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Building-related factors to consider in indoor air quality evaluations

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Abstract

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Many factors should be considered in an indoor air quality (IAQ) evaluation, and many of these factors are interactive. This article identifies building-related factors that may contribute to IAQ problems. Sixty percent of IAQ problems are related to ventilation and 30% result from air contamination, 20% from inside the building and 10% from outside the building. The remaining 10% are due to miscellaneous other causes (ref. 1). Specific problem areas for each of these categories

are discussed in this article. Elements of a proactive management style are also discussed, because management styles can influence how an IAQ episode is handled or prevented. (J ALLERGY CLIN IMMUNOL 1994;94:385-9.)

IAQ Indoor air quality



A wide range of factors should be considered in every indoor air quality (IAQ) evaluation. This article will discuss building-related factors. A summary of building-related factors that should be addressed in an IAQ evaluation is provided in ■Table I.

TABLE I. Building-related factors

- Site characteristics and prior land use
- Geographic variations and climate
- Building age
- Occupancy and zone loading
- Building design and construction
- Building maintenance
- Outdoor air quality
- Infiltration and building envelope integrity
- Heating, ventilation, and air conditioning system design and maintenance
- Renovations: controls used during renovation and materials used
- Renovations without mechanical system changes
- Furnishings
- Management style

Site Characteristics and Prior Land Use TOP

As a result of the pressure of continued population growth, land that previously had been considered undesirable is being reconsidered for development. Sites that have served several past purposes unrelated to the existing building are frequently encountered, and this situation will become more frequent.

Suburbs and housing developments have now encroached into areas that were once predominantly waste disposal sites or agricultural areas. Because many homes are now built “slab on grade,” the floors and the slab penetrations of the house are often in direct contact with soil that had been treated for many years with an assortment of chemicals, some of which have extended chemical

half-lives. In some documented cases contaminated agricultural lands have been the causal agent in home IAQ complaint episodes in Texas, Florida, and California. The environmental assessment literature is replete with situations where homes, offices, and other commercial buildings have been built on top of chemically contaminated soils from prior waste disposal sites, chemical facilities, or gasoline stations.

The original site may not be the only concern with respect to contaminated soils. Another concern involves fill dirt that may have been brought onto the site. In Florida, radon-bearing fill dirt was added to low-lying areas at several sites, which resulted in elevated indoor radon levels.

Geographic Variations and Climate

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Geographic variations and climate may include differences that are as obvious as the differences between South Florida and Minnesota. Each building site has problems that are unique to the location and climate. Location and climate factors are often important when a company has offices in various parts of the country and tries to build identical buildings at each of these different locations. Problems such as vapor barrier placement in the walls, insulation, heat, and humidity load calculations, and anticipated air conditioning duty times are factors that can greatly affect the design of the building with respect to geographic variations. For example, the hot, dry conditions of the Southwest may present very different IAQ challenges than the hot, humid conditions found in the Southeast.

Geographic variations and climate factors can be localized. In parts of Florida, Pennsylvania, and various western states there are known areas of elevated soil radon levels.² For example, within some Florida counties, home and office design must include radon remediation or control, whereas a few miles away the background radon level in the soil is barely detectable. Even at the sites that have elevated radon levels, seasonal climate and rainfall can significantly change the radon level in those buildings.³

Building Age

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Buildings are similar to people in that, although problems can occur at any age, the types of problems encountered during infancy, the “teens,” and old age are often very different. In a study that the author conducted in Florida, an IAQ risk profile was developed for buildings of various ages.⁴

New buildings often have IAQ problems that are associated with building material chemical emissions or inadequate outdoor air flows as a result of inadequate design or “test and balance” of the system. Biologic growths may be a problem in some new buildings, but generally this problem in a new building is the result of inadequate protection of the building materials or air handler system during construction. In the humid Southeastern states, excessive biologic growths generally become an issue after the building is approximately 8 to 10 years old.⁴

Age can also become a factor because during its lifetime a building is likely to be used for purposes

for which it was not originally designed. Walls are often installed without addressing the problems that will be created by deviating from the original mechanical engineering air flow pattern through the building. In addition to planned changes there are also unforeseen factors, such as increased roof and window leaks. These types of problems can also contribute to building deterioration, excessive microbial growths, and repair emission sources. In addition, as a building ages, the owners often fail to modify their maintenance activities until after a problem has occurred.

