

**Objectives:**

The student will be able to:

- ◆ List the characteristics of contaminated water.
- ◆ List the characteristics of clean (non-contaminated) water.
- ◆ Discuss what makes water contaminated.
- ◆ List ways to prevent water contamination.

**Suggested Grade Level:**

9-12

**Subjects:**

Chemistry, Biology,  
Environmental Science

**Time:**

2 Class Periods

**Materials:**

- Sets of questions
- Rules
- Index Cards

## BACKGROUND INFORMATION

Most Americans believe that their drinking water is the best in the world. Many U.S. citizens who travel abroad know the familiar problems of unsafe drinking water. At home, most of us seldom give it a thought. We believe that the purity of our water can be depended upon and usually we are right. Yet, every year, some Americans get sick from their drinking water. The Centers for disease Control and Prevention reports that there were almost 7,000 cases (on average) of illness in the U.S. linked to drinking water from 1971 to 1985. And a devastating 1993 waterborne cryptosporidiosis outbreak in Milwaukee, WI, sickened 400,000 and caused over 100 deaths.

## TERMS

**acute (toxic) effects:** adverse health effects which are observed rather quickly after exposure to a toxin; illness with rapid onset caused by a toxin.

**agriculture:** science of cultivating the soil, producing crops, and raising livestock; farming

**blackwater:** domestic wastewater containing human or animal waste or other sources of pathogens


**“blue baby” syndrome (methemoglobinemia):** pathological condition where the skin of infants (or other sensitive groups) turns blue due to nitrates bonding with red blood cells, which prevent the transport of oxygen throughout the body; can be caused by nitrate contamination in drinking water

**chemical water pollution:** introduction of chemicals into a waterbody

**chlorine:** a chemical compound used as disinfectant in wastewater treatment and drinking water treatment processes; symbol Cl<sub>2</sub>

**chronic (toxic) effects:** adverse health effects that are either the result of long-term (chronic) exposure or those that are permanent or long-lasting (e.g., cancer)

**Clean Water Act (CWA):** water pollution control law passed to restore and maintain the nation’s waters; the nation’s primary source of federal legislation



that specifies the methods to be used in determining how much treatment is required for discharges (effluents) from publicly owned treatment works

**cryptosporidiosis:** acute, highly infectious disease caused by the protozoan *Cryptosporidium parvum* that can be transmitted by contaminated food or water

**disinfection:** the use of chemicals and/or other means to kill potentially harmful microorganisms in water (the fifth step in drinking water treatment)

**Environmental Protection Agency (EPA):** the U.S. agency responsible for efforts to control air, land, and water pollution, radiation, and pesticide hazards, and to promote ecological research, pollution prevention, and proper solid waste disposal

**epidemic diseases:** diseases that spread rapidly by infection among many individuals in an area

**fecal coliform bacteria:** a type of coliform bacteria found in the intestines of humans and warm blooded animals that aids in the digestion process and is used as an indicator of fecal contamination and/or possible presence of pathogens

**feed lots:** confined areas where livestock is kept

**fertilizer:** natural and synthetic materials including manure, nitrogen, phosphorus and treated sewage sludge that are worked into the soil to provide nutrients and increase its fertility

**fluoride:** a binary compound of fluorine added to drinking water to help prevent tooth decay

**groundwater:** water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface; water within the zone of saturation

**leachate:** a liquid that results from water collecting contaminants as it trickles through wastes, or soil containing agricultural pesticides or fertilizers

**leaking underground storage tank:** underground storage tank which has spilled, leaked, emitted, discharged, leached, disposed, or otherwise allowed an escape of its contents into groundwater, surface water, or subsurface soils

**microbiology:** study of microorganisms, a large and diverse group of organisms that exists as single cells or cell clusters

**microorganisms:** microscopic or ultramicroscopic organisms (e.g., bacteria, protozoa, viruses)

**nitrate:** compounds containing nitrogen as nitrates ( $\text{NO}_3^-$ ). In the environment, these compounds are found in animal wastes, fertilizers, and in septic tanks and untreated municipal sewage. Their primary public health hazard is the cause of methemoglobinemia or “blue baby” syndrome.

