Mercury Compounds

Hazard Summary

Mercury exists in three forms: elemental mercury, inorganic mercury compounds (primarily mercuric chloride), and organic mercury compounds (primarily methyl mercury). All forms of mercury are quite toxic, and each form exhibits different health effects.
Acute (short-term) exposure to high levels of elemental mercury in humans results in central nervous system (CNS) effects such as tremors, mood changes, and slowed sensory and motor nerve function. Chronic (long-term) exposure to elemental mercury in humans also affects the CNS, with effects such as erethism (increased excitability), irritability, excessive shyness, and tremors. Human studies are inconclusive regarding elemental mercury and cancer.

Acute exposure to inorganic mercury by the oral route may result in effects such as nausea, vomiting, and severe abdominal pain. The major effect from chronic exposure to inorganic mercury is kidney damage. Animal studies have reported effects such as alterations in testicular tissue, increased resorption rates, and abnormalities of development. Mercuric chloride (an inorganic mercury compound) exposure has been shown to result in forestomach, thyroid, and renal tumors in experimental animals.

Acute exposure of humans to very high levels of methyl mercury results in CNS effects such as blindness, deafness, and impaired level of consciousness. Chronic exposure to methyl mercury in humans also affects theCNS with symptoms such as paresthesia (a sensation of pricking on the skin), blurred vision, malaise, speech difficulties, and constriction of the visual field. Methyl mercury exposure, via the oral route, has led to significant developmental effects. Infants born to women who ingested high levels of methyl mercury exhibited mental retardation, ataxia, constriction of the visual field, blindness, and cerebral palsy.

Please Note: The main sources of information for this fact sheet are EPA's Integrated Risk Information System (IRIS) (11), which contains information on inhalation chronic toxicity and the RfC for elemental mercury, oral chronic toxicity and the RfD for inorganic and methyl mercury, EPA's Mercury Study Report to Congress (2), and the Agency for Toxic Substances and Disease Registry's (ATSDR's) Toxicological Profile for Mercury. (1) Other secondary sources include the World Health Organization's Environmental Health Criteria Documents on Methyl Mercury and Inorganic Mercury. (8,9)

Uses

Elemental mercury

- Elemental mercury is used in thermometers, barometers, and pressure-sensing devices. It is also used in batteries, lamps, industrial processes, refining, lubrication oils, and dental amalgams. (1)

Inorganic Mercury

- Inorganic mercury was used in the past in laxatives, skin-lightening creams and soaps, and in latex paint. In 1990, EPA canceled registration for all interior paints that contained mercury. Mercury use in exterior paint was discontinued after 1991. Although most agricultural and pharmaceutical uses of inorganic mercury have been discontinued in the United States, mercuric chloride is still used as a disinfectant and pesticide. (1,7)

Methyl mercury

- Methyl mercury has no industrial uses; it is formed in the environment from the methylation of the inorganic mercurial ion. (1)

Sources and Potential Exposure

Elemental Mercury

- A major source of exposure for elemental mercury is through inhalation in occupational settings. (1,3,4)
- Another source of exposure to low levels of elemental mercury in the general population is elemental mercury released in the mouth from dental amalgam fillings. (3,4,5)

Inorganic Mercury

- The general population is usually not exposed to inorganic mercury compounds to any significant extent today, as most products containing these compounds have now been banned. Limited exposure could occur through the use of old cans of latex paint, which until 1990, could contain mercury compounds to prevent bacterial and fungal growth. (1,4)

Methyl mercury

- The most important organic mercury compound, in terms of human exposure, is methyl mercury. Methyl mercury exposure occurs primarily through the diet, with fish and fish products as the dominant source. Sources of past exposure to methyl mercury include fungicide-treated grains and meat from animals fed such grain. However, fungicides containing mercury are banned in the United States today, and this source of exposure is now negligible. (1)
- Mercury has been listed as a pollutant of concern to EPA's Great Waters Program due to its persistence in the environment, potential to bioaccumulate, and toxicity to humans and the environment. (6)

Assessing Personal Exposure

- Laboratory tests can detect mercury in blood, urine, and hair samples. (1)

