

# Drinking Water Standards and the Health Effects of Drinking Contaminated Water

Water Quality Fact Sheet 1

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When you fill a glass with water from your tap, you expect to drink water that is safe and pure. However, suspended or dissolved gases, minerals, bacteria, metals, or chemicals may influence the quality of your water. Contaminated drinking water can adversely affect your health.

## Drinking Water Standards

As authorized by the 1974 Safe Drinking Water Act and its amendments, the U.S. Environmental Protection Agency (EPA) has established limits, or standards, on the concentrations of certain contaminants that are allowed in public drinking water supplies. These standards are set to protect public health by ensuring good water quality. EPA standards for drinking water fall into two categories: primary standards and secondary standards.

### Primary Standards

Primary standards protect consumers from microbial contaminants, radioactive elements, and toxic chemicals. Primary standards set a limit, the maximum contaminant level (MCL), on the highest allowable concentration of a contaminant in public drinking water supplies. The MCL, which is enforced by the EPA, is set as close as possible to the maximum con-

taminant level goal (MCLG), a preliminary standard set but not enforced by the EPA. The MCLG is based entirely on health considerations; as a health goal, it is set at a level at which no adverse health effects should occur. The nonenforceable MCLG is used to establish the enforceable MCL, which also takes into consideration the feasibility and cost of analysis and treatment of the regulated contaminant.

### Secondary Standards

Secondary standards regulate contaminants that cause offensive taste, odor, color, corrosivity, foaming, or staining. The concentration limit is called the secondary maximum contaminant level (SMCL). Secondary standards are not enforced; they are guidelines for water treatment plant operators and state governments attempting to provide communities with the best quality water possible.

## How Standards Are Set

Primary standards for drinking water contaminants are based on three criteria:

- The contaminant causes adverse health effects.
- The contaminant is detectable in drinking water.

- The contaminant is known to occur in drinking water.

In setting primary standards for a drinking water contaminant, the EPA first looks at all the toxicological data on that contaminant, usually obtained from acute and chronic animal studies. (Human clinical or epidemiological data are used when they are available, but scientific data linking human health to drinking water contaminants are limited.) Experts use this information to estimate the concentration of the contaminant that may be toxic and the concentration level, if any, at which the contaminant causes no adverse health effects.

### **Acute and Chronic Health Effects**

Toxic doses of chemicals cause either acute or chronic health effects. An acute effect usually follows a large dose of a chemical and occurs almost immediately. Examples of acute health effects are nausea, lung irritation, skin rash, vomiting, dizziness, and even death.

The levels of contaminants found in drinking water are seldom high enough to cause acute health effects. They are most likely to cause chronic health effects, which occur long after exposure to small amounts of a contaminant. Examples of chronic health effects include cancer, birth defects, organ damage, disorders of the nervous system, and damage to the immune system.

### **Acceptable Daily Intake**

If a chemical does not cause cancer, drinking water standards are calculated from the acceptable daily intake (ADI). The ADI is the daily dose of a substance (including a safety margin) that a person can ingest over a lifetime without suffering adverse health effects. The ADI is used to establish the MCLG for a contaminant, which in turn is used to set the enforceable MCL.

### **Risk Estimate**

If a contaminant causes cancer, it is assumed that no concentration is safe. Consequently, the MCLG is set at zero, a level that is not always possible to achieve. However, at very low concentrations the risk of cancer becomes so small that it is considered negligible. Therefore, regulatory officials must decide what level of risk is acceptable. The concentration of a chemical estimated to cause this “acceptable level” of risk is the risk estimate.

## **Current Drinking Water Standards**

Regulations governing drinking water have more than tripled since the passage of the Safe Drinking Water Act Amendments in 1986. The EPA is required to update the list of regulated contaminants every 3 years. As of February 1993, the EPA had published 13 rules regulating more than 70 contaminants, with other rules proposed through 1995.

