Manganese Compounds

Hazard Summary

Manganese is naturally occurring in the environment. Manganese is essential for normal physiologic functioning in humans and animals, and exposure to low levels of manganese in the diet is considered to be nutritionally essential in humans. Chronic (long-term) exposure to high levels of manganese by inhalation in humans may result in central nervous system (CNS) effects. Visual reaction time, hand steadiness, and eye-hand coordination were affected in chronically-exposed workers. A syndrome named manganism may result from chronic exposure to higher levels; manganism is characterized by feelings of weakness and lethargy, tremors, a mask-like face, and psychological disturbances. Respiratory effects have also been noted in workers chronically exposed to manganese bearing particles by inhalation.

Please Note: The main sources of information for this fact sheet are the Agency for Toxic Substances and Disease Registry's (ATSDR's) *Toxicological Profile for Manganese* (1) and the EPA's Integrated Risk Information System (IRIS). (3)

Uses

- Metallic manganese is used primarily in steel production to improve hardness, stiffness, and strength. It is also used in carbon steel, stainless steel, and high-temperature steel, along with cast iron and superalloys. (1)
- Manganese compounds have a variety of uses. Manganese dioxide is used in the production of dry-cell batteries, matches, fireworks, and the production of other manganese compounds. (1)
- Manganese chloride is used as a catalyst in the chlorination of organic compounds, in animal feed, and in dry-cell batteries, while manganese sulfate is used as a fertilizer, livestock nutritional supplement, in glazes and varnishes, and in ceramics. (1)
- Potassium permanganate is used for water purification purposes in water and waste-treatment plants. (1)

Sources and Potential Exposure

- Manganese is a naturally occurring substance found in many types of rock and soil; it is ubiquitous in the environment and found in low levels in water air, soil, and food. (1)

- Because manganese is a natural component of the environment, people are always exposed to low levels of it in water, air, soil, and food. Manganese is routinely contained in groundwater, drinking water and soil at low levels. (1)
- The primary source of manganese intake is through diet. The average manganese levels in various media are as follows: levels in drinking water are approximately 0.004 parts per million (ppm); average air levels are approximately 0.02 micrograms per cubic meter ($\mu g/m^3$); levels in soil range from 40 to 900 ppm. (1)
- The average adult daily intake from food is estimated to be approximately 4 milligrams per day (mg/d). Other adult daily intake estimates range from 2 to 9 mg/d. (1)
- Manganese can also be released into the air by iron and steel production plants, power plants, and coke ovens, as well as mining activities. (1)
- The inhalation of air contaminated with particulate matter containing manganese is the primary source of excess manganese exposure for the general population in the United States. Populations living in close proximity to mining activities and industries using manganese may be exposed by inhalation to high levels of manganese in dust. Workers in these industries are especially vulnerable to exposure to manganese dust. (1)
- Manganese concentrations in soil may be elevated when the soil is in close proximity to a mining source or industry using manganese and may therefore pose a risk of excess exposure to children who ingest contaminated soil. Manganese is ubiquitous in drinking water in the United States. (1)
- The compounds most often encountered in the environment and the workplace are those containing inorganic manganese in the Mn(II), Mn(III), or Mn(IV) oxidation states. (1)
- People who smoke tobacco or inhale second-hand smoke are typically exposed to manganese at levels higher than those not exposed to tobacco smoke. (1)

Assessing Personal Exposure

- Tests are available for measuring manganese in blood, urine, hair, or feces. As manganese is naturally present in the body, some manganese is always found in these materials. In addition, excess manganese is usually removed from the body within a few days, making it difficult to measure past exposure to manganese. (1)

Health Hazard Information

Acute Effects:

- No reports of effects in humans following acute (short-term) effects of exposure to manganese are available.
- Acute inhalation studies in mice and rats have shown that exposure to high concentrations of manganese dusts can cause an inflammatory response of the lung, which can lead to impaired lung function. However, this response is characteristic of nearly all inhalable particulate matter and is not dependent on the manganese content in the particle. (1)

