First world estimate of metal pollution

Nearly every major industry releases one or more trace metals into the environment. Ore smelting spews arsenic and lead into the atmosphere. Urban wastes and coal ash disposal lace soils with zinc, copper and mercury. Power plants and smelters taint rivers, lakes and seas with selenium, cadmium and nickel. But unlike organic pollutants, these metals are not biodegradable; they stay in the ecosystem, building up to what can become toxic levels.

In the May 12 NATURE, two researchers present the first quantitative worldwide estimate of the annual industrial input of 16 trace metals into the air, soil and water. "On a global basis there are *tremendous* quantities of toxic metals released into the environment," says Jerome O. Nriagu, an environmental geochemist at Canada's National Water Research Institute in Burlington, Ontario. He compiled the figures for 1984 emissions with atmospheric chemist Jozef M. Pacyna of the Norwegian Institute for Air Pollution Research in Lillestrom. The researchers conclude the toxicity of the trace metals released each year now exceeds that of all radioactive and organic pollutants combined, assuming toxicity is measured as the amount of water that would be required to dilute pollutant concentrations to levels safe for drinking.

This study "illustrates pretty clearly that human activities are significantly altering the cycling of many heavy metals in the environment on a global scale, and not just in New York City or in your local sewage treatment plant," comments atmospheric chemist Robert A. Duce at the University of Rhode Island in Narragansett.

Nriagu and Pacyna's results are consistent with measurements of several trace metals made by Duce and his coworkers in remote regions of the Pacific Ocean. "We are definitely seeing the impact [of metal emissions] thousands of miles away from the sources," Duce says. "But the problem is what does it mean? Is it causing a problem? I don't think we have the answer to that."

Nriagu, however, says the accumulation of toxic metals in the human food chain is accelerating. He believes the world may be facing a "silent epidemic of environmental metal poisoning."

The NATURE paper expands upon atmospheric emission estimates of five metals Nriagu compiled in 1975. It is the first study to look at world metal inputs into soils and water, and as such helps scientists see how metals move between air, soil and water. The researchers note that contamination of freshwater in Europe, North America and Asia may be much more severe than generally realized and that in some parts of Japan and Europe, metal levels in soils have overwhelmed the environment's natural ability to cleanse itself.

Happily, not all of the news is bad. According to Nriagu, atmospheric levels of lead, zinc, cadmium and copper dropped between 1975 and 1984. Lead emissions will continue to fall, he says, mostly because of U.S., Canadian and European controls on leaded gasoline. Still, he adds, while the global numbers are encouraging, the problem is simply shifting from developed nations to the developing countries, which have no controls on lead and other metals.

— S. Weisburd

Copperless compounds and other superconducting matters

These days, the discovery of a new material that becomes a superconductor at a mere 30 kelvins, or -405°F, normally wouldn't rate much more than a footnote. In the race toward higher and higher transition temperatures, the leading contenders are copper-based superconductors, which start to lose all resistance to electric current at temperatures as high as 125 K (SN: 4/2/88, p.213). What makes the new formulation special is its absence of copper, the key element in all previously discovered high-temperature superconductors.

The new superconductor, found by Robert J. Cava and his colleagues at AT&T Bell Laboratories in Murray Hill, N.J., contains a combination of barium, potassium, bismuth and oxygen. Bismuth seems to play the same role in this compound that copper plays in other superconductors. However, whereas copper-oxide superconductors have a two-dimensional layered structure, the bismuth compounds assume a three-dimensional framework of connected bismuth and oxygen atoms.

The addition of the bismuth family significantly enlarges the pool of materials that researchers can study in their search for higher transition temperatures. Cava and his group suggest in the April 28 NATURE that exploring the properties of bismuth-based superconductors will help scientists understand why both bismuth- and copper-containing compounds become superconducting. It isn't clear yet whether the same mechanism is responsible for superconductivity in both systems.

Other recent studies provide improved evidence of a strong link between high-temperature superconductivity and magnetism. Two new reports of experiments done on copper-oxide systems support the idea that adding an impurity, such as strontium to lanthanum copper oxide, disturbs the magnetic interaction between copper atoms.

Usually, in the nonsuperconducting form of a material, the copper-copper interaction is said to be antiferromagnetic because adjacent copper atoms have oppositely directed spins, or magnetic moments. Adding impurity atoms introduces spins that upset this orderly arrangement. The result is a spin glass, meaning that the spins are randomly oriented. Finally, the addition of enough impurity creates the paired charge carriers necessary for superconductivity.

"Much remains to be done to elucidate the evolution of the magnetic state as charge carriers are introduced by doping or varying the oxygen content," comments Victor J. Emery of the Brookhaven National Laboratory in Upton, N.Y., in the May 5 NATURE. "One thing is clear; the magnetism cannot be ignored."

The discovery of a new superconducting substance immediately prompts efforts to grow single crystals of the material, to draw it into fine wires or to deposit it as thin, uniform films — all for the sake of potential applications in electronics and elsewhere. For example, superconductors containing the toxic element thallium first became known just a few months ago. Last week, researchers at the Sandia National Laboratories in Albuquerque, N.M., announced success in making the first thin films from this material.

The new films, much thinner than a sheet of paper, become superconducting at 97 K — the highest transition temperature for any thin film yet made. In addition, the films can carry a current of up to 110,000 amperes per square centimeter at 77 K, the temperature of liquid nitrogen. That current density is by far the highest for a superconducting film made up of many small crystals in contact.

Researchers at Japan's Fujitsu Laboratories have developed a technique for depositing thin superconducting films on a large area by vaporizing the essential ingredients, allowing them to react with each other in an atmosphere containing oxygen, helium and water vapor, and then letting the products settle on a magnesium oxide base. In this way, they produce a single-crystal film of the superconductor bismuth strontium calcium copper oxide.

Chemical vapor deposition, as the technique used by Fujitsu is called, is a versatile, inexpensive technique already widely used for producing semiconductor thin films for microelectronics applications. It may now find an important place in the mass production of high-quality, superconducting films for electronic devices.

— I. Peterson