Health Hazard Information

Acute Effects:
Elemental Mercury

- The major systems impacted by human inhalation of elemental mercury are the kidneys and central nervous system (CNS). Acute exposure to high levels of elemental mercury in humans results in CNS effects, such as tremors, irritability, insomnia, memory loss, neuromuscular changes, headaches, slowed sensory and motor nerve function, and reduction in cognitive function. (1,2)
- Acute inhalation exposure of humans to high concentrations has resulted in kidney effects ranging from mild transient proteinuria to acute renal failure. (1,2)
- Gastrointestinal effects and respiratory effects, such as chest pains, dyspnea, cough, pulmonary function impairment, and interstitial pneumonitis have also been noted from human inhalation exposure to elemental mercury. (1,2)

Inorganic Mercury

- Symptoms noted after acute oral exposure to inorganic mercury compounds include a metallic taste in the mouth, nausea, vomiting, and severe abdominal pain in humans. (1,2,7)
- The acute lethal dose for most inorganic mercury compounds for an adult is 1 to 4 grams (g) or 14 to 57 milligrams per kilogram body weight (mg/kg) for a 70-kg person. (1,7)

Methyl mercury

- Acute inhalation exposure to high levels of methyl mercury, which is extremely rare, has resulted in severe CNS effects, including blindness, deafness, and impaired level of consciousness in humans. (8)
- It has been estimated that the minimum lethal dose of methyl mercury for a 70-kg person ranges from 20 to 60 mg/kg. (8)

Chronic Effects (Noncancer):
Elemental Mercury

- The CNS is the major target organ for elemental mercury toxicity in humans. Effects noted include erethism (increased excitability), irritability, excessive shyness, insomnia, severe salivation, gingivitis, and tremors. (1,2,9)
- Chronic exposure to elemental mercury also affects the kidney in humans, with the development of proteinuria. (1,2,9)
- Acrodynia is a rare syndrome found in children exposed to elemental mercury compounds. It is characterized by severe leg cramps, irritability, paresthesia (a sensation of prickling on the skin), and painful pink fingers and peeling hands, feet, and nose. (1,2)
- EPA has not established a Reference Dose (RfD) for elemental mercury. (11)
- The Reference Concentration (RfC) for elemental mercury is 0.0003 milligrams per cubic meter (mg/m^3)based on CNS effects in humans. The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancer effects during a lifetime. It is not a direct estimator of risk but rather a reference point to gauge the potential effects. At exposures increasingly greater than the RfC, the potential for adverse health effects increases. Lifetime exposure above the RfC does not imply that an adverse health effect would necessarily occur. (11)
- EPA has medium confidence in the RfC due to: (1) medium confidence in the studies on which the RfC was based because while there were sufficient number of human subjects and appropriate control groups, exposure levels in a number of the studies had to be extrapolated from blood mercury levels; and (2) medium confidence in the database due to a lack of human or multispecies reproductive/developmental studies. (11)

Inorganic Mercury

- The primary effect from chronic exposure to inorganic mercury is kidney damage, primarily due to mercury-induced autoimmune glomerulonephritis (induction of an immune response to the body's kidney tissue) in humans. (1,2,7,9,10)
- Acrodynia may also occur from exposure to inorganic mercury compounds. (1,2,7,9,10)
- The RfD for inorganic mercury (mercuric chloride) is 0.0003 milligrams per kilogram body weight per day (mg/kg/d) based on autoimmune effects in rats. (12)
- EPA has high confidence in the RfD based on the weight of evidence from the studies using Brown-Norway rats and the entirety of the mercuric chloride database. (12)
- EPA has not established an RfC for inorganic mercury. (12)

Methyl mercury

- The primary effect from chronic exposure to methyl mercury in humans is damage to the CNS. The earliest effects are symptoms such as paresthesia, blurred vision, and malaise. Effects at higher doses include deafness, speech difficulties, and constriction of the visual field. (1,2,8)

- The RfD for methyl mercury is 0.0001 mg/kg/d based on developmental neurologic abnormalities in human infants. (13)
- EPA has medium confidence in the RfD due to: (1) medium confidence in the studies on which the RfD was based because the benchmark dose approach allowed use of the entire dose-response assessment, and the results of laboratory studies with nonhuman primates support the quantitative estimate of the no-observed-adverse-effect-level/ lowest-observed-adverse-effect-level (NOAEL/LOAEL) range of the benchmark dose that was indicated by the human studies; and (2) medium confidence in the database. (13)
- EPA has not established an RfC for methyl mercury. (13)

