

# WHAT'S IN YOUR DRINKING WATER?

## Description

This activity introduces students to the Safe Drinking Water Act and drinking water standards. After playing the Drinking Water Game, students will have a better understanding of contaminants present in drinking water and their associated health effects.

## Student Outcomes

Students will:

- Learn about federal regulations that ensure safe drinking water.
- Identify primary and secondary drinking water standards.
- Understand how contaminant standards are established.
- Correlate drinking water contaminants with human health effects.
- Recognize characteristics of twelve contaminants commonly found in drinking water.

## Student Products

- *Reading for Understanding Questions*
- *What's in Your Drinking Water?*
- *Conclusion Questions*

## Prerequisites

- Background Activity 3: *Source to Sink*



## National Standards

Subject Area Standards Covered: *Health, Language Arts, and Science*.  
See Appendix D for the complete list of national education standards.



## Teamwork Skills

Listen attentively to others.



## Activity Timing

Time Estimate	Two 50-minute Class Periods
30-60 min	Prep Time: photocopying and laminating (optional)
Homework	Background Reading and <i>Reading for Understanding Questions</i>
Day 1	Drinking Water Quality Terminology
Day 2	Drinking Water Game



## Materials

- Hydroville Journal

### Drinking Water Game (one per pair of students):

- Cardstock (blue, green, yellow)
- Twelve beans or paper clips (to be used as markers)
- One manila envelope (to hold game cards)
- Four laminating sleeves and laminator (optional)

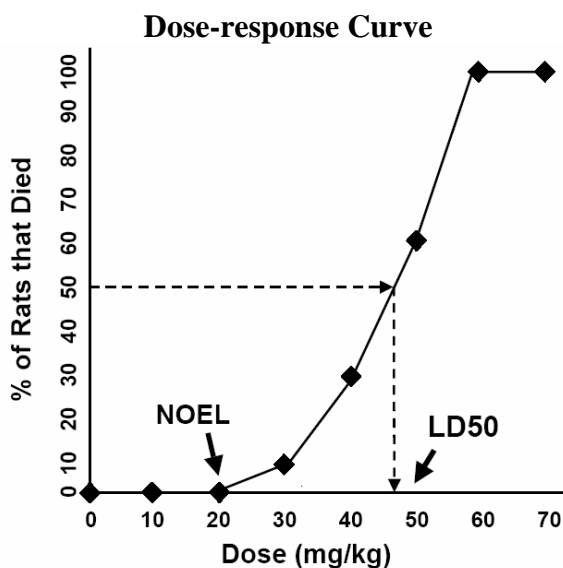
## Teacher Information

Review Background Reading: *Is Your Drinking Water Safe?* You will review this information with students using transparencies TM-2 to TM-9. The following explanation (from <http://www.epa.gov/safewater/standard/setting.html>) of how EPA establishes MCLs may be too complicated for your students but is important for your background understanding.

### How are MCLs established for water contaminants?

Because laboratory studies of toxic effects of chemicals on humans cannot be performed, studies in dogs, monkeys, and humans themselves are required. In these studies, identical groups of subjects are exposed to different amounts of the chemical, and the effects produced are measured. The data is then plotted on a graph called the **dose-response curve**. The dose (mg of the chemical tested/ kg of body weight) is plotted on the X axis and the percent of experimental animals showing the response is plotted on the Y axis. The observed response can vary from skin rash or diarrhea to cancerous tumors or death.

A dose-response curve can be used to describe the toxicity of a chemical in many different ways: lethal dose (LD50), toxic dose (TD50), or no observable effect level. **No Observable Effect Level (NOEL)** is the measurement used to establish drinking water standards. NOEL is defined as the highest dose or concentration tested at which the toxic effect is zero for a specific contaminant. NOEL is a useful measurement for extrapolating risk and safe exposure concentrations.



Dose(mg/kg)	Number of Deaths (%)	Dose(mg/kg)	Number of Deaths (%)
0	0/10 (0)	40	3/10 (30)
10	0/10 (0)	50	6/10 (60)
20	0/10 (0)	60	10/10 (100)
30	1/10 (10)	70	10/10 (100)

After reviewing health effects studies, EPA sets a **Maximum Contaminant Level Goal (MCLG)**, the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. MCLGs are non-enforceable public health goals. Since MCLGs consider only public health and not the limits of detection and treatment technology, sometimes they are set at a level which water systems cannot meet. When determining an MCLG, EPA considers the risk to sensitive subpopulations (infants, children, the elderly, and those with compromised immune systems) of experiencing a variety of adverse health effects.

- **Non-Carcinogens (not including microbial contaminants):** For chemicals that can cause adverse non-cancer health effects, the MCLG is based on the reference dose. A **reference dose (RFD)** is an estimate of the amount of a chemical that a person can be exposed to on a daily basis that is not anticipated to cause adverse health effects over a person's lifetime. In RFD calculations, sensitive subgroups are included, and uncertainty may span an order of magnitude.

--The RFD is multiplied by typical adult body weight (70 kg) and divided by daily water consumption (2 liters) to provide a Drinking Water Equivalent Level (DWEL).

--The DWEL is multiplied by a percentage of the total daily exposure contributed by drinking water (often 20 percent) to determine the MCLG.

- **Chemical Contaminants -- Carcinogens:** If there is evidence that a chemical may cause cancer, and there is no dose below which the chemical is considered safe, the MCLG is set at zero. If a chemical is carcinogenic and a safe dose can be determined, the MCLG is set at a level above zero that is safe.
- **Microbial Contaminants:** For microbial contaminants that may present public health risk, the MCLG is set at zero because ingesting one protozoa, virus, or bacterium may cause adverse health effects. EPA is conducting studies to determine whether there is a safe level above zero for some microbial contaminants. So far, however, this has not been established.

Once the MCLG is determined, EPA sets an enforceable standard. In most cases, the standard is a **Maximum Contaminant Level (MCL)**, the maximum permissible level of a contaminant in water which is delivered to any user of a public water system.

The MCL is set as close to the MCLG as feasible, which the Safe Drinking Water Act defines as the level that may be achieved with the use of the best available technology, treatment techniques, and other means which EPA finds are available (after examination for efficiency under field conditions and not solely under laboratory conditions) are available, taking cost into consideration.

When there is no reliable method that is economically and technically feasible to measure a contaminant at particularly low concentrations, a **Treatment Technique (TT)** is set rather than an MCL. A treatment technique (TT) is an enforceable procedure or level of technological performance which public water systems must follow to ensure control of a contaminant. Examples of Treatment Technique rules are the Surface Water Treatment Rule (disinfection and filtration) and the Lead and Copper Rule (optimized corrosion control).



