Microbial Air Quality in a 50-year-old Middle School

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Abstract

Millions of children and adults across the nation spend their days in school buildings, and they need safe, healthy environments to thrive, learn, and succeed. Almost any building surface can nourish mold growth. Elevated levels of indoor fungal spores result in significantly higher rates of illness (6). We enumerated the biological contaminants present in the indoor environment of a water-damaged, 50-year-old middle school in the San Francisco Bay Area. Indoor and outdoor air samples were taken with an impact air sampler. Swab samples and Rodac impression plates used to culture environmental surfaces. Fungi were grown on Sabouraud Dextrose agar Agar and bacteria on Nutrient Agar. Indoor airborne fungal spores were 11 times higher than outdoor. Concentrations of indoor and airborne bacteria were equal. Fungal and bacterial density and distribution were rank-ordered and compared with nearby buildings and outdoor air. Dominant species were identified. The significance of this contamination is discussed.

Aim

To analyze the air quality environment in a local middle school for biological contaminants.

Background

The excessive microbial contaminants in indoor air can cause significant health effects including those collectively known as sick building syndrome. In general, Californians, like others in industrialized nations, spend an average of 87% of their time indoors. Because of this, some scientists estimate that pollutants emitted indoors are about 1,000 times more likely to be inhaled than outdoor emissions of similar source (3).

Approximately 20% of the U.S. population, nearly 56 million people, spend their days in our schools. Approximately 20% of public schools reported that indoor air quality was less than satisfactory (5).

Burge stated that if indoor levels of airborne microbes are more than 33% higher than outdoor levels, then an indoor air quality problem is present and remedial action must be taken (1). In the majority of the studies, the indoor concentrations were well above this "safe" range (2).

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Poor indoor air quality costs Californians at least $45 billion each year (3), and more importantly, may cost us the health, motivation, and mental and physical development of the children in our schools.

Our test site was Pacific Heights Middle School, built in 1959. It is across the street from the main Skyline College campus (ca. 1969). The building has brick interior/ exterior walls, no central heating, and no ventilation. And it has significant water damage (**Figure 1**).

(a) Pacific Heights Middle School

(b) Interior/exterior brick walls

(c) Water damaged ceiling tiles

(d) Visible mold growth on plywood "windows"

Figure 1. Pacific Heights Middle School, San Bruno, CA. a) Built in 1959, the school has no air conditioning, central heating, or ventilation. b) It has interior/exterior brick walls and c) has suffered severe water damage. d) Windows have been replaced with plywood that shows mold growth resulting from absorption of water.

Methods

- 500-1000 L air samples taken with MicroBio (MB2) Impact Air Sampler (**Figure 2**).
- Surface samples were taken with Rodac plates (47 mm) or cotton swabs (10 cm^2).
- Bacterial samples were inoculated onto Nutrient Agar and incubated for 48 hr at 35°C.
- Fungal samples were inoculated onto Sabouraud Dextrose Agar and incubated for 72–96 hrs at 25°C.
- Data were compared to data previously collected for Skyline buildings (4).

Figure 2. The Microbio impact air sampler. Air is brought in so that airborne microbes are deposited on the surface of an agar plate.

Results

Airborne bacterial concentrations ranged from a maximum of 0–20 CFUs/1000 L (average = 4 CFUs/1000 L), which is comparable to the outdoor concentration, though higher than newer, Skyline campus buildings (**Figure 3**).

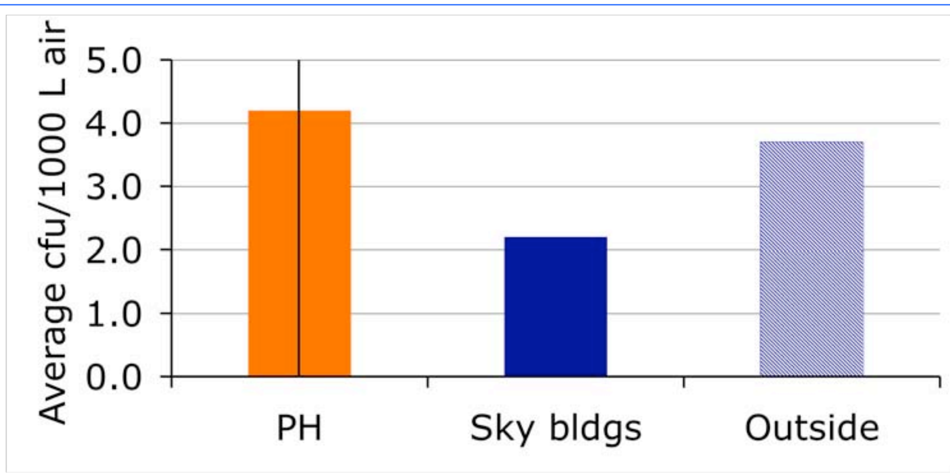

Figure 3. Indoor airborne bacterial concentrations were comparable throughout the study area. PH=Pacific Heights. Sky bldgs=Average for all Skyline College buildings. Bar=range

Fungal concentrations in Pacific Heights ranged from 0–195 CFUs/1000 L air (average = 10 CFUs/1000 L). This was significantly higher than both the average outdoor concentration and the average in the newer buildings (3 CFUs/1000 L) (**Figure 4**).