Although the EPA oversees community drinking water quality, regulatory officials in each state ultimately set and enforce drinking water standards for EPA-regulated and other contaminants. States are permitted to set standards that are stricter, but not less stringent, than the MCL's set by EPA. When a standard is exceeded, the EPA, through the designated state agency, requires that the contaminant level be reduced to the MCL. The corrective treatment is left to the individual water supply system.

### **Drinking Water Standards Are Not Absolute**

Setting drinking water standards is an imperfect process influenced by economic, political, and social considerations, in addition to scientific data. In fact, data relating human health effects to chemicals in drinking water are limited, and scientists have difficulty predicting the effects of drinking small amounts of chemicals for many years. Furthermore, standards do not take into account the presence of multiple chemicals, which may increase or decrease the toxicity of a particular contaminant.

For these reasons, it is important to understand that primary drinking water standards do not guarantee that water with a contaminant level below the standard is risk-free, nor do they indicate that water with a higher level is unsafe. Drinking water standards represent conservative judgments of scientists and regulatory officials, which are based on all available information on the health effects of drinking water contaminants.

Therefore, although current drinking water standards do not guarantee that the glass of water you draw from your tap is absolutely safe and pure, they do provide monitoring guidelines for public water supply systems and concerned individuals with private water supplies. Current drinking water standards reflect sound scientific judgment and are based on all the knowledge that is available at the time the stan-

## Regulated Contaminants

### Inorganic Contaminants

Inorganic contaminants occur naturally in soil and rocks and often contaminate water during mining processes. Additional sources include refining and other

industrial processes, sewage treatment, waste incineration, landfills, and industrial waste sites.

Contaminant	EPA standards	Possible chronic health effects
Antimony	MCL: 0.006 MCLG: 0.006	Decreases longevity; alters glucose and cholesterol levels
Arsenic <sup>a</sup>	MCL: 0.05 MCLG: 0.05	Skin and lung cancer; liver and kidney damage
Asbestos	MCL: 7.0 MFL MCLG: 7.0 MFL	Lung cancer; gastrointestinal cancer when swallowed fibers exceed 10 micrometers in length
Barium	MCL: 2.0 MCLG: 2.0	Hypertension; heart damage
Beryllium	MCL: 0.001 MCLG: 0.0	Cancer; lung and kidney damage
Cadmium	MCL: 0.005 MCLG: 0.005	Kidney damage
Chromium	MCL: 0.1 MCLG: 0.1	Liver, kidney, and lung damage
Copper	MCL: TT MCLG: 1.3	Liver and kidney damage; digestive disturbances; anemia
Cyanide	MCL: 0.2 MCLG: 0.2	Spleen and liver damage, brain damage
Fluoride	MCL: 4.0 MCLG: 4.0	Mottling of teeth; bone damage
Lead	MCL: TT MCLG: 0.0 AL: 0.015	Brain and nerve damage (especially in children); kidney damage; digestive disturbances; blood disorders; hypertension
and		Brain and nerve damage; kidney damage; birth defects Mercury MCL: 0.002 MCLG: 0.002 skin rash
Nickel	MCL: 0.1 MCLG: 0.1	Heart and liver damage
Nitrate (as N)	MCL: 10.0 MCLG: 10.0	Methemoglobinemia in infants (blue-baby syndrome)
Nitrite (as N)	MCL: 1.0 MCLG: 1.0	Methemoglobinemia in infants (blue-baby syndrome)
Nitrate & Nitrite	MCL: 10.0 MCLG: 10.0	Methemoglobinemia in infants (blue-baby syndrome)
Selenium	MCL: 0.05 MCLG: 0.05	Growth inhibition; skin discoloration; dental and digestive problems; liver damage and psychological disorders
Sulfate	MCL: 400–500 <sup>b</sup>	Acute diarrhea

(table continues)

## Inorganic Contaminants (continued)

Contaminant	EPA standards	Possible chronic health effects
Thallium	MCL: 0.002 MCLG: 0.0005	Kidney, liver, brain, and intestinal damage

*Note.* Unless otherwise noted, EPA standards are measured in milligrams per liter. MCL = maximum contaminant level; MCLG = maximum contaminant level goal; MFL = million fibers per liter; TT = treatment technique; AL = action level.

