1. PUBLIC HEALTH STATEMENT

This public health statement tells you about manganese 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. Manganese has been found in at least 603 of the 1,517 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 manganese 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 manganese, 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. This chapter discusses adverse (negative) effects from exposure to "high levels" or "too much" manganese. In general, these terms refer to levels of manganese reported in occupational settings, such as battery plants or smelters. Most people are not likely to be exposed to such high levels of manganese in a typical day. However, each person's body handles manganese differently; therefore, it is not possible to predict at what level of manganese a person would begin to show symptoms of health effects from exposure to increased manganese.

1.1 WHAT IS MANGANESE?

Manganese is a naturally occurring substance found in many types of rock. Manganese does not have a special taste or smell. Pure manganese is a silver-colored metal; however, it does not occur in the environment as a pure metal. Rather, it occurs combined with other substances such as oxygen, sulfur, and chlorine. These forms (called compounds) are solids that do not evaporate. However, small dust particles of the solid material can become suspended in air. Also, some manganese compounds can dissolve in water, and low levels of these compounds are normally present in lakes, streams, and the ocean. Manganese can change from one compound to another (either by natural processes or by human activity), but it does not break down or disappear in the environment.

Rocks with high levels of manganese compounds are mined and used to produce manganese metal. This manganese metal is mixed with iron to make various types of steel. Some manganese compounds are used in the production of batteries, in dietary supplements, and as ingredients in some ceramics, pesticides, and fertilizers.

Manganese is an essential trace element and is necessary for good health. The human body typically contains small quantities of manganese, and under normal circumstances, the body controls these amounts so that neither too little nor too much is present.

Different forms of manganese are discussed in this profile. These forms are either inorganic manganese or organic manganese. The inorganic manganese includes those forms of the element such as combustion products from cars or trucks, as well as the dusts that are present in steel or battery factories. Organic forms of manganese that are discussed are a gasoline additive, two pesticides, and a compound used in hospitals to test if a patient has certain types of cancer. The profile discusses what is known about the amount of these compounds that can be toxic to people and how these compounds can affect people's health.

Chapters 3, 4, and 5 have more information on the properties and uses of manganese and how it behaves in the environment.

1.2 WHAT HAPPENS TO MANGANESE WHEN IT ENTERS THE ENVIRONMENT?

Manganese and manganese compounds exist naturally in the environment as solids in the soil and as small particles in water. Manganese may also be present in small dust-like particles in the air. These manganese-containing particles usually settle out of the air within a few days depending on their size, weight, density, and the weather conditions. Manganese exists naturally in rivers and lakes, and is also naturally present in some underground water. Algae and plankton in the water can consume some manganese and concentrate it within themselves.

In addition to occurring naturally in the environment, manganese can be introduced by human activity. Manganese can be released into the air by industry and by the burning of fossil fuels. More specifically, sources of airborne manganese include iron- and steel-producing plants, power plants, coke ovens, and dust from uncontrolled mining operations. Manganese released from burning a gasoline additive may also be a source of manganese in the air. Manganese from these human-made sources can enter surface water, groundwater, and sewage waters. Small manganese particles can also be picked up by water flowing through landfills and soil. The chemical state of manganese and the type of soil determine how fast it moves through the soil and how much is retained in the soil. Maneb and mancozeb, two pesticides that contain manganese, may also add to the amount of manganese in the environment when they are applied to crops or released to the environment from packaging factories. There is information on the amount of maneb and mancozeb released into the environment from facilities that make or use these pesticides. However, the amount of manganese in the environment because of the release and use of these pesticides is not known.

To avoid staining clothes or plumbing fixtures, the EPA recommends that the concentration of manganese in drinking water not be more than 0.05 ppm. FDA has set the same level for bottled water. This concentration is believed to be more than adequate to protect human health. The EPA

has also established rules that set limits on the amount of manganese that factories can dump into water. EPA requires factories that use or produce manganese to report how much they dump in the environment. OSHA has set limits of 5 mg/m^3 for fume and 0.2 mg/m^3 for particulate matter as the average amounts of manganese in workplace air over 8-hour workday (OSHA 1998). Similarly, the ACGIH (American Conference of Governmental Industrial Hygienists) has set a limit of 1 mg/m^3 for manganese fume and 0.2 mg/m^3 for the average amount of manganese, either elemental or as inorganic compounds, that can be present in the air over an 8-hour workday (ACGIH 1998).

