

1. PUBLIC HEALTH STATEMENT

This public health statement tells you about beryllium and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Beryllium has been found in at least 535 of the 1,613 current or former NPL sites. However, the total number of NPL sites evaluated for this substance is not known. As more sites are evaluated, the sites at which beryllium is found may increase. This information is important because exposure to this substance may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to beryllium, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS BERYLLIUM?

Beryllium is an element that occurs naturally. It is present in a variety of materials, such as rocks, coal and oil, soil, and volcanic dust. Two kinds of mineral rocks, bertrandite and beryl, are mined commercially for the recovery of beryllium. Very pure gem-quality beryl is better known as either aquamarine (blue or blue-green) or emerald (green). Beryllium is the lightest metal. A key distinction among beryllium compounds is that some are soluble in water, but many are not.

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Most of the beryllium ore that is mined is converted into alloys (mixtures of metals). Most of these alloys are used in making electrical and electronic parts or as construction materials for machinery and molds for plastics. Beryllium alloys are also used in automobiles, computers, sports equipment (such as golf clubs and bicycle frames), and dental bridges. Pure beryllium metal is used in nuclear weapons and reactors, aircraft and space vehicle structures, instruments, x-ray machines, and mirrors. Beryllium oxide is also made from beryllium ores and is used to make specialty ceramics for electrical and high-technology applications. More information on the chemical and physical properties, production, and uses of beryllium is found in Chapters 4, 5, and 6.

1.2 WHAT HAPPENS TO BERYLLIUM WHEN IT ENTERS THE ENVIRONMENT?

Beryllium enters the air, water, and soil as a result of natural and human activities. Emissions from burning coal and oil increase beryllium levels in the air. In air, beryllium compounds are present mostly as fine dust particles. The dust eventually settles over land and water. Rain and snow aid in removing beryllium from air. Extremely small beryllium particles may remain in the air for about 10 days. Beryllium enters waterways from the wearing away of rocks and soil. Most beryllium products of human origin that enter waterways come from industry discharges of waste water and from beryllium dust in the air from industrial activities settling over water. Most of the beryllium in water settles in the material on the bottom with sediment. Insoluble beryllium compounds remain in ocean water for a few hundred years before settling to the bottom of the ocean. Beryllium, as a chemical component, occurs naturally in soil; however, disposal of coal ash, incinerator ash, and industrial wastes may increase the amount of beryllium in soil. A major portion of beryllium in soil does not dissolve in water and remains bound to soil, so it is not likely to move deeper into the ground and enter groundwater. In the environment, chemical reactions can change the water-soluble beryllium compounds into insoluble forms. In some cases, water-insoluble beryllium compounds can change to soluble forms. Exposure to water-soluble beryllium compounds in the environment, in general, will pose a greater threat to human health than exposure to water-insoluble forms.

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The amount of beryllium that has been measured in the air in different parts of the United States by EPA ranges from not detected to 2 millionths of a gram per cubic meter (g/m^3). Very small dust particles of beryllium in the air fall out of the air onto surface water, plant surfaces, and soil either by themselves or when rain or snow falls. These beryllium particles eventually end up back in the soil or in the bottoms of lakes, rivers, and ponds, where they stay and mix with beryllium that is already there.

Beryllium in water comes from different sources. Most of it comes from dissolving beryllium out of rocks and soil that water runs over and through. Only a very small part is from the settling of beryllium dust out of the air. Some beryllium is suspended in muddy-like (cloudy) water. EPA has found that the levels of beryllium in drinking water in different parts of the United States are extremely low in most cases, and that water containing beryllium at these commonly observed levels is safe to drink. Fish do not accumulate beryllium from water into their bodies to any great extent. Some fruits and vegetables such as garden peas, kidney beans, and pears may have above average levels of beryllium (see Chapter 6). Most of the beryllium that gets into livestock is eliminated quickly in urine and feces.

Beryllium is found in soil in amounts that vary over a wide range, but the typical concentration is 3 thousandths of a gram/kilogram (g/kg) of soil. Additional beryllium can be added by industrial activities. Soluble beryllium compounds can combine with other substances in the environment to form other beryllium compounds. Beryllium compounds may stay in the soil for thousands of years without moving downward into groundwater. In addition to the beryllium found naturally in minerals, beryllium metal and compounds that are left after humans mine and process the minerals can be released back into the environment as landfill waste. More information about the fate and movement of beryllium in the environment is found in Chapter 6.

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1.3 HOW MIGHT I BE EXPOSED TO BERYLLIUM?

