A Status Report

INDOOR AIR QUALITY

What research is now being done on the effect of indoor pollutants on the population and what investigations are planned for the future?

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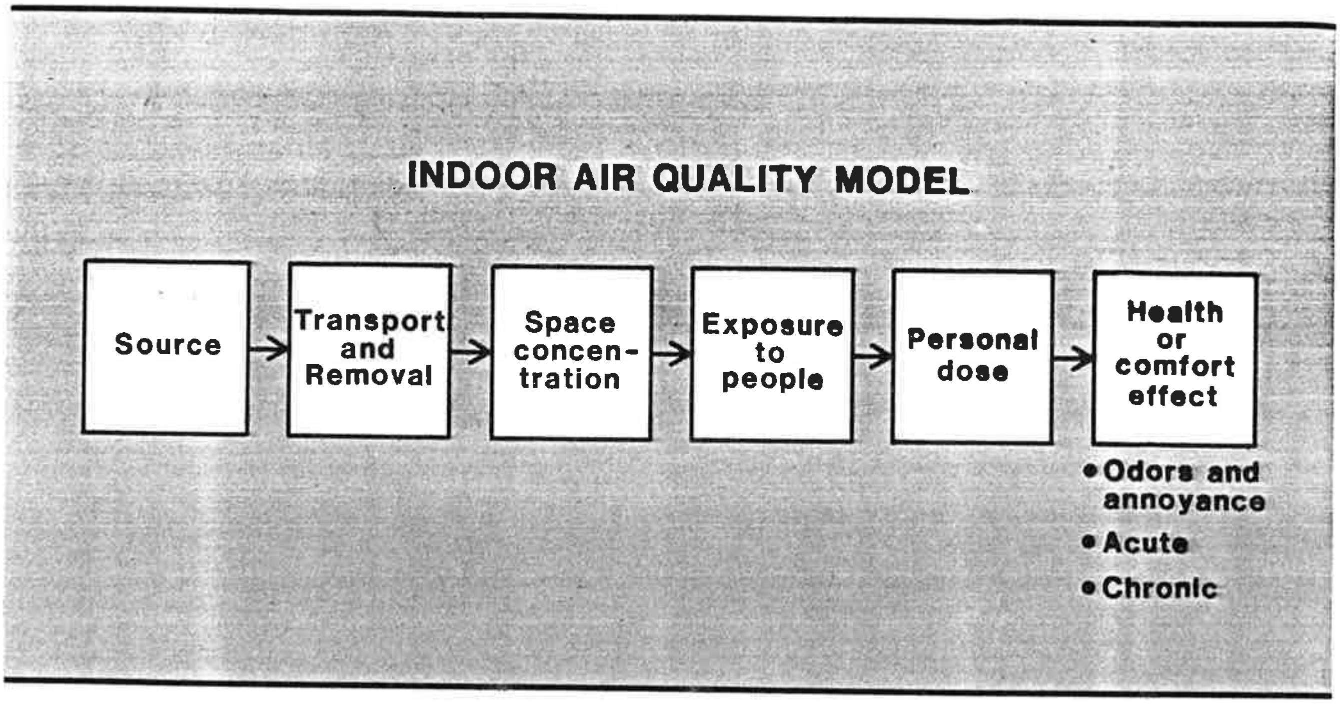
ENERGY conservation measures, resulting in tighter building envelopes, and the increased use of unvented appliances, as well as new materials and new equipment introduced into buildings, increase the concentrations of internally-generated contaminants. Air sampling in many buildings has indicated that indoor concentrations of known pollutants often exceed standards set for outdoor air and even those for industrial exposures. Complaints by occupants have also drawn attention to indoor pollutant levels, and raise questions as to the adequacy of indoor air quality to protect the health and welfare of the building occupants.

Surveys[1] show that up to 90 percent of the typical person's time is spent indoors, and a large fraction of that is spent in residential or commercial environments. In recent years, a number of problems have arisen. Legionnaires disease, "sick building" syndrome, radon in buildings, formaldehyde from urea-formaldehyde foam insulation, particleboard, etc., are only a few. Many recent studies have pointed out concerns about indoor air quality in both residential and commercial buildings [2,3,4,5].

