



PUBLIC HEALTH STATEMENT

Nickel

CAS#: 7440-02-0

Division of Toxicology

August 2005

This Public Health Statement is the summary chapter from the Toxicological Profile for Nickel. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-888-422-8737.

This public health statement tells you about nickel and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites are then placed on the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Nickel has been found in at least 882 of the 1,662 current or former NPL sites. Although the total number of NPL sites evaluated for this substance is not known, the possibility exists that the number of sites at which nickel is found may increase in the future as more sites are evaluated. This information is important because these sites may be sources of exposure and exposure to nickel may harm you.

When a substance is released either from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. Such a 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 nickel, many factors will determine whether you will 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 any other chemicals you are exposed to and your age, gender, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS NICKEL?

Pure nickel is a hard, silvery-white metal, which has properties that make it very desirable for combining with other metals to form mixtures called alloys. Some of the metals that nickel can be alloyed with are iron, copper, chromium, and zinc. These alloys are used in making metal coins and jewelry and in industry for making items such as valves and heat exchangers. Most nickel is used to make stainless steel. There are also compounds consisting of nickel combined with many other elements, including chlorine, sulfur, and oxygen. Many of these nickel compounds are water soluble (dissolve fairly easily in water) and have a characteristic green color. Nickel and its compounds have no characteristic odor or taste. Nickel compounds are used for nickel plating, to color ceramics, to make some batteries, and as substances known as catalysts that increase the rate of chemical reactions.

Nickel combined with other elements occurs naturally in the earth's crust. It is found in all soil, and is also emitted from volcanoes. Nickel is the 24th most abundant element. In the environment, it is primarily found combined with oxygen or sulfur as oxides or sulfides. Nickel is also found in meteorites and on the ocean floor in lumps of

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minerals called sea floor nodules. The earth's core is composed of 6% nickel. Nickel is released into the atmosphere during nickel mining and by industries that make or use nickel, nickel alloys, or nickel compounds. These industries also might discharge nickel in waste water. Nickel is also released into the atmosphere by oil-burning power plants, coal-burning power plants, and trash incinerators.

There are no nickel mining operations in the United States. Much of our nickel used in industries comes from recycling nickel-containing alloys or is imported mainly from Canada and Russia.

1.2 WHAT HAPPENS TO NICKEL WHEN IT ENTERS THE ENVIRONMENT?

Nickel may be released to the environment from the stacks of large furnaces used to make alloys or from power plants and trash incinerators. The nickel that comes out of the stacks of power plants attaches to small particles of dust that settle to the ground or are taken out of the air in rain or snow. It usually takes many days for nickel to be removed from the air. If the nickel is attached to very small particles, it can take more than a month to settle out of the air. Nickel can also be released in industrial waste water. A lot of nickel released into the environment ends up in soil or sediment where it strongly attaches to particles containing iron or manganese. Under acidic conditions, nickel is more mobile in soil and might seep into groundwater. Nickel does not appear to concentrate in fish. Studies show that some plants can take up and accumulate nickel. However, it has been shown that nickel does not

accumulate in small animals living on land that has been treated with nickel-containing sludge.

1.3 HOW MIGHT I BE EXPOSED TO NICKEL?

Nickel normally occurs at very low levels in the environment, so very sensitive methods are needed to detect nickel in most environmental samples. Food is the major source of exposure to nickel. You may also be exposed to nickel by breathing air, drinking water, or smoking tobacco containing nickel. Skin contact with soil, bath or shower water, or metals containing nickel, as well as, metals plated with nickel can also result in exposure. Stainless steel and coins contain nickel. Some jewelry is plated with nickel or made from nickel alloys. Patients may be exposed to nickel in artificial body parts made from nickel-containing alloys. Exposure of an unborn child to nickel is through the transfer of nickel from the mother's blood to fetal blood. Likewise, nursing infants are exposed to nickel through the transfer of nickel from the mother to breast milk. However, the concentration of nickel in breast milk is either similar or less than the concentration of nickel in infant formulas and cow's milk.

We often do not know the exact form of nickel we are exposed to, including at most hazardous waste sites. Much of the nickel found in air, soil, sediment, and rock is so strongly attached to dust and soil particles or embedded in minerals that it is not readily taken up by plants and animals and, therefore, cannot easily affect your health. In water and waste water, nickel can exist either dissolved in water or attached to material suspended in water.

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Nickel in air is attached to small particles. Over a 6-year period (1977–1982) in the United States, average nickel concentrations in cities and in the country ranged from 7 to 12 nanograms per cubic meter (ng/m^3 ; $1 \text{ ng}/\text{m}^3$ is equivalent to 1 billionth of a gram in a cubic meter of air). More recently, EPA estimates that the average nickel concentration in air in the United States has decreased to $2.2 \text{ ng}/\text{m}^3$, based on air quality information obtained from 1996.

