The hazards of trace elements

Environmental lead, nickel and cadmium are already of concern. Many others are being identified

by Richard H. Gilluly

The toxicology of the trace elements is immensely complicated. For some of them, the familiar threshold-versus-linear problem exists: Do they cause some poisoning in even the smallest amounts, or must a certain threshold be reached before harm is done? The compounds in which they occur are also often a key factor; for instance, various inorganic mercury compounds are relatively nontoxic in large quantities, whereas certain organic mercury compounds are highly toxic in small doses.

Many elements discovered in small quantities in air and water have been present in background amounts since long before the industrial revolution, and a number are essential to life and probably harmless in the amounts found.

Researchers at a metal-free laboratory at Brattleboro, Vt., working under a National Institutes of Health grant, have exposed rats and mice orally over their lifetimes to environmental amounts of all the elements found in the National Air Sampling Stations. The laboratory is not equipped for aerosol exposures. "We've narrowed the problem down to three elements that really concern us in the amounts found in the environment," says Dr. Henry A. Schroeder, director of the research.

Schroeder

Dr. Schroeder: Narrowing the problem to three elements of immediate concern.

The three are lead, nickel and cadmium.

Trace lead contamination has been a subject of concern for several years. This year, the Environmental Defense Fund has petitioned Health, Education and Welfare Secretary Robert Finch to require a halt in the use of the anti-knock additive, tetraethyl lead, in gasoline, and President Nixon has proposed a tax on lead, designed in part to discourage its use as an additive (SN: 5/23, p. 504). And with good reason, claims Dr. Schroeder: "Exposure to amounts of lead in the air near heavy traffic very probably results in a dangerous dose over a long enough period." Lead levels in heavy traffic reach 45 parts per million or more.

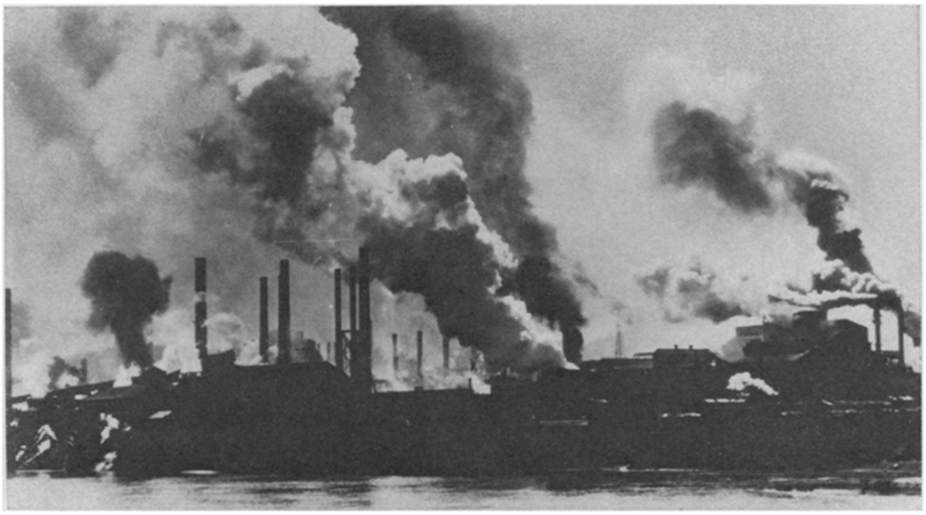
Lead kills outright at high doses. But in doses comparable to amounts that might accumulate in humans living near dense traffic, lead shortens life spans in Dr. Schroeder's experimental animals. In addition, it causes nervous system deterioration, and thus may be responsible for retardation in children. "Retarded children, significantly, have higher amounts of lead in their bloodstreams than normal children," he says.

Like other contaminants, notably persistent pesticides, lead accumulates in human tissues: "There is no question that amounts of lead in the human body increase with age—as shown in 200 autopsies recently," says Dr. Schroeder.

He suspects also that lead may be responsible for some of the endemic nervousness, fatigue and vague ill-health in the United States. But he concedes a great deal more evidence must be gathered before this is established.