There is some understanding and experience with general indoor pollution control methods[2,3,4,5]. Ventilation can be increased at increased energy and sometimes increased equipment cost, air treatment devices can be used, pollutants can be controlled at the source or substitute materials can be used to reduce contaminant emission rates. However, simplistic solutions may not be economically feasible. For example, it has been proposed to equip residences with air-to-air heat exchangers to increase ventilation rates, thereby saving energy and improving indoor air quality. Such a solution may not be cost effective. In considering any control strategy, we must know which residences could benefit. For all kinds of buildings, we must know the current and projected distribution of pollutants and their concentrations. We must further know their comfort effects and short- and long-term health effects on people. Peoples' temporal and spatial exposure patterns must be known to obtain the exposure levels. Then the efficacy of the known and future control strategies (dilution with ventilation, removal with air treatment devices, substitution of different materials, suppression by various coatings or manufacturing processes and behavior modification) must be ascertained for the multitude of applications. Only then can rational, technologically-based economic recommendations and policies be made. Until then, piecemeal efforts are being made to solve specific problems.

It is impossible in this brief article to mention all the research activities and important studies which have been done to date. However, several conferences and general studies have been published recently and the few listed in the references are representative[2,3,4,5]. These include studies in the U.S. and Canada, U.K., the Scandinavian countries, Germany, Japan and several other countries. The major research in the U.S. has been done by such laboratories as Lawrence Berkeley Laboratory, Harvard School of Public Health, Illinois Institute of Technology Research Institute, Yale University, Oak Ridge National Laboratory, the National Bureau of Standards and several other laboratories and universities. The large number of researchers and breadth of research are evident.

In the U.S., the important sponsoring agencies include the Federal Environmental Protection Agency, the Department of Energy, the Consumer Product Safety Commission, and the Department of Health and Human Services. The state and city governments are also involved



in doing research. Many also have regulations, or are considering them, and are involved with responding to citizen requests. Some private agencies such as the Gas Research Institute (GRI), the Electric Power Research Institute (EPRI) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) have also sponsored significant research.

General issues

The many contaminants in the indoor air can be divided into particulates (solids or liquid droplets) and gases or vapors. Within these types, there are constituents which are known to be annoying and which are, or are suspected of being, deleterious to health. Others may be identified in the future. Constituents which are annoying may impair human performance without being deleterious to health. ASHRAE Standard 62-1981, "Ventilation for Acceptable Indoor Air Quality,"[6] defines acceptable air quality as "air in which there are no known contaminants at harmful concentrations and with which a substantial majority of the people exposed do not express dissatisfaction." This recognizes both the health and comfort requirements of acceptable air quality.

Known contaminants

The following are some known important contaminants:

Particulates - Standards often specify a limit of the mass concentration of particulates expressed as micrograms per cubic meter ($\mu g/m^3$)[7]. These include all particle sizes or total suspended particulate concentration (TSP). Larger sizes may constitute annoyance more than health problems. For health, respirable suspended particulates are important, because such particles can lodge in the lung. Large particles lodge in the nasal passages and are handled ordinarily by the person unless they are, or contain, allergens or pathogens. Respirable particles are in the size range up to three micrometers (μm).

Particulates of specific interest include:

1. respirable particulates as a group
2. tobacco smoke (solids and liquids)
3. asbestos fibers
4. allergens (pollen and mold spores)
5. pathogens (bacteria and viruses), almost always contained on other particulates
6. radon progeny (radioactive decay products)

Vapors and gases of particular interest include:

1. carbon monoxide
2. radon (decay products are particulates)
3. carbon dioxide
4. formaldehyde and other aldehydes (require special attention as organics)
5. other volatile organic compounds (several hundred have been identified in tobacco smoke vapors alone)
6. oxides of nitrogen

Some contaminants enter with outside air brought in by purposeful ventilation or by uncontrolled infiltration. In the U.S., the EPA has established outdoor pollutant criteria[7]. However, many important indoor pollutants emanate from inside sources. People are sources of CO_2, H_2O and biomatter, as well as other particulates and vapors which are characterized as "body odors." People's activities, smoking, cleaning, hobby activities, such as gluing plastic models and refinishing furniture, cooking, etc., also cause pollution. Building materials and finishes can "outgas" pollutants. Furnishings, business machines and appliances, particularly unvented or poorly vented heaters and ranges can be sources. The building surroundings can also be a source of radon and insecticides which can enter indoors through cracks, drains, etc., or by diffusion. Heating, ventilation and air-conditioning (HVAC) systems, drains, plumbing systems and poor construction, housekeeping and maintenance can result in "environmental niches" where pathogens or allergenic organisms can collect and multiply to be reintroduced into the air[8].

