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Indoor Air Quality

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Abstract

[Excerpt] “Indoor air quality or IAQ” is what we experience as the temperature, humidity, ventilation, and chemical or biological contaminants of the air inside non-industrial buildings, such as schools, offices, hotels, or banks – environments typically considered pristine when compared with industrial settings. In today’s world, we spend about 90% of our day indoors and the pollution indoors can be 2 to 5 times – and occasionally more than 100 times -- higher than outdoor levels. After all, we humans exhale (and otherwise produce) the endproducts of metabolism. We shed hair and dander. We have in our buildings all kinds of textiles, equipment, paper, cleaning products, and maintenance activities – so the air can be very different from “fresh outside air.” We notice this difference – sometimes simply as odors and sometimes as symptoms such as:

• irritation of eyes, nose, or throat

• dry mucous membranes and skin

• erythema – reddening or flushing of the face or skin

• mental fatigue, headache, sleepiness

• airway infections, cough

• hoarseness, wheezing

• nausea, dizziness

• hypersensitivity reactions.

Studies of buildings have indicated that poor IAQ can cause health problems, affect occupants’ productivity and reduce learning, as well as have liability issues and cause poor public relations – a building gets a bad reputation which affects leasing and purchasing.

Keywords

indoor air quality, industrial settings, non-industrial buildings, irritants

Comments

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- hypersensitivity reactions

Studies of buildings have indicated that poor IAQ can cause health problems, affect occupants' productivity and reduce learning, as well as have liability issues and cause poor public relations – a building gets a bad reputation which affects leasing and purchasing.

Overall, there appear to be higher costs to fix problems than to prevent them. So, if we suspect an IAQ problem, how might we investigate it? Because, without a comprehensive building investigation, sampling results alone are only of limited value. So, let's look at some typical causes and solutions of IAQ problems. In a nutshell, a basic indoor air investigation consists of:

1. Collecting information from building occupants concerning the nature of the complaints; checking for patterns of symptoms and times at which they occur. (Medical expertise may be needed to investigate serious health problems.)
2. Investigating building ventilation for the nature of its operation, its adequacy, and maintenance; verifying with carbon dioxide or other measurements as appropriate
3. Seeking out sources of contaminants (sometimes with sampling or monitoring) which may originate from:
    a. inside the building

b. outside the building
c. biological contamination (fungi, "mold,", "mildew" and other) of the building
d. building construction materials ("building fabric")

4. Reporting and discussing findings and recommendations.

The USEPA recommends that building occupants should be kept informed during the entire process of indoor air quality (IAQ) investigation and mitigation including:

- how the investigation is progressing, the types of information being gathered, and ways that they can help the process along
- the nature of the health problems being reported; this enables occupants to put their symptoms into perspective
- how long the investigation is expected to last
- any attempts which are made to improve indoor air quality
- any remaining work which needs to be done and the schedule for its completion

BASIC INFORMATION ON THE BUILDING AND ITS HISTORY

How is the building constructed? Any remodeling/redecorating, storm events, sewer backups, flooding, or other problems?

VENTILATION INADEQUACY AS A SOURCE OF INDOOR AIR PROBLEMS:

Ventilation can be "inadequate" for one or more of several reasons. There may simply be insufficient fresh outdoor air being brought into the building, usually to lower heating/cooling costs; or the ventilation system doesn't match occupancy – it starts too late in the morning or shuts down too early in the afternoon. Sometimes there is poor air distribution and mixing – even an open-plan work area can have partitions down to the floor restricting airflow. Maintenance of the heating/ventilating/air-conditioning (HVAC) system can be improper, inadequate, or completely absent -- the accumulation of dirt and particulates (pollen, fibers, debris, bird nests and feces, leaves, etc) in air intakes, on filters, or in ductwork can lead to many health complaints, as well as provide habitats for microorganisms to flourish. A damaged bird screen on an air intake can allow all kinds of critters to enter, nest, and defecate in the ventilation system – and bring diseases with them.

