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[Editor's note: The full study, "Variabilities in Aerosolizing Activities and Airborne Fungal Concentrations in a Bakery" by Jonathan Levy, Urika Nishioka, Kathy Gilbert, Chuan-Hua Cheng, and Harriet Burge, appeared in *American Industrial Hygiene Association Journal*, Volume 60, Issue 3, pp. 317-325 (May/June 1999).]

CASE STUDY

[In each issue, **IEQS** *presents a case study on an indoor air investigation in a particular building. The information in the cases comes from various sources, including published material, reports in the public record, and, in some cases, reports supplied by the consultants involved in the case.* **IEQS** *presents a variety of approaches to investigation and mitigation implemented by consultants with a broad range of experience, philosophies, and expertise. Inclusion of a particular case study in the newsletter does not imply* **IEQS***'s endorsement of the investigative procedures, analysis, or mitigation techniques employed in the case.* **IEQS** *invites readers to submit comments, suggestions, and questions concerning the case. At the discretion of the editors, correspondence may be presented in a future issue.]*

Investigating Whether Water Leaks in an Apartment Complex Resulted in Amplification of Building-Related Bioaerosols

In 1996, Edward Olmsted, CIH, CSP, and principal of Olmsted Environmental Services of Garrison, New York, conducted a bioaerosol survey inside a large apartment complex in New York City. The complex landlord hired Olmsted to perform the survey to investigate if water leaks had led to "amplification of building-related bioaerosols." Olmsted inspected 25 apartments chosen by tenants.

Background and Survey Methods

The complex has two high-rise apartment buildings, one with 14 floors and the other with 34 floors. The structures are reinforced concrete with a brick facade and were built about 30 years ago. Exhaust vents in the apartment kitchens, bathrooms, and in common corridors discharge through roof exhaust-fan units. The apartments the consultant surveyed had two bedrooms and a living room in addition to the kitchen and bathroom.

Olmsted collected airborne fungal samples on petri dishes filled with 2% malt extract agar prepared by P&K Microbiology Services. He collected air samples using an Anderson N6 sieve-impaction sampler operating at 28.3 liters per minute calibrated with an in-line rotameter calibrated against a primary-flow standard. He sterilized the Anderson sampler with 70% isopropyl alcohol before collecting each sample.

He also collected 1-square-inch (6.452-square-centimeter) wipe samples and used a sterilized utility knife to collect bulk samples. He packaged both types of samples individually in polyethylene bags for subsequent analyses.

Visual Findings in Building 1

The consultant reported the following observations in Building 1:

Apartment 13A: A bathroom-ceiling pipe persistently leaked. The pipe and damaged plaster had been replaced five months prior to the bioaerosol investigation, but a leak continued and had damaged anew about 1 square foot (ft^2) (0.093 square meter [m^2]) of plaster. "There is visible mold growth on the water-damaged plaster," Olmsted wrote. "The small area of water damage and mold growth in the bathroom should not presently cause significant bioaerosol problems in the apartment, but continued leaks may lead to future problems."

Apartment 13K: A bathroom-ceiling leak had been repaired. "Although occupants of the apartment have reported allergies and skin rashes, there was little evidence of building-related sources for these symptoms."

Apartment 12G: The bathroom ceiling had a leak and 4 ft^2 (0.372 m^2) of plaster damage.

Apartment 11L: There had been no leaks.

Apartment 11J: There was a leak from ceiling pipes. "There is visible mold growth on the walls and approximately 10 ft^2 (0.93 m^2) of water-damaged plaster."

Apartment 10H: Pipes leaking inside a wall caused some 5 ft^2 of water damage.

Apartment 2J: A leak in an office area during rainstorms caused some 4 ft^2 of water damage. "The bathroom has approximately 10 ft^2 of water damage with visible mold growth due to pipe leaks."

The consultant concluded that the water damage he saw inside apartments in Building 1 was primarily due to bathroom plumbing leaks. "These water-damaged areas will promote mold and bacterial growth if allowed to continue, but these areas [currently] represent minor bioaerosol exposure problems. Therefore … air sampling and bulk sampling was not conducted in this building."

Observations in Building 2

The investigator found a different situation in the second apartment building. Water infiltrated the second building through exterior walls and through air-conditioner sleeves, he reported. Replacing bricks on upper floors had eliminated some of the leaks. He added, however, "The water damage from these leaks has taken place in living rooms and bedrooms, and … they represent a more significant personal exposure issue. Mold growth in a bedroom will result in exposure over longer periods of time for the apartment occupant."

He reported the following visual findings in Building 2:

Apartment 32A: There were leaks around air-conditioning sleeves in the living room and bedroom. A Sheetrock sample from the bedroom revealed "elevated levels of fungi and bacteria."

Apartment 33B: There was water damage from a leak that reportedly was ongoing. An air sample showed "moderately elevated levels of mold."

Apartment 31F: Water had leaked through a wall and air-conditioner sleeve in the bedroom. "An air sample and bulk sample in the bedroom revealed elevated levels of fungal contamination."