## Terminology

Consumer Confidence Report (CCR)	NOEL (No Observable Effect Level)
Disinfectant	Organic chemicals
Disinfectant byproduct	Parts per billion (ppb)
Dose	Parts per million (ppm)
Dose-response curve	Primary drinking water standards
Inorganic chemical	Radionuclide
Maximum Contaminant Level (MCL)	Safe Drinking Water Act (SWDA)
Maximum Contaminant Level Goal (MCLG)	Secondary drinking water standards
Microorganism	Toxicity
	Toxicology



## Suggested Lesson Plan

### Getting Started

1. Photocopy pages for the Drinking Water Game to make one game for every pair of students:
  - Two *Game Keys* (green cardstock)
  - One set of *Playing Cards* (on blue cardstock, cut into 12 separate cards)
  - One *Game Board* (yellow cardstock)
  - Laminate all of the game cards so they can be reused. (optional)
2. **Homework:** Assign the Background Reading: *Is Your Drinking Water Safe?* and Worksheet 1: *Reading for Understanding Questions*.

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## Day 1. Drinking Water Quality Terminology

### Doing the Activity

1. Assign **Journal Prompt-5 (TM-1)**:
  - a. What do you think is in your drinking water? List as many contaminants as you can. A contaminant is anything found in water (including microorganisms, minerals, chemicals, radiation, etc.) which may be harmful to human health. *Answers will vary.*
2. Review homework: *Reading for Understanding Questions* (WS-1).
3. Hand out *Playing Cards* and the *Game Keys* to each pair of students. Students use the cards to complete *What's in Your Drinking Water?* (WS-2).

**Note:** Do not hand out the *Game Board* until Day 2.
4. Review terminology, concepts, and answers from Worksheet 2 that are associated with water quality and the Drinking Water Game. Display transparencies (TM-2 through TM-10).
  - a. *Safe Drinking Water Act (SDWA)* (TM-2): Review the federal regulations that protect the nation's public drinking water supply.
  - b. *Primary Drinking Water Standards* (TM-3): Discuss "primary" drinking water standards that are regulated because these contaminants can cause adverse health effects. Review

Question 2 from Worksheet 2, “How many of the contaminants (playing cards) are primary drinking water standards?” (*Answer: 11*)

- c. *MCL and Dose Response* (TM-4): Explain how the EPA establishes the MCL concentrations for contaminants in drinking water based on dose-response graphs.
- d. *Secondary Drinking Water Standards* (TM-5): Compare the secondary (not regulated) standards that affect taste, color, and odor of drinking water, but do not cause harmful health effects. Review Question 2, “How many of the contaminants are secondary drinking water standards?” (*Answer: 4; copper and fluoride are both P & S*)
- e. *Categories of Contaminants* (TM-6 & TM-7): The EPA groups drinking water contaminants into six categories: organic chemicals, inorganic chemicals, microorganisms, radionuclides, disinfectants, and disinfectant byproducts. Review Question 3, “How many contaminants are in each category?” (*See Teacher Key for answers*)
- f. *Points of Entry—Where Contaminants Enter Drinking Water* (TM-8): Explain where contaminants can enter the drinking water system. There are three general locations: water sources (raw water), treatment plant (treated water), and the distribution system (pipes and plumbing). Review Question 5, “Where does each contaminant enter the drinking water system?” (*See Teacher Key for answers*)
- g. *Methods to Protect Drinking Water* (TM-9): Introduce the three methods to control, remove, or eliminate contaminants from the public water supply.
- h. *Potential Health Effects* (TM-10): This slide introduces the students to some of the potential health effects (and their abbreviations) of contaminants used in the drinking water game. You might make certain that the students understand what each of these terms mean. This is in no way a complete list. Review Question 7, “Which contaminants are carcinogens (cancer-causing)?” (*See Teacher Key for answers*)



**Tips from Teachers:**

- Introduce all twelve contaminants and their pronunciation prior to the game.
- Have pairs of students pre-read cards before playing the game to familiarize them with the information.
- Demonstrate how to play the game. Select one of the contaminants and then students practice asking questions and being the “guessers”.

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## Day 2. Drinking Water Game

### *Doing the Activity*

1. Hand out *Drinking Water Game - Instructions* (WS-3) to each pair of students. Review instructions and score card.
2. Students play one practice round and then three rounds of the game.
3. When finished with the game, students complete Conclusion Questions (WS-3, page 3).

### *Wrap-up*

As a class, discuss students' answers to Conclusion Questions.

## Assessment

The following student products can be used for assessment:

Individual

- *Reading for Understanding Questions* (WS-1)

Group

- *What's in Your Drinking Water?* (WS-2)
- *Drinking Water Game Conclusion Questions* (WS-3)



## Resources

See the Hydroville Water Quality Curriculum Web Resources webpage for current links:  
[http://www.hydroville.org/links/wq\\_resources.aspx](http://www.hydroville.org/links/wq_resources.aspx)

### Hardcopy resources

Francis, B. M. 1994. *Toxic Substances in the Environment*. Wiley-Interscience Publication. John Wiley & Sons, Inc., New York.

Klassen, C.D. 1996. *Toxicology*. McGraw-Hill, New York.

Marczewski, A. E. and Kamrin, M. 1991 *Toxicology for the citizen*. Institute for Environmental Toxicology, Michigan State University.

Ottoboni, M. A. 1984. *The Dose Makes the Poison*. Vincente Books, Berkley, CA

Prager, J.C. 1995. *Environmental Contaminant Reference Databook. Volume 1*. Van Nostrand Reinhold. New York.

Rodricks, J.V. 1992. *Calculated risks*. Cambridge University Press, New York

Stelljes, M. E. 1999. *Toxicology for Non-Toxicologists*.

Timbress, J.A. 1995. *Introduction to toxicology*. Taylor & Francis, London.



## Teacher Keys

### Reading for Understanding Questions (WS-1)

1. Why was the passage of the Safe Drinking Water Act in 1974 important? Give a couple of examples of how the SDWA protects drinking water.  
*The SDWA protects the quality of drinking water managed by public water system. These are a few of the approaches to protect drinking water:*
  - assess and protect drinking water sources;
  - protect public wells and collection systems;
  - ensure water is treated by qualified operators;
  - maintain distribution systems; and
  - make information available to the public on the quality of their drinking water.
2. Complete the sentence: Maximum Contaminant Levels (MCLs) are important because...  
*they establish a safe level of contaminants in drinking water.*
3. Some drinking water contaminants have primary standards and others have secondary standards. Define both primary drinking water standard and secondary standard. How are these standards different? How are they the same?  
*A primary drinking water standard specifies an enforceable maximum level of a contaminant which will adversely affect human health. A secondary standard is non-enforceable and not regulated because it does not cause health problems. Secondary water contaminants cause effects such as taste, odor or color; or tooth or skin discoloration. Both are regulated by the EPA and protect the drinking water of individuals on public water systems.*
4. Listed below are contaminants that are regulated by primary drinking water standards. Fill in the blank with the category of contaminant.

