

## 1. PUBLIC HEALTH STATEMENT

This public health statement tells you about cadmium 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 a long-term federal cleanup. Cadmium has been found in at least 776 of the 1,467 current or former NPL sites. However, its unknown how many NPL sites have been evaluated for this substance. As more sites are evaluated, the sites with cadmium may increase. This 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 can be 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 cadmium, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), the chemical or physical form of cadmium present, 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 CADMIUM?

Cadmium is an element that occurs naturally in the earth's crust. Pure cadmium is a soft, silverwhite metal. Cadmium is not usually present in the environment as a pure metal, but as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide). Cadmium is most often present in nature as complex oxides, sulfides, and carbonates in zinc, lead, and copper ores. It is rarely present in large quantities as the chlorides and sulfates. These different forms of cadmium compounds are solids

that dissolve in water to varying degrees. The chlorides and sulfates are the forms that most easily dissolve in water. Cadmium may change forms, but the cadmium metal itself does not disappear from the environment. Knowing the particular form of cadmium, however, is very important when determining the risk of potential adverse health effects.

Cadmium compounds are often found in or attached to small particles present in air. Most people can not tell by smell or taste that cadmium is present in air or water, because it does not have any recognizable taste or odor. Soils and rocks contain varying amounts of cadmium, generally in small amounts but sometimes in larger amounts (for example in some fossil fuels or fertilizers).

Most cadmium used in the United States is extracted as a by-product during the production of other metals such as zinc, lead, or copper. Cadmium has many uses in industry and consumer products, mainly in batteries, pigments, metal coatings, plastics, and some metal alloys.

For more information on the properties and uses of cadmium, see Chapters 3 and 4.

## **1.2 WHAT HAPPENS TO CADMIUM WHEN IT ENTERS THE ENVIRONMENT?**

It is estimated that about 25,000 to 30,000 tons of cadmium are released to the environment each year, about half from the weathering of rocks into river water and then to the oceans. Forest fires and volcanoes also release some cadmium to the air. Release of cadmium from human activities is estimated at from 4,000 to 13,000 tons per year, with major contributions from mining activities, and burning of fossil fuels. Cadmium can enter the air from the burning of fossil fuels (e.g., coal fired electrical plants) and from the burning of household waste. Because of regulations, only small amounts currently enter water from the disposal of waste water from households or industries. Fertilizers often contain some cadmium that will enter the soil when fertilizers are applied to crops. Cadmium can also enter the soil or water from spills or leaks at hazardous waste sites if large amounts of dissolved cadmium are present at the site. The form of cadmium at these sites is important since many forms do not easily dissolve in water.

Cadmium that is in or attached to small particles can enter the air and travel a long way before coming down to earth as dust, or in rain or snow. The cadmium metal itself does not break down in the environment, but it can change into different forms. Most forms of cadmium stay for a long time in the same place where they first entered the environment. Some forms of the cadmium that goes into the water will bind to soil, but some will remain in the water. Some forms of cadmium in soil can enter water or be taken up by plants. Fish, plants, and animals can take some forms of cadmium into their bodies from air, water, or food. Cadmium can change forms in the body, but it also stays in the body for a very long time (years).

For more information on how cadmium behaves in the environment, see Chapter 5.

### **1.3 HOW MIGHT I BE EXPOSED TO CADMIUM?**

Food and cigarette smoke are the biggest sources of cadmium exposure for people in the general population. Average cadmium levels in U.S. foods range from 2 to 40 parts of cadmium per billion parts of food (2-40 ppb). Lowest levels are in fruits and beverages, and highest levels are in leafy vegetables and potatoes. Air levels of cadmium in U.S. cities are low, ranging from less than 1 to 40 nanograms per cubic meter ( $\text{ng}/\text{m}^3$ ) (a nanogram is one billionth of a gram). Air levels greater than  $40 \text{ ng}/\text{m}^3$  may occur in urban areas with high levels of air pollution from the burning of fossil fuels. The level of cadmium in most drinking water supplies is less than 1 ppb, well below the drinking water standard of 50 ppb. Levels in drinking water, however, may vary greatly depending on local conditions. The average level of cadmium in unpolluted soil is about 250 ppb. At hazardous waste sites, cadmium levels have been measured in soil at about 4 parts cadmium per million parts (4 ppm; a part per million is 1,000 times more than a ppb) and in water at 6 ppm. In the United States, the average person eats food with about 30 micrograms ( $\mu\text{g}$ ) of cadmium in it each day, but only about 1-3  $\mu\text{g}$  per day of that cadmium from food is absorbed and enters the body. Cadmium exposure from smoking cigarettes may be a more serious health concern than cadmium in food. Smokers may double their daily intake of cadmium compared with nonsmokers. Each cigarette may contain from 1 to 2  $\mu\text{g}$  of cadmium, and 40-60% of the cadmium in the inhaled smoke can pass through the lungs into the body. This means that smokers

may take in an additional 1-3  $\mu\text{g}$  of cadmium into their body per day from each pack of cigarettes smoked. Smoke from other people's cigarettes probably does not cause nonsmokers to take in much cadmium.

