vigorously for 5 minutes to allow the floc to form.

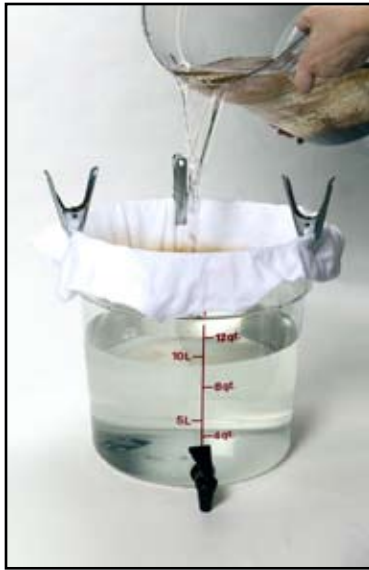
Have students record their observations during the flocculation process (student procedure step B).



- After stirring for 5 minutes, allow the floc to settle for an additional 5 minutes.

Assist students in answering the student procedure step C question as the floc is settling.





- Ask for 2-3 student volunteers to assist in student procedure step D.

Place a paper towel or piece of clean cloth over a 1L jar (or beaker).

Pour some of the liquid from the bucket through the towel (cloth), trying not to disturb the floc that is on the bottom. You may scoop some of the water out of the bucket if that is easier than pouring.

- Wait 20 minutes for the filtered water to become disinfected.

During this time, assist students in answering student procedure steps D-F questions.

During the 20-minute disinfection process, you may also visit the Children's Safe Drinking Water website with your students: <http://www.csdw.com/index.shtml>. At this site, students will discover additional background information and engaging videos highlighting the struggle to provide safe drinking water to developing countries.



- If you choose, you may now have the students sample the purified water using small plastic cups (student procedure step G). Make sure you have waited the full 20 minutes for disinfection to occur.

Background Information on the Chemistry of PUR Purifier of Water

The PUR Purifier of Water product is a point-of-use water purification product designed to allow people to treat and drink unclear or unsafe waters at low cost. It uses a ferric sulfate coagulant to remove contaminants from the water and a calcium hypochlorite disinfectant to kill bacteria and viruses. The ingredients used in the product are of drinking water quality and found in municipal water treatment systems around the world.

The product works in a step-wise process to clarify and disinfect water. First, the contaminants are removed by the ferric sulfate coagulant. As this begins to form a visible precipitate, the chlorine is released from the calcium hypochlorite ingredient to provide disinfection, killing the bacteria and viruses present in the water. After the contaminants completely precipitate from solution, they are removed by filtering. The filtered water can be drunk about 30 minutes after you start mixing.

Used per instructions, the PUR Purifier of Water product results in water quality that complies with pertinent World Health Organization (WHO) guidelines (i.e., the product does not add any chemical that would exceed WHO guidelines). Each packet treats 10 liters or 2.5 gallons of water.

Clean Up

If a cloth was used for filtering, wash it with soap and water, and let dry. Dispose of the floc in the toilet or at the base of a bush or tree, away from animals and children. The floc does not contain anything that was not originally in the soil (dirt, bacteria, and the components of PUR are already present in soil).

III. Cool Down



Students should work individually to complete the Cool Down questions, either in class or as a homework assignment. After the questions have been completed, lead the class through a guided discussion.

1. What evidence did you observe that water treated with PUR Purifier of Water is now good to drink?

Students should compare their original observations of the contaminated water with their final observations of the filtered water. The appearance of the filtered water should be clear and clean, and it should seem ready to drink. As an extension, you may have students compare the appearance and smell of the PUR Purifier of Water-treated water with a cup of tap water. The water samples should be similar. A slight odor of chlorine may be detected in the PUR-treated water, if allowed to sit for a few hours. This is also an opportunity to discuss chemical versus physical changes in matter. PUR Purifier of Water causes a chemical reaction to take place so that the contaminants can be removed during filtration. Evidence of a chemical change is the appearance of floc during the stirring process.

2. Explain why PUR Purifier of Water is a good water purification method for people in developing countries.

PUR powder is easy to use and can be used on small amounts of water. One PUR packet can purify 10 liters of contaminated water. This is more than enough clean water to supply the daily water needs of a family in a developing country. Because the PUR Purifier of Water product is packaged in small “sachets,” they can be delivered in bulk to remote areas of developing countries. Providing these countries with large water treatment plants like we have in the United States is not possible at this time due to many cultural, political, economic, and geographic constraints.

3. What are the disadvantages of using the PUR Purifier of Water method?

PUR Purifier of Water is not a long-term solution to water treatment for a community. New PUR packets must constantly be supplied and the process of treating the water must be repeated over and over again. This method does not supply good safe water directly to a household. People in developing countries must continue to walk many miles for dirty water that is then treated with PUR Purifier of Water.

4. A well is dug in the community, and residents now have a source of water that is relatively safe to drink and closer to home.

4a. How does this solve some of the disadvantages discussed in question 3?

This is a long-term solution for the community and provides clean and safe water that is close to home. A daily supply of PUR is no longer needed.

4b. What are the problems associated with having to dig a well?

Digging a well is expensive and may take some time to complete, so the solution to a community's water shortage is not immediate. The technology may not be available in all areas. Some areas may have environmental issues, resulting in the water pumped from a well not being safe to drink. In many of the Himalayans, arsenic is found in well water.

5. What steps would you take to help these disadvantaged people have access to PUR Purifier of Water?

Answers will vary among students. Encourage a discussion about realistic ways we could get the PUR packets to developing countries, especially to remote areas where normal modes of transportation are not possible. Accept all reasonable answers. The purpose of this question is for students to begin to understand the obstacles and challenges that must be overcome to bring this technology to the developing world. Another goal is for students to realize that they could make a difference in the lives of people; our world can be a global community.

6. In what other situations could PUR Purifier of Water be used to make water good to drink?

PUR packets were provided as part of the disaster relief efforts following the tsunami that devastated Southeast Asia in 2004 and the recent tsunami in Myanmar and earthquake in China in 2008. Drinking water often becomes contaminated as a result of such disasters. PUR Purifier of Water could also be used while backpacking to purify water from untreated sources. Another application could be when military troops in the field do not have access to clean water. Accept all reasonable suggestions from students.

Optional Extensions

Games & Activities

Visit <http://www.epa.gov/safewater/kids/index.html> to find links to many water activities for all grade levels. There is a link to games and activities for students, and also a link for teacher lessons. The lessons, games, and activities are of a wide variety from water quality issues to lessons about the water cycle. It is a great resource for children and adults alike.

Take a virtual tour of Zambia, a developing country, at <http://www.bized.co.uk/virtual/dc/index.htm>. Here students can tour Zambia and discover why it is a developing country. The website offers teacher resources and worksheets for students. This is a great opportunity for curriculum integration with social studies teachers in your school.

Helpful Websites

http://www.pg.com/company/our_commitment/drinking_water.jhtml

Visit this website to learn more about the Procter & Gamble Company and how the PUR Purifier of Water product can improve water quality.

http://en.wikipedia.org/wiki/Developing_countries

Visit this site to learn the basics about what qualifies a country as “developing” or being “less developed”. There are many links from this website to other resources concerning this topic.

Glossary of Key Words

Aeration

the process of supplying with air or exposing to the circulation of air. Synonyms: airing, ventilation, breathing.

Chlorination

the process of treating or combining with chlorine or a chlorine compound. Most often the purpose is to disinfect of harmful micro-organisms.

Coagulation

the transformation of a liquid into a soft, semisolid, or solid mass. Synonyms: clotting, congealing, curdling.

Developing country

a country that has a relatively low standard of living, an undeveloped industrial base, and a moderate to low Human Development Index score (HDI). A developing country can also be referred to as a “less developed country” (LDC) or a “less economically developed country” (LEDC). To research this topic further, visit the following website: http://en.wikipedia.org/wiki/Developing_countries.

Disinfect

to cleanse so as to destroy or prevent the growth of disease-carrying micro-organisms. Synonyms: decontaminate, sterilize, sanitize, clean.

Filtration

the act of passing a gas or liquid through a porous material in order to separate the fluid from suspended particulate matter.

Floc

a flocculent mass formed in a fluid through precipitation or aggregation of suspended particles.

Purify

to make or become clear by removal of impurities. Synonyms: cleanse, refine, purge.

Sedimentation

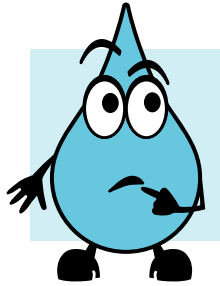
the act or process of depositing sediments.

(resource: <http://education.yahoo.com/>)

Need Help?

For assistance with chemistry and other scientific concepts, please contact Martha Brosz (martha.brosz@cincinnatiastate.edu) or Mary Repaske (mary.repaske@cincinnatiastate.edu) – Chemistry Instructors at Cincinnati State Technical and Community College.

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Appendix

Arsenicosis: Arsenic Poisoning

Drinking water rich in arsenic over a long period leads to arsenic poisoning or arsenicosis. Many waters contain some arsenic and excessive concentrations are known to naturally occur in some areas. The health effects are generally delayed and the most effective preventive measure is supply of drinking water low in arsenic concentration.

