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Impact of Bioaerosol on Indoor Air Quality- A Growing Concern

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Indoor air quality is important for human health and comfort because now a day's people spend most of their lives indoor. Long term contact of people with some species of microorganisms can be a source of serious illness, can influence a person's mental power and learning ability. Microflora of indoor air is influenced significantly by occupants, equipment, building materials, dust, air conditioning systems and many other sources present in enclosed spaces. Microorganism composition reflects indoor air qualitatively. The importance of qualitative and quantitative estimations of airborne microorganisms are that these values can be used as an index for cleanliness of the environment as well as an index they bear in relation to human health.

WHAT IS INDOOR AIR QUALITY?

There has been a growing concern in past few decades regarding the hazardous effects of poor indoor air quality on the health of individuals and that's why the world has started paying attention to 'Invironment'. This is a new terminology, being used increasingly to focus on Indoor Air Quality (IAQ) and its effect on human health. The terminology 'Indoor Air Quality' refers to the nature of the conditioned (heated/cooled) air that circulates throughout the space/area where we work and live, that is the air we breathe during most of our lives. This refers not only to the comfort, which is affected by temperature, humidity, odor, but also to the harmful chemical and biological contaminants present in the conditioned space.

PROMINENT BIOAEROSOLS IN INDOOR AIR

Bio-aerosols are airborne particles that are living (bacteria, viruses and fungi) or originate from living organisms. These particles are also referred to as organic dust. Their presence in air is the result of dispersal from a site of colonization or growth. Bio-aerosols contribute to about 5-34% of indoor air pollution. Particulates of airborne microbes such as bacteria, fungi, virus, actinomycetes and other microorganisms contribute significantly in this air pollution. These biological contaminants may breed in stagnant water that has accumulated in ducts, humidifiers and drain pans, or where water has collected on ceiling tiles, carpeting, plumbing leaks or insulation. Humidifiers are an important source for bacterial exposure that may lead to allergic type disease. Sometimes insects or birds droppings can be a source of biological contaminants. Improper ventilation causes condensation and hence moisture buildup inside buildings. Actinomycetes that originate from environmental sources rather than from humans are regarded as moisture indicator bacteria in indoor environment. The presence of thermophilic actinomycetes in air or in any reservoir in occupied environments is of concern.

Molds are ubiquitous in the biosphere and mold spores are a common component of household and workplace dust. Gravesen [1] carried out extensive survey of indoor microfungi in Danish homes. An analysis of house dust revealed the presence of species of *Absidia, Acrosperia, Alternaria, Arthrobotrys, Aspergillus, Bipolaris, Botrytis, Chaetomium, Cladosporium, Epicoccum, Fusarium, Humicola, Mucor, Phoma, Rhizopus, Tritirchium, Verticillum* and many more. *Trichoderma viride* and *Chaetomium sp*. have strong cellulose decomposing ability, due to which they possibly play an important role in degradation of textile fibers in dust. It is estimated that more than 10% of the Indian population suffers from one or the other

form of nasobronchial and/or dermal allergies. Allergologist have recognized the role of house dust mites and fungi in inducing allergy. Group 1 allergens of the mites *Dermatophagoides pteronyssinus* (*Der* p1) are one of the well known and significant allergens. *Penicillium* and *Aspergillus* species are generally isolated from indoor environment and can cause allergic responses. The major allergic diseases induced by fungi are asthma, rhinitis, allergic bronchopulmonary mycoses, and hypersensitivity pneumonia. As a known component of indoor bioaerosol, β(1→3)-glucan (cell wall components of most fungi) is proposed to be the causative agent of mold-induced nonallergic inflammatory reactions.

Molds can also present a health hazard to human, when present in abnormally high quantities. Fungal contaminants can be dangerous as pathogenic living cells because they can also secrete some substances harmful for health. Mycotoxin is one such toxic metabolic product. Ineffective ventilation may lead to an increase in concentration of mycotoxinogenic molds *Penicillium* and *Aspergillus* species. Aflatoxin from *Aspergillus flavus* is capable of causing liver cancer, while Ochratoxin A is a possible human carcinogen. Exposure to aflatoxin and ochratoxin occurs by ingestion, but can also occur by inhalation in industries such as peanut processing, livestock feed processing, or when grain dust exposure occurs [3-5].

Stachybotrys chartarum, is a hydrophillic, greenish-black fungus, that grows on material with a high cellulose and low nitrogen content that become water damaged as a result of excessive humidity, leaks, condensation, or flooding. Its presence is one of the clearest demonstrations that mold growth in a building is directly affecting the quality of the indoor environment, since *S. chartarum* is not common in the outdoors. Presence of large numbers of hydrophillic fungi are indicators of extremely wet amplification sites indoor, and therefore of poor indoor environmental quality. Moreover *S. chartarum* also damages extremely wet gypsum wallboards. The presence of this mold is of particular concern because several toxic secondary metabolites (e.g., macrocyclic trichothecenes and saratoxins) have been isolated from *S. chartarum*. Dermotoxic and cytotoxic symptoms can occur due to these metabolites in exposed individuals.

Though air conditioning systems provide occupants with a more comfortable environment, nevertheless such artificial environments may be favorable for fungi, bacteria, protozoan and mites growth, which may bring health problems to users, either in form of hypersensitivity or infection. According to American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE, 2007) the health effects caused by microorganisms that are in indoor environment with air conditioning systems can be infective or immunological.

