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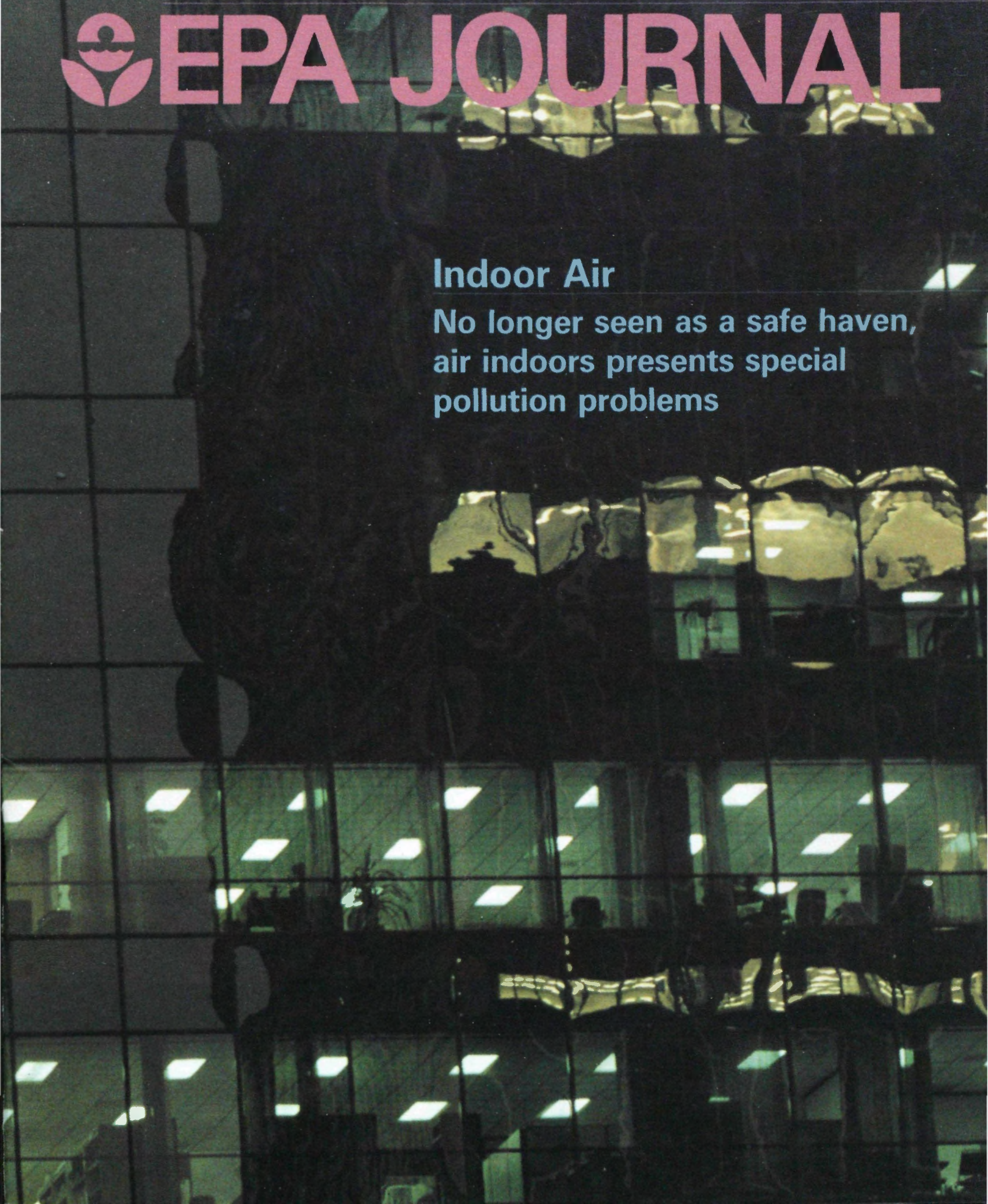

Indoor Air

No longer seen as a safe haven, air indoors presents special pollution problems

United States
Environmental Protection Agency

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Some sad news: New England and EPA lost a true advocate for the environment with the death of Paul G. Keough, Deputy Regional Administrator in Region 1. Paul was well known as a tough enforcer, a fair administrator, and a superb communicator. He was also a national leader in promoting environmental education and EPA's human resources, as Administrator Browner recognized by creating the Paul G. Keough Award for Administrative Excellence. He will be sorely missed.

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From the Editors

Mention air pollution, and most of us think of *outdoor* air pollution and regulatory standards under the Clean Air Act. Those of us who live in certain urban areas may think of "inversion" effects and smog alerts, when we may be advised against exercising out of doors.

But what about indoor air? Comparatively recent exposure monitoring studies, based on a concept called "total exposure assessment," have called into question the notion that indoor environments are a safe haven from air pollution. In fact, certain pollutants, such as benzene (a component in environmental tobacco smoke, or ETS) are sometimes found at higher levels indoors than outside. The implications of these findings are compelling. After all, 90 percent of our time, on average, is spent in indoor environments including residences and workplaces, various public and commercial buildings, and private and public transport vehicles (cars, buses, subway and other trains, and airplanes).

Outdoor ambient air-quality standards do not apply to indoor air. Even if they did, however, few observers believe that a traditional, pollutant-by-pollutant approach would be adequate to solve indoor air pollution problems. Among other reasons, many more pollutants are involved (4,000 in ETS alone) than are regulated in outdoor air, and there are many unanswered questions about such phenomena as "sick building syndrome" and multiple chemical sensitivity. What, then, is the best approach for protecting indoor air quality? Not everyone agrees, but several contributors to this issue of *EPA Journal* explore this question. Related articles discuss cutting edge research, regulatory and nonregulatory initiatives, and proposed legislation. Take a deep breath, and stay with us. □

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The U.S. environmental Protection Agency is charged by Congress to proteect the nation's land, air, and water systems. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

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EPA Responds to NAS Pesticide Report

EPA Administrator Carol Browner has announced actions that the Agency will take to carry out recommendations of the National Academy of Sciences report Pesticides in the Diets of Infants and Children. *Browner said: "The National Academy of Sciences' study makes three key recommendations that I strongly agree with. . . . One, we don't know enough about the dangers of the pesticides we use, and we need to find out more. Two, we don't know enough about the residues that remain on the food we eat, and we need to find out more. And three, we don't know what children's exposure is (to pesticides) because we don't know what children eat. We need to find out."*

Steve Delaney photo.

The Washington Post reported: ". . . It [the report] recommends that when adequate data on a given chemical are lacking, 'there should be a presumption of greater toxicity to infants and children.' In such cases, the NAS panel called for exposure standards 10 times more stringent than would normally be applied. But the study emphasizes that parents should not reduce their children's consumption of fruit or vegetables. . . . Currently, the Environmental Protection Agency regulates pesticide levels by balancing agricultural benefits with health risks, based on an extrapolation from figures on average adult consumption. That system does not take into account the dietary patterns of children, who eat fewer foods and consume much more of certain foods per unit of body weight than adults, the panel concluded. . . . To improve regulation of pesticides and increase understanding of how they affect children, the NAS panel urges federal regulators to:

- Use immature animals in addition to adult animals (usually rodents) to test for the toxicity of pesticides, to provide better information about how young organisms react to the chemicals.
- Conduct food consumption surveys at one-year intervals up to age 5, as well as surveys of children age 5 to 10 and 11 to 18. Surveys now use only broad groupings that do not reflect dramatic changes in dietary patterns at different ages.
- Increase sampling of pesticide residues from food consumed by infants and children.
- Consider all sources of dietary and non-dietary exposure to pesticides, including drinking water and water added to foods, as well as air, soil, lawns, pets and indoor surfaces. Apply new statistical methods in estimating risk for children. . . . "

The New York Times commented: ". . . Until now, critics charge, agencies in the Government have been at odds over agricultural chemicals and in recent years, especially during the Reagan and Bush administrations, there has been no effort to restrict their use. Until now, there has been no coordinated effort among the agencies, except when concerns about individual pesticides have raised public alarm. Otherwise, the environmental agency has dealt with analyzing the safety of pesticides, the health agency has tested for pesticide residues in food and the agricultural agency has worked to keep pesticides on the market to help farm production and income. 'The Agriculture Department, E.P.A. and the Food and Drug Administration are working together in a way they have never done before to benefit the American people,' said Carol M.

EPA, the Department of Agriculture, and the Food and Drug Administration are working together to learn more about children's exposure to pesticides.

Browner, Administrator of the E.P.A. . . . . The food and chemical industries say that the food supply is safe but agree that changes in regulations are in order. 'We need to be especially concerned about children,' said Lester Crawford, executive vice president for scientific affairs of the National Food Processors Association, 'because they will get 70 years of exposure. Changes ought to be made in E.P.A. regulations. . . . ' The National Food Processors, the Grocery Manufacturers of America and the United Fresh Fruit and Vegetable Association have been recommending that their members use Integrated Pest Management. . . . "

EPA Awards Environmental Education Grants

Under the National Environmental Education Act of 1990, EPA has awarded $2.7 million in grants for environmental education initiatives to schools, universities, and nonprofit organizations in all 50 states as well as Puerto Rico, American Samoa, the Republic of Palau, and the District of Columbia.

Administrator Browner said, "My administration has identified four priorities for the Agency: pollution prevention, ecosystem protection, partnerships, and environmental justice. The common thread through these priorities is environmental education. Through the awarding of these grants, we hope to educate children and adults about how their everyday actions have a direct impact on the world we live in."

In selecting grant winners, emphasis was placed on projects that improve environmental education by enhancing teaching skills; facilitate communication, information exchange, and partnerships; motivate the general public to be more environmentally conscious; and develop an environmental education practice, method, or technique that is new, has wide application, and addresses high priority environmental issues. EPA headquarters awarded the nine grants that exceed $25,000 each; EPA's regional public affairs offices chose the other 237 winners. Headquarters grant winners were the University of Rhode Island; Citizens Committee for New York City, Inc.; The League of Women Voters Education Fund, Washington, DC; North Carolina State University; Louisiana State University Agricultural Center; The Hazardous Materials Training Research Institute, Iowa; "E-Town" of Boulder, Colorado; Humboldt State University Foundation's Center for Indian Community Development, California; and the Washington State Office of the Superintendent of Public Instruction.

A 1992 grant winner, the Marin County, California, Office of Waste Management, operates a "composting across the curriculum" program for elementary and middle schools.

U.S. Leads in Envirotech Exports

An EPA report on international trade in environmental protection equipment shows that the United States has enjoyed an increasing surplus since 1989. The surplus stood at $1.1 billion in 1991, the last year for which data are available. This surplus contrasts with an overall U.S. trade deficit, which stood at $100 billion in 1990. The report, *International Trade in Environmental Equipment: An Assessment of Existing Data*, analyzes imports, exports, and balances between 1980 and 1991 for the United States, Germany, Japan, Canada, France, South Korea, Mexico, Taiwan, and Great Britain. EPA officials said that, while the report shows the United States to be in the lead, it leads by only a slim margin, and more must be done to stimulate competitiveness: Taken as a percentage of GDP, Germany, for example, exports four times as much as we do.

The Organization of Economic Cooperation and Development (OECD) estimates that the global market for environmental goods and services in 1990 was $200 billion; it projects the market will rise to $300 billion by the year 2000. EPA currently spends about $120 million on environmental-technology activities. President Clinton has asked for an additional $36 million in fiscal year 1994 and an $80 million increase in fiscal 1995.

Whirlpool Wins $30 Million Contract in Refrigerator Contest

In a contest sponsored by a consortium of 24 electric utilities, Whirlpool Corporation has won a $30 million contract to provide consumers with refrigerators that use 20 to 50 percent less electricity than that currently set by Department of Energy standards. The consortium, which runs the Super Efficient Refrigerator Program (SERP), also known as the Golden Carrot, developed the contest in close collaboration with EPA, the Electric Power Research Institute, the Natural Resources Defense Council, the American Council for an Energy-Efficient Economy, the Washington State Energy office, and others. Administrator Browner commented: "The SERP partnership will save consumers money and protect the environment. Here's a good example of environmental protection achieved not by expensive and contentious regulation, but by a voluntary, private-sector initiative that actually helps the economy."

The Los Angeles Times said: ". . . The competition, which drew 500 responses from around the world, was intended to accelerate development of a refrigerator that would be at least 25% more energy-efficient than today's models and use no ozone-depleting chlorofluorocarbons, or CFCs. David Goldstein of the Natural Resources Defense Council, which first proposed the contest idea, called the collaborative program 'a whole new way to address the energy policies of the nation.' Each of the utilities provided from $150,000 to $7 million, depending on the number of customers in their service area. Goldstein estimated that the new refrigerator will save utility customers $300 to $500 in electric bills during the appliance's lifetime. Across the country, state regulators are pressing utilities to find innovative ways to reduce customers' energy use instead of building new power plants to meet increased demand. Refrigerators, which use about 20% of the electricity in the average household, seemed like a logical first step, said Ray Farhang, an Edison executive who headed the utility consortium. . . . "

USA Today commented: ". . . Whirlpool's fridge, available from retailers early next year under the company's Whirlpool, KitchenAid and Kenmore brands, will cost $1,300 to $1,400. That's at the high end of the price range for similarly equipped but less-efficient models that use CFCs. . . . On the inside, Whirlpool's SERP fridge contains a computer chip that knows when to defrost and when the energy-sucking move isn't necessary. That's more efficient than defrosting on a regular, timed schedule whether needed or not. The model also has insulation made of CFC-free substances, high efficiency fan motors and a new type of refrigerant that does not include CFCs, such as Freon. Yet on the outside, the object of so much science and so much money looks pretty familiar. The model unveiled in front of 90 people at the Marriott Long Wharf Hotel is a tasteful white, 22 cubic-foot, side-by-side unit—'designer style #22.' It has an automatic ice maker, a utility bin, a crisper and a snack bin. The left door features an exterior water and ice dispenser—your choice, crushed or cubed. Will consumers buy it? That was the missing link at Tuesday's proceedings. Whirlpool's Fettig praises SERP for spurring development of a product 'that consumers, frankly, weren't asking for. The simple truth is consumers don't generally perceive the value of added efficiency'. . . . Initially, Whirlpool's winning model will be sold only in areas covered by contributing utilities. That's a condition for getting the prize. The areas include parts of Arizona, California, Idaho, Maine, Maryland, Massachusetts, Minnesota, Montana, California, New Jersey, New York, Oregon, Washington and Wisconsin. . . . "

Whirlpool photo

Whirlpool employee connects sensors for energy efficiency test at Refrigeration Technology Center in Evansville, Indiana. Whirlpool's CFC-free, super-efficient refrigerator will save consumers money on their electric bills

Ongoing Enforcement

$2.8 Million Sought for Failure to Report Chemical Releases

Administrative complaints totaling $2.8 million have been filed by EPA against 37 facilities for failing to make reports to the Toxic Release Inventory (TRI). The facilities are located in all 10 EPA regions. Under the Emergency Planning and Community Right to Know Act (EPCRA), companies must report to TRI by July 1 each year on releases or transfers of certain toxic chemicals. TRI currently lists more than 300 such chemicals. The Pollution Prevention Act requires that companies also report on source reduction and recycling activities associated with these chemicals. The complaints are against companies that failed to file reports for 1991 and preceding years. The companies include paper manufacturers, motor vehicle manufacturers, makers of railroad equipment, makers of specialty cleaning and sanitation preparations, ammunition makers, and many others. Companies who fail to submit TRI reports are subject to civil administrative penalties of up to $25,000 per day per violation. TRI allows EPA and the public to gauge progress in reducing toxic chemical waste. State and local emergency response officials, fire departments, and others use TRI to identify chemical threats.

Action to Stop Untreated Sewage Discharge in South Florida

The Department of Justice and the U.S. Attorney's office in Miami have filed a civil complaint on behalf of EPA to stop the illegal discharge of untreated sewage into the Miami River, Biscayne Bay, and other local waterways, and to replace the Cross-Bay line—a 37-year-old sewer pipe that carries untreated sewage from Miami under Biscayne Bay to a treatment plant on Virginia Key. The complaint, filed against metropolitan Dade County (Metro-Dade), Florida, and the Miami-Dade Water and Sewer Authority Department (MDWASAD), alleges numerous and repeated discharges of raw sewage into the Atlantic Ocean, Biscayne Bay, Gratigny Canal, and the Miami and Little rivers. As recently as last spring, some 25 million gallons of untreated wastewater were discharged into the Miami River because of a pump station failure. EPA and the State of Florida are working with county officials to develop a plan for expeditious replacement of the Cross-Bay line and for preventing further discharges from the wastewater collection and treatment system.

Hazardous Waste Action Against Air Force Base

The first imminent and substantial endangerment order ever issued to a military installation has been filed by EPA against the Reese Air Force Base, located near Lubbock, Texas. Samples drawn from one of the base's offsite monitoring wells for the area's aquifer contained carbon tetrachloride, chloroform, bromodichloromethane, and trichloroethylene (TCE). TCE, in concentrations exceeding EPA's drinking water standards, was also found in at least 10 residential, business, or church wells. TCE is associated with birth defects; some forms of it are classified as possible or probable human carcinogens. Texas Water Commission and EPA officials said that the most likely source of the contamination was a leaking industrial drain. They cited the cooperation of base officials, who supplied bottled water to affected residents. EPA's order was issued under the Resource Conservation and Recovery Act (RCRA); the Federal Facility Compliance Act authorizes the Agency to cite federal facilities just as it would private parties.

Booz-Allen and Hamilton Fined $1 Million for False Time Sheets

The U.S. District Court, Middle District of North Carolina, has fined Booz-Allen and Hamilton of McLean, Virginia, $1 million for submitting false time sheets on EPA contracts. The court has also ordered the company to pay restitution of $638,000. The company cooperated with the government in the investigation and has entered into a strict compliance agreement with EPA. EPA has agreed not to suspend or debar the company provided that it complies with the agreement. The case was investigated by EPA's Office of Inspector General, which alleged that employees of the company submitted time sheets showing work on EPA contracts when, in fact, they were attending to personal business or to company business unrelated to the contracts. Booz-Allen and Hamilton, Inc., is an international management and consulting firm whose customers include many of the largest industrial corporations in the United States and most departments and agencies of the federal government. □

Taking the True Measure of Air Pollution

We have to look where the people are

by Kirk R. Smith

Concern about air pollution has traditionally focused on the effects on outdoor environments. We have become accustomed to thinking of air pollution in the context of such visual symbols as the industrial smokestack and the dark layer smothering modern cities. In view of knowledge gained in recent years, this focus on outdoor air pollution and its sources has diverted attention from our principal goal of reducing the exposure of people to the health-damaging pollutants they actually breathe. These exposures can be caused by relatively small localized sources that are, literally, right under our noses: cigarettes, spray cans, and dry-cleaned clothes, for example. More often than not, these exposures occur indoors.

Although a number of adverse effects on human welfare are associated with outdoor air pollution, including property damage and loss of visibility, its impact on human health has been the focus of most concern. Primary standards for criteria pollutants under the Clean Air Act in the United States, as well as similar standards in other nations, have been established to avoid health damage. Evidence includes the acute episodes in London and in Donora, Pennsylvania; epidemiological studies of long- and short-term effects on different populations; and laboratory experiments with human volunteers. The current pattern of monitoring and regulation, however, may not directly address the locations and types of pollutants with the most damaging health impact.

Present standards apply to outdoor levels of pollution where measurements are most easily made. Most people, however, do not spend much time outdoors, particularly in temperate, developed countries. In the United States, for example, only about 10 percent of the population's time is spent outdoors. To measure the pollutant concentrations to which most people are exposed most of the time, it is also necessary to monitor indoor environments. A number of studies show that indoor and outdoor concentrations of most pollutants are often significantly different and that they do not correlate well with concentrations at the nearest outdoor monitoring site.

The first ever air-pollution monitoring network was located on the tops of London fire stations during the last century. Concentrations are still most often measured on the roofs of public buildings and at other locations chosen by a range of criteria such as convenience, security, geographic spread, and general congruence with population distribution. This placement assumes that outdoor levels reasonably indicate health-relevant exposures. Such measurements, however, do not truly represent individual or population exposures to many pollutants of interest. In some cases, total exposure is less than that indicated by outdoor measurements, because there are few indoor sources: for example, sulfur oxides. In other cases, total exposure is actually more, because there are significant indoor sources: for example, nitrogen dioxide from gas stoves.

The attention being given to indoor air pollution in recent years indicates a fundamental shift in environmental health science: recognition of the need

A 2-percent decrease in ETS would be equivalent to eliminating all the coal-fired power plants in the country.

Harvard School of Public Health photo

Harvard researcher Mark Davey, right, instructs a Particle TEAM volunteer in how to wear a personal exposure monitor. Particulate matter in the volunteer's breathing zone will be sampled during normal activities.

(Dr. Smith is Senior Fellow in the Program on Environment of the East-West Center in Honolulu, Hawaii.)

In the United States, people spend only about 10 percent of their time outdoors.

Mike Brisson photo

for total exposure assessment (TEA). The idea behind TEA is that if we are to understand how a particular pollutant affects humans and what the most effective control measure would be, it is necessary to account for all routes of exposure. Put more bluntly, to determine human exposure it is necessary to measure the exposures of humans directly. Studies of the microenvironments within which people spend time are needed. These can be done by measuring pollutant concentrations separately in each microenvironment, then taking the sum weighted by the amount of person-hours spent in each. Another approach is personal exposure monitoring, in which the air in the breathing zone of individuals is sampled during normal daily activities. A range of portable devices and techniques for both kinds of monitoring has been developed.

TEA across all times and locations is now a recognized way to conduct health-effects studies of air pollution. For many pollutants, small changes in indoor conditions affect total exposures more than do large differences in outdoor concentrations, even considering that indoor levels are partly due to penetrations of pollution from outside. Further, considering the most significant sources on the basis of exposure reveals that a quite different set of sources is important. Many of these sources, such as tobacco smoking, gas stoves, and chemicals in consumer products, occur indoors. On the other hand, localized outdoor sources may produce greater exposure than outdoor monitoring instruments would indicate because the instruments are remote. Lead exposure of people living near highways is an example.

The significance of looking where the people are can be illustrated by studies of recently targeted pollutants such as those volatile organic chemicals that are part of the category called "air toxics." The Total Exposure Assessment Methodology (TEAM) studies discussed on pages 23-24 provide ample evidence that outdoor measurements of these chemicals are often inadequate for determining total human exposures. This is also true for some of the more traditional pollutants, such as particulates and nitrogen dioxide.

In a feasibility study of the effectiveness of new nitrogen dioxide emission controls on vehicles in Chicago, for example, researchers found that even large decreases in average outdoor concentrations would have minor impact on total daily exposures. Peak concentrations along highways would be little affected by such controls. Also, daily average outdoor exposures were much less than the indoor exposures from gas stoves. Although vehicle emission controls could help Chicago meet ambient outdoor-air pollution standards, in this case they would not appreciably decrease actual human exposures to nitrogen dioxides. This is true even though there are many more tons per day of nitrogen dioxide emitted from cars than from stoves.

A pound of pollution released outdoors or in places where people do not spend much time is substantially less damaging to health than the same amount released near people. Stringent pollution controls, for example, are applied to coal-fired power plants in the United States, yet they collectively still release about 500,000 tons of particulates each year. Tobacco smoking, which fortunately is declining, now releases only about

20,000 tons each year. From a direct particulate emissions standpoint, therefore, power plants are 25 times more polluting than cigarettes. When the comparison is based on human exposure, however, the total exposure from environmental tobacco smoke (ETS), sometimes called passive smoking, is 50 times higher. This means that, from a particulate exposure standpoint, a 2-percent decrease in ETS would be equivalent to eliminating all the coal-fired power plants in the country.

