United States environmental regulations, intended to protect human health, generally fail to address major sources of pollutants that endanger human health. These sources are surprisingly close to us and within our control, such as consumer products and building materials that we use within our homes, workplaces, schools, and other indoor environments. Even though these indoor sources account for nearly 90% of our pollutant exposure, they are virtually unregulated by existing laws. Even pollutant levels found in typical homes, if found outdoors, would often violate federal environmental standards.

This article examines the importance of human exposure as a way to understand and reduce effects of pollutants on human health. Results from exposure studies challenge traditional thinking about pollutant hazards, and reveal deficiencies in our patchwork of laws. And results from epidemiological studies, showing increases in exposure-related diseases, underscore the need for new protections. Because we cannot rely solely on regulations to protect us, and because health effects from exposures can develop insidiously, greater efforts and innovative policies are needed to reduce and prevent significant exposures before they occur.

Pollutant Exposure Studies: Surprising Results


- We are regularly exposed to many toxic chemicals and carry them in our bodies, as evidenced by samples of human blood, breath, hair, tissue, and body fluids.

- Most of our exposures to these chemicals are not from sources traditionally regulated, such as remote waste sites and factories. Rather, the primary sources are close to us: within our indoor environments, and the personal activities, products, and materials inside those environments.

- Of more than several hundred pollutants regulated by federal laws, all but a few are higher indoors than outdoors, due to indoor sources.

- The sources of these pollutants are largely unregulated -- meaning that our environmental regulations, designed to protect and promote human health, are missing major sources of health risks.

- The public is generally unaware of these types of everyday exposures, their health consequences, and the relatively simple and cost-effective actions that could reduce health risks.

Exposure Science: Measuring Pollutants that Affect Humans

The science of human exposure emphasizes an important but often overlooked fact: The pollutants that affect human health are those that come in contact with humans (Ott, 1985). In this way, exposure science differs from traditional approaches to environmental management. Instead of identifying a pollutant source and then trying to trace emissions through the environment to see who or what might be affected, exposure science starts with the receptor of those pollutants -- humans. It identifies and measures the pollutants that have reached humans, and then traces the pollutants back to their sources. If a goal of environmental regulations is to protect and promote human health, then we need to address not only the pollutant sources but also the receptors.

Advances in the science of exposure assessment have enabled researchers to measure, with great accuracy, the types, concentrations, durations, and locations of human exposure to environmental pollutants. These advances are technological, such as the use of highly sensitive analytic instruments and portable exposure monitors, and methodological, such as the use of sophisticated probability sampling designs in large-scale field studies (Ott and Roberts, 1998).

In the 1980s and 1990s, the U.S. Environmental Protection Agency (EPA) and other researchers conducted the landmark TEAM (total exposure assessment methodology) studies that measured personal exposures to pollutants. These studies monitored more than 3,000 participants, in 18 U.S. urban and suburban cities and one Canadian province, for exposure to volatile organic compounds (VOCs) (Wallace, 1987; Wallace et al., 1991; Wallace, 1993), pesticides (Immerman and Schaum, 1990; Whitmore et al., 1994), carbon monoxide (Akland et al., 1985), particles (Ozkaynak et al., 1996a,b; Pellizzari et al., 1993), phthalates (plasticizers) and polycyclic aromatic compounds (PAHs) (Sheldon et al., 1993), among other pollutants. The participants carried around personal exposure monitors that indicated what, how much, and where pollutants were affecting them. In addition, the VOC and CO studies measured breath levels of 2000 participants to detect the chemicals in their bodies (Wallace et al., 1986; Wallace et al., 1988).

These studies produced a compelling finding: Most of our exposure to pollutants occurs indoors, and from products that we choose to use. This result contradicted conventional thinking, and conventional regulation, that focus on outdoor sources of emissions rather than indoor and personal sources of exposures.

What and where are these pollutant sources? Studies identified the following:

- consumer products, such as air fresheners, deodorizers, cleansers, disinfectants, personal care products, laundry supplies, moth repellants, cosmetics, dry-cleaned clothes, solvents, and pesticides.

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** building materials and furnishings, such as paints, varnishes, adhesives, solvents, carpets, vinyl flooring, pressed wood products, and combustion appliances.

** individual activities, such as bathing and washing in chlorinated water, burning firewood and candles, refueling an automobile tank, and cigarette smoking.

Specific results include the following.

