**Building Related Illness**

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# BUILDING RELATED ILLNESS

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Building related illnesses, sick building syndrome (SBS) and allergy and environmental problems in buildings can have direct and indirect impact on health, work place comfort and productivity of the occupants. The enhancement of Indoor air quality (IAQ) and the management of the above problems can lead to improvement in health and comfort and gains in productivity. Facilities managers, and human resource departments or those responsible for occupant health and safety at work often misunderstand the causes of illnesses and stress and sometimes concludes that it is an individual problem and completely ignore the fact that problems may lie within the workplace.

## Building related illness (BRI)

BRI is defined as the illness(s) caused directly as the result of being in and around the building environment. Building related illnesses and stresses can be caused by a number of factors individually or a combination of their synergetic effects. For example:

- Biological factors
- Physical factors
- Chemical factors
- Organizational and management factors
- Psychological and Psychosomatic factors

These factors will be discussed in detail, later in this article.

## Indoor and Outdoor Environment

The indoor and outdoor environment plays a significant role in determining the quality of air we breathe at our workplace or in our offices.

## Outdoor Environment (External Environment)

The external environment mainly contains pollutants e.g.:

- Traffic pollution (CO, CO2 , NOx , SOx etc)
- Radiation (Ultraviolet exposure)
- Contaminated land (Methane, Radon)

## Indoor Environment

The indoor environment is a cocktail of diverse pollutants. There are a very wide rage of potential indoor air pollution sources, the effects of which may impinge on the occupant's health or the synergetic effect of these factors may be the cause of health related problems in buildings.

Many factors influence the indoor environment within buildings, including the choice of building material, infestation by insect, pests and other forms of biological organisms and the efficiency of services equipment. The following list covers the broad areas of sources of indoor pollution:

- **Materials** - Formaldehyde, solvents, mineral fibres, radon gas, pesticides , interior furnishings and volatile organic compounds
- **Construction** - Air tightness and energy conservation vs. ventilation for occupants and fabric
- **Services and Controls** - Thermal comfort, lighting, air conditioning, and control of indoor micro climate
- **Workplace Design** - Building layouts, ceiling heights and volume of space per occupant
- **Occupants** - Occupant activities, moisture and introduction of pollutants, tobacco smoking, photocopying, cleaning and other activities – ozone, organic compounds, particulates
- **Environmental Factors** - Humidity and mould growth, noise, odour and irritation, emission of gases and outdoor pollution
- **Maintenance and Management Factors** – Poorly maintained building fabric, systems & controls and cleanliness routine and general office hygiene.

## Causal agents of illness and stresses

Causal agents of illnesses and stress in buildings maybe chemical, physical, biological, psychosomatic or their cocktail effect.

**Chemical**

| | | |
|---|---|---|
| Inorganic | Gaseous | SOx, NOx, COx, O3, Chlorine & ammonia |
| | Liquid | Aerosols (aerosols may be of gaseous, particulate, liquid or mixture of these) |
| | Particulate | Heavy metals, mineral fibers |

Organic

Very Volatile Organic Compounds (VVOC)
Boiling point range, <O C to 50-100°C e.g. formaldehyde, benzene, toluene

Volatile Organic Compounds (VOC)
Boiling point range 50-100°C to 240-260°C e.g. Solvents, plasticisers, wood preservative

Semi-Volatile Organic Compounds (SVOC)
Boiling point range 240-260°C to 380-400°C e.g. Pesticides, fungicides

Particulate Organic Matter (POM)
Boiling point range >380°C e.g. Soot dust.

The classification of volatile organic compounds is based on Curwell et at. (1990)

**Biological**

Biological contamination of the indoor environment has received increasing attention in recent years as a possible cause of indoor-air-related illness at home and at work (Singh 1993, Miller, 1990, Burge, 1990). The main biological factors causing building related illness(s) are as follows;

Microbes: - Viruses, Influenza; Bacteria, mycobacteria - Endotoxins, and Legionella pneumophila;
- Fungi, mycoplasmas, spores, toxins, mycotoxins, conidia, hyphae Thermophilics, actinomycetes , *Thermoactinomyces vulgaris, Saccharopolyspora rectivirgula (Micropolysporum faeni);*
- Plants Seed plants Pollen
- Arthropods, Mites House-dust mites, storage mites, Insects Cockroaches (disease carriers)
- Animals, Rodents, Rats (disease carriers), Pets, Excretions, animal dander, skin, scales, fur, feathers, serum proteins, Birds, Disease transmission, Humans, CO2 ammonia, disease carriers.