Aside from tobacco smokers, people who live near hazardous waste sites or factories that release cadmium into the air have the potential for exposure to cadmium in air. However, numerous state and federal regulations control the amount of cadmium that can be released to the air from waste sites and incinerators so that properly regulated sites are not hazardous. The general population and people living near hazardous waste sites may be exposed to cadmium in contaminated food, dust, or water from unregulated releases or accidental releases. Numerous regulations and use of pollution controls are enforced to prevent such releases.

Workers can be exposed to cadmium in air from the smelting and refining of metals, or from the air in plants that make cadmium products such as batteries, coatings, or plastics. Workers can also be exposed when soldering or welding metal that contains cadmium. Approximately 512,000 workers in the United States are in environments each year where a cadmium exposure may occur. Regulations that set permissible levels of exposure, however, are enforced to protect workers and to make sure that levels of cadmium in the air are considerably below levels thought to result in harmful effects.

In Chapter 5, you can find more information on how you might be exposed to cadmium.

#### **1.4 HOW CAN CADMIUM ENTER AND LEAVE MY BODY?**

Cadmium can enter your body from the food you eat, the water you drink, from particles it may be attached to in the air you breathe, or from breathing in cigarette smoke that contains cadmium. Higher amounts of cadmium can enter your body from the cadmium in air or smoke that you inhale (25 to 60% of the cadmium present) than from cadmium in foods you eat (about 5-10% enters the body). The cadmium not taken into your body through the lungs is breathed out. The cadmium not taken into your body from food or water leaves your body in feces. If you do not

eat foods that contain enough iron or other nutrients, you are likely to take up more cadmium from your food than usual. Virtually no cadmium enters your body through your skin.

Most of the cadmium that enters your body goes to your kidney and liver and can remain there for many years. A small portion of the cadmium that enters your body leaves slowly in urine and feces. Your body can change most cadmium to a form that is not harmful, but too much cadmium can overload the ability of your liver and kidney to change the cadmium to a harmless form, and the harmful form may damage your health.

More information on how cadmium enters and leaves the body is found in Chapter 2.

### **1.5 HOW CAN CADMIUM AFFECT MY HEALTH?**

The potential for cadmium to harm your health depends upon the form of cadmium present, the amount taken into your body, and whether the cadmium is eaten or breathed. There are no known good effects from taking in cadmium. Breathing air with very high levels of cadmium can severely damage the lungs and may cause death. Breathing air with lower levels of cadmium over long periods of time (for years) results in a build-up of cadmium in the kidney, and if sufficiently high, may result in kidney disease. Other effects that may occur after breathing cadmium for a long time are lung damage and fragile bones.

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

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compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

We do not have many good studies on the health effects of cadmium in people. Exposures to cadmium throughout most of the world are currently regulated so there are relatively few people receiving high levels, and the effects from long-term low-level exposure to cadmium are hard to determine with the many other factors that can come into play. A number of studies on workers exposed to cadmium in the air have not resulted in convincing evidence that cadmium can cause lung cancer in humans. In animals studies, mice or hamsters that breathed in cadmium did not get lung cancer, but rats that breathed in cadmium did develop lung cancer. There is no good information on people to suggest that breathing cadmium can affect your ability to have children. Female rats and mice, however, that breathed high levels of cadmium had fewer litters, and their babies may have had more birth defects than usual. Breathing cadmium has also been shown to cause liver damage and changes in the immune system in rats and mice. There is no reliable information on people to indicate that breathing cadmium harms peoples' liver, heart, nervous system, or immune system.

Eating food or drinking water with very high cadmium levels severely irritates the stomach, leading to vomiting and diarrhea, and sometimes death. Eating lower levels of cadmium over a long period of time can lead to a build-up of cadmium in the kidneys. If the levels reach a high enough level, the cadmium in the kidney will cause kidney damage, and also causes bones to become fragile and break easily. We do not have good direct information from people who have been exposed to cadmium to know if eating cadmium at levels, below which other toxic effects are not seen, might effect your ability to have children. Animals eating or drinking cadmium sometimes get high blood pressure, iron-poor blood, liver disease, and nerve or brain damage. We have no good information on people to indicate that the levels that people would need to eat or drink cadmium to result in these diseases, or if they would occur at all. Studies of humans or animals that eat or drink cadmium have not found increases in cancer, although additional research is needed to be more certain that eating or drinking cadmium definitely does or does not cause cancer. Skin contact with cadmium is not known to affect the health of people or animals

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because virtually no cadmium can enter the body through the skin under normal circumstances (i.e., without exposure to very high concentrations for long times or exposure to skin that was not damaged).

