Establishing standard methods for sampling of viable and non viable bioaerosols: A review

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Goal: Preventing occupational disease from inhaling bioaerosols in the workplace

Phase 1 Research occupational health

Partnering with physicians, other medical professionals and epidemiologists, the hygienist establishes a cause and effect relationship between inhalation of bioaerosols and organic dusts and specific occupational diseases.

Create standard methods for collecting, transporting and analyzing bioaerosols.

Establish occupational exposure limits for each biological agent.

Establish standard methods to reduce inhalation of airborne pathogen using engineering and personal protective equipment controls.

Goal: Preventing occupational disease from inhaling bioaerosols in the workplace

Phase 2 Routine occupational hygiene practice

Biological safety practice: to anticipate, identify, evaluate and control biological hazards in the workplace

Anticipation – workers are potentially exposed to airborne biological agents in several industries including food processing, agriculture, wood processing, metalworking, construction

Recognition- identify indoor and outdoor conditions, materials and operations that are sources of biological agents that under certain conditions could be released into the air creating a bioaerosol

Evaluation – using standard methods, conduct personal breathing zone sampling of workers potentially exposed to pathogenic biological agents

Control – reduce or eliminate worker exposure to airborne pathogens using ventilation or respiratory protective equipment

Achieving uniform terminology

Aerosol: airborne particles and the gas or vapor mixture in which they are suspended; a dispersion of solid and liquid particles in a gaseous medium (ASTM 2014)

Biological aerosol: an aerosol consisting of biological agents.

Biological **agents** include bacteria, fungi, viruses, other microbes, parts of microbes and associated microbial toxins.

Organic dusts include cotton, grain, flour and wood dusts and are NOT considered bioaerosols.

Viable bioaerosol particles are living microbes capable of reproduction either individually, as a group or adhered to a non-biological particle. An **infectious bioaerosol** is composed of viable biological agents.

Non-viable bioaerosol particles are not currently living and therefore are not capable of reproduction

Definitions: NIOSH Manual of Analytical Methods 5th edition 2016 (adopted ISO 215-18158)

Bioaerosol monitoring

The identification and measurement of concentrations of viable and non-viable biological particles in the air of the indoor (built) environment or the outdoor environment.

Occupational bioaerosol monitoring occurs in the industrial and non-industrial workplace.

Historically, bioaerosol monitoring has been based on the use of stationary samplers to define the exposure of workers and citizens to bioaerosols from environments such Non-industrial environ

Healthcare

Laboratory and research/development

Indoor Air Quality

Biological warfare and terrorism

Industrial workplaces

Area samples and sampling in the workplace

Area sample is an air sample taken at a fixed location in a workplace.(ACGIH 1998)

Area air samples are also referred to as

Fixed station sampling

Stationary air sampling

Static air sampling

Area Sampler SKC Glass Biosampler Impinger

Breathing zone samples and sampling in the workplace

Breathing zone sample is an air sample taken in such a way that the air sampled is within 30 cm of the nostrils of the person being sampled. (ACGIH 1998)

Breathing zone is a hemisphere forward of the shoulders within a radius of 6” to 9” OSHA Technical Manual 2018)

The breathing zone is within a 10” radius of the workers nose and mouth. (OSHA Lead in Construction regulation)

Breathing zone is a hemisphere generally accepted as 0.3 m or 30 cm extending in front of the human face, centered on a midpoint of a line joining the ears; the base of the hemisphere is a plane through this line, the top of the head and the larynx.

IOM Personal Inhalable Aerosol Sampler

Button Sampler

NIOSH Personal Bioaerosol Sampler

What do primary references advise : AS vs BZ sampling of bioaerosols?

Macher, J. (et al) Sampling Airborne Microorganisms and Aeroallergens. ACGIH Air Sampling Instruments. 8th edition, 1998.

There is no reference to difference between A and BZ sampling.

Macher, J. editor. Bioaerosols: Assessment and Control. ACGIH 1999.nCjapter 11 Air Sampling

(Willeke)

There is no reference to difference between A and BZ sampling.

Dillon,H.K. editor. Field Guide for the Determination of Biological Contamination in Environmental Samples. AIHA Biosafety Committee, 1996.

There is no reference to difference between A and BZ sampling.

Defining occupational exposures: AS or BZ?

1960- Jerry Sherwood invents the personal sampling pump.