<sup>a</sup>Proposed MCL is in the range of 0.002 to 0.02; the proposed MCLG is 0.0. The decision is expected in 1994.

<sup>b</sup>This is the proposed level; a decision is expected in 1994.

## Organic Contaminants

Organic contaminants originate from industrial manufacturing processes, agricultural chemicals man-

ufacture and application, and municipal and hazardous waste sites.

Contaminant	EPA standards	Possible chronic health effects
Acrylamide	MCL: TT MCLG: 0.0	Cancer; nervous system damage
Alachlor	MCL: 0.002 MCLG: 0.0	Cancer; eye and liver damage
Aldicarb <sup>a</sup>	MCL: 0.003 MCLG: 0.001	Central nervous system depression
Aldicarb sulfone <sup>a</sup>	MCL: 0.002 MCLG: 0.001	Central nervous system depression
Aldicarb sulfoxide <sup>a</sup>	MCL: 0.004 MCLG: 0.001	Central nervous system depression
Atrazine	MCL: 0.003 MCLG: 0.003	Dermatitis
Benzene	MCL: 0.005 MCLG: 0.0	Leukemia and other cancers; nerve, lung, kidney and reproductive organ damage; blood disorders
Benzo(a)pyrene	MCL: 0.0002 MCLG: 0.0	Cancer
Carbofuran	MCL: 0.04 MCLG: 0.04	Reproductive and immune system damage; cholinesterase inhibition
Carbon tetrachloride	MCL: 0.005 MCLG: 0.0	Central nervous system depression; liver and kidney damage; cancer
Chlordane	MCL: 0.002 MCLG: 0.0	Cancer; nerve and liver damage
2,4-D	MCL: 0.07 MCLG: 0.07	Liver, kidney, and muscle damage; skin irritations
Dalapon	MCL: 0.2 MCLG: 0.2	Kidney and liver damage
Dibromochloropropane	MCL: 0.0002 MCLG: 0.0	Kidney and liver damage; cancer; infertility

## Organic Contaminants (continued)

Contaminant	EPA standards	Possible chronic health effects
<i>p</i> -Dichlorobenzene	MCL: 0.075 MCLG: 0.075	Liver and kidney damage; blood disorders
<i>o</i> -Dichlorobenzene	MCL: 0.6 MCLG: 0.6	Liver and kidney damage; eye and nose irritation
1,2-Dichloroethane	MCL: 0.005 MCLG: 0.0	Cancer; lung, heart, kidney and liver damage; central nervous system depression
1,1-Dichloroethylene	MCL: 0.007 MCLG: 0.007	Central nervous system depression; liver, heart, and kidney damage
<i>cis</i> -1,2-Dichloroethylene	MCL: 0.07 MCLG: 0.07	Central nervous system depression; liver and kidney damage
<i>trans</i> -1,2-Dichloroethylene	MCL: 0.1 MCLG: 0.1	Central nervous system depression; ethylene liver and kidney damage
Dichloromethane	MCL: 0.005 MCLG: 0.0	Cancer
1,2-Dichloropropane	MCL: 0.005 MCLG: 0.0	Liver and kidney damage
Diadipate	MCL: 0.5 MCLG: 0.5	Liver and testes damage
Diphthalate	MCL: 0.006 MCLG: 0.0	Cancer
Dinoseb	MCL: 0.007 MCLG: 0.007	Thyroid and reproductive organ damage
Diquat	MCL: 0.02 MCLG: 0.02	Liver, kidney, and gastrointestinal tract damage; cataracts
Endothall	MCL: 0.1 MCLG: 0.1	Liver, kidney, gastrointestinal tract, and reproductive organ damage
Endrin	MCL: 0.002 MCLG: 0.002	Liver and nervous system damage; birth defects
Epichlorohydrin	MCL: TT MCLG: 0.0	Cancer; central nervous system, lung, liver, testes, and kidney damage
Ethylbenzene	MCL: 0.7 MCLG: 0.7	Nerve, brain, liver, and kidney damage
Ethylene dibromide	MCL: 0.00005 MCLG: 0.0	Cancer; liver, kidney, central nervous system, gastrointestinal, and reproductive organ damage
Glyphosphate	MCL: 0.7 MCLG: 0.7	Liver and kidney damage
Heptachlor	MCL: 0.0004 MCLG: 0.0	Cancer; liver and central nervous system damage
Heptachlorepoxyde	MCL: 0.0002 MCLG: 0.0	Cancer; liver and central nervous system damage
Hexachlorobenzene	MCL: 0.001 MCLG: 0.0	Cancer
Hexachlorocyclopentadiene	MCL: 0.05 MCLG: 0.05	Stomach and kidney damage

