

Elemental Metals and Toxic Effects

Many communities may have high levels of toxic metals in their drinking water, particularly those served by from private wells, because of contamination or as a result of the geology of the area.

The toxicity of a substance is derived from studies by observing the health effect on humans who have been exposed to the substance, where applicable or on laboratory animals such as rats.

Exposure to a substance is evaluated by three different ways:

1. The route of exposure: inhalation, digestion, or skin contact.
2. The duration of exposure: chronic or acute,
3. The amount of exposure: high or low concentration.

These factors are taken into consideration when determining the toxic effect of a substance and whether it is considered carcinogenic, cancer causing substance.

Metals are divided into the following categories:

Toxic and Human Carcinogens

Reasonably Anticipated Human Carcinogens

Toxic Metals

Essential Metals at low levels with Toxicity Potential at high levels

Heavy Metals

Carcinogenic Metals		Non-Carcinogenic Metals	
Toxic Metals	Metals Reasonably Anticipated To Be Human Carcinogens	Toxic Metals	Essential Metals with Toxicity Potential*
Arsenic (As)	Cobalt (Co)	Lead (Pb)	Aluminum (Al)
Beryllium (Be)	Nickel (Ni)	Mercury (Hg)	Chromium (Cr ⁺³)
Cadmium (Cd)	Selenium (Se)	Strontium (Sr)	Copper (Cu)
Chromium (Cr)		Antimony (Sb)	Cobalt as Vitamin B ₁₂ (Co)
		Barium (Ba)	Manganese (Mn)
		Boron (B)	Selenium (Se)
			Zinc (Zn)

* Some of these metals are considered essential for human health. However, if high levels are consumed, then potential toxicity and health effects may occur. Please refer to the Metals Toxicity Table.

Metals Toxicity and Health Effects

Metal	MCL mg/L	Background	Health Effects
Aluminum	0.05-0.2	Virtually all food, water, air, and soil contain some aluminum. Some people with kidney disease store a lot of aluminum in their bodies and sometimes develop bone or brain diseases which may be caused by excess aluminum.	Exposure to low levels of aluminum is usually not harmful, but exposure to high levels can affect your health. It does not appear that children are more sensitive to aluminum than adults.
Antimony	0.006	Because antimony is found naturally in the environment, the general population is exposed to low levels of it every day, primarily in food, drinking water, and air.	Exposure to antimony at high levels can result in a variety of adverse health effects. Ingesting antimony for long term may cause liver damage. It does not appear that children are more sensitive to antimony than adults.
Arsenic	0.01	Arsenic occurs naturally in soil and minerals; common arsenic compounds can dissolve in water. Therefore, many residences have the potential for high levels of arsenic in their drinking water, particularly those served by private wells, as a result of the geology of the area.	Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea, vomiting, and decreased production of red and white blood cells. There is some evidence that long-term exposure to arsenic in children may result in lower IQ scores. Cancer Effects: <i>Known to be a Human Carcinogen.</i>
Barium	2	Barium compounds, such as barium sulfate and barium carbonate, which do not dissolve well in water, remain stable in the environment for extended periods of time.	Barium has been found to potentially cause gastrointestinal disturbances and muscular weakness when people are exposed to it at levels above the EPA drinking water standards for relatively short periods of time. We do not know whether children are more or less sensitive than adults to barium toxicity.
Beryllium	0.004	Beryllium enters water from the erosion of rocks and soil, and from industrial waste. Some beryllium compounds will dissolve in water, but most settle into the sediment. The general population is normally exposed to low levels of beryllium in air, food, and water.	Swallowing beryllium has not been reported to cause harmful effects in humans because very little beryllium is absorbed into the blood stream. Beryllium contact with skin that has been scraped or cut may cause rashes or ulcers. It is unknown if exposure to beryllium will result in birth defects or other developmental effects in people. Cancer Effects: <i>Known to be a Human carcinogen.</i>