a. pesticides, fertilizers, gasoline, solvents	<u>Organic chemicals</u>
b. chlorine	<u>Disinfectants</u>
c. fecal matter, animal manure	<u>Microorganisms</u>
d. paint, pipes, metal, petroleum, glass, electronics	<u>Inorganic chemicals</u>
e. uranium, alpha particles, radium	<u>Radionuclides</u>
f. total trihalomethanes	<u>Disinfectant byproducts</u>
5. Suppose you had a problem with a leaky septic tank in your back yard. Which treatment method would you use and why?  
*Remediation. I would replace the leaky septic tank with a new one that did not leak.*
6. How are water suppliers required to get information about drinking water to their customers and how often?  
*Water suppliers must provide a Consumer Confidence Report to the public on the source and quality of their drinking water annually.*
7. In your own words, describe what is meant by the phrase, "The dose makes the poison." Give an example.  
*The harmful effects of a substance are determined by the amount absorbed into the body. Some substances can be both beneficial and harmful depending upon the dose.*

## Water Quality

### BA 4: What's in Your Drinking Water?

8. If a person works in the field of toxicology, what does she study?  
*She studies how chemicals can cause harmful effects.*
9. Name the six factors that affect the toxicity of a chemical.  
*Dose, frequency, duration, route, individual susceptibility and properties of the chemical*
10.
  - a. Define NOEL.  
*NOEL is the largest dose of a chemical that produces no noticeable effect.*
  - b. How is the NOEL of a chemical calculated?  
*The NOEL is calculated from a dose-response curve.*
  - c. How is the MCL for a chemical determined?  
*The MCL is calculated by dividing the NOEL by a safety factor of 100.*

### What's in Your Drinking Water? (WS-2)

2. Put a "P" for Primary and an "S" for Secondary next to the contaminant in the table below.

<i>P</i>	Chlorine	<i>P</i>	Total Coliforms
<i>P</i>	Chromium	<i>S</i>	Total Dissolved Solids
<i>P &amp; S</i>	Copper	<i>P</i>	Trichloroethylene (TCE)
<i>P &amp; S</i>	Fluoride	<i>P</i>	Total Trihalomethanes (TTHMs)
<i>P</i>	Lead	<i>P</i>	Turbidity
<i>P</i>	Nitrate	<i>P</i>	Vinyl chloride

3. Sort the *Playing Cards* by type of contaminant. Record the number of contaminants found in each category.

Categories of Contaminants	Total
Organic Chemicals	<i>2</i>
Inorganic Chemicals	<i>6</i>
Microorganisms	<i>2</i>
Radionuclides	<i>0</i>
Disinfectants	<i>1</i>
Disinfectant Byproducts	<i>1</i>

4. According to the background reading, which category has the greatest number of contaminants with primary standards?  
*Organic chemicals*

Water Quality

BA 4: What's in Your Drinking Water?

5. Sort the *Playing Cards* by where the contaminant originates, that is, the location of where it enters the drinking water system. List the contaminant under the appropriate heading. Some contaminants may appear more than once.

<b>Water Source</b>	<b>Treatment Plant</b>	<b>Distribution System</b>
<i>Trichloroethylene (TCE)</i>	<i>Chlorine</i>	<i>Copper</i>
<i>Copper</i>	<i>Fluoride</i>	<i>Lead</i>
<i>Chromium</i>	<i>Trihalomethanes (TTHMs)</i>	<i>Total Coliforms</i>
<i>Total Dissolved Solids</i>		
<i>Vinyl chloride</i>		
<i>Total Coliforms</i>		
<i>Lead</i>		
<i>Turbidity</i>		
<i>Fluoride</i>		
<i>Nitrate</i>		

6. Where do most of the contaminants enter the drinking water system? *Water source*

7. Which contaminants are carcinogens (cancer-causing)?  
*Trichloroethylene (TCE), chromium, vinyl chloride, and total trihalomethanes (TTHMs)*

**Conclusion Questions (WS-3)**

3. Compare the MCLs and rank the contaminants from the most hazardous to the least hazardous.

<b>Contaminant</b>	<b>MCL(ppm)</b>	<b>Ranking</b>
<b>Chlorine *</b>	<i>4.0</i>	<i>7 (tie)</i>
<b>Chromium</b>	<i>0.1</i>	<i>5</i>
<b>Copper</b>	<i>1.3</i>	<i>6</i>
<b>Fluoride</b>	<i>4.0</i>	<i>7 (tie)</i>
<b>Lead</b>	<i>0.015</i>	<i>3</i>
<b>Nitrate</b>	<i>10</i>	<i>8</i>
<b>Trichloroethylene (TCE)</b>	<i>0.005</i>	<i>2</i>
<b>Total Trihalomethanes (TTHMs)</b>	<i>0.080</i>	<i>4</i>
<b>Vinyl chloride</b>	<i>0.002</i>	<i>1</i>

\*MRDL – Maximum Residual Disinfectant Level

4. In the table below, list the top five most hazardous contaminants in the ranking and their potential health effects. You can abbreviate the health effects.

<b>Contaminant</b>	<b>Potential Health Effects</b>
<i>Vinyl chloride</i>	<i>Ca, CNS, LD</i>
<i>Trichloroethylene (TCE)</i>	<i>Ca, ID, KD, LD</i>
<i>Lead</i>	<i>CNS, Fa, He, KD</i>
<i>Trihalomethanes (TTHMs)</i>	<i>Ca, CNS, KD, LD</i>
<i>Chromium</i>	<i>Ca, CNS, KD, LD, Sk</i>

***Conclusion Questions (WS-3) – continued***

5. List the potential health effects that occur in **at least three** or more of the contaminants. Do not use abbreviations in your answer.

*Cancer, central nervous system, liver damage, and kidney damage*

6. Which contaminant(s) are you most concerned about and why?

*Answers will vary.*



**PAGES TO PHOTOCOPY**

**Handouts and Transparency Masters**

<b>Day</b>	<b>What is Needed</b>	<b>Type*</b>
<b>Prep</b>	<b><i>Drinking Water Game</i> – one game per pair of students</b>	The copy masters are located behind Worksheet 4
	One <i>Game Board</i> (print on yellow cardstock)	
	Twelve <i>Playing Cards</i> (print on blue cardstock), cut cards out individually to make one set and rubber band together	
	Two <i>Game Key</i> (print on green cardstock)	
	11 markers/board (beans, paper clips, paper, candy, etc.)	
<b>HW</b>	<i>Is Your Drinking Water Safe?</i>	BR
	<i>Reading for Understanding Questions</i>	WS-1
<b>1</b>	<i>Journal Prompt-5</i>	TM-1
	<i>What's in Your Drinking Water?</i>	WS-2
	<i>Safe Drinking Water Act (SDWA)</i>	TM-2
	<i>Primary Drinking Water Standards</i>	TM-3
	<i>Secondary Drinking Water Standards</i>	TM-4
	<i>Categories of Contaminants</i>	TM-5 & TM-6
	<i>Points of Entry-Where Contaminants Enter Drinking Water</i>	TM-7
	<i>Methods to Protect Drinking Water</i>	TM-8
	<i>Potential Health Effects</i>	TM-9
<b>2</b>	<i>The Drinking Water Game</i> (Instructions, Score Card, and Conclusion Questions)	WS-3

\* Type = Transparency Master (TM), Background Reading (BR), Worksheet (WS), Map (M)

## JOURNAL PROMPT-5



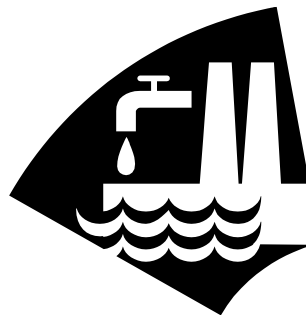
**What do you think is in your drinking water? List as many contaminants as you can.**

**A contaminant** is anything found in water (including microorganisms, minerals, chemicals, radiation, etc.) which may be harmful to human health.