Nickel is present in air samples from all over the nation. Because it seems to increase during colder months, its source may be fuel oil, suggests Dr. Schroeder. But the nickel oxides which make up about 10 percent of the fly ash from the fuel oils are much less a concern than a compound, nickel carbonyl, which results from a reaction between nickel and hot carbon monoxide—the reaction probably taking place in incinerators and in internal-combustion engines, especially diesel engines. "Nickel carbonyl is absorbed by the lungs and there is no doubt it is carcinogenic," says Dr. Schroeder. Ambient air samplings by the National Air Sampling Network identify only the element, nickel, and not the compounds in which it occurs. In a recent year, nickel in urban air averaged 0.032 micrograms per cubic meter and went as high as 0.690 micrograms. Most nickel compounds are solids and are removed through gross particulate abatement. Nickel carbonyl, however, is liquid or gaseous.

Cadmium is found in both air and water; its source in the air is probably metal refining industries, and in water probable sources include galvanized pipes. Inhaled, cadmium can cause em-



Steel mill: Dozens of undetected pollutants having unknown health effects.

Diesel: Nickel carbonyl source.

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Okun: Dual systems are what we need.

physema and bronchitis. Taken into the body, through the lungs or otherwise, it is associated with cardiovascular death rates, hypertension, kidney damage and a number of other illnesses. Orally administered, cadmium shortened life spans in Dr. Schroeder's rats and mice and also caused hypertension in the rats.

Cadmium, in fact, has been found harmful to nearly all human and animal systems. Atmospheric concentrations—as high as 0.350 micrograms per cubic meter in Newark, N.J., in one recent year, for example—have been correlated statistically with heart diseases.

Scarcely any research has been done on the synergistic effects of the trace elements—either with other trace elements or with pollutants that occur in large quantities. In one case, there is at least a presumption of danger: Vanadium catalyzes sulfur dioxide into sulfur trioxide, which becomes sulfuric acid when reacted with water. These reactions can occur in industrial flues or in the atmosphere, says Dr. Glen E. Gordon of the University of Maryland. Vanadium alone is nontoxic in laboratory animals in amounts far larger than found in the environment. But Drs. Gordon and Schroeder agree that it may facilitate creation of enough sulfur trioxide to cause problems.

One beneficial synergism has been recognized: adequate chromium in the diets of experimental rats will prevent the toxic effects of lead. "For some reason the chromium has a protective effect," says Dr. Schroeder, whose laboratory has just begun detailed work on the possible synergisms.

Abatement techniques for trace elements are still in their infancy. Some of the elements have declined in the environment over the past 20 years as a result of partial control of grosser pollution problems and generally better safeguards against release of environmental contaminants. Use of lower-sulfur fuel oil in New York power plants, for example, has probably also resulted in lower selenium levels.

An approach that has been suggested to deal with trace elements—as well as organic pollutants such as pesticides—in water supplies is to create dual water-supply systems, one system for industrial uses and residential uses such as sprinkling and toilet flushing and the second system for drinking water (SN: 4/20/68, p. 378). The first system would use reprocessed water from sewage treatment plants or from polluted rivers, chlorinated to remove pathogens. The second system would draw its water supplies from purer upland sources.

Such systems would have the advantage of conserving purer upland waters—which it is estimated would be used at a ratio of about 1:4 with the reprocessed water—now the only water for all purposes in some cities. They would also be a total approach to preventing human ingestion of the dissolved trace elements and other substances that are not removed in the usual reprocessing—also often the only source of water for all purposes for many cities.

Says Dr. Daniel A. Okun, a University of North Carolina environmental engineer who is a strong supporter of the dual-system approach: "It will be a long time before we clean up the rivers, and it is difficult just to keep up with new needs. The dual systems are inevitably the direction in which we will have to go."

In a number of Eastern Seaboard areas, for example, it would be feasible to install such systems. Upstream reservoirs in the Delaware River Basin could be used for Philadelphia drinking water requirements. The grosser supply could be drawn directly out of the river for reprocessing, as is done now for the total supply in many systems. The drinking water system could use higher-quality pipes and other materials, making for longer life as well as eliminating pollution due to pipe corrosion (a source of cadmium, says Dr. Schroeder). In arid areas, drinking water supplies might be obtained from desalination of brackish or saline waters.

But there is no feasible way now by which pure air can be channeled to human beings, and the only reasonable approach is to prevent emission of the harmful pollutants on a one-by-one basis as the sources are clearly identified. Use of higher-grade fuel oils in Boston, for example, may be the way to reduce the high levels of vanadium there, says Dr. Gordon. Elimination of tetraethyl lead additives from gasoline appears to be the only approach to the lead problem.

The fact that the toxicology of the trace elements is still in its infancy and that extrapolation of results of animal tests to humans is uncertain at best is no reason not to act, says Dr. Okun. "It is the better part of good sense to avoid exposing human beings to substances which may be harmful." □