The Disease And How It Affects People

Arsenicosis is the effect of arsenic poisoning, usually over a long period such as from 5 to 20 years. Drinking arsenic-rich water over a long period results in various health effects including skin problems (such as colour changes on the skin, and hard patches on the palms and soles of the feet), skin cancer, cancers of the bladder, kidney and lung, and diseases of the blood vessels of the legs and feet, and possibly also diabetes, high blood pressure and reproductive disorders.

Absorption of arsenic through the skin is minimal and thus hand-washing, bathing, laundry, etc. with water containing arsenic do not pose human health risks.

In China (Province of Taiwan) exposure to arsenic via drinking-water has been shown to cause a severe disease of the blood vessels, which leads to gangrene, known as 'black foot disease'. This disease has not been observed in other parts of the world, and it is possible that malnutrition contributes to its development. However, studies in several countries have demonstrated that arsenic causes other, less severe forms of peripheral vascular disease.

The Cause

Arsenicosis is caused by the chemical arsenic. Arsenic is a toxic element that has no apparent beneficial health effects for humans.

Natural arsenic salts are present in all waters but usually in only very small amounts. Most waters in the world have natural arsenic concentrations of less than 0.01 mg/litre.

Arsenicosis is caused by exposure over a period of time to arsenic in drinking water. It may also be due to intake of arsenic via food or air. The multiple routes of exposure contribute to chronic poisoning. Arsenic contamination in water may also be due to industrial processes such as those involved in mining, metal



The effects of Arsenic poisoning on the skin.

refining, and timber treatment. Malnutrition may aggravate the effects of arsenic in blood vessels.

WHO's Guideline Value for arsenic in drinking water is 0.01 mg /litre. This figure is limited by the ability to analyse low concentrations of arsenic in water. Distribution

Natural arsenic contamination is a cause for concern in many countries of the world including Argentina, Bangladesh, Chile, China, India, Mexico, Thailand and the United States of America.

Scope Of The Problem

Because of the delayed health effects, poor reporting, and low levels of awareness in some communities, the extent of the adverse health problems caused by arsenic in drinking-water is unclear and not well documented. As a result there is no reliable estimate of the extent of the problem worldwide. WHO is presently collecting information in order to make such an estimate.

Case reports on the situation in various countries have been compiled and the arsenic problem in Bangladesh in particular has prompted more intensive monitoring in many other countries. In Bangladesh, 27 % of shallow tube-wells have been shown to have

high levels of arsenic (above 0.05mg/l). It has been estimated that 35 - 77 million of the total population of 125 million of Bangladesh are at risk of drinking contaminated water (WHO bulletin, volume 78, (9):page 1096). Approximately 1 in 100 people who drink water containing 0.05 mg arsenic per litre or more for a long period may eventually die from arsenic related cancers.

Interventions

The most important action in affected communities is the prevention of further exposure to arsenic by provision of safe drinking-water. Arsenic-rich water can be used for other purposes such as washing and laundry. In the early stages of arsenicosis, drinking arsenic-free water can reverse some of the effects. Long term solutions for prevention of arsenicosis include:
For provision of safe drinking-water:

- Deeper wells are often less likely to be contaminated.
- Rain water harvesting in areas of high rainfall such as in Bangladesh. Care must be taken that collection systems are adequate and do not present risk of infection or provide breeding sites for mosquitoes.
- Use of arsenic removal systems in households (generally for shorter periods) and before water distribution in piped systems.
- Testing of water for levels of arsenic and informing users.

In order to effectively promote the health of people the following issues should be taken into account:

- Monitoring by health workers - people need to be checked for early signs of arsenicosis - usually skin problems in areas where arsenic is known to occur.
- Health education regarding harmful effects of arsenicosis and how to avoid them.

References

Arsenic in Drinking Water. WHO Fact Sheet No. 210.

Revised May 2001.

Bulletin of the World Health Organization, volume 78, (9):page 1096

Prepared for World Water Day 2001. Reviewed by staff and experts from the Programme for Promotion of Chemical Safety (PCS), and the Water, Sanitation and Health unit (WSH), World Health Organization (WHO), Geneva.

The preceding information from the World Health Organization (WHO) can be found at:

http://www.who.int/water_sanitation_health/diseases/arsenicosis/en/print.html.



Cholera

Cholera outbreaks can occur sporadically in any part of the world where water supplies, sanitation, food safety and hygiene practices are inadequate. Overcrowded communities with poor sanitation and unsafe drinking-water supplies are most frequently affected.

The Disease And How It Affects People

Cholera is an acute infection of the intestine, which begins suddenly with painless watery diarrhoea, nausea and vomiting. Most people who become infected have very mild diarrhoea or symptom-free infection. Malnourished people in particular experience more severe symptoms. Severe cholera cases present with profuse diarrhoea and vomiting. Severe, untreated cholera can lead to rapid dehydration and death. If untreated, 50% of people with severe cholera will die, but prompt and adequate treatment reduces this to less than 1% of cases.

The Cause

Cholera is caused by the bacterium *Vibrio cholerae*. People become infected after eating food or drinking water that has been contaminated by the faeces of infected persons. Raw or undercooked seafood may be a source of infection in areas where cholera is prevalent and sanitation is poor. Vegetables and fruit that have been washed with water contaminated by sewage may also transmit the infection if *V. cholerae* is present.

Distribution

Cholera cases and deaths were officially reported to WHO, in the year 2000, from 27 countries in Africa, 9 countries in Latin America, 13 countries in Asia, 2 countries in Europe, and 4 countries in Oceania.

Scope Of The Problem

Control of cholera is a major problem in several Asian countries as well as in Africa. In the year 2000, some 140,000 cases resulting in approximately 5000 deaths were officially notified to WHO. Africa accounted for 87% of these cases. After almost a century of no reported cases of the disease, cholera reached Latin America in 1991; however, the number of cases reported has been steadily declining since 1995.

Interventions

To prevent the spread of cholera, the following four interventions are essential:

- Provision of adequate safe drinking-water
- Proper personal hygiene
- Proper food hygiene
- Hygienic disposal of human excreta.

Treatment of cholera consists mainly in replacement of lost fluids and salts. The use of oral rehydration salts (ORS) is the quickest and most efficient way of doing this. Most people recover in 3 to 6 days. If the infected person becomes severely dehydrated, intravenous fluids can be given. Antibiotics are not necessary to successfully treat a cholera patient.

Prepared for World Water Day 2001. Reviewed by staff and experts from the cluster on Communicable Diseases (CDS) and the Water, Sanitation and Health unit (WSH), World Health Organization (WHO).

The preceding information from the World Health Organization (WHO) can be found at: http://www.who.int/water_sanitation_health/diseases/cholera/en/print.html.

Cholera

In January 1991, epidemic cholera appeared in South America and quickly spread to several countries. A few cases have occurred in the United States among persons who traveled to South America or ate contaminated food brought back by travelers.

Cholera has been very rare in industrialized nations for the last 100 years; however, the disease is still common today in other parts of the world, including the Indian subcontinent and sub-Saharan Africa.

Although cholera can be life-threatening, it is easily prevented and treated. In the United States, because of advanced water and sanitation systems, cholera is not

a major threat; however, everyone, especially travelers, should be aware of how the disease is transmitted and what can be done to prevent it.

What is cholera?

Cholera is an acute, diarrheal illness caused by infection of the intestine with the bacterium *Vibrio cholerae*. The infection is often mild or without symptoms, but sometimes it can be severe. Approximately one in 20 infected persons has severe disease characterized by profuse watery diarrhea, vomiting, and leg cramps. In these persons, rapid loss of body fluids leads to dehydration and shock. Without treatment, death can occur within hours.

How does a person get cholera?

A person may get cholera by drinking water or eating food contaminated with the cholera bacterium. In an epidemic, the source of the contamination is usually the feces of an infected person. The disease can spread rapidly in areas with inadequate treatment of sewage and drinking water.

The cholera bacterium may also live in the environment in brackish rivers and coastal waters. Shellfish eaten raw have been a source of cholera, and a few persons in the United States have contracted cholera after eating raw or undercooked shellfish from the Gulf of Mexico. The disease is not likely to spread directly from one person to another; therefore, casual contact with an infected person is not a risk for becoming ill.

What is the risk for cholera in the United States?

In the United States, cholera was prevalent in the 1800s but has been virtually eliminated by modern sewage and water treatment systems. However, as a result of improved transportation, more persons from the United States travel to parts of Africa, Asia, or Latin America where epidemic cholera is occurring. U.S. travelers to areas with epidemic cholera may be exposed to the cholera bacterium. In addition, travelers may bring contaminated seafood back to the United States; foodborne outbreaks have been caused by contaminated seafood brought into this country by travelers.

What should travelers do to avoid getting cholera?

The risk for cholera is very low for U.S. travelers visiting areas with epidemic cholera. When simple precautions are observed, contracting the disease is unlikely.

All travelers to areas where cholera has occurred should observe the following recommendations:

- Drink only water that you have boiled or treated with chlorine or iodine. Other safe beverages include tea and coffee made with boiled water and carbonated, bottled beverages with no ice.
- Eat only foods that have been thoroughly cooked and are still hot, or fruit that you have peeled yourself.
- Avoid undercooked or raw fish or shellfish, including ceviche.
- Make sure all vegetables are cooked avoid salads.
- Avoid foods and beverages from street vendors.
- Do not bring perishable seafood back to the United States.
- A simple rule of thumb is "Boil it, cook it, peel it, or forget it."

Is a vaccine available to prevent cholera?