## SAFE DRINKING WATER ACT (SDWA)

- Passed by Congress in 1974
- Protects public health by regulating the public water supply
- Gives the Environmental Protection Agency (EPA) responsibility for setting standards (maximum contaminant levels- MCLs) for over 90 contaminants that may occur in drinking water
- Regulates public water systems (does not apply to private wells)
- Amended in 1986 and 1996 to protect water sources, public wells, distribution systems, and to make information available to the public



***"A fundamental promise we must make to our people is that the food they eat and the water they drink are safe."***

*President Bill Clinton  
SDWA Reauthorization, August 6, 1996*

## PRIMARY DRINKING WATER STANDARDS



- Are legally-enforceable standards, regulated by the U.S. EPA
- Set a **Maximum Contaminant Level (MCL)** - a limit on the highest concentration allowable in drinking water (measured in mg/L = ppm)
- Regulate contaminants that can cause health problems (if levels are above the MCL)

### Example of a primary standard

MCL for copper is 1.3 mg/L (ppm)  
If a water sample contains 1.4 ppm, it is in violation. Long-term exposure can cause liver and kidney damage.

## SECONDARY DRINKING WATER STANDARDS



- Are non-enforceable (“non-regulated”) standards
- Are guidelines, not requirements  
States may choose to adopt them as enforceable standards.
- Are NOT harmful, but can cause other problems if levels are above the MCL

These contaminants can:

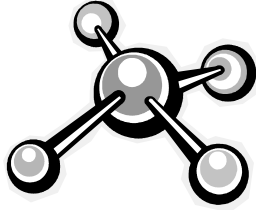
- affect taste, odor, or color of water
- cause skin or tooth discoloration
- cause corrosion of pipes, staining, or build up of sediments

### **Example of a secondary standard**

MCL for copper is 1 mg/L (ppm)

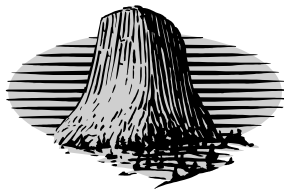
If a water sample contains 1.2 ppm, then the water can leave blue-green stains

## CLASSES OF CONTAMINANTS



### 1. Organic Chemicals

- carbon-based compounds
- examples: pesticides, fertilizers, gasoline
- runoff from farm fields, discharge from factories, leaching from buried waste
- 56 contaminants, e.g. TCE, benzene



### 2. Inorganic Chemicals

- naturally-occurring or man-made mineral compounds
- examples: paint, pipes, steel, glass, electronics, fertilizers
- erosion of natural deposits and mining, discharge from steel and pulp mills, corrosion of household plumbing
- 15 contaminants, e.g. lead, nitrate



### 3. Microorganisms

- microscopic organisms such as E.coli, coliform
- found in fecal matter, animal manure
- sewage discharges, leaky septic tanks, runoff from animal feedlots
- seven contaminants, e.g. total coliforms (*E. coli* and fecal coliform)

## CLASSES OF CONTAMINANTS



### 4. Disinfectants

- chlorine compounds
- added at the treatment plant to kill microorganisms
- three contaminants, e.g. chlorine

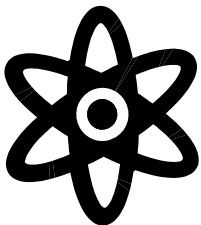
### 5. Disinfectant Byproducts

- chemical byproducts of disinfection process
- form when disinfectants react with plant matter and other organic materials in the water
- four contaminants, e.g. TTHMs (total trihalomethanes)

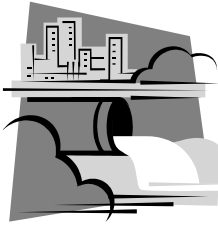
## DBP

### 6. Radionuclides

- unstable atoms that emit radiation
- naturally occurring in rocks and minerals or produced in nuclear reactors
- erosion of natural deposits or leakage from nuclear waste
- four contaminants, e.g. uranium



## POINTS OF ENTRY – WHERE CONTAMINANTS ENTER DRINKING WATER



### 1. Water Source

- organic chemicals
- inorganic chemicals
- microorganisms
- radionuclides

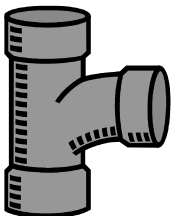
#### Contaminant sources:

- septic systems
- construction
- pesticides/fertilizers
- animal feedlots
- landfills and mining
- abandoned wells
- underground storage tanks



### 2. Treatment Plant

- chlorine
- disinfectant byproducts
- fluoride



### 3. Distribution System

- microorganisms
- lead & copper (from solder, pipes, and faucets in older homes)

## METHODS TO PROTECT DRINKING WATER

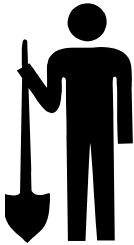
### Containment



*Prevent* the release of contaminants into water sources

- Contain animal waste in feedlots
- Protect and monitor water sources
- Educate the public to prevent dumping chemicals in watershed

### Removal



*Remove or clean up* contaminant sources

- Remove leaky underground storage tanks
- Clean up hazardous waste sites or old dumps

### Treatment



*Treat* water at treatment plants or in homes to remove contaminants

- Activated charcoal filters
- Reverse osmosis

## POTENTIAL HEALTH EFFECTS

The following are some of the health effects of water contaminants used in the Drinking Water Game.

<b>BB</b>	<b>Blue Baby Syndrome</b>	<b>He</b>	<b>Headache</b>
<b>BD</b>	<b>Bone Disease</b>	<b>IS</b>	<b>Immune System</b>
<b>Ca</b>	<b>Cancer</b>	<b>KD</b>	<b>Kidney Damage</b>
<b>CNS</b>	<b>Central Nervous System</b>	<b>LD</b>	<b>Liver Damage</b>
<b>Di</b>	<b>Diarrhea</b>	<b>Na</b>	<b>Nausea</b>
<b>EN</b>	<b>Eye/Nose irritation</b>	<b>SC</b>	<b>Stomach Cramps</b>
<b>Fa</b>	<b>Fatigue</b>	<b>Sk</b>	<b>Skin problems</b>



## BACKGROUND READING: IS YOUR DRINKING WATER SAFE?

The United States has one of the safest water supplies in the world. That's because drinking water and its water sources are protected by federal regulations. Even though drinking water quality varies from place to place, depending on the condition of the source water from which it is drawn and the treatment it receives, it is almost always guaranteed to be safe.

