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Toxic Moulds and Indoor Air Quality

Monitoring, Heath Hazards, Identification, Risk Assessment and Control in Buildings

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Summary

There are about 1.5 million fungi mostly live on decaying organic matter, in symbiotic relationship with lichens and mycorrhizal association and more than 1000 species have evolved to exploit the man-made spatial ecosystems of our built environment. In Britain and western Europe, on average we spend 80 - 90% of our time indoors and the indoor environment may influence the health comfort and productivity of occupants in buildings in the following ways.

- Sick Building Syndrome (SBS)
- Building related illnesses
- Allergy and environmental health problems (AEHP)
- Psychological and psychosomatic issues.

Many days of work are lost through absenteeism, lack of concentration, not feeling well at the workstation, a significant amount is caused by Sick Building Syndrome (SBS), Building related illnesses and Allergy and environmental health problems (AEHP, which can lead to low morale, inability to concentrate, eye strain and poor productivity.

Identification and risk management of moulds, indoor air quality problems and health hazardous in buildings is a complex issue; it required a multi-disciplinary integrated approach, which combines the skills of material scientists, environment monitoring and health specialists, occupational hygienists, toxicologists, engineers and architects.

The most common building health problems in domestic housing relates to dampness and condensation resulting in mould growth, house dust mite and a range of other fungal & insect pests, aggravating respiratory problems and allergies.

Stachybotrys chartarum and many fungi for example species of *Aspergillus, Penicillium, Fusarium, Trichoderma and Memnoniella* can produce potent mycotoxins. Mycotoxins are fungal metabolites that have been identified as toxic agents and for these reasons these fungi can be treated as toxic in the indoor environment. Mould growth in buildings may affect the health of occupants in many ways and may contribute to building related illnesses (BRI), Sick Building Syndrome (SBS) as well as allergy and other environmental health problems.

Extensive exposure to fungal contamination and the professional working in the renovation/cleaning/mould assessment may be at risk for developing organic dust toxic syndrome (ODTS), hypersensitivity Pneumonitis.

Health Effects

Indoor fungi can cause a number of different types of illness, through the production of spores, mycotoxins and VOC emissions to the occupants, for example;

- Allergic reaction; rhinitis and asthma
- Hypersensitivity pneumonoitis
- Infection for example, aspergillosis, histoplasmosis, cryptococcus and coccidioidomycosis
- Sick building syndrome
- Irritation, from fungal VOCs
- Inflammation, from fungal cell wall
- Toxic reactions from mycotoxins

- Immune disorder from immune suppressor mycotoxins
- Cancer from carcinogenic mycotoxins

Adverse health effects related to humid buildings appear mainly as respiratory symptoms, for example;

- Coughing,
- Wheezing,
- Inflammation in eyes and airways and
- Fatigue and Joint pain (As A general symptom)

A list of symptoms related to humid buildings and the underlying pathology of those symptoms is likely to be inflammation. These were as follows;

- Mucosal irritation (eye, nose, airways)
- Skin (rash, itching, burning, sensation)
- Systematic (joint pains, fatigue, lethargy, headaches)
- Neurological (pain, loss of sensitivity)
- The diseases related to the humid buildings were;
- Atopic sensitisation (with or with out symptoms)
- Allergy (asthma, rhinitis)
- Increased risk of infection
- Toxic pneumonitis
- Allergic alveolitis

In the most common allergic conditions the biological particles for example moulds involved generally have spore diameter greater than 5µm. This includes spores of most commonly occurring moulds such as the followings;

- Alternaria alternata,
- Botrytis cinera,
- Cladosporium herbarum, C. macrocarpum,
- Drechslera spp. and
- *Epicoccum purpurascens*

In the indoor environment, where there is dampness and condensation, fungi manipulate the microclimates and ecological niches of our buildings and feed on a variety of substrates. Over the last century the management of mould problems in buildings has largely relied on a misunderstanding and misdiagnosis of the biology, ecology and physiology of the causal organisms.

Allergy and Environmental Illnesses

Allergy at workplace environment is a growing concern to employers and it is a complex issue, which requires a multidisciplinary integrated approach. Exposure to indoor allergens is a risk factor for the development of allergic reactions and the incidence of the problem is increasing at an alarming rate. This reflects on the health, comfort and productivity of the occupants and also increases in the rate of sickness at work places. The fundamental understanding and close dialogue between employees & human resources; facilities managers & health & safety officers; architects, engineers and building health specialists is essential, in order to identify, evaluate, monitor and remedy allergic reactions in buildings. In this article we will be discussing allergic reactions in buildings, their signs & symptoms, types of allergies, indoor allergens & their management (3,4,5,6,8,9 & 10).

