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Airborne Mold Concentrations During Remediation of an Apartment Building

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Mold (fungi) is being recognized as an important health concern for those living in the indoor environment (Rylander, 2003). As a result of increased awareness of low level contaminates, mold is beginning to develop into a new environmental industry (Singh, 2001). However, little information has been published on exposure levels during actual abatement (Santilli and Rockwell, 2003). This paper provides information on exposure levels during abatement and compares these data with outside samples.

MATERIALS AND METHODS

This investigation collected samples during mold remediation (abatement) at a group of apartment buildings in the mid-western part of the United States during 2003. The mold problem developed as a result of the buildings being constructed over a former swampy-area that due to the construction allowed intrusion of water. The work involved removal of dry wall and related components, many of which had visible mold growth. This project occurred during the fall, consisted of about 750,000 square feet, and involved about 40 workers for a seven-month period.

Negative air filtration, plastic barriers and a full containment (three-stage decontamination unit) were employed in the remediation and were conducted for each apartment. A Clorox® solution was used to "disinfect" contaminated materials and for cleaning. A biocide was applied to surfaces after final cleaning. All materials were placed in 6 mil bags and disposed of as construction debris. Workers used tyvek® suits and half-mask respirators with HEPA filters. The air exchange rate was one to four per hour.

Air samples were collected as area samples both inside (indoors) and outside (outdoors) "residences using Air-O-Cell Cassettes (AOC) (SKC, Inc., Eighty Four, PA). The sampling rate was 15 lpm with a collection volume of 60 liters using a calibrated pump. Sample results are reported in counts/m^3- c/m^3 (Aizenber et al., 2000). Analysis of AOC's was performed using standard microbiology methods (Aizenber et al., 2000).

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Data are reported as summary statistics for total, Aspergillus/ Pencillium (A/P), Cladosporium (Cla) and other fungi (other). The highest value on each type of sample was tested for being an outlier (Grubbs test). Confidence intervals (CI) were calculated at 95% for non-normal populations (Daniel, 1991). Samples that reported no c/m^3 were not included in calculations for arithmetic means (AM), geometric mean (GM), standard deviation (SD) or geometric standard deviation (GSD). Any value reported as greater than were included in calculations as the number reported. Samples (9 samples) listed as overloaded were not included in calculations. Comparisons among groups were conducted using the Wilcoxon-Rank test. Significance was defined as less than 5%. Samples with a zero value were not included in the Wilcoxon-Rank test.

RESULTS AND DISCUSSION

Summary results are shown in table 1. These data show that total inside and A/P inside counts were significantly higher than outside. A/P inside was significantly higher than Cla inside and outside. If overloaded samples were included, summary averages would be higher. The highest value for each type of sample was an outlier except for totals. Previous studies (Curtis et al., 2000) have reported airborne environmental contaminates, including fungal counts, are non-normally distributed. The large GSD supports the finding of a non-normal distribution. Indoor to outdoor (I/O) ratios were greater than 1 for comparisons: totals, A/Ps, A/P inside vs. Cla inside, and A/P outside vs. Cla outside.

The higher concentration of total and A/P inside as compared to outside support the existence of mold contamination in the building. Historically, if the I/O ration is greater than one, a mold problem has been suggested to descriptively exist (Quezada and Lange, 2004). However, there must be some caution in universally applying this criterion as seen in the comparative ratio of A/P inside and Cla outside where a ration is greater than one, but is not significantly different. The ratios of inside to outside for totals, A/Ps, and A/P inside to Cla inside and outside are around 3-5. The inside ratio for A/P and Cla is around 7. These ratios demonstrate that mold is being released into the air during remediation suggesting an elevated occupational exposure level as compared to the outside. If the protection factor established for a half-mask respirator, which is 10, were applied using the indoor to outdoor ratio, this level would appear to be appropriate in protecting workers. The indoor to outdoor ratios, applying the highest comparison number, are suggested as criteria in selecting respirator protection.

This study illustrates an additional source of moisture that may infiltrate into a building and result in mold "contamination". Evaluation of ratios can be used for determining respiratory protection as well as whether a project has been successfully completed (Quezada and Lange, 2004). Further evaluation is also needed for engineering controls (Menetrez and Foarde, 2004) and its use in reducing occupational exposure. Additional research

Table 1. Summary statistics for air samples, in c/m^3

Samples		Parameters					
Type	No	AM	SD	CI	GM	GSD	Range
Total inside	16	47,502	133,683	33,420	10,116	4.4	>542,169-1,506
Total outside	11	10,099	9,302	2,802	7,252	2.3	24,375-3,012
A/P inside^	13	10,881	24,650	6,847	3,617	4.0	>90,361-602
A/P outside^	10	3,793	6,072	1,922	1,735	3.1	20,482-301
Cla inside§^	13	1,368	1,884	523	995	3.0	6,024-0
Cla outside+^	10	2,199	1,543	514	2,043	2.0	4,518-0
Other inside^	13	3,664	3,519	978	2,122	3.3	10,840-301
Other outside^	12	4,318	5,248	1,516	2,404	3.0	17,188-602

§ two samples were zero c/m^3, ^ outlier, + one sample was zero c/m^3

is needed on mold activities and exposure, especially with an increase in reports on health effects from indoor molds (Santilli and Rockwell, 2003).

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