Chronic Effects (Noncancer):

- Chronic exposure to manganese at low levels is nutritionally essential in humans. The recommended daily intake of manganese is 2 to 5 mg/d for adults and adolescents. (1)
- No cases of manganese deficiency have been observed in the general population. However, manganese deficiency in animals has been associated with impaired growth, skeletal abnormalities, impaired reproductive function in females, and testicular degeneration in males. (1)
- Chronic inhalation exposure of humans to manganese results primarily in effects on the nervous system. Slower visual reaction time, poorer hand steadiness, and impaired eye-hand coordination were reported in several studies of workers occupationally exposed to manganese dust in air. (1,3,5)
- Chronic inhalation exposure of humans to high levels may result in a syndrome called manganism and typically begins with feelings of weakness and lethargy and progresses to other symptoms such as gait disturbances, clumsiness, tremors, speech disturbances, a mask-like facial expression, and psychological disturbances. (1,3)
- Other chronic effects reported in humans from inhalation exposure to manganese-bearing particles are respiratory effects such as an increased incidence of cough, bronchitis, difficulty breathing during exercise, and an increased susceptibility to infectious lung disease. (1,3)
- The Agency for Toxic Substances and Disease Registry (ATSDR) has established a chronic minimal risk level (MRL) for manganese more recently than the assessment in which EPA derived a reference concentration. The MRL is 0.0003 mg/m^3 for manganese in respirable dust based on neurological effects in humans, such as reaction time, eye-hand coordination and hand steadiness. The ATSDR chronic MRL is a daily human exposure concentration at or below which adverse health effects are not likely to occur given chronic exposures of 365 days or longer. (1)

Reproductive/Developmental Effects:

- Reproductive effects, such as impotence and loss of libido, have been noted in male workers afflicted with manganism from occupational exposure to high levels of manganese by inhalation. (1)
- Animal studies have reported decreased activity levels and a decrease in pup weight in the offspring of mice exposed to manganese by inhalation. (1)
- Animal studies have reported degenerative changes in the seminiferous tubules leading to sterility from intratracheal instillation of high doses of manganese (experimentally delivering the manganese directly to the trachea). In young animals exposed to manganese orally, decreased testosterone production and retarded growth of the testes were reported. (1)
- Some studies suggest that exposure of children to high levels of manganese in drinking water may result in effects on behavior and cognitive function. (1)

Cancer Risk:

- No studies are available on the carcinogenic effects in humans or animals after inhalation exposure to inorganic or organic manganese. (1)
- A National Toxicology Program (NTP) study, in which laboratory animals were exposed to manganese in their food, reported “equivocal evidence of carcinogenic activity for manganese sulfate monohydrate in male and female mice and no evidence in rats”. (1,3)

- EPA has classified manganese as Group D, not classifiable as to carcinogenicity in humans. (3)

