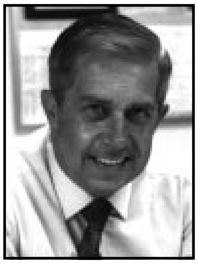

Fact or Fiction?

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Indoor Air Pollution

What's the most polluted atmosphere to which most of us are exposed? One clue—it's not the outdoor air that we've spent zillions of dollars to clean up. The answer? It's the air in our homes and offices. Enormous attention has been paid to outdoor pollution and its impact on health, but people spend up to 90 percent of their time inside, making indoor air quality extremely important.[1]

Many people perceive that the risk from outdoor air is substantially higher than indoor air. In fact, the home environment is rarely considered to be a risk in this regard. In terms of regulation and control, the principal sources of pollution, such as vehicles and factories, lend themselves to formal legislative control. By contrast, exposure in the home is very much dominated by personal choice and behavior.

Although it is still common in epidemiological studies to use outdoor pollutant levels and equate these with health effects in the population, the realization is dawning that much better accounts of indoor exposures need to be taken. We inhale about 20,000 liters of air each day. This equates to about 60 pounds of air flowing through our lungs each day—a volume far greater than the two liters of water and food we consume daily.[2]

You might be surprised to find that a great number of natural and man-made chemicals can be identified in the air inside a typical home, in addition to particulate material and potent allergens. Some of the more important indoor pollutants include tobacco smoke; carbon monoxide (CO); radon; oxides of nitrogen (NO_x); formaldehyde; volatile organic compounds (VOCs); chlorinated organic compounds; dust and particulates, PM10 (small particles less than 10 µm in diameter); house dust mite allergen; cat allergen; fungi and fungal spores; bacteria; pollen and asbestos fibers.[1]

Table 1*
Typical Average Concentrations of Some Pollutants Indoors & Out in the Avon area of England

	Outdoors, mg/m^3	**Indoors, mg/m^3**
Nitrogen dioxide	7-40	13-40 (electric cooking) 25-70 (gas cooking)
Formaldehyde	0.002	0.02
Volatile organics	0.02	0.2

* From Harrison, ref. 1.

Sick Building Syndrome

Couple this information with the fact that the drive to conserve energy has resulted in warmer, "tighter" buildings with reduced air exchanges, and you can envision how indoor air pollutants can build up. Part of the growing environmental consciousness that started in the mid-1970s led many Americans to think that steps must be taken to make our homes and public buildings more energy-efficient in order to reduce use of energy resources.[3] As part of this, homes and office buildings were made more airtight so that heat was not needlessly escaping. Concurrently, federal ventilation standards for public buildings and the workplace were also scaled back. Energy-saving measures recommended or mandated by the U.S. EPA and OSHA over the years have reduced the number of air changes in a house or small office building from about four changes per hour to about one per day. This is part of the reason that, according to Laudan,[3] "Air in airplanes and office buildings is now much staler than it used to be, and why the frequency of 'sick buildings' seems to be on the rise. The clear trade-off is that as structures become more airtight, the risks of all those airborne diseases to which we are prone—from the carcinogens in tobacco smoke and cooking oil to the smoke from our wood stoves and the germs from our office mate with flu—go up in direct proportion to the extent that we succeed in achieving energy savings as we seal up the places where we live and work."

It's estimated that up to 30 percent of all new buildings display classic "sick building syndrome" symptoms.[2]

Results of a number of studies comparing indoor air with outdoor air exposures have been published. One study in England looked at the indoor environment in 174 family homes in the Avon area for nitrogen dioxide, formaldehyde and other volatile compounds, house dust mites, bacteria and fungi. Examples of typical indoor and outdoor levels of the gaseous pollutants measured in this study are shown in Table 1.

A paper by Wallace *et al.*[4] summarized results of an EPA study of the relationship between the concentrations of a number of pollutants measured indoors, from outside and from personal monitoring. These studies, known as the total exposure assessment methodology, or TEAM, convincingly demonstrated how personal exposure can markedly exceed that anticipated from measurement of outside ambient concentrations.