Perhaps even more striking is that, per pound released, ETS is more than a thousand times (25 multiplied by 50) more dangerous than the smoke from power plants. This is not because of any difference in their composition, which here is assumed to be identical, but simply because of the differences in the place and time of release. The power plant smoke is mostly released from stacks high in the air and out of town, or at least in parts of town where few people live. ETS, on the other hand, is largely released indoors and often during human presence. Put another way, per pound released, a thousand times more ETS is actually inhaled by people than is the smoke from power plants. This difference is their relative "exposure effectiveness," based on a comparison of how much of what is emitted actually goes down people's throats.

This one comparison alone, if generally accepted, would have tremendous implications for air-pollution control strategy in the nation. It implies, for example, that we ought to be willing to pay a thousand times as much to control emissions that cause ETS as we are to control power-plant smoke. But this is only one example of how our present system of air pollution regulation and control tends to ignore the sometimes large differences in exposure effectiveness that can exist for the same pollutant in different situations.

Some argue, however, that indoor and outdoor exposures are fundamentally different and should not be so compared. Power plant smoke is imposed on people without their consent, the argument goes, and thus

Mike Brisson photo

Small changes indoors may affect total exposure more than may large changes outdoors.

warrants greater public concern than indoor sources that people in some way bring on themselves. This argument, however, has at least two major flaws.

First, it is only partly true that people knowingly decide to bring indoor exposures on themselves. How many members of the public are able to interpret the list of ingredients on a can of household cleaner or pesticide to decide how much exposure is warranted for them or their families? How are householders able to judge what chemicals will be released from a carpet or piece of furniture they buy? What can members of a single household do to determine what they are being exposed to in the water piped into their home?

The second flaw in this argument is the hidden assumption that the emissions from outdoor sources such as chemical plants are somehow different from those originating indoors. If we are serious about controlling benzene exposures for health reasons, should not we view each benzene molecule as our enemy and work to stop as many as possible from reaching people? What sense does it make to propose spending hundreds of millions controlling stationary outdoor sources, which cause relatively little human exposure, while ignoring indoor sources that cause much? Will the parents of a child afflicted by benzene-triggered leukemia be less upset if they are assured that the benzene probably came from indoor sources?

Another argument sometimes leveled at efforts to bring indoor and other total exposure considerations into regulatory frameworks is that somehow this will result in an infringement of individual rights—for example, big government will place electronic monitoring devices in every home. This is ridiculous; total exposures can be determined by statistical sampling techniques analogous to the way the Nielsen ratings of television viewing habits are done.

A variant on this Big Brother argument is that regulating indoor pollution will require the government to impose its will on the individual householder, meaning that pollution fines, limits, and other controls would be imposed on the "castle" that is each householder's home. In fact, the government already has ways to control much inside the castles that are our homes. Fuel quality is regulated by the government, as is the performance of stoves and other combustion devices. Building and fire codes already affect ventilation rates. Household chemical products are subject to regulation, some substances being banned, for example. Termite and other inspections are mandated in most states. Taxes, public education, and controls on advertisements have had clear impacts on tobacco consumption. There would seem to be little need to invent any other policy tools to control indoor air pollution, but rather to adjust the existing ones to reflect total exposure.

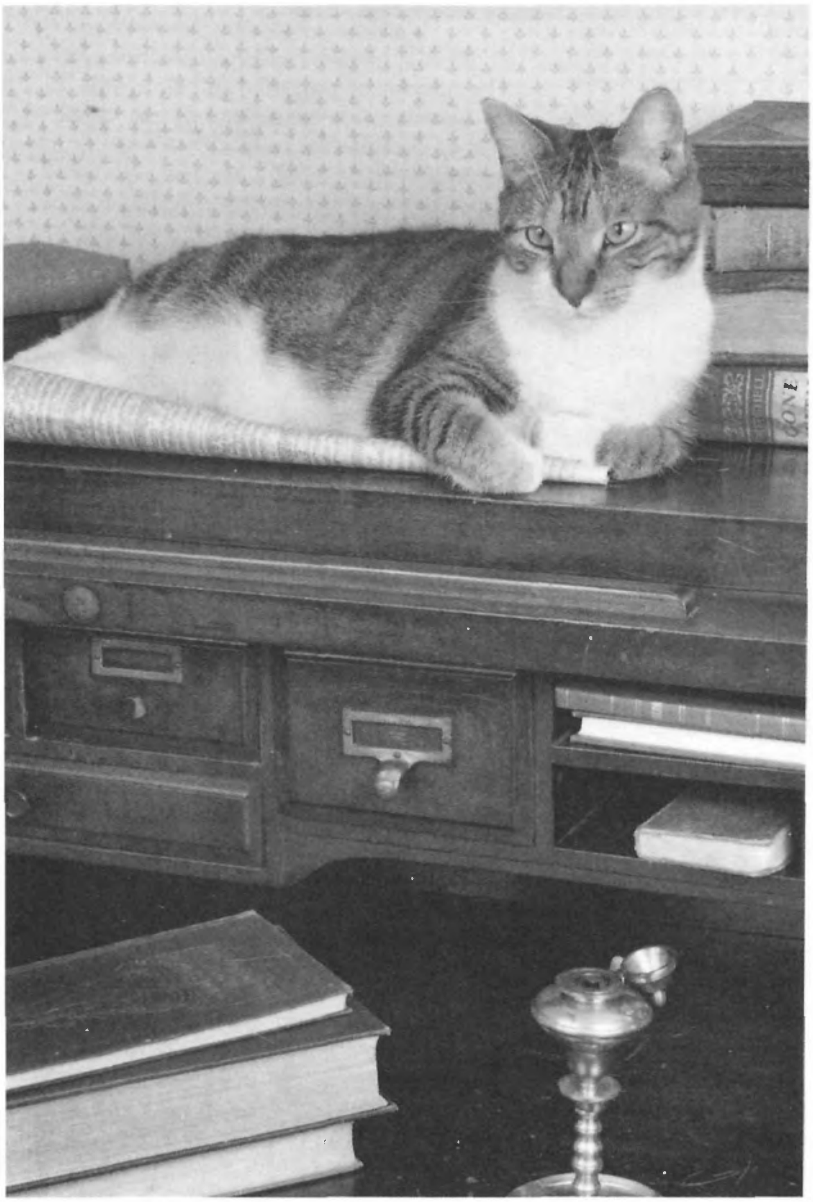
In summary, to be sure that we are protecting the most people possible from ill health induced by air pollution, we need to examine conditions where the people are. This will entail finding ways to take into consideration the indoors in addition to our already well-developed monitoring systems for the outdoors. □

An Inside Look at Air Pollution

by Ken Sexton

Complicated public policy issues are at stake

Larry Lefever photo. Grant Heilman.



Indoor environments contain a complex array of air pollution sources, including pets and household furnishings.

On particularly smoggy days, small children and people with respiratory illness are encouraged to stay indoors to avoid health risks from air pollution. While this may be good advice if the goal is to reduce exposures to, let's say, ozone, there is substantial evidence that concentrations of many airborne pollutants are often higher inside buildings and vehicles than outside. It is becoming increasingly apparent that being indoors, as, for example, in a residence, office, or automobile, can offer protection from exposure to some airborne agents, while at the same time increasing exposure to others.

Concerns about the healthfulness of indoor air are driven by six major factors. First, it is now widely recognized that most people spend more than 90 percent of their time indoors. Groups potentially more susceptible to the effects of air pollution, like infants, the infirm, and the elderly, are inside virtually all the time. Because most of us spend so much time inside, indoor pollution concentrations, even if they are uniformly lower than outdoor levels, make a significant contribution to our average exposure over a day, week, season, or year.

Second, modern indoor environments contain a complex array of potential sources of air pollution, including synthetic building materials, consumer products, and dust mites. Airborne emissions also occur because of the people, pets, and plants that inhabit these spaces. Efforts to lower energy costs by reducing ventilation rates have increased the likelihood that pollutants generated indoors will accumulate.

Third, monitoring studies inside buildings and vehicles have consistently found that concentrations of many air pollutants tend to be higher indoors than out. Indoor air has been shown to be a complex mixture of chemical, biological, and physical agents, only a small fraction of which has been characterized adequately. This complexity is illustrated by the fact that more than 4,000 different compounds have been identified in tobacco smoke alone.

Fourth, scientific reports indicate that indoor measurements are often better than outdoor measurements for classifying, estimating, and predicting human exposures to many air pollutants. This is true even for some agents that are primarily of outdoor origin. A promising approach to more realistic exposure estimation is the development and refinement of models that combine information about pollutant concentrations in both indoor and outdoor settings with data on time-activity patterns.

Fifth among the factors driving indoor air concerns, complaints about

(Dr. Sexton is Director of EPA's Office of Health Research and matrix manager of the indoor air research program. He was previously director of California's Indoor Air Research Program. The views expressed are those of the author and do not necessarily reflect the views and policies of EPA.)

In public places, the rationale for government regulation of indoor air is similar to that for outdoor air.

Mike Brisson photo.

inadequate indoor air quality and associated discomfort and illness are a burgeoning problem in our society. Reports of illness outbreaks among building occupants, particularly office workers, with no secondary spread of the illness to others outside the building with whom affected individuals come into contact, have become commonplace. EPA classifies these reports into two general categories. Building-related illness refers to episodes when symptoms of diagnosable illness are identified and can be attributed directly to airborne contaminants in the building. In contrast, sick-building syndrome is defined as situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in the building, but no specific illness or cause can be identified.

The so-called chemical sensitivity syndromes, which may be caused only partially or not at all by chemicals, are a different, although potentially related matter. Broadly defined, "multiple chemical sensitivity" (MCS) is postulated to be development of responsiveness, including manifestation of often disabling symptoms, to extremely low concentrations of chemicals following sensitization. A controversial and emotional topic, the concept of MCS as a distinct entity caused by exposure to chemicals has been challenged by the medical and scientific communities, and there appears to be consensus that substantially more study is needed before MCS should be considered as a clinical diagnosis. Nevertheless, many sufferers of MCS continue to believe that their conditions are either caused or exacerbated by indoor air pollution.

Monitoring studies inside buildings and vehicles have consistently found that concentrations of many air pollutants tend to be higher indoors than out.

And sixth, exposures to many indoor air pollutants are known or suspected to occur at levels sufficient to cause illness or injury. Scientific evidence suggests that respiratory disease, allergy, mucous membrane irritation, nervous system effects, cardiovascular effects, reproductive effects, and lung cancer may be linked to exposures to indoor air pollutants.

Scientists consistently rank indoor air pollution at or near the top of environmental health risks in the United States. EPA reports on risk-based priority setting, like *Unfinished Business* (1987), *Reducing Risk* (1990), and the *Regional Comparative Risk Projects* (1989-92), all ranked indoor air pollution as a high-priority risk to human health. Public opinion polls, however, continue to find that most Americans do not perceive the risks of indoor air pollution to be great.

The specter of potential public health risks from contaminated indoor air presents decision makers with a dilemma. Is the problem serious enough to warrant intervention, and, if so, what preventive or remedial actions are most appropriate?

The significance of indoor air exposures for acute and chronic health effects remains uncertain in most cases. Nevertheless, there is ample reason for concern and caution. For example, it has been estimated that exposures of nonsmokers to ETS may cause as many as 3,000 lung cancer deaths annually in the United States, as well as contribute to a wide range of noncancer diseases, including pneumonia, bronchitis, and asthma. Findings from several studies suggest that indoor concentrations of nitrogen dioxide, carbon monoxide, and respirable particles can exceed the

Grant Heilman photo

Often present but unseen in offices and residences, cockroaches and their feces can be a source of allergens.

National Ambient (Outdoor) Air Quality Standards set by EPA to protect public health. And results from many studies show that a plethora of volatile organic chemicals and pesticides known to be toxic and/or carcinogenic can occur indoors at concentrations significantly higher than levels that create concerns in outdoor air.

Designing effective and efficient indoor control strategies requires an understanding of several pertinent factors. Contaminant characteristics need to be considered, including factors like concentration, reactivity, and physical state. Emission source configurations (e.g., area or point sources) must be taken into account, and it is necessary to determine whether discharges are continuous or intermittent. It is also important to understand the dose-response relationship for the contaminant of interest so that informed decisions can be made whether individuals are to be protected from short-term exposures to peak concentrations or from long-term exposures to relatively low concentrations. And, of course, the type of indoor enclosure (e.g., residence, office, car) has ramifications for which approaches and methods are viable options.

But providing and maintaining healthful indoor air quality is more than just a complex scientific and technical issue. Realization that contaminated indoor air may pose an unacceptable health hazard raises complicated policy questions about the proper role of government in safeguarding people's health inside public and private spaces.

Because concerns about adverse health consequences from air pollution have focused traditionally on outdoor and occupational exposures, federal and state government programs concentrate on protecting public health from outdoor air pollutants or protecting workers' health from dangerous air pollutants in the industrial workplace. As mentioned earlier, EPA sets and enforces National Ambient Air Quality Standards that are designed to protect the general public to within an adequate margin of safety. The Occupational Safety and Health Administration enforces consensus standards for industrial work environments, which are designed such that no employee will suffer material impairment of health or functional capacity. However, federal responsibility and authority for indoor air quality in the nonworkplace are less well defined.

There is ample precedent for government authority and responsibility to protect public health and welfare inside buildings. It is common practice, for instance, to regulate construction and operation of public buildings to ensure that adequate provisions are made for health and safety. Government inspectors routinely enforce building codes, health regulations, safety rules, and fire ordinances. While government has an obligation to protect public health in indoor as well as outdoor environments, the justification for direct government intervention varies according to the characteristics associated with different types of indoor settings.

Creation of a regulatory framework for protecting indoor environmental quality poses special policy issues. Promulgation of indoor air quality standards and other regulations must acknowledge that individuals, especially in private residences, are already making decisions about their own air quality. Development of effective and reasonable policy requires an appreciation of the scope for private action, as well as consideration of the likelihood that public intervention will foster improved private choices.

This is not to suggest that rules and regulations have no part to play in safeguarding indoor air quality. This form of intervention is, however, not necessarily optimal or even desirable in certain types of indoor environments. There are, of course, many different types of indoor environments—for example, occupational settings, both industrial and nonindustrial;

Key Questions About Indoor Air Pollution

Answers to the following key questions are critical to improving our understanding of the relative risks associated with indoor air pollution; whether these risks are unacceptable; and what to do about those that are.

Problem Definition: Is there an existing or potential indoor air problem that may have public health significance?

- What are the key health effects associated with indoor air pollution, and what pollutants and mixtures cause these effects?
- What are the key pollutant sources, exposure scenarios, and building practices that influence indoor exposures?
- How do indoor air quality complaints/problems relate to other indoor environmental factors, e.g., thermal comfort, odor, lighting, noise?
- How does the perception of indoor air quality affect worker productivity? Absenteeism? Health care costs?

Risk Assessment: If indoor air poses serious risks to human health, what are the likelihood and magnitude of those risks?

- What are typical and high-end indoor exposures, and how do these exposures relate to indoor pollutant levels?
- What are the most severe human health effects associated with exposures to indoor pollutants and pollutant mixtures?
- How do the relative risks of a particular indoor pollutant or pollutant mixture compare with: other indoor air problems? outdoor air problems? environmental hazards in other media?

Risk Management: If the associated human health risks are deemed unacceptable, what are the most effective approaches to preventing/reducing these risks?

- How can indoor pollutant sources be eliminated or modified to prevent indoor air pollution?
- What are the most cost-effective ways to design, construct, operate, and maintain buildings to optimize indoor air quality and energy efficiency?
- When steps are taken to prevent or reduce risks, how effective and durable are they?

nonoccupational settings, including residential, commercial, institutional, and public; and transportation microenvironments, such as automobiles, airplanes, subways, and trains.

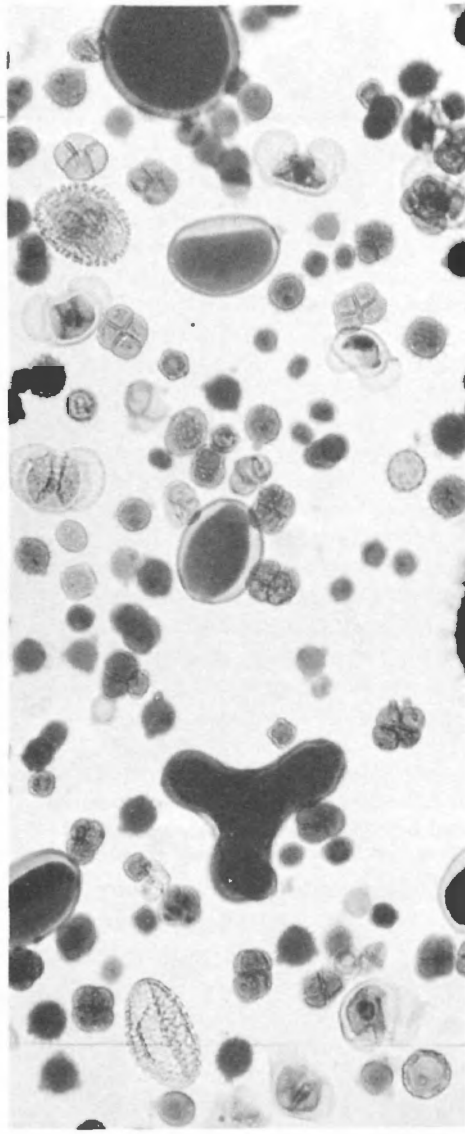
The role of government varies according to the "publicness" of a particular space as well as the nature of air-pollution health risks, either voluntary or nonvoluntary. Understanding the diversity of nonindustrial indoor environments is an important step in the design and implementation of practical and cost-effective control strategies.

The rationale for government regulation of outdoor air pollution is based in part on a definition of outdoor air as a "public good" and on the realization that those who suffer the effects of such pollution are neither compensated by, nor powerful in influencing, polluters. The situation is quite different for some indoor environments, especially private residences, for both the costs and benefits of pollution control are internalized with households.

If occupants foul the air in their home, they are forced to breathe it. If they attempt to improve its quality by increasing ventilation or installing air-cleaning devices, they bear the costs and enjoy the benefits. For some contaminants, such as tobacco smoke, odorants, and water vapor, benefits are readily recognizable through improvements in perceptible air quality and reduction of corrosion, soiling, and molds.

The closed-loop, cost-benefit cycle within residences suggests that individual decisions are important determinants of indoor air quality. However, unlike residential energy consumption, where monthly bills from the local utility company provide periodic feedback to consumers, indoor contaminants may be below irritation or odor thresholds. Thus, although individuals are certainly making decisions about their own air quality, it is not clear that these are "informed" decisions. Government actions aimed at improving personal decisions about indoor air quality may be preferable to rules and regulations (e.g., simple warning devices, product labeling, or information programs).

It has been suggested that the Clean Air Act be amended to give EPA authority to control indoor air pollution



Runk Schoenberger photo Grant Heilman

Biological pollutants, such as pollen, are a major cause of health complaints and illnesses.

in much the same way that outdoor air pollution is currently controlled. However, setting and enforcing strict indoor air quality standards, similar to existing National Ambient Air Quality Standards, would be impractical because of the prohibitive monitoring costs and the difficulty of enforcement within approximately 82 million residences in the United States.

Perhaps the most serious impediment to implementing a regulatory approach is public antipathy towards this form of intervention inside the home. Restriction of indoor pollution sources, certification of "safe" indoor concentrations, product emission standards, disclosure of potential sources upon transfer of ownership, and specification of minimum ventilation requirements are examples of government actions that are likely to be less costly and more effective than indoor air quality standards.

Not all buildings are residences, and not all residences are owner-occupied. The rationale for direct government intervention aimed at improving indoor air quality is much stronger in public, as opposed to private buildings. Air quality in large public buildings, for instance, displays many characteristics of a public good. A person sensitive to tobacco smoke would not rationally pay the costs of cleaning the air in a large convention hall. The costs would greatly exceed any personal benefits an individual might derive from smoke-free air, and those who did not contribute could not be excluded from enjoying the benefits. In this situation, the rationale for regulation is similar to that for outdoor air pollution.

There is also substantial justification for regulatory intervention in private and public buildings where occupants do not have control over their own environment—for example, modern high-rise office buildings. Typically, building managers are responsible for operation and maintenance of heating, ventilation, and air-conditioning (HVAC) systems. Occupants of the building, including both employers and employees, often have little or no direct control of temperature, fresh air input, and ventilation rate. Because HVAC systems are normally operated to minimize energy costs, the health and comfort of tenants rarely become an issue unless a significant number of complaints are reported.

Because health risks in this situation tend to be nonvoluntary, government may have a responsibility to safeguard public health by defining what constitutes acceptable indoor air and taking steps to ensure that those criteria are met. Examples of government actions that might be warranted include specification of minimum ventilation rates necessary to achieve healthful indoor air quality, establishment of emission limitations for building materials, and development of indoor air quality guidelines or standards for important contaminants.

As a practical matter, however, development of a comprehensive federal approach to address problems of indoor air pollution awaits resolution of important public policy and public health questions about the proper role of government in safeguarding the air quality inside public and private spaces. □

Indoor Allergens: A Report

Wall-to-wall carpeting is a good reservoir

by Andrew M. Pope

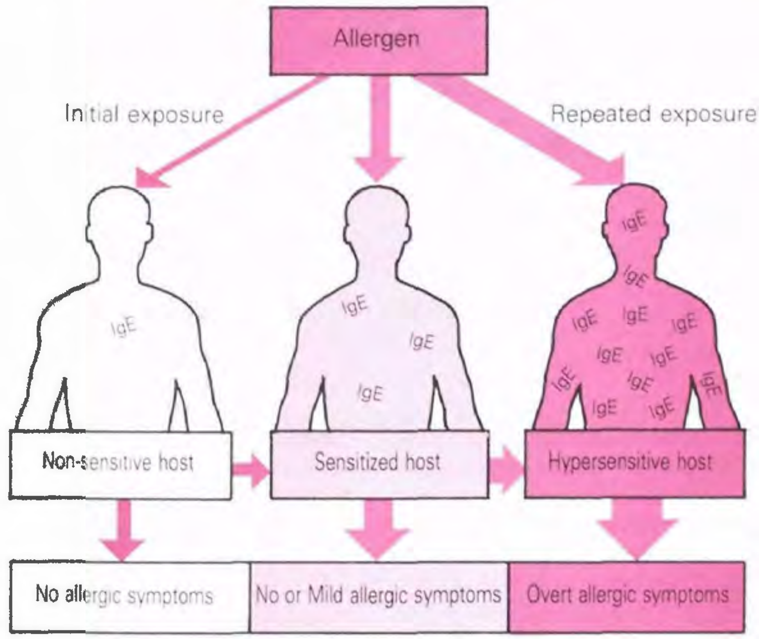
One of five Americans will experience allergy-related illness at some point during their lives, and indoor allergens will be responsible for a substantial number of those cases, according to a recent report from the Institute of Medicine, *Indoor Allergens: Assessing and Controlling Adverse Health Effects*.

The report describes *allergy*, generally speaking, as "the state of immune hypersensitivity that exists in an individual who has been exposed to an allergen and has responded with an overproduction of certain immune system components such as immunoglobulin E (IgE) antibodies. About 40 percent of the population have IgE antibodies against environmental allergens, 20 percent have clinical allergic disease, and 10 percent have significant or severe allergic disease."

The report lists major sources of indoor allergens in the United States as house dust mites, fungi and other microorganisms, domestic pets (usually cats and dogs), and cockroaches. The most common allergic diseases related to these allergens are allergic rhinitis, asthma, and allergic skin diseases.