The **Safe Drinking Water Act (SDWA)** was passed by Congress in 1974 to protect the quality of drinking water nationwide. The SDWA was amended in 1986 and 1996 to include actions that

- assess and protect water sources;
- protect public wells and collection systems;
- ensure water is treated by qualified operators;
- maintain distribution systems, and
- make information available to the public on the quality of their drinking water

The SDWA also authorizes the U.S. Environmental Protection Agency (EPA) to set primary drinking water standards that protect the health of the 250 million people who get their water from **public water systems**. A public water system provides water to at least 25 people for at least 60 days annually.



### What are drinking water standards?

Under the authority of the Safe Drinking Water Act, the EPA has established **primary drinking water standards** to protect the public from contaminants that can cause health problems. For each of these contaminants, EPA sets a legal limit, called a **maximum contaminant level (MCL)**. The MCL is the highest concentration of a contaminant that is allowed in drinking water. If water exceeds these standards, the supplier is in violation of the law and must treat the water accordingly. The EPA sets levels based on cost and available technology so that water treatment plants can meet MCLs. Some states set **MCLGs (Maximum Contaminant Level Goals)** which are stricter than EPA's MCLs and are levels where the contaminants have no known or expected health risk. This goal is not always economically or technologically feasible.

MCL and MCLG are measured in concentration units of milligrams per liter – 1 mg/L is equivalent to 1 ppm. **Parts per million (ppm)** means one particle of a given substance for every 999,999 other particles. This is roughly equivalent to one drop of ink in a 150 liter (40 gallon) drum of water. For example, the MCL for nitrate is 10 mg/L or 10 ppm. This means only 10 milligrams of nitrate is allowable in 1 liter of drinking water. Parts per billion may also be used when the MCL is very small. 1ppb = 0.001 ppm

The EPA also had guidelines for **secondary drinking water standards** to ensure that your drinking water tastes and looks good, and does not leave a residue in your sink or tub. Public water systems are not required to meet secondary standards, but some states have chosen to adopt them.



## Primary Drinking Water Standards



**Primary Drinking Water Standards** are regulated and enforceable. They protect public health by listing MCLs for about 90 contaminants that the EPA considers harmful to human health. Long-term exposure to these contaminants can cause problems with the digestive, reproductive, or nervous systems; cause liver or kidney damage; eye/nose or skin irritation; or even cancer.

## Secondary Drinking Water Standards

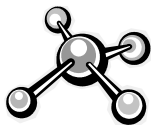


The EPA has established **Secondary Drinking Water Standards** for 15 contaminants that are **NOT** considered a risk to human health, and therefore are not regulated or enforceable. These standards protect drinking water from other non-health related problems such as

- an undesirable taste or odor (e.g. sulfate), or color (e.g. copper, sulfate)
- skin discoloration (e.g. silver) or tooth discoloration or pitting (e.g. fluoride)
- corrosion and staining (e.g. iron), hard water buildup and sediments (e.g. total dissolved solids)

## Categories of Contaminants

Drinking water contaminants can be divided into in six categories:



**Organic chemicals** are carbon-based compounds found in pesticides, fertilizers, gasoline, solvents, and many other products. Organic chemicals can get into water by runoff from farm fields, discharge from factories, leaching from buried waste, or illegal dumping. Organic chemicals include TCE, vinyl chloride, PCBs, and benzene. The EPA has set MCLs for over 50 organic chemicals making this the largest category of contaminants.



**Inorganic chemicals** are mineral-based compounds either naturally occurring or manmade. They are used in paint, pipes, steel, glass, electronics, and fertilizers. Inorganic chemicals can get into water through erosion of natural deposits and mining, discharge from steel and pulp mills, corrosion of household plumbing, and runoff from landfills and crop land. The EPA has set MCLs for 15 inorganic contaminants, such as arsenic, fluoride, copper, lead, and nitrates.



**Microorganisms** are tiny living organisms that can only be seen with a microscope. Microorganisms are often found in water as a result of fecal matter from sewage discharges, leaking septic tanks, or runoff from animal feedlots. Some microbes such as bacteria, *E. coli*, viruses, and protozoa can cause health problems. Seven types of microorganisms are controlled by primary standards.



**Radionuclides** are unstable atoms that emit radiation. Uranium, alpha particles, and radium can enter water by erosion of natural deposits or from nuclear waste. Radionuclides are common in volcanic rocks and also where radon is present in bedrock. The EPA has set legal limits on four radionuclides.



**Disinfectants** are added to treat raw water to form “finished water” – water that has been processed in a water treatment plant and is ready to be delivered to customers. Chemicals such as chlorine are added during treatment to kill microorganisms. There are three disinfectants that have primary drinking water standards.

## DBP

**Disinfectant byproducts** form when disinfectants (e.g. chlorine) react with organic matter and other naturally occurring materials in treated water. Secondary products such as total trihalomethanes (“*TRY-hay-low-METH-ines*”) (TTHMs) form as chemical byproducts of the disinfection process. The EPA sets MCLs on four disinfectant byproducts.

## Methods to Protect Drinking Water

These methods are used to control, remove, or eliminate contaminants from water sources or finished water.



### Containment

Actions to prevent or control the release of contaminants into water sources

- Contain animal waste in feedlots
- Monitor and protect water sources: groundwater and surface water



### Removal

Technologies or other methods that remove or clean up contaminant sources

- Remove leaky underground storage tanks
- Clean up hazardous waste sites or old dumps



### Treatment

Treat water at treatment plants or in homes to remove contaminants

- Activated charcoal filters
- Reverse osmosis

## Public Information

The Safe Drinking Water Act recognizes that since everyone drinks water, everyone has the right to know what's in their water and where it comes from. Public water suppliers must make information on the source and quality of their drinking water available to the public. A water quality report, often referred to as a **Consumer Confidence Report (CCR)**, includes information on water sources, water treatment process, contaminants detected in finished water, and more. CCRs must be published every year. If you are interested in reading your city's water quality report, look for it online or call your local water supplier.



To learn more about the Safe Drinking Water Act or drinking water in general, call EPA's Safe Drinking Water Hotline at 1-800-426-4791.



## How Do We Know When a Contaminant is Toxic?

For centuries, humans have observed that some chemicals found in nature were poisonous. Examples include snake and insect venoms, poisonous plants (hemlock, poison ivy), and minerals such as lead and arsenic. The 16th century physician Paracelsus recognized that the same chemical could have both therapeutic and toxic properties depending upon how much of it was used. He wrote, "All substances are poisons; there is none which is not a poison. The right dose differentiates a poison from a remedy."

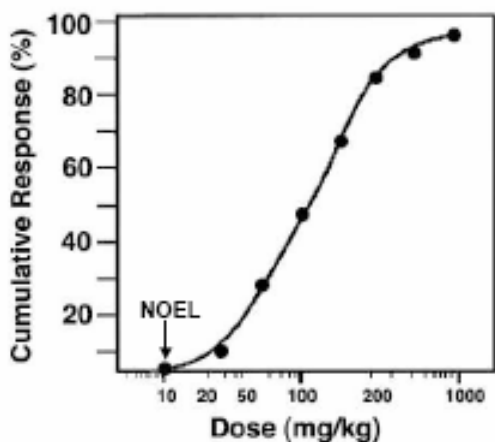


The beneficial or harmful effects of a chemical are dependent upon the amount of the chemical that gets into an organism. That amount is called the **dose**. In addition to dose, the **toxicity** or harmful effects from a chemical are also influenced by:

- *Frequency* (how often does someone come in contact with the chemical)
- *Duration* (how long is the contact)
- *Route* (how the chemical enters the body: through eating, breathing, or skin absorption)
- *Individual susceptibility* (Toxicity varies from person to person based on age, body weight, gender, genetics, and personal health.)
- *Properties of the contaminant* (All chemicals interact with the body in different ways.)