Boron		Boron is widely distributed in surface water and groundwater. Boron cannot be easily stabilized in the environment. It can easily change its form and become attached or separated from particles in soil, sediment, and water.	Exposure to large amounts of boron (about 30 g of boric acid) over short periods of time can affect the stomach, intestines, liver, kidney, and brain, and can eventually lead to death. It is likely that children would show the same health effects as adults.
Cadmium	0.005	All soils and rocks contain some cadmium. Environmentally available cadmium enters soil, water, and air from mining, industry, burning coal and household wastes.	Long-term exposure to lower levels of cadmium in air, food, or water leads to a buildup of cadmium in the kidneys which can lead to possible kidney disease. Other long-term effects are lung damage and brittle bones. The health effects in children are expected to be similar to the effects seen in adults. Cancer Effects: <i>Known to be a Human Carcinogen.</i>
Chromium	0.1	Chromium can be found in air and soil. Chromium does not usually remain in the atmosphere, but is deposited into the soil and water. It can easily change from one form to another in water and soil, depending on the conditions present.	Chromium (III) is an essential nutrient that helps the body use sugar, protein, and fat. Some people are extremely sensitive to chromium (VI) or chromium (III). Allergic reactions consisting of severe redness and swelling of the skin have been noted. It is unknown if exposure to chromium will result in birth defects or other developmental effects in people. Cancer Effects: <i>Known to be a Human Carcinogen.</i>
Cobalt		Some cobalt compounds are water-soluble. Other forms of the element are known to settle out in bottom sediments. Radioactive decay decreases the amount of radioactive cobalt in the environment.	Cobalt can benefit or harm human health. Cobalt is beneficial for humans because it is part of vitamin B12. Exposure to high levels of cobalt can result in lung and heart effects and dermatitis. The general population is rarely exposed to radioactive cobalt unless a person is undergoing radiation therapy. Cancer Effects: <i>Reasonably Anticipated to be Human Carcinogen.</i>
Copper	1.3	Copper is released from natural sources, like volcanoes, windblown dusts, decaying vegetation, and forest fires. Drinking water may have high levels of copper if the residence has copper pipes and corrosive water.	Everyone must absorb small amounts of copper every day because it is essential for good health. Ingesting high levels of copper can cause nausea, vomiting, and diarrhea. It can also cause damage to your liver and kidneys, and can even cause death. Studies in animals suggest that the young may experience more severe effects than adults, but it is not known if this would also be true in human children.

Lead	0.015	<p>Lead can be found in all parts of our environment. Much of it comes from human activities.</p> <p>We may be exposed to lead by eating food or drinking water that has been contaminated through fallout from airborne dust or lead-based solders in copper plumbing.</p> <p>Exposure can also come from spending time in areas where lead-based paints have been used and are deteriorating.</p> <p>Small children can be exposed by eating lead-based paint chips, chewing on objects painted with lead-based paint or swallowing house dust or soil that contains lead.</p>	<p>Lead can affect almost every organ and system in your body. The most critical target for lead toxicity is the nervous system, both in adults and children.</p> <p>Long-term exposure to lead can result in decreased functions of the nervous system.</p> <p>Exposure to high lead levels can severely damage the brain and kidneys in adults and children and ultimately cause death.</p> <p>In pregnant women, high levels of lead may be transferred to the fetus and cause miscarriage. Harmful effects may also include premature births and/or smaller babies.</p> <p>It may cause decreased mental ability in the infant and learning difficulties and reduced growth in young children.</p>
Manganese		<p>Manganese is a naturally occurring metal that is found in many types of rocks. Manganese is routinely contained in groundwater, drinking water, and soil at low levels. Drinking water containing significant levels of manganese or swimming or bathing in water containing manganese may expose you to low levels of this chemical. Manganese may enter the body orally or through swimming or bathing.</p>	<p>Manganese is an essential nutrient, and eating a small amount of it each day is important to stay healthy.</p> <p>Exposure to high levels of manganese may cause behavioral changes and other nervous system effects such as decreased dexterity. Studies in children have suggested that extremely high levels of manganese exposure may have undesirable effects on brain development, including changes in behavior and a decrease in the ability to learn and remember.</p>
Mercury	0.002	<p>Mercury is the only metal on earth which is liquid at room temperatures.</p> <p>Inorganic mercury enter water or soil from the weathering of rocks that contain mercury, from factories or water treatment facilities that release water contaminated with mercury, and from incineration of municipal garbage that contains mercury (for example, in thermometers, electrical switches, fluorescent light bulbs, or batteries that have been thrown away).</p>	<p>When exposed to mercury, very young children are more sensitive than adults to its' effect.</p> <p>Children 5 years of age and younger are considered to be particularly sensitive to the effects of mercury on the nervous system, since their central nervous system is still developing.</p> <p>When pregnant women are exposed to mercury, the mercury can pass from the mother's body to the developing fetus; it can also be passed to a nursing infant through breast milk.</p> <p>Mercury can enter and accumulate throughout the food chain.</p>
Nickel		<p>Nickel is a very abundant natural element. Nickel can be combined with other metals, such as iron, copper, chromium, and zinc, to form alloys. Most nickel is used to make stainless steel.</p> <p>Many nickel compounds dissolve fairly easy in water and have a green color.</p>	<p>The most common harmful health effect of nickel in humans is an allergic reaction. Less frequently, some people who are sensitive to nickel have asthma attacks following exposure to nickel.</p> <p>Some sensitized people react when they... consume food or water containing nickel.</p>