A majority of the occupants in these buildings complain, and most frequent complaint is irritation of eyes, nose, and throat. Many different factors are known to be potential agents for the symptoms and no definitive causality has been identified yet.

Allergy and Indoor Environment

Allergy & Damp-building syndrome

Buildings which suffer from dampness (Rising or penetrating dampness), moisture problems due to condensation, fire and flood damage can significantly higher the number of micro-organisms in the indoor environment. This creates problems for allergic patients. A prolonged residual moisture problem may also cause troubles for nonallergic people, who may develop several of the mucosal and general symptoms.

Indoor Allergens

There are more than 100,000 species of fungi. The genera and species that cause human disease involve a wide array of fungi. The most common fungi in both adult and pediatric populations in descending order of frequency were *Alternaria, Helminthosporium, Cladosporium, Fusarium, Aspergillus, Phoma and Penicillium*

Other moulds of allergenic importance include, for example, *Botrytis, Rhizopus* and *Trichoderma*. Fungi for example both moulds and yeast; moulds have hyphae and yeast's are unicellular fungi that reproduce by budding or fission. A clinically important yeast allergen is Candida, which forms pseudohyphae.

Fungi produces large numbers of spores and when these spores liberated from infected buildings to the indoor air, it can be regarded as organic dust. These spores can, like other types of dust, sediment on surfaces or it could be inhaled by occupants and deposited on the mucosal surface of the upper airways and in the eyes. Repeated exposure to large amount of fungal propagule risks the development of specific allergic reactions.

The house dust mites, moulds and, less commonly, amoebae that can colonise building structures, services & furnishing & finishes and can cause allergic and other diseases. House dust mites, fungi and yeast's are potent sensitizers, and they flourish in an environment of high relative humidity and low ventilation. Fragments of these organisms or their decayed material or their metabolites, becoming airborne, can be inhaled and cause allergic disease.

Common Examples of Allergic Readings

The Common Cold The common cold is due to infection by rhinoviruses. (close personal contact and nasal mucus on hands), and spread is facilitated by overcrowding and poor ventilation. On average, individuals suffer 2-3 colds per year but the incidence lessens with age, presumably as a result of accumulating immunity to the causative virus strains. The incubation is from 12 h to an upper limit of 5 days. The symptoms are tiredness, slight pyrexia, malaise and a sore nose and pyrexia, malaise.

Sinusitis Sinusitis is an infection of upper respiratory tract e.g. allergic rhinitis. Acute infections are usually caused by *Streptococcus pneumoniae* and *Haemophilus influenzae*. Symptoms include frontal headache and facial pain and tenderness, usually with nasal discharge, but are often difficult to differentiate from symptoms of

the common cold. Chronic sinusitis can be a cause of headache, but often these headaches are due to tension.

Rhinitis Rhinitis (sneezing attacks, nasal discharge or blockage) maybe seasonal (Hay Fever or Allergic Rhinitis) or throughout the year (Perennial Rhinitis).

Seasonal rhinitis (Hay fever or Allergic Rhinitis), is the most common of all allergic diseases. Nasal irritation, sneezing are the most common symptoms but many also suffer from itching of the eyes. Symptoms are due to allergy to pollens and Cladosporium herbarum.

Perennial Allergic Rhinitis This is most commonly associated with allergens come house dust mite, domestic pets and industrial dust, vapours and fumes. The latter are more likely to cause occupationally related perennial rhinitis than asthma. The housedust mite itself is <0.5 mm in size, invisible to the naked eye and is found in dust throughout the house, particularly in older, damp dwellings. They depend for nourishment upon desquamated human skin scales and are found in abundance (4000 mites per gram of surface dust) in human bedding. Allergens from the faecal particles of the house-dust mite are the most important extrinsic cause of asthma world-wide.

Environmental Monitoring for Volatiles

Fungal volatiles affect health of the occupants by causing, for example, nasal irritation and feelings of stuffiness. Moulds can produce a variety of volatile substances, including, alcohols and ketones such as 3-methylbutanol, octen-3-one, octan-3-one, octain-3-ol, 2-octen-1-ol, 1-octen-3-01 and 1,10-dimethyl-trans-9-decalol (geosmin).

Other compound such as 2-methyl isoborneol and 2-methoxy-3-isopropylpyrazine, which may contribute to "musty", "mouldy" or "earthy" odours associated with mould growth in damp buildings. The principal volatile of moulds is ethanol in damp buildings.

Environmental Monitoring for Mycotoxins

Mould spores contain a variety of biologically active molecules called mycotoxins other than allergens. There is adequate evidence that inhalation of fungi, particularly those that produce mycotoxins – results in immunological disregulation, with potential neurological effects i.e. interference with pulmonary macrophage function. It is also possible that straightforward mycotoxicosis from inhalation exposure occurs under some circumstances (15 to 18).