**Physical** The main physical factors are as follows:

Sensible: Temperature, humidity (at extremes); Light (glare, flicker); circadian dis - synchronization; Noise - Printer; Vibration - Traffic, Trains, Aircraft.

Insensible: Static electricity - ve + ve ion imbalance; Electromagnetic radiation (EMF): Ionizing: Radon, Non- Ionizing, UV under/over exposure, bio-electromagnetic effects.

## Sealed Buildings

The indoor environment in sealed buildings allows the accumulation and proliferation of the above agents causing stresses and illnesses. For example, the microorganisms and their metabolites (i.e. endotoxins and mycotoxins and volatile organic compounds) as well as their spores and hyphae, and chemical pollutants from the building material and construction and their circulation within the indoor air of tight buildings leads to a range of complaints from the occupants, if poorly monitored. These organisms grow and proliferate in the ductwork and filtration equipment, which is contaminated with the dust, and produce variety of spores, which are then re-distributed in the indoor environment.

**Organisational, Management and Cultural Factors**

E.g. Depression, anxiety, overwork and frustration.

**Psychosomatic and Psychogenic**

## Legislation

The health and safety executive and the local environmental health departments are endorsed by current legislation on building related illnesses e.g.;

- 1974 The Health and Safety at Work etc Act
- 1992 Workplace (Health, Safety and Welfare) Regulations
- 1992 Display Screen Equipment at Work Regulations
- 1992 Provision and Use of Work Equipment Regulations
- 1994 COSHH, Control of Substances Hazardous to Health Regulations
- 1995 The New Disability Discrimination Act
- 1987, The Control of Asbestos at Work Regulations
- 1987 Health & Safety Executive Legionnaires Disease
- The control of Legionellosis Proposals for Statutory Action

## Examples of Building Related illnesses

| | |
|---|---|
| **Asbestos Related Diseases** | - Asbestos is hazardous to health when it is in the form of airborne respirable dust and can cause a number of diseases. |
| **Asbestosis** | - Fibrosis of the lung parenchyma. |
| **Bronchial carcinoma** | - Lung cancer |
| **Mesothelioma** | - Tumor development in the membrane of the lung. |

**Man-made mineral Fibers (MMMF)**

There are three main types of MMMF used in building and construction industry:

- **Vitreous fibres** e.g. Mineral woods glass fibers etc
- **Ceramic fibres** e.g. Silica
- **Refractory Fibers** e.g. Crystalline of Alumina, Silica etc.

MMMF are widely used in filtration equipment, sound attenuaters, internal insulation e.g. cavity wall and loft insulation. Long term exposure to MMMF can result in irritation of the upper respiratory tract. The Health and Safety Commission set out exposure limits to MMMF in the indoor environment in H & S Commission 1979 Discussion Document: Man-made Mineral Fibers. WHO, (1988) which draws attention to higher potential risks of lung cancer, where a substantially higher concentration of dust occurs.

## Damp and Moulds

Buildings, which suffer from water damage, allow the growth of a variety of moulds including black mould. It is believed that this black mould may be responsible for cases of sudden infant death syndrome or Cot death (New Scientist 1997). In 1944, Doctors at case Western Reserve University in Cleveland noticed a number of babies dying from pulmonary haemosiderosis – bleeding of the lungs – with no known cause. They discovered that the growth of black mould *Stachybotrys atra* in houses might be responsible. Dearborn (New Scientist 1997) believes that the inhalation of the black mould spores, which contain mycotoxins called Trichthecene can inhibit the production of proteins. In babies whose lungs are growing rapidly, reduction in protein synthesis may result in blood vessels lining the lungs becoming unusually fragile, exposure to other indoor pollutants such as cigarette smoke can cause these capillaries break (New Scientist 1997).