Apartment 31G: The tenant said water persistently leaked into the living room and bedroom through the air conditioner. In the bedroom, a bulk sample showed moderately elevated levels of fungi and bacteria.

Apartment 5G: There were no water leaks. Bulk samples revealed no fungal growth, and air samples showed no elevated fungi.

Apartment 30G: Had no leaks through walls or the air conditioner. Water occasionally leaked through the ceiling, possibly from a washing machine in the apartment above it.

Apartment 29G: Had a history of leaks through the bedroom and living room walls. Repairs to the brick facade ended those leaks, and the landlord replaced the water-damaged walls. A corner of the bedroom, however, had a square foot of water damage from leaky pipes. "A sample of the water-damaged Sheetrock had elevated *Stachybotrys chartarum* and bacteria levels. Another sample of Sheetrock that had no water damage showed no fungi but moderate levels of bacteria. This wall comes in contact with the cement-block exterior wall," the investigator noted.

Apartments 29A and 29D: When it rained, water leaked into the bedrooms through air-conditioner sleeves. In Apartment 29A, a bulk sample of water-damaged Sheetrock showed moderately elevated levels of fungi and bacteria.

Apartment 28F: Water leaked through walls into the bedroom and living room when it rained. The bedroom wall and carpet were wet, and a wipe sample of the carpet backing showed elevated bacteria.

Apartment 25G: Had persistent leaks coming from the bathroom in the apartment above. The landlord had replaced the bathroom and living room ceilings several times. A bulk sample of Sheetrock at floor level showed elevated fungi and bacteria.

Apartment 19G: Had sustained some leaks through the bedroom and living room walls and showed small areas of water damage. "The bathroom ceiling is entirely covered with visible spots of mold," the investigator found. "A wipe sample of the carpet backing showed elevated fungal growth."

Apartment 12C: Showed no evidence of water damage.

Apartment 9C: Had sustained ceiling leaks several times, probably from a washing machine in the apartment above it. Rain also leaked in through the air conditioner.

Apartment 9F: Rain had leaked through the air conditioner sleeve. A steam leak also damaged a wall.

Bioaerosol Sampling

The greater potential for bioaerosol exposure in Building 2 prompted the investigator to take air, bulk, and wipe samples, he said.

"The organisms detected in the air samples are ubiquitous indoors and outdoors, making it difficult to interpret air-sampling results. Levels of airborne [organisms] inside buildings and outdoors fluctuate over time. The air samples ... are only a snapshot in time and may detect daily fluctuations." For reference levels, the investigator took air samples outside and in a control apartment that reported no water or mold complaints. "When there are elevated indoor levels compared to outdoors, or when species found indoors are different from outdoors, it indicates that the building may be a source of bioaerosols."

The investigator's air samples generally indicated that water-damaged apartments had levels of airborne fungi "moderately elevated above the reference levels" (see Table 2). He noted, "Apartments 31F and 29G had the highest levels of airborne fungi, and the samples indicated the presence of airborne *Aspergillus versicolor* and *Stachybotrys chartarum*. These are indicators of water damage in buildings. These fungi were also detected in bulk samples taken in these rooms" (see Table 3).

Analyses of bulk samples showed that water-damaged materials had been a source of mold growth in the apartments, he reported.

Discussion

Scientific evidence indicates "that excessive water damage in buildings is the most important factor in the promotion of mold growth," he noted. Numerous studies have shown that inhaling mold causes allergic symptoms such as rhinitis, skin rash, eye irritation, upper respiratory irritation, and asthma. Some molds, including *Stachybotrys*,

Table 2 — Air Sampling Results in Building 2

Location	Result (cfu/m³)	Mold Species
Apartment 33B, living room	212	*Acremonium* *Penicillium* *Phoma* *Rhodotorula*
Apartment 31F, bedroom	1,979	*Acremonium* *Alternaria* *Aspergillus versicolor* *Chaetomium* *Epicoccum* *Rhodotorula* *Stachybotrys* *Tritirachium* *Ulocladium* Sterile fungi
Apartment 5G, master bedroom	106	*Botryosporium* *Nodulisporium* Sterile fungi
Apartment 29G, master bedroom	636	*Acremonium* *Aspergillus versicolor* *Penicillium* *Stachybotrys* *Sterile fungi*
Apartment 10F, living room	71	*Aspergillus versicolor* *Penicillium*
Outside building, street level	106	*Acremonium* *Cladosporium* *Rhodotorula*