Allergy plays a key but sometimes unrecognized role in triggering asthma, a disease that deserves special attention because of its prevalence, cost, and potential severity. In 1988, 4,580 people died of asthma in the United States, and the mortality rate is rising, particularly in blacks. Depending on age, blacks are three to five times more likely than whites to die from asthma. In 1987 (the most recent available data), asthma was the first-listed diagnosis for more than

(Dr. Pope is Study Director, Division of Health Promotion and Disease Prevention, Institute of Medicine. Indoor Allergens *is the work of a multidisciplinary committee on the Health Effects of Indoor Allergens (Roy Patterson, M.D., Chair, and Harriet Burge, Ph.D., Vice-Chair). The report is available from the National Academy Press; call 202/334-3313 or 800/624-6242.)*



Source: Fireman & Slavin, 1991

450,000 hospitalizations in the United States.

Allergy to house dust mites and cats increases the risk of childhood asthma fourfold to sixfold. In addition, indoor allergens are thought to be responsible for much of the acute asthma in adults under the age of 50 years.

The total annual cost associated with asthma in the United States has been estimated at more than $6.2 billion. This estimate includes direct and indirect costs and is a 30-percent increase over the estimated cost of the disease in 1985.

For most allergenic agents, exposure clearly creates a risk of allergic sensitization, but insufficient data are available to identify thresholds or risk levels. The report indicates, however, that a positive relationship has been found between cumulative exposure to dust mite allergen and the risk of sensitization. This finding has long been suspected, but never demonstrated.

Avoiding specific allergens can lessen the probability of initial sensitization and can improve dramatically the condition of people with a known sensitivity by reducing the cascade of symptoms that result from exposure. Because of the amount of time people spend sleeping, the bedroom is one area where steps to reduce exposure to allergens can be especially beneficial. For example, covering mattresses and pillows with impermeable materials is an effective way to limit exposure to dust mite allergens.

Wall-to-wall carpeting in homes, schools, hospitals, and offices is a good reservoir for both dust mite and mold allergens if the premises are damp; vacuum cleaning is probably not an effective intervention. In fact, vacuum cleaning disperses and suspends allergens and other particles in the air. (Removing carpet might work better in such circumstances.)

A thorough understanding of how building systems and structures operate and perform is essential for assessing and controlling indoor air quality problems. The reduction and/or elimination of human exposure is probably best achieved by simultaneously controlling allergen sources and improving building ventilation—that is, the design, operation, and maintenance of heating, ventilation, and air-conditioning systems. □

Improving IAQ: EPA's Program

Pollution prevention must become routine

by Bob Axelrad

Because of the possibility of serious impacts on the health of individuals who may experience indoor air-quality problems—as well as the dollar costs to society if indoor air pollution is not addressed—EPA has developed a comprehensive program to better understand the problem and to take decisive steps to reduce people's exposures to indoor air contaminants of all types. The program is predicated on three primary principles.

First, even in the absence of complete scientific understanding of indoor air pollution, prudent public policy dictates that reasonable efforts be undertaken to reduce peoples exposure to potentially harmful levels of indoor air pollutants, using the authorities available to the federal government under current laws.

Second, pollution prevention—and efficient resolution of indoor air-quality problems of all types—must become a routine aspect of the design, construction, maintenance, and operation of public and commercial buildings, homes, health and day care facilities, educational institutions, and other special-use buildings.

Third, an effective research and development program must be conducted to achieve a more complete understanding of the factors affecting indoor air quality. Through this program, we also need to acquire a better understanding of exposure patterns, health effects, and control techniques for improving indoor air quality.

(Axelrad is Director of EPA's Indoor Air Division.)

EPA is working to implement these principles using non-regulatory as well as regulatory tools available under a number of federal laws to provide information and incentives for action to product manufacturers, architects, engineers, builders, building owners and managers, and building occupants. The primary objectives of EPA's program are to:

- Establish effective partnerships with organizations representing the range of target audiences to communicate specific guidance and information and promote timely action on indoor air quality issues
- Forge constructive alliances with other federal agencies to leverage resources and ensure that existing statutory authorities are used most effectively
- Develop practical guidance on indoor air quality issues using a broad-based consensus approach which includes representatives from industry and public interest groups to ensure that information provided is accurate and practical
- Design market-based incentives for industries to lower chemical emissions from their products and provide consumers and other decision makers with information needed to make informed purchasing decisions
- Sharpen the focus of the chemical screening and risk management program under the Toxic Substances Control Act (TSCA) and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) to ensure that chemicals that pose unreasonable risks indoors are identified and addressed
- Identify and fill research gaps in order to address outstanding policy issues concerning indoor air quality
- Select appropriate environmental indicators to measure progress in reducing population exposure to indoor air-quality problems as the program matures
- Bring about substantial reductions in human exposure to the entire range of indoor air pollutants.

Reducing Pollutant Levels Indoors

The Building System Approach

EPA has set a high priority on improving the way buildings are designed and operated, having concluded that people's exposure to indoor air pollutants can be reduced significantly by implementing current knowledge about sound building operation and maintenance practices. Some of the major actions to date include:

- Issuance, in cooperation with the National Institute for Occupational Safety and Health, of comprehensive guidance, entitled *Building Air Quality: A Guide for Building Owners and Facility Managers*, on how to prevent and resolve the full range of indoor air-quality problems in public and commercial buildings
- Publication of *The Inside Story: A Guide to Indoor Air Quality* to help people identify and correct potential indoor air-quality problems in their own homes.

In addition, EPA is developing guidance for school facility managers, new home buyers, and architects and design engineers to acquaint them with the most current information on how to prevent indoor air-quality problems from occurring or resolve them quickly if they do occur.

People's exposure to indoor air pollutants can be reduced significantly by implementing current knowledge about sound building operation and maintenance practices.

The Pollutant-Specific Approach

The emphasis on a buildings approach holds the most promise for addressing all of the factors—including those related to the ventilation system as well as sources of individual pollutants—that affect indoor air quality. However, the Agency also strongly believes that it must aggressively utilize its combined statutory authorities to identify specific pollutants that present direct health risks in the indoor environment, and to use a variety of means to reduce their levels indoors. The indoor air pollutants that are currently receiving significant Agency attention include:

Radon. The Indoor Radon Abatement Act of 1988 directs EPA's non-regulatory radon program to work with states to reduce radon risks through voluntary action and to serve as the federal lead agency on radon policy. This approach encompasses a range of activities which include: developing and distributing public information and education materials; supporting industry proficiency programs; providing financial and technical assistance to states; developing and encouraging adoption of radon-resistant building practices; establishing training centers; and conducting mitigation research in different building types.

Environmental Tobacco Smoke. EPA has completed a major report on the respiratory health effects associated with environmental tobacco smoke. The report, entitled *Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders*, concludes that each year secondhand smoke is responsible for about 3,000 lung-cancer deaths in non-smokers and causes respiratory health problems for hundreds of thousands of young children. As the first step in its education and outreach program to inform the public about the risks of passive smoking, EPA has published a brochure advising parents, decision makers, and building occupants of actions they can take to

Berns & Kay

Bird droppings have collected near this unprotected air intake. Many indoor air quality problems can be avoided through sound building operation practices.

Young children are at particular risk because they are more likely to swallow lead dust and because the impact on their developing nervous systems is more severe.

prevent involuntary exposure to ETS in indoor environments.

Toxic Substances. TSCA grants EPA broad authority to control chemical substances and mixtures that present an unreasonable risk of injury to health and the environment. EPA has authority to require testing of chemical substances and mixtures; regulate hazardous chemical substances and mixtures by prohibiting or restricting their manufacture, processing, distribution, and disposal; review new chemicals and their intended uses; and impose labeling or notification requirements. TSCA has been used to regulate asbestos. In addition to using TSCA to regulate individual chemicals, the Agency is now evaluating groups of chemicals in selected use categories for their effect on people in indoor environments.

Asbestos. Under the Asbestos Hazard Emergency Response Act, passed in 1986, EPA established a regulatory framework for addressing the management or abatement of asbestos in schools. As mandated by the Asbestos School Hazard Abatement Reauthorization Act of 1990, the standards that the Agency established for state accreditation of school personnel are currently being revised to include certain workers in public and commercial buildings and to increase the minimum number of training hours required. EPA continues to be involved in a range of outreach, grant, and technical assistance activities as well. This past year, EPA offered \$5.7 million in grants and \$70.5 million in interest-free loans for abatement projects in 156 school districts across the nation.

Lead. Exposure to dust from lead-based paint can pose a serious health threat in homes or apartments built before 1978—the year residential use of lead-based paint was banned by the Consumer Product Safety Commission. Young children are at particular risk because they are more likely to swallow lead dust and because the impact on their developing nervous systems is more severe. EPA, along with other federal agencies, is working to develop a comprehensive strategy to address lead exposures indoors and to develop effective procedures for lead testing and abatement procedures through implementation of the Residential Lead-Based Paint Hazard Reduction Act of 1992.

Formaldehyde. EPA is implementing a project, focused on newly constructed housing, to test exposure to formaldehyde in indoor air. This undertaking is part of an investigation being conducted under TSCA. It will provide data that the Agency will use to determine if there is a need to reduce permissible formaldehyde emissions from interior pressed-wood building materials, such as particleboard flooring and wall paneling, and from related products, including cabinets and furniture.

Carpet. EPA, along with other federal agencies, the carpet industry, and others, has been investigating the role that carpet plays in indoor air quality. While some people report symptoms which they associate with new carpet, the cause remains elusive. The carpet industry has initiated a major research and information program—including a new carpet consumer-information label—to improve understanding of the relationship between carpet and indoor air quality.

Pesticides. FIFRA authorizes EPA to control pesticide exposures by requiring that any pesticide be registered with the Agency before it may be sold, distributed, or used in this country. EPA is evaluating the health impacts of indoor products including insecticide sprays, termiticides, and wood preservatives. Major accomplishments include the withdrawal from the market of chlordane as a termiticide in homes and mercury used as a mildewcide in many indoor paints. This past year EPA distributed to school districts across the nation brochures encouraging pesticide use reduction and alternative pest-control methods through Integrated Pest Management.

Indoor Air Pollutants from Drinking Water. The Safe Drinking Water Act authorizes EPA to set and enforce standards for contaminants in public water systems to protect against both health and welfare effects. Besides setting standards for contaminants in drinking water, EPA sets standards for volatile organic compounds (VOCs) that can enter the air through volatilization from water used in a residence or other building. Many VOCs have already been regulated. EPA is also currently developing a standard for radon in drinking water.

Increasing Access to Indoor Air Information

Information Dissemination

In addition to publishing a wide range of information materials on indoor air quality, EPA is also developing additional strategies for disseminating information to key audiences. To ensure that a full range of information about indoor air-quality problems and solutions is readily available to both the technical and nontechnical public, EPA's Indoor Air Quality Information Clearinghouse (IAQ INFO) began operation in fall 1992. The Clearinghouse is equipped with toll-free, operator-assisted telephone access and provides written information including fact sheets and brochures, performs literature searches, and makes referrals to appropriate federal, state, and regional resources. IAQ INFO answered 17,000 telephone requests for information and mailed out over 130,000 publications last year.

Training Key Audiences. Because concern about indoor air problems is a relatively recent phenomenon, many of the people who are in the best position to prevent problems or resolve them when they do occur are not sufficiently informed about the issue.

Many indoor air-quality problems can be avoided through sound building-operation practices, or resolved by knowledgeable building personnel without the need for potentially costly outside assistance. EPA has developed a training course for building owners and managers to acquaint them with the guidance contained in *Building Air Quality: A Guide for Building Owners and Facility Managers* (December 1991). Because many indoor air-quality problems are best resolved by responsible government agencies at the state and local level, EPA has developed both a live instructional course on indoor air-quality issues, entitled *Orientation to Indoor Air Quality*, and a self-paced learning module entitled *Introduction to Indoor Air Quality* (April 1991) for these audiences.

Forging Cooperative Partnerships. Many groups share EPA's interest in indoor air quality. EPA is working with numerous public and private sector groups to leverage our resources and to transfer information to target audiences who can implement our policies and take action to improve indoor air. Some examples include the American Lung Association, the Building Owners and Managers Association International, the International Union of Operating Engineers, and the Consumer Federation of America.

Advancing the Science of Indoor Air Quality. EPA is conducting studies to assess indoor air conditions in the nation's existing building stock. Special emphasis is being given to identifying those factors that exert the greatest influence on overall indoor air quality (IAQ). The information gained will be used to improve IAQ diagnostic procedures as well as to provide a basis for evaluating the effectiveness of our pollution-reduction strategies over time. Another set of studies now underway is designed to quantify the costs of key options for controlling indoor-air pollution in typical building structures.

EPA's Office of Research and Development conducts a multi-disciplinary research program which encompasses studies of the health effects associated with indoor-air pollution; assessments of indoor air pollution sources and control approaches; building studies and investigation methods; risk assessments of indoor air pollutants; and a recently initiated program on biocontaminants.

Working with Other Federal Agencies

More than 20 different federal agencies have responsibilities associated with indoor air quality, either through their own statutory responsibilities or because they are major property managers. The activities of these agencies are coordinated through a variety of mechanisms, including an interagency Committee on Indoor Air Quality (CIAQ) which meets on a quarterly basis to exchange information on indoor air issues. Five federal agencies—EPA, the Consumer Product Safety Commission, the Department of Energy, the National Institute for Occupational Safety and Health, and the Occupational Safety and Health Administration—are CIAQ co-chair agencies. In addition, EPA works closely with other agencies on regulatory and information-development efforts and jointly sponsors many of its guidance and public information documents with these other agencies to help ensure that federal actions are well-coordinated. □

Steve Kelley cartoon. Reprinted with permission of Copley News Service

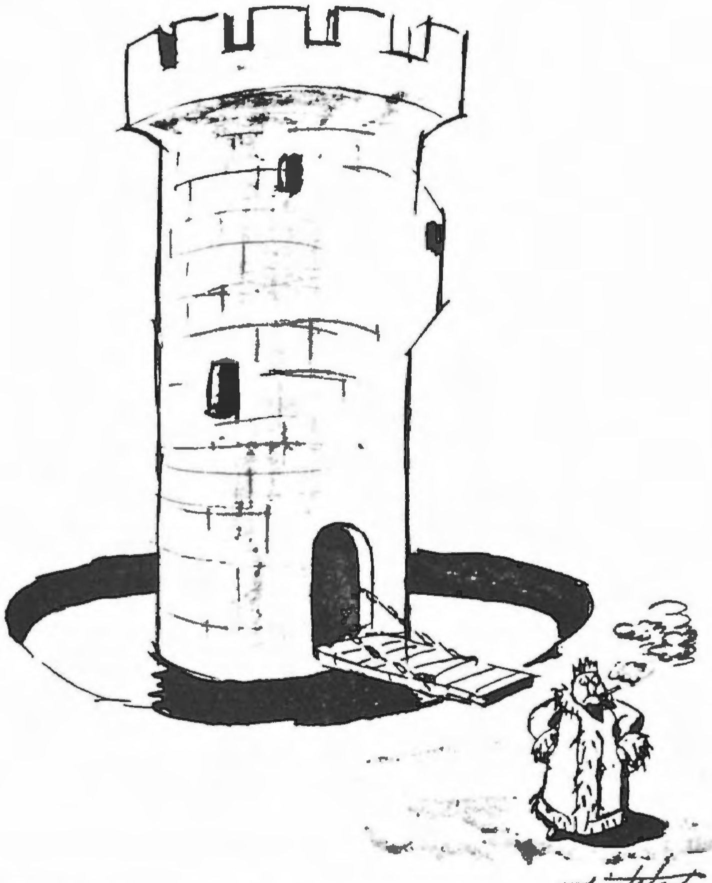
Environmental Tobacco Smoke: EPA's Report

by Carol M. Browner

ETS is classified as a known human carcinogen

Environmental tobacco smoke (ETS), also termed secondhand smoke, harms the health of thousands of Americans each year. ETS is a mixture of the smoke given off by the burning end of cigarettes, pipes, or cigars, and the smoke exhaled from the lungs of smokers. This mixture contains over 4,000 substances. More than 40 of these are known to cause cancer in humans and animals, and many are strong respiratory irritants.

Exposure to secondhand smoke, called involuntary smoking or passive smoking, is concentrated indoors, where ETS is often the most significant pollutant. Indoor levels of the particles you may inhale (the "tars" in the cigarettes) from ETS often exceed the national air quality standard established by EPA for outdoor air. The high levels of carbon monoxide in secondhand smoke also warrant concern.



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(Browner is Administrator of EPA.)

In January 1993, EPA released an assessment of the health risks of passive smoking in a report entitled *Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders*. The report summarizes the findings of an extensive investigation conducted by the Agency. It incorporates comments from two open public reviews and recommendations from EPA's Science Advisory Board—a panel of independent scientific experts in this field. The board endorsed the conclusions of the report and the methodologies used. In particular, the board unanimously endorsed the report's classification of ETS as a human lung carcinogen.

Based on the overall weight of available scientific evidence, EPA concluded that widespread exposure to secondhand smoke in the United States presents a serious and substantial public health risk.

Secondhand smoke is responsible for approximately 3,000 lung cancer deaths annually in nonsmokers in the United States. ETS is classified as a known human, or Group A, carcinogen under EPA's carcinogen assessment guidelines. This classification is reserved for those compounds or mixtures that show the strongest evidence of a cause-and-effect relationship in humans. Other agents classified by EPA as Group A carcinogens include radon, asbestos, and benzene, to name a few. Of these, ETS is the only one found to cause elevated cancer risks at commonly found indoor levels.

The report also includes the finding that secondhand smoke has subtle but significant other effects on the respiratory health of adult nonsmokers.

These include coughing, phlegm production, chest discomfort, and reduced lung function.

Infants and young children whose parents smoke are among the most seriously affected by exposure to secondhand smoke. They experience an increased risk of lower respiratory tract infections such as pneumonia and bronchitis. EPA estimates that passive smoking is responsible for between 150,000 and 300,000 lower respiratory tract infections in infants and children under 18 months of age annually, resulting in between 7,500 and 15,000 hospitalizations each year. Children who have been exposed to secondhand smoke are also more likely to have reduced lung function and symptoms of respiratory irritation such as cough, excess phlegm, and wheezing. Passive smoking can lead to a buildup of fluid in the middle ear, the single most common cause of hospitalization of children for an operation.

Asthmatic children are especially at risk. EPA estimates that exposure to secondhand smoke increases the number of episodes and the severity of symptoms for between 200,000 and one million asthmatic children. Passive smoking is also a risk factor contributing to the development of new asthma cases in thousands of children each year.

EPA firmly believes that the scientific evidence is sufficient to warrant actions to protect nonsmokers from involuntary exposure to secondhand smoke. Accordingly, we are conducting a public outreach program to communicate the findings of the report to the public.

In July, the Agency published a brochure, *What You Can Do About Secondhand Smoke,* which specifies actions that parents, decision makers, and building occupants can take to protect nonsmokers, including children, from indoor exposure to secondhand smoke. The brochure also contains a special message for smokers about how they can help protect people around them. Copies of the publication may be obtained by calling EPA's Indoor Air Quality Information Clearinghouse at 800-438-4318.

What kinds of actions are being advised? The following steps can help curb ETS exposure in the home, at child-care centers and schools, in the workplace, and in restaurants and bars:

- Don't smoke in your home or permit others to do so. If a family member smokes indoors, we recommend increasing ventilation in the area by opening windows or using exhaust fans. We also recommend that smoking should not occur if children are present, particularly infants and toddlers. Baby-sitters and others who work in the home should not be allowed to smoke indoors or near children.

- Every organization dealing with children— schools, day-care facilities, and other places where children spend time—should have a smoking policy that protects children from exposure to ETS.

- Every company should have a smoking policy that protects nonsmokers from involuntary exposure to tobacco smoke. Many businesses and organizations already have policies in place and more and more are instituting them, but these policies vary in their effectiveness. Simply separating smokers and nonsmokers within the same area, such as a cafeteria, will still expose nonsmokers to recirculated smoke and to smoke drifting in from smoking areas. Instead, companies should either prohibit smoking indoors or limit smoking to rooms that have been specially designed to prevent smoke from escaping to other areas of the building.

- If smoking is permitted in a restaurant or bar, smoking areas should be located in well-ventilated areas so nonsmoker will face less exposure. More and more restaurants and restaurant chains are prohibiting smoking in their facilities, and cities and counties across the United States are restricting smoking in restaurants within their jurisdictions.

EPA will be publishing guidance to help organizations establish smoking policies in indoor environments. Providing our children and the public with a smoke-free environment must be a national priority. □

Video on ETS and Children

A 12-minute video entitled *Poisoning Your Children: The Perils of Secondhand Smoke* is available from the American Academy of Otolaryngology (the specialty of ear, nose, and throat medicine). The film features Surgeon General Jocelyn Elders voicing her concern about this health hazard. EPA's report on passive smoking is also discussed as well as the type of injury passive smoking can cause to infants and children. For ordering information, please call 703-519-1528.

Steve Delaney photo

Spraying tobacco. Secondhand smoke contains over 4,000 substances; more than 40 are known human carcinogens.


Sethanne Peterson photo

Environmental Tobacco Smoke: Industry's Suit

Charges focus on epidemiology studies

by Steven Bayard and Jennifer Jinot

In June 1993, the tobacco industry filed suit in the Middle District Court of North Carolina claiming that EPA's classification of environmental tobacco smoke (ETS) as a known human lung carcinogen was "arbitrary and capricious." The industry has petitioned the court to compel EPA to rescind its classification of ETS and to withdraw its risk assessment. (The suit does not challenge EPA's characterization of the respiratory effects of ETS on children.)

To put the industry's challenge into perspective, one should look at the history of the case and the body of evidence connecting ETS and lung cancer. EPA's 530-page health risk assessment, which took nearly four years to complete, is an extensive review and evaluation of several hundred scientific studies on ETS. Two separate drafts were reviewed externally, and public comments obtained. Two public review meetings were held by an EPA Science Advisory Board (SAB) committee of 18 independent experts in the field. Following their second review meeting in July 1992, the SAB concurred in EPA's methodology and *unanimously* endorsed the classification of ETS as a "Group A" (known human) lung carcinogen. The board also commended the report's assessment of the respiratory effects of ETS other than cancer. No other report in recent memory has received a stronger SAB endorsement.

In addition, the National Cancer Institute and the Department of Health and Human Services have endorsed the assessment. So have the American Medical Association, the American Public Health Association, the American Lung Association, and the American Cancer Society.

EPA is neither alone nor the first to find exposure to ETS hazardous. It has merely assessed the largest database. Both the U.S. Surgeon General and the National Research Council of the National Academy of Sciences produced reports with substantially the same conclusions in 1986. In 1991, the National Institute of Occupational Safety and Health reviewed the evidence and concluded that not only was ETS a "potential occupational carcinogen" but it could possibly cause heart disease as well. Even a working group of academicians (primarily at McGill University) financially supported by one of the plaintiffs concluded there was strong evidence linking "residential exposure to ETS and both respiratory illness and reduction in lung function."

More specifically, the tobacco industry's lawsuit charges that EPA used unscientific methods, did not include the proper studies, loosened its statistical standards, purposely excluded studies that did not support its conclusions, and violated its own guidelines for conducting the assessment. These charges focus mainly on 30 epidemiology studies used in assessing the relationship between ETS and lung cancer in women who never smoked themselves but who were exposed to their spouses' ETS. The lawsuit also charges that "EPA completely ignored two large studies published in the United States . . . prior to its release of the final ETS risk assessment."

In focusing on these 30 epidemiology studies, the EPA report included all available lung cancer studies of never-smoking women and ETS which appeared prior to a necessary cutoff date for literature review. The evaluation involved five separate statistical analyses, including dose-response analyses and calculation of risks to the women in the highest exposure groups. The results of all five analyses were consistent, and the dose-response analyses and high-exposure group risk analyses provided very strong evidence of an ETS hazard. For example, of the 30 studies, 17 provided data on risks by amount of exposure; in all 17, those women whose husbands smoked the most had increased lung cancer risk, and nine of these increases were statistically significant despite small sample sizes. Moreover, in the three lung cancer studies which were published *after* the cutoff date, the women with the most ETS exposure also had significantly increased risks.

