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.

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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.

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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.

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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.

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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-

ment between the nonspecific assay and the sum of the specific proteins-ovalbumin, ovomucoid, and lysozyme (correlation coefficient of the log-transformed data was 0.88, $p<0.0001$). These methods can be utilized to evaluate employee exposure to egg proteins and may be used to assess exposure to other proteinaceous materials.

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HAZARD IDENTIFICATION ON FARM OPERATIONS FROM ACROSS THE STATE OF IOWA. M. Jones, S. Reynolds, C. Zwerling, M. Lewis, University of Iowa, Iowa City, IA; W. Popendorf, Utah State University, Logan, UT

Over the last decade the agricultural sector (12 to 15 million) of the United States (U.S.) has seen little change in injury and fatality rates, and has been ranked as one of the most dangerous industries in the U.S. Recent epidemiologic studies have identified animal handling and farm equipment, notably tractors, as major risk factors for injury. As part of a multiyear medical and environmental surveillance project (Farm Family Health Hazard Survey) in the state of Iowa, a 1-year cross-sectional industrial hygiene (IH) study of 121 farm operations was competed from August 1995 to July 1996. A stratified two-stage cluster sampling procedure was utilized to randomly select the farm operations for study from eighteen different counties distributed among Iowa's nine different soil conservation districts. The components of the IH on-farm study included the assessment of exposure to an array of air contaminants and noise, along with observational and subjective measurements of the farm operator's or worker's activities, attitudes, equipment and facilities. This presentation will focus on the display of photographs taken of health and safety hazards and/or conditions identified during the 121 IH on-farm assessments. These photographs clearly illustrate the severe nature and diverse array of different hazards present in the agricultural sector today from (1) fixed and mobile farm equipment; (2) farm equipment storage and maintenance facilities; (3) chemical, fuel and gain storage facilities; and (4) animal handling and husbandry facilities. It is concluded that the presence and usage of antiquated, poorly designed and maintained farm equipment and buildings plays a major role in the frequency and severity of injuries experienced by this population.

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OCCUPATIONAL PESTICIDE USE BY NORTHEAST COLORADO FARMERS. L.K. Criswell, L. Stallones, T. Keefe, P. Bigelow, Colorado State University, Fort Collins, CO

The health and safety of farm operators, including the acute and chronic effects of chemical exposure, are important concerns for Colorado residents. The purpose of this study is to describe personal occupational pesticide use by farm operators in eight northeast Colorado counties. The farms in each county were selected using a stratified probability sampling technique. Personal interviews were conducted with 345 farm operators. Data collected included farm size and production; personal use of pesticides; demographic characteristics; and work hours for tasks on the farm. Median size of farms was 1075 acres. Operators were predominantly (96.2%) male. The mean age of operators was 50 years. Race was 96.8% white. Ethnicity was 1.5% Hispanic. Pesticide use was lower than expected in this population, based on an Extension Service survey of local pesticide dealers. Herbicides were used on 74% of surveyed farms; 47% of farmers reported personal use. Crop insecticides were used on 53% of the farms; personal use was reported by 33% of operators. Livestock insecticides were used on 49% of the study farms; 43% of participants reported personal use. Personal protective equipment worn by pesticide users included gloves, coveralls, rubber boots, and respirators. Logistic regression was used to model personal pesticide use. Significant predictors of personal herbicide use included crop production; age less than 55 years; corn, sugar beet, and nonalfalfa hay crops; fall crop production work hours; and full-time farm employment. Variables significantly associated with personal crop insecticide use included corn and sugar beet crops; age less than 65 years; full-time farm work; winter maintenance work hours; and spring animal handling work hours. Cattle and livestock production; age less than 65 years; and winter animal handling work hours were significantly associated with personal livestock insecticide use.

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ASSESSMENT OF TOTAL PESTICIDE EXPOSURE FOR FRUIT FARMERS IN SOUTHERN TAIWAN. H.Y. Chang, T.N. Wu, N.W. Guo, S.Y. Chou, Y.L. Guo, Department of Environmental and Occupational Health, National Cheng Kung University, Tainan, Taiwan, ROC, Department of Health, The Executive Yuan, Taipei, Taiwan, ROC, Department of Psychology, Kaohsiung Medical College, Kaohsiung, Taiwan, ROC

Including insecticides, herbicides, fungicides, fumigants, different pesticides were mixedly used to control pests in the fruit farm in Southern Taiwan. The challenges for an industrial hygienistto assess the exposure is not only the difficulty in dealing with the vast variety of pesticides, but also the difficulty in handling various dilution protocols, different spraying duration, and different personal protective equipment farmers applied. In this study, the/exposure matrices were built based on the component of the pesticide, dilution factor, spraying duration and frequency as well as the usage of personal protective equipment. History of pesticide intoxication, spirometric measurement, dermatological fundings, blood cholinesterase level were used as outcome variables to correlate with exposure index. Almost 300 farmers were followed in this study for one year. We found the exposure index we developed in this study was a good surrogate to access the exposure judged by the outcome variables. History of acute poisoning episodes was associated with the high dose usage of some pesticides. We suggested the longitudinal study for accessing the accurate exposure of multi-pesticides should be extended to validate this methodology.