For more information on manganese in the environment, see Chapter 5.

1.3 HOW MIGHT I BE EXPOSED TO MANGANESE?

Because manganese is a natural component of the environment, you are always exposed to low levels of it in water, air, soil, and food. In drinking water, levels are usually about 0.004 parts manganese per million parts (ppm) of water. In air, levels are usually about 0.00002 milligrams manganese per cubic meter (mg/m^3) of air. Natural levels in soil usually range from 40 to 900 ppm. Manganese is also a normal part of living things, including both plants and animals, so it is present in foods. For nearly all people, food is the main source of manganese, and usual daily intakes range from about 1 to 10 mg/day. The exact amount you take in depends on your diet.

You are most likely to be exposed to higher-than-usual levels of manganese or manganese-containing chemicals if you work in a factory where manganese metal is produced from manganese ores or where manganese compounds are used to make steel or other products. In these factories you would be exposed mainly by breathing in manganese dust. If you live near such a factory you could also be exposed to higher-than-usual levels of manganese dust in the outside air, although the amounts would be much lower than in the factory. You might be exposed to higher-than-usual levels if you live near a coal- or oil-burning factory because manganese is released into the air when these fossil fuels are burned. Some areas of the country use a

gasoline that has manganese added to it to increase performance. You could also be exposed to higher-than-usual levels of manganese if you live in a major urban area where such gasoline is used, if you have a job in which you make or have contact with that gasoline every day (such as a mechanic), or if you are exposed to a high amount of car exhaust on a daily basis (at bus stops, gas stations, etc.). You can also be exposed to manganese if you use pesticides that contain it. People who deal with such pesticides may be exposed through skin contact, but there have been instances in which workers may have accidentally eaten or inhaled some pesticides. You may also be exposed to manganese by eating foods that contain small, leftover amounts (residues) of these pesticides.

If manganese compounds, either naturally-occurring or from a factory or a hazardous waste site, get into water, you could be exposed to higher-than-usual levels by drinking the water.

See Chapter 5 for more information on how you might be exposed to manganese or its compounds.

1.4 HOW CAN MANGANESE ENTER AND LEAVE MY BODY?

Humans are exposed to manganese in the food and water they eat and drink and in the air they breathe. Infants eat manganese that is present in breast milk, soy-based infant formulas, or cow's milk. The amount of manganese in these sources is generally not a problem, and they provide the manganese that is necessary for normal functioning of the body. If you live near a hazardous waste site, you could possibly eat or drink higher-than usual levels of manganese that are in soil or water or breathe manganese-containing dust particles in the air that come from the waste site. The contribution of these exposure routes to manganese's toxicity is uncertain; in general, adverse effects in people exposed through these routes have only been reported when environmental manganese levels were quite high. If you get manganese-contaminated soil or water on your skin, very little will enter your body, so this is not of concern. If you swallow manganese in water or in soil, most is excreted in the feces. However, about 3–5% is usually taken up and kept in the body. If you breathe air containing manganese dust, many of the smaller

dust particles will be trapped in your lungs. Some of the manganese in these small particles may then dissolve in the lungs and enter the blood. The exact amount that may enter the blood is not known. Larger particles and those that do not dissolve will be coughed up, in a sticky layer of mucus, out of the lungs and into the throat, where they will be swallowed and will enter the stomach.

Manganese is a regular part of the human body; it is a necessary component in order for the body to work properly. The body normally controls the amount of absorbed manganese. For example, if large amounts of manganese are eaten in the diet, the body excretes large amounts in the feces. Therefore, the total amount of manganese in the body tends to stay about the same, even when exposure rates are higher or lower than usual. However, if too much manganese is taken in, the body may not be able to adjust for the added amount.

