

PREVENTING DISEASE THROUGH HEALTHY ENVIRONMENTS

EXPOSURE TO CADMIUM: A MAJOR PUBLIC HEALTH CONCERN

Cadmium exerts toxic effects on the kidney, the skeletal system and the respiratory system and is classified as a human carcinogen.^{1,2} It is generally present in the environment at low levels; however, human activity has greatly increased those levels.³ Cadmium can travel long distances from the source of emission by atmospheric transport.⁴ It is readily accumulated in many organisms, notably molluscs and crustaceans. Lower concentrations are found in vegetables, cereals and starchy roots. Human exposure occurs mainly from consumption of contaminated food, active and passive inhalation of tobacco smoke and inhalation by workers in the non-ferrous metal industry.^{2,5} National, regional and global actions are needed to decrease global environmental cadmium releases and reduce occupational and environmental exposure.

Sources of exposure to cadmium

Cadmium can be released to the environment in a number of ways, including:

- natural activities, such as volcanic activity (both on land and in the deep sea), weathering and erosion, and river transport;
- human activities, such as tobacco smoking, mining, smelting and refining of non-ferrous metals,⁶ fossil fuel combustion, incineration of municipal waste (especially cadmium-containing batteries and plastics), manufacture of phosphate fertilizers, and recycling of cadmium-plated steel scrap and electric and electronic waste⁷;
- remobilization of historic sources, such as the contamination of watercourses by drainage water from metal mines.

Cadmium releases can be carried to and deposited on areas remote from the sources of emission by means of long-range atmospheric transport.⁶

Industrial processes

Commercial cadmium production started only at the beginning of the 20th century. Initially, its main use was in electroplating, but since 1960, cadmium has been used for manufacturing nickel–cadmium batteries. Cadmium is also used in paint pigments, for electroplating and in making polyvinyl chloride plastics. The majority of cadmium present in the atmosphere is the result of human activities, especially smelting of non-ferrous metal ores, fossil fuel combustion and municipal waste incineration.⁴ Soluble inorganic cadmium compounds are of greatest concern for occupational safety. Occupational exposure of workers in the non-ferrous smelting industry can be significant. Smelting and mining operations contaminate the aquatic environment, as does the effluent produced by air pollution control (gas scrubbers, in the absence of strict control measures). Atmospheric deposition of cadmium on arable soils exceeds its elimination in many countries, resulting in a gradual increase in cadmium levels in soils and crops.⁴ Application of municipal sewage sludge to agricultural soil can also be a significant source of cadmium.³

Food and drinking-water

Cadmium contained in soil and water can be taken up by certain crops and aquatic organisms and accumulate in the food-chain.⁴ Food constitutes the main environmental source of cadmium for non-smokers. Highest cadmium levels are found in the kidney and liver of mammals fed with cadmium-rich diets and in certain species of oysters, scallops, mussels and crustaceans. Lower cadmium concentrations are found in vegetables, cereals and starchy roots. Owing to the larger consumption of such food items, they represent the greater part of daily cadmium intake in most populations.^{2,5} Some crops, such as rice, can accumulate high concentrations of cadmium if grown on cadmium-polluted soil. Acidification of cadmium-containing soils may increase the cadmium concentrations in crops.

Cadmium exposure from drinking-water is relatively unimportant compared with exposure from the diet. However, impurities in the zinc of galvanized pipes and solders in fittings, water heaters, water coolers and taps can sometimes lead to increased cadmium levels in drinking-water.

Smoking

The tobacco plant naturally accumulates relatively high concentrations of cadmium in its leaves. Thus, smoking tobacco is an important source of exposure, and the daily intake may exceed that from food in the case of heavy smokers. Cigarette smoking can cause significant increases in the concentrations of cadmium in the kidney, the main target organ for cadmium toxicity.

World Health Organization (WHO) cadmium guidelines
<p>Provisional tolerable monthly intake (PTMI)</p> <p>The Joint Food and Agriculture Organization of the United Nations (FAO)/WHO Expert Committee on Food Additives (JECFA) recently (in 2010) established a provisional tolerable monthly intake for cadmium of 25 µg/kg body weight.⁵</p>
<p>Drinking-water</p> <p>3 µg/l^{8,9}</p>
<p>Air</p> <p>5 ng/m³ (annual average)⁶</p>

Health effects²

- The kidney is the critical target organ. Cadmium accumulates primarily in the kidneys, and its biological half-life in humans is 10–35 years.⁹ This accumulation may lead to renal tubular dysfunction, which results in increased excretion of low molecular weight proteins in the urine. This is generally irreversible.
- High intake of cadmium can lead to disturbances in calcium metabolism and the formation of kidney stones. Softening of the bones and osteoporosis may occur in those exposed through living or working in cadmium-contaminated areas. In an area of Japan where soil has been contaminated with cadmium from zinc/lead mines, Itai-itai disease used to be widespread and is still seen in women over 50 years of age. It is

characterized by osteomalacia, osteoporosis, painful bone fractures and kidney dysfunction.