Occupancy and Zone Loading

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As was mentioned previously, the existing building purpose may be very different from the original purpose, and the types of operations and number of people in the space may be very different from that for which the building was constructed. Although the total number of people in a building may not have changed, the number of people in a particular zone may have increased and can exceed the design air flows for that area. "Tight building" types of complaints may occur in this latter situation and include symptoms such as frequent headaches, excessive tiredness, and eye and upper respiratory irritation.⁵

Building Design, Construction, and Maintenance

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The design and building construction techniques can have a significant bearing on IAQ in the building. Besides the more obvious factors, such as building material emissions, vapor barriers, and building envelope integrity, subtle factors such as the number of square feet allocated for mechanical services can have a significant impact on the future maintenance of the equipment. If air handler equipment is not properly serviced and maintained because of inadequate access, excessive microbial growth conditions can occur. These excessive microbial growths in the air handlers can cause allergic, toxic, and infectious problems in the building.

As was pointed out previously, the types and frequency of building maintenance also may need to be changed as a building ages. A failure to make these maintenance changes often results in IAQ problems. The improper selection or misuse of maintenance chemicals, such as pesticides, carpet cleaners, air handler system cleaners, and deodorizers, are periodically the cause of an IAQ problem.

Outdoor Air Quality

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It is not uncommon when investigating an IAQ problem to find that the source of the problem is located outside the building. Probably the best documented example of this situation was the outbreak of Legionnaire's disease in Philadelphia.⁶ Outdoor air may contain biologic agents (allergens, infectious agents from cooling towers, roof water retention, fountains, or sewer stacks) or odoriferous or toxic chemicals (ambient air contaminants, combustion products, or building exhausts). Although these agents are usually brought into the building by the intake of outdoor make-up air, building leakage should also be considered.

Infiltration and Building Envelope Integrity

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Infiltration and building envelope integrity is sufficiently important that it should be addressed separately, although this issue maybe directly related to building design, outdoor air quality, building operation and maintenance, and management priorities. Ideally, outdoor air flow into a building should be controlled and conditioned before its entry within the building spaces. Most building envelopes appear to be superficial barriers to uncontrolled air flows. In reality, most conventionally constructed buildings have significant porosity through this envelope, which allows contaminants, heat, and moisture to enter these exterior barriers. Operating a building under a slight negative pressure, that is, by exhausting more air than is being purposely brought into the building, can greatly exacerbate this problem.^{7, 8} For example, moisture may be drawn into a building's wall cavities by leakage, negative pressurization, or both, which can result in surface mold growths and bioaerosol releases.⁷ The building envelope includes not only the roof and walls, but also the flooring. Radon can penetrate the floor envelope and become a problem in buildings with inadequate make-up outdoor air flows and negative pressurization.⁸

Indoor air quality problems that are associated with infiltration can be caused directly by the material that is brought into the building or indirectly by allergen or biotoxin production inside the building secondary to moisture infiltration. In urban environments, vehicle emissions can be drawn into the building and result in odor, chemical irritation, or toxic effects. Mold spores and other outdoor allergens can be pulled into structures that have large amounts of vegetation next to them.

Heating, Ventilation and Air Conditioning System Design and Maintenance

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Air handler design problems exist in both commercial and residential systems. Air handler system design problems that can contribute to IAQ include the following: insulation materials on the inside of the air handler system (air handler and ducts); flat bottom condensation pans with side-mounted drains that allow condensate water to pool; low efficiency filters; short-circuiting of supply air to the return ducts; and improper air flows and distribution.

Ventilation-related problems are the most frequently encountered cause of IAQ complaints and account for more than 60% of IAQ problems. Inadequate air flow and distribution are the principal ventilation-related problems. Inadequate outdoor make-up air flow can result from poor initial design, outdoor dampers closed to "save energy," inadequate maintenance of dampers and control linkages, and obstructed outdoor air screens. Inadequate air flows to a space can result from the fan being linked to the thermostat (which operates the fan only when there is a demand for heating or cooling), building renovations without changes in the mechanical engineering, variable air volume boxes that close excessively when the temperature to the space is satisfied, broken or slipping fan belts, poorly balanced air systems, air registers obstructed by occupants, and improper pressurization and exhaust flows from the building.

Renovations

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IAQ complaints occur frequently after building renovations have been completed. These types of problems can result from contamination of the air handler system with dusts during construction, the use of materials with high off-gassing rates, or inadequate air handler systems to accommodate the intended use of the space. It is necessary to remove asbestos building materials before the renovation if asbestos materials are likely to be disturbed in the process. Solvents are often used during the removal of asbestos floor mastics, which can result in persistent odor and chemical irritation complaints long after the space has been reoccupied. The source of this persistent problem is usually found in floor cracks or under wall baseboards, or the problem may result from improperly rinsed floors. Inadequately rinsed floors can present future problems with improper curing of adhesives for future floor coverings.