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MODELS FOR PESTICIDE EXPOSURE. P. Kalliokoski, M. Elmi, K. Savolainen, University of Kuopio, Kuopio, Finland; J. Kangas, S. Kaismala, Kuopio Regional Institute of Occupational Health Kuopio, Kuopio, Finland

Several models have been developed to predict agricultural workers' exposure to pesticides. These models are based on existing exposure databases. In all models, work is divided at least into mixing/loading and application phases. A distinction is also made between liquid and solid formulations. Both inhalation and dermal exposures are taken into consideration. On the other hand, the models differ in selection of the exposure parameters and statistics. In this study, Finnish potato farmers' exposure to propamocarb was investigated, and the observed exposure levels were compared with the levels given by the Dutch, German and US-Canadian models. All five farmers used tractor-mounted boom sprayers. They wore protective clothes, gloves, and boots. Three farmers also used respirators. Air samples were collected on glass fiber filters. Dermal exposure was estimated by using patch samples. Analyses were performed with gas chromatography. The mean concentration of propamocarb in the farmers' breathing zone was 0.4 $\mu g/m^3$ corresponding to a mean daily dose of 0.1 µg. The average total daily doses of propamocarb on the clothes and skin were 1 and 0.2 mg, respectively. The doses given by the models for inhalation exposure, clothing contamination, and skin exposure were 0.2, 150, and 75; 0.0001, 6, and 0.2; and 0.004, 9, and 0.1 mg for the Dutch, German and US-Canadian models, respectively. Thus, the German model gave always the most accurate estimates. The US-Canadian model predicted well the contamination of the clothes and skin but overestimated the inhalation exposure. The Dutch model yielded by far too high doses. The Dutch model, otherwise than the others, is constructed to estimate the highest possible exposure.

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THE RELATIVE IMPORTANCE OF TEMPERATURE, HUMIDITY AND FABRIC PERFORMANCE TO OTHER HEAT STRESS FACTORS. J.P. Zeigler, DuPont Nonwovens, Richmond, VA

Heat stress is a common risk. Indoor environments can exceed action limits anytime and anyplace. Outdoor temperatures and humidity exceed threshold limits in most cities sometime each year. Activity levels, rest/work cycles, temperature, humidity, worker acclimatization and garment performance are just some factors that must be integrated into a heat stress management plan. The significance of some factors, such as temperature and humidity, are well defined. Less well understood and often misrepresented are other factors, such as garment heat transport,

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PRAGMATIC PRINCIPLES FOR AVOIDING MANAGEMENT PITFALLS. M.L. Sanders, Naval Engineering Field Activity, Poulsbo, WA

Making the transition from an industrial hygienist managing programs to a manager programming industrial hygienists can be traumatic and career damaging. Keen technical and verbal skills are common entrance requirements to the people-management arena, but industrial hygienists who desire to make that professional move must be aware of three particularly dangerous pitfalls which neither of those skills will protect against.

One pitfall results from failure to distinguish between leadership and management, another from failing to distinguish between organizational process and function, and the third for failing to recognize the customer. Industrial hygienists must have the insight to recognize and evaluate those pitfalls, avoiding or backfilling in order to walk safely over them.

Specific and succinct descriptions of principles for both the prevention and the resolution of these problem areas have been developed; use of these principles is the catalyst for efficacious management. Whether the professional industrial hygienist is in the private or the public sector, assuming the responsibility for a controlled management response using these principles in the face of business adversity can turn impending failure into resounding success and ensure career growth.

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SCIENTIFIC CONTRIBUTIONS TO THE REVISION OF THE OSHA'S 1,3-BUTADIENE HEALTH STANDARDS. C.T. Chen, OSHA, Washington, DC

The current OSHA's 1,3-butadiene (BD) health standard is an 8-hour time-weighted average (TWA) exposure of 1,000 ppm for workers exposure to BD which is adopted from 1968 American Conference of Governmental Industrial Hygienist's (ACGIH's) threshold limit values (TLVs®) in 1971 to prevent irritation and narcosis effects. Due to the demonstration that BD causes multiple cancers in two animal studies in 1983, OSHA was petitioned by unions in 1984 and referred by EPA in 1985 for regulatory action. In 1990, OSHA published a proposed BD standard with an 8-hour TWA exposure of 2 ppm, a short-term exposure limit (STEL) of 10 ppm, and the ancillary provisions. There are many scientific studies contained in OSHA BD docket which enhanced the completion of a BD standard. Animal bioassays, human epidemiologic studies, experimental investigations on the metabolites and their mechanism in vitro and in vivo systems provides convincing evidence that BD is a probable human carcinogen. Three out of five quantitative risk assessments used NTP study with exposures of 6.25–625 ppm BD to calculate their best estimates of risk. Due to the availability of three breakthrough studies on BD, OSHA was able to allow the use of cartridges and canisters for respiratory protection that would enhance workers' protection, address industry's concerns, and reduce compliance cost. A series of plant visits conducted by the National Institute of Occupational Safety and Health (NIOSH) produced worker exposure profiles and information on technological feasibility which greatly helped in economic analysis. An epidemiologic study sponsored by the International Institute of Synthetic Rubber Producers (IISRP) completed in late 1995 clearly demonstrated an excess risk of cancer among workers exposed to BD which is complementary to the animal studies. This promoted IISRP to engage with unions to reach agreement on a standard with an 8-hour TWA exposure of 1 ppm, a STEL of 5 ppm, and other aspects of standard. This demonstrates that studies from various disciplines of science will greatly enhance the development of a workplace health standard. The opinion expressed here is sole of author.

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CIH PLUS IHIT UTILIZATION BY INDUSTRY OR INDUSTRY GROUP, AND PRELIMINARY PROJECTIONS OF FUTURE NEED FOR SUCH INDUSTRIAL HYGIENE PROFESSIONALS. L.W. Whitehead, CIH University of Texas-Houston Houston, TX, M. West Baylor College of Medicine, Houston, TX

Estimates of future need for public health professionals are very useful for planning educational programs and incentives for graduate education, and for staffing projections. No such estimates are known to exist for