You can be exposed to normal levels of beryllium by breathing air, eating food, or drinking water that contains beryllium. In the United States, the average concentration of beryllium in air is 0.03 nanograms (ng) (1 ng=1 billionth of a gram) in a cubic meter (ng/m³) of air. In U.S. cities, the average air concentration is higher, and its value is 0.2 ng in a cubic meter (m³) of air. Cities have higher levels of beryllium in the air because beryllium is released from burning coal and fuel oil. The amount of beryllium that has been measured in drinking water in different parts of the United States by EPA is generally less than 2 trillionths of a gram for every liter of water. Beryllium was found in only 5% of 1,577 drinking water samples obtained throughout the United States. Of these positive samples, the average beryllium concentration was only 190 ng in a liter (L) of water. Beryllium, as a chemical component, is found naturally in some food. The concentration of beryllium in both raw carrots and field corn grown in the United States is less than 25 micrograms (µg) (1 µg=1 millionth of a gram) in a kilogram (kg) of the fresh vegetables. Thus, in comparison with other harmful elements, such as lead and chromium, to which we are (by necessity) exposed on a daily basis, beryllium exposure is not significant.

In certain workplaces, you can be exposed to higher-than-normal levels of beryllium, mostly in the form of beryllium oxide and beryllium metal. Occupational exposure to beryllium occurs at places where the chemical is mined, processed, or converted into metal, alloys, and other chemicals. Workers engaged in machining metals containing beryllium, recycling beryllium from scrap alloys, or using beryllium products may also be exposed to higher levels of beryllium. The number of workers exposed to beryllium or beryllium compounds has been estimated to be 21,000.

As a member of the general public, you may be exposed to higher-than-normal levels of beryllium if you live near an industry that processes or uses beryllium. People who live near hazardous landfill sites that contain high concentrations of beryllium may also be exposed to higher-than-normal levels of beryllium. Beryllium, as a chemical component, occurs naturally in tobacco and may be inhaled from cigarette smoke. People who smoke may breathe higher-than-normal levels of beryllium than people who do not smoke.

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Beryllium metal and metal alloys may be found in consumer products such as electronic devices (e.g., televisions, calculators, and personal computers) and special nonsparking tools. Direct contact with beryllium metal and metal alloys is not likely, since these materials are typically enclosed within a protected case that prevents exposure. No other consumer products or products used in crafts, hobbies, or cottage industries contain significant amounts of beryllium. It is therefore unlikely that beryllium present in consumer products poses any hazard. More information about beryllium exposure can be found in Chapter 6.

1.4 HOW CAN BERYLLIUM ENTER AND LEAVE MY BODY?

Beryllium can enter your body if you breathe air, eat food, or drink water containing it. Beryllium will not enter your body from skin contact with the metal unless the skin is scraped or cut and beryllium particles become imbedded in the wound. Only a small amount of beryllium may enter your body if your skin comes into contact with a beryllium salt dissolved in water. When you breathe air containing beryllium, beryllium particles can be deposited in the lungs. The beryllium that you breathe in slowly dissolves in the lungs and moves slowly into the bloodstream. Some of the beryllium deposited in the lungs can be moved to the mouth and then swallowed; the rest can remain in your lungs for a long time. If you eat food or drink water that contains beryllium, less than 1% passes from your stomach and intestines into the bloodstream. Therefore, most of the beryllium that you swallow leaves your body through the feces without entering the bloodstream. The small amount of beryllium that moves from the lungs, stomach, and intestines into the bloodstream is carried by the blood to the kidneys. Beryllium leaves the kidneys by the urine. Some beryllium can also be carried by the blood to the liver and bones where it may remain for long periods. If you swallow beryllium, beryllium leaves the body in a few days. However, if you inhale beryllium, it may take months to years before your body rids itself of beryllium. This is because it takes a long time before all the beryllium in the lungs enters the bloodstream. For more information, please read Chapter 3.

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1.5 HOW CAN BERYLLIUM AFFECT MY HEALTH?

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Beryllium is a metal that can be harmful when you breathe it. The effects depend on how much and how long you are exposed to it. When you breathe it in, beryllium can damage your lungs. When you breathe in large amounts of soluble beryllium compounds (greater than 1 mg beryllium per cubic meter of air, 1 mg/m³), the lung damage resembles pneumonia with reddening and swelling of the lungs. This condition is called acute beryllium disease. The lung damage may heal if beryllium exposure is stopped. Human studies have shown that occupational and community ambient air standards were effective in eliminating most acute lung disease. Some people can become sensitive to beryllium. This is known as hypersensitivity or allergy. If you become sensitive (allergic) to beryllium, you may develop an immune or inflammatory reaction to small amounts of beryllium that do not cause effects in people who are not sensitive to beryllium. When this occurs, white cells accumulate around the beryllium and form a chronic inflammatory reaction called granulomas (granulomas are not tumors). This condition is called chronic beryllium disease (CBD). This disease can occur long after exposure (10–15 years) to small amounts of either soluble or insoluble forms of beryllium (greater than 0.0005 mg/m³). If you have this disease, you may feel weak, tired, and have difficulty breathing. Some individuals that have CBD may experience anorexia, weight loss, and blueness of hands and feet. This disease could also lead to heart enlargement and heart disease in advanced cases.

