

# Toxic metals

With the development of modern technology, the production of toxic metals, especially non-ferrous metals, is increasing, contaminating the air, the surface layers of the soil and are particularly dangerous when contaminating food and groundwater. Their sources are mainly **metal production** (pyrometallurgical and hydrometallurgical processes), **exhaust gases** (tetraethylol, tetraethyl copper), **fossil fuel combustion** (mainly younger coal with relatively high ash content), urban waste incineration...

## Lead Pb

It is a blue-silver-white soft metal. Its inorganic salts are poorly soluble in water, except acetate, nitrate, chlorate, chlorate, and to some extent chloride.

### Occurrence and use

Lead is the most abundant of the heavy metals, occurring in nature as galena (lead sulphide), cerussite (lead carbonate) and anglesite (lead sulphate). It is used in the manufacture of batteries, automotive anti-knock agents (tetraethyl and tetramethyl lead), shot, cables, alloys, in the glass industry, etc.

### Absorption and effects on the human body

**Respiratory absorption** can be estimated based on knowledge of the aerodynamic characteristics of the aerosol and on physiological respiratory parameters. About 40 % is absorbed in this way. In the **GIT** about 5-8 % is absorbed, in children it may be more. In animal experiments, it has been found that the use of milk, low calcium and vitamin D, iron and fasting can increase lead absorption. In the blood, it is 98% bound to erythrocytes, has a high affinity for SH-groups, and is therefore able to inhibit enzymes (mainly enzymes of heme synthesis). It readily crosses the placenta and hematoencephalon. It does not accumulate in the brain. It accumulates in the bones. The haematopoietic system, nervous system, GIT and kidneys are most affected.

- The most common form of acute poisoning is **GIT involvement**, anorexia, dyspepsia, constipation, colicky abdominal pain.
- **Acute encephalopathy** occurs mainly in children - apathy, drowsiness, stupor, ataxia, hyperactivity, coma and death by cardiac and respiratory arrest. It can go chronic. Diffuse atrophic changes in the cerebral cortex have been found, most prominently in the temporal and frontal lobes. The most sensitive effects of lead in children include neurobehavioral and developmental changes.
- Effects on the PNS as a result of **demyelination and degenerative changes** of axons: polyneuropathy, muscle fibrillation,
- Inhibition of heme synthesis and erythrocyte survival causes **micro- or normocytic anemia**, especially in occupational exposures where plumbemia reaches above 0.5 mg/l. Basophilic punctate erythrocytes and reticulocytes appear in the blood. Inhibition of haem synthesis leads to increased urinary excretion of 5-aminolevulinic acid (ALA) and coproporphyrin III.
- In pregnant women - effects on the fetus: lower birth weight, slower CNS development, slower growth.
- Renal damage: impaired renal tubular function, decreased glomerular filtration rate;, irreversible changes after long-term lead exposure - nonspecific nephropathy with interstitial fibrosis and tubular dilatation with atrophic changes.
- Effect on the immune system: immunosuppression - decrease in IgD, IgM and complement production.

### Therapy

Chelating agents are administered - DMSA, in mild poisoning the treatment is symptomatic, mainly sedatives (diazepam).

## Arsenic As

Already Paracelsus described the clinical picture of arsenic poisoning and its treatment. In nature it is found in the form of sulfides, the most widespread is arsenopyrite. It occurs as a constituent of other ores and is obtained as a by-product of the processing of these ores. In the past it was used as a component of fertilisers, today for preserving wood against fungi, in small quantities in the pharmaceutical industry, in glass, for veterinary purposes, in some herbicides, lasers, in warfare chemicals, in alloys to improve their mechanical and physical properties, etc. Arsenic preparations have been used for therapeutic purposes in a wide range of diseases - in the treatment of lues in combination with ATBs, in sleeping sickness, amebiasis and in veterinary medicine. **In the Czech Republic, the use of arsenic is prohibited!!!!**

Arsenic is one of the oldest known poisons of the Middle Ages (prepared from arsenic). Today, poisonings are largely accidental. Preparations given parenterally are rapidly absorbed and accumulate in the liver and later in the kidneys; small amounts also accumulate in the brain, heart, uterus and muscles. Due to the high affinity of arsenic for SH-groups, significant accumulation occurs after 48 h in ectodermal tissues - skin and its adnexa (keratin, scleroprotein). Inorganic does not penetrate HEB, but penetrates the placenta and is excreted in both cow's and mother's milk.