**pathogens:** disease-causing agents, especially disease-producing microorganisms

**percolate:** to drain or seep through a porous and permeable substance; to filter such as a liquid passing through a porous body (water through soil to the aquifer)

**pH:** a measure of the concentration of hydrogen ions ( $\text{H}^+$ ) in a solution; the pH scale ranges from 0 to 14, where 7 is neutral, values less than 7 are acidic, and values greater than 7 are basic or alkaline. It is measured by an inverted logarithmic scale so that every unit decrease in pH means a 10-fold increase in hydrogen ion concentration. Thus, a pH of 3 is 10 times as acidic as a pH of 4 and 100 times as acidic as a pH of 5.

**pollution:** an unwanted change in air, water, or soil (usually through the introduction of pollutants or contaminants) that can affect the health and survival of humans and other organisms

**privy:** an outhouse; a latrine

**radionuclides:** types of atoms which spontaneously undergo radioactive decay; usually naturally occurring, and can contaminate water or indoor air (e.g., radon)

**radon:** colorless, odorless, tasteless, naturally occurring radioactive gas formed from natural deposits of uranium that can cause lung cancer. It can enter the home around plumbing pipes and/or through cracks and openings in the foundation.

**sewage contamination:** the introduction of untreated or improperly treated sewage into a water body

**sulfuric acid:** (chemical formula,  $\text{H}_2\text{SO}_4$ ) the most widely used industrial chemical; a major component of acid rain that is formed by sulfur oxides combining with atmospheric moisture

**surface water:** precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration. It is stored in streams, lakes, rivers, ponds, wetlands, oceans, and reservoirs.

**toxic chemical:** a chemical with the potential of causing death or damage to humans, animals, plants, or protists; poison

**typhoid fever:** acute, highly infectious disease caused by *Salmonella typhosa* bacteria that can be transmitted by contaminated food or water

**underground storage tank (UST):** any tank, including underground piping connected to the tank, that has at least 10% of its volume underground and contains petroleum products or hazardous substances (except heating oil tanks and some motor fuel tanks used for farming or residential purposes)

**waterborne diseases:** diseases spread by contaminated water

**water quality:** the condition of water with respect to its content of contaminants, natural or anthropogenic

## ADVANCE PREPARATION

A. Put the questions and answers on the index cards and put the categories on the board. (See Teacher Sheets.)

Example:                      Level: 3  
Q: What is the chemical formula for water?  
\_\_\_\_\_

A: H<sub>2</sub>O

B. Give students a list of the terms and definitions to study the day before the game.

## PROCEDURE

I. Setting the stage

A. Duties

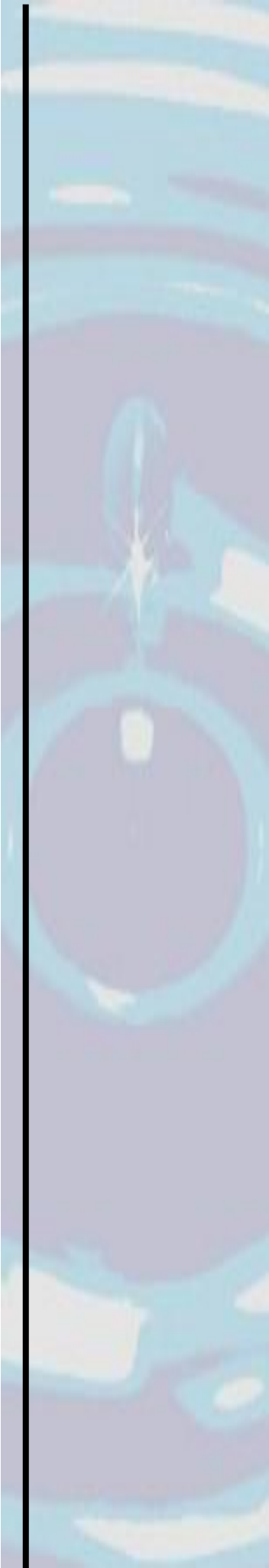
1. Moderator: reads the questions
2. Scorekeeper: records each team's scores on the board
3. Timekeeper: allows only the specified amount of time for each question
4. Judge: makes the final decision about answers and rules (teacher)

B. Divide the class into 2 groups (teams). Decide which team will go first. Select a captain for each team.

C. Rules

1. Ahead of time, place the categories on the board. Example:

Level 4\* 40, 40, 40, 40, 40, 40, 40, 40, 40, 40  
Level 3\* 30, 30, 30, 30, 30, 30, 30, 30, 30, 30  
Level 2\* 20, 20, 20, 20, 20, 20, 20, 20, 20, 20  
Level 1\* 10, 10, 10, 10, 10, 10, 10, 10, 10, 10



2. Each time a team chooses a level, the scorekeeper needs to eliminate that item (ex. Level 2-- , 20, 20) by marking over or erasing it. If a team correctly answers the question on any chosen level, those points are awarded to that team. Allow 5 seconds for each question to be answered. If the question is correctly answered [the answer must come from the person who raised his/her hand first], the moderator will read a bonus question. The team will have 15 seconds to discuss the bonus question. The bonus answer must be given by the captain. Bonus questions are worth the same amount as the original question.