- High inhalation exposure to cadmium oxide fume results in acute pneumonitis with pulmonary oedema, which may be lethal. Long-term, high-level occupational exposure is associated with lung changes, primarily characterized by chronic obstructive airway disease.
- There is sufficient evidence that long-term occupational exposure to cadmium (e.g. through cadmium fume) contributes to the development of lung cancer. There is limited evidence that cadmium may also cause cancers of the kidney and prostate. The International Agency for Research on Cancer (IARC) has classified cadmium and cadmium compounds as *carcinogenic to humans* (Group 1), meaning that there is sufficient evidence for their carcinogenicity in humans.^{10,11}

Risk mitigation recommendations

To decrease global environmental cadmium releases and reduce occupational and environmental exposure to cadmium and associated health effects, the following actions are needed:

- Prohibit smoking in public places.
- Reduce as far as is practicable emissions of cadmium—particularly into surface waters—from mining and smelting, waste incineration, application of sewage sludge to the land, and use of phosphate fertilizers and cadmium-containing manure. Develop techniques for the safe disposal of cadmium-containing wastes and effluents.
- Promote effective measures to increase recycling of cadmium and to restrict non-recyclable uses.
- Reduce cadmium exposure by, for instance, improving working conditions in the non-ferrous smelting industry and disseminating information on the proper use of fertilizers (which sometimes contain high levels of cadmium).
- Raise global awareness on the importance of minimizing waste discharges of cadmium.

References

1. IPCS (2005–2007). *Cadmium, cadmium chloride, cadmium oxide, cadmium sulphide, cadmium acetate, cadmium sulphate*. Geneva, World Health Organization, International Programme on Chemical Safety (International Chemical Safety Cards 0020, 0116, 0117, 0404, 1075 and 1318; <http://www.who.int/ipcs/publications/icsc/en/index.html>).
2. IPCS (1992). *Cadmium*. Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 134; <http://www.inchem.org/documents/ehc/ehc/ehc134.htm>).
3. IPCS (1992). *Cadmium—Environmental aspects*. Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 135; <http://www.inchem.org/documents/ehc/ehc/ehc135.htm>).
4. WHO (2007). *Health risks of heavy metals from long-range transboundary air pollution*. Copenhagen, World Health Organization Regional Office for Europe (<http://www.euro.who.int/document/E91044.pdf>).
5. WHO (in preparation). *Safety evaluation of certain food additives and contaminants in food*. Geneva, World Health Organization (WHO Food Additives Series, No. 64;

- <http://www.who.int/ipcs/publications/jecfa/monographs/en/index.html>) [summary in FAO/WHO (2010). *Summary and conclusions of the seventy-third meeting of the Joint FAO/WHO Expert Committee on Food Additives, Geneva, 8–17 June 2010*. Rome, Food and Agriculture Organization of the United Nations; Geneva, World Health Organization (JECFA/73/SC; <http://www.who.int/entity/foodsafety/publications/chem/summary73.pdf>)].
6. WHO (2000). Cadmium. In: *Air quality guidelines for Europe*, 2nd ed. Copenhagen, World Health Organization Regional Office for Europe (http://www.euro.who.int/_data/assets/pdf_file/0005/74732/E71922.pdf).
 7. UNEP (2008). *Draft final review of scientific information on cadmium*. United Nations Environment Programme, Chemicals Branch (http://www.chem.unep.ch/Pb_and_Cd/SR/Draft_final_reviews/Cd_Review/Final_UNEP_Cadmium_review_Nov_2008.pdf).
 8. WHO (2004). *Cadmium in drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality*. Geneva, World Health Organization (WHO/SDE/WSH/03.04/80; http://www.who.int/water_sanitation_health/dwq/chemicals/cadmium.pdf).
 9. WHO (2008). Cadmium. In: *Guidelines for drinking-water quality*, 3rd edition incorporating 1st and 2nd addenda. Vol. 1. *Recommendations*. Geneva, World Health Organization, pp. 317–319 (http://www.who.int/water_sanitation_health/dwq/GDW12rev1and2.pdf).
 10. IARC (1993). *Summaries & evaluations: Cadmium and cadmium compounds (Group 1)*. Lyon, International Agency for Research on Cancer, p. 119 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 58; <http://www.inchem.org/documents/iarc/vol58/mono58-2.html>).
 11. IARC (in preparation). A review of human carcinogens. C: Metals, arsenic, dusts, and fibres. Lyon, International Agency for Research on Cancer (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 100) [summary in Straif K et al. (2009). A review of human carcinogens—Part C: Metals, arsenic, dusts, and fibres. *The Lancet Oncology*, 10:453–454 ([http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045\(09\)70134-2/fulltext](http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(09)70134-2/fulltext)).]

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