**Toxicology** is the science that studies the ability of chemicals to cause harmful effects. Because studies with humans are not allowed, toxicologists use animal models to determine the toxic effects that a chemical can cause and the doses at which those effects occur. Mice and rats are the subjects used in the majority of toxicology studies. The animal data are used to predict safe levels of exposure for humans to these chemicals.

In these studies, identical groups of subjects are exposed to different amounts of the chemical, and the effects produced are measured. The data is then plotted on a graph called the **dose - response curve**. The dose (mg of the chemical tested/ kg of body weight) is plotted on the X axis and the percent of experimental animals showing the response is plotted on the Y axis. The observed response can vary from skin rash or diarrhea to cancerous tumors or death. The **No Observable Effect Level (NOEL)** is the highest dose or concentration tested at which the toxic effect is zero for a specific contaminant.



The EPA uses the NOEL and a safety factor that takes into account sensitive populations and the amount of water a person consumes in a lifetime to set a **Maximum Contaminant Level Goal (MCLG)** for each contaminant. The MCLG is the maximum concentration of a substance in drinking water at which no known or anticipated adverse effect on the health of the person would occur. The EPA enforceable standards (MCLs) for public drinking water systems are set as close to the MCLG as possible given measurement technology limitations and costs to the public.



## WORKSHEET 1: READING FOR UNDERSTANDING QUESTIONS

1. Why was the passage of the Safe Drinking Water Act in 1974 important? Give a couple of examples of how the SDWA protects drinking water.
2. Complete the sentence: Maximum Contaminant Levels (MCLs) are important because...
3. Some drinking water contaminants have primary standards and others have secondary standards. Define both primary drinking water standard and secondary standard. How are these standards different? How are they the same?
4. Listed below are contaminants that are regulated by primary drinking water standards. Fill in the blank with the category of contaminant.
  - a. pesticides, fertilizers, gasoline, solvents \_\_\_\_\_
  - b. chlorine \_\_\_\_\_
  - c. fecal matter, animal manure \_\_\_\_\_
  - d. paint, pipes, metal, petroleum, glass, electronics \_\_\_\_\_
  - e. uranium, alpha particles, radium \_\_\_\_\_
  - f. total trihalomethanes \_\_\_\_\_
5. Suppose you had a problem with a leaky septic tank in your back yard. Which treatment method would you use and why?





## WORKSHEET 2: WHAT'S IN YOUR DRINKING WATER?

### Introduction

As a concerned citizen, you may want to know what is in your drinking water and whether it is safe. There are over 90 different contaminants that regulated by primary and secondary drinking water standards. This game features only 12 of the contaminants that may be found in drinking water. As you play the game, you should begin to recognize different categories of contaminants, primary or secondary standards, potential health effects, and methods to protect drinking water.

### Materials

- *Game Key* - green (one/student)
- *Playing Cards* - blue (one set/pair of students)
- Background Reading: *Is Your Drinking Water Safe?*

### Procedure

1. Working in pairs, use the *Playing Cards* (blue) to answer questions 2 – 7 on this worksheet. Refer to the *Game Key* (green card) for definitions and symbols.
2. Sort the blue *Playing Cards* by contaminants that have primary drinking water standards and those that have secondary standards. Put a “P” for Primary and an “S” for Secondary next to the contaminant in the table below.

	<b>Chlorine</b>		<b>Total Coliforms</b>
	<b>Chromium</b>		<b>Total Dissolved Solids</b>
	<b>Copper</b>		<b>Trichloroethylene (TCE)</b>
	<b>Fluoride</b>		<b>Total Trihalomethanes (TTHMs)</b>
	<b>Lead</b>		<b>Turbidity</b>
	<b>Nitrate</b>		<b>Vinyl chloride</b>

3. Sort the *Playing Cards* by type of contaminant. Record the total number of contaminants found in each category.

<b>Categories of Contaminants</b>	<b>Total</b>
Organic Chemicals	
Inorganic Chemicals	
Microorganisms	
Radionuclides	
Disinfectants	
Disinfectant Byproducts	

4. According to the background reading, which category has the greatest number of contaminants with primary standards?



5. Sort the *Playing Cards* by where the contaminant originates, that is, the location of where it enters the drinking water system. List the contaminant under the appropriate heading. Some contaminants may appear more than once.

Water Source	Treatment Plant	Distribution System

6. Where do most of the contaminants enter the drinking water system?

7. Which contaminants are carcinogens (cancer-causing)?



## WORKSHEET 3: DRINKING WATER GAME - INSTRUCTIONS

### Introduction

This game is played like *21 Questions*. You only get to ask “yes” or “no” questions to guess one of the 12 contaminants in the Drinking Water Game. The player that guesses the correct contaminant asking the fewest questions wins!

### Materials

- *Game Key* - green (one/student)
- *Playing Cards* - blue (one set/pair of students)
- *Game Board* - yellow (one/pair of students)
- Markers

### Procedure

1. Play the game in pairs. One person is the “*drinking water specialist*” – the one who knows the drinking water contaminant, the other person is the “*guesser*” – the one who tries to guess the contaminant.
2. Lay the stack of *Game Cards* (blue) face down on the table. The “*drinking water specialist*” draws the top card from the pile and does not show it to the “*guesser*” since this is the contaminant the “*guesser*” is trying to identify.
3. Each player should have a *Game Key card* (green) to use as a reference.
4. The “*guesser*” can only ask “yes” or “no” questions. For example: *Is it a primary standard?*  
**Note:** Both players must use the correct vocabulary. If they do not, add one point.  
For example:
  - **Incorrect:** *Is it a stop sign? (No, it's not a stop sign.)*
  - **Correct:** *Is the contaminant controlled by control and prevention?*
5. The “*guesser*” uses the *Game Board* (yellow) like a bingo card. Place a marker (bean, paper clip, etc.) on each contaminant that has been eliminated after asking a “yes” or “no” question.
6. The “*drinking water specialist*” keeps track of each question asked on the *Score Card* (Worksheet 3). After the player guesses the correct answer, total the number of questions he/she took to get it right.
7. Read out loud to your partner the information on the *Playing Card*. On the *Score Card*, write down one interesting fact you both learned about this contaminant.
8. Players should switch roles and continue playing Round 1.
9. The winner of each round is the player who guesses the drinking water contaminant using the fewest questions. If a player guesses it incorrectly, then add one point to their score.
10. Play three more rounds of the game to see who the real drinking water specialist is!



