Current Comments

Indoor Pollution: Why Environmental Protection May Also Be an Inside Job

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Paris is a city full of mirrors. The hotels are full of them. The last time I was there I stayed at a small hotel called La Suede. When I got to my room the maid had just cleaned the mirrors, as well as windows and fixtures. The smell of wood alcohol was everywhere. Methyl alcohol is in fact one of the most widely used cleaning products in Europe. The smell of methanol is distinctive, and the maid had obviously used it generously. Indeed, to say the fumes were overwhelming is an understatement. Even when I opened the windows to the street it was impossible to vent the smell because the bathroom itself did not have a window or ventilation shaft. Though it was winter I had to leave the room.

When I told the manager he was not the least surprised or concerned. Since he didn't seem to care about its impact on guests I tried another ploy. I suggested it might not be healthy for the maids to be breathing methanol regularly in such large doses. He smiled and shrugged his shoulders and replied, "Monsieur, they can't even smell it." In other words, they get used to the smell—just like people who work in garbage dumps, sewers, and a lot of other pleasant places. In fact, a single inhalation of methanol may not be harmful. But daily exposure can cause the same effects as drinking methanol: headache, weakness, dizziness, vertigo, abdominal pain, blurred vision, and eye tenderness. Severe exposure to methanol fumes may cause blindness.[1,2]

But methyl alcohol is not the only ingredient to worry about. The array of cleaners we use in our homes and workplaces does indeed contain a variety of solvents and propellants, many of which are toxic. And household chemicals are just one facet of the problem of indoor air pollution. Indoor pollution occurs when the amount of toxic substances in indoor air reaches unhealthful levels. Indoor pollution is getting a lot of attention today because it is a side effect of the energy crisis. Indoor concentrations of pollutants can increase as people seal up their homes and workplaces to save energy.

One corporation's experience with indoor pollution dramatizes the problem. A few days after the Itel Corporation, Port Washington, New York, moved into a new, energy-efficient building, workers began to complain about nausea, dizziness, and fatigue. The managers feared they were facing an outbreak of Legionnaires' Disease or some other ailment. While the 150 employees were moved to trailers, the Center for Disease Control (CDC)[3] was called in. CDC investigators traced the health problems to a combination of cigarette smoke, formaldehyde, photocopier fumes, and other substances. The building was sealed so tightly that the buildup of these indoor pollutants reached toxic levels. The fumes could not escape to the outdoors because of inadequate ventilation.[4]

Such experiences underline a dilemma of modern architecture. When we

designed our new ISI® headquarters in Philadelphia, we were conscious of this problem. We wanted to make sure our air quality was high. To ensure efficient replacement of stale air with fresh air, we designed a separate air handling system for each floor. Though we work in one four-story building, for ventilation purposes we have four one-story buildings. It is easier to ventilate a small building than a large one.

We also took other, more modest steps. Unlike many buildings, ours has windows that can be opened in case of an air conditioner breakdown. This also increases natural ventilation. Windows that are fixed shut allow less outside air to infiltrate the building. Since we have an "open-space" landscape at ISI[5,6] we had a chance to practice small-scale environmental engineering to protect our employees from cigarette and especially strong cigar and pipe fumes. Over the work areas of the cigar and pipe smokers, we installed extra fans that draw local smoke upward.

About 30 percent of US energy consumption goes into indoor heat, light, cooling, hot water, and cooking.[7] The energy crisis has emphasized the need to seal up buildings. But as Itel's experience shows, too little ventilation can prevent the escape of pollutants. In those circumstances anything not breathable becomes a pollutant.