Similarly, there are many mechanisms which remove contaminants from the indoor air. General and local exhaust systems are important as is the uncontrolled exfiltration of inside air. Particles also settle out due to gravitational forces and are precipitated on surfaces by electrostatic forces, diffusion and air motion.

Vapors and gases can be absorbed or adsorbed on materials of many kinds, and can react with other airborne pollutants and be changed in character. Ozone reacts with many substances to become O_2. All of the above mechanisms occur all the time at generally uncontrolled rates.

Standards (mandatory limits) and guidelines (suggested limits) have been established for many pollutants in the indoor air[6,7]. Many of these have not been accepted as technically sound. Much work on standards and guidelines remains.

Air cleaners can also be used to remove contaminants. Particulate removal is well developed. Gaseous removal is less so, with activated charcoal and potassium permanganate being best developed.

The complexity of the problem requires careful research planning employing many technologies. Otherwise, data collected will have limited utility for providing a useful data base for the development of generally applicable economic methods for improving indoor air quality and for generating national policies.

ASHRAE's original work on ventilation[9] was conducted for the purpose of establishing criteria for comfortable, non-annoying environments. Over the years, comfort has been an important consideration in ventilation standards[6]. Discomfort motivates people to try to regulate their environment by opening windows, etc. A question arises as to whether discomfort due to air quality perceptions or thermal effect is, or can become, a health problem by reducing the body's defense against disease[2]. Certainly air quality and thermal comfort must be provided for in any solutions to air quality problems. In about one-half of the "sick building" investigations to date, the only significant findings were that good ventilation and/or thermal control were perceived to be lacking. Subjective responses often indicated that the environment was "stuffy" and "too warm"[2].

The engineering aspects of ventilation solutions should also be emphasized. More effective ventilation systems, air treatment devices, material substitutions, and barriers to source emissions are all being investigated and hold the promise of cost-effective solutions when more research on acceptable contaminant levels is complete.

For this summary, several contaminants of importance are discussed. For each, current knowledge is covered, as well as needed technical advances. Each pollutant is described. Its sources and, where not obvious, its entry into the indoor environment are covered, as well as the geographical distribution and the general type of structure in which it is important. Existing standards and guidelines are mentioned. The comfort and health effects covered are categorized in three ways. The first is annoyance; i.e., the pollutant can be perceived by occupants as not desirable. The second is an acute effect resulting in symptoms of respiratory tract dysfunction or other short-term disease. The third is a chronic or long-term effect, which may take decades to produce, such as lung cancer, emphysema and heart disease. The state of measuring instrumentation is then covered. Current knowledge concerning mitigation techniques is treated, followed by a summary of suggested future research.

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Radon

Description - Radon is a radioactive gas, the first decay product of Radium-228. It is an alpha emitter with a half-life of 3.6 days. It decays further into solid alpha emitters which can become attached to dust particles and surfaces in the environment and become lodged in the lungs.

Sources - Radium is distributed in the earth's crust in widely varying concentrations. Well water and natural gas in some locations have high concentrations of radon. In some specific cases (Sweden) masonry building blocks have high radium concentrations. The earth around buildings is the principal source and radon penetrates cracks and drain openings in foundations, into basements and crawl spaces. Water containing radon will outgas into spaces when drawn for use indoors. Some building materials will outgas radon, some of which may enter buildings.

Location and Type of Structure - Geological studies have indicated geographic areas of high radon concentration in soils and water[4]. Therefore, attention has been given to these areas. It is not possible, however, to predict which subgroup of structures will be problems, due to the many other factors involved such as the fill variations around buildings and the foundation tightness. Radon is associated primarily with low-rise residential dwellings with concentrations higher in basements than in upper floors.