The objective of this study was to estimate the distribution of exposures to ~20 toxic substances for a target population in an industrial/chemical manufacturing area (Bayonne and Elizabeth, NJ) and to carry out smaller studies for populations in non-chemical manufacturing areas (Greensboro, NC and Devils Lake, ND). Greensboro was chosen because its population was similar in size to the Bayonne-Elizabeth area, and because it had small industries but no chemical manufacturing or petroleum refining operations. Devils Lake was selected to provide data on the population of a small, rural agricultural town far from any industry. Exposures to 20 VOCs were measured in personal air, outdoor air, drinking water and breath. Data are presented in Table 2 for indoor and outdoor air. Breath sample data were also obtained, but are not included in the table in order to keep it more manageable. The table shows the following.

- Ten chemicals were prevalent in the air samples. For New Jersey, an eleventh chemical, carbon tetrachloride, was present.
- In New Jersey, personal air medians exceeded the outdoor air medians for every chemical in every season, usually by factors of 2–5. Similar results were observed for median air and breath concentrations in North Carolina and North Dakota.
- Outdoor air was noticeably cleaner in North Dakota than in New Jersey or North Carolina.

Other interesting results from this study included the following:

- Smokers had significantly elevated breath levels of benzene, styrene, ethylbenzene and m,p-xylene.
- Use of hot water in homes (for activities such as washing clothes and dishes, and bathing or showering) is the main source of airborne chloroform.
- Benzene exposures while filling gas tanks may exceed 1000 $\mu g/m^3$. People who reported filling their tanks with gasoline had twice as much benzene on their breath as a person who did not.
- Moth crystals and room air deodorizers are responsible for noticeably increased concentrations of p-dichlorobenzene. About 80 percent of the homes in the survey had these materials.
- Tetrachloroethylene exposures are elevated by wearing and storing dry-cleaned clothes.
- Employment leads to increased exposures of some toxic chemicals. Activities identified with increased exposures included pumping gasoline, visiting service stations, visiting dry cleaners, traveling in a car, furniture refinishing, painting, scale model building, pesticide use and smoking.

What do the data in Tables 1 and 2 mean? The answer is that we should be concerned but not overly alarmed, and clearly we can control the situation on our own—at least in our own homes.

In summarizing the data in Table 1, Harrison[1] points out that any risk of respiratory illness from the levels of NO_2 currently found in most homes is small, and current exposure in homes to formaldehyde or VOCs does not pose a risk to health. Harrison does state that house dust mites are potentially one of the most important indoor problems, because of the role they may play in the incidence and prevalence of asthma.

Tobacco smoke is a problem all by itself, and anyone who is not aware of this issue is brain dead. More than 2000 compounds have been identified in cigarette smoke. Many of these are known carcinogens and irritants.[5] Smokers are prohibited from lighting up in workplaces, public buildings and now even in some bars (at least in California). They aren't prohibited from lighting up in their own homes, where they can do serious harm to their family and friends.

Next to smoking, carbon monoxide is the most obviously identifiable problem. According to the U.S. Consumer Product Safety Commission, 250 to 300 people in the U.S. are killed every year by carbon monoxide from space heaters, furnaces or other household devices. Another 5,000 to 10,000 victims do not die, yet suffer acute carbon monoxide poisoning.[6]

Everyone has heard the bad words about asbestos. More "scare press" has been written about it and dollars thrown at its removal than just about anything else. In spite of the billions of dollars spent in removing it from buildings, here are some words directly from Moore:[7]

"As published research mounted during the 1980s, it became increasingly clear that asbestos levels in buildings, including schools, are barely detectable and over one-thousand times lower than occupational levels found to be harmful. Richard Doll, who originally demonstrated that occupational exposure to asbestos increased lung cancer rates, stated that the risk to building occupants from exposure to asbestos was minimal, comparable to that associated with smoking half a cigarette in a lifetime."