## DRINKING WATER GAME - SCORE CARD

### Round 1

Player's Name	Number of Questions Asked	Total

Interesting Fact:

### Round 2

Player's Name	Number of Questions Asked	Total

Interesting Fact:

### Round 3

Player's Name	Number of Questions Asked	Total

Interesting Fact:

### Round 4

Player's Name	Number of Questions Asked	Total

Interesting Fact:



## Conclusion Questions

1. From the stack of *Playing Cards*, sort out the contaminants that are regulated by Primary Standards. **Do not include the secondary standards.**
2. Find the MCL for each one, and record it in the table below next to the contaminant.
3. Compare the MCLs and rank the contaminants from the most hazardous to the least hazardous.

**IMPORTANT: The lower the MCL, the more hazardous the chemical.**

Contaminant	MCL (mg/L)	Ranking
Chlorine *		
Chromium		
Copper		
Fluoride		
Lead		
Nitrate		
Trichloroethylene (TCE)		
Total Trihalomethanes (TTHMs)		
Vinyl chloride		

\*MRDL – Maximum Residual Disinfectant Level

4. In the table below, list the top five most hazardous contaminants in the ranking and their potential health effects. You can abbreviate the health effects.

Contaminant	Potential Health Effects

5. List the potential health effects that occur **in at least three** or more of the contaminants. Do not use abbreviations in your answer.
6. Which contaminant(s) are you most concerned about and why?














Hydroville, USA

**GAME MASTERS**

**WHAT'S IN YOUR DRINKING WATER?**

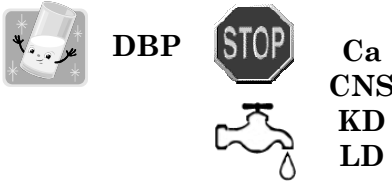
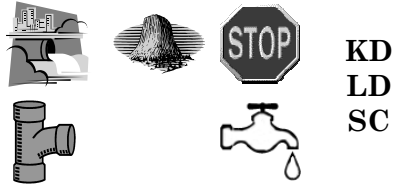

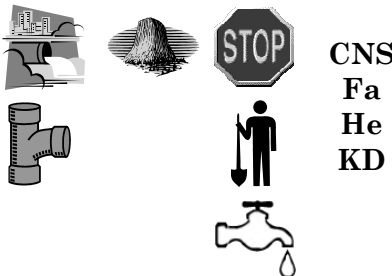
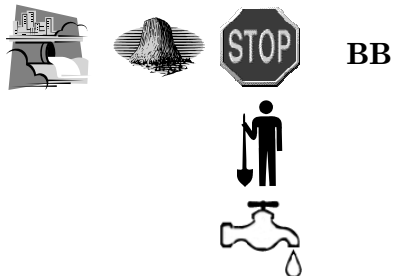
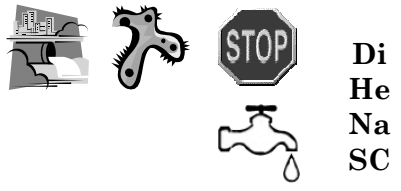

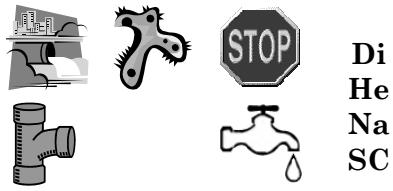
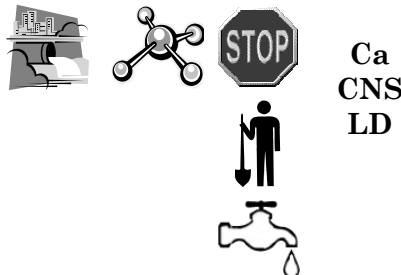
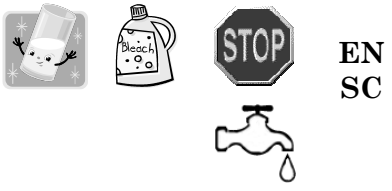
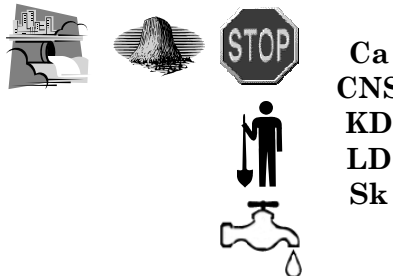
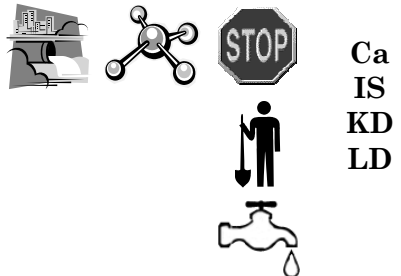
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## GAME KEY

Points of Entry		Classes of Contaminants			
Water Source		<b>Organic Chemicals</b>		<b>Disinfectants</b>	
Treatment Plant		<b>Inorganic Chemicals</b>		<b>Disinfectant Byproducts</b>	<b>DBP</b>
Distribution System		<b>Microorganisms</b>		<b>Radionuclides</b>	
Methods to Protect Drinking Water		Potential Health Effects			
Containment		<b>BB</b> Blue Baby Syndrome	<b>He</b> Headache		
		<b>BD</b> Bone Disease	<b>IS</b> Immune System		
Removal		<b>Ca</b> Cancer	<b>KD</b> Kidney Damage		
		<b>CNS</b> Central Nervous System	<b>LD</b> Liver Damage		
Treatment		<b>Di</b> Diarrhea	<b>Na</b> Nausea		
		<b>EN</b> Eye/Nose irritation	<b>SC</b> Stomach Cramps		
		<b>Fa</b> Fatigue	<b>Sk</b> Skin problems		
Definitions					
<b>ppb</b>	Parts per billion. A measurement of concentration. (1 in 1,000,000,000)				
<b>ppm</b>	Parts per million. A measurement of concentration. (1 in 1,000,000)				
<b>Maximum Contaminant Level (MCL)</b>	The maximum level of a regulated contaminant allowed in drinking water by federal or state laws.				
<b>Maximum Contaminant Level Goal (MCLG)</b>	The contaminant level below which there is no known or expected health risk. MCLGs are often lower than MCLs and based on the best treatment technology available.				
<b>Maximum Residual Disinfectant Level (MRDL)</b>	The highest level of a disinfectant allowed in drinking water.				
<b>Treatment Technique (TT)</b>	A Treatment Technique is used to regulate or reduce the concentration of a contaminant in drinking water. For example, lead which requires treatment plants to control the corrosiveness of the water.				