Standards and Guidelines - Several standards and guidelines exist. The U.S. Mine Safety and Health Administration[10] uses 16 picocuries per liter as its maximum radon level for action. The U.S. Bonneville Power Administration (of DOE)[10] uses five as its maximum level and the Environmental Protection Administration[10] and ASHRAE Standard 62-1981[6] use four and two respectively.

Comfort and Health Effects - No sensory perception or acute health effects are known. The chronic effect is suspected to be lung cancer or other lung dysfunction due to retention in the lung of radon decay products. These chronic effects are among the best known, as the result of studies on uranium miners for many years[11]. It is speculated that non-occupational radon exposure in the U.S. may cause between 2,000 and 20,000 additional cancer deaths per year, and that one million U.S. dwellings have concentrations which may cause a significant risk to their occupants[12].

Measuring Instruments - Relatively inexpensive passive track-etch detectors (less than $50) are available for survey use, integrating radon concentration over a one- to three-month period. Air sampling instruments (scintillation counters for example) are more expensive. No inexpensive method exists to measure radon daughter concentrations.

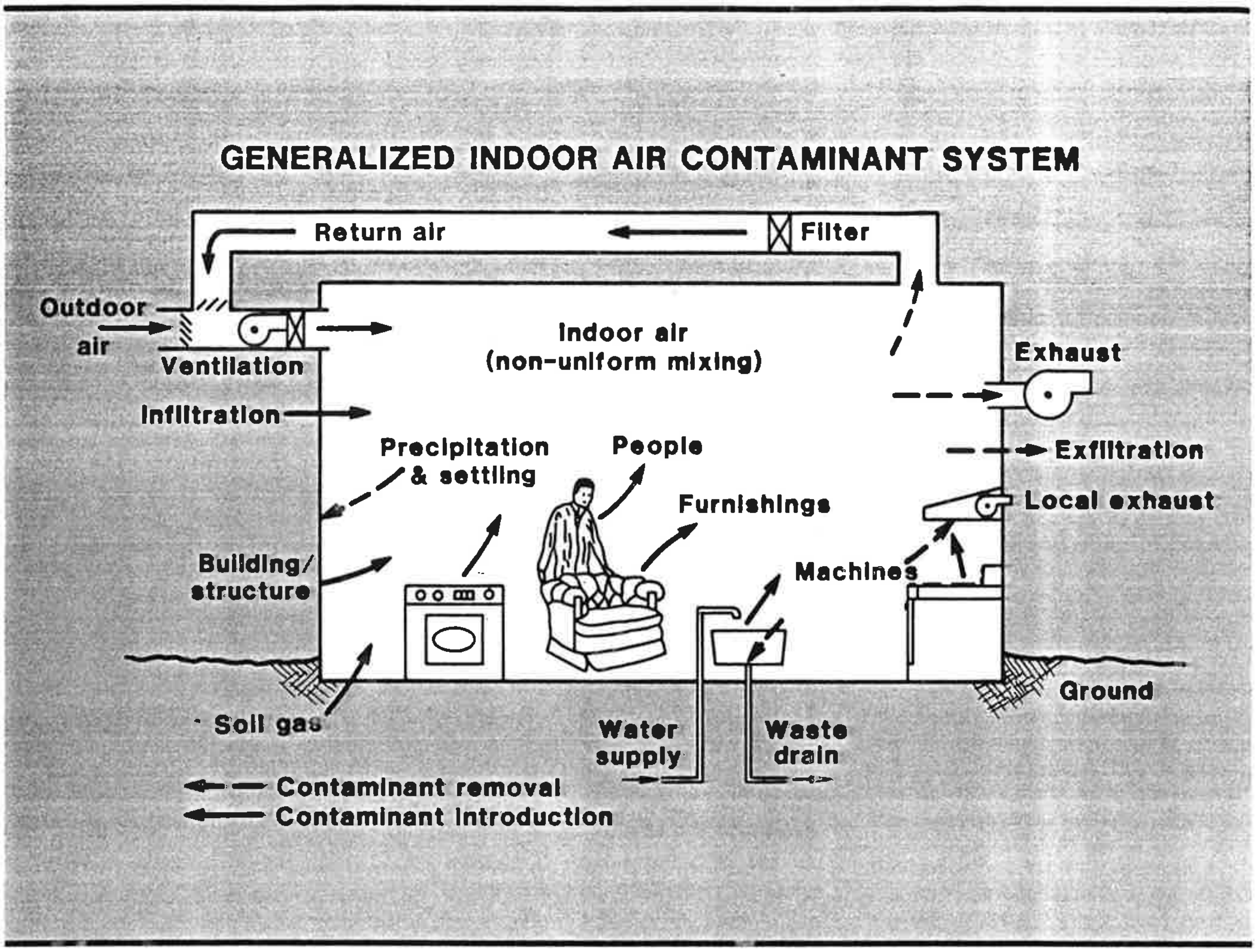
Mitigation Measures - Scaling of foundations to prevent entry has been demonstrated to be effective[13]. Specific ventilation of basement areas and crawl spaces has also been shown to be effective. Increased ventilation with outdoor air will lower radon levels for a given building. However, radon levels do not correlate well with ventilation rates among different buildings[3]. This is because source strengths of soil radon are quite variable. Therefore, increased ventilation cannot lower radon levels enough in all buildings.