A recently developed oral vaccine for cholera is licensed and available in other countries (Dukoral from SBL Vaccines). The vaccine appears to provide somewhat better immunity and have fewer adverse effects than the previously available vaccine. However, CDC does not recommend cholera vaccines for most travelers, nor is the vaccine available in the United States.

Can cholera be treated?

Cholera can be simply and successfully treated by immediate replacement of the fluid and salts lost through diarrhea. Patients can be treated with oral rehydration solution, a prepackaged mixture of sugar and salts to be mixed with water and drunk in large amounts. This solution is used throughout the world to treat diarrhea. Severe cases also require intravenous fluid replacement. With prompt rehydration, fewer than 1% of cholera patients die.

Antibiotics shorten the course and diminish the severity of the illness, but they are not as important as rehydration. Persons who develop severe diarrhea and vomiting in countries where cholera occurs should seek medical attention promptly.

How long will the current epidemic last?

Predicting how long a Cholera epidemic will last is difficult. The cholera epidemic in Africa has lasted more than 30 years. In areas with inadequate sanitation, a cholera epidemic cannot be stopped immediately, and, although far fewer cases have been reported from Latin America and Asia in recent years, there are no signs that the global Cholera pandemic will end soon. Major improvements in sewage and water treatment systems are needed in many countries to prevent future epidemic cholera.

What is the U.S. government doing to combat cholera?

U.S. and international public health authorities are working to enhance surveillance for cholera, investigate cholera outbreaks, and design and implement preventive measures. The Centers for Disease Control and Prevention investigates epidemic cholera wherever it occurs and trains laboratory workers in proper techniques for identification of *V. cholerae*. In addition, the Centers for Disease Control and Prevention provides information on diagnosis, treatment, and prevention of cholera to public health officials and educates the public about effective preventive measures.

The U.S. Agency for International Development is sponsoring some of the international government activities and is providing medical supplies to affected countries.

The Environmental Protection Agency is working with water and sewage treatment operators in the United States to prevent contamination of water with the cholera bacterium.

The Food and Drug Administration is testing imported and domestic shellfish for *V. cholerae* and monitoring the safety of U.S. shellfish beds through the shellfish sanitation program.

With cooperation at the state and local, national, and international levels, assistance will be provided to countries where cholera is present, and the risk to U.S. residents will remain small.

Where can a traveler get information about cholera?

The global picture of cholera changes periodically, so travelers should seek updated information on countries of interest. The Centers for Disease Control and Prevention maintains a travelers' information telephone line on which callers can receive recent information on cholera and other diseases of concern to travelers. Data for this service are obtained from the World Health Organization. The number is 877-FYI-TRIP (394-8747) or check out <http://www.cdc.gov/travel>

The preceding information from the Centers for Disease Control can be found at: http://www.cdc.gov/ncidod/dbmd/diseaseinfo/cholera_g.htm

Cryptosporidiosis: Crypto Infection

During the past two decades, “crypto” has become recognized as one of the most common causes of waterborne disease within humans in the United States. The parasite may be found in drinking water and recreational water in every region of the United States and throughout the world.

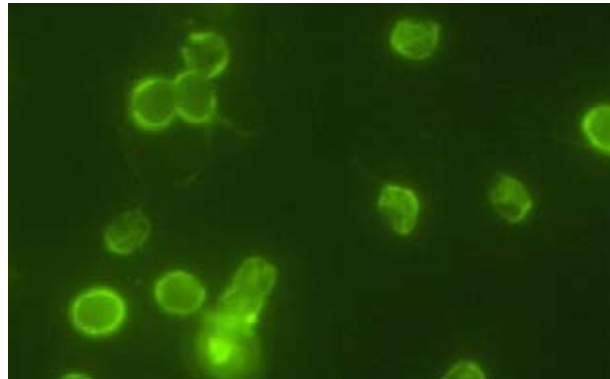
What is cryptosporidiosis?

Cryptosporidiosis is a diarrheal disease caused by microscopic parasites of the genus *Cryptosporidium*. Once an animal or person is infected, the parasite lives in the intestine and passes in the stool. The parasite is protected by an outer shell that allows it to survive outside the body for long periods of time and makes it very resistant to chlorine-based disinfectants. Both the disease and the parasite are commonly known as “crypto.”

How is cryptosporidiosis spread?

Cryptosporidium lives in the intestine of infected humans or animals. Millions of crypto germs can be released in a bowel movement from an infected human or animal. Consequently, *Cryptosporidium* is found in soil, food, water, or surfaces that have been contaminated with infected human or animal feces. If a person swallows the parasite they become infected. You cannot become infected through contact with blood. The parasite can be spread by:

- Accidentally putting something into your mouth or swallowing something that has come into contact with feces of a person or animal infected with *Cryptosporidium*.
- Swallowing recreational water contaminated with *Cryptosporidium* (Recreational water includes water in swimming pools, hot tubs, jacuzzis, fountains, lakes, rivers, springs, ponds, or streams that can be contaminated with sewage or feces from humans or animals.) Note: *Cryptosporidium* can survive for days in swimming pools with adequate chlorine levels.
- Eating uncooked food contaminated with *Cryptosporidium*. Thoroughly wash with clean, safe water all vegetables and fruits you plan to eat raw. See below for information on making water safe.
- Accidentally swallowing *Cryptosporidium* picked up from surfaces (such as bathroom fixtures, changing tables, diaper pails, or toys) contaminated with feces from an infected person.



Cryptosporidium (Source: EPA)

What are the symptoms of cryptosporidiosis?

The most common symptom of cryptosporidiosis is watery diarrhea. Other symptoms include:

- Dehydration
- Weight loss
- Stomach cramps or pain
- Fever
- Nausea
- Vomiting

Some people with crypto will have no symptoms at all. While the small intestine is the site most commonly affected, *Cryptosporidium* infections could possibly affect other areas of the digestive or the respiratory tract.

How long after infection do symptoms appear?

Symptoms of cryptosporidiosis generally begin 2 to 10 days (average 7 days) after becoming infected with the parasite.

How long will symptoms last?

In persons with healthy immune systems, symptoms usually last about 1 to 2 weeks. The symptoms may go in cycles in which you may seem to get better for a few days, then feel worse again before the illness ends.



If I have been diagnosed with Cryptosporidium, should I worry about spreading the infection to others?

Yes, Cryptosporidium can be very contagious. Follow these guidelines to avoid spreading the disease to others:

1. Wash your hands with soap and water after using the toilet, changing diapers, and before eating or preparing food.
2. Do not swim in recreational water (pools, hot tubs, lakes or rivers, the ocean, etc.) if you have cryptosporidiosis and for at least 2 weeks after diarrhea stops. You can pass Cryptosporidium in your stool and contaminate water for several weeks after your symptoms have ended. This has resulted in outbreaks of cryptosporidiosis among recreational water users. **Note:** Cryptosporidium can be spread in a chlorinated pool because it is resistant to chlorine and, therefore, can live for days in chlorine-treated swimming pools.

Who is most at risk for cryptosporidiosis?

People who are most likely to become infected with Cryptosporidium include:

- Children who attend day care centers, including diaper-aged children
- Child care workers
- Parents of infected children
- International travelers
- Backpackers, hikers, and campers who drink unfiltered, untreated water
- Swimmers who swallow water while swimming in swimming pools, lakes, rivers, ponds, and streams
- People who drink from shallow, unprotected wells
- People who swallow water from contaminated sources. Contaminated water includes water that has not been boiled or filtered. Several community-wide outbreaks of cryptosporidiosis have been linked to drinking municipal water or recreational water contaminated with Cryptosporidium.

Who is most at risk for getting seriously ill with cryptosporidiosis?

Although Crypto can infect all people, some groups are more likely to develop more serious illness:

- Young children and pregnant women may be more susceptible to the dehydration resulting from diarrhea and should drink plenty of fluids while ill. If you have a severely weakened immune system, talk to your health care provider for additional guidance. You can also call the CDC AIDS HOTLINE toll-free

at 1-800-342-2437. Ask for more information on cryptosporidiosis, or go to the CDC fact sheet Preventing Cryptosporidiosis: A Guide for People with Compromised Immune Systems available by visiting http://www.cdc.gov/ncidod/dpd/parasites/cryptosporidiosis/factsht_crypto_prevent_ci.htm

- If you have a severely weakened immune system, you are at risk for more serious disease. Your symptoms may be more severe and could lead to serious or lifethreatening illness. Examples of persons with weakened immune systems include those with HIV/AIDS; cancer and transplant patients who are taking certain immunosuppressive drugs; and those with inherited diseases that affect the immune system.

What should I do if I think I may have cryptosporidiosis?

If you suspect that you have cryptosporidiosis, see your health care provider.

How is a cryptosporidiosis diagnosed?

Your health care provider will ask you to submit stool samples to see if you are infected. Because testing for Crypto can be difficult, you may be asked to submit several stool specimens over several days. Tests for Crypto are not routinely done in most laboratories; therefore, your health care provider should specifically request testing for the parasite.

What is the treatment for cryptosporidiosis?