3. If one team misses the answer, the opposite team may have a choice to answer the question. If a team member answers incorrectly, the amount of points are subtracted from the team's total points. If both teams answer incorrectly, the moderator answers the question. At the end of a certain amount of time (20 minutes) or the end of the questions, the team with the most points wins the game.

II. Activity - Play the game.

## **RESOURCES**

Nebel, Bernard J. and Richard T. Wright, *Environmental Science: The Way The World Works*, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

National Drinking Water Clearinghouse, West Virginia University, Morgantown, WV, 26506- 6064, 800-624-8301.

Safe Drinking Water Hotline: 800-426-4791.

**Thank you to the Environmental Protection Agency *Water Sourcebook* for this activity!**

[http://water.epa.gov/learn/kids/drinkingwater/wsb\\_index.cfm](http://water.epa.gov/learn/kids/drinkingwater/wsb_index.cfm)

## Questions & Answers

### Level 1

1. Immediate illnesses which can come from a virus or poison. *acute illnesses*
2. Define waterborne diseases. *diseases spread by contaminated water*
3. Long-term illnesses that are developed over many years. *chronic illnesses*
4. Sources of water supply are being endangered by chemicals. *True/False*
5. Contaminated water may increase cancer and heart disease rates. *True/False*
6. What does CDC stand for? *Centers for Disease Control and Prevention*
7. Who is responsible for making laws to ensure that our drinking water is safe? *U.S. Congress*
8. What can cause typhoid fever? *drinking contaminated water*
9. The Safe Drinking Water Act of 1986 banned all future use of what kind of pipes in public drinking water systems? *lead*
10. What does EPA stand for? *Environmental Protection Agency*
11. Why should water system owner/operators disinfect the drinking water supplies? *to help kill harmful microorganisms*
12. If a public water system is contaminated and its water causes acute illnesses, the owner/operator

### Level 2

1. What is the name of the bacteria that comes from human and animal waste that can contaminate drinking water? *Coliform bacteria*
2. Boiling water will eliminate nitrate contamination. *True/False*
3. What is the chemical formula for water? *H O 2*
4. Clear water is always clean and safe to use. *True/False*
5. What is the suggested pH level range of drinking water? *6.5 to 8.5*
6. Too much fluoride causes a brownish discoloration of teeth. *True/False*
7. Where is the main office of the Centers for Disease Control and Prevention located? *Atlanta, GA*

8. What are microorganisms? *microscopic or ultramicroscopic organisms too small to be seen with the unaided eye*

9. Pesticides can contaminate drinking water sources. *True/False*

10. Owners/operators of water plants must check water samples regularly for contaminants. *True/False*

11. Is drinking water from private household wells subject to regulation by federal drinking water standards? *No*

### **Level 3**

1. Nitrates present in large amounts can reduce the amounts of oxygen in an infant's blood. What is the chemical symbol for nitrates? *NO<sub>3</sub>*

2. What can the ingestion of radon in water cause? *cancer*

3. Excessive levels of copper in drinking water cause a metallic taste. *True/False*

4. What are pathogens? *disease - causing agents, especially microorganisms*

5. What type of microorganism is a virus? *a parasite*

6. What is surface water? *precipitation that does not soak into the ground. It is stored in streams, lakes, rivers, ponds, wetlands, oceans, and reservoirs.*

7. What is groundwater? *water that is stored below the Earth's surface*

8. Is radon more of a problem in groundwater or surface water? Explain. *groundwater - because radon in surface water usually escapes to outside air*

9. Is there more exposure to radon in the bedroom or the bathroom of your house? Explain. *could be bathroom if water use is from a well and the radon in water levels are high*

10. How does radon from the soil enter into a home? *through cracks and openings in the foundations, floors, or walls that are in contact with the soil or through plumbing*

11. Define microbiology. *the study of microorganisms, a large and diverse group of organisms that exist as single cells or cell clusters.*

