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Project Summary

Microbiological Screening of the Indoor Air Quality in the Polk County Administration Building

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Designing and operating a ventilation system for increased outdoor air rates, as required by ASHRAE Standard 62-1989, improves indoor air quality (IAQ) but is thought to extract a penalty in energy costs and, potentially, increased microbial contamination in a hot humid climate. A two-part research program into the impact of increased outdoor air rates (per ASHRAE 62-1989) on building microbial contamination and the cost of providing that outdoor air was initiated by the Research Triangle Institute for the U.S. EPA. The Polk County Administration Building (PCAB), a large negatively pressurized building, not known to be biocontaminated, was selected for the study. The microbiological screening of the PCAB is the subject of this report; the energy/cost analysis is the subject of a separate report.

The microbiological screening included bioaerosol, bulk material, condensate, surface, and building floor dust samples taken at multiple locations. In general, the microbial results were consistent with the PCAB's being a non-problem building. However, the study was too limited in both duration and number of sample locations to completely evaluate the building. The results of a few samples indicated microbiological conditions that might warrant further investigation but were not of themselves adequate to indicate a building-wide problem.

This Project Summary was developed by the National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This research was an indoor microbiological screening of the Polk County Administration Building (PCAB) in Bartow, FL. Its goal was to generate a baseline measurement that could be used, in conjuction with additional sampling that has not been undertaken at this time, to evaluate the impact of ventilation system design and operation on the microbiological aspects of indoor air quality (IAQ).

Indoor microbiological contamination can be a significant cause of poor IAQ and is known to be associated with building ventilation systems. The impact of a building's ventilation system on biocontamination is complicated. On the positive side, building pressurization reduces the infiltration of biocontaminants, while maintenance of relatively dry indoor environmental conditions prevents the growth of the microorganism spores inside. Biocontaminants will grow and amplify on building materials at lower moisture levels than previously reported, and the appropriate level of moisture remains under investigation. Filtration equipment in the ventilation systems can similarly reduce the influx of environmental microorganisms. On the other hand, improperly designed, maintained, or operated ventilation systems can contribute to indoor biocontamination. In addition, the increased outdoor air rates called for in ASHRAE Standard 62-1989 are said to both increase building energy requirements

and lead to increased microbiological contamination in hot and humid climates.

The PCAB was not thought to have a microbiological (or any other) problem. However, a neighboring building with some characteristics similar to the PCAB was known to have had a very significant microbial contamination problem. The PCAB operated under negative pressure, which had the potential to bring in outdoor microorganisms. Microbiological investigations are commonly conducted in problem buildings, and the mere presence of microorganisms in a building does not in itself indicate a problem. Microorganisms are endemic in buildings, their concentrations can vary widely over short periods of time, and the "grab-sample" nature of bioaerosol samplers makes the results of a small number of short-term samples difficult to analyze. The indoor and outdoor levels and types of organisms must be interpreted in relation to those in nearby buildings or control areas of the same building. For these reasons, a screening study such as this one is too limited in both duration and number of sample locations to completely evaluate a building.

During this study, microbiological data were collected from bulk, surface, and bioaerosol samples, and the moisture content of some building materials was measured. Each of the measurements approaches the question of biocontamination from a different perspective, thus addressing the problem of identifying the sources of biocontamination.

The PCAB is a 5-story, 14,000 m^2 (149,000 ft^2) brick-faced building constructed in 1988. It has a permanent occupancy of approximately 300 county employees and elected officials, and also has a transient population who come to the building to conduct county business. Bartow is in central Florida and has the hot, humid climate typical of that area.

The heating, ventilating, and air-conditioning (HVAC) system in the PCAB utilizes variable air volume delivery of conditioned air and a plenum return. The air is conditioned in chilled water coils located in variable air volume (VAV) air handling units (AHUs), filtered with 5-cm (2-in.) ASHRAE-30 filters, then reheated as required for delivery to the space. The air is distributed to fan-powered VAV terminal boxes. The relative humidity in the building is controlled to approximately 40%. Each floor has multiple HVAC zones.

Procedure

The screening study included a building walk-through, outdoor and indoor bioaerosol sampling, bulk and surface sampling, and occasional building material moisture measurement. All sampling was conducted in April 1994. Bulk samples consisted of HVAC fiberglass ductliner, condensate from drain pans, and composite carpet dust. Surface samples included swabs from inside selected AHUs and the back side of ceiling tiles. This study was HVAC-system driven, and the test plan allowed some adjustment of test sites and other aspects of the study based on conditions in the building. All microbial samples were shipped to RTI for analysis.