Reproductive/Developmental Effects:
Elemental mercury

- Studies on the reproductive and developmental effects of elemental mercury in humans have shown mixed results. One study did not see an association between mercury exposure and miscarriages, while another revealed an increase in the rate of spontaneous abortions. Another study showed a higher than expected frequency of birth defects, which was not confirmed in a fourth study. (1,9)

Inorganic Mercury
- No information is available on the reproductive or developmental effects of inorganic mercury in humans.
- Animal studies have reported effects including alterations in testicular tissue, increased resorption rates, and abnormalities of development. (1,7,9)

Methyl mercury
- A large number of human studies on the systemic effects of methyl mercury have been carried out. This is the result of two large scale poisoning incidents in Japan and Iraq and several epidemiologic studies investigating populations that consume large quantities of fish. (1,2)
- Oral exposure to methyl mercury has been observed to produce significant developmental effects in humans. Infants born to women who ingested high concentrations of methyl mercury exhibited CNS effects, such as mental retardation, ataxia, deafness, constriction of the visual field, blindness, and cerebral palsy. At lower methyl mercury concentrations, developmental delays and abnormal reflexes were noted. (1,2,8)
- Considerable new data on the health effects of methyl mercury are becoming available. Large studies of fish and marine mammal consuming populations in Seychelles and Faroe Islands are being carried out. Smaller scale studies also describe effects around the U.S. Great Lakes. (1,2)

Cancer Risk:
Elemental Mercury

- Several studies have been carried out regarding elemental mercury and cancer in humans. These studies are inconclusive due to lack of valid exposure data and confounding factors. (1,2,9)
- EPA has classified elemental mercury as a Group D, not classifiable as to human carcinogenicity, based on inadequate human and animal data. (12)

Inorganic Mercury

- No studies are available on the carcinogenic effects of inorganic mercury in humans.
- A chronic study on mercuric chloride in rats and mice reported an increased incidence of forestomach and thyroid tumors in rats, and an increased incidence of renal tumors in mice. (14)
- EPA has classified an inorganic mercury compound, mercuric chloride, as a Group C, possible human carcinogen, based on the absence of data in humans and limited evidence of carcinogenicity in rats and mice.(12)