Important Areas for Future Research - Predictive models to assist in pinpointing problem structures are needed. Development of better cost-effective mitigation methods, devices and materials are needed. Better standards are needed to guide economic mitigation measures.

Asbestos

Description - Asbestos is composed of small natural mineral silicate fibers widely used in insulation and other building materials until recently. The use of asbestos-containing spray-on materials is banned in U.S. buildings today[14].

Standards and Guidelines - There is currently no known maximum "safe" concentration. The U.S. National Institute of Occupational Safety and Health (NIOSH) is using a level of 0.1 fibers



longer than five μm per cubic centimeter (f/cm^3) as the level above which abatement action must be taken.[15]. Currently there is discussion as to whether a level of 0.01 f/cm^3 may be more appropriate.

Comfort and Health Effects - Fibers deposited in the lung are the only known cause of mesothelioma, a fatal cancer of the pleural or peritoneal area of the lung. Asbestosis and other lung conditions also have been identified.[16]. Extensive studies with asbestos workers have established the seriousness of these chronic problems.

Measuring Instruments - Phase contrast microscopy is used as a screening method for sampling asbestos fibers in the air[15]. A sample is collected on a membrane filter. Part of the filter is treated chemically to render the filter transparent. Particles are observed for shape and size, and the results are presented as f/cm^3 of five or longer. Fibers other than asbestos (e.g., glass, cellulose) are also counted[17]. However, electron microscopy is a method, which can distinguish asbestos definitively, but is much more expensive.

Mitigation Measures - Asbestos abatement in the U.S. is being handled as a special important case separately from other air pollutants by U.S. agencies due to the perceived high public risk[14,15]. Reference 17 gives a more complete discussion of asbestos in buildings and suggested abatement guidelines. References 15 and 18 contain some regulations.

Areas of Future Research - Due to the time-varying nature of fiber release into the air caused by a number of activities in buildings, a better method of assessing the exposure of occupants is needed. Health effects of low exposure levels needs further work, as does the measurement and abatement methods which are very expensive.

Tobacco smoke

Description - Tobacco smoke consists of particulates and gases resulting from tobacco combustion. Particles of condensed combustion products are almost all in the respirable range, and over 2,000 specific materials have been identified in the particles and associated gases so far[19].

Standards and Guidelines - No general levels have been agreed upon. ASHRAE Standard 62-1981[6] specifies dilution with smoke-free air in quantities of 7-17.5 L/s per person, where smoking is permitted, depending upon the type of space. The standard is currently being revised but no significant change in these levels is now contemplated.

Comfort and Health Effects - Most people who do not smoke object to smoke in their environments as an annoyance[19]. Tobacco smoke's health effect on nonsmokers (passive smoking) has had increased research attention recently[19]. Its effects on smokers are well known. Acute health effects have been found in the lung function of children and spouses of smokers[20]. Allergic reactions occur in a fraction of the population. Some studies suggest that the chronic lung cancer risk of nonsmokers exposed to significant levels of smoke may be twice that of people who are not exposed to significant passive smoking[21].

Measuring Instruments - Particulate concentration is measured on filters. Gas chromatographs are used for gases. Enough work has been done so that reasonable estimates of the source strength can be made by simply counting smokers and knowing that about 30 percent of adults each smoke about two cigarettes per hour while active[2].