The concentration of nickel in the water of rivers and lakes is very low, with the average concentration usually less than 10 parts of nickel in a billion parts of water (ppb). The level of nickel in water is often so low that we cannot measure it unless we use very sensitive instruments. The average concentration of nickel in drinking water in the United States is between 2 and 4.3 ppb. However, you may be exposed to higher-than-average levels of nickel in drinking water if you live near industries that process or use nickel. The highest levels of nickel in drinking water, about 72 ppb, were found near areas of a large natural nickel deposit where nickel is mined and refined.

Soil usually contains between 4 and 80 parts of nickel in a million parts of soil (ppm; $1 \text{ ppm}=1,000 \text{ ppb}$). The highest soil concentrations (up to 9,000 ppm) are found near industries that extract nickel from ore. High concentrations of nickel occur as dust that is released into air from stacks during processing and settles on the ground. You may be exposed to nickel in soil by skin contact. Children may also be exposed to nickel by eating soil.

Food contains nickel and is the major source of nickel exposure for the general population. You eat about 170 micrograms (μg ; $1 \mu\text{g}=1$ millionth of a gram) of nickel in your food every day. Foods naturally high in nickel include chocolate, soybeans, nuts, and oatmeal. Our daily intake of nickel from drinking water is only about $2 \mu\text{g}$. We breathe in between 0.1 and $1 \mu\text{g}$ nickel/day, excluding nickel in tobacco smoke. We are exposed to nickel when we handle coins and touch other metals containing nickel.

You may be exposed to higher levels of nickel if you work in industries that process or use nickel. You also may be exposed to nickel by breathing dust or fumes (as from welding) or by skin contact with nickel-containing metal and dust or solutions containing dissolved nickel compounds. A national survey conducted from 1980 to 1983 estimated that 727,240 workers are potentially exposed to nickel metal, nickel alloys, or nickel compounds.

1.4 HOW CAN NICKEL ENTER AND LEAVE MY BODY?

Nickel can enter your body when you breathe air containing nickel, when you drink water or eat food that contains nickel, and when your skin comes into contact with nickel. If you breathe air that contains nickel, the amount of nickel you inhale that reaches your lungs and enters your blood depends on the size of the nickel particles. If the particles are large, they stay in your nose. If the particles are small, they can enter deep into your lungs. More nickel is absorbed from your lungs into your body when the nickel particles can dissolve easily in water. When the particles do not dissolve easily in water, the

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nickel may remain in your lungs for a long time. Some of these nickel particles can leave the lungs with mucus that you spit out or swallow. More nickel will pass into your body through your stomach and intestines if you drink water containing nickel than if you eat food containing the same amount of nickel. A small amount of nickel can enter your bloodstream from skin contact. After nickel gets into your body, it can go to all organs, but it mainly goes to the kidneys. The nickel that gets into your bloodstream leaves in the urine. After nickel is eaten, most of it leaves quickly in the feces, and the small amount that gets into your blood leaves in the urine.

1.5 HOW CAN NICKEL AFFECT MY HEALTH?

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways for treating persons who have been harmed.

One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing may also help identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal care guidelines because laws today protect the welfare of research animals.

The most common harmful health effect of nickel in humans is an allergic reaction. Approximately 10–20% of the population is sensitive to nickel. A person can become sensitive to nickel when jewelry or other items containing nickel are in direct contact and prolonged contact with the skin. Wearing jewelry containing nickel in ears or other body parts that have been newly pierced may also sensitize a person to nickel. However, not all jewelry containing nickel releases enough of the nickel ion to sensitize a person. Once a person is sensitized to nickel, further contact with the metal may produce a reaction. The most common reaction is a skin rash at the site of contact. In some sensitized people, dermatitis (a type of skin rash) may develop in an area of the skin that is away from the site of contact. For example, hand eczema (another type of skin rash) is fairly common among people sensitized to nickel. Some workers exposed to nickel by inhalation can become sensitized and have asthma attacks, but this is rare. People who are sensitive to nickel have reactions when nickel comes into prolonged contact with the skin. Some sensitized individuals react when they eat nickel in food or water or breathe dust containing nickel. More women are sensitive to nickel than men. This difference between men and women is thought to be a result of greater exposure of women to nickel through jewelry and other metal items.

People who are not sensitive to nickel must eat very large amounts of nickel to suffer harmful health effects. Workers who accidentally drank light-green water containing 250 ppm of nickel from a contaminated drinking fountain had stomach aches and suffered adverse effects in their blood (increased red blood cells) and kidneys (increased protein in the urine). This concentration of nickel is

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more than 100,000 times greater than the amount usually found in drinking water.