See Chapter 2 for more information on how manganese enters and leaves the body.

1.5 HOW CAN MANGANESE 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.

Manganese is an essential nutrient, and eating a small amount of it each day is important to stay healthy. Manganese is present in many foods, including grains and cereals, and is found in high

concentrations in many foods, such as tea. The amount of manganese in typical western diets (about 1–10 mg manganese per day) appears to be enough to meet daily needs. Human diets with too little manganese can lead to slowed blood clotting, skin problems, changes in hair color, lowered cholesterol levels, and other alterations in metabolism. In animals, eating too little manganese can interfere with normal growth, bone formation, and reproduction.

Too much manganese may also cause serious illness. Most manganese compounds seem to cause the same effects, although it is unknown whether exposure to different manganese compounds results in slight differences in adverse effects. Manganese miners or steel workers exposed to high levels of manganese dust in air may have mental and emotional disturbances, and their body movements may become slow and clumsy. This combination of symptoms is a disease called 'manganism.' Workers do not usually develop symptoms of manganism unless they have been exposed to manganese for many months or years. Manganism occurs because too much manganese injures a part of the brain that helps control body movements. Some of the symptoms of manganism may improve upon certain medical treatments, but the improvements are usually temporary, and the brain injury is permanent. Manganism has been reported most often in miners. It has only been reported a few times in other workers exposed to the metal, such as steel workers. The symptoms most commonly observed in occupational workers (other than miners) include difficulty in the following motor skills: holding one's hand steady, performing fast hand movements, and maintaining balance when tested. These symptoms are not as severe as those related to manganism, indicating that the effects caused by manganese over-exposure are related to the level of exposure.

Most people who inhale manganese are involved in jobs where they are exposed to the metal. There is a possibility that people can be exposed to manganese in the air if they live near a plant that uses manganese, or if they live in a high traffic area and the automobiles burn manganese in the gasoline. A recent study showed that people who inhaled manganese from the air and who had high levels of manganese in their blood showed signs of neurological problems that were similar to those reported in occupationally-exposed persons. The neurological problems were most significant in the people aged 50 years and older.

It is not certain whether eating or drinking too much manganese can cause symptoms of manganism. In one report, people who drank water containing high concentrations of manganese developed a number of symptoms that were similar to those seen in manganese miners and steel workers. However, it is not clear whether these effects were caused by the manganese alone; other effects were noted, suggesting that other compounds may have been involved. In another report, people who drank water with above-average levels of manganese seemed to have a slightly higher frequency of symptoms such as weakness, stiff muscles, and trembling hands. However, these symptoms are not specific for manganism and might have been caused by other factors. Another study discovered that people who ate food with high concentrations of manganese, while also eating a diet low in magnesium, suffered nerve disease. Another study in adults over 40 years old who drank water with high manganese levels for at least 10 years reported no changes in behavior and no symptoms, that commonly occur in people exposed to excess levels of manganese. Two studies reported that children who drank water and who ate food with higher-than-usual levels of manganese did more poorly in school and on specific tests that measure coordination than children who had not eaten above-average amounts of manganese. However, these studies included several limitations; it is not clear whether the adverse effects in the children were caused only by eating too much manganese.

Studies in animals have shown that very high levels of manganese in food or water can cause changes in the brain. This information suggests that high levels of manganese in food or water might cause changes in the function of the nervous system. However, people exposed to manganese concentrations typically found in food, water, or air have little cause for concern.

Breathing too much manganese dust over a short or long time can cause irritation of the lungs. Sometimes this makes breathing difficult, and it can also increase the chances of getting a lung infection, such as pneumonia. However, this can happen from breathing in many kinds of dust particles and not just those that contain manganese.

A common effect in men who are exposed to high levels (levels seen in some occupational studies) of manganese dust in the air over a long time is impotence. Studies in animals show that too much

manganese may also injure the testes. Much less is known about the effects of too much manganese on women's ability to reproduce. Studies in animals suggest that too much manganese can negatively affect a female's ability to reproduce.

