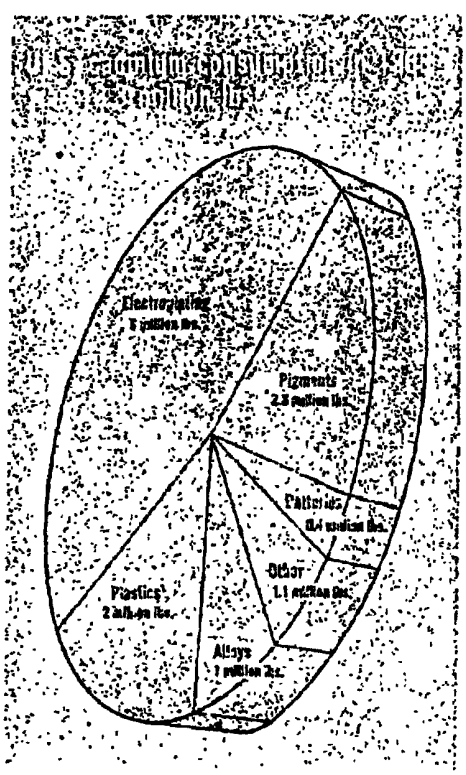
# Metals focus shifts to cadmium

*Although it's a potentially hazardous pollutant and many questions remain to be answered, there will probably be no "cadmium crisis"*



The Japanese call it "itai-itai byo"—the ouch-ouch disease—because of the excruciating pain accompanying a bizarre skeletal disorder known as osteomalacia. In those affected with itai-itai, bones may become so fragile that mere coughing is sufficiently traumatic to fracture ribs.

For years in the aftermath of World War II, farmers in Japan's Jintsu River Basin, where itai-itai was most prevalent, had complained that waste water from a zinc mine, discharging directly into the river used for irrigating rice paddies, was spoiling crops. But it wasn't until last year that Okayama University's Jun Kobayashi established the common denominator between the frequently fatal itai-itai and failing rice crops. The culprit was cadmium—a metal intimately associated with lead and zinc deposits and long known to be harmful to man.




Although toxicologists now believe that various nutritional deficiencies play a critical role in the full-blown itai-itai syndrome, the discovery that populations could be exposed to toxic quantities of cadmium by contaminated water caused a nation still jittery over the mercury pollution of Minamata Bay to shudder anew at the prospect of yet another heavy metal disaster. And more than a little concern was expressed in the U.S. last year over findings that showed many municipal water supplies contain significantly more than the 0.1 parts per million of cadmium considered to be "safe" for drinking.

As with mercury, very little was known about the fate and distribution of cadmium in the environment. What was known was scary enough. What was not known was even scarier.

It was known, for example, that cadmium has a very long biological half-life in man and therefore tends to accumulate in the body. Estimates ranged from 10–25 years, compared with about 70 days for methyl mercury. It was also known from industrial toxicology that cadmium could cause severe liver and kidney damage, pulmonary disease, and death.

In the absence of solid toxicological data, speculative analogies between mercury and cadmium were common. Was there, for example, a process similar to the microbial methylation of mercury which would concentrate cadmium in the food chain? Fortunately, that hypothesis appears to be incorrect. Nevertheless, disturbing questions about the amount of cadmium discharged into air and water and the effects of chronic exposure to cadmium remained.

In an effort to answer some of those questions the Environmental Protection Agency (EPA) commissioned studies to determine just how serious a threat cadmium poses. Although more work remains to be done, a picture is beginning to develop that is not quite so black as might have been imagined. The consensus of opinion is that although cadmium is a potentially dangerous pollutant, there is no reason to believe that a "cadmium crisis" is imminent. Cadmium is not "another mercury."

### Distribution

Cadmium is a relatively rare metal—the earth's crust contains an average of only 0.5 ppm. It occurs chiefly as the sulfide, greenockite, in various zinc, lead, and copper ores. Nearly all the cadmium produced in the world is a by-product of zinc smelting. Recycling is virtually nonexistent. Only 4% of the 10.6 million pounds of cadmium produced in the U.S. during 1968 was derived from reprocessing cadmium-containing scrap.

Cadmium does not degrade in the environment. As greater quantities of cadmium are refined, more and more of it becomes available to interact with man. Domestic consumption of cadmium was more than 15 million lbs. in 1969 (the last year for which official statistics are available). That's a whopping 13% jump over the figure for 1968. All indications point to further sharp increases in consumption for the foreseeable future. And because nearly everything produced by cadmium-using industries sooner or later winds up on the junk pile, the potential for environmental contamination is considerable.

Studies funded by the EPA provide a fairly complete inventory of sources and amounts of cadmium emissions into the atmosphere. Parallel studies for cadmium in water supplies, however, are lacking. Nearly 4.6 million pounds of cadmium was emitted into the atmosphere in the U.S. during 1968, according to a study prepared for the National Air Pollution Control Administration in 1970. Lee J. McCabe, director of Epidemiology and Biometrics for EPA's Office of Water Programs says there's "some but not much" cadmium in drinking water. Just how much is discharged into waterways is not known.