All buildings tend to ventilate naturally. Cracks and leaks in the walls and windows let outside air in and stale air out, even when the doors and windows are shut. The rate of such natural ventilation is measured in air changes per hour (ACH). The ACH value specifies how many times per hour the air in a building is replaced by outside air.[8]

Certain modern methods of construction, such as insulated walls, double-glazed windows, and window and door caulking, can reduce the ACH to 0.1 to 0.2. It may take five to ten hours to completely "freshen" the indoor atmosphere.[7] Obviously a low ACH rate cuts down on the exchange of heated or cooled air, and saves energy. If we reduced our ACH by half, we might cut our ventilation energy bill by about half. But low ACH also means higher levels of indoor pollution. However, there is no ideal ACH rate that applies to all buildings. A laboratory doing animal experiments would have very different ACH requirements than a building where the worst pollutants are photocopiers.

ISI's *minimum* ACH rate is 0.4, which allows more ventilation than many office buildings. However, that figure is an annual approximation; it does not reflect seasonal variations. In spring we allow for more ventilation than in winter. We do not bind ourselves to an ACH rate of 0.4 at any given time; we can adjust it to a higher rate whenever it is appropriate. Also, our ventilation needs vary from one section of our building to another, depending on how many workers we have in them. Our first floor is less populated than our second or third, so we can sometimes get by with less ventilation there.

Only a few indoor pollutants have been studied in detail as health hazards in recent years. One of the best known is radon 222, a gas that is readily inhaled. It is a product of radium 226, a radioactive material found in soil, rock, and building materials such as brick and concrete. Radium 226 has a half-life of 1,602 years; it is constantly decaying into radon 222. Radon 222 has a half-life of 3.8 days. When it decays it produces four "daughter" substances, each with a half-life of less than 30 minutes. Two of them, polonium 214 and polonium 218, emit alpha particles, which can cause lung cancer.[8]

The decay of matter cannot be arrested, but there are two ways that indoor concentrations of radon can be reduced. Better ventilation is the first. The second is to block the radon from the source. Radon levels can be reduced by sealing the cracks and wire pipe en-

try points in the foundation.[8] Our building has no cracks, but we did seal the areas around pipes.

Another well-known indoor health hazard is asbestos. In the 1930s, asbestos became a popular building material. It had 3,000 possible uses, the most common of which was as a fireproofing spray for walls, steel girders, etc. About 30 million tons of asbestos have been used in the US since 1900. The potential health hazards of asbestos were suspected when it was first used. But the problems became evident in the 1960s. Asbestos can produce dust when materials treated with it are sawed, cut, sanded, or otherwise disturbed. The diseases associated with the inhalation of asbestos flakes are *asbestosis* (rigidity of the lung tissue), *mesothelioma* (cancer of the membrane that lines the chest or abdominal cavity), and *lung cancer*. Unfortunately the health effects on a person who inhales asbestos fibers may not become apparent for 30 years.[9]

These and other health problems are more common among asbestos workers.[9] And the danger is not limited to the workplace. In 1971, Henry Anderson and colleagues, City University of New York, studied 326 people who had come into contact with asbestos brought home inadvertently by asbestos workers. Thirty-five percent of them had chest x-ray abnormalities attributable to asbestos.[10]

As of late 1980, regulatory agencies were gearing up to do something about the asbestos problem. The Occupational Safety & Health Administration (OSHA) was considering lowering the permitted rate of occupational exposure.[11] The Consumer Product Safety Commission (CPSC) was trying to identify all asbestos-containing products on the market. And the Environmental Protection Agency (EPA) was considering limiting manufacture or import of asbestos.[11] The EPA was also trying to identify all public school buildings insulated with asbestos, and remove the asbestos from places where it creates a hazard. Asbestos flaking is thought to be especially common in public schools due to vandalism and aging buildings. Larry Longanecker, EPA, predicts that 10,000 US schools would be found to contain dangerous asbestos levels.[12] Recently parents in one Philadelphia neighborhood blocked the doors of a public school until the school was closed so asbestos problems could be dealt with.[13]

Homeowners can alleviate the domestic asbestos problem through ventilation. But asbestos fibers can be stopped at their source. They can be enclosed within suspended ceilings. Or flaking can be stopped by spraying the area with penetrants or sealants.[12]