Environmental Exposure and Assessment of Spores

The spores not just the vegetative mycelium, of many toxigenic moulds have been demonstrated to contain mixtures of the toxins, which are known to be produced by the species. For example, the conidia of number of moulds contains toxins, these include, *Fusarium graminearum* (DON), F. sporotrichioides (T-2), F. moniliforme (fumonisin), *Stachybotrys chartarum (atra)* (satratoxins), *Penicillium expansum* (citrinin), P, chrysogenum (roquefortine C), P. brevicompactum (mycophenolic acid), *Aspergillus versicolor* (sterigmatocystin), A flavus, A. parasiticus (aflotoxins) (15 to 18).

Exposures to the spores of *Stachybotrys chartarum (atra)* from handling contaminated hay and a wide variety of symptoms associated with such exposures

have been reported, including respiratory tract bleeding. Occupants of an office building and other cases of building related exposure to S. *chartarum* (atra) and its toxins contaminated by the organism have been reported to cause respiratory and other symptoms (15 to 18).

Fungal spores contain biologically-active B-1,3-glucan as a component in walls of spores and hyphae. A variety of substances in fungal spores, including mycotoxins and B-1,3-glucan, can then interfere with normal functioning of macrophage cells. Both inactivation and stimulation of pulmonary alveolar macrophage cells would have important physiological consequences, as macrophages are primarily responsible for the clearance of insoluble particles. The response of pulmonary alveolar macrophages and the immune system to B-1,3-glucan is only partially understood, but it appears that exposure causes inflammation reactions in lymphocytes affecting lymphocyte mitogenicity, affects IL-1 secretion (via T-calls) and stimulates bacterial and tumour defence. The glucan decreases the number of pulmonary alveolar macrophages and also phagocytosis (15 to 18).

Inhalation exposure to very high concentrations of fungal spores leading to hypersensitivity pneumonitis, lower levels of exposure to conidia also have consequences, for atopic and non-atopic individuals. In addition to allergic effects that they may have on atopics, such exposures apparently produce a variety of non-allergic effects on lung function, particularly interference with pulmonary alveolar macrophage cells. A variety of undesirable effects occur if sufficient numbers of these cells are damaged a variety of biochemical changes occur. Unusual exposure to fungal spores, alone and in combination with biotic and abiotic factors can be expected to promote viral and bacterial disease and decrease general well being.

A range of instrumentation is available for monitoring physical, biological and chemical pollutants in the buildings. For example, biological risk assessment of moulds, bacteria and house dust mites in the indoor environment is carried out by a range of instrumentation. The choice of sampler requires careful consideration of the purposes of the investigation, the information required, the characteristics of the biological pollutants in the environment being studied and the sampling and trapping efficiencies of the available samplers. Other methods include sampling airborne allergens, airborne mycotoxins, sampling volatile metabolites and endotoxins.

Outbreaks of allergic diseases such as allergic rhinitis, asthma, and hypersensitivity pneumonitis may also be an indication for microbial contaminants. Identifying a single causative agent is virtually impossible because many of these factors are highly interrelated with one another. For example, newer buildings are more likely to be closed, mechanically ventilated structures with high levels of centrally controlled fluorescent lighting and modern furnishing that may emit moderate levels of VOCs.

Similarly sampling methods for Man-made mineral fibres, natural dusts and particulates, Gases, vapours and fumes are available.

It is important to establish from health and safety point the following

- Maximum exposure limits
- Occupational exposure standards
- Compliance with regulatory standards

Management

Allergen Avoidance

Removal of a household pet or total enclosure of industrial processes releasing sensitizing agents can lead to cure of rhinitis and, indeed, asthma.
The house-dust mite infests most areas of the house, and is not confined to the bedroom. Mite counts are extremely low, where carpets are absent, floors are cleaned frequently and mattresses and pillows are covered in plastic sheeting that can be wiped down. Similar conditions may be reproduced if mite counts are to be reduced. Where there is risk of exposure to a known material with a record for causing allergy, the management of that material can be achieved by the principles of substitution, containment, local exhaust ventilation and finally personal protection.

Environmental Control of Allergens

Environmental control of allergens consists of three possible treatment methods that can be used singly or in combination: avoidance, pharmacotherapy, and immuno-therapy. For example, elimination of allergen reservoirs, control of humidity, exposure to heat or cold and air filtration. Air filtration and vacuum cleaning have long been recommended for control of dust mites, their efficacy has been variable. If filtration is to be recommenced, high-efficiency particulate air (HEPA) filters are probably most effective.

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