1977- Leidel, N. et al. NIOSH Occupational Exposure Sampling Strategy Manual. Jan. 1977 77-173

Leidel quotes Sherwood-static samplers may generally misrepresent the exposure of workers who are likely exposed to airborne (radio)activity of their own making. He showed wide variation (typically 100 fold) of air concentrations at particular work stations.

Leidel also referenced Ayer, Shulte, Linch, Baretta and NIOSH 1973 Beryllium standard. No reliable conversion was found between results of personal total and respirable dust and general air sampling.

1999- Cherrie, JW- compared personal samples with area samples from various studies:

Asbestos -8.5, Total dust-5, Cotton-4.5, Xylene-2.6, Styrene-1.8 He concluded as room size increases or dilution ventilation rate increases the ratio of BZ to AS increases.

Composting Operations, Bioaerosols and Adverse Health Effects – HSE 2003 2010

2003

There is limited information on personal worker exposure to bioaerosols associated with composting processes. Few studies give details of exposures related to workers tasks associated with controls such as respiratory protective equipment.

Recommendation: Studies on composting should include personal exposures measured with task analysis to establish task-related exposure assessment.

2010

Bioaerosols were sampled using IOM breathing zone samplers. Results: If workers not protected from exposure, they may be exposed to concentrations of bacteria and fungi that frequently exceed 10E5 cfu/M3 and occasionally exceed 1,000,000 cfu/M3. There was no apparent attempt to conduct health assessments to establish relationship between airborne concentrations and signs and symptoms of occupational disease.

Organic dust: cotton dust

OSHA 1910.1043 Cotton dust

Definition: Dust present in the air during processing of cotton which may contain a mixture of substances including: plant matter, fiber, bacteria, fungi, soil, pesticides, non-plant matter.

This is the only OSHA regulation that requires **area sampling** for cotton dust using the vertical elutriator.

In 1992, Niven published a study comparing breathing zone and area samples in 8 Lancashire cotton spinning mills(305 work area samples and 252 personal breathing zone samples)>

BZ concentrations exceed area samples by factors of: 7.8, 4.9, 4.3, 1.4 and 2.5.

Conclusion: Work area sampling may significantly underestimate dust exposure in high risk areas and is outdated.

In 2008, Mehta in cotton mills found BZ samples exceeded area samples by factors of: 3,14.1,4.3, 5.1, 5.1, and 14

Standard Guide for Air Sampling Strategies from Worker and Workplace Protection ASTM 2014

Section 8 Factors affecting air sampling- breathing zone samplers vs. area samplers

Where a workers activities cause the emission of a contaminant, breathing zone samples will usually indicate concentrations up to one order of magnitude higher (x 10) than nearby fixed location (samplers)

Where a workers activities do NOT cause the emission of a contaminant, the breathing zone sampler will usually indicate concentrations the same as or lower than nearby fixed locations.

Is this a valid recommendation to apply to bioaerosols and organic dusts in 2018?

Findings and Recommendations

1. Occupational hygienists should stop using stationary bioaerosol samplers to evaluate the concentration of airborne pathogenic bioaerosols and organic dusts to define the exposure of workers.

Reason: Occupational hygienists cannot establish valid dose-response relationships between airborne concentrations of airborne biological agents and the development of specific occupational diseases without accurate exposure and dose assessments.

2. The ACGIH Bioaerosols Committee identifies four classes of bioaerosols:

Total culturable or countable; Specific culturable or countable; Infectious agents; Assayable biological contaminants

Position: It is not possible to establish occupational exposure limits because its not possible to establish exposure-dose-response relationships because of the extreme variation in response to different agents and different concentrations of agents among exposed workers

Findings and Recommendations

The ACGIH Bioaerosols Committee has published the same recommendations for 20 years with no progress toward resolving whether

A. industrial bioaerosols cause occupational disease among exposed workers?

B. the frequency and severity of disease among exposed workers is dose related? And

C. if it is not possible to identify high risk workers, is it possible to medically supervise workers to identify workers in the early stages of disease and implement the necessary controls to prevent disease?

3. In order to advance the practice, the discipline of biological safety should be reorganized into Healthcare, Laboratory/Research, Biowarfare and Terrorism, Indoor air quality and industrial Biosafety based on four factors:

source of bioaerosol, method of release into the air, method of transport to the worker and

the susceptibility of each person to infection, allergy, asthma, inflammation and intoxication