### **Level 4**

1. Define water quality. *the condition of water with respect to the amount of pollutants in it*


2. Define underground storage tanks. *tanks such as gasoline tanks that are buried underground*


3. Define toxic chemicals. *chemicals with the potential of causing death or damage to humans, animals, plants, or protists*
4. Define sulfuric acid. *a product that forms when sulfur oxides combine with atmospheric moisture; a component of acid rain*
5. Define septic tank. *a tank, commonly buried, to which all of the wastewaters from the home should flow; the main part of a septic system where scum and sludge accumulate*
6. Define percolate. *to drain or seep through a porous and permeable substance*
7. Define sewage contamination. *the introduction of untreated or improperly treated sewage into a water body*
8. Define agriculture. *the science of cultivating the soil, producing crops, and raising livestock*
9. Define epidemic disease. *disease that spreads rapidly by infection among many individuals in an area*
10. Define Clean Water Act. *a water pollution control law intended to restore and maintain the nation's waters*
11. Show the chemical formula for sulfuric acid.  $H_2SO_4$

### **Bonus**

1. Name 3 reasons why the body needs water.  
Examples:  
To dilute harmful substances (all may not be poisonous)  
To have healthier skin  
To regulate body temperature  
To deliver oxygen and other nutrients to organs
2. Water has a nutritional value. True/*False*
3. What is the function of CDC? *to study and monitor disease control and health issues and to facilitate disease prevention*
4. Why was the Safe Drinking Water Act established? *to ensure safe public water supplies primarily through the establishment of drinking water standards and source water protection*
5. Name 3 types of waterborne diseases. *Examples: typhoid fever, cholera, infectious hepatitis, dysentery, cryptosporidiosis*



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6. What is the “blue baby” syndrome? *pathological condition where blood is incapable of carrying oxygen resulting in the skin turning blue in infants; can be caused by nitrate contamination of drinking water*
  7. Why is fluoride added to drinking water? *to help prevent tooth decay*
  8. Why is chlorine added to drinking water? *to help kill microorganisms*
  9. What are pesticides? *chemicals that kill plant or animal pests* (usually insects)
  10. Name 2 ways that farming practices could cause drinking water contamination.  
*Examples: excess fertilizers, oil and gas leakage from storage tanks, livestock waste, improper or excessive use of pesticides*
  11. What is the source of radon? *naturally occurring uranium found in soil and rock*
  12. Name 3 groups of microorganisms. *Examples: bacteria, protozoa, viruses, some algae*
  13. Hepatitis is caused by the smallest and simplest common form of microorganism that is known as a \_\_\_\_\_. *Virus*
  14. How do you recognize radon as a problem in your home? *Test*
  15. Name 2 sources of surface water. *Examples: streams, rivers, lakes, ponds, wetlands oceans, and reservoirs*
  16. Name 2 sources of groundwater. *Examples: wells and springs*
  17. What is hydrology? *the study of water, its properties, distribution, and circulation on Earth*
  18. Name 3 activities or land uses that can threaten and contaminate water supplies.  
*Examples: septic tanks, landfills, agricultural activities, lawn and crop fertilizer, transporting chemicals or waste by road, wastewater discharges, abandoned wells*
  19. Why is radon from well water more of a problem and more present in the bathroom, kitchen, and laundry rooms? *It escapes to the air (comes out of solution) when faucets, toilets, showers, washing machines, etc. are used.*
  20. Define chemical pollution of water. *introduction of harmful chemicals into a water body*



21. How could a leaking underground storage tank cause groundwater contamination? ***The contents in the tank or the associated piping could leak into the soil and groundwater.***

22. What is black water? ***domestic wastewater containing human or animal waste or other sources of pathogens***

23. How does the privy (outdoor toilet) contribute to groundwater contamination? ***The bacteria in human waste percolate through the soil to the groundwater.***

24. Describe the purpose of the Resource Conservation & Recovery Act with respect to water protection. ***a law intended to protect waterways and groundwater from hazardous waste contamination***

25. Explain why Congress decided to pass the Clean Water Act. ***to protect the nation's waters***

26. What agency is responsible for enforcing federal water-related regulations? ***EPA***

27. What should you do if you suspect contamination in a public water supply? ***Don't use it and notify your water supplier immediately.***

28. Boiling water kills all microorganisms. True/***False***

29. How can oil spills contribute to groundwater contamination? ***The chemicals***

30. What is the chemical symbol for chlorine gas? ***Cl<sub>2</sub>***