Arsenites induce a profound disruption of oxidative phosphorylation reactions by causing energetically unfavourable oxidation of substrates, thereby damaging mitochondria, especially mitochondria of hepatocytes.

## Symptoms of poisoning

- Acute poisoning: the lethal dose is 60-80 mg. A **GIT syndrome picture** develops due to **mesenteric capillary paralysis** (As is a potent capillary-toxic poison), increased salivation, weight loss are observed. In more severe poisoning, the poisoning is accompanied by **paralytic asphyctic syndrome** with rapid unconsciousness and paralysis of circulation and respiration. If the person survives the acute phase, his condition is complicated by encephalitis, myelitis, nephritis or dermatitis.
- Chronic poisoning has a varied clinical picture:
  - changes on the skin (allergic dermatitis, eczema, inflammation of the scrotum, redness, boils). Of the skin changes, it is also a typical melanosis differing from Addison's melanosis in that it does not affect the mucous membranes. Vasomotor changes, eczema, ragades, hyperkeratosis, malignant degeneration, allergic dermatitis, purplish-red smooth shiny fingers with transverse white striae of the nails.
  - neurological (polyneuritis, motor palsy, personality changes, encephalopathy, Wernicke syndrome, Korsakov psychosis),
  - haematological (inhibitory effect on haematopoiesis - hypoplastic anaemia, agranulocytosis, thrombocytopenia)
  - When exposed through the respiratory tract, it causes lung cancer, and tumours of other organs (liver, kidney, bladder, skin tumours) are also common.

Further, non-specific symptoms occur - increased salivation, digestive problems, rare degenerative changes in the optics.

- As has demonstrable **teratogenic effects**.

Characteristic of arsenic poisoning is the large individual difference in dose size and latency time!!!

The protective effect of thiolates (glutathione, cysteine) against the toxic effects of trivalent As has shown that its toxic effects are probably due to reversible binding with sulfhydryl groups of proteins (Bencko, Cikrt, & Lener, 1995).

## Mercury Hg

In nature it occurs predominantly in the form of sulphides (vermillion, cinnabarite), rare are chloride, iodide and oxide. It enters the environment from the combustion of fossil fuels, waste, industrial and agricultural processes, but also by evaporation from the surface of the earth and oceans, in the manufacture of mercury measuring instruments, batteries, it is also used in dentistry, as an electrode in the production of chlorine from NaCl, etc.

The affinity of mercury for sulfur and SH-group is a determining factor of biological effects on the organism (it disrupts membrane function and enzyme activity). There are significant differences in the metabolism and toxic effects of different forms of mercury, as one form is transformed into another in the organism.

One of the most toxic mercury compounds is methylmercury (methylmercury compounds).

The most significant absorption of mercury vapour is by inhalation (up to 80% absorbed). In short-term exposure, it damages the lungs (erosive bronchitis, bronchiolitis with interstitial pneumonia), but the target organ is damaged, especially in chronic exposure, is the cerebral and cerebellar cortex and ganglia (micromercurialism - non-specific symptoms, develops into hand tremor typical of typing), but mainly the kidneys (accumulates mainly in the cortex, may develop nephrotic sy.) and liver. Excretion of mercury is slow and irregular. Some mercury is deposited in the hair and nails and excreted in sweat and breast milk.

The soluble divalent salts of mercury are absorbed in the GIT; ingestion of metallic mercury does not cause poisoning (only 5% is absorbed). Systemic administration of metallic mercury into a vein also does not cause poisoning, but there is a risk of embolism into the lungs. Chronic poisoning is also induced by skin masts (treatment of psoriasis)

## Symptoms of poisoning

- **Acute poisoning'**: coughing, choking, fever in chemical pneumonia, haemoptysis in pulmonary oedema; GIT - vomiting, tenesmus, mucosal necrosis, severe diarrhoea with pieces of detached mucosa, proteinuria, haematuria, renal failure due to severe tubular necrosis.
- **Chronic poisoning'**: Triad - gingivitis (gingivitis, salivation, tooth loss) + tremor of cerebellar expy origin (subtle, then pronounced intense tremor, first of limbs only, then also of eyelids and lips, ataxia with gait disturbances, fasciculations, neuropathies with acral paresthesias) + erethism (toxic organic psychosis - anxiety, shyness, nervousness, argumentativeness, emotional lability, cognitive decline, IQ decline). Deafness and narrowing of the field of vision may also occur with organic compounds.

