Risk of Disease from Exposure to Mold, Legionella and Endotoxin in the Industrial Workplace: Review of Literature

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What is Industrial Biosafety

The discipline of biological safety (biosafety) has several subdisciplines by occupational setting:

- Community environment to biological agents (Public Exposure)
- Healthcare environment
- Laboratory environment
- Biological defense/antiterrorism

*Industrial biosafety: prevention of occupational disease due to workplace exposure to specific biological agents associated with specific tasks or operations*
Occupational diseases caused by biological agents

Infectious disease
Respiratory, skin and gastrointestinal disease
Non-infectious disease
Respiratory
Mold, Legionella and Endotoxin: reservoirs

Fungi and fungal spores are ubiquitous in the environment with soil and water as reservoirs

Legionella bacteria are ubiquitous in the environment with soil and water as reservoirs; Legionella are gram negative and therefore have endotoxin

Endotoxin is the outer cell wall of gram negative bacteria and these bacteria are ubiquitous in the soil
Mold, Legionella and Endotoxin: primary resources for the OH

American Industrial Hygiene Association (AIHA)
Def. A biohazardous agent is one of biological origin that has the capacity to produce deleterious effects upon humans and includes organisms, toxins and allergens.

Recognition, Evaluation and Control of Indoor Mold (2008); does not address fungal infections or other adverse health effects of mold in the workplace; IAQ/public exp.

American Conference of Governmental Industrial Hygienists (ACGIH)
Def. Biological agent refers to a substance of biological origin that is capable of producing an adverse (health) effect e.g. infection, irritant, hypersensitivity, inflammatory or other response.

Evidence does not yet support TLVs for mold, Legionella or endotoxin
Mold, Legionella and Endotoxin: primary resources for the OH

Occupational Safety and Health Administration

1910.143 cotton dust (2000 rev). Keeping endotoxin low is crucial to avoiding byssinosis. 10 ng/M3 (100 EU/M3) for washed cotton is below a threshold for acute airway response.

Most molds are harmless but some cause infection, allergy symptoms and produce (myco)toxins. Preventing worker exposures and Legionellosis cases depends on implementing an effective water management plan (2019)

National Institute for Occupational Safety and Health
National Occupational Research Agenda (NORA) Jan.2019

Work-related respiratory diseases: infectious disease-RPD/influenza (no other agents). Prevent work-related upper airways disease-occupational rhinitis and sinusitis due to inhalation

American Biological Safety Association (ABSA)- no industrial biosafety guidance
Does Mold Cause Occupational Disease?


Conclusion:

An LOEL of 10 E5 spores/M3 seems appropriate as a basis for an Occupational Exposure Limit for spores from diverse fungi. This LOEL is probably too high if spores from mycotoxin-producing species or opportunistic infection species.

Individuals with asthma and sensitized to fungal allergens are more sensitive than working population and suggest a safety factor of 10, 10 E4 spores/M3.
Does Mold Cause Occupational Disease?

Case: Construction of a 3000 acre solar panel energy plant in California.

Disease: Coccidiomycosis (CM) (Valley Fever)

Agent: Coccidioides immitis

Reservoir: Soil (terrestrial)

Route of exposure: inhalation of fungal arthroconidia (spores) due to active soil movement

Attack rate: 2400 workers; 9 confirmed cases of CM 1,095/100,000; community attack rate: 17.5/100,000

Regulatory response: Cal OSHA $240,000 fine-poor (soil) dust control, poor worker training, poor respiratory protective device use training, poor health risk training
Aerosol transmissible Disease (Human Reservoir/Source)

Occupational exposure: any work activity or condition that creates an elevated risk of contracting disease caused by AT pathogen; elevated risk is risk higher than worker exposure to the general public

Regulates: Healthcare, Police, Emergency Response, Public Health Agencies

5199.1-ATD-Zoonoses (Animal Reservoir/Source)

Occupational exposure: work exposure to source of ATP-Z that creates a risk of contracting disease

Regulates: Any occupation or workplace that involve live animals, domestic or wild, carcasses or wastes

Comment: Cal OSHA regulates human and animal sources of infectious disease agents in the workplace but does not regulate environmental reservoirs: WATER (aquatic) or SOIL (terrestrial)
Cal OSHA – Biological Safety Regulations

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Cal OSHA and Legionella

Health Official Testifies that Disneyland Cooling Tower was Likely Source of 22 Legionnaires Disease (LD) Cases

Three employees (cast members) developed LD, two hospitalized.

The employer did not follow the manufacturers cooling tower start up maintenance and water treatment procedure to control outbreaks of LD.

Disney Theme Parks fined $33,000. for failing to report, failing to operate equipment per manufacturer

The source of the outbreak has never been scientifically determined.
Is Legionellosis an Occupational Disease?

There are two forms of Legionellosis: Legionnaires Disease (LD) and Pontiac Fever (PF).

Principe states: The occupational impact of the disease (Legionellosis) has been overlooked until recently probably because the risk of acquiring LD or PF did not appear specific for certain industries and jobs. The List of Occupational Diseases (ILO,2010) does not list LD or PF among work related diseases.

