# Manganese (Mn)

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Atomic Number: 25

Atomic Symbol: Mn

Atomic Weight: 54.9380

Manganese is paramagnetic heavy metal that is widely distributed in the environment, being present in air, water, and food. It is the twelfth most common element in the earth's crust and the fourth most widely used metal in the world. It is a gray-white soft metal resembling iron, but it is harder and very brittle. Manganese minerals are widely distributed; oxides, silicates, and carbonates are the most common.

Most manganese today is obtained from ores found in Russia, Brazil, Australia, Republic of S. Africa, Gabon, and India. Pyrolusite and rhodochrosite are among the most common manganese minerals. The metal is obtained by reduction of the oxide with sodium, magnesium, aluminum, or by electrolysis. The most commercially important of these is pyrolusite which is made up primarily of manganese dioxide. More than 8 million tons of manganese is extracted annually.

## Usage and exposure

Manganese is used to form many important alloys. In steel, manganese improves the rolling and forging qualities, strength, toughness, stiffness, wear resistance, and hardness. Metallurgic applications account for most manganese consumption, with about 90% used in steelmaking. Fourteen kilograms of manganese are required for

each ton of steel production. Iron and steel alloys made with manganese demonstrate increased durability and corrosion resistance. With aluminum and antimony, especially with small amounts of copper, manganese forms highly ferromagnetic alloys.

Manganese and manganese compounds are used in the manufacture of welding rods, dry cell batteries as a depolarizer, paints, varnishes, inks, dyes, bleaching agents, laboratory reagents, motor oils, and fertilizers. In the chemical industry, manganese dioxide ores are used in the production of hydroquinone, potassium permanganate, and magnesium sulfate. Chemicals containing manganese are used in the ceramics industries to color glass and to make face brick. Manganese is used in bactericidal and fungicidal agents, and as an antiknock agent in gasoline.

**Routes of exposure:** inhalation, oral.

Manganese and its compounds are found readily as dusts, fumes, and solutes in groundwater; the primary routes of exposure are inhalation and oral ingestion. Inhalation of dusts or fumes is the major route of entry in occupational manganese poisoning. Oral entry can occur under poor conditions of industrial or personal hygiene.

## Metabolism

Manganese is an essential mineral for humans and animals. It is necessary for normal bone formation and for the synthesis of chondroitin sulfate. Manganese is required for optimal melanocyte function and for metabolism of catecholamines in the brain [1]. The average adult's body contains about 12 mg of manganese. About 43% is found in the skeletal system, with the rest occurring in soft tissues including liver, pancreas, kidneys, brain, and central nervous system.



 

Manganese can exist in eight oxidation states, the most important being +2, +3, and +7. In general, the higher the oxidation state of manganese, the more toxic the compound. The exception is Mn+2, which is 2.5-3 times more toxic than Mn+3.

Manganese dioxide and manganese compounds, which occur as volatile by-products of metal refining, are practically insoluble in water. Thus, only particles small enough to reach the alveoli are eventually absorbed into the blood. Alveolar absorption is possible by passive diffusion into the capillary vascular system. Large inhaled particles may be cleared from the respiratory tract and swallowed [2].

Excess metal may be distributed to other tissues such as kidneys, small intestines, endocrine glands and bones. Manganese concentrates in mitochondria-rich tissues, and the highest concentrations are found in brain, kidney, pancreas, and liver (in descending order). It also penetrates the blood-brain barrier and the placenta. Higher concentrations of manganese are also associated with pigmented portions of the body, including the retina, pigmented conjunctiva and dark skin. Dark hair also accumulates manganese.

The biological half-life for manganese is between 36 and 41 days, but for manganese sequestered in the brain, the half-life is considerably longer. In the blood, manganese is bound to proteins.

Absorbed manganese (Mn+3) rapidly appears in bile fluid and undergoes enteropathic circulation followed by excretion [3]. Bile flow is the main route of excretion of manganese. Consequently, it is eliminated almost entirely with faeces, and only 0.1 to 1.3% of daily intake with urine.

## Target organs

The primary target organs of manganese toxicity are the brain and the lungs.



 

## Health effects

### Acute toxicity

Manganese compounds are irritant to the skin' eyes and mucous membranes' at high exposure levels [4].

Acute exposure to manganese may produce a collection of flu-like symptoms, termed metal fume fever or manganese pneumonitis. Metal fume fever is caused by the inhalation of the finely divided powder of manganese oxide and is usually self-limiting. The syndrome is characterized by fever, chills, nausea, coughing, and congestion. Pneumonitis appears to be due to direct damage to the epithelium as well as an immunodepressant action. Manganese dioxide has been shown to depress humoral immunity, alveolar macrophage function, and phagocytic activity. Manganese pneumonitis may be relatively more severe and require antibiotic and bronchodilator therapy. Episodes of manganese pneumonitis put workers at risk for the development of hyperreactive airways disease and chronic pulmonary disease [5].