## Therapy

In acute inhalation poisoning - fresh air and bed rest, or further symptomatic treatment. Otherwise administer DMSA (dimercaptoacetic acid) or DMPS (dimercaptopropane sulfonate), more severe neurological disorders tend to be irreversible.

## Cadmium Cd

It is a white metal chemically similar to zinc, insoluble in water but soluble in acids. It occurs in nature as sulphide, accompanying the zinc ores from which it is produced. Its compounds are extremely poisonous and its danger lies in the fact that it also forms organic compounds. It is used in alloys, for the production of galvanic cells, as a neutron trap in nuclear power plants, anticorrosive material, stabilizer in the production of plastics, etc. The combustion of fuels and oils and the use of pesticides containing it are also important sources today. It is also contained in cigarette smoke.

### Effects on the human body

The elimination of cadmium from the body is very slow. Cadmium accumulates mainly in the kidneys and liver, which can lead to prostate and respiratory cancers. Little of it circulates in the blood, but it crosses the placenta and is dangerous to the foetus. It can displace zinc from enzymes and thus interfere with metabolism. According to the IARC and the US EPA, it is a probable carcinogen!!!

- **Acute poisoning'**: increased blood pressure, renal failure, erythrocyte breakdown (hypochromic microcytic anaemia), intense salivation, nausea, vomiting (typically a short interval between ingestion of contaminated food and vomiting!!!), abdominal cramps, headache, followed by shock from fluid loss, acute renal, cardiac, pulmonary failure (oedema), death within 24 hours to 14 days.
- **Chronic poisoning'**: development lasts well over 9 years with signs of dyspnea and pulmonary edema. Renal damage is manifested by tubular proteinuria, nephrolithiasis from disturbed calcium metabolism, osteomalacia combined with osteoporosis (Japanese itai-itai disease), glycosuria and sometimes increased gluconeogenesis; prostate carcinoma.

### Treatment

For acute exposure to cadmium in air, 3,4-dimercaptopropanol (BAL) is administered while monitoring renal function. BAL should not be administered to persons with a history of long-term cadmium exposure!!!

## Chromium Cr

It is a very hard metal in crystalline form. It occurs in nature only in compounds, most notably as the ore chromite. It has been found free only in meteorites. Occupational exposure occurs in the metallurgical and chemical industries, in the manufacture of leather, mirrors, chrome pigments, in the wood industry (preservatives), in the electroplating of metals, etc. **In its trivalent form, it is a biogenic element involved in the metabolism of sugars.**

### Effects on humans

Around 10% is absorbed from natural food. Increased absorption has been observed in achilles.

The manifestations of poisoning are mainly caused by hexavalent chromium. Local manifestations include skin inflammation (chromium ulcers), acute irritative dermatitis, allergic eczematous dermatitis, perforation of the nasal septum. On the lungs we find nodular changes (pneumoconiosis).  $\text{Cr}^{6+}$  is a potent allergen - increased incidence of bronchial asthma. Among the most serious effects of chromium are its carcinogenic effects.

## Manganese Mn

In nature it occurs in the form of ores as oxide, carbonate and silicate. It is mainly used in alloys, where it acts as a deoxidizing agent and increases their strength.

Chronic manganese poisoning can occur after exposure for a few months, but usually for more than two years. Three periods of chronic poisoning can be distinguished:

1. **subclinical** stage with indeterminate symptomatology
2. Initial stage with **psychiatric and neurological symptoms** (psychomotor symptoms, hand tremors, dysarthria, somnolence, uncontrolled laughter, impulsivity, headaches)
3. stage of **full development'** - psychosis of manic or depressive type, but mainly under the image of Parkinson's syndrome (characteristic damage of ganglion cells in the basal ganglia).

Chemical pneumonitis, lobar pneumonia, etc., may also occur, but neurological symptoms markedly predominate.

Factors that are likely to influence the development of chronic poisoning are: alcoholism, chronic infections, avitaminosis, liver function disorders.

- As has demonstrable **teratogenic effects**.

# Links

## Sources

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## Recommended literature

- <http://arnika.org/chemicke-latky>