A Canadian government commission made the following statement:[8]

"Even a building whose air has a fiber level up to 10 times greater than that found in typical outdoor air would create a risk of fatality that was less than one-fiftieth the risk of having a fatal accident while driving to and from the building."

Although EPA has raged a relentless battle on radon as a cause of cancer, epidemiological data show no such effect from radon by itself in moderate doses.[9,10] There is evidence, however, that high levels of radon, together with cigarette smoking, significantly increases the probability of lung cancer.

Control Measures

The first control measure is to remove all smokers from your house, because all other potential indoor pollutants pale by comparison with tobacco smoke. Clearly, much easier said than done. Then make sure you have no potential problems with CO. Buy carbon monoxide detectors and place them near potential sources of toxic fumes, such as the hot water heater or furnace. Another important step is to make sure you have a vacuum cleaner

Table 2**
Weighted Medians for Air Samples (mg/m^3)

Chemical	New Jersey Personal Air	New Jersey Outdoor Air	Greensboro, NC Personal Air	Greensboro, NC Outdoor Air	Devils Lake, ND Personal Air	Devils Lake, ND Outdoor Air
1,1,1 Trichloroethane	17	4.6	32	60	2.5	0.05*
Benzene	16	7.2	9.8	0.4	–	–
m,p-xylene	16	9.0	6.9	1.5	6.2	0.05*
Carbon tetrachloride	1.5	0.87	–	–	–	–
Trichloroethylene	2.4	1.4	1.5	0.2	0.50	0.05*
Tetrachloroethylene	7.4	3.1	3.3	0.7	5.0	0.69
Styrene	1.9	0.66	1.4	0.1	–	–
p-dichlorobenzene	3.6	1.0	2.6	0.4	1.7	0.07*
Ethylbenzene	7.1	3.0	2.5	0.3	2.1	0.03*
O-xylene	5.4	3.0	3.6	0.6	2.7	0.05*
Chloroform	3.2	0.63	1.7	0.14	0.38	0.05*

* Not detected; value is one-half the limit of detection.
** From Wallace, *et al*., ref. 4.

that really vacuums. Roos,[11] in discussing the "clean air syndrome" refers to a vacuum cleaner as a dust recycler. He points out that the cleaning ritual of a vacuum cleaner looks like this:

1. Large visible dust particles are sucked up.
2. Impaction with dust pack produces a lot of fine particles.
3. Particles are small enough to follow air stream lines.
4. Particles are "treated," so as to be modified in the motor region.
5. A cloud of invisible particles will fill the room after the cleaning procedure.
6. Coagulation will ensure that these particles become increasingly visible.
7. These larger particles will settle and form a dust layer.
8. Vacuum cleaner is needed to remove the dust.
9. Return to Step 1.

Now that you've eliminated smoking, CO, and have a vacuum cleaner that doesn't recycle the dust, other strategies include a combination of ventilation, source removal or substitution, source modification and air purification changes.

Summary

Findings available from many studies show that the same air pollutants covered by environmental laws outdoors are usually found at much higher levels in the average home. As Ott and Roberts stated,[12] "Sadly, most people—including officials of the U.S. government—are rather complacent about such indoor pollutants. Yet, if these same substances were found in outdoor air, the legal machinery of the Clean Air Act of 1990 would apply. If truckloads of dust with the same concentration of toxic chemicals as is found in most carpets were deposited outside, these locations would be considered hazardous waste dumps."

Ironically, in one of his final official acts as EPA administrator with the Bush administration, William K. Reilly said he thought it "odd" that the federal agency had spent most of its energy and federal funding regulating environmental problems that pose small public health risks and far too little time targeting bigger threats.[2] If you're concerned about toxic substances in your home, you don't have to wait for EPA, OSHA or some other regulatory agency to do something about it. You can reduce exposure with only modest alterations in your daily routine.

Lastly, if you're looking for new business opportunities, be aware that by the year 2000, the indoor air quality market is projected to be $3.6 billion, of which more than an 11-percent share is expected for analytical and consulting services.[13,14] P&SF

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