Mitigation Measures - Prohibition of smoking in public spaces is becoming more common. Isolation of smokers is partially effective, but it usually also requires careful management of ventilation to be most effective[16]. High efficiency air cleaners and gas filters are sometimes effective, if well applied and properly maintained. Increased ventilation is partially effective, but dilution in general spaces is often not totally effective, since very large ventilation rates are necessary to dilute smoke enough to be unobjectionable to nonsmokers.

Areas of Future Research - Better quantification of health effects on nonsmokers is needed. The development of more economical filter systems and ventilation strategies are needed.

Formaldehyde

Description - Formaldehyde (HCHO) is a colorless water-soluble gas, which, due to its wide use and possible health effects, is such an important volatile organic compound (VOC) as to be considered separately.

Sources - Materials containing formaldehyde are widely used in buildings, furnishings and consumer products. Urea-formaldehyde resins are used in the manufacture of plywoods, particleboards and textiles. Some buildings have been insulated in the side walls with urea-formaldehyde foam insulation (UFFI). This product is banned in Canada and unsuccessful attempts were made to ban it in the U.S. The resulting publicity has effectively closed that market. However, in the U.S., as many as 500,000 homes have been insulated with UFFI. Formaldehyde outgases from the above-mentioned products and UFFI has been a serious problem in many residences. Mobile homes have been particularly affected because of their small volume and the large amounts of formaldehyde-containing products found in them. Tobacco smoke and other combustion products are lesser sources. Indications are that time diminishes the outgassing from materials, so concentrations in spaces diminish with time. However, several years may be necessary to alleviate some problems.

Standards and Guidelines - There is much controversy on appropriate maximum levels for human occupancy. Scandinavian countries have established 0.1 ppm as a limit. ASHRAE has also included 0.1 ppm in its Standard 62-1981[6], but the standard has yet to be made mandatory because of the controversy. Some states in the U.S. have established 0.4 ppm in their codes for residences.

Comfort and Health Effects - Formaldehyde has a pungent odor and is easily detected by most people at levels of about 0.1 ppm[20]. Besides the annoyance, it also causes acute eye burning and irrates the mucous membranes and respiratory tract[22]. Formaldehyde has also caused nasal cancer in laboratory animals, but the chronic effects have not been established for human beings[12]. A number of people exhibit a high sensitivity to very small concentrations[22].

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Measuring Instruments - Inexpensive passive samplers have been developed but their accuracies are not well established[3]. Formaldehyde is extracted from the solid adsorbent in the passive samplers by water. The more traditional method of collecting formaldehyde is by impingers. Formaldehyde concentrations are usually determined by the pararosaniline or chromotropic acid methods. A third, the acetylacetone method, is less common[3].

Mitigation Measures - For problem UFFI cases, removal is indicated. The cost can be as high as $20,000 for a residence. Even then, residual material may remain in the structure and continue to outgas. Increased temperature, humidity and ventilation will accelerate outgassing. Manufacturers are producing products with much lower outgassing rates. In the U.S., the Department of Housing and Urban Development has developed a product standard for emission rates of plywood and other wood materials for manufactured housing[23]. Some surface treatments are being used to seal against outgassing.

Areas for Further Research - Concentration standards need further development. Product standards to limit outgassing need further development and application. More practical remedial measures to use in existing buildings are needed. Better material outgassing characteristics and models are needed.

Nitrogen oxides

Description - NO_2 is a highly reactive oxidant. NO is also often present with NO_2.

Sources - The primary sources indoors arise from combustion processes, such as unvented gas ranges, other unvented heaters and tobacco smoke. Unvented heaters are experiencing increased use in residences recently in the U.S. due to their perceived energy-saving potential in dwellings.

Standards and Guidelines - None have been agreed to for indoor air. The U.S. National Ambient Air Quality Standards list 100 $\mu g/m^3$ as the long-term limit[7].

Acute effects

Comfort and Health Effects - Oxides of nitrogen have no sensory effect in low concentrations. Acute effects of lung dysfunction have been reported. Chronic effects are not well established.

Instrumentation - Small passive NO_2 monitors suitable for field use are available[3].