HOSPITALS AND ITS IAQ

Dispersion and dilution by large volume of air is an inherent mechanism of air sanitation in outside air. The indoor air environment of hospitals can potentially place patients and health workers at greater risk than the outside environment because enclosed spaces can confine aerosol and allow them to build up to infectious levels. Hospital indoor environment may consist of high level of potentially hazardous bacteria, fungi and other allergenic and/ or immunotoxic agents. These agents may penetrate into lungs of exposed residences or dwellers and evoke inflammatory reaction leading to respiratory diseases such as asthma, mucous membrane irritation, allergic alveolitis etc. Healthcare facilities have to pay particular care and attention to indoor air concerns because people with pre-existing health problems who are going through treatment and those who may have depressed immune systems are very susceptible to indoor air exposures. Hospital acquired (nosocomial) *Aspergillus* infection may be serious problem at hospital wards with patients suffering from neutropenia. Favero et al. have demonstrated that bioaerosol contaminants were mainly associated with emissions from human hair, skin and respiratory tract, in hospital operating rooms. Members of *Klebsiella, Enterobacter* and *Serratia* groups, and *Pseudomonas aeruginosa*, *P. cepacia, Flavobacteria* and other non-fermentative bacilli can able to grow well in environmental fluids. Some bacteria such as *Streptococcus pyogens, Neisseria meningitidis, Corynebacterium diphtheriae* and *Mycobacterium tuberculosis* are known to be transmitted predominantly by airborne droplets from infected people, and they may cause nosocomial infection. Poor hospital IAQ may cause outbreaks of sick hospital syndrome (SHS), causing headaches, fatigue, eye and skin irritations, and other symptoms. More seriously, improper control of hospital IAQ may cause hospital-acquired (nosocomial) infections and

occupational diseases [6-7]. Bioaerosol monitoring in hospitals can provide information for epidemiological investigation of nosocomial infectious diseases, research into air borne microorganism spread and control, monitoring biohazard procedures, and can be used as quality control measure.

OCCUPATIONAL SITES AND SICK BUILDING SYNDROMES

At occupational places, poor indoor air quality leads to increased incidence of health related symptoms, which in turn can lead to an increase in absenteeism and a loss in productivity. Some of the common symptoms can be related to Sick Building Syndrome (SBS). SBS is a term that describes the presence of acute, non-specific symptoms in the majority of the people, caused by working in building with an adverse indoor environment. According to ASHRAE, if 20% or more users of such environment present the above mentioned symptoms, these places are considered as SBS. Lack of cleaning and checking out of the heating, ventilation and air conditioning systems (HVAC) may allow microbial growth, which causes rhinitis, bronchitis, pharyngitis, pneumonia, congunctivitis and keratitis in the users. SBS influence public health and economy negatively, because some of these diseases decrease worker's productivity and cause their absence at work. Though biological factors plays a pivotal role in SBS resulting in symptoms and discomfort, other factors leading to SBS are chemical, physical and psychosocial in nature. SBS is a cluster of complex irritative symptoms that include irritation of the eyes, blocked nose and throat, headache, dizziness, lethargy, fatigue, irritation, wheezing, sinus congestion, dry skin, skin rash, sensory discomfort from odors and nausea. The MELISA (Memory Lymphocyte Immunostimulation Assay) test is used in occupational medicine and environmental health. It has been used to screen workers exposed to physical (e.g. metals), chemicals or other allergens in their workplace[8-10].

HOW TO IMPROVE IAQ

Indoor air quality can be improved by removal or destruction of microorganisms. Oiling floors, bedclothes, curtains, and other textiles is a highly effective method of control of dust. Carpets which harbor dust mites and molds should be removed. To control dust mites dust proof mattress and pillows should be used and sheets should be washed weekly in hot water. Use of dry vacuum pick up, followed by the application of an appropriate disinfectant-detergent solution is also recommended for dust removal. Water leakages should be repaired in order to avoid humidity buildup. The another solution to bioaerosol pollution is dilution. Removal of contaminants from buildings or reducing its concentration within hospital can be accomplished by passive or active fresh air ventilation. Ultraviolet radiations are microbicidal in nature and hence irradiation of unoccupied rooms effectively reduces the aero-microflora [2-5]. Vapors of propylene glycol and triethylene glycol are strongly germicidal. For high-risk patients, like those whose immune systems are compromised, there may be special rooms that are under positive pressure in which fresh air flows into the room and there is positive pressure built up so that no contaminants can come in from the outside. These rooms are called protective isolation rooms since they are designed to protect the patient. In a critical area serving an immunocompromised patient, a high-efficiency particulate air (HEPA) filter with 99.97% efficiency on 0.3 μm particles should be used. Ultra-low penetration air (ULPA) filters at 99.999% efficiency on 0.1–0.2 μm particles are also available. All parts of the humidification and dehumidification systems must be kept clean and dry to prevent growth of bacteria and fungi. Increasing the number of air exchanges can solve problem of SBS, The ASHRAE recommend a minimum of 8.4 air exchanges per 24 hour period.

CONCLUSION

The frequency of media headlines on the consequences of indoor-air and indoor-environment problems indicates that much is still to be done in identifying and managing indoor-air deficiencies. It is therefore important to evaluate the quality of the air we breathe. The number and types of airborne microorganisms can be used to determine the source of human discomfort.

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