Test Locations

A walk-through of the entire building to note any visible potential microbial problems was the first step of the screening study. Study locations were chosen to be in both the interior and exterior HVAC zones and would have been chosen to coincide with a potential problem area had one been observed. Each indoor bioaerosol sample was paired with an outdoor sample near the outdoor air intake for the HVAC unit serving the indoor site. The majority of the screening samples were collected in two rooms on the first floor, two rooms on the fourth floor, and at one location on the fifth floor.

Sampling and Inspection

The HVAC systems serving the test zones were inspected for visible problems (standing water, plugged condensate drains, duct leaks, etc.), and samples were obtained when appropriate.

Cleanliness near the air sampling regions was evaluated qualitatively by inspection and noted on the data sheet by location.

Building material moisture content was evaluated when appropriate using a conductivity meter internally calibrated and set on the concrete and plaster scale. The readings are relative, and the instrument was used to help identify any moist locations that might be microbial reservoirs or have the potential to become microbial sources.

Biocontaminant Sampling

All bioaerosol sampling was conducted in temporarily vacated offices or after work hours to avoid disturbing the PCAB occupants. Indoor and outdoor air samples were obtained with Mattson-Garvin slit-to-agar samplers operated for 30 minutes indoors and 5 minutes outdoors. Tests were conducted at nine sites, and at each site duplicate samples were collected sequentially with each of two fungal media and one bacterial media, for a total of 54 Mattson-Garvin runs. At a single test site, the total period during which sampling was conducted was about 90 minutes indoors and 45 minutes outdoors.

Swab surface and bulk material samples were collected at appropriate locations to assess microbial flora within the PCAB. Three microbiological media were employed during the analysis to cover as broad a range of microorganisms as possible.

Results and Discussion

Air Samples

Table 1 summarizes the mean levels of colony forming units (CFU)/m^3 for the xerophilic (low water requirement) fungi and the bacteria at each of the nine sites sampled. The results of the analyses on the general fungal media are not shown but supported those for the xerophilic media. Each entry is the mean of sequential duplicate measurements. A comparison of the outdoor and indoor mean levels shows that for all the pairs there were less organisms isolated indoors than out. This result is consistent with that found in a non-problem building. However, the mean values given in Table 1 do not show that for Rooms 170 and 413 there were considerable differences between the results for the two sequential duplicates. In both rooms, one of the two replicates was several times higher than the other, and that result was observed on both media collected at the same time. Thus the elevated values are not experimental error, but true measurements of a short-term elevated level. This difference between sequential duplicate sampling runs in the same room suggested that comparisons should be made between the runs based on the identification of the organisms.

Cladosporium spp. predominated in all the outdoor samples taken at the PCAB, with over 50% of the total CFUs identified as belonging to that genus. The second most commonly isolated mold in the outdoor air was *Penicillium* with less than 25% of the total colonies. It is generally expected that the numbers and distribution of indoor airborne fungi in mechanically ventilated non-problem buildings will reflect those found in the outdoors, but at lower levels. In most of the indoor sampling locations in the PCAB, *Cladosporium* was the predominant genus followed by *Penicillium*. The duplicate samples for Rooms 170 and 413 were noticeably different in that there was a change in the distribution of the predominant fungi. In Room 170 there was an increase in the *Penicillium* isolated from 7 to 28%. In Room 413, the numbers were 14 and

Table 1. *Mean Total Airborne Fungi and Bacteria in CFU/m³*

Location	*Room*	*Xerophilic Fungi*	*Bacteria*
1st floor NE	*Outdoor Air*	*1100*	*520*
1st floor NE	*Room 170*	*610*	*330*
1st floor SW	*Outdoor Air*	*580*	*1900*
1st floor SW	*Room 138A*	*110*	*270*
*4th floor NE**	*Outdoor Air*	*530*	*250*
4th floor NE	*Room 413*	*210*	*80*
4th floor SW	*Outdoor Air*	*830*	*440*
4th floor SW	*Room 440*	*80*	*190*
5th floor NE	*Outdoor Air*	*530*	*250*
5th floor NE	*Indoors*	*30*	*30*

* The outdoor air sample collected on the 5th floor NE was paired with both the 5th floor indoor sample and the sample collected in Room 413 because it was near both the 4th and 5th floor outdoor air intakes.