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Both the short-term, pneumonia-like disease and the chronic beryllium disease can be fatal. Exposure levels associated with acute or chronic beryllium disease are more 100,000 times higher than normal air levels of beryllium. Long periods of exposure to beryllium have been reported to cause cancer in laboratory animals. Some studies of workers reported an increased risk of lung cancer. The U.S. Department of Health and Human Services and the International Agency for Research on Cancer have determined that beryllium and beryllium compounds are human carcinogens. EPA has determined that beryllium is a probable human carcinogen. EPA has estimated that lifetime exposure to 0.00004 mg beryllium/m³ can result in a one in a thousand chance of developing cancer. We do not know if breathing air, eating food, or drinking water that contains beryllium or having skin contact with beryllium has any effects on reproduction or causes birth defects in humans or animals. Swallowing beryllium has not been reported to cause effects in humans because very little beryllium can move from the stomach or intestines into the bloodstream. Ulcers have been seen in dogs ingesting soluble beryllium salts in the diet. Beryllium contact with skin that has been scraped or cut may cause rashes or ulcers. If you have developed an allergy to beryllium and have skin contact with it, you can get granulomas on the skin. These skin granulomas appear as a rash or as nodules. The skin granulomas are formed in the same way that lung granulomas are formed in sensitive people. For more information on how beryllium can affect your health, please read Chapter 3.

1.6 HOW CAN BERYLLIUM AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans.

It is likely that the health effects seen in children exposed to beryllium will be similar to the effects seen in adults; chronic beryllium disease was found in a child living near a beryllium factory. We do not know whether children differ from adults in their susceptibility to beryllium.

We do not know if exposure to beryllium will result in birth defects or other developmental effects in people. The studies on developmental effects in animals are not conclusive. We have no information to suggest that there are any differences between children and adults in terms of

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how much beryllium will enter the body, where beryllium can be found in the body, and how fast beryllium will leave the body. It is likely that beryllium can be transferred from the mother to an infant in breast milk or that it can cross the placenta.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO BERYLLIUM?

If your doctor finds that you have been exposed to significant amounts of beryllium, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

Higher-than-normal levels of beryllium may be in soil at hazardous waste sites. Some children eat a lot of dirt. You should prevent your children from eating dirt. Make sure they wash their hands frequently, and before eating. If you live near a hazardous waste site, discourage your children from putting their hands in their mouths or from engaging in other hand-to-mouth activities. Some children may be exposed to beryllium by contact with a family member who works in a facility using beryllium. If you work at a facility that uses beryllium, make sure you change your clothes and clean your hair and skin before leaving your job and returning home. Also, do not bring objects home such as work tools that may be contaminated with beryllium.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO BERYLLIUM?

Beryllium can be measured in the urine and blood, but the amount of beryllium in the urine or blood may not reflect the amount to which you were exposed. The measurement of beryllium in urine and blood may not determine how recently you were exposed. Small amounts of human lung and skin can be removed from the body and examined to determine whether beryllium is present in these tissues. These tests can be done in a doctor's office or in a hospital. While high levels of beryllium in urine, blood, or tissues indicate that you were exposed to an excessive amount of beryllium, low levels of beryllium do not necessarily mean that you were not exposed to an excessive amount. A blood test called the beryllium lymphocyte proliferation test (BeLPT)

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can determine if you have become sensitive to beryllium and may have chronic beryllium disease. For more information, please read Chapters 3 and 7.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH ?

The federal government develops regulations and recommendations to protect public health. Regulations *can* be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA).

Recommendations provide valuable guidelines to protect public health but *cannot* be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for beryllium include the following:

OSHA has set a limit of 2 μg beryllium/ m^3 of workroom air for an 8-hour work shift. NIOSH recommends a standard for occupational exposure of 0.5 μg beryllium/ m^3 of workroom air during an 8-hour shift to protect workers from the increased cancer risk associated with beryllium exposure. EPA restricts the amount of beryllium released into the air to 0.01 μg beryllium/ m^3 of air, averaged over a 30-day period. The Department of Energy (DOE) has developed a program to reduce beryllium exposure in workers at DOE facilities. EPA has set a

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maximum allowable amount of 0.004 mg/L beryllium in drinking water. For more information, please read Chapter 8.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333
Web site: <http://www.atsdr.cdc.gov>

* Information line and technical assistance

Phone: 1-888-42-ATSDR (1-888-422-8737)
Fax: 1-404-498-0057

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

* To order toxicological profiles, contact

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000