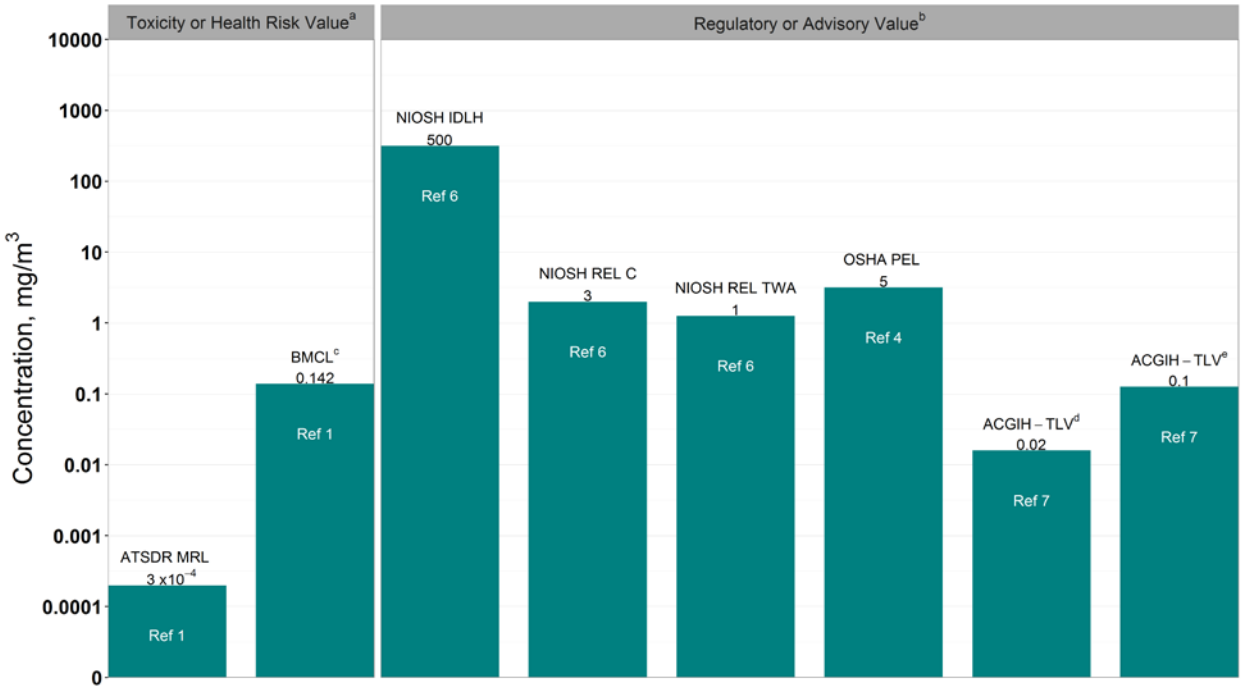
Physical Properties

- Manganese is a combustible, lustrous, brittle, silvery, soft metal that forms compounds in the environment with chemicals such as oxygen, sulfur, and chlorine. (1,2)
- Manganese compounds are solids that do not evaporate; however, small dust particles can become suspended in air. (1)
- The chemical symbol for manganese is Mn, and elemental manganese has an atomic weight of 54.94 g/mol. (2)

Conversion Factors:

To convert concentrations in air (at 25 °C) from ppm to mg/m³: mg/m³ = (ppm) × (molecular weight of the compound)/(24.45). For manganese: 1 ppm = 2.25 mg/m³. To convert concentrations in air from µg/m³ to mg/m³: mg/m³ = (µg/m³) × (1 mg/1,000 µg).

Health Data from Inhalation Exposure



ATSDR MRL--Agency for Toxic Substances and Disease Registry's Minimum Risk Level, which is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure.
ACGIH TLV--American Conference of Governmental and Industrial Hygienists' threshold limit value expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects.
BMCL--benchmark dose concentration lower confidence limit.

NIOSH IDLH--NIOSH's immediately dangerous to life or health concentration; NIOSH recommended exposure limit to ensure that a worker can escape from an exposure condition that is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from the environment.
NIOSH REL TWA--NIOSH recommended exposure limit for an 8- or 10-h time-weighted average exposure.
NIOSH REL C--NIOSH recommended ceiling exposure limit.
OSHA PEL--Occupational Safety and Health Administration's permissible exposure limit expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effect averaged over a normal 8-hour workday or a 40-hour workweek.

[a]Health numbers are toxicological numbers from animal testing or risk assessment values developed by EPA.
[b]Regulatory numbers are values that have been incorporated in Government regulations, while advisory numbers are nonregulatory values provided by the Government or other groups as advice. OSHA numbers are regulatory, whereas NIOSH and ACGIH numbers are advisory.
[c]This BMCL is from the critical study used as the basis for the ATSDR chronic MRL.
[d]ACGIH TLV for respirable fraction.
[e]ACGIH TLV for inhalable fraction.

Summary created in April 1992, updated in July 2016

References

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