At least one insulating material has been directly implicated as a pollution source. Formaldehyde is used in over 500,000 US homes.[14] People can detect the characteristic pungent odor of formaldehyde at concentration of less than one part per million of air. Even at that concentration, formaldehyde can cause swelling of mucous membranes, burning eyes, and irritation of respiratory passages. Ten times that level can cause coughing, chest constriction, and headaches.[15]

A recent study reported in the *Journal of the American Medical Association* found that in many homes, formaldehyde levels exceed the levels permitted in factories where the substance is manufactured.[16] Formaldehyde also causes nose tumors in rats. The CPSC recently proposed that the substance be banned as an insulator.[14] It has already been banned in Massachusetts,[14] and The Netherlands has established maximum allowable indoor concentrations of 0.1 parts per million.[17]

Radon, asbestos, and formaldehyde do not exhaust the list of indoor pollutants. Most homes contain furnaces or gas stoves which can emit combustion products in high concentrations. R.J.W. Melia and co-workers, St.

Thomas's Hospital Medical School, London, compared children who lived in homes with electric stoves to those with gas stoves. Children in the gas-equipped homes had a higher incidence of respiratory diseases such as bronchitis, coughs, wheezing, and asthma. The investigators inferred that nitrogen oxides emitted from the gas stoves may be the culprit.[18]

One of the most annoying and common indoor pollutants is cigarette smoke. I've discussed nicotine addiction in the past.[19] For years people have been aware that cigarette smoking endangers the health of smokers. The upsurge of interest in indoor pollution should focus more attention on the fact that smoking also endangers nonsmokers. In some ways, the smoke that the smoker inhales (mainstream smoke) is *less* dangerous than the smoke the nonsmoker may have to breathe (sidestream smoke). The average cigarette produces twice as much sidestream smoke as it does mainstream smoke. And sidestream smoke may have a higher concentration of dangerous substances. For example, nitrosamines, proven in animal studies to be carcinogens, are present in sidestream smoke in 50 times greater concentration than mainstream smoke.[20]

The battle against smoking is likely to intensify due to recent news from Japan. Takeshi Hirayama, National Cancer Center Research Institute, Tokyo, recently observed over 91,000 nonsmoking wives. The researcher reported in the *British Medical Journal* that the wives of heavy smokers were at increased risk of lung cancer.[21]

Not only do pollutants in the air create possible health hazards, but it now appears that air conditioners can create risks as well. I noted years ago that air conditioners and air heating systems were suspected of promoting fungus growth and spreading organic matter through the air, thus causing respiratory ailments and other diseases.[22] The most famous example of this kind of disease later turned out to be Legionnaires' Disease, which is caused by a bacterium which may be linked to air conditioners.[23] The Centers for Disease Control has also been studying other diseases now believed to originate from air conditioners and humidifiers, according to Peter Baxter, Chronic Disease Division.[24]

Baxter's group is concentrating on two similar diseases: hypersensitivity pneumonitis and humidifier fever. Hypersensitivity pneumonitis (HP) can be caused by a type of fungus, *thermophilic actinomycetes*, in air conditioners. When fungus particles are blown through air conditioners and become airborne, they can cause an allergic reaction with chills, fever, labored breathing, and dry cough. HP was linked to air conditioners in 1970, when Edward F. Banaszak, St. Luke's Hospital, Milwaukee, and colleagues cured four separate cases by having employers switch from water supply cooling to electric refrigeration of the air.[25]

The other disorder being studied by the Chronic Disease Division, humidifier fever (HF), is probably caused by amoebas growing in the water reservoirs of humidifiers. As with HP, symptoms include respiratory effects, though they are usually milder. Humidifier fever gets its name from the devices it has been linked to: humidifiers which allow water cascading from a reservoir or sprayed at rotating disks to humidify the air. In several British studies, three out of four cases of humidifier fever in four factories were solved by eliminating such systems and converting to steam humidification. It has also been suggested that HP and HF can be prevented by periodically cleaning reservoirs and changing filters.[26,27]