No studies have been done to determine whether breathing manganese dust causes cancer in humans. Some studies in animals show that eating large amounts of manganese might increase the chances of getting cancer. However, only a few animals in these studies developed cancer, and it was difficult to tell whether the tumors were really caused by the excess manganese. Thus, there is little evidence to suggest that cancer is a major concern for people exposed to manganese in the environment or near hazardous waste sites. The EPA has determined that manganese is not classifiable as a human carcinogen.

One compound that contains manganese, potassium permanganate, damages the skin. Two other compounds that contain manganese, the pesticides maneb and mancozeb, can cause skin reactions in people who have allergies to these pesticides. Skin rashes can occur because of these allergies, but once the exposure to the pesticide is stopped, the rashes and any other effects will usually go away. However, once a person has developed an allergy to a particular manganese-containing pesticide, that person may have similar allergic reactions to different, but related, pesticides.

The negative adverse effects of exposure to excess levels of manganese have been observed in all ages. Several studies in humans and animals indicate that the elderly may be a potentially susceptible population to the adverse effects of manganese exposure. Further, studies show that the young may also be a susceptible population. Effects of exposure to high levels of manganese in children are discussed in section 1.6.

Chapter 2 has more information on the health effects of manganese exposure in humans and animals.

1.6 HOW CAN MANGANESE 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.

Children, like adults, are primarily exposed to manganese through the food they eat. The human diet typically provides the amount of manganese required for the normal functioning of a healthy body. Children, like adults, can also inhale manganese if it is present in the air.

In their daily activities, children contact a very different physical environment than adults do. Therefore, their behavior in their surroundings might allow them to contact manganese in ways in which adults typically would not. Young children sometimes eat dirt on purpose and often eat dirt accidentally by putting their hands into their mouths. If the soil contains manganese, children can be exposed to manganese in this unique way. However, there is little information on how well manganese in soil can be taken up from the stomach into the body if children eat it. Most soils contain a background concentration of the metal (values range from 40–900 ppm, with an average estimated at 330 ppm). However, eating small amounts of soils containing background concentrations of manganese should not cause harm to most healthy children because of the tight control the body has over the amount of manganese it maintains.

No studies have discovered how much manganese children need to stay healthy or how much manganese they absorb from all environmental sources. Therefore, it is not known whether the amount of manganese per kilogram of body weight that children take into their bodies through eating or breathing is different from that amount in adults. Animal studies indicate that infant rats take in and retain more manganese than adult rats; therefore, infants and young children may also take up more manganese than adults.

Children who ate or drank above-average amounts of manganese did more poorly in school and on tests that measure coordination than other children who had not eaten increased amounts of

manganese. Although the amounts of manganese in the water and food were measured, the amounts eaten by the children were not known. However, the studies that reported these results in children had several flaws; it is unclear if eating too much manganese was the cause for the difference in the children.

Adverse health effects have also been observed in children who cannot get rid of extra manganese from their body, such as children whose livers do not function properly. These effects include a lack of control over movements in their arms and legs, a tendency to overbalance when walking, and uncontrollable shaking in their arms and hands. In addition to children with problems removing excess manganese from their bodies, some, but not all, children who must have liquid-form nutrition injected into their veins, called total parenteral nutrition (TPN), have also shown these effects. In the cases involving liquid diets, the children had no control over the foods they ate, and there may have been too much manganese in the liquid food. These same effects have been observed in adults with similar liver conditions or on liquid diets. More serious health effects are typically observed only in people who have inhaled manganese in a work environment for many years. These occupational environments tend to have manganese levels that are much higher than the typical environment (10–70 nanograms/m^3 in urban areas with no significant sources of manganese). The severe and permanent neurological effects and mood swings that might be anticipated from occupational studies of adults have not been reported in children. Workers who have been overexposed to manganese particles in the air have suffered wild mood swings, uncontrollable laughter or crying at inappropriate times, and abnormal facial expressions (stiff with grimacing or blank with no expression). Similar effects have also been seen in monkeys who have been injected with low levels of manganese for only a few days. These serious effects of manganese overexposure might be expected in children who have been exposed to high concentrations of manganese for extended periods, although it is not known for sure. The levels of manganese children would have to breathe or eat before they showed these effects is not known.