The most serious harmful health effects from exposure to nickel, such as chronic bronchitis, reduced lung function, and cancer of the lung and nasal sinus, have occurred in people who have breathed dust containing certain nickel compounds while working in nickel refineries or nickel-processing plants. The levels of nickel in these workplaces were much higher than usual (background) levels in the environment. Lung and nasal sinus cancers occurred in workers who were exposed to more than 10 mg nickel/m³ as nickel compounds that were hard to dissolve (such as nickel subsulfide). Exposure to high levels of nickel compounds that dissolve easily in water (soluble) may also result in cancer when nickel compounds that are hard to dissolve (less soluble) are present, or when other chemicals that can produce cancer are present. The concentrations of soluble and less-soluble nickel compounds that were found to have produced cancers were 100,000 to 1 million times greater than the usual level of nickel in the air in the United States. The U.S. Department of Health and Human Services (DHHS) has determined that nickel metal may reasonably be anticipated to be a carcinogen and nickel compounds are known human carcinogens. The International Agency for Research on Cancer (IARC) has determined that some nickel compounds are carcinogenic to humans and that metallic nickel may possibly be carcinogenic to humans. The EPA has determined that nickel refinery dust and nickel subsulfide are human carcinogens. These cancer classifications were based on studies of nickel workers and laboratory animals.

Lung inflammation and damage to the nasal cavity have been observed in animals exposed to nickel compounds. At high concentrations, the lung damage is severe enough to affect lung function. Long-term exposure to lower levels of a nickel compound that dissolves easily in water did not produce cancer in animals. Lung cancer developed in rats exposed for a long time to nickel compounds that do not dissolve easily in water.

Oral exposure of humans to high levels of soluble nickel compounds through the environment is extremely unlikely. Because humans have only rarely been exposed to high levels of nickel in water or food, much of our knowledge of the harmful effects of nickel is based on animal studies. Eating or drinking levels of nickel much greater than the levels normally found in food and water have been reported to produce lung disease in dogs and rats and to affect the stomach, blood, liver, kidneys, and immune system in rats and mice, as well as their reproduction and development.

1.6 HOW CAN NICKEL AFFECT CHILDREN?

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age. It is likely that the health effects seen in children exposed to nickel will be similar to the effects seen in adults. We do not know whether children differ from adults in their susceptibility to nickel. Human studies that examined whether nickel can harm the developing fetus are inconclusive. Animal studies have found increases in newborn deaths and decreases in newborn weight after ingesting nickel.

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These doses are 1,000 times higher than levels typically found in drinking water. It is likely that nickel can be transferred from the mother to an infant in breast milk and can cross the placenta. The nickel levels in breast milk are likely to be similar to the levels in cow's milk-based or soy-milk-based infant formula.

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

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

People may be exposed to nickel by wearing jewelry that contains nickel. In some people, wearing jewelry that contains nickel produces skin irritation. Avoiding jewelry containing nickel will eliminate risks of exposure to this source of this metal.

Other sources of nickel exposure are through foods that you eat and drinking water. However, the amount of nickel in foods and drinking water are too low to be of concern.

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

Measurements of the amount of nickel in your blood, feces, and urine can be used to estimate your exposure to nickel. More nickel was found in the

urine of workers who were exposed to nickel compounds that dissolve easily in water (soluble) than in the urine of workers exposed to compounds that are hard to dissolve (less soluble). This means that it is easier to tell if you have been exposed to soluble nickel compounds than less-soluble compounds. The nickel measurements do not accurately predict potential health effects from exposure to nickel.

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. The EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA) are some federal agencies that develop regulations for toxic substances. Recommendations provide valuable guidelines to protect public health, but *cannot* be enforced by law. The Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH) are two federal organizations that develop recommendations for toxic substances.

Regulations and recommendations can be expressed as "not-to-exceed" levels, that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value that is usually based on levels that affect animals; they are then adjusted to levels that will help protect humans. Sometimes these not-to-exceed levels differ among federal organizations because they used different exposure

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times (an 8-hour workday or a 24-hour day), different animal studies, or other factors.

Recommendations and regulations are also updated periodically 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 nickel include the following:

OSHA has set an enforceable limit of 1.0 mg nickel/m³ for metallic nickel and nickel compounds in workroom air to protect workers during an 8-hour shift over a 40-hour work week. EPA recommends that drinking water levels for nickel should not be more than 0.1 mg per liter.

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, your regional Nuclear Regulatory Commission office, or contact ATSDR at the address and phone number below.

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.

Toxicological profiles are also available on-line at www.atsdr.cdc.gov and on CD-ROM. You may request a copy of the ATSDR ToxProfiles CD-ROM by calling the information and technical assistance toll-free number at 1-888-42ATSDR

(1-888-422-8737), by email at atsdric@cdc.gov, or by writing to:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE
Mailstop F-32
Atlanta, GA 30333
Fax: 1-770-488-4178

For-profit organizations may request a copy of final profiles from the following:

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000
Web site: <http://www.ntis.gov/>

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