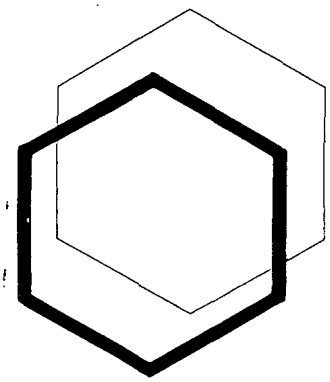
United States
Environmental Protection
Agency

Office of Pesticides and
Toxic Substances TS-793
Washington D C 20460

EPA

Toxics Information Series



Cadmium

Cadmium, first produced commercially in 1907, is a valuable industrial metal. Although U.S. production is relatively low--approximately 1,942 metric tons per year--large amounts are imported annually for manufacturing purposes. Workplace exposure to cadmium has been regulated for some time because of its known toxic properties. However, scientists now believe the health hazards associated with long-term low level exposure in the environment may be more serious and more widespread than previously suspected. Cadmium has been included in the recent carcinogen list of the Carcinogen Assessment Group of the U.S. Environmental Protection Agency (EPA). This Information Bulletin describes some of the known and suspected health hazards of cadmium and what EPA and others are doing to reduce the risks associated with cadmium exposure.

Cadmium-- what is it?

A soft, silvery metal, cadmium is a relatively rare element found in sulfide deposits primarily in zinc ores, and to a lesser extent in lead and copper ores and high sulphur coal. Most industrial cadmium is produced as a by-product of zinc refining.

Cadmium is currently used almost exclusively in the U.S. in industrial processes (e.g., 1,242 metric tons were used in the first nine months of 1979). Cadmium is used for electroplating because it has high retention of luster, deposits readily and uniformly, has good solderability characteristics, and is a corrosion preventive. It is also used in pigments for higher quality plastics, paints and inks; plastic stabilizers; as alloys in batteries; and as an alloy in other processes. As an industrial metal, cadmium is in great demand because of its many important characteristics: low electrical resistance, high resistance to corrosion and heat, colorfastness, lightfastness, long life and thin coating and precise conformity. Although substitutes are available for most industrial cadmium uses, in some cases they tend to be less effective, and in other instances more toxic than cadmium. One successful cadmium substitute, recently developed for use in photocells, is silicon sheet to replace cadmium sulfide and cadmium telluride in solar energy production.

Why is cadmium a problem?

Cadmium is hazardous to human health, both in high concentrations for short periods of time and in low doses for prolonged periods. In the natural environment, localized cadmium ore deposits would pose little threat to public health, though there are a few agricultural areas with very high natural cadmium levels (e.g., Salinas Valley). Industrial production has redistributed the metal throughout the environment causing widespread cadmium contamination.

Approximately 68% of the cadmium in the U.S. environment is in waste piles and landfills. Since cadmium recycling is currently negligible, it is eventually released as a waste product in some form. Sewage sludge, used as fertilizer and soil conditioner, may contain between 1-1500 parts per million cadmium. Major industrial sources of land destined wastes include electroplating companies and battery and paint manufacturers. Electroplating also accounts for nearly 75 percent of the water-borne cadmium wastes. The largest single source of cadmium air contamination is zinc smelters which account for about 50 percent of the air emissions. However, zinc smelters, which are few in number and generally located in isolated areas, may pose a smaller risk to the general public than do other sources, such as iron and steel mills and municipal incinerators, which contribute a smaller percentage of the total emissions, but affect a greater number of people. Also, cadmium is released into the environment through its use in pesticides, although this is not a major exposure route.

As a natural element, cadmium does not decompose or break down into less toxic components over time. Once released into the environment, cadmium remains available for absorption from air, water and soil by various plants and organisms.

Cadmium is absorbed into the human body by the inhalation of air-borne cadmium, the smoking of tobacco, and the ingestion of food and water containing cadmium. This is scientific consensus that the most significant route of human exposure is through the food chain. Air-borne cadmium is mostly a worker exposure problem. However, fall-out from air-borne cadmium presents a greater problem when it contaminates croplands. Likewise, smokers, particularly smokers who work in industries using cadmium or live near industries discharging cadmium emissions, run a higher risk of cadmium-related disease than do other segments of the population.

Cadmium creates both acute and chronic health effects. Acute poisoning produces respiratory or gastrointestinal symptoms. Inhalation of large amounts of cadmium causes pulmonary enema (fluid retention in the lungs), with symptoms resembling pneumonia. Severe edema may result in death. Ingestion of large amounts of cadmium can cause nausea, vomiting, diarrhea, abdominal cramping and excessive salivation. Acute poisoning is very rare; however, chronic exposure to low levels of cadmium is widespread.

Respiratory disease: Inhalation of cadmium over prolonged periods of time can cause serious damage to the respiratory system. Emphysema, commonly thought of as a smoker's disease, may also be caused by low level exposure to cadmium fumes and dust over prolonged periods. Clinical studies indicate pulmonary capacity is reduced after exposure to levels as low as 66 micrograms per cubic meter ($66ug/m^3$) from two to twenty-five years. Laboratory tests using rabbits and rats have also produced emphysema and other respiratory ailments in the test animal.