Legionellosis and Dental Health Care Workers

Petti states: Assessing the occupational risk of Legionella infection to dental staff is not a marginal question since there are approximately 1 million exposed dentists, hygienists and assistants in the US and Europe.

Finding: Between 1985 and 2008, there were 7 primary studies involving 2232 DHCW and 1172 unexposed persons. DHCW were at occupational Legionella infection risk in the 80’s and 90’s with prevalence ratios greater than 1 while since 2000, the occupational risk is negligible.

Reason: Publication of 1993 CDC Infection Control Guidelines in Dental HC Settings.

Legionellosis and Automobile and Metal Shredding Facility (NY)

Process: Automobiles and other waste metals are dropped into shredder and placed onto moving belt conveyor belt where workers sort metal pieces (picking). Shredder cooled by potable water which is partially converted to steam through contact with hot surfaces. Wastewater flows across ground to drains and sewer.

Disease: 5 workers (pickers) with LD 2008-2011. 43 total workers in production.

Conclusion: In this type of industrial setting, Legionnaires Disease should be considered when persons work around standing (stagnant) water (200,000 Lp/ml) with potential for aerosolization and present with an acute febrile respiratory illness with systemic symptoms.

Legionellosis, Endotoxin and Food Processing

Process: Cleaning 5 10 foot vertical tubes in an evaporator vessel, which contained sugar beet residue and precipitate. Two power washers at 20,000 psi created aerosolized materials and water.

Disease: 14/15 workers develop Pontiac Fever/ 1 case of pneumonia LD

Water source: Treated process water stored in outdoor lagoons, then in clearwell however clearwell contaminated by untreated water.

Power wash water microbial analysis per mL:

- $\geq 2E4$ coliform
- Legionella
- E6 L. pneumophila sero 1,3,4,6
- Endotoxin $2E4$ EU

Agricultural Workers and Respiratory Disease from Biological Agents


Conclusion: Few studies have measured inhalation exposures while simultaneously assessing the impact of the exposure on the lung function of dairy workers.

Review period: 2002-2012 (10 years) 147 citations: 30 included either quantitative and qualitative exposure assessment and health studies, 10 quantitative measurements of exposure.

Four Respiratory diseases identified:

- Asthma
- COPD defined as FEV1/FVC >5% loss
- Hypersensitivity pneumonitis
- Chronic bronchitis
Compost Workers and Respiratory Disease from Biological Agents


Papers identified: 536; papers meet criteria- 66; 48 exposure studies only; 9 health and exposure studies.

Conclusion: Health studies provide some evidence of potential short-term respiratory, gastrointestinal and proinflammatory effects at high exposures.

Findings: Fungi exposure: 10 – E7 cfu/M3  Endotoxin exposure: 1-E4 EU/M4

Comment: The primary question: Do compost workers experience occupational diseases at elevated rates above the general population or a cohort of unexposed workers? Only 9 out of 526 scientific studies addressed the primary question.
ACGIH: TLV-TWA 1 mg/M3 is recommended to protect workers from upper and lower respiratory tract irritation and decrease in pulmonary function.
Sewer Workers and Respiratory Disease from Biological Agents


Period reviewed: 950 papers 190-2015

Papers meeting criteria: 14 studies identifying causality and general health symptoms bacteria and endotoxin

Findings: Most studies do not show evidence of causality of health symptoms or biomarkers of biohazards commonly found in sewage or findings indicate risk is small.


Environmental and Health Study: 67 wastewater treatment plants, 371 exposed workers, 97 unexposed workers (cohort).

Findings: Personal sampling for 8 hr endotoxin concentrations above 200 EU/M3 Had significant upper respiratory symptoms and flu-like and systemic symptoms (Lower RT and skin not significant).
Obstacles to progress: Clarification of terminology used in industrial biosafety in 2019

Exposure Science
Exposome
Quantitative microbial risk assessment
Human microbiome
  Human lung microbiome
One Health
Infection preventionists
NIOSH Exposure Banding Protocol
Primary, secondary and tertiary prevention
Summary of findings

- Industrial Biosafety is the least recognized area of biological safety

- Industrial Biosafety studies occupational infectious diseases and non-infectious disease caused by organic dusts including both the substrate dust (wood fiber) and the biological agents that travel on the dust and with the dust

- Mold, Legionella and Endotoxin are found in any workplace where tasks and operations involve soil or water is processed-the issue is not agent presence but concentration, aerosolization, aerosol size and composition and employee exposure
Summary of findings (continued)

AIHA, ACGIH, ABSA, NIOSH and OSHA provide extremely limited guidance to occupational hygienists in the areas of

Medical surveillance of employees for evidence of disease caused by biological agents

Development of dose–response evidence leading to OEL

Development of bioaerosol sampling methods

Development of bioaerosol analysis methods

Lack of OEL prevents rational control method recommendations

Future IBS studies must be team based: Physician – Epidemiologist–Hygienist (too many environmental studies, too few health studies!)