Probably the best analysis for evidence of a causal relationship between ETS exposure and lung cancer is an analysis for dose-response trends. Of the 14 epidemiology studies which provided data sufficient for dose-response testing, all had positive trends, and 10 of these were statistically significant. The probability of this high a proportion of significant trend tests occurring by chance is less than one in one billion. Also, it is worth noting that two of the three recent studies had statistically significant dose-response trends.

Of course, the EPA report examined the total weight of the evidence, not just the 30 epidemiology studies. Especially compelling evidence of the carcinogenicity of ETS is the known human-lung carcinogenicity of "mainstream" tobacco smoke inhaled by active smokers. For mainstream tobacco smoke, a dose-response result has been obtained down to very low levels—and with no evidence of a threshold. The similarities of ETS and mainstream smoke (they come from the same cigarette) and the known exposure of nonsmokers to ETS at levels which can be considered risky are well documented in EPA's risk assessment. □

(Drs. Bayard and Jinot of the Agency's Office of Research and Development are coauthors of EPA's 1993 report on ETS.)

Laws Protecting Nonsmokers

So far, no state bans smoking in all public places

by Fran Du Melle

Mike Brisson photo

For more than 40 years, the American Lung Association has fought to eliminate air pollution from both outdoor and indoor environments. In recent years, environmental tobacco smoke—or ETS—has become a major focus.

To understand why a pollutant such as ETS can be so harmful, think about your lungs.For all practical purposes, they are an external organ exposed to the atmosphere as surely as is your skin. If spread out end-to-end, the gossamer-thin membrane lining of your lungs would cover an area the size of a tennis court. Even minute amounts of air pollution can damage this intricate breathing system, especially in infants and young children.

Right now, according to the Centers for Disease Control, 25.7 percent of all adults in the United States smoke. They consume nearly one trillion cigarettes each year. That many people smoking that many cigarettes mean a lot of ETS assaulting our lungs.

The health effects of ETS were first reviewed 20 years ago in the 1972 U.S. Surgeon General's report on smoking and health. Since that time, public health advocates like the American Lung Association have urged adoption of laws and regulations making public places, workplaces, and schools smoke free. Release of EPA's January 1993 assessment of the health risks of exposure to ETS provided a new framework for encouraging policy makers at the federal, state, and local levels to take action to protect everyone—smokers and nonsmokers alike—from the dangers of ETS.

Smokers in the United States consume nearly one trillion cigarettes each year. That means a lot of ETS.

(Du Melle is Deputy Managing Director of the American Lung Association.)

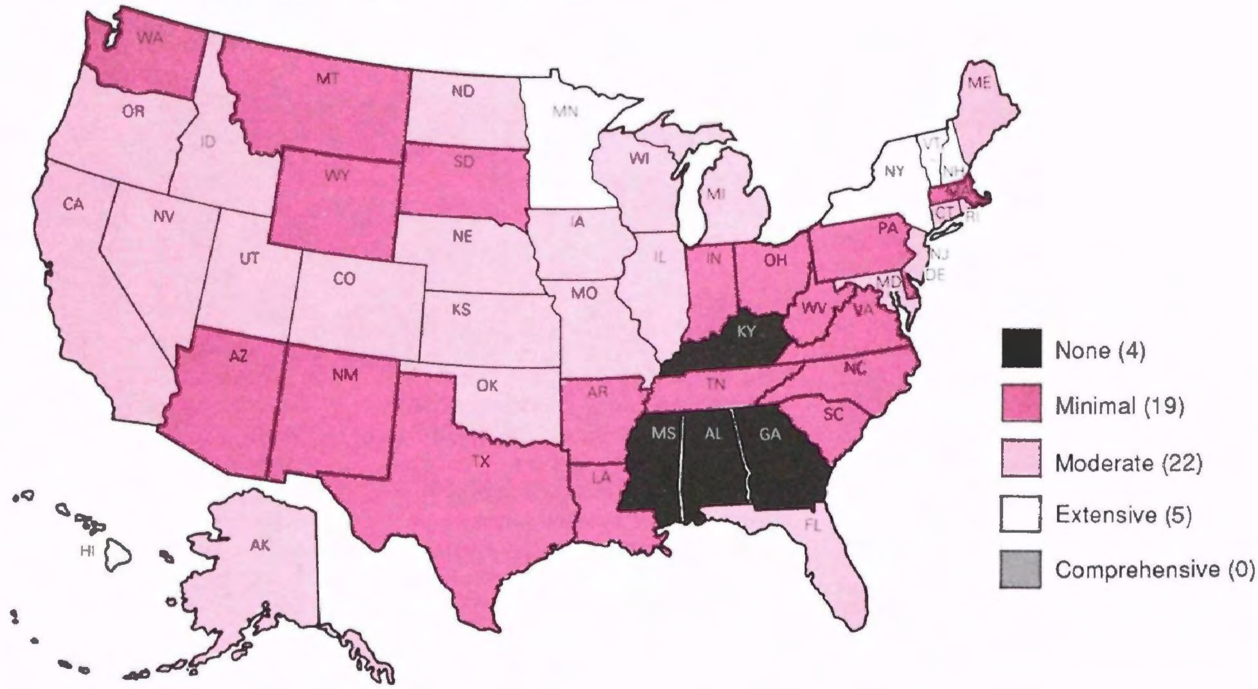
Exposure to ETS needn't be very large to translate into a significant public health hazard. The risk assessment indicates that the dangers from exposure to ETS are dose-response related— the greater the exposure, the greater the risk of injury. Thus, policy makers can focus on banning or at least restricting smoking in places where people spend most of their time. For adults, that means the workplace; for children, it means day-care centers and schools.

Many state and local governments as well as private organizations and companies have responded to the EPA risk assessment by evaluating their own laws, regulations, and policies on smoking. The American Lung Association has been pleased by this response. However, much remains to be done. Laws protecting nonsmokers remain inconsistent from state to state and from city to city.

Today, 46 states restrict smoking in public worksites to one extent or another, but many still allow smoking in designated areas with or without separate ventilation systems. The EPA risk assessment has already spurred several states, including Vermont and Missouri, to enact new restrictions. However, in a majority of states, workers remain unprotected from ETS in private worksites. California, for example, responded to the EPA report by issuing an executive order banning smoking in all state buildings. Yet that state failed to pass legislation providing the same protection in private worksites. North Carolina has a new law declaring that state buildings cannot be totally smoke-free—each must have an area designated for smoking.

When it comes to protecting children from ETS, state action has been very

Restrictions on Smoking in Public Places



limited. Where steps have been taken, they are frustratingly inconsistent. Although 39 states and the District of Columbia have laws restricting smoking on school property, only a few states—Hawaii, Kansas, Minnesota, New Hampshire, New Jersey, Washington—ban tobacco use by both students and faculty in school buildings at all times.

For infants and toddlers—children with the tiniest, most vulnerable lungs—there are no significant state-level protections from ETS. Alaska and Michigan are among only a very few states that prohibit smoking in day-care facilities. Other states have some restrictions but allow smoking in designated areas or at times when children are not present. Few states regulate smoking for day-care centers located in private homes.

The EPA risk assessment provided an incentive to the American Lung Association and its partners in the Coalition on Smoking OR Health, the American Cancer Society, and the American Heart Association to re-evaluate the way we assess laws or regulations to protect individuals from ETS. In the past, we simply examined the number of places covered by a law. The Coalition now examines, in detail, the actual provisions of each law restricting smoking in public workplaces, private workplaces, schools and day-care centers, health-care facilities, and public places and restaurants.

The risk assessment indicates that the dangers from exposure to ETS are dose-response related—the greater the exposure, the greater the risk of injury.

Our new rating system is presented in *State Legislated Actions on Tobacco Use,* an annual Coalition publication. We found that although 46 states have restrictions on smoking in public places, 19 have laws we consider "minimal" and 22 we consider "moderate."

States with "minimal" restrictions require employers to establish a written smoking policy. Details of the policy are determined by the writer of the policy—the employer, building owner, etc. In some states, designated smoking areas may be *required*. In other words, a worksite could not be declared completely smoke free. In a worst-case scenario, an entire building could be designated as a smoking area.

States with "moderate" restrictions are likely to ban smoking outright in a few places, such as retail stores, public transportation, hospitals, and elevators, and these states call for mandatory designated smoking areas in many places.

States with "extensive" restrictions ban smoking more widely in public places but still permit some designated smoking areas. Only three states—Minnesota, New Hampshire, and New York— received "extensive" ratings.

States with "comprehensive" restrictions—the Coalition's top rating category—ban smoking in all public areas. No state has achieved this status—yet.

The inequities of this "patchwork quilt" must be corrected to protect everyone from exposure to ETS in public places or at work. The American Lung Association is certain that, as public awareness and concern about ETS grow, policy makers will heed the concerns of the people they serve. In the coming years, more states and localities will move into the "extensive" and "comprehensive" categories. □

(To obtain a copy of *State Legislated Actions on Tobacco Use,* contact the Coalition on Smoking OR Health, 1150 Connecticut Avenue, NW, Suite 820, Washington, DC 20036; telephone: 202/452-1184.)

The TEAM Studies

by Lance Wallace

Hot showers produced elevated levels of chloroform

What links cigarettes, air deodorizers, and hot showers? If you respond that they are among the major sources of human exposure for certain toxic chemicals, you probably have been reading about the results of EPA's TEAM (Total Exposure Assessment Methodology) studies. EPA's Office of Research and Development developed the TEAM concept in 1979, and for more than a decade—by directly measuring the exposure of individuals—these studies have supplied a wealth of information on our actual exposure to pollutants in air and drinking water. As discussed earlier in this issue of *EPA Journal* (see articles on page 6 and 9), knowing more about exposure enables us to better estimate risk.

Participants in a TEAM study are selected randomly, as in a Gallup poll, to represent a much larger group. Target pollutants are selected on the basis of toxicity, carcinogenicity, and production volume. To measure exposure where people are, personal air quality monitors are provided to accompany participants on their normal daily activities. If drinking water is a likely source of a pollutant, samples are collected from the tap at home and at work. Samples of food or house dust may be collected as well. Breath samples are collected to determine levels of certain pollutants in people's bodies. Outdoor air samples are collected near the participant's house to determine what proportion of the exposure is contributed by outdoor air.

To date, about 2,500 people, representing a total population of about 3 million residents of various cities, have taken part in TEAM studies. The TEAM concept has also been applied in large-scale studies by industry and by foreign governments.

(Dr. Wallace is an environmental scientist at EPA's Atmospheric Research and Exposure Assessment Laboratory. He has worked for the Agency's Office of Research and Development since 1977.)

The premier TEAM study was the first and the largest study that attempted to determine whether persons living close to chemical plants and petroleum refineries had higher exposures to toxic volatile organic compounds than persons living a few miles away. No such effect was found at any of the study sites—Elizabeth and Bayonne, New Jersey, and Los Angeles, Antioch, and Pittsburg, California. Surprisingly, the median air concentrations of the 18 targeted chemicals ranged from 2 to 20 times higher in participants' homes than in the outdoors. In short, even in these areas that were thought to be highly polluted, outdoor air, on average, accounted for only about 2 percent to 25 percent of total airborne exposure. The bulk of the exposure, for every chemical, came from indoor sources.

What were these sources? The study was able to identify some, but not all, of the important sources for certain toxic chemicals. For example, measurements of exhaled breath revealed that smokers have 6 to 10 times the amount of benzene in their blood as nonsmokers. In fact, for average smokers, cigarettes provide about 90 percent of their total exposure to benzene. Moreover, indoor air in homes with smokers had about 50 percent more benzene than in homes without smokers.

A second toxic chemical included in this study was para-dichlorobenzene (p-DCB), a registered pesticide commonly used to control moths but also used as a bathroom air deodorizer. It is used in most public toilets in the United States, and it is the active ingredient in products for the home—"stickups," sprays, liquids—that are used as a room air or toilet bowl deodorants. About a third of the 750 homes measured in the TEAM VOC studies had elevated levels of p-DCB. By putting a common bathroom air deodorizer into a home and measuring concentrations of p-DCB both in indoor air and in the exhaled breath of the residents, the investigators were able to track sharply increasing concentrations of P-DCB in the blood of the residents over a three-day period.

This first TEAM study suggested that elevated indoor air concentrations of chloroform are caused by heated water uses in the home, especially hot showers and washing clothes and dishes. Measurements of tap water showed that it too was an important source of exposure to chloroform. Finally, measurements of food and beverages showed the presence of chloroform at low levels in soft drinks, milk, and dairy products such as butter and cheese.

A special TEAM study determined that bringing home freshly dry-cleaned clothes elevates indoor levels of dry-cleaning chemical (usually tetrachloroethylene) to concentrations about 100 times outdoor concentrations. Levels remain elevated for at least a week. The major pathway of exposure was determined to be the outgassing of the chemical residues remaining on the clothes.

Another special TEAM study of three new buildings and seven older ones showed that the new buildings had concentrations of eight chemicals that were typically 100 times outdoor concentrations. These chemicals included xylenes, ethylbenzene, decane, and undecane, which are commonly used in paints and adhesives. Repeated visits to the three new buildings over the three months following their completion suggested that it would take six months to a year for the chemical concentrations to decline to the levels observed in the seven older buildings.

A TEAM study of exposure to carbon monoxide (CO) in winter was carried out in Washington, DC, and Denver, Colorado. More than 800 people in Washington and 450 in Denver carried a newly designed personal CO monitor for a day. The findings confirmed suggestions from earlier studies that driving was the most common source of concentrated exposure to CO. But they also showed that attached garages, gas stoves, and environmental tobacco smoke (ETS) could elevate exposures.

A TEAM study of exposure to airborne pesticides (the Nonoccupational Pesticide Exposure Study, or NOPES) was carried out in Jacksonville, Florida, and Springfield and Chickopee, Massachusetts. Indoor sources accounted for 90 percent or more of the total airborne exposure to most of these pesticides, some of which had already been banned or otherwise regulated by EPA (aldrin, dieldrin, heptachlor, and chlordane) but continued to be found in the homes.

Since these pesticides were previously used widely to prevent termites, they are believed to have entered the homes via diffusion of soil gas into basements, in much the same way as radon enters homes. Another pesticide, DDT, banned for nearly 20 years, was found in house dust in five of eight homes. Later studies, which included measurements in soil just outside the home, suggested that DDT and other long-lasting pesticides may be tracked in from soil clinging to shoes.

It is almost as if the participants were walking about in their own personal cloud of particles, a sort of Pigpen *effect. . . .*

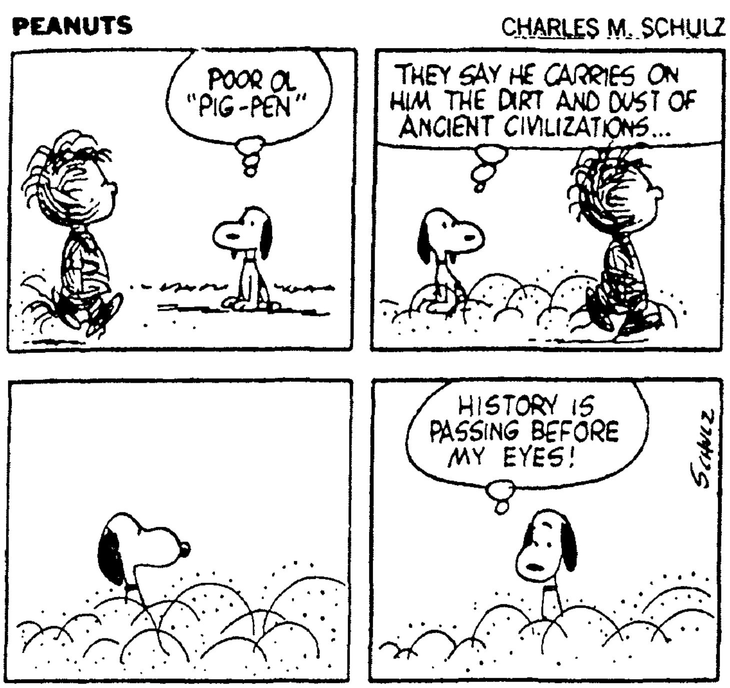
The most recent TEAM study was performed in Riverside, California. This was the Particle TEAM, or PTEAM, study. A personal monitor collected particles (and also nicotine) in the breathing area of 178 Riverside residents for two consecutive 12-hour periods. The filters were later analyzed for 15 elements, including lead, chlorine, and sulfur.

A major surprising finding was that daytime personal exposures were 50 percent higher than concurrent indoor air concentrations measured by a fixed monitor in the home. It is almost as if the participants were walking about in their own personal cloud of particles, a sort of *Pigpen* effect, after the character in the *Peanuts* comic strip. This excess exposure—including exposure to 14 of the 15 elements—may be due to particles from carpets, furniture, or clothing that are resuspended through walking, sitting, or other movements. Other important indoor sources of particles were smoking and cooking. Cooking resulted in increased levels of particles and organic chemicals known as polyaromatic hydrocarbons (PAHs).

In summary, the findings of the TEAM studies underline the importance of actually measuring human exposure, rather than estimating it from measurements of outdoor (or indoor) air. Without the measurements made possible by personal monitors, we might still think that urban-industrial areas, chemical plants, and petroleum refineries provide our major sources of exposure to toxic chemicals. Instead, the TEAM studies suggest that the major sources for many chemicals are literally under our noses.

Should we be worried about these chemicals? The TEAM studies alone do not answer this question. In the case of benzene, both the International Agency for Research on Cancer (IARC) and EPA have determined that benzene causes leukemia in humans. Further, studies have shown that children of smokers die of leukemia at twice the rate as children of nonsmokers. Many of the other chemicals mentioned above—chloroform, tetrachloro-ethylene, PAHs, p-DCB—cause cancer in rats and mice; they mayor may not cause cancer in humans. Some of the remaining chemicals—xylenes, decane, undecane—act on the central nervous system at high concentrations, causing dizziness and headaches. Because these symptoms are common in Sick Building Syndrome (SBS), particularly in new or renovated buildings where concentrations of these chemicals are high, some investigators believe that these and related VOCs may be one of the causes of SBS.

What can you do to reduce your exposure to indoor air pollutants? A number of simple and inexpensive measures, such as maintaining a smoke-free home and routinely using a doormat or even establishing a "no shoes indoors" policy to avoid tracking soil into the house can reduce exposures considerably. To obtain a free booklet, *The Inside Story*, which describes actions people can take to reduce their exposures to indoor pollution, contact: Indoor Air Quality INFO, P.O. Box 37133, Washington, DC 20013-7133; phone: 800/438-4318. □



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Investigating Sick Buildings

No obvious sources of contaminants are found

By Brian Leaderer

Steve Delaney photo

The symptoms of sick building syndrome usually diminish when the individual is away from work.

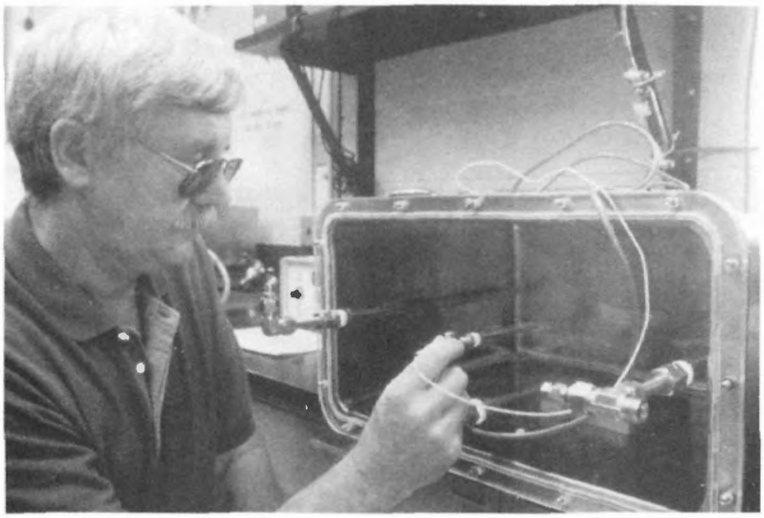
It is a winter afternoon. You are at your desk feeling uncomfortable. Your eyes and throat are irritated; you have a slight headache and feel lethargic. You find that several of your coworkers are experiencing these same symptoms plus others: nose irritation, fatigue, watering eyes, stuffy nose, dry or itching skin, and difficulty breathing. These symptoms seem to occur only during working hours, are highly variable in their degree of severity, and affect a variable percent of your building's occupants on any given day. A few occupants seem to be severely affected.

You and the other building occupants fear that poor air quality is responsible for all of your symptoms. The building owners call in a group of experts to determine the nature and cause of the complaints. Levels of microbiologicals, volatile organics, and particulates are found to be well within accepted standards. No obvious sources of contaminants are found. Fresh-air supply rates are at the low end of accepted guidelines; the engineering drawings of the building do not reflect the many changes made to the building's heating, air conditioning, and ventilation system. Thermal conditions are within the accepted comfort range but somewhat variable. The quality of lighting is variable, and the office space is dusty.

The experts are unable to find a direct relation between employee symptoms and any physical, chemical, or biological factors in the building. They recommend increased fresh air supply rates, better building maintenance and record keeping, improved lighting at work stations, and more direct occupant control of their thermal environment. No guarantees are given that these steps will reduce the occupants' symptoms, particularly the most severe symptoms. When asked whether the symptom rates are high and reason for health concern, the experts can only say that they have no basis of comparison upon which to make that judgment. The building owner makes the recommended changes and hopes the problem will disappear.

The situation described above has become known as building-related occupancy complying syndrome (BROCS), sick building syndrome (SBS), or tight building syndrome. It occurs in nonindustrial workplaces such as schools, office buildings, commercial buildings, and hospitals throughout the world. The incidence of these outbreaks has increased with the

(Dr. Leaderer is a Professor and Head of the Division of Environmental Health Sciences, Department of Epidemiology and Public Health at the Yale University School of Medicine. He is also a fellow at the John B. Pierce Laboratory.)



Bruce Tichenor, environmental engineer at EPA's Air and Energy Research Laboratory in RTP, North Carolina, adjusts a temperature probe for a small environmental test chamber. The interactions of so many factors (including temperature) make sick building syndrome difficult to study.

EPA photo

development of strategies to reduce energy consumption and with the introduction of new materials and machinery into the workplace. BROCS/SBS is loosely defined as an increase in the frequency of a constellation of acute, nonspecific symptoms characteristically affecting multiple occupants of a building. The symptoms usually, though not always, diminish while the individual is away from the building. The most common include irritation of the eyes, nose, and throat; headache; fatigue; nausea; and lethargy. Sore or dry eyes, stuffy or runny nose, sore throat, difficulty breathing, and dry or itching skin have also been associated with the syndrome. The symptoms do not fit any specific clinical syndrome and are typically not associated with any single source or specific air contaminant.

BROCS/SBS is one of two building-related problems. The second is known as building-related illnesses (BRI). Unlike BROCS/SBS, BRI are illnesses with a specific clinical syndrome that is associated with exposure to specific or general categories of contaminants related to identifiable sources. Examples include: Legionnaires' disease, associated with exposure to bacteria; hypersensitivity pneumonitis and humidifier fever, associated with exposure to bioaerosols such as fungi and bacteria; and symptoms associated with specific chemical exposures, such as headaches and cardiovascular effects resulting from carbon monoxide exposure or eye irritation associated with exposure to formaldehyde.

The cause of the complaints associated with BROCS/SBS is believed to involve a complex interaction of a number of factors. These indoor factors include: chemical and biological emissions from building materials, furnishings and surfaces; building environmental systems; building use; physical factors such as temperature, humidity, air flow, noise, and light; ergonomics; individual characteristics such as age, gender, race, smoking status, and health; and social dynamics—job stress, job satisfaction, privacy. The nonspecific nature of the complaints and the complex interaction of the factors make BROCS/SBS difficult to study.