Mitigation Measures - Venting with outdoor air at the NO_2 source is the most practical measure for existing conditions. Limited exposure to sources through behavior modification could be of some benefit. Manufacturers are developing devices having lower NO_2 generation.

Area of Future Research - Better methods of predicting where problems exist and the development of more practical mitigation measures are needed.

Volatile organic compounds

Description - There are hundreds of other volatile organic compounds (VOC) that are found in the indoor air, sometimes in concentrations which are suspected of being harmful. The following are some examples, but not a complete list: acetone, alcohols and acids, which are effluents from peoples' metabolism; aromatic hydrocarbons, which come from various combustion products; chlorinated hydrocarbons and organophosphates, which come from pesticides; and chlorinated compounds, acetone, ammonia, toluene and benzene, which come from building materials, personal care products, cleaners and paints.

Measuring Instruments - Gas chromatographs are used for laboratory and some field studies. No inexpensive monitors suitable for extensive field use exist.

Standards and Guidelines - None have been set for indoor air. NIOSH[24] has set occupational standards for many compounds. ASHRAE Standard

62-1981[6] includes a rationale suggesting that in the absence of better data, the NIOSH limits be divided by 10, to account for the possible continuous, rather than workplace, time of exposure, and to account for the elderly, young and infirm in the general population as opposed to the working population.

Comfort and Health Effects - Several of these compounds have been identified individually as causing acute and chronic effects at high concentrations[24]. Some cause cancer. The effects of combinations of these compounds at low concentrations have been suggested in several "sick building" investigations[2].

Location and Type of Structure - These are widely distributed in all building types.

Mitigation Measures - Where practical, uses of these sources should be restricted and these materials should be stored in well ventilated areas apart from occupied zones.

Areas of Future Research - Determination of the health effects of combinations of VOC at lower concentrations found in buildings is a need. Inexpensive sensors would be useful. Practical removal hardware and other control devices are needed. Studies of substitute-material compositions for lower emissions are needed.

Carbon monoxide

Description - CO results from incomplete combustion of carbon in fuels. It is colorless, odorless and tasteless.

Sources - Any incomplete combustion may cause high concentrations in inside air. Gas ranges, unvented heaters, leaky wood and coal stoves, and tobacco smoke are indoor sources. Only worn or poorly adjusted and maintained combustion devices seem to be significant indoor sources. Automobile exhaust may enter houses from attached garages and enter other buildings built over garages or near busy trafficways.

Standards and Guidelines - The U.S. National Ambient Air Quality Standards lists 40 mg/m^3 as the one-hour limit[7].

Comfort and Health Effects - Acute affects are due to the formation of carboxyhemoglobin in the blood, inhibiting oxygen intake. In moderate concentrations, cardiovascular disease, impaired vision and loss of brain function may result. At higher concentrations it is fatal[4]. CO is a serious problem in dwellings in developing countries due to unvented heating and cooking uses.

Instruments - Some relatively high-cost infrared-radiation absorption instruments exist.

Mitigation Measures - It is most important to be sure appliances are clean and properly adjusted. Automobiles should not be run in attached garages. Additional ventilation can be used as a temporary measure when CO is expected for short periods of time.

> **"CO_2 has been proposed as an indicator of general air pollution problems and body odors when human occupancy is the major cause of pollution"**

Areas for Further Research - CO and its perils have been well known for a long time and public awareness is high. A low-cost alarm system is needed which could save some of the CO-related deaths.

Carbon dioxide

Description - CO_2 is an odorless, tasteless and colorless product of complete carbon combustion.

Sources - All practical combustion processes and metabolic processes are CO_2 sources.

Location and Type of Structure - CO_2 is primarily associated with residences since unvented combustion is not usually permitted in other buildings. Low concentrations of CO_2 from people and smoking in buildings are almost always present.

Standards and Guidelines - NASA employs CO_2 levels of one percent or less for space environments, and U.S. submarines operate at 0.7 percent or less, indicating that young people in good health can perform without hazard at these levels. World Health Organization (WHO) guidelines[25] are 0.5 percent for indoor air and ASHRAE Standard 62-1981[6] sets 0.25 percent as the upper limit. The outdoor level is usually 0.03 percent. Indoor concentrations ar usually in the range of 0.1 percent.