By far the largest single user of cadmium is the electroplating indus-

**Pounds of cadmium emitted to atmosphere in U.S. in 1968**

| | | |
|---|---|---|
| Among ead metallurgical processing | | 2,100,530 |
| mining | 530 | |
| Cd separation from ore | 2,100,000 | |
| Incineration and disposal | | 2,440,000 |
| plated metal | 2,000,000 | |
| radiators | 250,000 | |
| other | 190,000 | |
| Industrial reprocessing | | 33,529 |
| pigments | 21,000 | |
| plastics | 6,000 | |
| alloys | 5,000 | |
| batteries | 400 | |
| miscellaneous | 1,128 | |
| Consumptive uses | | 14,630 |
| rubber tires | 11,400 | |
| motor oil | 1,820 | |
| fertilizers | 910 | |
| fungicides | 500 | |
| | Total | 4,588,688 |

Source: National Inventory of Sources and Emissions

try. The metal imparts an attractive, corrosion-resistant finish to ferrous metals. Virtually no cadmium escapes into the atmosphere from electroplating operations; how much gets into water from plating baths is anybody's guess. Hopefully, says McCabe, such information will be forthcoming in the next couple of years as discharge permits, required by the Army Corps of Engineers, are processed (see "What's the U.S. Army doing in water pollution control?" ES&T, December 1970, page 1101).

Other important applications for cadmium include pigments, plastics stabilizers, alloys, and batteries. Together with electroplating, these five product groups account for more than 90% of the cadmium used domestically. A wide variety of minor applications—television picture tube phosphors, fungicides for golf courses, control rods and shields in nuclear reactors, and curing agents for rubber, among others—accounts for the remaining 9 10%.

### Emissions

Most cadmium emissions into the atmosphere fall into two general categories—disposal and metallurgical processing. Disposal includes incineration and recycling of ferrous scrap and accounts for more than half the cadmium put into the air each year. The biggest chunk is lost in reclamation of scrap steel and recovery of copper from automobile radiators. Incineration of plastic products—ranging from bottles to baby pants—also adds cadmium to the atmosphere.

Metallurgical processing emits nearly as much cadmium to the air as disposal does. Although actual mining operations contribute only slightly to atmospheric cadmium levels, roasting and sintering of ore release vast quantities of cadmium into the air. Smaller amounts of cadmium in the air come from a variety of manufacturing processes as well as the use of certain fertilizers, fungicides, motor oils, and rubber tires.

Against this backdrop of emissions data, EPA commissioned three Swedish veteran cadmium watchers from Stockholm's Karolinska Institute to prepare a report on the health effects of cadmium in the environment. The trio, Lars Friberg, Magnus Piscator, and Gunnar Nordberg, recently presented the results of their review to a symposium at the University of Rochester School of Medicine.

The Swedish report says that although the body contains only 1 μg of cadmium at birth, a 50-year old, 70-kg (155-lb) "standard man" has a body burden 30,000 times that amount (30 mg). Excessive exposure to cadmium can damage the liver, kidneys, spleen, or thyroid, but the amount of cadmium needed to produce severe damage is not known.

Ambient air contains only a small amount of cadmium, the report says, but in the vicinity of certain factories, concentrations can be much higher. Cadmium is absorbed either by inhalation or ingestion and human beings are exposed to substantial amounts in food, according to the report. A differential absorption rate, however, makes inhalation of cadmium more dangerous than ingestion. Only about 5% of ingested cadmium is absorbed by the body; estimates for absorption of inhaled cadmium run as high as 40%, but actual amounts are probably lower. Recent work by Harold G. Petering at the University of Cincinnati indicates that people who smoke as few as 10 cigarettes per day —or the equivalent in other tobacco products—are exposed to concentrations of cadmium from 10-100 times greater than those in the ambient air. Worse yet, smoke from smoldering tobacco that is not inhaled—the sidestream—contains more cadmium than the mainstream inhaled by the smoker. Thus, everyone in the same room with a smoker is exposed to elevated cadmium levels.

Cadmium has also been implicated in cardiovascular disorders and cancer, although the Swedish team emphasizes that there is no conclusive statistical evidence linking cadmium with these diseases.

### Research needs

The Friberg-Piscator-Nordberg report lists several research priorities including:

- The "urgent and immediate" need for experiments on dose-response relationships considering absorption and excretion rates, particle size, and exposure routes;
- Studies on concentration of cadmium in various organs relative to total body burden;
- Development of better indicators of cadmium levels in the body;
- Further work on teratogenic or carcinogenic effects of cadmium, both alone and in combination with naturally occurring chelating agents such as EDTA and NTA)
- The definition of mechanisms for accumulation in food chains; and
- Metabolic studies establishing the role of essential trace metals in cadmium accumulation.

There is no doubt that cadmium has "caused trouble," according to Robert J. M. Horton, senior research advisor for EPA's Air Programs Office, Division of Effects Research. But, he adds, "I can't think of any reason why there should be a panic reaction." What steps will be taken by the EPA to control cadmium remain uncertain, but Friberg offers some advice: "All such long half-life substances should be controlled to the greatest extent possible." IMM