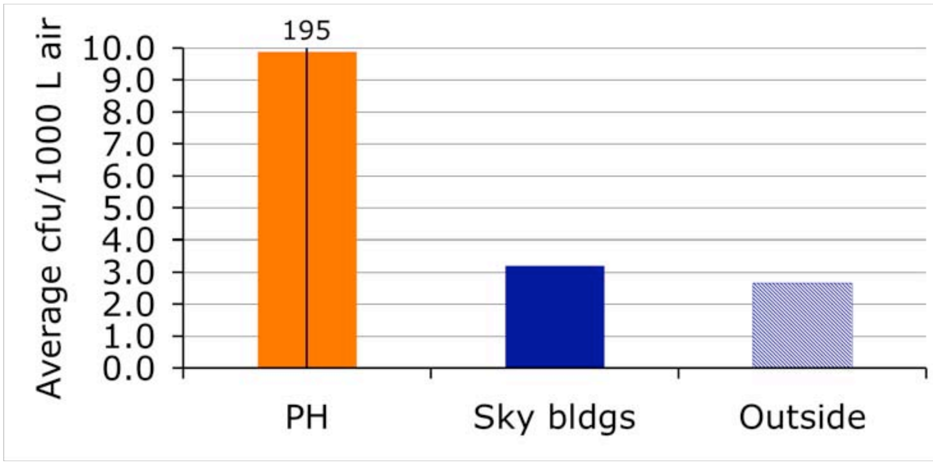

Figure 4. Airborne fungal concentrations were significantly higher than outdoors and in nearby buildings. PH=Pacific Heights. Sky bldgs=Average for all Skyline College buildings. Bar=range

The dominant species of fungi were *Aspergillus* sp., *Fonsaeca* sp., and *Penicillium* sp. (**Figure 5**).

Figure 5. Culture from swab of brick grout on interior-facing surface.

Rank correlation showed that airborne fungi may originate from areas of fungal growth in one wing of the building. We used surface samples along with the air samples to map the areas of highest contamination (**Figure 6**).

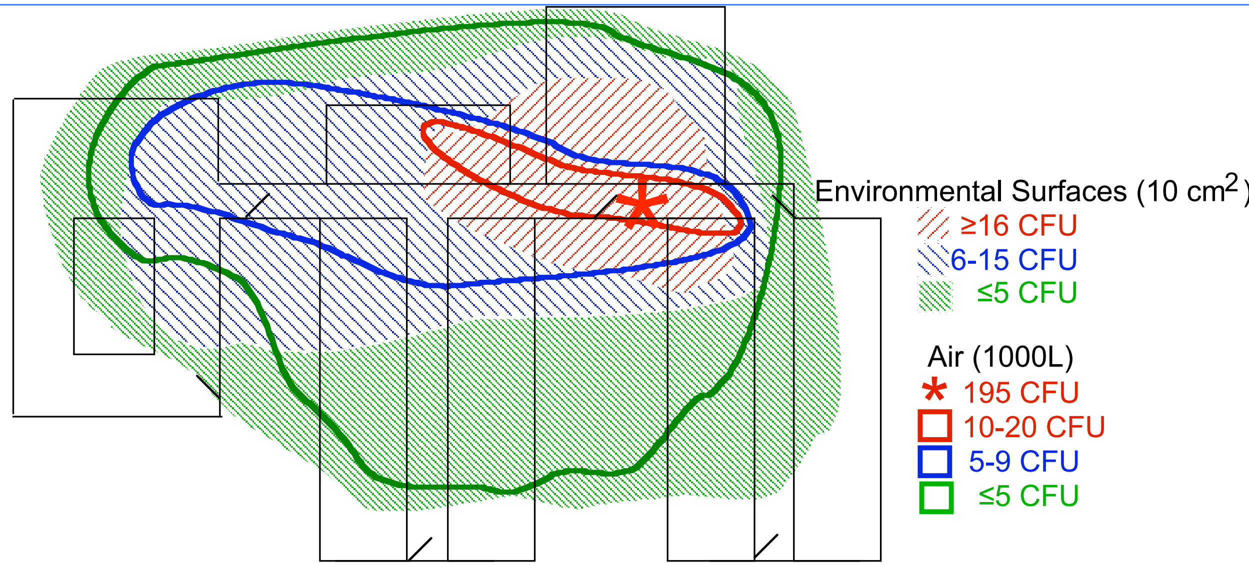

Figure 6. Distribution of fungi through Pacific Heights. Contour lines = Airborne fungi. * = Highest air count. Shaded areas = surface fungi. Airborne fungi are higher in areas of excessive water damage. The red areas are primarily associated with plywood window replacements.

Discussion & Conclusion

The average concentration of airborne fungi in the Pacific Heights Middle School was approximately 300% higher than the concentration in outdoor air and well beyond the recommended safe limits defined by Burge (1). There is a significant gap in the difference in indoor air quality between buildings in the same geographical area but differing in construction and age by approximately 20 years. The airborne fungal concentration was 280% higher in Pacific Heights than in newer onsite buildings (4).

Airborne fungi may emanate from surface growth in areas of excessive water damage. During this study employees and students in the building complained about the moldy odor. Results of this study indicate employees and students may be at significant risk for symptoms related to sick building syndrome.

The problem should be addressed by pressure-washing the brick walls, replacing the plywood “windows,” and repairing water-damaged ceilings.

Literature Cited

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