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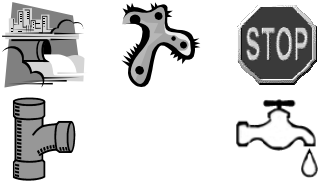
# GAME BOARD

<p><b>Total Trihalomethanes (TTHMs)</b></p> <p><i>Primary Standard</i></p>  <p>DBP Ca CNS KD LD</p>	<p><b>Copper (Cu)</b></p> <p><i>Primary &amp; Secondary Standard</i></p>  <p>KD LD SC</p>	<p><b>Total Dissolved Solids (TDS)</b></p> <p><i>Secondary Standard</i></p>  <p>None</p>
<p><b>Lead (Pb)</b></p> <p><i>Primary Standard</i></p>  <p>CNS Fa He KD</p>	<p><b>Nitrate (NO<sub>3</sub><sup>-</sup>)</b></p> <p><i>Primary Standard</i></p>  <p>BB</p>	<p><b>Turbidity</b></p> <p><i>Primary Standard</i></p>  <p>Di He Na SC</p>
<p><b>Fluoride (F<sup>-</sup>)</b></p> <p><i>Primary &amp; Secondary Standard</i></p>  <p>BD Stains teeth</p>	<p><b>Total Coliforms</b></p> <p><i>Primary Standard</i></p>  <p>Di He Na SC</p>	<p><b>Vinyl chloride</b></p> <p><i>Primary Standard</i></p>  <p>Ca CNS LD</p>
<p><b>Chlorine (Cl<sub>2</sub>)</b></p> <p><i>Primary Standard</i></p>  <p>EN SC</p>	<p><b>Chromium (Cr)</b></p> <p><i>Primary Standard</i></p>  <p>Ca CNS KD LD Sk</p>	<p><b>Trichloroethylene (TCE)</b></p> <p><i>Primary Standard</i></p>  <p>Ca IS KD LD</p>

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## Total Coliforms

Primary Standard



Di  
He  
Na  
SC

Total Coliforms represent bacteria such as fecal coliforms and *E. coli* that are naturally present in the environment. They come from human and animal fecal waste. Total coliforms indicate whether other potentially harmful bacteria may be present. These disease-causing microbes cause the health effects. Total coliforms must be less than 5% in monthly water samples.

## Turbidity

Primary Standard



Di  
He  
Na  
SC

Turbidity is a measure of the cloudiness of water. It indicates the presence of disease-causing microorganisms such as viruses, parasites, and bacteria. Soil runoff also contributes to turbidity. High levels of turbidity may interfere with disinfection. Turbidity cannot exceed 5 NTU (nephelometric turbidity units) in 95% of daily samples.

## Total Trihalomethanes (TTHMs)

Primary Standard



Ca  
CNS  
KD  
LD

Total Trihalomethanes (*TRY-hay-low-METH-ines*) are byproducts of disinfection. TTHMs form when disinfectants (e.g. chlorine) react with organic matter in raw water. Some of the TTHMs in drinking water may come from industrial processes. The major exposure route is inhalation during showering, bathing, general cleaning and washing clothes and dishes. The MCL is 0.080 ppm.

## Fluoride (F<sup>-</sup>)

Primary & Secondary Standard

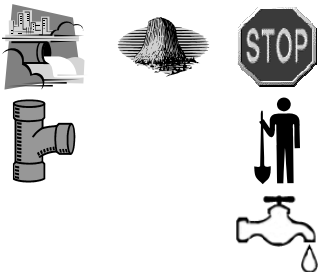


BD  
Stains  
teeth

Many water suppliers add fluoride to drinking water to promote dental health for young children. Fluoride may also come from erosion of natural deposits, discharge from fertilizer, and aluminum factories. If MCL exceeds 4 ppm, it can cause pain and tenderness of the bones in adults. The secondary standard is 2 ppm which may result in a brown staining and/or pitting of permanent teeth.

## Lead (Pb)

Primary Standard

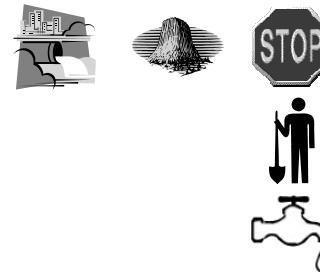


CNS  
Fa  
He  
KD

Lead is a metal found in natural deposits. It is used in batteries, ammunition, household plumbing, and distribution pipes. Lead enters tap water through corrosion of household plumbing systems in older buildings and erosion of natural deposits. Levels are safe if 90% of homes tested are below 0.015 ppm. Can cause physical or mental delays in infants and children.

## Nitrate (NO<sub>3</sub><sup>-</sup>)

Primary Standard



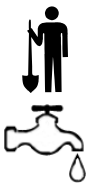
BB

Nitrate is a major component of animal manure, human sewage and waste, and fertilizer. Sources are runoff from fertilizer use; leaching from septic tanks; sewage and erosion of natural deposits. Infants under 6 months old are especially sensitive to nitrates. Symptoms include "blue baby syndrome" which is the inability for the blood to carry oxygen to vital body tissues. The MCL is 10 ppm.

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## Trichloroethylene (TCE)

Primary Standard

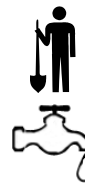


Ca  
IS  
KD  
LD

Trichloroethylene (try-KLOR-o-ETH-i-leen) does not occur naturally in the environment. TCE is a solvent used in adhesives, paint removers, and dry cleaning. TCE can be discharged from metal degreasing sites or released into the environment through evaporation, spills, and leaks in underground storage tanks. The MCL is 0.005 ppm (5 ppb).

## Chromium (Cr)

Primary Standard



Ca  
CNS  
KD  
LD  
Sk

Chromium is a naturally occurring metal found in rocks, soil, and in volcanic dust and gases. Chromium is used for making steel, chrome plating, dyes and pigments, tanning leather, and preserving wood. Sources are from steel and pulp mills, erosion of natural deposits, and runoff at mining sites. The MCL for chromium is 0.10 ppm.

## Copper (Cu)

Primary & Secondary Standard



KD  
LD  
SC

Copper is a metal found in natural ore deposits. It is used to make pennies, electrical wiring, and widely used in household plumbing materials. High levels of copper occur if corrosive water comes in contact with household plumbing. Copper must be below 1.3 ppm in 90% of homes tested. If level exceeds 1.0 ppm, water can leave blue-green stains on bathroom fixtures.

## Total Dissolved Solids (TDS)

Secondary Standard



None

Water with total dissolved solids is often hard, cloudy, and smelly, with a salty or bitter taste. Total dissolved solids originate from natural sources or minerals, such as calcium, phosphorus, and magnesium. They also come from industrial wastes. TDS can stain clothing and leave scaly deposits on fixtures if the MCL is over 500 ppm.

## Chlorine (Cl<sub>2</sub>)

Primary Standard



EN  
SC

Chlorine forms sodium hypochlorite, the active ingredient in bleach. It is a disinfectant added to control microorganisms in drinking water and in the distribution system. The MRDL (Maximum Residual Disinfectant Level) for chlorine is 4.0 ppm. Chlorine may give off a distinct odor if levels are high in drinking water.

## Vinyl chloride

Primary Standard



Ca  
CNS  
LD

Vinyl chloride is a colorless gas. It is used to make polyvinyl chloride (PVC), plastic products, including pipes, wire and cable coatings, and packaging materials. Vinyl chloride can enter drinking water from plastics factories, hazardous waste sites, landfills, and when TCE (trichloroethylene) breaks down in the environment. The MCL is 0.002 ppm (2 ppb).

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