Several investigations, some involving thousands of office workers in several buildings, have been undertaken to characterize the nature and prevalence of building-related symptoms and to determine whether an association can be established between them and the factors mentioned above. Typically, there are no obvious sources. A complex mix of contaminants is measured, with all individual constituents well below industrial or ambient air standards. There are no relevant indoor air quality standards or guidelines that apply, although there are ventilation and thermal guidelines issued by the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE). Occupant complaints are nonspecific, episodic in nature, and affect varying numbers of occupants. Invariably, the symptoms are absent when investigations are conducted—the "you should have been here yesterday" effect.

Further, there is a lack of normative data: What is a "healthy" building? In setting criteria for thermal conditions in a building, it is generally accepted that only 80 to 90 percent of the occupants need be satisfied. No data exist, however, that establish the baseline rates in "normal" buildings for the prevalence and severity of symptoms or environmental factors. Without normative data, it is difficult to identify problem buildings.

Field study efforts to characterize the nature of building-related symptoms have had difficulties for two major reasons. First, questionnaires used for self-reported symptoms have not adequately addressed such issues as frequency of symptoms, temporal distribution, and whether they are work-related (i.e., symptoms disappear away from work). Also, they have not obtained information on such important factors as health status and job satisfaction. Second, only a few environmental variables have been monitored, the temporal and spatial representation of the monitoring has been poor, and the measurements typically have not been coincident with the reporting of symptoms by occupants.

In spite of all the problems with studying BROCS/SBS, progress is being made. Recent investigations (see box) have used methodologies that address many of the shortcomings of previous ones. EPA has sponsored development of standardized protocols and will fund their application in hundreds of normal and problem buildings across the United States. This will allow the pooling of data, the analysis of which will provide definitions of what "healthy" and "sick" buildings are.

New statistical methods are being applied that should advance our understanding of the interrelationships among factors associated with BROCS/SBS. Scientists have recently initiated animal and human studies into the nature and degree of eye, nose, and throat irritation (among the major BROCS/SBS symptoms); they are also examining how low levels of complex volatile organic compounds emitted from building materials and furnishings affect irritation.

Perhaps, one day when occupants complain of a host of nonspecific symptoms related to their nonindustrial workplace, the experts called in to investigate may actually be able to provide solutions. □

EPA and LOC Buildings Examined for SBS

One of the most comprehensive investigations of workplace indoor air quality was conducted at Washington, DC, offices of EPA and the Library of Congress. Shown is EPA headquarters' West Tower building.

Steve Delaney photo.

The Indoor Air Quality and Work Environment Study of the Library of Congress (LOC) Madison Memorial Building and the EPA headquarters buildings (Waterside Mall complex, Fairchild Building, and Crystal Mall) in Washington, DC, is one of the largest and most comprehensive BROCS/SBS investigations ever conducted. The study was undertaken in the winter of 1989 in response to a long history of complaints reported by the occupants and to their concerns about indoor air quality in their work environment. The study was designed and conducted by an interdisciplinary group of researchers from the John B. Pierce Laboratory at the Yale University School of Medicine, the National Institute for Occupational Safety and Health, EPA, the National Institute of Standards, and Westat, Inc.

The primary objectives were to survey health symptoms and comfort concerns of employees, characterize the indoor environment in selected locations, and analyze possible associations between health or comfort symptoms and conditions in the building. The study provided researchers with an opportunity to test protocols which could address many of the problems inherent in studying BROCS/SBS issues.

The study was conducted in two stages. The first consisted of a self-administered questionnaire that all occupants of the buildings were asked to complete. Respondents provided information on work-station characteristics, work-related acute health symptoms and thermal discomfort, perceived sources of poor air quality and effects, demographics, and psychosocial factors including job stressors. The questionnaire was distributed to 8,076 employees and completed by 6,800 for a response rate of 84 percent. From the results of this initial survey, areas of the buildings were ranked according to health-symptom and thermal-discomfort prevalence; areas with low and high reporting rates were chosen for inclusion in the second stage of the study.

In the second stage, environmental monitoring was conducted at the high and low symptom and thermal discomfort locations, and a supplemental questionnaire was administered to occupants near the monitoring sites. This questionnaire assessed health and comfort status and mood states during the same period the monitoring was performed. Monitoring included measurements of temperature, humidity, ventilation rates, and a host of air contaminants. The second questionnaire was administered to approximately 1,300 occupants.

The investigation has produced a rich database, the analysis of which is ongoing. Descriptive analysis of the initial questionnaire showed BROCS/SBS symptoms to vary between buildings, with the LOC building generally showing a higher rate of symptoms than the EPA buildings. Symptom prevalence rates were typically less than 20 percent.

Without normative data, it is difficult to determine whether rates were higher than should be expected. Thermal discomfort was high in all buildings, with as many as 55 percent of the Waterside Mall occupants indicating that they would like to adjust the temperature. Multivariate analysis showed that several of the workplace factors were associated with variations in symptoms—stuffy air, respondent allergies, thermal conditions, dustiness, glare, etc. These factors generally explained between 15 to 25 percent of the variation in reported symptoms. Measured levels of air contaminants were not associated with the symptoms. As the statistical analysis of the data proceeds, we expect to learn more of the relation between symptoms and exposures.

The LOC/EPA study, while not providing any clear cause for the symptoms experienced by the building occupants, did advance our understanding of BROCS/SBS and has led to new lines of investigation of the nature and causes of building-related symptoms and discomfort.

Economic Effects of Poor IAQ

by Curtis Haymore and
Rosemarie Odom

Just opening a window can disrupt production

Poor indoor air quality (IAQ) takes its toll in a variety of ways. It damages our health and our possessions; it lowers our productivity at work; and it diverts resources to diagnosing and solving problems that result from it. Although the economic costs of some of these damages are fairly tangible and easy to quantify, a large portion are hidden. The cumulative impact can easily reach into the billions of dollars.

The cost to diagnose, mitigate, and litigate IAQ problems is evidenced by the burgeoning number of businesses providing these services. A recent EPA survey indicated that over 1,500 firms specialize in IAQ services, a 25-percent increase from 1988. The median price for evaluating and balancing ventilation systems ranges from $250 to $1,500. The median for duct-cleaning services is about $500 and for asbestos abatement and construction/renovation, about $5,000. Costs can be as high as $50,000 for some of these services.

In addition, the cost of fees, awards, and settlements is also growing as an increasing number of IAQ-related cases are being litigated. Although most IAQ complaints are resolved through settlements, enormous sums of money have to be invested in investigations, testing, and expert testimony, in addition to legal fees. The settlements themselves are often in the hundreds of thousands to millions of dollars.

The economic costs of poor IAQ also include the actual damages to property caused by contaminants. Indoor air pollutants can damage metals, paints, textiles, paper, and magnetic storage media and can cause increased soiling, deterioration of appearance, and reduced service life for furniture, draperies, interiors, and heating, ventilation, and air conditioning (HVAC) equipment.

Some objects and materials are "sensitive populations" and are particularly susceptible to damage. For example, antique leather- bound books and fine art are particularly vulnerable to a number of contaminants. Electronic equipment, which is particularly susceptible to corrosion, represents a large investment at risk from poor IAQ.

Injury to people represents an even larger cost of poor IAQ. EPA ranks IAQ problems as one of the largest remaining health risks in the United States. Health effects range from the mildly irritating, such as headaches and allergies, to the life threatening, such as cancer and heart disease. Medical costs due to excess cancer cases caused by indoor air contaminants are estimated to range from $188 million to $1.375 billion nationwide. Heart disease caused by exposure to environmental tobacco smoke can equal another $300 million. One study indicated that for every 100 white collar workers, poor IAQ would cause an extra 24 doctor visits per year. This amounts to another $288 million.

One of the "invisible" costs of poor IAQ is the lost productivity of workers who experience headaches, eye irritation, and fatigue, among other symptoms. Productivity drops as employees are less effective at their tasks, spend more time away from their work stations, or require more frequent breaks. Even a seemingly minor activity such as taking a pain reliever or opening a window can disrupt productivity. In more severe cases, increased absenteeism and plummeting morale result. One study found that 14 minutes are lost per 8-hour day due to poor IAQ. In addition, for every 10 workers, poor IAQ causes an additional six sick days per year. If this is true, the resulting cost of the lost productivity for the United States is $41.4 billion.

Given these large costs of living wit poor-quality indoor air, what can be done? The long-run answer is that buildings can be designed better. The short-run answer is to correct problem in existing buildings. What does it cost? Our research has shown that better practices often save money. In any event, they are a small fraction of overall building costs, and they are substantially less than the price we pa for poor IAQ.

Better Designs Save Money

About 1,250,000 new housing units and new office, retail, and factory buildings are built each year. In these new structures, architects and builders have the opportunity to "do it right th first time."

The first step in better designs is to avoid contaminants. Architects and builders can:

- Insist on building materials that have fewer potential contaminants or have lower concentrations of contaminants
- Change the mix of materials (for example, using linoleum instead of carpeting usually results in fewer potential contaminants and a lower building cost)
- "Air out" materials before they are used, and air out the building before it is occupied
- Place air intakes away from sources of contaminants, such as parking areas street traffic, and exhaust vents

(Haymore is Vice President of the Energy and Environment Division, Socio-Technical Research Applications, Inc. Odom is a Senior Associate at Socio-Technical Research Applications, Inc.)

The Old Reading Room at the Folger Shakespeare Library, Washington, DC. Fine art and antique leather-bound books are particularly vulnerable to some contaminants.

Folger Shakespeare Library photo

- Avoid breeding bacteria by exercising good ductwork design, use of materials that won't trap moisture, and design of the HVAC system for easy inspection and cleaning.

Did you ever notice that bathrooms usually have separate exhaust fans that pump bad air directly outside? This same principle should be used in areas where indoor air contaminants are likely to be present, such as kitchens and smoking lounges. But by far the most common technique for improving IAQ is to use bigger HVAC equipment to move more outside "fresh" air into the building, replacing some of the "stale" or contaminated air. New buildings can also use more sophisticated filters that better remove contaminants from the air stream.

Good Operations Cost Can Also Save

Most buildings will be in use for at least 20 to 30 years. Indoor air quality depends on maintaining the building and its HVAC system well. This requires periodic replacement of equipment, preventive maintenance to avoid problems, and monitoring building conditions.

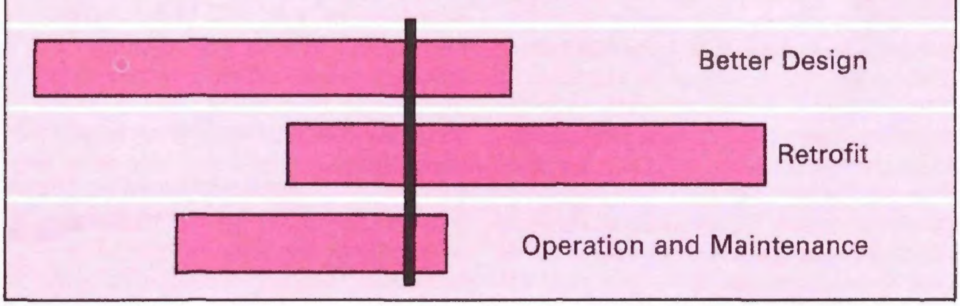
A good maintenance program monitors the actual performance of a building and surveys the building occupants to discover problems. Some common maintenance procedures include inspecting, cleaning, or repairing the following:

Outdoor air intakes
Mixing plenums (where outside air is mixed with recirculating indoor air)
Filters
Heating and cooling coils
Air supply fans
Ducts
Humidity controls
HVAC system controls.

Although owners might fear the costs of improving the IAQ of their buildings, our research has shown that well-run buildings cost less to operate. Here are some ways in which building owners can save money:

- Well-run buildings use less electricity and other forms of power.

Relative Costs and Savings of Measures to Improve IAQ



- Good IAQ practices result in lower life-cycle costs for equipment, less frequent repairs and system shutdowns, and longer life of HVAC equipment.

- The major reason most tenants move is not cost or location or space, but their dissatisfaction with their current buildings systems. If tenants experience three basic building problems in a year, there is greater than a 50-percent chance they will relocate ("three strikes and theyre out!"). Good IAQ practices help keep tenants.

Why Isn't More Being Done?

If good IAQ is so cost effective, why isn't it pursued? First of all, a lot of people simply dont know about indoor air quality and its costs. Tenants dont demand good IAQ practices when they choose office space, so building owners and operators have no incentive to invest in them. Moreover, investors tend to act on the "edifice complex." In other words, they prefer to invest in the outward appearance of buildings rather than their mechanical systems. Most people never see the HVAC system in a building, so little attention is paid to it. Until public awareness increases and tenants and consumers begin demanding good IAQ, the costs of poor IAQ will continue to drain our resources and burden our economy. □

Regulating IAQ: The Economist's View

Indoor air is air that someone owns

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by Robert G. Hansen and John R. Lott, Jr.

Marketplace forces don't always produce the desired results in environmental quality. Outdoor air pollution, for example, is a difficult problem to solve using the free market. In large cities there are thousands of sources of pollution and millions of potential victims. If left to their own desires, would those individuals responsible for outside air pollution assume the cost of reducing pollution but share the benefits with everyone who might be affected? Altruism seems unlikely to be enough to solve this pollution problem, and the likely answer is no. In the case of outdoor air pollution, then, most economists would advocate taxes to make those who produce the pollution bear the costs that they are imposing upon others. Indoor air pollution is another matter.

In general, environmental problems arise precisely because decision makers do not bear all the costs resulting from their decisions. Economists refer to one version of this problem as the "common pool" or "overfishing" problem. In the case of fisheries, fishermen overfish an area until the stock of fish has been depleted because they stand to gain nothing for letting a fish remain uncaught. If one fisherman lets a fish go so that it might mature and produce more offspring, there is no guarantee that another fisherman will not catch that same fish. Therefore, the fishermen catch the fish as quickly as they can, and the outcome is that the fishery is depleted.

One solution to this problem, favored by economists, is to ensure that one person owns the fishery. When a fishery is privately owned and not open to just anyone who desires to fish there, it is in the owner's interest to maximize the long-term value of that property. Moreover, if fish become a scarce commodity in the future, the individual owner stands to earn an even greater return for abstaining from fishing today so that more fish will be available for sale at a higher market price later.

The irony in the current debate over indoor air pollution is that indoor air fits the classic case where economists argue government intervention is most unwelcome. By definition, indoor air is air within a building that someone owns. As long as someone owns the air, he or she obtains both the benefits and the costs from deciding how clean it should be.

The most obvious case is where someone owns and lives in a home alone. No problem exists since the owner/occupant bears all the costs and benefits of any pollution produced within. This is just as true for the decision to smoke cigarettes as it is to purchase less expensive products that emit toxic fumes, such as benzene or formaldehyde, instead of more expensive ones that do not. Even with more than one occupant in the house, there would still not be a case for government intervention. Since those affected are few in number, they should easily be able to reach agreement on air quality within the house.

If government intervention occurs in such a case, it should be limited to providing individuals unbiased information—though it is not obvious why the market would not provide such information if really desired by people. (For example, the information could be produced through *Consumer Reports* or private firms rating the condition of houses.)

Cost-benefit calculations done by the government are not a close substitute for private decision making. Individuals' decisions may differ from regulators' because individuals may be inarticulate and uninformed, or perhaps because they may attach different values to their health and length of life than do the regulators.

Cost-benefit analysis goes to great lengths to approximate peoples values for these things, but this is one area where we can simply rely on those affected individuals to reveal this information themselves. Moreover, binding regulations ignore the possibility that just as some individuals are happiest when taking risks like bungee jumping, there may be a few whose utility is greatest when they take risks that most people deem unacceptable.

Individuals undoubtedly make mistakes, but the government must find some way of distinguishing whether people are underestimating the risks of their actions or are simply attaching different values to things than regulators do. The problem is even more complicated in that individuals may be just as likely to overestimate the risks from their actions as they are to underestimate them. Evidence from opinion surveys

(Hansen is an associate professor at Tuck School of Business at Dartmouth College; Lott is the Carl D. Covitz Assistant Professor at the Wharton School of Business at the University of Pennsylvania.)

Wide World photo

and econometric studies of smoking suggest that people have a greater fear of getting cancer from smoking than is justified by actual cancer statistics. Any honest appraisal would also have to admit that the government also makes its share of mistakes. As examples, consider the mandates for use of oxygenated auto fuels during the winter or for asbestos removal from buildings, or the Food and Drug Administration's restrictions on vitamins over the past 30 years.

Government regulation of indoor air quality in office buildings and restaurants is similarly unwarranted, for there is still one person—the owner—who has clear incentives to do the best possible cost-benefit analysis. The question of allowing smoking in a restaurant is no different than the question whether the restaurant provides music or other amenities. Some customers may value music with their meals, just as some value being able to smoke cigarettes. Presumably, regulators are not concerned about whether restaurants are failing to provide the right amount or type of music, and the reason for this is pretty obvious: If restaurants do not provide the service wanted by the customers, they will go out of business. Nor does there currently seem to be a strong movement to ensure that additional or fewer restaurants provide vegetarian foods or steaks. When restaurants make the wrong decision, customers take their business elsewhere.

Restaurants offer customers nonsmoking areas, without any government mandates, and Muse Air tried to offer completely nonsmoking flights during the 1980s but eventually went out of business. Economists would infer from Muse Air's experience that smokers valued smoking in airlines (even if restricted to certain smoking sections) more than nonsmokers valued completely smoke-free air. To force airlines to ban smoking on all flights thus makes smokers worse off by a greater amount than it benefits nonsmokers.

Similar considerations apply to employers and employees. For employees, there is a large economics literature identifying the higher wages firms must pay their workers in order for these workers to be willing to undertake riskier activities. Firms requiring that their workers inhabit so-called "sick buildings" not only face greater costs through higher absenteeism, but also higher wage costs as workers find those jobs less desirable places to be. Workers value their health, but they also value higher wages. It is not obvious who, other than the workers and owners, is in a better position to judge the trade-offs that workers are willing to make between these two values.

The bottom line is that even the most efficiency-motivated government is unable to improve upon the cost-benefit calculus done by those affected by indoor air pollution. In the real world the true choice is even clearer. Governments face many conflicting interests that have nothing to do with maximizing consumer or worker welfare. Government bureaucrats' preferences are not necessarily superior to those they are regulating. Who is to say that citizens are making mistakes whenever their decisions differ from what the regulators desire? □

The question of allowing smoking in a restaurant is no different than the question whether the restaurant provides music or other amenities.

California's Program

Indoor air problems aren't amenable to regulation

by Jerome Wesolowski

In 1982, California's legislature established an Indoor Air Quality Program (CIAQP) in the Department of Health Services to carry out research on the nature and extent of the indoor air problem (excluding industrial worksites), to find appropriate mitigation measures, and to promote and coordinate the efforts of other state agencies. Since indoor air problems usually are not amenable to regulatory solutions, regulatory authority was not included in the mandate.

Seven technical people work in the program. They represent several disciplines, including chemistry, epidemiology, industrial hygiene, ventilation engineering, psychology, and microbiology. The group also draws on other professionals in the Department of Health Services (DHS), such as toxicologists, physicians, sanitarians, and risk assessors.

The program conducts research into a wide range of contaminants—radon, asbestos, formaldehyde, carbon monoxide, volatile organic compounds, environmental tobacco smoke (ETS), as well as into biological aerosols that cause such diseases as Legionnaires disease, tuberculosis, allergies, and asthma. Studies are also carried out to better understand the Sick Building Syndrome. The research includes field surveys to determine the exposure of the population to specific contaminants and experiments in the laboratory to develop protocols for reducing exposures. The research emphasizes measurement of exposure—concentration multiplied by the time a person is exposed—as opposed to measurement of concentration only.

(The late Jerome Wesolowski was the Chief of the Environmental Health Laboratory of the California Department of Health Services and an Adjunct Professor at the University of California, Berkeley. He died on January 1, 1994, at the age of 61. Donations in his name may be made either to environmental conservancy agencies or to cancer research.)

The research provides a scientific basis for policy. For example, radon surveys were used in developing the state's mitigation objectives. These objectives are somewhat less ambitious than those of other states, because the survey found that radon levels in California were generally lower than levels in other states.

The research component also provides the scientific foundation for the education component. Education includes workshops, technical conferences, telephone response to citizen questions, and the development of pamphlets and guidelines for the general public, building owners and managers, and hospital staff. Pamphlets and guidelines include: *A Californian's Guide to Radon, Using Ultraviolet Radiation and Ventilation to Control Tuberculosis, Guidelines for Reduction of Exposure to Volatile Organic Compounds (VOC) in Newly Constructed or Remodeled Office Buildings*, and *Control of Asbestos in Public Buildings*. Because resources don't cover investigative services for individual citizens or building owners and managers, the group has developed an assistance directory which lists the names, addresses, telephone numbers, and IAQ diagnostic and mitigation services offered by private companies in California.

The program coordinates other state IAQ activities through an Interagency Working Group. The group consists of representatives from state and local agencies, private companies, and environmental groups; it meets at least quarterly. State agencies include the Air Resources Board (ARB), the California Energy Commission, CalOSHA (Occupational Safety and Health Administration), the Department of Consumer Affairs, the Office of the State Architect, the Department of Housing and Community Development, the Department of Education, and the Department of General Services. Many of these agencies have minimal IAQ resources.

An exception is the ARB. In 1986, the legislature gave the ARB authority to carry out exposure-assessment research through extramural grants. The ARB was required to assess both indoor and outdoor exposures when estimating the risks posed by pollutants considered under the toxic air contaminants program. Again, no regulatory authority was included. Notable research efforts, often in cooperation with the CIAQP and federal EPA, include: studies to determine what percentage of time Californians spend on various activities in different environments (home, car, work, etc.); and exposure assessments for contaminants such as formaldehyde, volatile organic compounds, small particles, radon, and polynuclear aromatic compounds. For many of the pollutants studied, exposures were found to be much higher indoors than outdoors.

Although the largest programs are those of the DHS and ARB, the other agencies also explore ways to improve IAQ. For example, Cal/OSHA, with technical assistance from CIAQP, has promulgated a Minimum Building Ventilation Standard that assures that ventilation systems are not only correctly designed and installed, but are also properly operated and maintained.

City and county governments play an important role in improving IAQ by adopting and enforcing local building codes, by responding to citizen complaints, and by adopting smoking ordinances. Approximately 300 of 458 cities have significant nonsmoker protection laws. CIAQP carries out research to establish the efficiency of various ETS exposure reduction techniques in office buildings.

The State's Tobacco Control Program, a multimillion dollar effort funded by a 25-cents-per-pack cigarette tax, attempts to protect the public through a strong education campaign on the significant health aspects of "involuntary smoking." Numerous TV, radio, billboard, and newspaper and magazine advertisements inform the general public, particularly parents, of the hazards of ETS. Funds are given to local health departments to help them educate local businesses, youth organizations, and policy makers and to assist them in developing legislation to provide smoke-free environments. Additionally, a competitive grants process funds projects to inform the public of ETS hazards through labor unions, child-care facilities, and health care facilities.

In 1993, Governor Wilson signed an executive order banning smoking in all public buildings. The order was subsequently made into law. A law has also been signed which bans smoking in all licensed child-care facilities.

IAQ in California is also improved through an unlikely mechanism, Proposition 65. Among other features, Prop. 65 declares that people may not be exposed knowingly to significant amounts of a toxic substance without first receiving a warning. This includes exposures from air, water, and consumer products. A unique feature of the law is that any individual or group may inform the appropriate authority (e.g., the Attorney General) of their intention to sue a business that they believe is in violation. If the authority does not prosecute the purported violator within 60 days, the individual or group is allowed to proceed with a suit and, if it is successful, they will retain a portion of the penalty provided by the law.

Proposition 65 declares that people may not be exposed knowingly to significant amounts of a toxic substance without first receiving a warning.