(table continues)

## Organic Contaminants (continued)

Contaminant	EPA standards	Possible chronic health effects
Lindane	MCL: 0.0002 MCLG: 0.0002	Liver and kidney damage
Methoxychlor	MCL: 0.04 MCLG: 0.04	Central nervous system, liver and kidney damage
Monochlorobenzene	MCL: 0.1 MCLG: 0.1	Eye, nose, and skin irritant; drowsiness; incoherence; liver damage
Oxamyl (Vydate)	MCL: 0.2 MCLG: 0.2	Kidney damage
reproductive disorders	Pentachlorophenol (PCP)	Liver, kidney, nervous system, immune system, and organ damage; blood
Picloram	MCL: 0.5 MCLG: 0.5	Liver and kidney damage
Polychlorinated biphenyls (PCBs)	MCL: 0.0005 MCLG: 0.0	Cancer; liver damage
Simazine	MCL: 0.004 MCLG: 0.004	Cancer
Styrene	MCL: 0.1 MCLG: 0.1	Liver damage
Tetrachloroethylene	MCL: 0.005 MCLG: 0.0	Cancer; liver and kidney damage; central nervous system depression
Toluene	MCL: 1.0 MCLG: 1.0	Central nervous system depression; kidney damage
Toxaphene	MCL: 0.005 MCLG: 0.0	Cancer; liver and kidney damage
2,4,5-TP (Silvex)	MCL: 0.05 MCLG: 0.05	Liver and kidney damage
1,2,4- Trichlorobenzene	MCL: 0.07 MCLG: 0.07	Liver and kidney damage
1,1,1- Trichloroethane	MCL: 0.2 MCLG: 0.2	Central nervous system depression; liver and cardiovascular damage
1,1,2- Trichloroethane	MCL: 0.005 MCLG: 0.003	Kidney and liver damage
2,3,7,8-TCDD (dioxin)	MCL: $5 \times 10^{-8}$ MCLG: 0.0	Cancer
Trichloroethylene (TCE)	MCL: 0.005 MCLG: 0.0	Cancer; central nervous system depression; heart, liver, and kidney damage
Total trihalomethanes	MCL: 0.1 MCLG: 0.0	Cancer; heart, lung, kidney, and liver damage
		Cancer; central nervous system depression; liver, reproductive, and digestive tract dam-

## Organic Contaminants (continued)

age; Vinyl chloride	MCLG: 0.0	birth defects
Contaminant	EPA standards	Possible chronic health effects
Xylenes (total)	MCL: 10.0 MCLG: 10.0	Central nervous system and reproductive organ damage

*Note.* Unless otherwise noted, EPA standards are measured in milligrams per liter. MCL = maximum contaminant level; MCLG = maximum contaminant level goal; TT = treatment technique.

## Microbial Contaminants

Microbial contaminants are usually present in sewage and also in animal waste. The major sources of micro-

bial contamination are septic systems and agricultural practices such as manure spreading.