Pets can be another source of indoor pollution. It is well-known that many people are allergic to animals.[28] Pet owners become adjusted to animal hair

or dander, or are not bothered by it in the first place. They may not even suspect how large the concentration may be. To avoid this problem it is preferable to acquire a pet that can be kept outdoors most of the time. But many pet owners are oblivious to the problems of people who have respiratory disorders that are aggravated by the presence of pets. I suppose eventually those friends do not return.

As we have seen, most indoor pollution can be stopped or reduced by better ventilation or stopping the pollutant at its source. But there may be other ways to deal with the problem. Heat exchangers are devices that pull fresh air inside and blow stagnant air outside. The two airstreams go through separate but adjacent ducts. Some of the heat from the outgoing air is absorbed by the incoming air. Heat exchangers for the home resemble air conditioners and cost as little as $200.[29,30]

A Moorestown, New Jersey, company has, since 1978, marketed a device to clean the indoor air. The Airomax, sold by Medical Air Purification, Inc., simply filters pollutants from the air. Different filters are used for different substances.[31] Company founder Vince Morgan tells us that the Airomax is effective only if the building is adequately ventilated, since Airomax is not in itself a ventilation device.[32]

Air ionizer manufacturers have been claiming for years that their devices clean dust from the air. Some also say the devices, which increase the number of supposedly beneficial negative air ions, can improve one's mental or physical health. While the former claim may have some validity, the FDA's Medical Devices Bureau forbids manufacturers to make the latter claim.[33]

Clearly, more research is needed to define the extent of the problem and determine solutions. There is no journal devoted to indoor pollution, but papers occasionally appear in environmental science and energy journals. These include *Energy & Buildings*, covered in *Current Contents®/Engineering, Technology & Applied Sciences*; *Clean Air*, covered in *CC®/Agriculture, Biology & Environmental Sciences*; and *Archives of Environmental Health*, covered in *CC/Life Sciences* and *CC/Agriculture, Biology & Environmental Sciences*.

Indoor pollution is an issue that is just beginning to come to the public's attention. The problems discussed here will get more serious as more and more people seal up their homes and workplaces. Unfortunately, the indoor pollution problem complicates the energy crisis. There are compromises between air quality and energy efficiency that must be made. But it would be unfortunate if people used indoor pollution as an excuse to neglect energy conservation.

The problem of indoor pollution is characteristic of our technological age. One technology is used to solve a problem only to generate another one. There never seems to be a perfect technological fix. We have to assess the risks involved in alternative technologies or no technology at all. The area of risk-benefit analysis[34] is an emerging area of research to which I hope to devote some attention in the future.

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REFERENCES

1. **Sax N I.** General chemicals. (Sax N I, ed.) *Dangerous properties of industrial materials.* New York: Van Nostrand Reinhold, 1975. p. 909.
2. **Courl D & Nachtman J P.** Toxicology of alcohols, ketones and esters—inhalation. *NIDA Res. Monogr. Ser.* 15:112-23, 1977.
3. **Garfield E.** Is preventive medicine taking off at last? *Current Contents* (52):5-10, 29 December 1980.