Methyl mercury

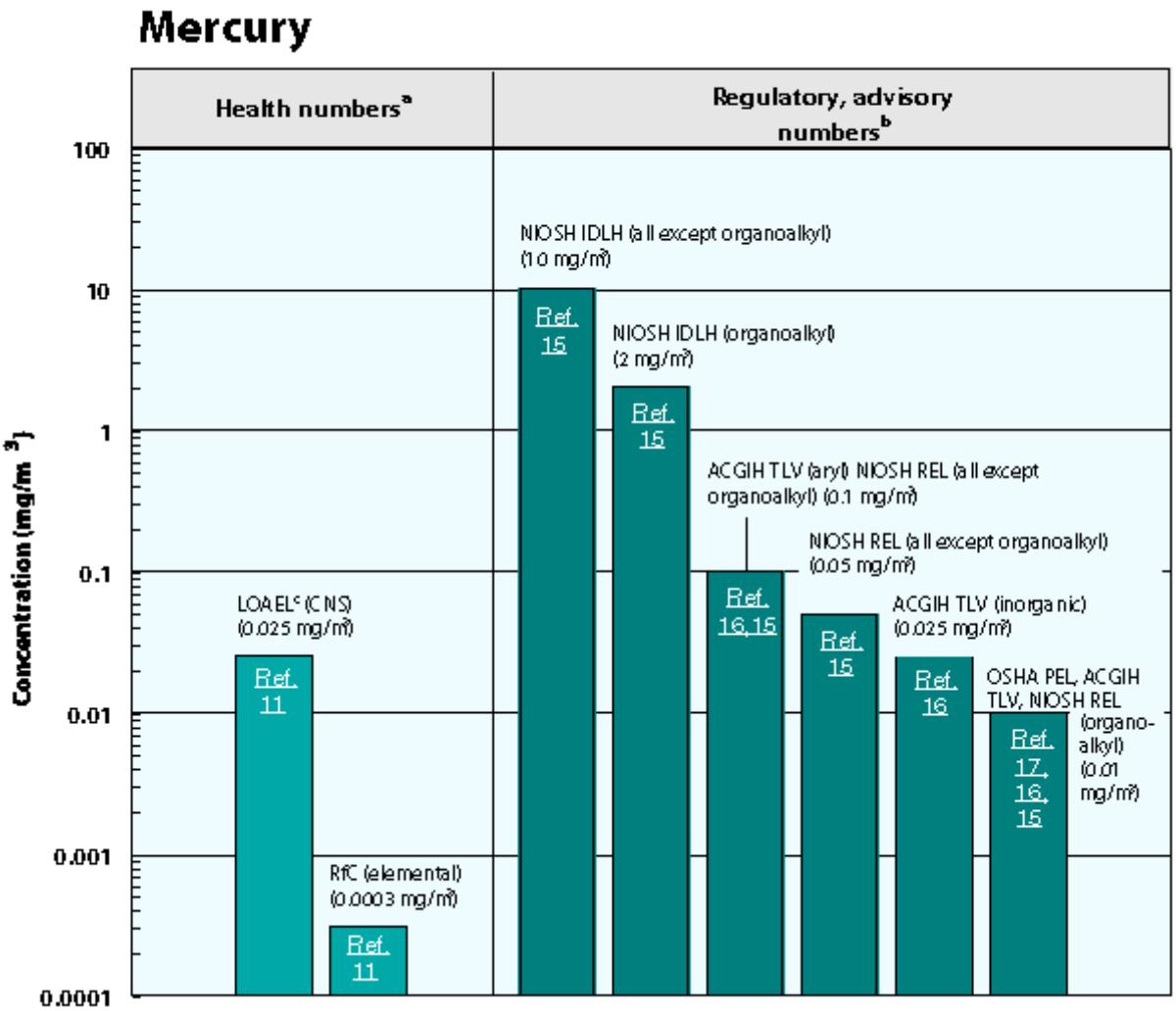
- No studies are available on the carcinogenic effects of methyl mercury in humans, and the one available animal study reported renal tumors in mice. (1,2,13)
- EPA has classified methyl mercury as Group C, possible human carcinogen, based on inadequate data in humans and limited evidence of carcinogenicity in animals. (13)

Physical Properties

- Elemental mercury is a silver-white metal with an atomic weight of 200.59 g/mol. (1)
- Mercury is a liquid at room temperature and has a vapor pressure of 0.002 mm Hg at 25 °C. (1)
- Mercury can exist in three oxidation states-elemental(Hg), mercurous (Hg^{+}), and mercuric (Hg^{++})-and it can be part of both inorganic and organic compounds. (1)
- Inorganic mercury compounds include mercuric chloride, mercuric sulfide, mercurous chloride. Organic mercury compounds include mercuric acetate, methylmercuric chloride, dimethyl mercury, and phenylmercuric acetate. (1)

Conversion Factors:
To convert concentrations in air (25°C) from ppm to mg/m^3: mg/m^3 = (ppm) × (molecular weight of the compound)/(24.45). For elemental mercury: 1 ppm = 8.2 mg/m^3. For mercuric chloride: 1 ppm = 11.1 mg/m^3. For methyl mercuric chloride: 1 ppm = 10.3 mg/m^3.

Health Data from Inhalation 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 effect.

NIOSH IDLH --National Institue of Occupational Safety and Health's immediately dangerous to life or health value; the maximum environmental concentration of a contaminant from which one could escape within 30 min without any escape-impairing symptoms or irreversibe health effects.

NIOSH REL --National Institute of Occupational Safety and Health's recommended exposure limit; NIOSH-recommended exposure limit for an 8- or 10-h time-weighted-average exposure and/or ceiling.

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-h workday or a 40-h workweek.

The health and regulatory values cited in this factsheet were obtained in December 1999.

[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] The LOAEL is from the critical study used as the basis for the EPA RfC for elemental mercury.

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