A 1989 consumer product case illustrates how the process works. It involved a product many clerical workers and graphic artists use regularly, namely typing correction fluid. The case was initiated by an environmental group, which claimed various manufacturers were in violation of the adequate warning provision of Prop. 65. The group alleged that the manufacturers' products contained amounts of trichloroethylene (TCE) sufficient to cause significant cancer risk to consumers using the product in a reasonable way. The significant cancer risk level is defined as one excess cancer case per 100,000 people exposed for a lifetime.

Chemical analysis of randomly selected samples purchased from retailers revealed that many of the products did contain TCE in amounts of about 30 to 50 percent by weight. Of course, the question is not what is in the bottle, but what is the consumer's exposure. Prop. 65 simply refers to the "level in question." The California Health and Welfare Agency has interpreted this to mean exposure which is the result of *reasonably* anticipated use at an *average* rate of consumption by the *typical* consumer. Although it can be argued that this is still somewhat vague, it does make it clear that exposure estimates are not to be based on the worst possible scenario.

The anticipated exposure was estimated by simulating the use of these products by a researcher in a simulated office exposure chamber. TCE was measured—using a personal sampler as well as area samplers located in various parts of the room—throughout the day as the researcher used typing correction fluids under typical conditions. For example, it was assumed that a typical use of the product might involve correcting 10 standard type characters at a frequency of one application every two hours during the workday. The measurements indicated a typical office worker would receive an exposure much higher than that which would trigger the significant cancer risk under Prop. 65 guidelines.

The Attorney General decided that this was sufficiently high to proceed with the case. Manufacturers decided to reformulate many of the correction fluids rather than face litigation.

Of necessity, a state IAQ program will be complex and involve many agencies and groups. It is important that one organization be responsible for coordinating the efforts and assuring that important aspects of the problem are not overlooked. In particular, it is critical that IAQ programs vigorously address the ETS problem. An IAQ program that does not make ETS a high priority is failing to address a major public health issue. □

ON THE FASTRACK ® **By Bill Holbrook**

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IAQ: Whose Responsibility?

The problem is not energy conservation

by Hal Levin

A popular myth holds that energy conservation measures, implemented since the oil crises of the 1970s, cause indoor air pollution problems. This myth ignores the fact that most indoor air pollutant sources have little or nothing to do with energy conservation. In at least one study conducted before 1973, the air inside buildings was found to be more polluted than outdoor air even during severe air pollution events. In fact, only two types of conservation measures directly increase indoor air pollutant concentrations: inappropriately reducing ventilation and using sealants and caulks that emit pollutants.

The myth ignores the fundamental responsibility (and ability) of architects, engineers, and building operators to create indoor environments that are both habitable and environmentally responsible. Achieving good indoor air quality (IAQ) is as essential as providing comfortable, healthy thermal conditions and functional, aesthetically sound lighting and acoustical environments.

How Ventilation Affects IAQ

Changes in ventilation rates generally affect IAQ only indirectly. What directly impacts IAQ is the *relationship* between ventilation and pollutant sources. Consider the following three factors.

First, there would be no indoor air contamination if there were no pollutant sources. The sources have changed in number and kind during the past 45 years or so; abundant, harmful pollutant sources have resulted from new building materials, furnishings, equipment, and consumer products.

Second, thermal control has become the dominant driving force in system design. The need to maintain good IAQ by adequate outdoor air exchange has become incidental.

Finally, in the majority of buildings with IAQ problems, ventilation systems do not function as designed. Many of these failures result from problems in operation and maintenance. As many as 75 percent stem from design and construction flaws because designers simply did not place enough emphasis on IAQ.

Thermal Control vs. Air Quality

Historically, ventilation requirements were set to maintain air quality. In the 19th century, before people began to bathe frequently and use personal deodorants, rates were specified to keep human body odor at acceptable levels. Traditionally, architects and engineers designed mechanical or natural building ventilation on the basis of established outside air requirements for assumed occupant loads and activities in the building program.

With the advent of variable air volume systems in the 1950s, thermal control objectives came to drive system design. The shift became more important as buildings became larger. There was more space remote from the envelope, or exterior, of the building and concomitant lost access to daylight and ventilation through windows. This shift has led to the notion that "energy conservation causes indoor air pollution." At most, reduced air exchange to conserve energy exacerbates IAQ problems, but, for the most part, the causes of indoor air pollution are not the direct result of energy conservation.

Determining Loads

Maintaining a healthy, safe, and productive environment requires that ventilation be sufficient to maintain a quality. The amount of ventilation required depends on the occupant density, the types of activities that tal place in the building, and the strengt of pollutant sources (from equipment building materials, and consumer products). Since these factors vary independently, it is difficult to provid universally applicable ventilation rate: The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) sets minimum ventilation values, but these assume r "unusual sources" of indoor pollutant The burden is on designers to determine the nature of pollutant sources and whether they require moı than the recommended minimums.

Sources of Indoor Air Pollutants

There are many sources of pollutants in buildings, and they vary considerably from building to building For that reason, addressing these sources effectively must be part of the design process. Simply following the general guidance for ventilation as a means of controlling pollutants means choosing the default solution; it does not represent the best effort of a good designer.

It is important to understand the relative contributions of various sources and to address the strongest ones. We must go after the ones with the most surface area, the most mass, and the emissions that we know or believe to be most irritating or toxic.

Emissions from new building materials far exceed emissions from aged materials. However, maintenance refinishing, and replacement activities do result in significant increases in

(Levin is a California research architect and editor of Indoor Air Bulletin.)

The fundamental responsibility of architects, engineers, and building operators is to create habitable indoor environments. *Mike Brisson photo*

pollutant emissions. Therefore, the durability of a material impacts IAQ significantly. It is important to note that "wet" products such as paints, adhesives, caulks, cleaners, waxes, and polishes emit very large fractions of their mass into the building air, and usually soon after application. However, even after these products are functionally dry, they continue to emit very slowly for a very long time.

In the past 40 years, building materials have changed in ways that make them stronger sources of indoor air pollutants than "traditional" materials. For example, composite wood products have replaced solid wood materials, bringing binders, adhesives, and other chemical additives indoors. The best-known and perhaps most widely used examples are particleboard, plywood, and other composite wood products based on urea-formaldehyde resins. Fortunately, these resins are being replaced by more stable phenol-formaldehyde resins, and some manufacturers are developing and even marketing products that use no formaldehyde-based resins at all.

New low-emitting adhesives are now available for installing flooring products. Paints that use far less organic solvent are also becoming more common. However, replacing a strong emitter with a nondurable, low-emitting product may result in more maintenance and replacement. This can mean more frequent, short-term emissions. Durability can therefore be a very important determinant of IAQ.

Architects' and Designers' Roles

Architects and designers can substantially reduce indoor air pollution by proactively minimizing undesirable sources. They can limit chemicals with known toxic effects to levels that will not cause adverse reactions. For example, the California Air Resources Board recommends that formaldehyde levels not exceed 50 parts per billion. Since it's known that most particleboard, plywood, hard-board fiberglass insulation batts and boards, some textiles, and many other building products emit formaldehyde, architects and designers must try to limit their quantities, select lower-emitting products, or choose substitute materials. They can calculate emissions from these products based on test data. Knowing ventilation rates, they can estimate formaldehyde concentrations in indoor air and change specifications if necessary.

This approach, although it seems rather unscientific and not very specific, is, in fact, similar to the way we design illumination and acoustic and thermal control. This brings us back to our title topic. We don't say that energy efficiency causes poor lighting or visibility problems in buildings; instead we determine what lighting levels are necessary to perform the task for which the building is designed and built, then we attempt to achieve those levels in an energy-efficient manner. We must recognize the need to apply the same approach to IAQ. □

Lessons From Radon

Consumers need user-friendly information

by Mary Nichols

When I joined EPA a few months ago, I was struck by the impressive public outreach program that the Office of Air and Radiation (OAR) had developed for radon. I believe the radon program has lessons for other complex environmental problems that have no immediate regulatory solution.

Radon is a naturally occurring environmental pollutant that poses unique challenges for those who would foster public awareness and concern. You can not see, taste, or smell radon, and it produces no immediate health symptoms. EPA's challenge is to bring together such diverse professionals as risk communicators, scientists, economists, lawyers, and politicians to forge a common view of the problem.

To meet the difficult challenge radon presented, OAR's Radon Division developed working relationships with national nonprofit groups who share our mission. These groups have well-established communication networks with their memberships for advancing their goals. Such diverse groups as the American Lung Association, the Advertising Council, the National Association of Counties (NACo), the Consumer Federation of America, the National Association of Homebuilders, and the National Safety Council have joined with EPA to reduce radon health risks.

The diverse priorities, purposes, and ideologies of these groups could be seen as a challenge to forward progress; however, EPA saw this diversity not as an obstacle but as an opportunity to enrich the radon program. Great care was taken to build strong relationships based on mutual trust and to discourage potential conflict. A key to success: EPA and its partner groups all share the same mission and are committed to achieving risk reduction. As part of the process, partner groups continue to look to EPA for vision and leadership on how to best get bottom-line results.

Through this alliance, EPA has been able to take advantage of communication channels that it could never replicate on its own. Every group working with EPA disseminates the radon message through its own established channels to reach its constituency. These partners wield authority in their fields and are ideal for addressing the concerns of their audiences. For example, the American Medical Association has its own means of addressing physicians through the *Journal of American Medicine*, AM NEWS, American Medical Television, and continuing education conferences. Similarly, the National Medical Association and the National Coalition of Hispanic Health Services Organization use newsletters, conventions, special publications, and community outreach to bring the message to African-American and Hispanic communities less likely to hear about radon through the mainstream media.

(Nichols is EPA's Assistant Administrator for Air and Radiation.)

Cooperating groups can influence state or local public policy on radon risk reduction or can convince individual homeowners to test and repair. For instance, NACo sends the message to local government officials that they should be aware of radon so as to help protect public health and forestall costly and difficult mandates. NACo's communication channels include newsletters, workshops, grant programs, public service announcements, and national conferences. The association has developed a Radon Advisory Committee to tap into their extensive membership network of more than 12,000 county officials in very diverse communities across the country. In turn, these officials can use their strong ties with local community programs and networks to reach millions of county citizens. One of the big benefits of working with these organizations is their ability to target high-risk populations and areas at the local level.

Despite the difficulties inherent in communicating the radon issue, substantial accomplishments have been made. Kentucky's public health clinics are a shining example of how one simple change can be leveraged into significant gains. Viola Brown, chief state nurse, amended the state's medical history forms to include a question about whether patients had tested their homes for radon. If not, a public health nurse would then explain radon risks and present a brochure on how to test a home cheaply and quickly for radon. With one simple change in a form, some 70,000 Kentucky citizens are now being reached every year.

Each partner, often an influential leader in the community, knows the best way to reach local individuals. Homeowners who might ignore a message from the federal government will receive reminders from a partner organization or from other sources—a nurse or doctor, a builder, home inspector, realtor, county or city government, teacher, or the media. This process of repeating and reinforcing a message has been used effectively by other public health programs, like smoking cessation, seat-belt use, and promotion of smoke detectors.

EPA has also benefitted from partnerships with the business community. One of the first was with the Advertising Council, a group that acts as a conduit to bring Madison Avenue talent together to create public service campaigns.

Radon public service announcements have been produced for use in television, radio, print, and direct mail campaigns. The estimated value of media air time and print placement donated to carry the radon message now tops $100 million, according to Ad Council figures. Another program, created by the Ad Council and sponsored by the National Safety Council, uses direct marketing techniques to offer consumers discounted radon testing services, then evaluates consumers' response to varied radon messages.

The Results

Organizing diverse national, state, and local interests in a voluntary program to meet an invisible public health threat is not an easy way to approach environmental problems, but the results are gratifying.

In the six years of the program, EPA estimates that more than nine million homes have been tested for radon and three hundred thousand have been mitigated. Grassroots awareness and support have produced real estate radon disclosure laws in nine states, and the real estate industry has voluntarily adopted disclosure policies in other areas of the country. The relocation industry regularly requires a radon test and remediation (if necessary) as a condition of property transfer. Based on discussions with states and on EPA's national school survey, it is estimated that about 20 percent of U.S. schools have been tested for radon.

Increasingly, Americans are realizing that their behavior as consumers has a direct impact on their health and environment, and they are seeking user friendly information to help them act. Governments, in turn, are facing up to the political and financial costs of mandating and enforcing citizen behavior and are searching for innovative nonregulatory tools. The lessons gleaned from our success with radon point to an important untapped resource in reaching national environmental goals within the confines of today's resource realities. □

The View From Congress

We can no longer overlook the indoors

by Representative Henry A. Waxman

Today's growing awareness of indoor environmental hazards reminds me of an old Liza Minnelli song—the one about Shirley Devore, who "travelled 'round the world to meet the guy next door."

Since the first Earth Day over 20 years ago, the environmental movement has been fighting problems caused by industrial pollution, like acid rain, polluted rivers, and toxic waste dumps. These battles have produced landmark laws, like the Clean Air Act and the Clean Water Act, from which the public has benefitted immeasurably.

But like Shirley Devore discovering the guy next door, many experts are now realizing that some of the greatest environmental threats to health are those closest to home. The new frontier for EPA has become the great indoors.

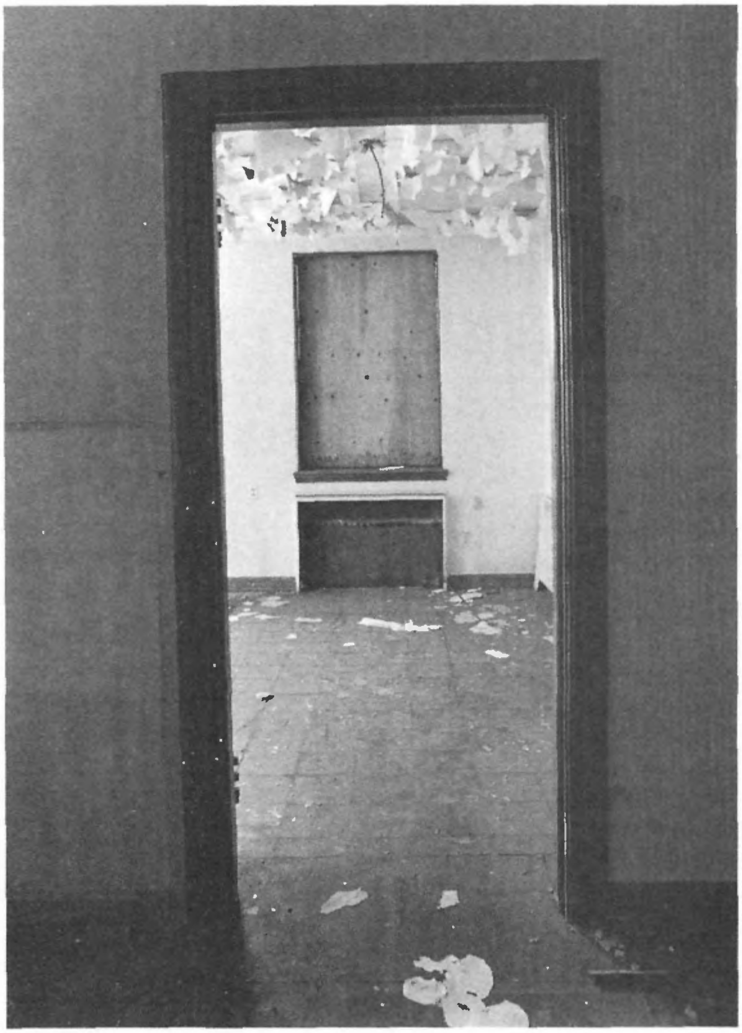
Indoor pollution problems are serious and widespread. According to the Centers for Disease Control (CDC), the most common and societally devastating environmental disease of young children, lead poisoning, is caused by hazards hidden inside millions of American homes—deteriorating lead paint, high levels of lead in household dust and soil, and contaminated drinking water. As many as three million children—one out of every six—have enough lead in their blood from these sources to cause subtle brain damage, including a loss of IQ.

Another indoor environmental threat—exposure to secondhand tobacco smoke—is the third leading cause of premature death in the United States, killing over 50,000 Americans each year, according to the Surgeon General. Secondhand smoke is also a severe threat to children, causing hundreds of thousands of cases of bronchitis and pneumonia each year. Up to a million asthmatic children suffer attacks when exposed to tobacco smoke; many cannot lead normal lives because of the risks of encountering tobacco smoke in public places.

One of these asthmatic children, nine-year-old Michelle Dart, told my subcommittee earlier this year what exposure to secondhand smoke means to her: "I get dizzy, I start to sneeze, I can't breathe very well, and sometimes . . . I get too much smoke in my lungs and go into the hospital." No air pollutant—especially one that is so easily prevented—should ever be allowed to cause so much harm to an innocent child.

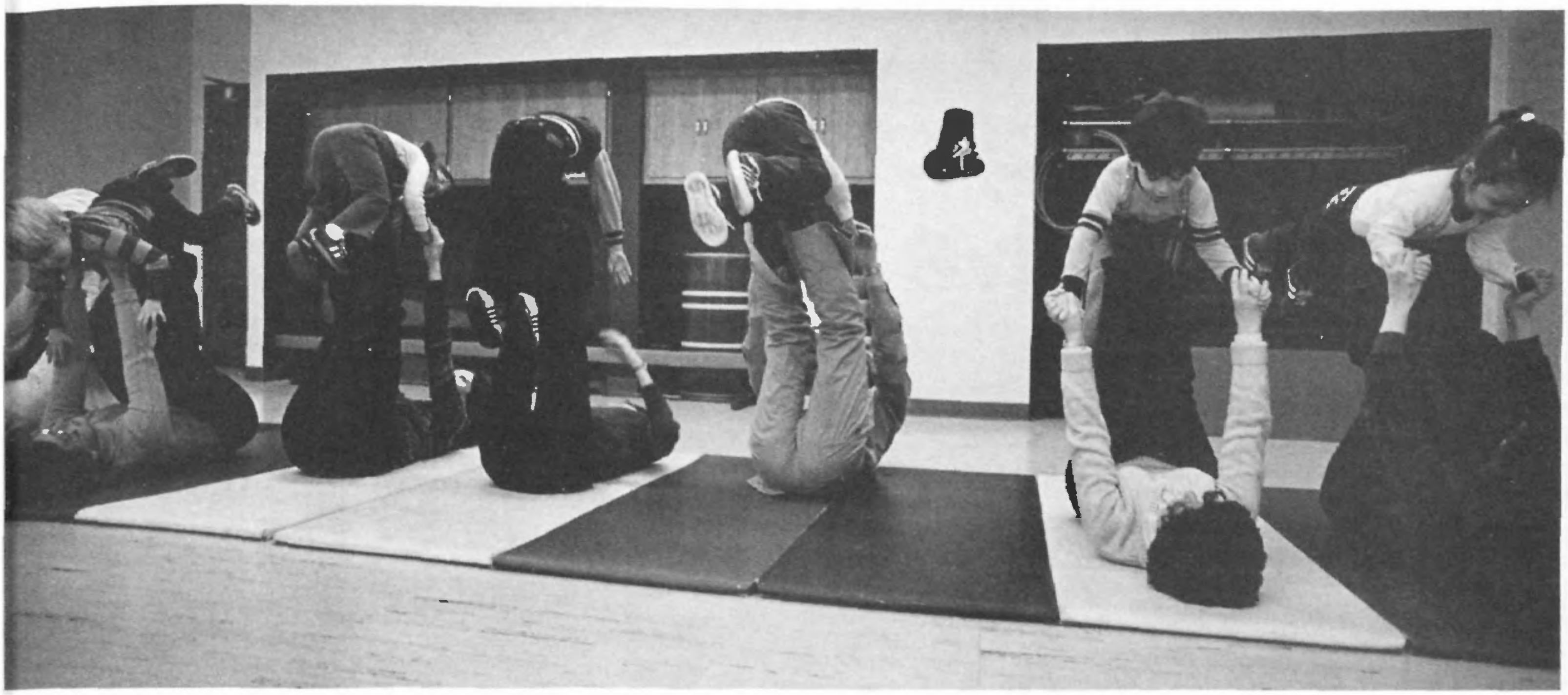
A third indoor pollutant, radon gas, which seeps into homes from soil, is the second leading cause of lung cancer in the United States. According to EPA and CDC, it causes 14,000 lung cancer deaths each year—more deaths than drowning, fires, and airline crashes combined.

(Representative Waxman (D-California) chairs the House Subcommittee on Health and the Environment.)



Peeling paint. Under the Lead Hazard Reduction Act, realtors and landlords will have to provide information on lead hazards before they sell or rent homes.

Mike Brisson photo



Children are especially susceptible to environmental hazards. The author believes Congress should enact legislation to improve the indoor environments of schools and day care centers. *Mike Brisson photo*

An important precedent was set in 1992, when Congress enacted the Lead Hazard Reduction Act, one of its first substantive efforts to address an indoor environmental threat. Under this law, EPA is expected to issue a regulation by October 1995, requiring realtors and landlords to provide home buyers and renters with information on lead hazards before they move into a home; the parties involved must sign disclosure forms acknowledging awareness of any lead hazards; and home buyers will be allowed a 10-day inspection period. Moreover, home-remodeling contractors and the burgeoning lead abatement industry will be licensed and regulated to prevent the creation of new lead hazards and insure the proper cleanup of old ones.

This year, Congress has accelerated its efforts to safeguard the indoor environment, with three major pieces of legislation pending in the House. Under Administrator Carol Browner, EPA has become a full partner—indeed, often a leader—in these efforts.

The first bill, the Smoke-Free Environment Act of 1993, would guarantee all Americans a smoke-free environment by prohibiting smoking in buildings accessible to the public, except in designated, separately ventilated smoking rooms.

This is an opportunity we cannot afford to miss. For virtually no cost, the bill would save tens of thousands of lives and protect hundreds of thousands of children each year, not to mention the building fires and maintenance costs, which would be reduced. By providing nationwide protection, the bill would eliminate countless battles for smoking restrictions at the local level.

The second bill, the Radon Awareness and Disclosure Act of 1993, introduced by Representative Ed Markey (D-Massachusetts), applies ideas embodied in the 1992 Lead Hazard Reduction Act to reduce radon risks. Under its market-based approach, home buyers would be fully informed of the risks of radon and have an opportunity to conduct an inspection before signing a contract. This approach has achieved considerable consensus, being supported by the Consumers Federation of America, the National Association of Realtors, and the National Association of Home Builders.

The third bill, the Indoor Air Act of 1993, introduced by Representative Joe Kennedy (D-Massachusetts), establishes a national framework for addressing indoor air problems other than secondhand smoke and radon. It calls upon EPA to identify common indoor air hazards—levels of individual pollutants or faulty ventilation systems—then issue guidelines for identifying, eliminating, and preventing them. If the voluntary guidelines do not succeed in protecting the public, EPA would have the authority to take appropriate regulatory action. For the third Congress in a row, Senator George Mitchell's (D-Maine) indoor air bill has passed the Senate. The Kennedy bill finally provides a viable legislative vehicle for House action.

Beyond these important measures, Congress should also enact comprehensive legislation to improve indoor environments in schools and day care centers. Children are especially susceptible to environmental hazards, and recent hearings of my subcommittee have found that many schools and day care centers harbor hidden environmental hazards. In New York City, for instance, thousands of classrooms—nearly one out of every four—has a lead hazard. Nationwide, one out of every five schools has at least one classroom with an elevated radon level.

For too long, federal environmental policy has overlooked the environmental hazards lurking in our homes, schools, and offices. For the sake of the millions of Americans afflicted by these contaminants, now is the time for a change. □

Simulating a Radioactive Release

by Brad Nelson

From the safety of a hotel conference room, officials play out a scenario

An insistent beeping pierced the sleep of the off-duty EPA Radiological Response Coordinator. The SkyPager on the table across the room displayed the phone number for the National Response Center. It was 4:00 a.m. in Washington, DC. The center always waits for the work day to begin before making routine notifications, so this had to be an emergency. The coordinator, groggy with sleep, stumbled in the dark to the telephone and dialed the center's number.