As a conservative approach, and based on the limited human data and the studies in rats, the United States Department of Health and Human Services (DHHS) has determined that cadmium and cadmium compounds may reasonably be anticipated to be carcinogens. The International Agency for Research on Cancer (IARC) has determined that cadmium is carcinogenic to humans. The EPA has determined that cadmium is a probable human carcinogen by inhalation. More information on how cadmium can affect your health is found in Chapter 2.

**1.6 HOW CAN CADMIUM AFFECT CHILDREN?**

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans. Potential effects on children resulting from exposures of the parents are also considered.

The health effects seen in children from exposure to toxic levels of cadmium are expected to be similar to the effects seen in adults (kidney, lung, and intestinal damage depending on, the route of exposure). These effects are most easily seen in short-term high-level exposures. Harmful effects on child development or behavior have not generally been seen in populations exposed to cadmium, but more research is needed. It is also difficult to determine the cause of harmful effects on child behavior or development from exposures to low levels over long periods of time, which are the most likely exposures for children as well adults in the general population.

We do not know whether cadmium can cause birth defects in people. Studies in animals exposed to high enough levels of cadmium during pregnancy have resulted in harmful effects in the young. The nervous system appears to be the most sensitive target. Young animals exposed to cadmium before birth have shown effects on behavior and learning. There is also some information from

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animal studies that high enough exposures to cadmium before birth can reduce body weights and affect the skeleton in the developing young. Similar effects, however, have not been observed in humans. Humans may respond differently or the exposure levels in humans may be considerably below the levels that produced these adverse effects in animals. More research on human health effects is needed to answer these questions.

Most cadmium taken into the stomach and intestines passes through without being absorbed. At high enough levels, however, damage to the stomach and intestines can occur. A few studies in animals indicate that younger animals absorb more cadmium than adults. Animal studies also indicate that the young are more susceptible than adults to a loss of bone and decreased bone strength from exposure to cadmium. Animal studies also indicate that more cadmium is absorbed into the body from the diet if the diet is low in calcium, protein, or iron, or if the diet is high in fat (because fat slows down the passage of food in the gut and allows more time for absorption). Children who do not get enough iron, calcium, or protein may also absorb more cadmium.

Women with low levels of calcium or iron, due to multiple pregnancies and/or dietary deficiencies, may also absorb more cadmium when exposed to cadmium in food or water. Cadmium does not readily go from a pregnant woman's body into the developing child, but some can cross the placenta. Cadmium levels in human milk can also be from 5 to 10% of the levels found in the mother's blood.

**1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO CADMIUM?**

If your doctor finds that you have been exposed to significant amounts of cadmium, ask your doctor if children may also be exposed. When necessary, your doctor may need to ask your state public health department to investigate.

You can reduce the risk of your family being exposed to cadmium by identifying potential sources of cadmium exposure (in or around your home, at work, or where your children play), and by taking measures to prevent your family members from being exposed. A balanced diet that



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includes enough calcium, iron, protein, and zinc will also help reduce the amount of cadmium that may be absorbed into the body from food or drink.

Take an inventory of items in and around your home that might contain cadmium. Examples include fungicides (cadmium chloride), batteries (nickel-cadmium batteries also called Ni-Cad batteries), and hobbies that use materials that contain cadmium (electroplating or welding of metals, some fabric dyes, ceramic and glass glazes). Generally, the label of ingredients for a product will list cadmium or a cadmium compound as an active ingredient, or you can contact the manufacturer and ask whether the item contains cadmium. If you think that a fertilizer might contain cadmium, ask the supplier or the manufacturer. The cadmium in these items would have to get into your body before it could do any harm. This could happen if, for example, a fungicide containing cadmium was accidentally or intentionally swallowed, or if Ni-Cad batteries were being burned in a waste incinerator and a family member was breathing in the smoke, or if you were welding metal alloys that contain cadmium or using a cadmium glaze on a piece of pottery and were breathing in fumes that contained cadmium. You can prevent these exposures by making sure that you and your family members do not accidentally swallow substances that contain cadmium or breathe in air contaminated with cadmium. All cadmium-containing fungicides or dyes should be properly stored, safely out of the reach of children. If you or your family members have a hobby where metals or materials that contain cadmium are being heated or welded, you should seek advice on proper ventilation of your workspace and the proper use of a safety respirator.