A new drug, nitazoxanide, has been approved for treatment of diarrhea caused by Cryptosporidium in people with healthy immune systems. Consult with your health care provider for more information. Most people who have a healthy immune system will recover without treatment. The symptoms of diarrhea can be treated. If you have diarrhea, drink plenty of fluids to prevent dehydration. Rapid loss of fluids from diarrhea may be especially life threatening to babies; therefore, parents should talk to their health care provider about fluid replacement therapy options for infants. Anti-diarrheal medicine may help slow down diarrhea, but talk to your health care provider before taking it. People who are in poor health or who have a weakened immune system are at higher risk for more severe and more prolonged illness. The effectiveness of nitazoxanide in immunosuppressed individuals is unclear. For persons with AIDS, anti-retroviral therapy that improves immune status will also decrease or eliminate symptoms of Crypto. However, even if symptoms disappear, cryptosporidiosis is usually not curable and the symptoms may return if the immune status worsens. See your health care provider to discuss anti-retroviral therapy used to improve your immune status.

How can I prevent cryptosporidiosis?

Practice good hygiene:

1. Wash hands thoroughly with soap and water.
 - a. Wash hands after using the toilet and before handling or eating food (especially for persons with diarrhea).
 - b. Wash hands after every diaper change, especially if you work with diaper-aged children, even if you are wearing gloves.
2. Protect others by not swimming if you are experiencing diarrhea (essential for children in diapers).

Avoid water that might be contaminated:

1. Do not swallow recreational water.
2. Do not drink untreated water from shallow wells, lakes, rivers, springs, ponds, and streams.
3. Do not drink untreated water during community-wide outbreaks of disease caused by contaminated drinking water. For information on recreational water-related illnesses, visit CDC's Healthy Swimming website at <http://www.cdc.gov/healthyswimming>.
4. Do not use untreated ice or drinking water when traveling in countries where the water supply might be unsafe. In the United States, nationally distributed brands of bottled or canned carbonated soft drinks are safe to drink. Commercially packaged non-carbonated soft drinks and fruit juices that do not require refrigeration until after they are opened (those that are stored unrefrigerated on grocery shelves) also are safe.

If you are unable to avoid using or drinking water that might be contaminated, then you can make the water safe to drink by doing one of the following:

- Heat the water to a rolling boil for at least 1 minute.
OR
- Use a filter that has an absolute pore size of at least 1 micron or one that has been NSF rated for "cyst removal." Do not rely on chemicals to disinfect water and kill *Cryptosporidium*. Because it has a thick outer shell, this particular parasite is highly resistant to disinfectants such as chlorine and iodine.

Avoid food that might be contaminated:

1. Wash and/or peel all raw vegetables and fruits before eating.
2. Use safe, uncontaminated water to wash all food that is to be eaten raw.
3. Avoid eating uncooked foods when traveling in countries with minimal water treatment and sanitation systems.

Take extra care when traveling.

If you travel to developing nations, you may be at a greater risk for *Cryptosporidium* infection because of poorer water treatment and food sanitation. Warnings about food, drinks, and swimming are even more important when visiting developing countries. Avoid foods and drinks, in particular raw fruits and vegetables, tap water, or ice made from tap water, unpasteurized milk or dairy products, and items purchased from street vendors. These items may be contaminated with *Cryptosporidium*. Steaming-hot foods, fruits you peel yourself, bottled and canned processed drinks, and hot coffee or hot tea are probably safe. Talk with your health care provider about other guidelines for travel abroad.

This fact sheet is for information only and is not meant to be used for self-diagnosis or as a substitute for consultation with a health care provider. If you have any questions about the disease described above or think that you may have a parasitic

For information on choosing safe bottled water, see the CDC fact sheet entitled "Preventing Cryptosporidiosis: A Guide to Water Filters and Bottled Water," available by visiting <http://www.cdc.gov/ncidod/dpd/parasites/cryptosporidiosis/>

For information on choosing a water filter, see the CDC fact sheet entitled "Preventing Cryptosporidiosis: A Guide to Water Filters and Bottled Water," available by visiting <http://www.cdc.gov/ncidod/dpd/parasites/cryptosporidiosis/>

The preceding fact sheet from the Centers for Disease Control (CDC) can be found at: http://www.cdc.gov/Ncidod/dpd/parasites/cryptosporidiosis/2004_PDF_Cryptosporidiosis.pdf.



Diarrhea

Diarrhea occurs world-wide and causes 4% of all deaths and 5% of health loss to disability. It is most commonly caused by gastrointestinal infections which kill around 2.2 million people globally each year, mostly children in developing countries.

The use of water in hygiene is an important preventive measure but contaminated water is also an important cause of diarrhea. Cholera and dysentery cause severe, sometimes life threatening forms of diarrhea.

The Disease And How It Affects People

Diarrhea is the passage of loose or liquid stools more frequently than is normal for the individual. It is primarily a symptom of gastrointestinal infection. Depending on the type of infection, the diarrhea may be watery (for example in cholera) or passed with blood (in dysentery for example).

Diarrhea due to infection may last a few days, or several weeks, as in persistent diarrhea. Severe diarrhea may be life threatening due to fluid loss in watery diarrhea, particularly in infants and young children, the malnourished and people with impaired immunity. The impact of repeated or persistent diarrhea on nutrition and the effect of malnutrition on susceptibility to infectious diarrhea can be linked in a vicious cycle amongst children, especially in developing countries. Diarrhea is also associated with other infections such as malaria and measles. Chemical irritation of the gut or non-infectious bowel disease can also result in diarrhea.

The Cause

Diarrhea is a symptom of infection caused by a host of bacterial, viral and parasitic organisms most of which can be spread by contaminated water. It is more common when there is a shortage of clean water for drinking, cooking and cleaning and basic hygiene is important in prevention.

Water contaminated with human feces for example from municipal sewage, septic tanks and latrines is of special concern. Animal feces also contain microorganisms that can cause diarrhea.

Diarrhea can also spread from person to person, aggravated by poor personal hygiene. Food is another major cause of diarrhea when it is prepared or stored

in unhygienic conditions. Water can contaminate food during irrigation, and fish and seafood from polluted water may also contribute to the disease.

Distribution

The infectious agents that cause diarrhea are present or are sporadically introduced throughout the world. Diarrhea is a rare occurrence for most people who live in developed countries where sanitation is widely available, access to safe water is high and personal and domestic hygiene is relatively good. World-wide around 1.1 billion people lack access to improved water sources and 2.4 billion have no basic sanitation. Diarrhea due to infection is widespread throughout the developing world. In Southeast Asia and Africa, diarrhea is responsible for as much as 8.5% and 7.7% of all deaths respectively.

Scope Of The Problem

Amongst the poor and especially in developing countries, diarrhea is a major killer. In 1998, diarrhea was estimated to have killed 2.2 million people, most of whom were under 5 years of age (WHO, 2000). Each year there are approximately 4 billion cases of diarrhea worldwide.

Interventions

Key measures to reduce the number of cases of diarrhea include:

- Access to safe drinking water.
- Improved sanitation.
- Good personal and food hygiene.
- Health education about how infections spread.
- Key measures to treat diarrhea include:
- Giving more fluids than usual, including oral rehydration salts solution, to prevent dehydration.
- Continue feeding.
- Consulting a health worker if there are signs of dehydration or other problems.

References

WHO(2000) *Global Water Supply and Sanitation Assessment*. World Health Organization. Geneva
The World Health Report 2000, World Health Organization (WHO), Geneva
Prepared for World Water Day. Reviewed by staff and experts in Family and Community Health Unit (FCH), and the Water, Sanitation and Health Unit (WSH), World Health Organization (WHO), Geneva.

The preceding information from the World Health Organization (WHO) can be found at: http://www.who.int/water_sanitation_health/diseases/diarrhoea/en/print.html.

Dracunculiasis: Guinea Worm Disease

Dracunculiasis, more commonly known as Guinea worm disease (GWD), is a preventable infection caused by the parasite *Dracunculus medinensis*. Infection affects poor communities in remote parts of Africa that do not have safe water to drink.

Currently, many organizations, including The Global 2000 program of The Carter Center of Emory University, UNICEF, Centers for Disease Control and Prevention (CDC), and the World Health Organization (WHO) are helping the last 12 countries in the world (all in Africa) to eradicate the disease. Since 1986, when an estimated 3.5 million people were infected annually, the campaign has eliminated much of the disease.

In 2003, only 32,193 cases of GWD were reported. Most (63%) of those cases were from Sudan where the ongoing civil war makes it impossible to eradicate the disease. All affected countries except Sudan are aiming to eliminate Guinea worm disease as soon as possible.

How does Guinea worm disease spread?

Adult female *Dracunculus* worms emerge from the skin of infected persons annually. Persons with worms protruding through the skin may enter sources of drinking water and unwittingly allow the worm to release larvae into the water. These larvae are ingested by fresh water copepods ("water fleas") where these develop into the infective stage in 10-14 days. Persons become infected by drinking water containing the water fleas harboring the infective stage larvae of *Dracunculus medinensis*.

Once inside the body, the stomach acid digests the water flea, but not the Guinea worm. These larvae find their way to the small intestine, where they penetrate the wall of the intestine and pass into the body cavity. During the next 10-14 months, the female Guinea worm grows to a full size adult 60-100 centimeters (2-3 feet) long and as wide as a cooked spaghetti noodle, and migrates to the site where she will emerge, usually the lower limbs.

A blister develops on the skin at the site where the worm will emerge. This blister causes a very painful burning sensation and it will eventually (within 24-72 hours) rupture. For relief, persons will immerse the affected limb into water, or may just walk in to fetch water. When someone with a Guinea worm ulcer enters the water, the adult female releases a milky white liquid



Dracunculiasis is spread through infected water

containing millions of immature larvae into the water, thus contaminating the water supply. For several days after it has emerged from the ulcer, the female Guinea worm is capable of releasing more larvae whenever it comes in contact with water.