The National Response Center, located at Coast Guard Headquarters in Washington, is staffed 24 hours a day, seven days a week. The senior officer on watch took the coordinator's call and relayed the news: The Emergency Preparedness Directorate of the neighboring country to the north had just reported an incident at the Boom Nuclear Power Station (NPS). A major radiological release was probable. The power station was just across the international border from the U.S. town of "Spaburg" (see map). The coordinator took down all the information the center had, requested that the officer follow up his oral report with a fax, and hung up.

This was big. At worst, thousands of people would have to be evacuated on both sides of the border to prevent them from receiving hazardous doses of radiation. At best, it was still an international incident that would be all over the news in a few hours.

The coordinator called the Emergency Preparedness Directorate across the border to confirm the report and get additional details. As it happened, a fire in a switchboard at Boom NPS had caused the loss of several power supplies, leading to emergency shutdown of the reactor. There was a loss of primary coolant, with an increasing radioactive contamination level in the containment structure. Boom officials had informed authorities that, in the worst case, the uncovering of radioactive fuel could occur in about five hours—around 9:00 a.m. The containment was designed to hold contamination during just such an accident. However, to be safe, government authorities had based their assessment of the offsite consequences on containment failure.

The coordinator next called the head of the radiation control program in the U.S. state nearest the accident to confirm that state personnel had been notified of the incident by their neighboring province. They had.

Then, since under the Federal Radiological Emergency Response Plan EPA is the lead federal agency for foreign radiological emergencies which could affect the United States, it was time to take charge, get the word out, and prepare for the worst. As the lead agency, EPA would handle all technical details, including monitoring and recommending public actions, whereas the Federal Emergency Management Agency would handle all administrative matters.

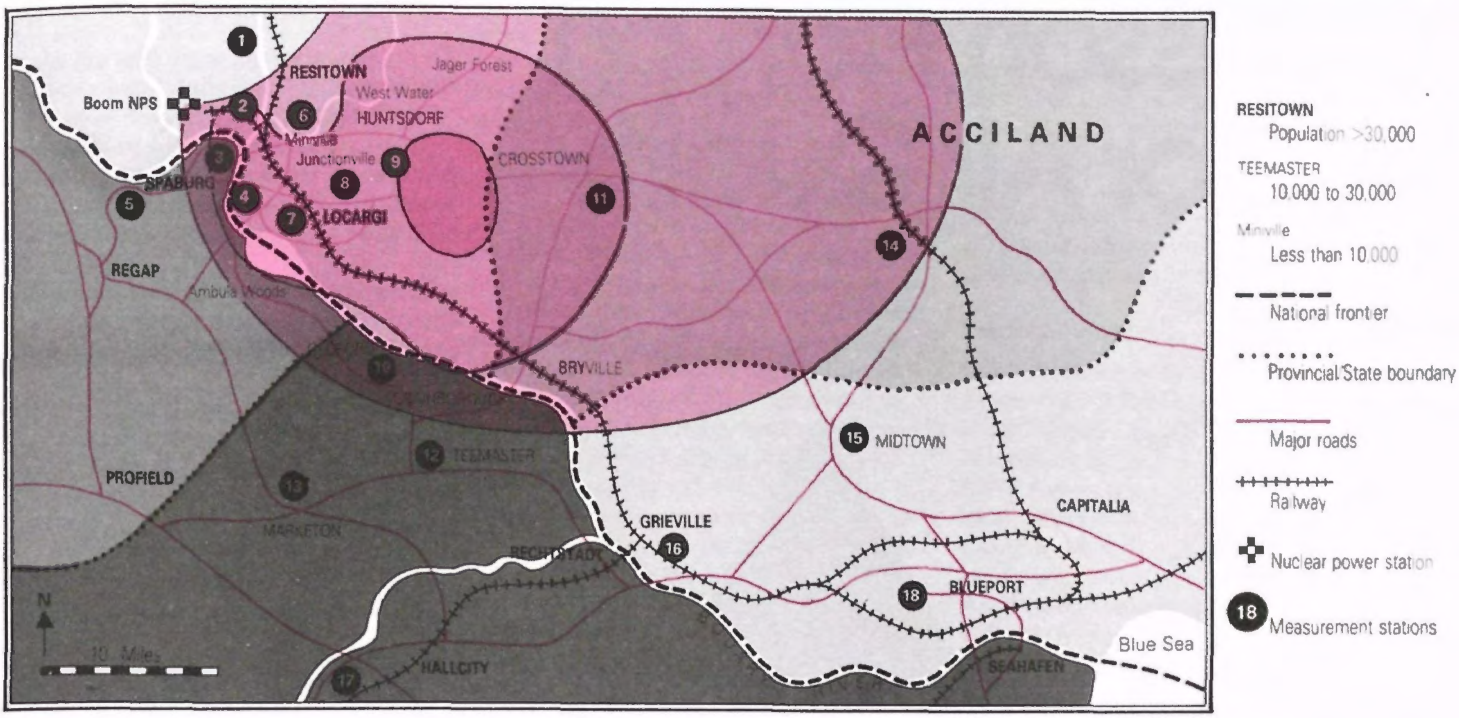
The coordinator phoned his superiors to describe the situation; Administrator Browner would inform the President. Calls to the Nuclear Regulatory Commission (NRC) Operations Center and the State Department revealed that they had already learned of the incident.

The Chemical Emergency Preparedness and Prevention Office (CEPPO) activated the EPA Emergency Operations Center and assigned staff to continue the notifications to other EPA offices and other federal agencies. The coordinator jumped into some clothes, grabbed a couple of bagels, and headed for the EPA center, located in the basement of EPA Headquarters at Waterside Mall.

Calls to the regional radiation program manager and to the state radiation program manager revealed that the state was planning a preemptive evacuation of Spaburg because of deteriorating conditions at the power plant. If officials waited until they were absolutely sure a release would occur, there wouldn't be time to move people. The state was doing the right thing, according to guidance published by EPA, so the coordinator agreed with the evacuation decision. However, the neighboring foreign province was keeping its citizens at home until officials were sure of the release. That was going to be tough to explain to the public; they all watched the same TV channels and listened to the same radio stations.

The director of EPA's Office of Radiation and Indoor Air (ORIA) arrived at the Emergency Operations Center just as CNN was breaking the story. After being briefed by the coordinator, she called Administrator Browner to report the latest developments and to lay out ORIA's response strategy, which was to activate the Federal Radiological Emergency Response Plan and establish a Federal Joint Information Center. EPA would then work with the Department of Energy to airlift the Federal Radiological Monitoring and Assessment Center's staff and equipment to the scene to monitor the anticipated plume.

(Nelson is a Nuclear Engineer for EPA's Emergency Response Section, Office of Radiation and Indoor Air.)



Meanwhile, additional emergency response staff from ORIA and from CEPPO reported to the emergency operations center. They exchanged information and made arrangements for the monitoring teams. Their faces became sober as they monitored the incident, gave advice to the state, and directed the response to an event which might seriously impact the United States but which they could not control. They worked together with their counterparts across the border, drawing upon relationships and knowledge gained from training exercises they had hoped they would never have to use. The wall clock unreeled the hours as if driven by a falling weight.

At noon, EPA was informed that the Boom Station's containment had failed, and a significant radioactive release had begun. However, the release was smaller than worst-case predictions. At 1:30 p.m., word came that nuclear fuel cooling had been restored and the containment leak identified. By 2:00 p.m., containment integrity was reported restored.

By 4:00 p.m., the invisible radioactive plume from the release was already beginning to fall out and dissipate. That was the worst of it. The Department of Energy had a plane tracking the cloud and sending data to a computer at a ground location out of the plume pathway. At the request of the neighboring country, the plane, like the plume it was tracking, was ignoring the international boundary. In a couple of hours, the computer would print a dose-contour map that combined the aerial survey results with Global Information System data already in its memory.

The survey indicated that the release was not as extensive as projected. That was not unusual. Predicting within a factor of 10 was considered a success. Further, it was better to err on the side of caution. It was easier for the Governor to tell citizens that their 100 mile round trip in the family car wasn't necessary than to tell them that their children's lifetime cancer risk was now higher than it was 24 hours ago.

During the next few days, monitoring teams on the ground took surveys and analyzed samples to verify the results of the aerial survey. They also measured concentrations of specific isotopes in the soil, in drinking water supplies, and in livestock forage. Emergency workers, public health officials, and agriculture experts on both sides of the border worked to analyze the growing mass of data and to make sense of it to the public.

Most of the people who had been evacuated were given permission to return to their homes. However, those who lived within a two-mile radius of Boom NPS would not be allowed to return right away, nor would those in a similar area 15 miles away where precipitation had occurred and the plume had been "rained out" onto the ground.

The above scenario was played out in a hotel conference room by representatives from EPA and other federal agencies, Canada, the State of New York, the Nuclear Regulatory Commission, and the departments of State, Energy, Agriculture, and Health and Human Services. The intense day-long session was conducted by ORIA last May. It was one of more than a dozen identical exercises conducted this past spring by Nuclear Energy Agency (NEA) member countries to increase their preparedness and to identify deficiencies in international radiological emergency response. The players concentrated on notification and communication, protective actions for people, safeguards for food and agriculture, and international assistance.

A follow-up meeting to present the results of all NEA exercises was held in Paris in June 1993. Of particular interest to other countries was the unique participation by the United States and Canada in each other's exercises. To maintain the readiness of governments to respond to such disasters, another exercise is recommended two years hence. □

A Lesson Plan on Indoor Air Quality

by Stephen Tchudi

To the Teacher: Discussing indoor air quality (IAQ) is as relevant to our lives as our next breath. The difficulty in studying it comes from the fact that much indoor air pollution is invisible, *a point made in several of the classroom activities that follow. However, a great deal of scientific information is available on visible and invisible indoor air pollution, not only in this issue of* EPA Journal, *but through myriad leaflets, brochures, and pamphlets provided by government and public-service agencies. To prepare for this unit, have students write in* advance *for information from the agencies listed at the close of this article. In addition, contact (or have your students call) your city, county, or state public-health agencies as well as hospitals and university extension services in your region and ask for available materials on IAQ. As the literature flows into your classroom, you might have individuals read up on one topic or another*—e.g., passive smoking, radon, asbestos, ventilation—*thus becoming the class expert. Or you might simply store the materials and, after the opening exercise below, pass out the literature and invite the students to delve into the reading to accompany your choice of the following activities.*

(Tchudi is Professor of English at the University of Nevada, Reno, and has a long standing interest in interdisciplinary and environmental education.)

Beginning the Unit

Read or paraphrase the following script aloud and have the students do some "deep breathing" exercises.

"Take a deep breath and hold it. Did you know that when you breathe in, your lungs take in billions upon billions of air molecules? Now breathe out!

"Breathe in. Did know that along with air, each lungful you inhale can contain hundreds of pollutants? Breathe out.

"Breathe in some air. It may contain cigarette smoke, tiny airborne insects, dust, carbon monoxide, viruses and bacteria, fungi, and chemical fumes. Breathe out.

"Breathe in. Did you know that evidence of smoky, bad air has been found in the mummified lungs of people who lived hundreds, even thousands of years ago? Breathe out.

"Breathe in. Did you realize that in our time, there are more harmful pollutants in the air than ever before—chemical, biological pollutants, things that cause allergic reactions, poisons? Breathe out.

"Now can anybody tell me why it might be important for us to study Indoor Air Quality—or what we call IAQ?"

[At this point, present an overview of the different kinds of IAQ topics that students might study. You can use this issue of *EPA Journal* as a guide. Also especially helpful is EPA's *Introduction to Indoor Air Quality: A Self-paced Learning Module* (see *Places to Write.*) This would also be a good time to show *Air Pollution: Indoors.* (*See Videos.*)]

• *It's in the Air.* To help the students get a sense of the visible pollutants in the air, try this experiment adapted from Julianne Bochinshki's *Complete Handbook of Science Fair Projects* (New York: John Wiley, 1991). Draw a two-inch circle on each of a dozen or so blank index cards; then spread a thin layer of petroleum jelly in each circle. Next, place the index cards at various places around the classroom and/or the school where they will not be disturbed: on the teacher's desk, near a window that is opened regularly, near a heat register or vent. Write the location on the card. After 24 and 48 hours, have the students look at the sticky circle with a magnifying glass and discuss what kind of stuff has accumulated. Point out to the students that (1) this is only a measure of visible pollutants, and (2) their very own breathing passages and lungs, which have mucous linings, can collect visible pollutants in much the same way.

• *The Smoking Debate.* Have students collect and analyze advertisements from tobacco companies. First, have them study the warning labels of cigarette advertising: What sorts of illnesses are discussed in the Surgeon General's warnings? Second, to get another side of the story, have your students write to various tobacco companies (their addresses can be found in the advertisements) asking for their side of the active and passive smoke inhalation debate. Students can compare and contrast the companies' literature with that supplied by EPA, the Surgeon General, and groups like the American Lung Association. For additional information, students might contact city agencies and/or restaurateurs to get their points of view. Finally, have the students stage a debate on the IAQ aspects of smoking. Should smoking be banned in all public places? In some? In none?

• *Radon Detection.* Through the yellow pages, locate a firm that specializes in radon detection and/or the commercial reduction of radon rates. Or call your local health agencies to find someone who is a specialist in this area. Invite a speaker to the class to explain what radon is, what it does, how it can be detected, how it can be eliminated. (See also the useful video on this topic, listed under *Videos*.) On the basis of the presentation, have your students develop leaflets or fliers or simply a letter to the adults at home summarizing their knowledge and advising how best to deal with radon.

• *The Story of a Flame.* Light a household candle and have a student hold a light-colored ceramic plate about six inches above the flame. Then have the students take a peek at the visible pollutants collecting on the bottom of the plate. Extinguish the flame and quickly place a match about two inches above the wick in the rising plume of smoke; students will see the flame travel down the unburned particulates of the smoke to relight the candle. Use these demonstrations as a jumping off point for a discussion of indoor pollution created by appliances that use flames from gas, kerosene, or wood products: stoves, furnaces, water heaters, fireplaces, charcoal grills. Remind them that although flames in appliances often burn more cleanly than a candle, each of these is producing various invisible byproducts of combustion. Gather instructions and operating manuals from flame appliances (those leaflets you stuffed away in a drawer or put on a shelf near the furnace) and discuss the consumer advice that is given there. End this lesson with a detailed discussion of the need for proper ventilation and use of flame-powered appliances.

• *Protection Masks.* Have student volunteers go to a hardware store and study the instructions and fine print on air filters, face masks, and respirators. What protection does a breathing mask or filter offer a user? Is it a good idea to use one while, say, sanding down a floor or jogging on a smoggy or cold day? What myths and facts can the kids learn about respirators? How often should a furnace air filter be replaced? (As a shocker, bring in a used furnace air filter, especially if, like most of us, you don't change the filter at the recommended intervals.) As a follow-up, students might put in a call to the fire department to learn about how fire fighters protect themselves from both visible and invisible pollutants at a fire or accident scene.

• *Under the Rug.* Students may be surprised to learn that new carpeting is a source of pollutants, both from the chemicals used in the creation of most carpets and from the adhesives that are frequently used to hold the carpeting in place. A visit to a carpet store can help students learn about a new consumer information label being placed on carpets concerning IAQ.

Places to Write

U.S. Environmental Protection Agency, IAQ INFO, P.O. Box 37133, Washington, DC 20013-7133. Telephone 800-438-4318; **American Lung Association** (write or phone your local office); **Centers for Disease Control**, Mail Stop K-50, 4770 Buford Highway, Atlanta, GA 30341; **Gas Appliance Manufacturers Association**, 1901 N. Moore Street, Suite 1100, Arlington, VA 22209; **National Cancer Institute**, Building 31, Room 10A24, Bethesda, MD 20892; **National Heart, Lung, and Blood Institute**, Information Center, 4733 Bethesda Avenue, Suite 530, Bethesda, MD 20814; **National Institute for Occupational Safety and Health**, 4676 Columbia Parkway, Cincinnati, OH 45226-1998; **National Kerosene Heater Association**, 3100 West End Avenue, Suite 250, Nashville, TN 37203; **U.S. Consumer Product Safety Commission**, Washington, DC. 20207; **Wood Heating Alliance**, 1101 Connecticut Avenue, N.W., Suite 700, Washington, DC. 20036.

Videos

Air Pollution: Indoors; Radon. Princeton, NJ: Films for the Humanities, 1988. □

CHRONICLE

Legendary Pest Remedies

Miss Muffet should have asked her father

by Christine L. Gillis

Little Miss Muffet sat on a tuffet eating her curds and whey. There came a big spider who sat down beside her and frightened Miss Muffet away.

—17th century nursery rhyme

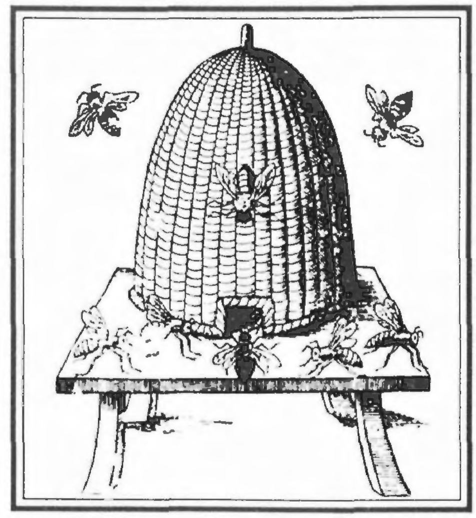
Legend has it that little Miss Muffet was the daughter of a real-life entomologist and "doctor in physick," one Thomas Muffet (alias Mouffet or Moffet), who may himself have been the author of the nursery rhyme. In any case, Thomas Muffet is better known in history for having published, in 1658, the first English work of entomology. The work is entitled *The Theatre Of Insects: Or, Lesser Living Creatures. As Bees, Flies, Caterpillars, Spiders, Worms, & C. A Most Elaborate Work* (1028 pp.), and it proffers a host of "remedies" for getting rid of unwanted spiders and the like. Clearly, pest control has been an issue over the centuries.

So what were some of the pest remedies recommended by the good Doctor Muffet? Dr. Muffet notes that "for as Virgil hath it in his Georgicks: The weevil spoils a mighty heap of corn." Thus, for weevil infestations in corn, the prescription is as follows: "Against Weevils, that are a certain plague to Corn, it is good to dawb the walls [husks] with lime and hair both within and without." Alternatively, the weevils might be persuaded to leave if you "sprinkle on salt water where Garlick hath been infused, or Hops, Elder-leaves, worm-wood, Rue, Nigella feed, wilde mints, Walnut leaves, Savoury, Lavender, Southern-wood, Flea-wort, Bean trifoly, boyld [boiled] in vinegar of squills."

To control nematodes in fig orchards, Dr. Muffet suggests "ashes laid to fig trees, drive away worms, for it hath the force of salt, though not so strong." With remedies such as "pouring often upon the roots, Bulls gall, and lees of Oyl...," says the doctor, "Peaches, Pomegranates, Quinces, Pears, Apples, Olives, and Okes, and other trees are kept sound a long time, and almost free from worms." Problems with spiders? The good Dr. Muffet dedicates several chapters to getting rid of arachnids.

By the 18th century, according to James Whorton, author of *Before Silent Spring: Pesticides & Public Health in Pre-DDT America* (1974), "there had accumulated a veritable 'pharmacopoeia' of insect remedies that leaned quite heavily on herbal and animal preparations similar to those which dominated the official lists of drugs for human illnesses." Organic insecticidal preparations such as ground tobacco, the Pyrethrum flower, and organic plant materials containing rotenone continued to be widely used in the 19th century. (In the last decade of the 20th century, Pyrethrum-based and rotenone-based insecticides are still widely used—for example, in pet sprays, industrial sanitation sprays, and products to protect stored foods in warehouses.)

Most popular in the mid-19th century were inorganic pesticides such as the so-called Paris Green and London Purple products, both of which belong to a group of compounds called arsenicals. The story goes that the insecticidal properties of Paris Green (composed of copper acetoarsenite) were discovered by a farmer who, after painting his window shutters with the green paint, discarded the remaining paint by throwing it over his beetle-infested potato plants. Whorton also notes that Paris Green's rival, London Purple, was a byproduct of the aniline dye industry, and was composed largely of calcium arsenite. For years it had been dumped at sea (another story) because of its toxicity and presumed uselessness until the dye producer began shipping packages of London Purple to American agriculturalists for testing as an insecticide.



LONDON, Printed by E.C. 1658

The release of DDT during World War II heralded the era of synthetic pesticides. DDT gained popularity as a pesticide for controlling insects on a variety of crops, including cotton, peanuts, and soybeans, among others. But by 1962, due in part to the publication of Rachel Carson's book, *Silent Spring*, DDT became a widely publicized topic of concern over its adverse environmental side effects. In 1972, all of DDT's domestic uses, except for public health and quarantine, were canceled based on studies confirming its deleterious effects on the environment.

With the advent of DDT and the post-World-War II era of chemical pesticides, many organic remedies such as Dr. Muffet's prescriptions fell out of fashion. Now, half a century later, there is a groundswell of interest in reducing overall use of chemical pesticides. The current administration is developing a comprehensive regulatory and nonregulatory strategy designed to reduce pesticide use by discouraging the use of higher risk products and encouraging alternative methods of pest management, such as Integrated Pest Management and Sustainable Agriculture, including biological and cultural systems. Who knows? Maybe some of Doctor Muffet's remedies deserve reconsideration. □

(Gillis is an Assistant Editor of EPA Journal *on detail from the Office of Pesticide Programs.)*

ON THE MOVE

Michael Vandenbergh

William Finister

Jean Nelson

Mary Nichols

Lynn Goldman

Michael Vandenbergh is EPA's new Chief of Staff. He advises the Administrator on policy and budgetary matters and serves as White House liaison for policy matters. Vandenbergh joined EPA as a Special Assistant to the Administrator in January 1993 and also served as Associate Deputy Administrator prior to this appointment.

Vandenbergh is an environmental attorney who has worked for two private firms in Washington, DC, Latham & Watkins and Hogan & Hartson, and for the National Wildlife Federation. Prior to joining EPA, he was the North Carolina Field Director for the Clinton/Gore campaign and Associate Counsel to the Presidential Transition.

Vandenbergh graduated from the University of North Carolina at Chapel Hill with a B.A. in zoology in 1983 and from the University of Virginia School of Law in 1987, where he was the Editor-in-Chief of the *Virginia Law Review.*

William Finister has been appointed Deputy Chief of Staff. He brings to the position extensive experience in administrative management, human resources, budget, and policy development and implementation.

Finister joined EPA in 1983 and since then has served in several positions in the Office of Administration and Resources Management (OARM). From 1987 until his present appointment, he was Deputy Director of the Office of Administration. Previously, he was Director of the Facilities Management and Services Division (1985-1987), Director of the OARM Program Operations Support Staff (1983-1985), and Special Assistant to OARM's Deputy Assistant Administrator (1983).

From 1970 to 1983, Finister was a field representative at the Office of Management and Budget, working with state and local officials to resolve intergovernmental issues. During this period, he also served as the Assistant Director for Administration and Management for the Council on Wage and Price Stability.

Earlier experience includes work for the Office of Economic Opportunity and for VISTA. Finister served as a Peace Corps volunteer in the Philippines (1961-1963).

He holds a B.S. in Education from Duquesne University (1958) and did graduate work at the University of San Francisco.

Jean Nelson, EPA's new General Counsel, comes to EPA with extensive experience in administrative law, general business litigation, and government, as well as in environmental issues.