Nickel-cadmium batteries are not harmful when properly used, but can release cadmium fumes if burned in an incinerator or waste fire. Breathing in these fumes may be harmful to your health. Small children also may mistake Ni-Cad batteries for toys and may accidentally swallow them. If the battery case is damaged, then some cadmium could escape and come in contact with the stomach or intestines. Keep Ni-Cad batteries out of the reach of small children, and teach your older children that the contents in Ni-Cad batteries can be harmful to their health if swallowed or burned. Teach your family how to properly dispose of the batteries. Information on where to

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dispose of Ni-Cad batteries is available from your city or county waste disposal office or the office for a waste disposal service.

If you are using fungicides or fertilizers that contain cadmium on your lawn or garden, read the instructions to learn the safe way to use these materials. One possible route of exposure from fungicides or fertilizers would be from breathing in small particles of cadmium-containing dusts. Protective safety gear including dust masks are available at hardware and building supply stores.

If you have a water well and are concerned that your water may contain cadmium, you can have your water tested. Water filters that remove cadmium, as well as lead and other metals, from drinking water are also available at your local stores. You should ask for advice from your public health officials or from knowledgeable suppliers of water filters on the proper filter or filters to use for your water system.

It is sometimes possible to carry cadmium-containing dust from work on your clothing, skin, hair, tools, or other objects removed from the workplace. This is particularly true when working in buildings where there is smelting or refining of cadmium-containing metal ores, soldering or welding of metals that contain cadmium, or where cadmium batteries, coatings, or plastics are made. You may contaminate your car, home, or other locations outside work where children might be exposed to cadmium.

Your occupational health and safety officer at work can and should tell you whether chemicals you work with are dangerous and likely to be carried home on your clothes, body, or tools and whether you should be showering and changing clothes before you leave work, storing your street clothes in a separate area of the workplace, or laundering your work clothes at home separately from other clothes. If cadmium is being used in your workplace, there should be a material safety data sheet (MSDS) available at your place of work, as required by the Occupational Safety and Health Administration (OSHA). The MSDS information will include the chemical name(s) of any hazardous cadmium ingredients, fire and explosion data, potential health effects, how you get the chemical(s) in your body, how to properly handle the materials, and what to do in an emergency.

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Your employer is legally responsible for providing a safe workplace and should freely answer your questions about hazardous chemicals. Your OSHA-approved state occupational safety and health program or OSHA can answer any further questions, and help your employer identify and correct problems with hazardous substances. Your OSHA-approved state occupational health program or OSHA will also listen to formal complaints you would like to make about workplace health hazards and will inspect your workplace, if necessary. Employees have a right to seek safety and health on the job without fear of punishment.

Potential sources of exposure to cadmium away from home include exposures at hazardous waste sites or from air near waste incinerators. Young children should not play near or in hazardous wastes sites, and regulations that prevent this activity are generally enforced. Proper enforcement of regulations also prevents releases of cadmium to the air from waste incinerators or to water from hazardous waste sites. If you or your family live near a hazardous waste site and you have reason to believe that regulations are not being enforced and that you or your children are being exposed to cadmium, contact your local health official and report your concern.

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

You can be tested for exposure to cadmium in several ways. The amount of cadmium in your blood, urine, hair, or nails can be measured by some medical laboratories. The amount of cadmium in your blood shows your recent exposure to cadmium. The amount of cadmium in your urine shows both your recent and your past exposure. Cadmium levels in hair or nails are not as useful as an indication of when or how much cadmium you may have taken in, partly because cadmium from outside of your body may attach to the hair or nails. Tests are also available to measure the amount of cadmium inside your liver and kidneys. The results of these tests can help a doctor evaluate the risk of liver or kidney disease. However, these tests are too costly and inconvenient for routine use. Your urine can be tested to see if your kidneys are damaged. If you do have kidney damage, the urine tests do not prove that cadmium caused the damage.

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More information on how cadmium can be measured in exposed humans is presented in Chapters 2 and 6.

### **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 cadmium include the following:

The government has taken steps to protect humans from excessive cadmium exposure. The EPA allows only up to 5 parts of cadmium per billion parts of water (5 ppb) in drinking water. The EPA also limits how much cadmium can be put into lakes, rivers, dumps, and cropland, and does not allow cadmium in pesticides. The FDA limits the amount of cadmium in food colors to 15 parts per million (ppm).

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OSHA now limits the amount of cadmium in workplace air to 5 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ).

More information on governmental rules regarding cadmium can be found in Chapter 7.

**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

\* Information line and technical assistance

Phone: 1-800-447-1544  
Fax: (404) 639-6359

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: (800) 553-6847 or (703) 487-4650