What are the signs & symptoms of Guinea worm disease?

Infected persons do not usually have symptoms until about 1 year after they become infected. A few days to hours before the worm emerges, the person may develop a fever, swelling, and pain in the area. More than 90% of the worms appear on the legs and feet, but may occur anywhere on the body.

People, in remote, rural communities who are most commonly affected by GWD do not have access to medical care. Almost invariably the skin lesions caused by the worm develop secondary bacterial infections, which exacerbate the pain, and extend the period of incapacitation to weeks or months-causing in some cases disabling complications, such as locked joints and even permanent crippling. Each time a Guinea worm emerges, persons may be unable to work or resume daily activities for an average of 3 months. This usually occurs during planting or harvesting season, resulting in heavy crop losses. Parents who have active GWD may not be able to care for their children. They also cannot tend or harvest or crops, which leads to financial problems for the entire family.

What is the treatment for Guinea worm disease?

Once the worm emerges from the wound, it can only be pulled out a few centimeters each day and wrapped around a small stick. Sometimes the worm can be pulled out completely within a few days, but this process usually takes weeks or months.

No medication is available to end or prevent infection. However, the worm can be surgically removed before an ulcer forms. Analgesics, such as aspirin or ibuprofen, can help reduce swelling; antibiotic ointment can help prevent bacterial infections.

Where is Guinea worm disease found?

Dracunculiasis now occurs only in 12 countries in sub-Saharan Africa. Transmission of the disease is most common in very remote rural villages and in areas visited by nomadic groups. In 2003 the three most endemic countries, i.e., Sudan, Ghana, and Nigeria reported 20,299, 8,290, and Nigeria 1,459 cases of GWD. Other endemic countries reporting cases of GWD in 2003 were: Benin (30 cases), Burkina Faso (203 cases), Cote d'Ivoire (42 cases), Ethiopia (28 cases), Mali (829 cases), Mauritania (13 cases), Niger (293 cases), Togo (669 cases), and Uganda (26 cases).

Asia is now free of the disease. Transmission of GWD no longer occurs in several African countries, including Kenya, Senegal, Cameroon, Chad, and Central African Republic. No locally acquired cases of disease have been reported in these countries in the last year or more. The World Health Organization has certified 168 countries free of transmission of dracunculiasis, including four formerly endemic countries: Pakistan (in 1996), India (2000), and in Senegal and Yemen (in 2004).

Who is at risk for infection?

Anyone who drinks standing pond water contaminated by persons with GWD is at risk for infection. People who live in villages where the infection is common are at greatest risk.

Is Guinea worm disease a serious illness?

Yes. The disease causes preventable suffering for infected persons and is a heavy economic and social burden for affected communities.

Is a person immune to Guinea worm disease once he or she has it?

No. Infection does not produce immunity, and many people in affected villages suffer disease year after year.

How can Guinea worm disease be prevented?

Because GWD can only be transmitted via drinking contaminated water, educating people to follow these simple control measures can completely prevent illness and eliminate transmission of the disease.

- Drink only water from underground sources (such as from borehole or hand-dug wells) free from contamination.
- Prevent persons with an open Guinea worm ulcer from entering ponds and wells used for drinking water.
- Always filter drinking water, using a cloth filter, to remove the water fleas.

Additionally, unsafe sources of drinking water can be treated with an approved larvicide, such as ABATE®*, that kills water fleas, and communities can be provided with new safe sources of drinking water, or have existing dysfunctional ones repaired.

Eradication of Guinea Worm Disease

Guinea worm disease may soon become only the second disease (smallpox was the first) to be eradicated or abolished from the earth. In 1986 the Carter Center (a nonprofit organization founded by former President Jimmy Carter and his wife Rosalynn in collaboration with Emory University) and its partners began a quest to eradicate guinea worm disease. In that year, an estimated 3.5 million cases of guinea worm disease occurred in 20 countries in Africa and Asia. By 2006, the number of cases of guinea worm disease was reduced to 25,000 in nine African countries, with five of these countries having fewer than 30 cases each. Over 98 percent of the world's remaining cases occur in war-ravaged Sudan and Ghana.

** Use of trade names is for identification only and does not imply endorsement by the Public Health Service or by the U.S. Department of Health and Human Services.*

This fact sheet is for information only and is not meant to be used for self-diagnosis or as a substitute for consultation with a health care provider. If you have any questions about the disease described above or think that you may have a parasitic infection, consult a health care provider. Revised September 28, 2004

The preceding fact sheet from the Centers for Disease Control (CDC) can be found at: http://www.cdc.gov/Ncidod/dpd/parasites/dracunculiasis/2004_PDF_Dracunculiasis.pdf

Lead Poisoning

Exposure to lead causes a variety of health effects, and affects children in particular. Water is rarely an important source of lead exposure except where lead pipes, for instance in old buildings, are common. Removal of old pipes is costly but the most effective measure to reduce lead exposure from water.

The Disease And How It Affects People

Lead is a metal with no known biological benefit to humans. Too much lead can damage various systems of the body including the nervous and reproductive systems and the kidneys, and it can cause high blood pressure and anemia. Lead accumulates in the bones and lead poisoning may be diagnosed from a blue line around the gums. Lead is especially harmful to the developing brains of fetuses and young children and to pregnant women. Lead interferes with the metabolism of calcium and Vitamin D. High blood lead levels in children can cause consequences which may be irreversible including learning disabilities, behavioral problems, and mental retardation. At very high levels, lead can cause convulsions, coma and death.

The Cause

People are exposed to lead through the air they breathe, through water and through food/ingestion. Toxic effects are usually due to long term exposure. The population groups at greatest risk of exposure are young children and workers. A recent report suggests that even a blood level of 10 micrograms per decilitre can have harmful effects on children's learning and behavior (CDC, 2000). People can be exposed to lead contamination from the motor vehicle exhaust of leaded gasoline, as well as from industrial sources such as smelters and lead manufacturing and recycling industries, from cottage industry uses and waste sites (e.g. contaminated landfills).

Exposure to lead through water is generally low in comparison with exposure through air or food. Lead from natural sources is present in tap water to some extent, but analysis of both surface and ground water suggests that lead concentration is fairly low. The main source of lead in drinking water is (old) lead piping and lead-combining solders. Removing old piping is costly and lead continues to dissolve even from old pipes. The amount of lead that may dissolve in water depends on acidity (pH), temperature, water hardness and standing time of the water. Secondary pollution from industry can contaminate water through the effluents produced.

Other sources include use of lead-containing ceramics for cooking, eating or drinking. In some countries, people are exposed to lead after eating food products from cans that contain lead solder in the seams of the cans. Very small children are especially at risk to exposure, for example through the ingestion of paint chips from lead-based paint.

Scope Of The Problem

The major sources of lead vary according to the region and include: industrial use of lead, lead recycling, leaded gasoline and lead piping used in water distribution systems. Lead in the environment is distributed mostly by air but there is some discharge into soil and water. Water is not normally considered the major source of pollution exposure to lead. In individual households with lead piping and soft waters it may be important. As other sources of exposure to lead are increasingly controlled, water attracts increasing attention.

Preventive Measures Include:

- Environmental standards that remove lead from petrol/gasoline, paint and plumbing.
- If lead pipes cannot be removed, water (cold should be flushed through in the morning before drinking).
- Enforcement of occupational health standards.
- Surveillance of potentially exposed population groups, especially the vulnerable ones (small children, pregnant women, workers).
- Water treatment.
- Removing lead solder from food cans.
- Use of lead-free paint in homes.
- Screening of children for blood levels over acceptable limit and referral for medical care as necessary.
- The health based guideline for lead in drinking water is 0.1 milligrams per litre (WHO, 1993). If high levels are detected in a supply, alternative supplies or bottled water maybe necessary to protect young children.

References

CDC Childhood Lead Poisoning Prevention Program
WHO. *Guidelines for drinking water quality*. 2nd
edition. Volume 1: Recommendations. Geneva: WHO,
1993 p49-50

Prepared for World Water Day 2001. Reviewed by
staff and experts in the Programme of Chemical Safety
(PCS), and Water, Sanitation and Health Unit (WSH),
World Health Organization (WHO), Geneva.

The preceding information from the World Health
Organization (WHO) can be found at: [http://www.who.
int/water_sanitation_health/diseases/lead/en/print.html](http://www.who.int/water_sanitation_health/diseases/lead/en/print.html).

Typhoid & Paratyphoid Fevers

Typhoid and paratyphoid fevers are infections caused by bacteria which are transmitted from faeces to ingestion. Clean water, hygiene and good sanitation prevent the spread of typhoid and paratyphoid. Contaminated water is one of the pathways of transmission of the disease.

The Disease And How It Affects People

Typhoid fever is a bacterial infection of the intestinal tract and bloodstream. Symptoms can be mild or severe and include sustained fever as high as 39°-40° C, malaise, anorexia, headache, constipation or diarrhoea, rose-coloured spots on the chest area and enlarged spleen and liver. Most people show symptoms 1-3 weeks after exposure. Paratyphoid fever has similar symptoms to typhoid fever but is generally a milder disease.

