

between exposures measurements and subject work histories. When we considered the highest quality studies that assessed exposures 5B10 years before cancer diagnosis or death, the dose-response relationship was significant for brain cancer (1.86-fold increase in the odds ratio for 1 mT increase in exposure,  $p < 0.001$ ) and nearly significant for chronic lymphocytic leukemia (4.07-fold increase per mT,  $p = 0.082$ ). Including the weaker study, the brain cancer dose-response was not significant ( $p = 0.16$ ). No significant dose-response with power-frequency magnetic fields was found for any other cancer studied in men. This synthesis of epidemiologic findings provides some support for the hypothesis that increasing workers' TWA magnetic field exposure may raise their risk of brain cancer and, with less certainty, chronic lymphocytic leukemia.

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THE BEGINNING, MIDDLE, AND END: DEVELOPMENT OF A JOB EXPOSURE MATRIX FOR THREE CHEMICALS OVER FOUR DECADES FOR ONE EPIDEMIOLOGIC STUDY. S.H. Ahrenholz, NIOSH, Cincinnati, OH

The process to develop a job exposure matrix (JEM) includes the identification, acquisition, assembly, manipulation, interpretation, and application of data. Original industrial hygiene data collected over 40 years (at a gaseous diffusion plant) were used to estimate airborne concentrations of uranium, nickel, and fluorides. This process began with the identification of about 16,000 industrial hygiene surveys and initially covered over 100 buildings. Sampling methods ranged from Greenberg-Smith impingers to current day filter cassettes. Unification of contaminant identities and units was necessary to facilitate subsequent exposure characterization. A total of 5220 industrial hygiene sample results were used in the final JEM. Problems encountered during data processing included censored data, missing limits of detection, unknown sample volumes and durations, and unsampled time intervals. Buildings ultimately included in the JEM were those with 50 or more samples. Industrial hygiene data were pooled by decade based on historical knowledge of site activities and to compensate for unsampled periods. The skewness of the historic industrial hygiene data prompted the development of exceedance values for the uranium and fluoride data assigned to a decade. Exceedance values represented the proportion of airborne contaminant values that exceeded an occupational exposure limit during a decade. Reference exposure limits used were the threshold limit values existing at the start of plant operations. The process enabled an assignment of exposure based on the proportion of time contaminant levels may have exceeded an advisory level, utilizing contaminant data collected during the time period of interest. The effort required to produce the JEM was more involved than the final product suggests.

## INDOOR AIR QUALITY — SESSION II

### Papers 187 – 194

## 187

A COMPARATIVE ANALYSIS OF INDOOR ENVIRONMENTAL MANAGEMENT STRATEGIES. J.R. Guemsey, C. Daly, Dalhousie University, Halifax, NS, Canada

The resolution of indoor environmental problems continues to pose difficult challenges for building owners and managers. In an attempt to seek a new approach, we developed a list of themes comprising requisite elements of an overall proactive indoor environmental policy for building managers. We then compared this list with currently available indoor air quality (IAQ) management schemes.

The requisite themes were identified through a review of the indoor air quality and sick building syndrome literature and IAQ litigation case law and through an assessment of published IAQ guidelines and standards.

A matrix of suggested elements for an indoor environmental management policy was then constructed using the themes. These elements were validated through interviews of building managers who had experienced IAW problems on-site. Eight IAQ management strategies were then compared and contrasted for the presence of these elements. While, collectively, the IAQ management strategies addressed all the elements, individual schemes were found to be lacking in one or more components. We conclude that a formal, proactive approach to indoor environmental management that includes all policy elements and is part of the normal building management practice will most likely lead to the absence of building-related environmental problems.

## 188

REMEDICATION OF AN OFFICE WITH FUNGAL CONTAMINATION IN THE HEATING, VENTILATION, AND AIR-CONDITIONING SYSTEM. L-L. Hung, U.S. Public Health Service/FOH, Philadelphia, PA; K. Kawar, Bridge Environmental Management Group, Naperville, IL

During an indoor environmental quality investigation in a one-story office, visible fungal growth was observed on the fiber glass insulation inside the ductwork. The objectives of this survey were to evaluate and characterize the fungal population in this office, design remediation specifications, develop and implement a monitoring strategy for clearance sampling, and perform postremediation evaluation. Baseline air, wipe, contact plate, and bulk samples were collected from various locations in the office and a reference area. Bioaerosol samples were collected by an Anderson N-6 sampler with flow rate of 28.3 L/min. Two percent malt extract agar plates were used for recovery of fungal species. Carpet dust samples were collected from various locations with a high efficiency particulate air (HEPA) vacuum cleaner.

Fungal concentrations in the interior fiber glass insulation were at the  $10^7$  colony forming units (CFU)/g level, with *Cladosporium* as the predominant fungi. *Cladosporium* was also the predominant fungal genus recovered from various sample types. Initial indoor airborne fungal levels were comparable with those of outdoors.

However, high fungal levels were detected on horizontal surfaces, such as window ledges. A diverse fungal population was recovered from vacuumed carpet dust samples with fungal concentrations at  $10^5$  CFU/g levels.

Remediation included isolating the office area by creating a negative air pressure containment, removal of ceiling tiles, and HVAC duct. Decontamination work consisted of wet-wiping with isopropyl alcohol and HEPA vacuuming. Removal of the ductwork resulted in a significant increase of airborne fungal levels within the containment.

Clearance samples (various types) were collected 48 hours after conclusion of the decontamination procedures. Clearance indoor airborne fungal concentrations were significantly lower than those of the baseline. Similar results were obtained from wipe and contact plate samples. Moreover, fungal concentrations in vacuumed carpet dust were significantly reduced as compared with the baseline.

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SAMPLING FOR FUNGI IN BUILDINGS: HOW SHOULD THE DATA BE INTERPRETED? P.R. Morey, AQS Services, Inc., Gettysburg, PA

Over the past decade considerable progress has occurred on understanding fungal problems in indoor environments. Consensus documents have suggested that in nonproblem buildings the mix of fungi found indoors and outdoors should be similar. The unacceptability of sustained fungal growth on interior surfaces has been widely recognized in several documents. In 1996 the AIHA Field Guide recommended that risk management decisions be made if the presence of certain fungal species indoors was confirmed. Some confusion on the part of practitioners has resulted from this recommendation. The purpose of this presentation is to provide a view of how fungal sampling data can be interpreted.

Air sampling for culturable fungi including *Aspergillus fumigatus* (AF) and *A. versicolor* (AV) was performed in approximately 10 moisture-damaged buildings. In some of the buildings AF and AV occurred at background outdoor concentrations. In other buildings indoor levels of AF or AV were greater than the background but considerably less than the total concentration of culturable fungi. In still other buildings the mix of fungi indoors was becoming unbalanced in the sense that species such as AF and AV were increasingly well-represented and even dominant in some rooms. While every building is different and many variables can effect the indoor mycobiota, several general conclusions as follows were apparent from the study: (a) The presence of fungal species such as AF and AV at concentrations above the background indicates the existence of a moisture problem that should be corrected; (b) the mix of fungal species indoors tends to become more out of balance as the moisture problem becomes more severe; and (c) visibly moldy and water-damaged materials should be removed irrespective of the results of air sampling.

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FUNGAL SPORES DISPERSED FROM AIR HANDLING SYSTEM DUCT: A COMPARISON OF THREE FUNGAL-CONTAMINATED DUCT MATERIALS. L.D. Stetzenbach, M.

**Abstracts**

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