visible contamination at indoor control locations where MVOC concentrations were significantly higher than those measured outdoors. Although further validation studies are needed, the use of MVOCs as a reliable indicator for microbiological contamination in buildings is promising.

115

QUANTITATIVE LIPID BIOMARKER ANALYSIS OF AIRBORNE MICROORGANISMS IN INDOOR ENVIRONMENTS. A. White, Microbial Insights, Inc., Knoxville, TN; D. White, Center for Environmental Biotechnology, Knoxville, TN; R. Gall, ISEP Consulting, Knoxville, TN

There is increasing concern over airborne microorganisms in indoor air environments. Standard microbiological methods based on microorganism culture have severe limitations for the analysis of indoor air samples. Counts of culturable bacteria from environmental samples consistently underestimate the actual viable community by 90-99%. All viable cells contain a phospholipid membrane. Examination of the phospholipid components of airborne microorganisms provides a quantitative and comprehensive method to define the viable biomass, community composition and nutritional/physiological activity of the airborne microbial community. To determine if there is a connection between viable biomass and community composition and "sick building syndrome," we have begun an ongoing process of compiling a database comprising the phospholipid fatty acid profiles and biomass contents of indoor air. Filtration sampling of large volumes of air allowed us to obtain airborne particulate matter from a number of test sites that included office and industrial space. Membrane lipids were extracted from the filter, the lipids fractionated and the polar lipid fraction analyzed by gas chromatography-mass spectrometry. This provided quantitative data which enabled determination of the microbial biomass, community composition and physiological activity of the airborne microorganisms. For comparison with the conventional methodology, we also sampled the culturable bacterial and fungal biomass at each test location. The airborne viable biomass as measured by phospholipid fatty acid analysis was 2-3 orders of magnitude greater than that measured using plate cultural techniques. Changes in the physiological status of the airborne biomass as detected by phospholipid fatty acid analysis could be directly related to the indoor air conditions.

Agricultural Safety and Health Papers 116–122

116

EVALUATION OF TWO METHODS TO CONTROL ODOR IN LIVESTOCK BUILDINGS. U. Krishnan, C. Wachenheim, M. Jones, Illinois State University, Normal, IL

Odorous gases generated in livestock buildings are often carried downwind. The potential nuisance to neighboring properties threatens neighbor relations to the extent of shutting down some facilities or thwarting efforts to expand or build new facilities. Several products are commercially available to swine producers for addition to animal feed or manure to obtain odor reduction. However, there are very few studies that have evaluated the products in the laboratory. This study was undertaken to evaluate the odor reducing potential of four commonly used feed additives. Twenty four pigs were randomly assigned to six pens. Pigs in two pens were fed a control ration while pigs in the other pens were fed a ration mixed with one of the four feed additives. Pens were raised above the ground and fitted with flush pans underneath to hold the waste. Manure was collected every week from each pen for nine weeks. Since ammonia and hydrogen sulfide are key odorous compounds in animal wastes, concentrations of these gases were determined in the headspace using Dräeger tubes. Hydrogen sulfide levels were below the detection limit of the method. Ammonia levels ranged from 40 to 400 ppm and was correlated with the ambient temperature. Ammonia levels in the treated groups did not significantly differ from the control groups. In a related study, when air above the standing manure was made to pass through a thick cotton cloth or a cotton plug saturated with water, a ten to thirty fold reduction in ammonia level was obtained depending on the thickness of the cotton layer. It is concluded that significant reduction in ammonia can be obtained by moving the odorous air through a wet cotton cover. However, feed additives that were tested were not effective in reducing the levels of the highly odorous and pungent ammonia gas.

117

EVALUATION OF A TRACTOR CAB USING REAL-TIME AEROSOL COUNTING INSTRUMENTATION. R. Hall, W. Heitbrink, NIOSH, Cincinnati, OH; N. West, John Deere Product Engineering Center, Waterloo, IA

Aerosol instrumentation was used to evaluate air infiltration into tractor cabs that are used to protect the agricultural worker during pesticide applications. The laboratory and field tests were conducted on a John Deere 7000 series tractor cab equipped with high efficiency particulate air (HEPA) media. HEPA media was used to eliminate filtration efficiency considerations and to remove atmospheric condensation nuclei which was used as the test aerosol. Thus, the major source of aerosols was assumed to be leakage around filters and seals. Three particle counters were used to measure the concentration of ambient aerosols inside and outside of the enclosure over the range 0.01-15 µm. The ratio of the outside to inside measurements was used to calculate a protection factor. During the evaluations, two counters were placed inside the tractor cab (near the operator's breathing zone) and two were places outside (near the air intake). During our evaluations, the instruments were rotated to prevent instrument bias from affecting the findings. The ratio of the two measurements was used to calculate how efficient the tractor cab was at removing aerosols. The results of the laboratory evaluation indicated that the enclosure was 99% efficient at removing aerosols between the range of 0.3-15 µm. During the field evaluation, the results indicated that the enclosure was 96-99% efficient at removing aerosols between the range of 0.3-6.5 µm. The cab was capable of providing an average protection factor of 38 (ratio of outside/inside aerosol counts in the range of 0.1-1.0 µm) during the laboratory evaluation and 43 during the field evaluation. A particle counter was also used to identify any leak sources in the ventilation system. The test results in the ventilation system indicated that some small aerosols (<1 µm) can penetrate the seals around the fresh air blower. The results from this study indicate that tractor cabs can be very effective at removing different size aerosols depending on the seals and filters used with the enclosure. This study has also demonstrated the practical use of real-time aerosol counting instrumentation to evaluate the effectiveness of enclosures and to help identify leak sources. The method used in this study can be applied to various cabs used in different industries including agriculture, construction, and manufacturing.

118

METHODS AND RESULTS OF AN INVESTIGATION OF EGG PROTEIN EXPOSURE IN AN EGG PROCESSING PLANT. M. Boeniger, NIOSH, Cincinnati, OH; Z. Lummus, University of Cincinnati, Cincinnati, OH; R. Biagini, M. Massoudi, NIOSH, Cincinnati, OH

Proteinaceous materials in the air can be highly allergenic and result in a range of immunologically mediated respiratory effects, including asthma. We report on the largest evaluation of exposure to date of airborne egg protein concentrations in an egg breaking and processing plant that had reported cases of occupational asthma. Personal air sampling among employees in each department was conducted to determine magnitude of exposure. Stationary area sampling with 10-mm cyclones and total matched pairs were used to assess the proportion of respirable and total aerosol concentrations. Egg protein was analyzed in duplicate on each Teflon® filter using two analytical methods: (1) a commercial BCA protein assay for nonspecific total protein, and (2) indirect competitive inhibition ELISA, with the use of an IgG isotype-specific assay for rabbit antibody bound to antigen-coated plates for specific egg protein components. The results of this study indicated those departments where the highest concentrations of egg protein exist and where efforts to improve engineering controls might be focused. The highest concentrations, in the egg washing room (mean exposure 644 $\mu g/m^3$) and breaking room (255 $\mu g/m^3$), also coincide with the departments from which the most employees sensitized to egg-protein had worked. About half of the total protein concentration was of a respirable size, and the difference between the respirable mass and total mass collected was statistically significant. There was excellent quantitative agree-

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