The Cause

Typhoid and paratyphoid fevers are caused by the bacteria *Salmonella typhi* and *Salmonella paratyphi* respectively. Typhoid and paratyphoid germs are passed in the faeces and urine of infected people. People become infected after eating food or drinking beverages that have been handled by a person who is infected or by drinking water that has been contaminated by sewage containing the bacteria. Once the bacteria enter the person's body they multiply and spread from the intestines, into the bloodstream. Even after recovery from typhoid or paratyphoid, a small number of individuals (called carriers) continue to carry the bacteria. These people can be a source of infection for others. The transmission of typhoid and paratyphoid in less-industrialized countries may be due to contaminated food or water. In some countries, shellfish taken from sewage-contaminated beds is an important route of infection. Where water quality is high, and chlorinated water piped into the house is widely available, transmission is more likely to occur via food contaminated by carriers handling food.

Distribution

Typhoid and paratyphoid fevers are common in less-industrialized countries, principally owing to the problem of unsafe drinking-water, inadequate sewage disposal and flooding.

Scope Of The Problem

The annual incidence of typhoid is estimated to be about 17 million cases worldwide.

Interventions

Public health interventions to prevent typhoid and paratyphoid include:

- health education about personal hygiene, especially regarding hand-washing after toilet use and before food preparation; provision of a safe water supply;
- proper sanitation systems;
- excluding disease carriers from food handling.

Control measures to combat typhoid include health education and antibiotic treatment. A vaccine is available, although it is not routinely recommended except for those who will have prolonged exposure to potentially contaminated food and water in high-risk areas. The vaccine does not provide full protection from infection.

Prepared for World Water Day 2001. Reviewed by staff and experts from the cluster on Communicable Diseases (CDS) and the Water, Sanitation and Health unit (WSH), World Health Organization (WHO).

The preceding information from the World Health Organization (WHO) can be found at: http://www.who.int/water_sanitation_health/diseases/typhoid/en/print.html.

Typhoid Mary

Mary Mallon seemed a healthy woman when a health inspector knocked on her door in 1907, yet she was the cause of several typhoid outbreaks. Since Mary was the first “healthy carrier” of typhoid fever in the United States, she did not understand how someone not sick could spread disease—so she tried to fight back. After a trial and then a short run from health officials, Mary was recaptured and forced to live in relative seclusion upon North Brother Island off New York.

An Investigation

For the summer of 1906, New York banker Charles Henry Warren wanted to take his family on vacation. They rented a summer home from George Thompson and his wife in Oyster Bay, Long Island. Also for the summer, the Warrens hired Marry Mallon to be their cook.

On August 27, one of the Warren’s daughters became ill with typhoid fever.

Soon, Mrs. Warren and two maids became ill; followed by the gardener and another Warren daughter. In total, six of the eleven people in the house came down with typhoid.

Since the common way typhoid spread was through water or food sources, the owners of the home feared they would not be able to rent the property again without first discovering the source of the outbreak. The Thompsons first hired investigators to find the cause, but they were unsuccessful.

Then the Thompsons hired George Soper, a civil engineer with experience in typhoid fever outbreaks. It was Soper who believed the recently hired cook, Mary Mallon, was the cause. Mallon had left the Warren’s approximately three weeks after the outbreak. Soper began to research her employment history for more clues.

Mary Mallon was born on September 23, 1869 in Cookstown, Ireland. According to what she told friends, Mallon emigrated to America around the age of 15. Like most Irish immigrant women, Mallon found a job as a domestic servant. Finding she had a talent for cooking, Mallon became a cook, which paid better wages than many other domestic service positions. Soper was able to trace Mallon’s employment history back to 1900. He found that typhoid outbreaks had followed Mallon from job to job. From 1900 to 1907, Soper found that Mallon had worked at seven jobs in

which 22 people had become ill, including one young girl who died, with typhoid fever shortly after Mallon had come to work for them.¹

Soper was satisfied that this was much more than a coincidence; yet, he needed stool and blood samples from Mallon to scientifically prove she was the carrier.

Capture And Isolation

In March 1907, Soper found Mallon working as a cook in the home of Walter Bowen and his family. To get samples from Mallon, he approached her at her place of work. Having a strange man come up to you, to accuse you (who seems completely healthy) of spreading disease and of killing people and then be asked for some of your blood and excrement, well, it does seem it would make just about anybody skeptical.

“I had my first talk with Mary in the kitchen of this house... I was as diplomatic as possible, but I had to say I suspected her of making people sick and that I wanted specimens of her urine, feces and blood. It did not take Mary long to react to this suggestion. She seized a carving fork and advanced in my direction. I passed rapidly down the long narrow hall, through the tall iron gate, ...and so to the sidewalk. I felt rather lucky to escape.”²

This violent reaction from Mallon did not stop Soper. Soper tracked Mallon to her home. He tried to approach her again, but this time, he brought an assistant (Dr. Bert Raymond Hoobler) for support. Again, Mallon became enraged, made clear they were unwelcome and shouted expletives at them as they made a hurried departure.

Realizing it was going to take more persuasiveness than he was able to offer, Soper handed his research and hypothesis over to Hermann Biggs at the New York City Health Department. Biggs agreed with Soper’s hypothesis. Biggs sent Dr. S. Josephine Baker to talk to Mallon.

Mallon, now extremely suspicious of these health officials, refused to listen to Baker, Baker returned with the aid of five police officers and an ambulance. Mallon was prepared this time. Baker describes the scene:

"Mary was on the lookout and peered out, a long kitchen fork in her hand like a rapier. As she lunged at me with the fork, I stepped back, recoiled on the policeman and so confused matters that, by the time we got through the door, Mary had disappeared. 'Disappear' is too matter-of-fact a word; she had completely vanished."³

Baker and the police searched the house. Eventually, footprints were spotted leading from the house to a chair placed next to a fence. Over the fence was a neighbor's property.

They spent five hours searching both properties, until, finally, they found "a tiny scrap of blue calico caught in the door of the areaway closet under the high outside stairway leading to the front door."

Baker describes the emergence of Mallon from the closet:

"She came out fighting and swearing, both of which she could do with appalling efficiency and vigor. I made another effort to talk to her sensibly and asked her again to let me have the specimens, but it was of no use. By that time she was convinced that the law was wantonly persecuting her, when she had done nothing wrong. She knew she had never had typhoid fever; she was maniacal in her integrity. There was nothing I could do but take her with us. The policemen lifted her into the ambulance and I literally sat on her all the way to the hospital; it was like being in a cage with an angry lion."⁵

Mallon was taken to the Willard Parker Hospital in New York. There, samples were taken and examined; typhoid bacilli was found in her stool.

The health department then transferred Mallon to an isolated cottage (part of the Riverside Hospital) on North Brother Island (in the East River near the Bronx).

Can The Government Do This?

Mary Mallon was taken by force and against her will and was held without a trial. She had not broken any laws. So how could the government lock her up in isolation indefinitely?

That's not easy to answer. The health officials were basing their power on sections 1169 and 1170 of the

Greater New York Charter:

The board of health shall use all reasonable means for ascertaining the existence and cause of disease or peril to life or health, and for averting the same, throughout the city. [Section 1169]

Said board may remove or cause to be removed to [a] proper place to be by it designated, any person sick with any contagious, pestilential or infectious disease; shall have exclusive charge and control of the hospitals for the treatment of such cases. [Section 1170]⁶

This charter was written before anyone knew of "healthy carriers" -- people who seemed healthy but carried a contagious form of a disease that could infect others. Health officials believed healthy carriers to be more dangerous than those sick with the disease because there is no way to visually identify a healthy carrier in order to avoid them. But to many, locking up a healthy person seemed wrong.

Freedom

Mary Mallon believed she was being unfairly persecuted. Wasn't she healthy? She could not understand how she could have spread disease and caused a death when she, herself, seemed healthy.

"I never had typhoid in my life, and have always been healthy. Why should I be banished like a leper and compelled to live in solitary confinement with only a dog for a companion?"⁷

In 1909, after having been isolated for two years on North Brother Island, Mallon sued the health department.

During Mallon's confinement, health officials had taken and analyzed stool samples from Mallon approximately once a week. The samples came back intermittently positive with typhoid, but mostly positive (120 of 163 samples tested positive).⁸ For nearly a year preceding the trial, Mallon also sent samples of her stool to a private lab where all her samples tested negative for typhoid. Feeling healthy and with her own lab results, Mallon believed she was being unfairly held.

This contention that I am a perpetual menace in the spread of typhoid germs is not true. My own doctors say I have no typhoid germs. I am an innocent human being. I have committed no crime and I am treated like an outcast -- a criminal. It is unjust, outrageous, uncivilized. It seems incredible that in a Christian community a defenseless woman can be treated in this manner.⁹



Mallon did not understand a lot about typhoid fever and, unfortunately, no one tried to explain it to her. Not all people have a strong bout of typhoid fever; some people can have such a weak case that they only experience flu-like symptoms. Thus, Mallon could have had typhoid fever but never known it. Though commonly known at the time that typhoid could be spread by water or food products, people who are infected by the typhoid bacillus could also pass the disease from their infected stool onto food via unwashed hands. For this reason, infected persons who were cooks (like Mallon) or food handlers had the most likelihood of spreading the disease.

The judge ruled in favor of the health officials and Mallon, now popularly known as “Typhoid Mary,” “was remanded to the custody of the Board of Health of the City of New York.”¹⁰ Mallon went back to the isolated cottage on North Brother Island with little hope of being released.