From 1989 until 1993, Nelson was Chief Deputy Attorney General for the Tennessee Attorney General. There she managed an office of 200 people (110 lawyers), supervised legal work on specific major actions of the office, initiated changes within the office for more effective execution of priorities, and managed tight budgets and reorganizations within the office. She also worked with the Attorney General in establishing legal policy for the state and as liaison between the Attorney General's Office and all parts of the Tennessee state government. During her tenure as Chief Deputy, she was a leader in the National Association of Attorneys General.

From 1979 to 1988, Nelson was a partner at the law firm of Gullett, Sanford, Robinson and Martin in Nashville, Tennessee, and an associate from 1975 to 1979. During that time, she held leadership positions in state and local Bar activities and numerous other community organizations.

Her interest in the environment led her to serve as member of the Executive Committee, Southern Environmental Law Center; Chair of the Greenways Commission for Metropolitan Nashville and Davidson County; Board member of the Tennessee Environmental Council; and President of the Environmental Action Fund.

Nelson was Chief of Staff for Tipper Gore in the 1992 presidential campaign. During the 1988 Gore-for-President campaign, she served as Tennessee Campaign Manager and as delegate to the Democratic convention.

She received a B.A. (1969) and a J.D. (1975) from Vanderbilt University.

Mary Nichols has been confirmed as Assistant Administrator for Air and Radiation. She brings to the Agency extensive experience in environmental law and policy and public administration.

From 1989 to 1993, Nichols served as Senior Staff Attorney and Director of the Los Angeles office of the Natural Resources Defense Council. Previously, as one of California's first environmental lawyers, she brought some of the first test cases under the federal Clean Air Act and California air quality laws while a staff attorney for the Center for Law in the Public Interest.

From 1979 to 1982, under Governor Edmund G. Brown, she chaired the California Air Resources Board, which sets air quality and automotive standards. In that capacity, she sponsored some of the original research on economic incentives for emissions control. In California, she also acted as Secretary for Environmental Affairs, the cabinet-level agency responsible for air, water, and solid waste management. Her public service experience includes being Commissioner for the Los Angeles City Recreation and Parks (1984 to 1990) and the city's Department of Water and Power (1990 to 1992).

Nichols, who has written and taught widely on environmental and legal issues, received a B.A. degree from Cornell University in 1966 and a J.D. degree from Yale Law School in 1971.

Lynn Goldman is EPA's new Assistant Administrator for Prevention, Pesticides, and Toxic Substances.

A pediatrician and epidemiologist, Dr. Goldman previously served in California's Department of Health Services as Acting Chief of the Division of Environmental and Occupational Disease Control. There she was responsible for environmental investigations, occupational health, childhood lead-poisoning prevention, and birth defects monitoring. She has written and published extensively in these areas.

Goldman, a fellow of the American Academy of Pediatrics, is a member of its Environmental Health Committee. Prior to joining EPA, she was a member of the National Research Council's Water Science and Technology Board and its Committee on Environmental Epidemiology. In addition, she served as a member of the U.S. Centers for Disease Control Advisory Committee on Childhood Lead Poisoning Prevention.

Goldman received a B.A. in Conservation of Natural Resources in 1976 and an M.S. in Health

Robert Perciasepe

Elliott P. Laws

Jonathan Cannon

Denise Graveline

and Medical Sciences in 1979 from the University of California, Berkeley. She also holds an M.P.H. from John Hopkins (1981) and an M.D from the University of California, San Francisco (1981).

Robert Perciasepe, EPA's new Assistant Administrator for the Office of Water, is responsible for the national water quality management program.

The program includes water quality criteria and standards; drinking water criteria and standards; National Pollution Discharge Elimination Systems (NPDES) permits for point sources of water pollution; stormwater sources; and the polluted runoff (nonpoint source) control program.

In addition, Perciasepe is in charge of linking ecosystem management with water quality programs; the State Revolving Fund program for constructing municipal wastewater treatment plants; and working with the U.S. Army Corps of Engineers for wetlands regulation and disposal of dredged material.

Before joining the Agency, Perciasepe was Secretary of Maryland's Department of Environment (MDE) from 1991 to 1993, directing pollution control and environmental protection for the state. Prior to that, he served as MDE's Deputy and Assistant Secretary for Planning and Capital Programs. Previously, he was Assistant Director of Planning for the City of Baltimore, covering capital budget, infrastructure, and environmental issues. Perciasepe also worked with county and regional planning agencies in New York and at the State University of New York.

He received his B.S. in environmental sciences from Cornell University in 1974 and a master's degree in planning from the Maxwell School of Citizenship and Public Affairs at Syracuse University in 1976.

Elliott P. Laws has been appointed Assistant Administrator for Solid Waste and Emergency Response.

Prior to his appointment at the Agency, he was a partner specializing in environmental law and legislation and municipal representation at the law firm of Patton, Boggs & Blow. There he focused primarily on CERCLA, air, water, and recycling issues.

Before joining Patton, Boggs & Blow, Laws was a trial attorney in the Environmental Defense Section at the U.S. Department of Justice. There he conducted litigation primarily on behalf of EPA but also for other federal agencies, including the Departments of the Army and the Air Force. His representation of EPA involved both District Court and Court of Appeals litigation under Superfund, the Clean Water Act, and other environmental statutes.

From 1984 to 1985, Laws was an enforcement attorney with EPA's Water Enforcement Division.

Laws has been Co-Chair of the Environmental Committee of the Bar Association of the District of Columbia (1991 to 1993) and is co-author of several articles and books on environmental issues. He began his legal career as an Assistant District Attorney in New York County (Manhattan). He is a graduate of Georgetown University Law Center (1980) and St. John's University (1977). He is a member of the bars of New York and the District of Columbia.

Jonathan Cannon is Assistant Administrator for the Office of Administration and Resources Management. He brings a long, distinguished career at EPA to his new post.

In 1993, Cannon held three top Agency posts: Special Advisor to the Administrator, Acting Deputy Administrator, and Acting Assistant Administrator of the Office of Policy, Planning, and Evaluation. From 1992 to 1993, he was Director of EPA's Gulf of Mexico Program.

Other Agency positions he has held include Acting Assistant Administrator (1989) and Deputy Assistant Administrator (1988) of the Office of Solid Waste and Emergency Response; Deputy Assistant Administrator (Civil), Office of Enforcement and Compliance Monitoring (1987-1988); and Deputy General Counsel, Litigation and Regional Operations, Office of General Counsel (1987).

Cannon's non-EPA background includes his work at Beveridge & Diamond, P.C. (1975 to 1986 and 1990 to 1992), where he became a partner in 1980, and his service as law clerk to the Honorable David L. Bazelon at the U.S. Court of Appeals, DC Circuit.

He graduated *cum laude* from the University of Pennsylvania Law School in 1974 and was Editor-in-Chief of the Law Review. He attended Oxford University's Worcester College (1968) and graduated from Williams College with a B.A., *summa cum laude*, in 1967.

Denise Graveline is the new Deputy Associate Administrator for Communications, Education, and Public Affairs. Her background includes extensive experience in journalism, policy research, media and public relations, and management and budgeting.

She comes to EPA from the American Association for the Advancement of Science (AAAS), where she directed the Office of Communications and served as primary spokesperson for the world's largest general scientific organization. Her duties at AAAS ranged from interpreting and releasing research findings from the association's peer-reviewed journals, including *Science*, to successfully managing the communications office's budget. Among other responsibilities, Graveline directed production of AAAS publications such as *Science Sources*, a popular annual directory for reporters.

From 1987 to 1990, she directed media relations and served as primary spokesperson for the Robert Wood Johnson Foundation in Princeton, the nation's largest health care philanthropy with more than $2 billion in assets. In this post, she generated coverage by the print and broadcast media on medicine, education, health policy and financing, and philanthropy. As a member of the foundation's program staff, she supervised grants and contracts related to news media, including the PBS series now called *The Health Quarterly*.

As an independent writer and consultant (1984 to 1987), she authored articles on health and education for magazines including *Better Homes and Gardens*, *Ms.*, and *Family Circle*. Previously, she worked as an editor and writer for Whittle Communications, a national magazine publisher.

She graduated *magna cum laude* from the Boston University School of Public Communication with a B.S. in Journalism.

Kathryn S. Schmoll

Kathleen Aterno

Kathryn S. Schmoll is the Agency's new Comptroller.

Before her recent move to EPA, Schmoll was the Assistant Associate Administrator for Institutions in the Office of Space, Science, and Applications (OSSA) at the National Aeronautics and Space Administration (NASA). At OSSA, she performed a wide range of business management duties, institutional and external relations management functions, and oversight of all human resources activities for OSSA and the Goddard Space Flight Center.

Other positions held by Schmoll in OSSA include: Director of the Administration and Resources Division and Acting Director and Deputy Director of the Microgravity Science and Application Division.

Schmoll is a member of several Agency-level committees and boards, including the Equal Opportunity Council and the Contract Adjustment Board. She has received numerous awards, including the William A. Jump Award for Exemplary Service in Public Administration, the 1991 Outstanding Achievement Award for Women in Aerospace, a 1991 Presidential Rank of Meritorious Executive, and a NASA Outstanding Leadership Medal in 1992.

Schmoll graduated from Indiana University in 1975 and recently attended Harvard Business School's Advanced Management Program.

Kathleen Aterno has been appointed Deputy Assistant Administrator for Management and Administration in the Office of Administration and Resources Management.

She previously held positions as Acting Executive Director and Managing Director for Clean Water Action from 1987 to 1993. There, among other tasks, she developed and implemented budgeting and financial systems, organizational and personnel policies, and legislative and constituent strategies.

In 1990, she was Executive Director for the Michigan Democratic Party coordinated campaign. In that capacity, she developed and directed statewide campaigns for federal, state, and local leaders.

From 1984 to 1985, Aterno served as Administrative Assistant for Representative Bill Richardson (D-New Mexico). From 1977 to 1984, she was Administrative Assistant for Representative David Bonior (D-Michigan).

Aterno graduated from George Washington University with a major in political science and earned a master's degree in public administration from George Mason University. □

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Progress or Illusion?

I agree with Mr. Nitze's "four critical elements in a successful technology cooperation strategy" mentioned in his article entitled "Stopping the Waste" (April-June 1993 *EPA Journal*, pages 31-33). I question, however, the third reason he states as to why it will be possible "to reduce the average amount of pollution and natural resources depletion per unit of income." He says, "the richer industrialized countries are already moving in the direction of more service-oriented, less resource- and pollution-intensive economies, and a number of developing countries are beginning to follow. Information processing and telecommunications are inherently less polluting and resource intensive than steel or paper manufacturing."

Are the richer industrialized countries really using less paper and steel, or have they just exported the pollution of manufacturing to less developed countries? If all countries are to move toward "paper pushing" (service), who is going to do the paper manufacturing? If you manufacture less paper per unit of income, but more total paper (due to increased total income), has there really been any improvement? I agree that technology itself is not the problem, but it is important to differentiate between real progress in reducing pollution and illusion created because the pollution is out of sight.

Mary Bergs
Resident Research Associate
National Research Council
Athens, Georgia

William A. Nitze *replies:*

My colleagues at the Alliance to Save Energy and I share your concern that the export of such pollution is a potential problem, but our research has found no evidence that it is actually taking place, at least from the United States. In our analysis, resource- and pollution-intensity is declining in most countries, including major developing countries. For example, China's energy intensity has dropped by about 3 percent per year for almost 10 years. The real problem is not that richer countries are exporting pollution to poorer countries, but that the overall level of pollution continues to increase as the global economy grows. The only way to reverse this trend is to accelerate the decline in pollution per unit of output on a global basis. Achieving this goal will in turn require more rapid structural change and deployment of green technologies within and among richer and poorer countries alike.

Access to Safe Drinking Water?

I can't believe our nation does not know the percentage of users who have access to safe water, but all six others do on your map displayed on pages 8 and 9 of the April-June 1993 *EPA Journal*. I read on the front page of *USA Today* (September 27, 1993), that "120 million may get unsafe drinking water." How does this relate to "access to safe water (rural population)?" Or can we not agree on the definition of safe water?

A subscriber named Bob

EPA Journal *replies:*

*Figures for Bangladesh, Brazil, China, Ethiopia, Romania, and Zimbabwe were obtained from the sources cited on the map (*The 1993 Information Please Environmental Almanac *and* the Atlas of the Environment*). A comparable figure was not available for U.S. access to safe water (rural population). Such a figure would need to include the 15 percent of all Americans who get their water from private water wells. Because EPA does not have the authority to regulate domestic wells, the Agency is not in a position to generalize about the safety of the wells serving this population.*

As mentioned in the USA Today *article you cited, EPA Administrator Carol Browner does indeed believe drinking water regulation should be toughened. This administration will be working with Congress on legislation to improve the nation's 200,000 public water systems, of which the majority serve under a thousand people.*

Salute to Peace Corps Experience

Thank you for the wide-ranging discussion of sustainable development in the April-June 1993 issue of *EPA Journal*. I was surprised to note, however, that no reference was made to the work of Peace Corps volunteers, particularly when so many returned volunteers work for EPA. Contributors made valid points about the importance of capacity building, local level involvement in program planning, dissemination of appropriate technologies, and the effects of widespread poverty on the potential success of development strategies. For most volunteers, however, I suspect these were among the first lessons learned in the field.

It's been said that there are probably as many different volunteer experiences as there are returned volunteers, but some common themes run through our stories. Many of us worked to reinforce existing local community networks, to empower small groups to manage their own resources, to provide technical support to local government agencies, and to help people gain access to credit that would allow them to try new technologies. We know that some of the strategies described in the *Journal* are likely to succeed because we have experienced their successes first hand; we've also learned, the hard way, why some approaches are more likely to fail.

I hope that EPA will look to the returned volunteers on its staff for practical insights to sustainable development at the grassroots level, and especially for input on working with community groups and local government in other countries.

Judi Brown,
Program Analyst
Planning and Evaluation Branch
Office of Policy and Management
Region 2

Risk and Arithmetic

An error appeared in Robert Scheuplein's article entitled "Uncertainty and the Flavors of Risk" on page 17 of the January-March 1993 *EPA Journal*. The error occurs in the last sentence of the first column: "Cancer risks of less than 10^{-6}—one in a million per lifetime or one in 14,000 per year or 7 per 100,000 per year or 0.007 percent—are usually not considered worth regulating." The next sentence correctly reads, "Lifetime risks are approximately 70 times *higher* than annual risks if the risks are similar from year to year for a lifetime." However, the risk number of "one in a million per lifetime" is erroneously much smaller than the calculated annual risk of "one in 14,000." The writer has mistakenly multiplied where he should have divided by 70.

Leo Casey
U.S. Department of Transportation
Cambridge, Massachusetts

Robert J. Scheuplein replies:

Correct. The sentence should read, "Cancer risks of less than 10^{-6}—one in a million per lifetime or one in 70 million per year or 0.0014 per year per 100,000 or 0.0000014 percent—are usually not considered worth regulating."

Radon and Pollution Prevention

In the boxed article "An Ounce of Pollution Prevention" in the July-September 1993 *EPA Journal* (page 8), the radioactive gas radon was used as an example of a pollutant which cannot be prevented. While it is true that the decay chain of uranium, which produces radon, cannot be stopped under our house foundations, harmful radon radioactivity can be redirected so that it does not come in contact with occupants. Radon can be funneled through a gas-tight vent pipe from beneath the floor out above the roofline where it dissipates harmlessly into the atmosphere.

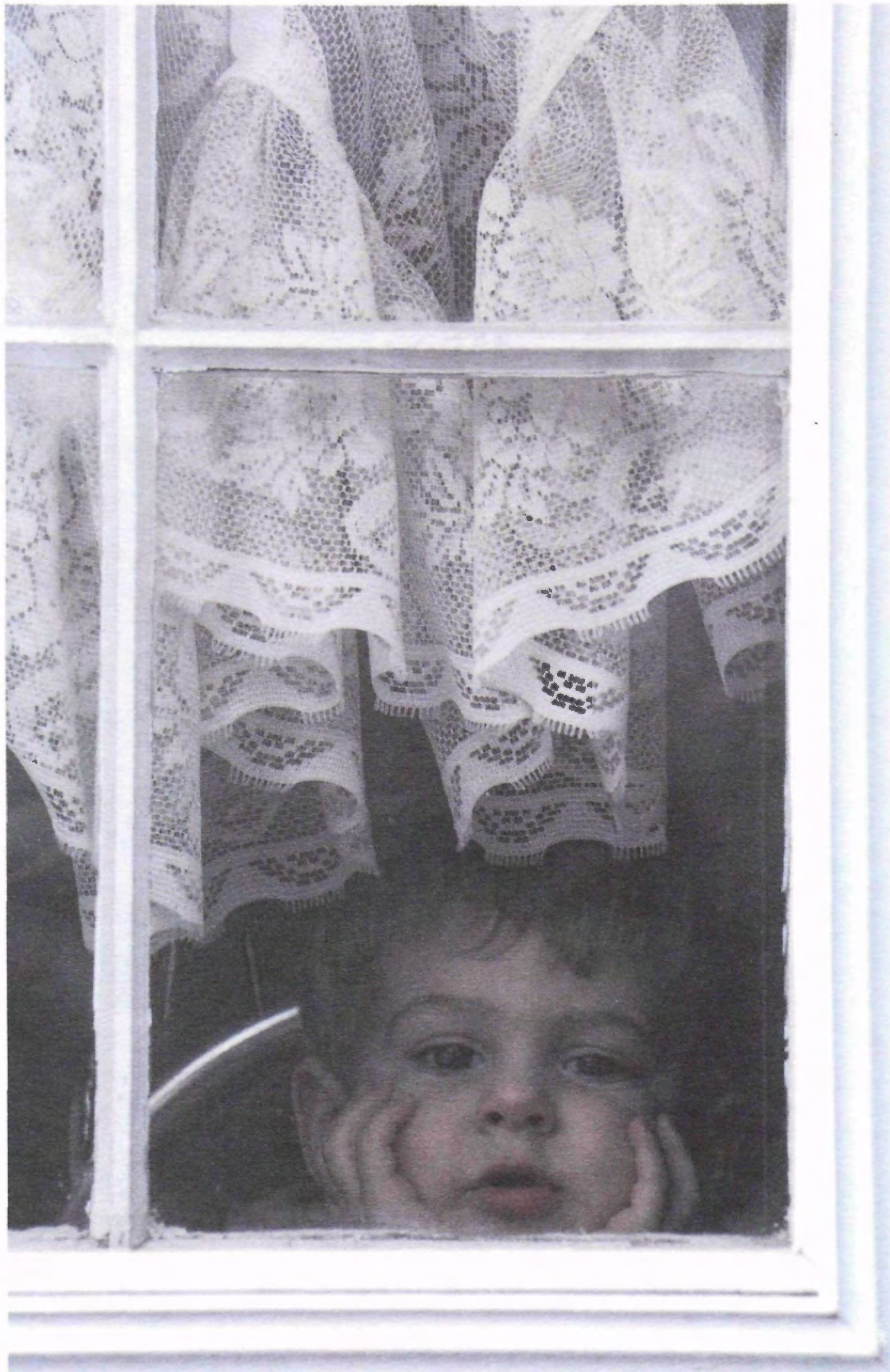
This winter, EPA and the National Association of Home Builders will publish a guide for using radon-reduction techniques in constructing homes, entitled *Model Standards and Techniques for Control of Radon in New Residential Buildings*. To install a radon-reduction system at the time of construction, the average cost per home is only $350 to $500—compared with an average $1,250 for retrofitting a home for radon removal.

Therefore, we believe that the phrase "an ounce of prevention is worth a pound of cure" *can* be applied to radon, if preventative radon control systems are installed at the time of construction of a home in an area where there is a high potential for elevated indoor radon levels.

Stephen D. Page
Director of EPA's Radon Division

EPA Journal *replies:*

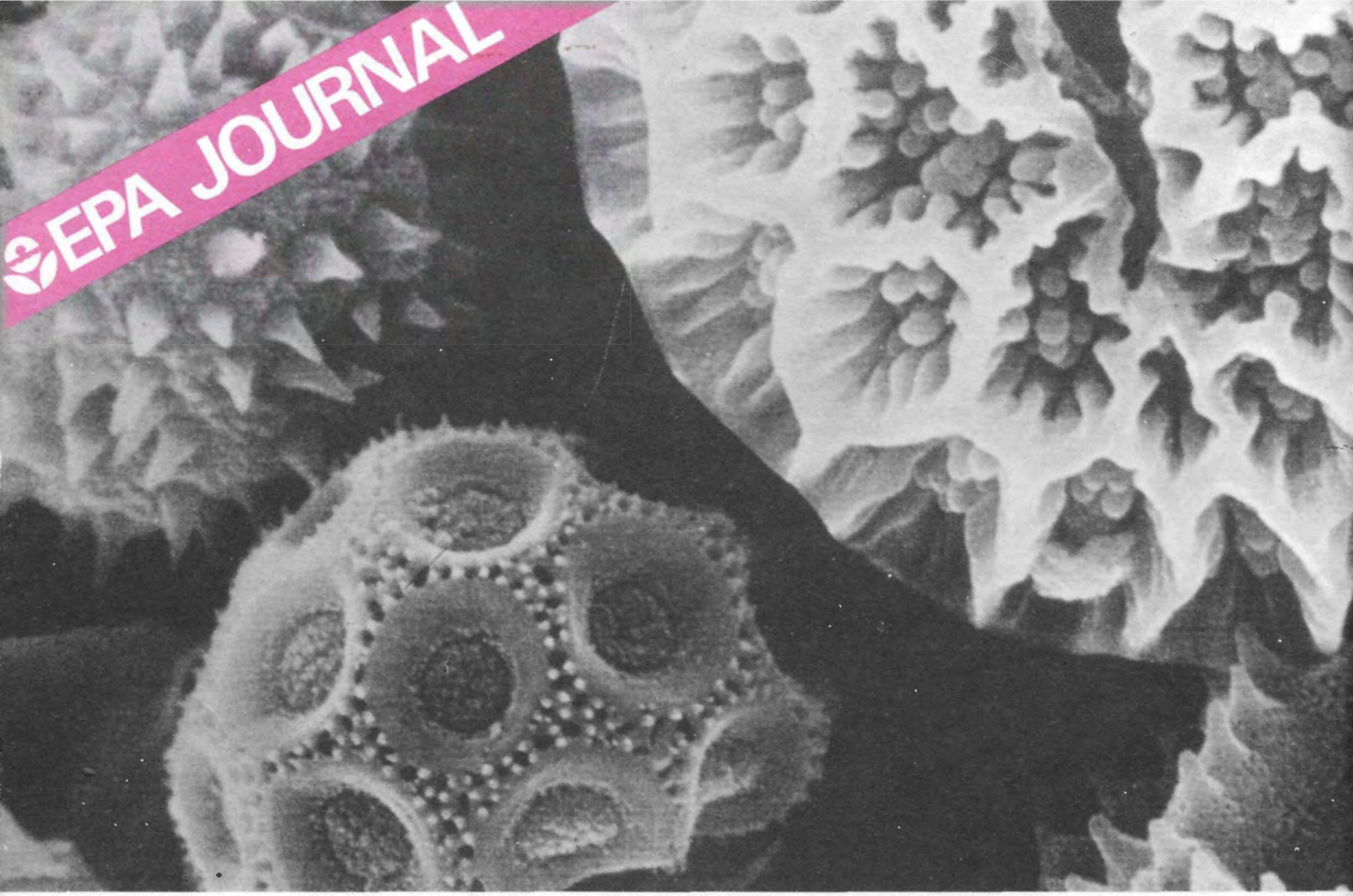
Your point is well taken. Nevertheless, the strict meaning of the term "pollution prevention" is source reduction (as opposed to source control), and that is the sense in which we meant to use the term in the short commentary entitled "An Ounce of Pollution Prevention." □



Home is one of many indoor environments we inhabit.

Richard Quataert photo for Folio, Inc.

(Back cover)
Pollen grains from trees and plants—these common allergens easily find their way indoors.



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