67%. By itself, the 28% *Penicillium spp.* isolated from Room 170 might not be excessive. However, there was also a 10-fold increase in total counts between the duplicates, suggesting that an indoor source might be present. In the same samples, the airborne concentrations of *Aspergillis spp.* also increased. For Room 413, while the counts on the second replicate increased, the total level was only 332 CFU/m³ and, therefore, not excessively high. However, that 67% of those were *Penicillium* suggests again that an indoor source might be present. Although airborne fungal measurements are grab samples and subject to considerable variability, in both of these rooms the increase in *Penicillium* was detected by two different samplers on two different media at the same time. The combined evidence indicates that potential source reservoirs of *Penicillium spp.* may be contaminating the rooms.

Surface and Bulk Samples

A number of different surface and bulk samples were collected: condensate from drain pans, swabs of ceiling tiles and AHUs, bulk samples of fiberglass ductliner, and composite carpet dust. None of these samples showed any remarkable levels or distribution of bacteria or fungi.

The other bulk samples, fiberglass ductliner samples from the 4th floor AHU and swab samples from the 1st floor southwest AHU and the 4th floor northeast AHU, yielded potentially significant numbers of *Penicillium* in practically pure culture. Swab samples of a small patch of white mycelial-like material were taken in AHU2 located on the 1st floor (southwest) and AHU9 located on the 4th floor (northeast). Analysis showed they were a pure growth of *Penicillium*. Isolation of *Penicillium* species from both the AHU swabs and the fiberglass ductliner suggests that possible source reservoirs may have been identified. Although speciation of the *Penicillium* was not performed, isolation of the colonies in some of the AHUs is consistent with the evidence of potential contamination suggested by the air sampling, though it does not confirm the identification of a source reservoir.

Moisture and Cleanliness

Moisture meter readings were taken at a variety of locations within the building. Only one potential water stain was identified during inspection of the building. No readings suggested moisture problems. Cleanliness was also determined visually. Overall, the impression of the building was that of a clean, well-maintained facility.

Conclusions and Recommendations

The overall impression of the PCAB was of a clean, well-maintained, low occupancy (relative to the HVAC flows) structure. The combined results of the air, bulk, and surface sampling did not indicate a clear biocontaminant problem in the building. On the other hand, the sampling period was short and samples were taken in only a few locations. The elevated airborne levels for one of two sequential airborne fungi samples in each of two different rooms (confirmed by the second fungal media), coupled with the isolation of essentially pure *Penicillium* in some of the AHUs, give some cause for concern. Considering that the building is located in a hot, humid climate, that biological contamination problems have occurred in adjacent county buildings (and some occupants have been exposed and may have been sensitized to fungal contamination), further investigation for potential source reservoirs might be prudent.

The PCAB is negatively pressurized and appears to have restricted outdoor air intakes. Infiltration air is unfiltered and unconditioned, and the potential exists for transport of biocontaminants in the infiltrating air, condensation of water vapor in infiltration paths, and consequent building contamination. On the other hand, the PCAB is operated at a low relative humidity that tends to prevent microbial growth, though it is presumably expensive to operate. This combination of characteristics presents a number of research opportunities:

1) The results of this screening study are not conclusive to either identify the PCAB as a biocontaminated problem building or clearly show that biocontamination is not an issue in the PCAB. The study was not designed to accomplish that task. The results do show that fungi (*Penicillium spp.*) may have become established in some AHUs and are either established in some parts of the ventilation system downstream of the filters or at least occasionally transported through the filters to some rooms at levels above those found in most PCAB indoor locations and roughly equivalent to outdoor levels. The building may be in transition from non-problem to problem, and as such presents an unusual opportunity to study some important questions, such as: a) How extensive is the HVAC system contamination? b) What conditions led to that contamination? c) Is PCAB becoming a problem building and is the contamination getting worse? and d) Can conditions be modified to prevent a serious contamination problem from developing?
2) The PCAB could be modified physically to operate at a controlled positive pressure to ensure that air entering the building is conditioned. Both short- and long-term studies of the microbial ecology in the building would provide valuable information concerning the impact of building pressurization in a hot and humid climate.
3) In combination with pressurization, a reduced-energy operating mode could be designed for the PCAB to, potentially, provide both reduced costs and reduced microbial contamination potential.
4) In addition to building pressurization, the impact of building ventilation rates on microbial contamination and general indoor air quality could be studied by modifying the outdoor air intakes to allow increased outdoor air delivery. Such operation should be optimized for energy efficiency consistent with prevention of conditions conducive to microbial growth in the building.

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The complete report, entitled "Microbiological Screening of the Indoor Air Quality in the Polk County Administration Building," (Order No. PB95-243085; Cost: $17.50, subject to change) will be available only from:
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