In February of 1910, a new health commissioner decided that Mallon could go free as long as she agreed never to work as a cook again. Anxious to regain her freedom, Mallon accepted the conditions. On February 19, 1910, Mary Mallon agreed that she “is prepared to change her occupation (that of cook), and will give assurance by affidavit that she will upon her release take such hygienic precautions as will protect those with whom she comes in contact, from infection.”¹¹ She was let free.

Recapture

Some people believe that Mallon never had any intention of following the health officials’ rules; thus they believe Mallon had a malicious intent with her cooking. But not working as a cook pushed Mallon into service in other domestic positions which did not pay as well. Feeling healthy, Mallon still did not really believe that she could spread typhoid. Though in the beginning Mallon tried to be a laundress as well as worked at other jobs, for a reason that has not been left in any documents, Mallon eventually went back to working as a cook.

In January of 1915 (nearly five years after Mallon’s release), the Sloane Maternity Hospital in Manhattan suffered a typhoid fever outbreak. Twenty-five people became ill and two of them died.

Soon, evidence pointed to a recently-hired cook, Mrs. Brown. Mrs. Brown was really Mary Mallon, using a pseudonym.

If the public had shown Mary Mallon some sympathy during her first period of confinement because she was an unwitting typhoid carrier, all of the sympathy disappeared after her recapture. This time, Typhoid Mary knew of her healthy carrier status - even if she didn’t believe it; thus she willingly and knowingly caused pain and death to her victims. Using a pseudonym made even more people feel that Mallon knew she was guilty.

Mallon was again sent to North Brother Island to live in the same isolated cottage that she had inhabited during her last confinement. For twenty-three more years, Mary Mallon remained imprisoned on the island. The exact life she led on the island is unclear, but it is known that she helped around the hospital, gaining the title “nurse” in 1922 and then “hospital helper” sometime later. In 1925, Mallon began to help in the hospital’s lab.

In December 1932, Mary Mallon suffered a large stroke that left her paralyzed. She was then transferred from her cottage to a bed in the children’s ward of the hospital on the island, where she stayed until her death six years later, on November 11, 1938.

Typhoid Mary Lives On

Since Mary Mallon’s death, the name “Typhoid Mary” has grown into a term disassociated from the person. Anyone who has a contagious illness can be termed, sometimes jokingly, a “Typhoid Mary.” If someone changes their jobs frequently, they are sometimes referred to as a “Typhoid Mary.” (Mary Mallon changed jobs frequently. Some people believed it to be because she knew she was guilty, but most probably it was because domestic jobs during the time were not long lasting service jobs.)

But why does everyone know about Typhoid Mary? Though Mallon was the first carrier found, she was not the only healthy carrier of typhoid during that time. An estimated 3,000 to 4,500 new cases of typhoid fever were reported in New York City alone and it was estimated that about three percent of those who had typhoid fever become carriers, creating 90-135 new carriers a year.

Mallon was also not the most deadly. Forty-seven illnesses and three deaths were attributed to Mallon while Tony Labella (another healthy carrier) caused 122 people to become ill and five deaths. Labella was isolated for two weeks and then released.

Mallon was not the only healthy carrier who broke the health officials' rules after being told of their contagious status. Alphonse Cotils, a restaurant and bakery owner, was told not to prepare food for other people. When health officials found him back at work, they agreed to let him go free when he promised to conduct his business over the phone.

So why is Mary Mallon so infamously remembered as "Typhoid Mary"? Why was she the only healthy carrier isolated for life? These questions are hard to answer. Judith Leavitt, author of *Typhoid Mary*, believes that her personal identity contributed to the extreme treatment she received from health officials. Leavitt claims that there was prejudice against Mallon not only for being Irish and a woman, but also for being a domestic servant, not having a family, not being considered a "bread earner," having a temper, and not believing in her carrier status.¹²

During her life, Mary Mallon experienced extreme punishment for something in which she had no control and, for whatever reason, has gone down in history as the evasive and malicious "Typhoid Mary."

Notes

1. Judith Walzer Leavitt, *Typhoid Mary: Captive to the Public's Health* (Boston: Beacon Press, 1996) 16-17.
2. George Soper as quoted in Leavitt, *Typhoid Mary* 43.
3. Dr. S. Josephine Baker as quoted in Leavitt, *Typhoid Mary* 46.
4. Leavitt, *Typhoid Mary* 46.
5. Dr. S. Josephine Baker as quoted in Leavitt, *Typhoid Mary* 46.
6. Leavitt, *Typhoid Mary* 71.
7. Mary Mallon as quoted in Leavitt, *Typhoid Mary* 180.
8. Leavitt, *Typhoid Mary* 32.
9. Mary Mallon as quoted in Leavitt, *Typhoid Mary* 180.
10. Leavitt, *Typhoid Mary* 34.
11. Leavitt, *Typhoid Mary* 188.
12. Leavitt, *Typhoid Mary* 96-125.

Bibliography

Leavitt, Judith Walzer. *Typhoid Mary: Captive to the Public's Health*. Boston: Beacon Press, 1996.

The preceding information about Typhoid Mary can be found at:

<http://history1900s.about.com/od/1900s/a/typhoidmary.htm>

History of Dry Chlorine

The introduction of dry chlorine in 1927 marked a life-saving breakthrough in sanitizing water.



In 1927, American cities were in the early stages of using liquid chlorine or so-called bleaching powder (generally chlorinated lime) to treat drinking water and sewage effluent as a means of preventing deadly outbreaks of typhoid and cholera that still claimed thousands of lives nationwide. That year, the Mathieson Alkali Works -- a key predecessor company to Arch Chemicals and its HTH Water Products business -- achieved a major breakthrough when it introduced the first dry chlorine product in a granular form -- which it called HTH® for High Test Hypochlorite.

This calcium hypochlorite compound not only dissolved easily in water, but it was more stable than bleaching powders and offered twice the available chlorine content -- a critical benefit in destroying the microorganisms that carried life-threatening diseases. Mathieson quickly developed feeder systems for applying HTH to drinking water and sewage effluent and for use in sanitizing water in food processing and other industrial applications. The same public health concerns applied to swimming pools.

Today, with the hindsight afforded by history, the value of using chlorine to sanitize water is starkly evident in some simple facts: in 1908, when chlorine was first used in a continuous application to treat drinking water in Jersey City, New Jersey, the average life expectancy in America was 49 years. Now, at the dawn of the 21st Century, the average life expectancy has risen into the 80s for many segments of society, and it's still climbing. This explains why Time magazine at the turn of the new millennium hailed the use of chlorine as a water sanitizer as one of the major scientific achievements of the 20th Century.

This life-saving benefit was colorfully described in a document -- the "Hypo-Chlorination of Water" -- that was published in 1941 by Mathieson Alkali Works. "The fearsome specter of water-borne diseases, including typhoid fever, so prevalent before the advent of chlorination, can be successfully laid to rest," the publication asserted. "The water works operator, by his testing and treating, stands as a vigilant sentinel to prevent armies of billions of disease organisms from

invading the homes of his community."

The use of dry, calcium hypochlorite to sanitize swimming pool water emerged during the 1930s. That was a time when officials who were responsible for sanitizing drinking water also often oversaw the operation of municipal swimming pools. These officials either manually distributed HTH into pools or used early feeder systems. They also prepared solutions of this product for use in sanitizing the floors of swimming pool locker rooms, shower rooms, bathrooms and even diving boards. Today, Arch offers Pulsar® calcium hypochlorite briquettes and feeder systems for municipal pools, a recent refinement in the history of dry chlorine.

Although HTH and rival products have been improved over the years to increase their efficacy, stability and cost-effectiveness, these and other forms of "dry chlorine" remain a vital, first-line defense against deadly, water-borne diseases -- whether in recreational water, drinking water systems or the post-harvest washing of fruits and vegetables.

Arch Chemicals also has a long history of supplying calcium hypochlorite to international relief agencies in the wake of wars and natural disasters, where it is used to sanitize drinking water and even cooking utensils and equipment. The Company also works with such agencies to provide simple feeder systems and calcium hypochlorite for use in poor rural villages and urban areas in Central and South America and Africa. Arch's calcium hypochlorite is also the sanitizing agent in Procter & Gamble's PuR® sachets -- small pouches that can be used to treat up to 10 liters of drinking water at a time. These sachets were distributed by the millions in the wake of the Christmas tsunami disaster in East Asia, and they have been distributed widely in Haiti, Africa and other undeveloped regions to provide individuals and families with a method of sanitizing contaminated water.



The Chemistry Of Coagulation & Disinfection

Lesson 2

Activated Charcoal Chemistry

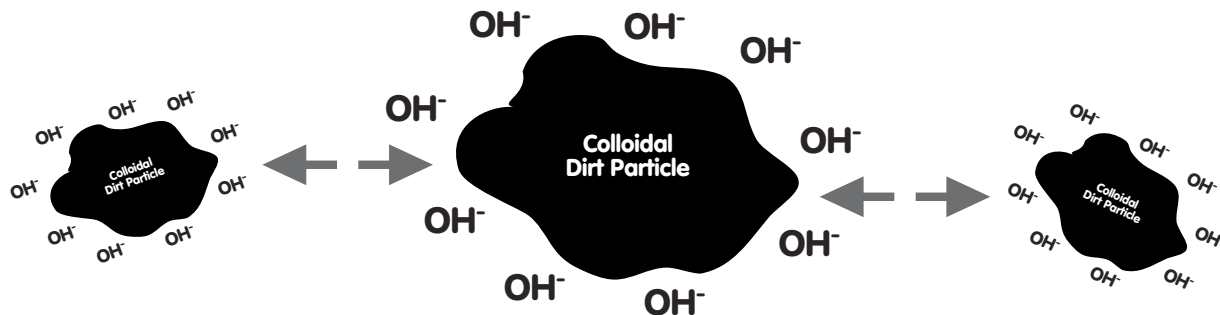
One of the components in a filtration system is activated charcoal. It is also called decolorizing carbon. Activated charcoal is carbon that has been treated with oxygen. The treatment results in a highly porous charcoal. These tiny holes give the charcoal a large surface area, allowing liquids, gases, or large polar colored impurities to pass through the charcoal and interact with the exposed carbon. The carbon adsorbs a wide range of impurities and contaminants. Adsorption works by chemically binding the impurities to the carbon.