Comfort and Health Effects - At concentrations above one percent in air, some loss of mental acuity has been noted. No major comfort or health effects in buildings have been noted because building levels are well below one percent.

Measuring Instruments - Instruments exist which are reliable and inexpensive enough for some commercial ventilation applications.

Area for Further Research - CO_2 has been proposed as an indicator of general air pollution problems and body odors when human occupancy is the major cause of pollution. But as is seen in this article, many other important pollutants which are not related to CO_2 can often be present. It has also been tested experimentally as a "people-counter" in buildings to control ventilation proportional to the occupancy as an energy-saving strategy. Lower cost sensors and more field demonstration are needed.

Microorganisms

Description - Biological material, bacteria, viruses, mold spores, pollens, insect parts and feces, house dust mites, etc. are ubiquitous in indoor environments. These particulates range from less than one to several μm in size. When airborne, they are usually attached to dust particles of various sizes so that all sizes of airborne particulates may include them.

Sources - People and pets "shed" such materials. Indoors, bedding, carpeting and other places where dust collects can harbor them. Cooling towers have been known to be incubators of legionella. Dirty air-conditioning equipment, humidifiers, condensate drains and ductwork can incubate bacteria and molds[2]. High humidity areas exacerbate their growth.

Standards and Guidelines - No standards for general indoor air applications exist. Cooling tower treatment procedures to reduce legionnella do exist[26].

Comfort and Health Effects - Tuberculosis, measles, small pox, staphylococcus and influenza are known to be transmitted by air as is legionnaires disease[16]. Upper respiratory disease, causing each person an average of about four days restricted activity per year, is a large cost associated with airborne transmission[16]. "Indoor airborne viruses and bacteria are the most important cause of acute disabling illnesses in the U.S."[27]. Pollens, molds, etc, cause allergic reactions for a significant portion of the population.

Measuring Instruments - Air samples can be collected on filters or impactors and incubated for visual examination of viable growths. Microscopic examinations of collected dust can be used to identify molds and pollen. No inexpensive field monitors exist which are suitable for large-scale use. Coated microscopic slides and Petri dishes, which collect settled particles for laboratory analysis, have limited utility in surveys.

Mitigation Measures - Good housekeeping and maintenance of air-conditioning equipment is important. Adequate ventilation and good air distribution can help. High-efficiency air cleaners remove viable particles.

Areas for Further Research - The relationship of concentration of pathogens in the air to disease transmission is not well established. More economical air-treatment devices are needed, as well as better understanding of the roles of housekeeping and air-conditioning systems maintenance.

Even with the extensive work to date, much more needs to be done before being able to answer, in a practical way, the questions posed by any building owner or occupant. They are: How do I determine if a have an indoor air quality problem? And, if I do, what can I do about it?

Comfort and health effects need to be better determined. Verified predictive methods, inexpensive monitors and extensive field surveys are needed before the first question can be answered.

The answers to the second question depend upon advances in methods for improving ventilation efficiency and mixing methods and better mitigation techniques leading to more practical solutions.

Work planned in the U.S. by the Government Interagency Committee on Indoor Air Quality[12] will address these problems by directing further research on the following general thrusts:

Task 1. Determination of Indoor Air Pollutant Sources and Factors Affecting Human Exposure.

Task 2. Characterization of Indoor Air Quality in the United States.

Task 3. Determination of the Relationship Between Energy Conservation and Indoor Air Quality.

Task 4. Determination of Health Effects of Indoor Air Pollution.

Task 5. Development of Effective Control and Mitigation Techniques.

Task 6. National Multi-Pollutant Field Survey.

The Interagency Committee on Indoor Air Quality was formed to respond to a Congressional request to better coordinate the programs of the various Federal Agencies. There are 15 Federal Agencies represented in this effort. The report[12] recognizes the extensive work already done on these six tasks and recommends a coordinated program contributing towards the multi-pollutant survey planned for late 1987 and 1988. A national radon survey could be completed earlier since that program is much further advanced. Formaldehyde (CHCO) research is also advanced and a special survey for it could also be undertaken before 1987. ■

"...Much more needs to be done before being able to answer, in a practical way, the questions posed by any building owner or occupant"

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