Limited information suggests that higher-than-usual amounts of manganese can cause birth defects. One study in humans suggests that high levels of exposure to environmental manganese

(in the soil, water, air, or food) might increase the chances of birth defects. However, it is not possible to reach a conclusion from this study because other factors were present that may have caused the birth defects. Studies involving animals exposed to manganese in air are limited. One study in animals shows that exposure of pregnant females to high levels of manganese in air resulted in decreased body weight in the pups. Other studies investigating birth defects have used different exposure methods. One study that involved exposing pregnant rats and their offspring to manganese in drinking water (over 21,000 times the amount that is typically recommended as safe for people to eat each day) found that the rat pups had a short-lived decrease in body weight and an increase in activity. Higher concentrations (approximately 37,000 times the recommended safe amount for humans) of manganese provided in food to animals were associated with decreased activity, while lower concentrations (approximately 1,100 times the recommended safe amount for humans) given all at once each day to rodents can cause delays in the growth of reproductive organs, decreased pup weight, mistakes in skeletal formation, behavioral differences in animals, and changes in the brain.

Other studies in which pregnant animals have been injected with manganese show that negative effects can be seen in unborn pups. These studies have reported delays in formation of skeletal bones and internal organs, suggesting that the skeletal system is a target for birth defects caused by manganese. However, except when manganese is administered via a liquid form of nutrition injected into their veins, humans are not exposed to manganese through injection.

Because manganese is a normal part of the human body, it is always present in the tissues and bloodstream of the mother; in addition, it can cross the placenta and enter an unborn baby. Manganese has been measured in plasma from the umbilical cord blood of premature and full-term babies, as well as in the blood of their mothers. The concentrations of manganese found in full-term babies were slightly higher than the concentrations found in premature babies, though these levels were not significantly different. Also, manganese levels in the livers of pregnant rats were much higher than those in non-pregnant rats, and the manganese levels in their unborn pups were higher than usual. Although the few available animal studies indicate that excess manganese interferes with normal development of the fetus, the relevance of these studies

to humans is not known. There is no information available on the effects in pregnant women from exposure to excess levels of manganese in air, food, or water.

Manganese is necessary for proper nutrition for a rapidly growing infant. The element is present in breast milk at approximately 4–10 μg/L, an amount that appears to be adequate for a nursing baby. Studies show that infant formulas contain more manganese than breast milk, but that infants absorb the same proportion of manganese from infant formulas, cow's milk, and breast milk. However, because cow milk formulas and soy formulas contain much larger amounts of manganese than breast milk, infants who are fed these formulas ingest much higher amounts of manganese than breast-fed infants. Whether these higher amounts of manganese are unhealthy for the infant is unknown.

Sections 2.6 and 5.6 contain more information on the effects of manganese on children.

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

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

In typical situations, there is no need to reduce exposure to manganese. A healthy body regulates the amount of manganese that it either keeps or eliminates based on the foods eaten and the air breathed. Because manganese is the twelfth most common element in the earth's crust, it is always found in measurable concentrations in topsoil. If young children eat soil, it is unknown whether they are able to absorb the manganese in the soil. No studies were located that would show how much, if any, manganese can be absorbed after eating soil. Despite this lack of information, manganese concentrations in soil are not typically high, and therefore, the amount of manganese that children might take in from eating soil should not be a great concern. However, if soil in your neighborhood contains large amounts of manganese from hazardous waste or other

environmental sources, you should prevent your children from eating it and discourage children from putting their hands in their mouths or performing other hand-to-mouth activity.

Manganese is also present in drinking water. The EPA has set a Secondary Maximum Contaminant Level (MCL) for the metal in drinking water at 0.05 ppm because at higher concentrations it can stain clothes or plumbing fixtures. The Food and Drug Administration (FDA) has also set this level for bottled water, and it is believed to be low enough to protect human health. Individuals with well water that leaves black deposits or dark stains in their sinks and other fixtures may want to have their water tested for high levels of manganese.