One way to determine if there is sufficient fresh air supplied in a building to meet the needs of the occupants is to consult ASHRAE Standard 62.1 *"Ventilation for Acceptable Indoor Air Quality."* (ASHRAE is the American Society of Heating, Refrigerating, and Air-Conditioning Engineers.) This standard attempts to maintain good indoor air quality by recommending sufficient fresh air to keep the concentrations of carbon dioxide in the occupied spaces at no more than 700 ppm higher than the outside air concentration (typically about 400 ppm). Carbon dioxide is exhaled by people, so the CO_2 level inside the building is usually higher than that outside the building anyway. At these levels, CO_2 itself is not likely to be high enough to cause problems, but it is a useful surrogate –

especially as inadequate ventilation can cause other air contaminants to build up to concentrations at which they can cause symptoms.

For evaluating temperature and humidity in a building, the ASHRAE Standard 55 on *"Thermal environmental conditions for human occupancy"* is useful. This standard has charts recommending acceptable ranges of temperature and humidity for people in typical summer and winter clothing doing light, primarily sedentary, activity and aims for 80% of the occupants to be satisfied/comfortable. No minimum humidity limit is recommended for thermal comfort; however, very low humidity could produce skin drying, irritation of mucus membranes, dryness of the eyes, and static electricity generation. Also, very dry air can make us feel that temperatures are cooler. Similarly, the maximum recommended humidity addresses human comfort only, not the potential for high humidity levels resulting in condensation on building surfaces which in turn could lead to microbial growth.

INSIDE SOURCES OF INDOOR AIR CONTAMINANTS:

Exploring inside sources of air contaminants involves evaluating the processes and products which are used indoors -- many can produce irritants, allergens, or particulates in the air. Exposure to these items can be aggravated where there is a lack of sufficient ventilation as these contaminants cannot be diluted and flushed from the building (where this is possible for the contaminant in question). These are some possibilities:

- paints, varnishes, glues; often made with solvents
- pesticides, due to active ingredients and/or the solvent carriers
- offgassing from new carpets, floor tiles, wall coverings, furniture, partitions; especially plywood, particleboard, strand board, etc. or from new equipment such as computers
- custodial products used for cleaning, disinfecting, or polishing
- fibers from textiles, insulation, paper products, ceiling tiles, air filters
- ozone and nitrogen dioxide from xerography (photocopying); these gases plus ultrafine particulates from printers (especially laser printers)
- nitrogen oxides, sulfur oxides, formaldehyde, and miscellaneous other contaminants from smoking, cooking, pilot lights, heaters, boilers
- formaldehyde and dusts from carbonless copy paper

Due to the trend of adult-onset asthma, it is prudent to consider removing from the indoor environment potential triggers of allergy, such as fragrances. It is also important to convey to building occupants that they need to have any products that they bring into the workplace screened by the employer so that the employer can determine if such items are necessary and to obtain their safety data sheets (as per OSHA regulations), as well as provide any necessary training and protective measures. Note that custodial work and the use of cleaning products often occurs at night when ventilation in the building may be reduced (or even off). This means potential chemical

exposure for housekeeping staff, plus air contaminants remain in the building for the next day's occupants to breathe.

Solutions for inside sources may involve: choosing alternative products or processes for doing the task, scheduling the task to avoid exposure by building occupants, or using local exhaust ventilation (such as venting a high-use copier to the outside when more frequent replacement of the carbon filter on its exhaust is not sufficient).

The "dust" in a building can include grit, plastic dusts, fibers from carpets and clothing, human dander, pet dander (which people bring to work on clothing), pollen, mold spores, and dust mites (and their excrement). To reduce allergens, especially to dust mites, it could be helpful to upgrade the vacuum cleaner to one with a high-efficiency particulate air (HEPA) filter. While removing carpet can also help with dust mite problems, it is not always an option – especially if the workplace uses the carpet to control noise. While PCBs may be present in some finishes/sealants used on cabinets, typical levels in the indoor air are extremely low at pictogram per cubic meter of air.

Smoking, even when restricted to the outdoors, should be kept at a distance from air intakes or entrances. An alternative would be to move the smoking area further out into the parking area, provide a small shelter for it, or ban it from the property altogether.