During some construction and in most renovations, the air conditioning system operates during the inside “build-out” construction phase. Unfortunately, the contractors are not required to upgrade the filter removal efficiency or protect the return air ducts or plenum from excessive dust accumulations during this time. These construction dusts can be carried throughout the air handler system and building and can contaminate surfaces. The immediate health concerns are usually associated with eye, nose, and upper respiratory system irritation. These materials, if left in the air handler system, can become a nutrient source for many types of microbes and result in bioamplification within the building and air handler system. The health concerns from this bioamplification result from exposures to microorganisms and their products.

A building owner who fails to address the potential contamination of the air handler system during renovations also usually lacks awareness or concern about products with elevated emission rates and the required air flows to accommodate the needs of the space. Thus several different types of IAQ problems are frequently encountered simultaneously after renovations.

It is not uncommon that the renovations of many public buildings (especially schools) and some lower-priced commercial spaces involve the installation of walls and doors without any changes in the mechanical air handling system. The types of IAQ problems that can occur in adjacent rooms can vary and may include “tight building” conditions, excessive cooling or heating, wide temperature fluctuations, persistent odors, and stale air conditions. Increased rates of upper respiratory illness may also be observed in the rooms with inadequate air flows.

A change in furnishings after renovations may be the source of IAQ complaints. Less than approximately 10% of reported IAQ complaints have been linked to furnishings, although furnishings are frequently suspected by the lay community. Manufacturers have become aware of these types of problems, and many products have either been removed from the market or redesigned to reduce the emissions. A classic example of such beneficial changes is the problem of formaldehyde emissions from building materials and furnishings. During the late 1970s and early 1980s, formaldehyde emissions and upper respiratory irritation complaints were frequently encountered in IAQ investigations. Formaldehyde resin manufacturers aggressively worked on product quality control and modified chemical formulations, and users became more aware of the potential of formaldehyde problems with certain products. The result is that product emission problems from formaldehyde are currently less frequent.

The role of management styles in the area of IAQ has often been inadequately addressed. Two aspects need to be addressed in solving all IAQ complaint episodes. These two aspects include the technical issues associated with the causes and corrections of the problem and the “people aspects.” The management of the “people aspect” of a IAQ problem determines if the problem expands into an uncontrolled event or is limited in scope and restricted only to the areas that actually have a problem. A proactive management style not only reduces the likelihood of adversarial roles evolving between labor and management but also results in prompt resolution of the episode once the problem has been diagnosed and a plan of correction has been announced. Persistent or recurring IAQ complaints in a building generally reflect a lack of understanding or concern by management about IAQ problems. This lack of awareness or sensitivity is often the trigger that initiates much of the litigation that arises from these episodes. Management can greatly reduce much of the unwanted publicity, bad employee relations, and recurrence of complaints by becoming proactive in the initial complaint stages. A good manager will be proactive, genuinely concerned about possible problems, and aggressive in seeking qualified professionals to conduct an evaluation. One of the worst mistakes a manager can make is to dismiss IAQ complaints as “women's problems” or “usual complaining” by a particular group or person. It is not uncommon for complaints to be made by a small group of employees because IAQ problems are often isolated to particular sections within a building. Some employees, such as those with sinusitis or inhalant allergies, may be predisposed to low-level continuous chemical exposures. These predisposed persons tend to be affected sooner and more seriously than other employees. Management should conduct an informational meeting with concerned building occupants once the IAQ evaluation has been conducted and the causes and solutions determined. It is often helpful if a knowledgeable health professional is present during this meeting to answer questions and dispel any misinformation that may have arisen. Unfortunately, many physicians are not properly trained to serve in this capacity or are not up-to-date on these issues. Management should use this time to reassure employees that the problem is being taken seriously and that the cause of the problem will be promptly eliminated or corrected. Interim measures to provide relief should be discussed if the solution will require an extended time for correction.

A proactive management style is important not only in dealing with an IAQ episode but, more importantly, in preventing potential IAQ problems. Proactive measures that help minimize IAQ problems include ensuring that the building complies with currently recommended IAQ guidelines, maintaining and servicing the building properly, establishing avenues for IAQ complaints to promptly come to the attention of management, and minimizing chemical exposures of employees by scheduling maintenance services (pesticide applications, cleaning, and air handler cleaning) during unoccupied times.

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