The exact amounts of manganese necessary for proper body functioning in an infant or child are not known. However, the effects of getting too little manganese are well known in adults, and recorded cases of manganese deficiency are very rare. Therefore, it appears that humans get adequate amounts of manganese from their diets. Children are not likely to be exposed to toxic amounts of manganese in the diet. However, manganese can be absorbed in higher-than-usual amounts if the diet is low in iron. Therefore, it is very important to provide your child with a well-balanced diet. The Food and Nutrition Board of the National Research Council (NRC) has not established a Recommended Daily Allowance for manganese because too little is known about the dietary requirements of this trace element. However, an Estimated Safe and Adequate Daily Dietary Intake (ESADDI) for manganese has been estimated as 0.3–0.6 mg/day for infants from birth to 6 months, 0.6–1 mg/day for infants aged 6 months to 1 year, 1–1.5 mg/day for children aged 1–3 years, 1–2 mg/day for children aged 4–10 years of age, and 2–5 mg/day for children aged 10 years to adult.

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

Several tests are available to measure manganese in blood, urine, hair, or feces. Because manganese is a normal part of the body, some is always found in tissues or fluids. Concentrations in blood, urine, hair, or feces are often found to be higher than average in groups of people

exposed to higher-than-usual levels of manganese. Because the levels in different people can vary widely, these methods are not very reliable to determine whether a single person has been exposed to higher-than-usual levels. However, blood or urine levels in groups of people who have been exposed to higher-than-usual amounts are useful indicators of exposure when compared with reference levels from people who have not been exposed. The normal range of manganese levels in blood is 4–14 μg/L, 0.97–1.07 μg/L in urine, and 0.15–2.65 μg/L in serum (the fluid portion of the blood). Because excess manganese is usually removed from the body within a few days, past exposures are difficult to measure with common laboratory tests.

A medical test known as magnetic resonance imaging, or MRI, can detect the presence of increased amounts of manganese in the brain. This test has been very useful in determining whether people have accumulated higher-than-usual amounts of manganese in the body. This tool is often used when a person is showing severe signs of manganese toxicity, as in manganism, or in other diseases that affect the brain, such as Parkinson's disease or Alzheimer's disease. The results must be used along with a complete medical history because other diseases affecting the brain can cause abnormal MRI scans. MRI is not useful, though, in determining the source of increased exposure or in establishing the amount of manganese that you might have been exposed to. Furthermore, MRI analysis will not necessarily detect manganese in the brain after exposure to the metal has ceased. Most people who have increased manganese concentrations in their body do so as a result of increased exposure to the compound (most often by work exposures); others have increased levels because they are unable to clear manganese from their bodies. A medical test would not be able to tell the difference between these two possibilities, and further testing would be needed to find the cause of increased exposure. Also, exposure to high levels of manganese (such as in the case of manganese miners) may cause a permanent effect on the brain, depending on the length and level of manganese exposure.

Chapters 2 and 6 have more information on how manganese can be measured in exposed humans.

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 manganese include the following:

To avoid staining clothes or plumbing fixtures, the EPA recommends that the concentration of manganese in drinking water be not more than 0.05 ppm. FDA has set the same level for bottled water. This concentration is believed to be more than adequate to protect human health. The EPA has also established rules that set limits on the amount of manganese that factories can dump into water. EPA requires factories that use or produce manganese to report how much they dump in the environment. OSHA has set a limit of 5 mg/m^3 for the average amount of manganese in workplace air over an 8-hour workday (OSHA 1998).

Manganese is an essential element of the diet. Like a number of metals (for example, chromium, copper, iron, and zinc) manganese is important in the normal functioning of the body. Therefore, both too little or too much can be harmful. The Food and Nutrition Board of the National Research Council has set an ESADDI for manganese. The ESADDI for manganese ranges from 0.3 up to 5 mg/day for different age groups (1–10 mg/day is about the amount found in the diet of an adult; Freeland-Graves 1994; Gibson 1994).

Chapter 7 has more information on governmental rules regarding manganese.

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: 1-888-422-8737
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) 605-6000