Contaminant	EPA standards	Possible chronic health effects
<i>Giardia lamblia</i>	MCL: TT MCLG: 0.0	Giardiasis: gastrointestinal infection causing fatigue, diarrhea, abdominal cramps, and gas
<i>Legionella</i>	MCL: TT MCLG: 0.0	Legionnaires' disease; Pontiac Fever
Standard plate count	MCL: TT MCLG: Not applicable	Not applicable
Total coliforms	MCL: < 5% positive MCLG: 0.0	Gastroenteritis; typhoid fever; dysentery; cholera and salmonella infection
Turbidity	MCL: PS MCLG: Not applicable	Not applicable
Viruses	MCL: TT MCLG: 0.0	Gastroenteric and other viral diseases; hepatitis

*Note.* Unless otherwise noted, EPA standards are measured in milligrams per liter. MCL = maximum contaminant level; MCLG = maximum contaminant level goal; TT = treatment technique; PS = performance standard (0.5–1.0 ntu).

## Radionuclide Contaminants

The primary source of radionuclides is the natural decay of uranium in rocks and soil.

Contaminant	EPA standards	Possible chronic health effects
Alpha emitters	MCL: 15 pCi/L MCLG: 0.0	Cancer
Beta-particles	MCL: 4 mrem MCLG: 0.0	Cancer; bone and kidney damage

(table continues)

## Radionuclide Contaminants (continued)

Contaminant	EPA standards	Possible chronic health effects
Photon emitters <sup>a</sup>	MCL: 4 mrem MCLG: 0.0	Cancer
Radium-226 <sup>a</sup>	MCL: 20 pCi/L	Cancer
Radium-228 <sup>a</sup>	MCL: 20 pCi/L MCLG: 0.0	Cancer
Radon <sup>a</sup>	MCL: 300 pCi/L MCLG: 0.0	Cancer
Radium-226+228	MCL: 5 pCi/L MCLG: 0.0	Bone cancer; kidney damage; birth defects
Uranium <sup>a</sup>	MCL: 20 mg/L MCLG: 0.0	Cancer

*Note.* Unless otherwise noted, EPA standards are measured in milligrams per liter. MCL = maximum contaminant level; MCLG = maximum contaminant level goal; mrem = millirem (measure of radiation); pCi/L = picocuries per liter.

<sup>a</sup>Proposed regulations. Standards will be issued in 1994.

## References

- \_\_\_\_\_. 1985. National primary drinking water regulations; volatile synthetic organic chemicals. *Federal Register* 50(219): 46879–46934.
- \_\_\_\_\_. 1985. National primary drinking water regulations; synthetic organic chemicals, inorganic chemicals, and microorganisms. *Federal Register* 50(219): 46935–47022.
- \_\_\_\_\_. 1987. National primary drinking water regulations; synthetic organic chemicals; monitoring for unregulated contaminants. *Federal Register* 52(130): 25690–25734.
- Boyd, S., A. Jones, A. Knaus, and C. McGrath, eds. 1986. *Drinking water: A community action guide*. Washington, DC: Concern Inc.
- Council on Environmental Quality. 1981. *Contamination of ground water by toxic organic chemicals*. Washington, DC: U.S. Government Printing Office.
- Pontius, F. W. 1993. Federal drinking water regulation update. *Journal AWWA* 85: 42–51.
- Pontius, F. W., and J. A. Roberson. 1994. The current regulatory agenda: An update. *Journal AWWA* 86: 54–63.
- Safe Drinking Water Committee. National Academy of Sciences, National Research Council. 1986. *Drinking water and health*. Vol. 6. Washington, DC: National Academy Press.
- WaterTest Corporation. 1986. *Manual*. 6th ed. Manchester, NH: WaterTest Corporation.
- Environmental Protection Agency. 1986. Regulated contaminants and their health effects. *EPA Journal* 12(7): 26–28.
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