4. **Kaufman J.** Indoor air pollution raises risks for people in new office buildings. *Wall St. J.*, 16 July 1980, p. 27; 31.
5. **Garfield E.** New year, new building. *Current Contents* (1):5-8, 7 January 1980.
6. **Constantine E M.** The sophisticated shed. *Archit. Rec.* 167(5):97-100, May 1980.
7. **Hollowell C D, Berk J V & Traynor G W.** *Indoor air quality measurements in energy efficient buildings.* Berkeley, CA: Lawrence Berkeley Laboratory, 1978. 17 p. LBL-7831.
8. **Budnitz R J, Berk J V, Hollowell C D, Nazaroff W W, Nero A V & Rosenfeld A H.** Human disease from radon exposures: the impact of energy conservation in residential buildings. *Energ. Bldg.* 2:209-15, 1979.
9. The asbestos problem. *Harvard Med. Sch. Health Lett.* 5(10):1-2; 5, August 1980.
10. **Anderson H A, Lilis R, Daum S M, Fischbein A S & Selikoff I J.** Household-contact asbestos neoplastic risk. *Ann. NY Acad. Sci.* 271:311-23, 1976.
11. **Pincus W.** Asbestos coming under massive attack by 3 regulatory agencies. *Wash. Post*, 8 December 1980, p. 3.
12. The attack on academic asbestos. *Sci. News* 118:215, 1980.
13. **Nichols R.** School shut for cleanup of asbestos. *Phila. Inquirer*, 5 December 1980, p. 1-B; 2-B.
14. Banning a foam as home insulation proposed by agency. *Wall St. J.*, 14 January 1981, p. 5.
15. **Hollowell C D, Berk J V, Boegel M L, Miksch R R, Nazaroff W W & Traynor G W.** Building ventilation and indoor air quality. *Atmospheric pollution 1980: proceedings of the 14th international colloquium, UNESCO Building, Paris, France, 5-8 May 1980.* New York: Elsevier, 1980. p. 387-96.
16. **Harris J C, Rumack B H & Aldrich F D.** Toxicology of urea formaldehyde and polyurethane foam insulation. *J. Amer. Med. Assn.* 245(3):243-6, 16 January 1981.
17. **Hollowell C D, Berk J V & Traynor G W.** Impact of reduced infiltration and ventilation on indoor air quality in residential buildings. *ASHRAE Trans.* 85:816-27, 1979.
18. **Melia R J W, Florey C du V, Altman D G & Swan A V.** Association between gas cooking and respiratory disease in children. *Brit. Med. J.* 2:149-52, 1977.
19. **Garfield E.** Nicotine addiction is a major medical problem: why so much government inertia? *Current Contents* (31):5-13, 30 July 1979.
20. **Stock S.** The perils of second-hand smoking. *New Sci.* 88(1221):10-3, 2 October 1980.
21. **Hirayama T.** Non-smoking wives of heavy smokers have a higher risk of lung cancer: a study from Japan. *Brit. Med. J.* 282(6259):183-5, 17 January 1981.
22. **Garfield E.** What your air-conditioner may be giving you besides relief. *Current Contents* (34):5-6, 23 August 1972.*
23. **Kirby B D, Snyder K M, Meyer R D & Finegold S M.** Legionnaires' Disease: report of sixty-five nosocomially acquired cases and review of the literature. *Medicine* 59:188-205, 1980.
24. **Baxter P.** Telephone communication. 17 November 1980.
25. **Banaszak E F, Thiede W H & Fink J N.** Hypersensitivity pneumonitis due to contamination of an air conditioner. *N. Engl. J. Med.* 283:271-6, 1970.
26. Humidifier fever revisited. *Lancet* 1:1286-7, 1980.
27. Inhalation fevers. *Lancet* 1:249-50, 1978.
28. **Baker E.** A veterinarian looks at the animal allergy problem. *Ann. Allergy* 43:214-6, 1979.
29. **Gold M.** Indoor air pollution. *Science 80* 1(3):30-3, March-April 1980.
30. Conserving energy can damage your health. *Economist* 275(7134):109-10, 24 May 1980.
31. Cleaning up indoor air pollution. *Focus* (Philadelphia) (637):22-3, 14 January 1981.
32. **Morgan V.** Telephone communication. 28 January 1981.
33. **Garfield E.** Do air ions affect our lives and health? *Current Contents* (23):5-11, 4 June 1979.
34. **Okrent D.** Risk-benefit evaluation for large technological systems. *Nucl. Safety* 20:148-64, 1979.

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