** VOC exposures indoors are typically 5 to 50 times higher than outdoors, even in cities with relatively high levels of outdoor pollution and heavy industry. New buildings often contain VOC levels that are hundreds of times higher than outdoor levels (Sheldon et al., 1988b; Wallace 2001). Common VOCs cause both acute and chronic health effects, ranging from sensory irritation and headaches, to neurological damage and cancer (Pierson et al., 1990; Otto et al., 1990, NIH, 2003).

** Pesticide levels can be 5 to 10 or more times higher indoors than outdoors, even though some pesticides are used only outdoors (Whitmore et al., 1994). Reasons are that pesticides used outdoors, such as termiticides, can seep indoors or be tracked inside by shoes; plus, pesticides can persist much longer indoors where they are protected from degradation. In addition, past applications of pesticides can persist in the environment and in human bodies for decades after the initial application. For instance, the pesticide dichlorodiphenyltrichloroethane (DDT), which was banned in 1972, was nonetheless found in carpets of 25% of 362 Midwestern homes (Camann et al., 2000). In addition, polycyclic aromatic compound concentrations found in carpet dust of 89% of these homes were more than seven times the Superfund preliminary remediation goal for outdoor soil. This implies that an average urban infant, consuming an average of 100 mg. of dust containing 100 nanograms of benzo(a)pyrene a day, could be exposed to an amount equivalent to smoking 2.8 cigarettes a day (Ott and Roberts, 1998).

Partly influenced by the TEAM Study findings, several national and regional task forces attempted to compare a wide selection of environmental risks. The consensus was that the risk from indoor air pollution and consumer products was far greater than most of the other risk factors surveyed, including hazardous waste sites and outdoor air pollution (EPA 1987, 1988a, 1989a; Omenn, 1997).

The U.S. Centers for Disease Control and Prevention (CDC) recently conducted two nationwide assessments of human exposure to toxic chemicals in air, water, food, soil, dust, and other media (such as consumer products). The First National Report on Human Exposure to Environmental Chemicals (CDC, 2001) presented exposure data for 27 chemicals (lead, mercury, cadmium, and other metals; metabolites of organophosphate pesticides; cotinine; and phthalates). The Second National Report (CDC, 2003) included these 27 chemicals and added 89 more, including polycyclic aromatic hydrocarbons; dioxins, furans, and coplanar polychlorinated biphenyls (PCBs); non-coplanar PCBs; phytoestrogens; organophosphate, organochlorine, and carbamate pesticides; herbicides; pest repellants; and disinfectants.

Results showed some success in dealing with prior problems, such as exposures to lead and environmental tobacco smoke. But they also revealed new problems. One is exposure to phthalates, which virtually all Americans now carry in their bodies. Phthalates are found in numerous consumer products such as soft plastics, pesticides, pharmaceuticals, lotion, children's toys, adhesives, detergents, lubricants, food packaging, soap, shampoo, hairspray, nail polish, and products made from polyvinyl chloride (PVC). Levels of phthalates were highest in children and women of reproductive age, posing risks of developmental and reproductive abnormalities, such as infertility, precocious thelarche (onset of breast development before age eight in girls), sperm damage, and birth defects (Raloff, 2000; NTS, 2000; CERHR, 2000). Another is the prevalence of pesticides and the levels of pesticides, especially in children. Metabolites of the pesticide chlorpyrifos were nearly twice as high in children (age 6-11) than as in adults. Metabolites of the organochlorine pesticide DDT were clearly measurable in young adults ages 12 to 19, even though they were born after the U.S. ban (CDC, 2003). [For a report on known and potential health effects of chemicals in these CDC studies, see PSR (2003).]

A recent exposure study, led by Mount Sinai School of Medicine in New York, in collaboration with the Environmental Working Group and Commonweal (EWG, 2003) evaluated nine adult subjects, none of who work with chemicals, and all of whom were regarded as leading healthy lives. The study found 167 industrial compounds (average of 91 compounds) in the blood and urine of these subjects, including breakdown products from organochlorine and organophosphate pesticides, polychlorinated biphenyls, dioxins, furans, and phthalates. These chemicals are associated with cancer, brain damage, hormonal disruption, birth defects, developmental abnormalities, reproductive system defects, and immune system damage (EWG, 2003; NIH, 2003). Among the chemicals tested, the most prevalent were 77 semivolatile and volatile organic chemicals, present in common consumer products, solvents, cleaners, and paints. None of these 77 compounds was tested in the CDC studies, and each of them was found in at least one subject in this study.

Next week: What are the health consequences of these chemicals in our bodies, and what might we do about them?
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