OUTSIDE SOURCES OF INDOOR AIR CONTAMINANTS:

Exploring potential outside sources of indoor air contaminants involves looking at building exhausts as well as products and processes which happen adjacent or nearby to the building -- these could be brought into the building through air intakes or infiltration (leakage around windows and doors). Some examples would be exhaust gases from traffic (including idling delivery trucks) or exhaust air from the building (including boiler stacks and sanitary stacks) which is brought back in the air intakes. A building operated under negative pressure may result in the pressure differences causing the air flow where unwanted, such as backwards down the sanitary stacks. Solutions could include: raising stacks to allow better dispersal of exhausts, or separating intakes and exhausts through height or distance; or relocating air intakes. As NYSDEC has a regulation which limits the idling of vehicles, it could be helpful to put up signage forbidding idling and enforcing it for delivery trucks. ASHRAE 62.1 makes recommendations for the air intake minimum separation distance so that air intakes are well-separated from contaminant sources such as building exhausts, vents, and stacks.

BIOLOGICAL SOURCES OF INDOOR AIR CONTAMINANTS:

Investigation of biological sources tends to reveal that they are commonly related to a current or past history of building water damage from leaks, storm events, sewer backups, flooding, pipe breaks, or condensation, standing water in ducting or other parts of an HVAC system, biofilms on HVAC components (such as coils), or high building

humidity levels. Sometimes they are related to a very tight building causing the recirculation of aerosols from occupants coughing or sneezing. Other sources may include infestations of insects or rodents due to the availability of food sources, inadequate bird screens, or mites in paper storage or archival areas. Some contaminants may be allergens such as cockroaches, rodents, or pet dander (as noted above). It can be helpful to inquire whether a building has an integrated pest management program so that critters can be controlled using methods of lowest risk to occupants.

NIOSH has building mold assessment tools for general buildings and for schools which assist in evaluating water stains, water damage, and mold. Removable, cleanable rugs at doors can be very useful to stop dirt and moisture being tracked into the building where they can provide habitat for bacterial or fungal growth in carpets. Similar rugs should be placed at all doorways that lead into carpeted areas. A moisture meter can be used to determine if results would be expected to support microbial growth. Fixing a moisture or mold problem involves solving the water/moisture source and disinfection and remediation of salvageable items with disposal of items which cannot be salvaged. To address water concerns in a building:

- fix leaks in the building envelope as soon as possible
- fix plumbing leaks as soon as possible
- vent moisture-generating appliances, such as dryers, dishwashers, cooking, to the outside where possible
- perform regular building and HVAC inspections and maintenance as scheduled
- perform periodic inspection of ductwork and HVAC units; clean as needed using a vacuum with HEPA filtration
- don't let foundations stay wet; provide drainage and slope the ground away from the foundation
- avoid standing water in ventilation system components: prevent rain/snow from entering air intakes; use continuous drainage of cooling coils or condensation; disinfect moist areas

A damaged and loose bird screen should be repaired to prevent birds, insects, or vermin from entering the HVAC system and their droppings providing habitat for fungal growth. Fruit flies may be associated with cans and bottles collected for recycling which contain residues that attract and support flies. Besides better rinsing of these containers, they could be placed in sealed plastic trash bags or sealed containers soon after rinsing.

BUILDING FABRIC SOURCES OF INDOOR AIR CONTAMINANTS:

Investigating sources of air contaminants which arise from the construction materials of the building could involve the off-gassing of new materials (such as plywood or particle board), dusts from installation of drywall, or fibers from insulation such as fiberglass or asbestos. (Asbestos is a serious issue requiring procedures/remediation using USEPA criteria.) PCBs may be present in old caulk. Another example of this category would be exposure to formaldehyde from urea-formaldehyde foam insulation. Typically,

offgassing from new materials tends to be most troublesome in the first few months after installation. For future prevention, potential solutions could include setting specifications for low emissions products in the bid or contract, as well as specifying materials which are not acceptable.