Lessons 3 & 4

Coagulation/Flocculation and Sedimentation

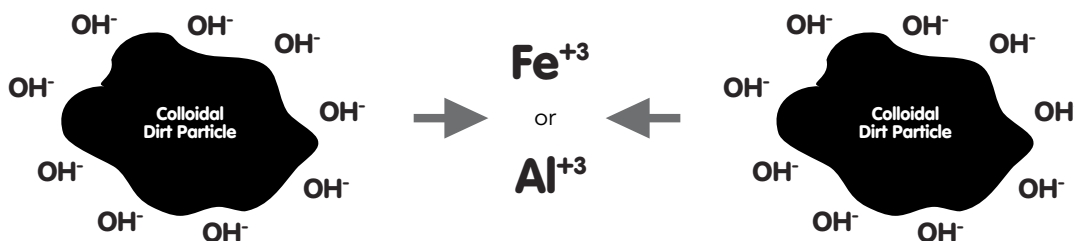
Aluminum sulfate (alum, or Al^{+3}) or ferric sulfate (Fe^{+3}) can be used to coagulate colloidal particles of dirt and cause them to settle (flocculate) from the solution.

Colloidal particles are small enough to stay suspended in a liquid like water. They also often have a negative electrical charge (OH^{-1}) on their outside layer that keeps them repelled from each other, overcoming the force of gravity and allowing them to stay suspended, as illustrated below.



In order to cause them flocculate out of the solution, they must be made into larger particles that are too big to stay suspended and made electrically neutral so they don't repel each other.

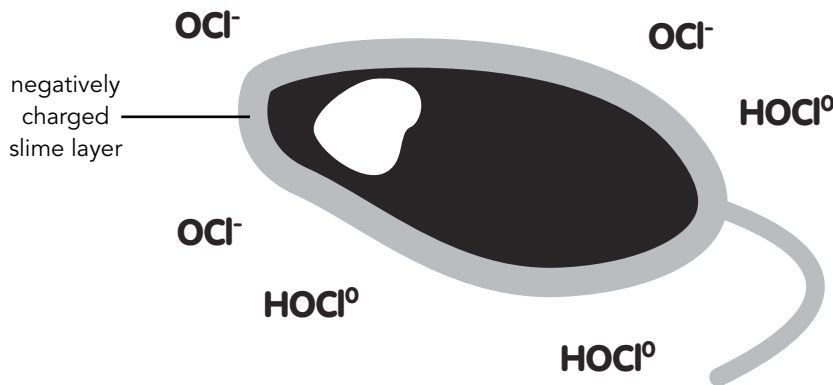
The Al^{+3} ions in aluminum sulfate (alum) and the Fe^{+3} ions in ferric sulfate are attracted to the negative surface of the colloidal dirt particle. Because the charges on these ions are highly positive, they can then attract the OH^{-1} ions on several dirt colloidal particles, pulling them together, and allowing them to clump into large particles. When these particles are then neutralized and become larger, they will no longer stay suspended and they will fall out of the solution (flocculate, coagulate), as illustrated below.



In order for this to happen, the solution must not be acidic. If the solution is acidic the OH^{-1} ions on the surface of the dirt will also react with the H^{+1} in the acid. The +3 ions are needed to pull together the colloidal particles. In order to keep the solution somewhat basic, lime (calcium hydroxide) or some other buffering agent (calcium carbonate is used in PUR) is added to the solution.

Lesson 4 Disinfection Process

The chemical that often serves as a disinfectant in water purification is calcium hypochlorite. When it is added to water it forms hypochlorous acid (HOCl) and the hypochlorite ion (OCl^{-1}). The hypochlorous acid attacks the surface layer (called the slime layer or lipid layer) of the germ/bacteria. Because this surface layer has a negative electrical charge, the hypochlorous acid is less repelled from the negative surface layer than the negatively charged hypochlorite ion. This hypochlorous acid penetrates the surface, breaking through the slime layer, as illustrated below.



Once inside the cell of the bacteria, the disinfectant causes the enzymes, that are needed by the bacteria to survive, to oxidize. This is why bleach, which is hypochlorite, is called an oxidizing agent. When these enzymes are oxidized into other compounds, the bacteria that need the enzymes for their own chemical metabolic processes can no longer live.

What is unique about the calcium hypochlorite disinfectant in PUR, made by Arch Chemicals (www.archchemicals.com), is that it is made in large particle size which allows it to dissolve slowly (time-released). Because of this, the disinfection process begins after the coagulation of the large particles in the dirty water. Additional disinfection occurs after the filtration. The free chlorine (hypochlorous acid and hypochlorite ion) therefore is not wasted on the large particles of organic matter (soil, leaves, etc) that is filtered out following coagulation.

Components of PUR Purifier of Water include (but are not limited to)

Ferric sulfate (Fe^{+3}) – cationic coagulant

Polyacrylamide – aids in the coagulation of particles

Calcium carbonate – keeps the pH at the correct level (buffer) so the ferric sulfate can be attracted to the negatively charged surface of several dirt particles

Calcium Hypochlorite – a time-released disinfection agent manufactured by Arch Chemicals

Glossary of Key Words

Access

The ability or right to make use of.

Aeration

the process of supplying with air or exposing to the circulation of air. Synonyms: airing, ventilation, breathing.

Bacteria

any of the unicellular prokaryotic microorganisms of the class Schizomycetes, which vary in terms of morphology, oxygen and nutritional requirements, and motility, and may be free-living, saprophytic, or pathogenic in plants or animals.

Chlorination

the process of treating or combining with chlorine or a chlorine compound. Most often the purpose is to disinfect of harmful microorganisms.

Coagulation

the transformation of a liquid into a soft, semisolid, or solid mass. Synonyms: clotting, congealing, curdling

Contagious

capable of being transmitted by bodily contact with an infected person, other organisms (example consumption of contaminated organisms) or object. Synonyms: catching, communicable, infectious.

Contaminated

made impure or unclean by contact or mixing. Synonyms: defiled, fouled, poisoned, polluted.

Developed country

A developed country has a relatively high standard of living and is advanced in industrial capability, technological sophistication, and economic productivity. Some examples are the United States and most of Europe.

Developing country

a developing country has a relatively low standard of living, an undeveloped industrial base, and a relatively low Human Development Index score (HDI). In developing countries, there is low per capita income, widespread poverty, and low capital formation. Some examples are Algeria, Botswana, Armenia, Azerbaijan, Guatemala, Brazil, and Paraguay. (<http://en.wikipedia.org/wiki/developing-country>)

Disinfect

to cleanse so as to destroy or prevent the growth of disease-carrying micro-organisms. Synonyms: decontaminate, sterilize, sanitize, clean.

Epidemic

spreading rapidly and extensively by infection and affecting many individuals in an area or a population at the same time. Synonyms: outbreak, plague.

Epidemiology

the branch of medicine that deals with the study of the causes, distribution, and control of disease in populations.

Fertilizer

any of a large number of natural and synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its capacity to support plant growth.

Filtration

the act of passing a gas or liquid through a porous material in order to separate the fluid from suspended particulate matter.

Herbicide

a chemical substance used to destroy or inhibit the growth of plants, especially weeds.

Hygiene

Conditions and practices that serve to promote health.

Micro-organism

an organism of microscopic or submicroscopic size, especially a bacterium or protozoan. Synonyms: germ, microbe.

Parasite

an organism that grows, feeds, and is sheltered on or in a different organism while contributing nothing to the survival of its host.

Parasitic worms

are a division of eukaryotic parasites that, unlike external parasites such as lice and fleas, live inside their host. They are worm-like organisms that live and feed off living hosts, receiving nourishment and protection while disrupting their hosts' nutrient absorption, causing weakness and disease. Those that live inside



the digestive tract are called intestinal parasites. They can live inside humans as well as other animals.

Pesticide

a chemical used to kill pests, especially insects.

Potable

fit to drink. Synonym: drinkable.

Purify

To become clean or pure. Synonym: clean.

Sanitation

formulation and application of measures designed to protect public health.

Sedimentation

the act or process of depositing sediments.

Sewage

Liquid and solid waste carried off in sewers or drains.

Toxic Metal (Heavy Metal)

a metal capable of causing injury or death, especially by chemical means. Synonym: poisonous metal

Virus

any of various simple submicroscopic parasites of plants, animals, and bacteria that often cause disease and that consist essentially of a core of RNA or DNA surrounded by a protein coat. Unable to replicate without a host cell, viruses are typically not considered a living organism.

Waterborne

transmitted in water.

Water quality

the degree to which water is suitable for different uses such as drinking, bathing, or recreation.