Table 3 — Bulk Sampling Results in Building 2

Apartment 32A, water-damaged bedroom wall Fungi = 1,440,000 cfu/g *Acremonium* (2) *Cladosporium* (4) *Exophiala* (47) *Phoma* (4) *Rhodotorula* (15)	Bacteria = >40,000,000 cfu/g Overloaded with gram negative bacteria and others
Apartment 31F, water-damaged bedroom wall Fungi = 48,837 cfu/g *Aspergillus versicolor* (2) *Cladosporium* *Penicillium* *Ulocladium*	Bacteria = 1,554,651 cfu/g Bacillus (3) Gram negative bacteria and others
Apartment 31G, water-damaged bedroom wall Fungi = 12,644 cfu/g *Acremonium* *Aspergillus flavipes* *Aspergillus versicolor* *Chaetomium* *Cladosporium* *Paelomyces* *Penicillium*	Bacteria = 2,882,533 cfu/g Actinomycetes Bacillus Rhodococcus Gram negative bacteria
Apartment 5G, bedroom wall, not water damaged Fungi = <4,611 cfu/g No fungal growth	Bacteria = 1,382 cfu/g
Apartment 29G, bedroom wall, not water damaged Fungi = 1,376 cfu/g *Acremonium* *Aspergillus versicolor*	Bacteria = 451,876 cfu/g Actinomycetes Bacillus Gram negative bacteria
Apartment 29G, water damaged bedroom wall Fungi = 2,788,000 cfu/g *Acremonium* *Aspergillus versicolor* *Cladosporium* *Penicillium* *Stachybotrys chartarum* *Ulocladium*	Bacteria = 464,667 cfu/g Actinomycetes Gram negative bacteria
Apartment 29A, water-damaged bedroom wall under air-conditioner sleeve Fungi = 332,432 cfu/g *Acremonium* *Aspergillus versicolor* *Stachybotrys chartarum*	Bacteria = 5,762,162 cfu/g Actinomycetes Bacillus Gram negative bacteria
Apartment 25G, water-damaged living room wall Fungi = 666,966 cfu/g *Aspergillus versicolor* *Aureobasidium* *Rhodotorula* Yeasts	Bacteria = 39,234,450 cfu/g Overloaded with bacteria

produce mycotoxins. Toxins can damage numerous body organs.

"The scope of this survey did not include a determination of whether the building occupants were experiencing increased rates of allergy or asthma. What can be concluded from this survey is that the water-damaged materials have allowed for the growth of mold. The presence of mold in building materials will result in periodic releases of mold spores. Air sampling of water-damaged apartments indicates that airborne mold levels are higher than outdoors and consist of different mold species compared to outdoors. The conclusion from this survey is that the building has water-damaged materials and is a source of mold amplification."

The investigator noted that some allergy sufferers in the building might be reacting to other sources of allergens, including animal dander, dust mites, cockroach allergens, and pollen.

Recommendations

The consultant made the following recommendations:

- Apartments with water damage should be remediated by personnel trained to remediate materials contaminated by fungi. Water-damaged materials should be replaced.
- All leaking air-conditioner sleeves should be repaired.
- All leaks through the building facade should be repaired.
- Leaking pipes must be promptly repaired, and any current leaks should be repaired immediately.
- Maintenance staff "must respond swiftly" when pipes burst, washing machines leak, or similar leaks occur. Wet materials must be dried within 24-36 hours. Materials that can't be quickly dried should be discarded.

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NEWS, ANALYSIS, AND UPDATES

Critics Found Little to Like During Review of ASHRAE Standard 62.2

The 60-day public review of the American Society for Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) Standard 62.2P, *Ventilation for Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, is over. If the 500 people who submitted roughly 2,000 comments had comprised the equivalent of a popular vote on the code-intended standard, they would have defeated the proposed reform in a landslide. Instead, ASHRAE's Board of Directors — the society's Electoral College equivalent — will make the final decision.

Standard 62.2P would set the stage to put mechanical ventilation in every new home by setting minimum standards for mechanical ventilation in dwellings with three or fewer floors. Most folks who commented during the public review that ended on October 10, 2000, dislike the idea. Standard 62.2 Committee members hope to meet with the folks to address their concerns at next month's ASHRAE *Winter Meeting* in Atlanta, Georgia, says Max Sherman, Standard 62.2 Committee chairman. Sherman has tentatively scheduled meetings from 2pm-6 pm on Friday, January 26, 2001, and for six hours beginning at 8:30 am on January 27.

Sherman's committee is required by ASHRAE regulations to respond to every comment, but it can issue one response to all comments that make essentially the same point. In this case, Sherman says, an overwhelming majority of the submissions essentially deal with the same six issues. The problem isn't in the sheer number of comments "apparently made by many builders," he says; it lies in the nature of their six issues. Five of them involve the proposed requirements for:

- Filtration and air-handling systems
- Carbon monoxide alarms
- Sound (sono) ratings for fans
- Whole-house mechanical ventilation
- Backdraft testing

Submitters Suggest Quick "Fix"

Many folks who made public comments had a simple solution for handling those proposed requirements: delete them. Sherman observes, however, that such a move would produce a ventilation standard with no ventilation requirement.

The sixth issue that dominated respondents' submissions was their recommendation to allow windows to meet the whole-house ventilation requirements rather than installing a sound-rated bathroom fan as proposed. Sherman notes, "We already allow natural ventilation through kitchen windows as part of our compromise with NAHB [National Association of Home Builders]. NAHB officials argued that home kitchens that had center-located stoves would make it difficult and expensive to duct to the outside, so we compromised [before submitting the proposed standard for public review]. A major reason we would require bath ventilation is to remove moisture, and using a bathroom window could carry that moisture into the rest of the house rather than outside."