		Nickel released in industrial wastewater ends up in soil, sediment, or water where it strongly attaches to particles containing iron or manganese.	Eating or drinking large amounts of nickel has caused lung disease in dogs and rats and has affected their stomach, blood, liver, kidneys, and immune system, as well as their reproduction and development. Cancer Effects: <i>Reasonably Anticipated to be Human Carcinogen.</i>
Selenium	0.05	Selenium is a naturally occurring mineral element and can enter water from rocks, soil, and from agricultural and industrial waste. Some selenium compounds can easily dissolve in water, and some will settle to the bottom as particles. Selenium may accumulate and move freely through the food chain.	Selenium has both beneficial and harmful effects. Low doses of selenium are needed to maintain good health. Chronic oral exposure to high concentrations of selenium compounds can produce a disease called selenosis. The major signs of selenosis are hair loss, nail brittleness, and neurological abnormalities. Selenium compounds have not been shown to cause birth defects in humans or in other mammals. Cancer Effects: <i>Reasonably Anticipated to be Human Carcinogen.</i>
Strontium		Strontium in the environment exists in four stable isotopes, 84Sr (read as strontium eighty-four), 86Sr, 87Sr, and 88Sr. Food and drinking water are the largest sources of exposure to strontium.	Exposure to low levels of stable strontium has not been shown to affect adult health, but may harm children. Exposure to high levels of stable strontium can result in impaired bone growth in children.
Thallium	0.002	In the past, thallium was obtained as a by-product from smelting other metals. It has not been produced in the USA since 1984. Currently, all thallium is obtained from imports and from thallium reserves. It stays in the air, water, and soil for a long time and is not easily stabilized. It is absorbed by plants and moves throughout the food chain. It accumulates in fish and shellfish tissue.	Studies of people who ingested large amounts of thallium over a short time reported vomiting, diarrhea, temporary hair loss, and effects on the nervous system, lungs, heart, liver, and kidneys. It has caused death. Exposure to high levels of thallium showed adverse developmental effects.
Vanadium		Vanadium and vanadium compounds can be found in the earth's crust, rocks, some iron ores, and crude oil deposits. Vanadium mainly enters the environment from natural sources and from the burning of fuel oils. It stays in the air, water, and soil for a long time. It does not dissolve well in water.	Nausea, mild diarrhea, and stomach cramps have been reported in people who have ingested vanadium. A number of effects have been found in animals who have ingested vanadium including decreased number of red blood cells, increased blood pressure, and mild neurological effects. Studies of animals exposed to vanadium during pregnancy have shown a decrease in growth and an increase in the occurrence of birth defects.

Zinc	5.0	Zinc is one of the most common elements in the earth's crust. It is found in air, soil, water, and is present in most foods. It builds up in fish and other animals, but it does not build up in plants. Zinc is present in contaminated drinking water that flows through galvanized pipes coated with zinc in order to resist rust.	Zinc is an essential element in our diet. Too little zinc can cause problems, but too much zinc is also harmful. Harmful effects generally begin at levels 10-15 times higher than the amount needed for good health. Large doses taken by mouth even for a short time can cause stomach cramps, nausea, and vomiting.
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EPA's Maximum Contaminant Level (MCL). Maximum Contaminant Levels are the maximum permissible level of a contaminant in water delivered to users of a public water system.
mg/L = milligrams per liter is equivalent to parts per million (ppm).

References:

Agency of Toxic Substances and Disease Registry:

<http://www.atsdr.cdc.gov/az/a.html>

<http://www.atsdr.cdc.gov/mrls/mrllist.asp#34tag>