### Chronic toxicity

The first report of manganism among men who worked in a manganese ore crushing plant in France was made in 1837 by Dr. John Couper [6]. These patients were reported to have muscle weakness, bent posture, whispering speech, limb tremor, and salivation.

The central nervous system effects of manganese have been the ones most closely studied. The clinical features of manganese neurotoxicity include psychiatric features, parkinsonism, and dystonia. Patients with extreme exposure are reported to have suffered acute behavioral disturbances, hallucinations, and psychoses, referred to as "manganese madness" or "locura manganica" [7].

Exposure to high airborne levels of manganese fumes has been associated with neurotoxicity that resembles Parkinson's disease. Low grade exposures to manganese fumes may increase the risk for Parkinson's disease and other basal ganglia and movement disorders [8].

The onset of manganism is insidious and appears after months or years of manganese exposure. Toxicity does not seem to correlate with serum manganese concentration. Extrapyramidal features are the most common manifestation and include gait dysfunction with propensity to fall backward, postural instability, bradykinesia, rigidity, micrographia, masked face, and speech disturbances. Tremor is less common and tends to be postural or kinetic. Patients with manganese-induced parkinsonism also frequently experience characteristic forms of dystonia consisting of facial grimacing and/or plantar flexion of the foot, which interferes with gait and is known as "coq au pied" or "cock walk".

Three stages can be differentiated:

Prodromal - aesthesia, anorexia, nonspecific muscular pain, nervousness, irritability, insomnia, decreased libido, impotence, labile affect;

Intermediate - beginning of compulsive inappropriate laughter or crying, clumsiness of movement, speech disorder;

Established - generalized muscular weakness, difficulty in walking, impairment of propulsion and retropulsion, stiffness, impaired speech.

The most common neurological signs are a "mask like" expressionless face, decreased postural reflexes, increased muscle tone, slow and shuffling forward gait.

In Sweden Fored et al. examined the relation between employment as a welder and basal ganglia and movement disorders. The study did not show increased risks of Parkinson's disease and other basal ganglia and movement disorders [Fored].



 

Another study examined the effects on the nervous system in enamel -production workers who have low levels of, and long exposure to, manganese. The findings of the study are consistent with the knowledge that the low levels of Mn in the blood (<200 nmol/L), respirable Mn of approximately 200 mcg/m3, and long-term exposure of about 20 years induce potentially mild subjective symptoms but do not lead to adverse effects on nervous system functions [9].

The ability to distinguish manganese-induced parkinsonism from Parkinson's disease has recently been clarified. Manganese-induced parkinsonism reflects pallidal degeneration and is characterized by gait and balance dysfunction, speech impairment, no asymmetry, absence of resting tremor, and little response to levodopa. MRI studies show a characteristic bilateral high signal abnormality in the pallidum on T1-weighted scans, and FD-PET studies are normal. At pathology, damage primarily affects the pallidum, and the nigrostriatal system is spared. Pathology is not observed in substantia nigra, locus coeruleus, the nucleus basalis of Meynert, or the dorsal motor nucleus of the vagus and there are no Lewy bodies [Olanow].

Manganism should be differentiated from Parkinson's disease (PD) and other forms of parkinsonism. Clinical picture is similar to PD, however, certain features support manganism: symmetric impairment, postural or kinetic tremor (vs. resting tremor in PD), early onset of gait dysfunction with peculiar high-stepped gait, tendency to fall backwards, pronounced dystonia, facial grimacing, psychiatric disturbances in the course of disease, earlier age of onset (vs. on average > 60 years in PD) and poor response to levodopa. Neurologic damage is mainly in the globus pallidus, with the substantia nigra not affected [Information notices on occupational diseases].

The Mn-exposed workers reported more respiratory symptoms and a significantly higher prevalence of all grades of pulmonary function impairment. All predicted

symptoms, except for asthma, increased significantly in the current smoking group compared with the non-smoking group. There was a significant decrease in FEV1, FVC, and FEV1 values in exposed workers compared with controls [10].

Clinical and epidemiological evidence suggests that the incidence of abnormal electrocardiogram is significantly higher in Mn-exposed workers than in the control subjects. The main types of abnormal ECG include sinus tachycardia, sinus bradycardia, sinus arrhythmia, sinister megacardia, and ST-T changes. Animal studies indicate that Mn is capable of quickly accumulating in heart tissue, resulting in acute or subacute cardiovascular disorders, such as acute cardio-depression and hypotension. These toxic outcomes appear to be associated with Mn-induced mitochondrial damage and interaction with the calcium channel in the cardiovascular system [11]. Another study indicates that manganese exposure can increase the serum prolactin concentration [12].

Manganese is not classifiable as to its carcinogenicity to humans.

## References


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