Kidney and liver damage: Approximately 70 percent of the cadmium absorbed by the body is accumulated in the kidney and liver. Functional liver damage has been reported on rare occasions in cadmium workers, but scientists are more concerned about the effects of cadmium on the kidneys. Serious structural damage to the kidneys have been observed in workers exposed to cadmium over prolonged periods and laboratory tests have produced like results. Scientists note that prolonged exposure at 66 ug/m^3 produces proteinuria, usually the first symptom of kidney disease. The World Health Organization has recommended that cadmium exposure should be 57-71 ug/day or less. Major structural damage has been recorded at levels of 200 ug/m^3 in the kidney kidney. However, some experts believe damage may occur at half that amount, while others believe that damage doesn't occur until levels of 300-400 ug/m^3 are reached.

Cancer: Recent studies indicate cadmium may also be a human carcinogen or cancer-causing agent. Like other known human carcinogens, cadmium induces mutations in bacteria and mammalian cells. Laboratory animals injected with cadmium develop cancer at the site of injection and in other organs. Reports of significant increases in prostate cancer in persons occupationally exposed to cadmium for prolonged periods seem to corroborate the laboratory data.

Birth defects: Human birth defects attributable to cadmium have not been documented. Nevertheless, one study of mothers working in the cadmium industry recorded lower birth weights, signs of rickets and delayed development of teeth in newborn children. Laboratory tests in which pregnant rats, mice, hamsters and frogs are fed cadmium have produced birth defects in the offspring.

Other effects: Cadmium has toxic effects on a variety of organs and systems in test animals, and there are indications that humans may be affected in similar ways. Injection of cadmium into rats, rabbits and dogs have induced hypertension. Similarly, chronic oral exposure to low concentrations has created hypertension in rats. Direct cause and effect relationship between cadmium exposure and hypertension, however, has not yet been established in test animals or humans.

Moderate anemia has been reported in cases of occupational exposure to cadmium dust and fumes. Anemia is a common finding in cadmium chronic exposure experiments with several species of laboratory animals. Central nervous system disorders have been observed in storage battery factory workers exposed to cadmium and brittle bone conditions have been reported among workers in a variety of cadmium industries. Also, people who suffer from iron, calcium, and other dietary deficiencies are highly susceptible to cadmium absorption.

What is the government doing about this hazard?

Federal regulation of human exposure to cadmium cadmium began in the occupational environment where exposure was the greatest, and has since been expanded to include cadmium contamination of food, land, water and air. In 1970, the Occupational Safety and Health Administration (OSHA) adopted occupational exposure standards set voluntarily by industry in the 1940's to curb acute cadmium poisoning. OSHA is currently reviewing a proposal to lower those limits of 0.1 milligrams per cubimeter (0.1 mg/m^3) for cadmium fumes and 0.2 mg/m^3 for cadmium dusts to 40 migcrograms per cubic meter (40ug/m^3) for combined dust and fumes. (A milligram is 1/1000 of a gram and a microgram is one millionth of a gram). The standard is being strenghtened to protect workers against the development of kidney damage which has been reported at exposure levels as low as 66 ug/m^3.

The Food and Drug Administration (FDA), concerned with the dietary intake of cadmium, is surveying foods available in grocery stores for the presence of cadmium, and testing the ability of cadmium to leach from cookware. They are also evaluating current analytical methods for detecting cadmium in foods. The FDA, EPA and U.S. Department of Agriculture (USDA) are jointly involved in a four-year survey (started in 1979) of 6,000 crop samples and 18,000 associated soil samples from major crop producing regions of the U.S. to assess cadmium content and availability. A long-term study sponsored by EPA and USDA is analyzing the flow of cadmium from sewage sludge in a food chain system utilizing sludge-fertilized corn fed to dairy goats. Another EPA and FDA study is examining impacts of incorporating cadmium-contaminated sewage sludge into cattle feed.

To curb the increasing cadmium contamination of soil resources, EPA has established criteria for the disposal of sewage sludge containing cadmium on agricultural lands (1979 regulations), and proposes to promulgate rules for municipal and home use and disposal of sludge in the near future. Regulations governing the management of hazardous cadmium wastes from industrial sources have also been proposed under the authority of the Resource Conservation and Recovery Act.

To reduce cadmium levels in water, EPA used the authority of the Clean Water Act in 1979 to set effluent guidelines which limit the amount of cadmium in waste water discharges from electroplating plants into publicly-owned waste water treatment works. A drinking water standard of 0.01 mg of cadmium per liter of water has also been set. EPA draft water criteria for cadmium will serve as the basis for any additional regulation of cadmium content in water.

The health effects, sources of emissions, population exposure and risk of cadmium in the air have been analyzed by EPA and regulation of cadmium as an airborne carcinogen under the authority of the Clean Air Act is under consideration. Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), EPA also is conducting an in-depth risk/benefit review of registered cadmium pesticide uses through the "rebuttal presumption against registration" (RPAR) process. This review could result in continuation, restriction or final cancellation of the presently registered cadmium pesticide uses.

In Summary: Cadmium is of concern because of its known toxicity at very low levels, its bioaccumulation in soils, its potential as a human carcinogen, and the widespread exposure of the American public to cadmium levels which approach those known to cause significant health hazards. The major uses of cadmium have been banned by the Swedish Government.