## Risk Assessment

**Investigation of Environmental Conditions**

The investigation of external and internal environmental conditions should be made, using appropriate instrumentation. This may include the use of monitoring systems for a range of pollutants including a full installation of indoor air stations. There are a variety of instruments which can be used to measure the environmental parameters in the built environment (Singh, 1994a).

These instruments range from simple hand-held capacitance and moisture meters to computational fluid dynamics using tracer gases and infrared photoacoustic detector immune based detection of biological contaminants.

Temperature measurement can be carried out using thermometers, or thermocouples and a data logger. The detailed description of inspection and monitoring of environmental conditions within the building fabric is beyond the scope of this paper.

**Data Acquisition**

Data acquired from physical, chemical and biological factors in the building can be interpreted to identify the cause and effect of the problem. These measures combined with observation of the occupants' activities, building design, materials, finishes and maintenance, could lead to a better understanding of the risk assessment. Environmental reactions and ill health associated with buildings are so variable that it is difficult to establish that symptoms are caused by a specific factor measured. A high level of fungus spores in building, particularly of types, which are known to cause serious health effects (for Example, *Aspergillus flavus, A. parasiticus* and *Stachybotrys sp*.) should be considered a potential risk for disease and a potential cause for non-specific building-related complaint (Morey et all 1990; Kuehn et al., 1992 and Singh,1996)

## Remediation and Prevention Measures

There are health implications in the use of certain building materials, the type of building design and construction, and the lack of maintenance and management schedules. Remedial and preventative measures should focus on the selection of materials with minimum indoor pollution impact. For example, the use of pesticides, fungicides, solvent based paints, timber treatment chemicals, asbestos, and substances such as CFCs, which contribute to ozone depletion, should be avoided.

## Solutions

Solutions for indoor air pollution should be addressed as follows:

**Buildings** - Improve aspects of design, construction, surrounding of building and its services and furnishings which contribute to the building related illnesses

**Materials** - Control of source (i.e. use of non-toxic materials)

**Indoor Environment** - Improve indoor environment and organise management of various indoor environmental pollution sources and factors

**Local Environment Controls (workstation control)** - Improve organisational function and culture to alleviate stress

**Occupant Response** - Identify individual behavioral factors and state of mental and psychological health

**Design, Maintenance and Management Procedures**

Design with end user needs, e.g. flexibility, robustness and controllability. Increase rate of fresh air, the use of aromatherapy, or use of plants. Disinfecting and cleaning of air distribution systems (ensure that disinfecting chemicals have no ill effect). Negative air ionisation, improved filtration, increase building user awareness, improve maintenance and management procedures.

## Building Health Questionnaire

In order to identify and assess the building related health problems, it is necessary to employ the use of a questionnaire. The questionnaire should aim to cover the various aspects of building design and construction, services and controls, management and organisation, cultural aspects, occupancy and use of the building and the building environment. The following set of questionnaires may be helpful in identifying some of the causes and symptoms and the information gained may be useful to prepare a scheme for preventing and controlling the risk.

**Questionnaire 1**

Mainly aimed at building services, ergonomics, acoustic and HVAC and their impact on occupants' health, noise levels, lighting, odour, furniture room layout, personal health

**Questionnaire 2**

This questionnaire is mainly aimed at management and organisational cultural aspects and also the role of individuals in the organisation.

The questionnaires 1 and 2 can consist of 30-40 questions, depending upon the size, function and complexity of the organisation.

**Questionnaire 3**

This questionnaire is mainly related to finding out the cause and effect of the building related problems. It covers a range of symptoms experienced by the occupants e.g. headache, eye irritation, nose irritation, throat irritation, dry mouth, backache, shortness of breath, chest pains, nausea, fever, flu-like symptoms, fatigue, malaise, lethargy, drowsiness, dizziness and faintness, difficulty in concentrating, skin dryness, rash irritation, etc.

The next section of the questionnaire asks to describe symptom patterns, e.g. symptoms occur continuously, intermittently and for how long they last (several minutes, several hours, all day, all week, etc). What months of the year the symptoms are experienced and time of the day – a.m. or p.m. and are the symptoms experienced away from work, for example, at home or other locations.

## Preventative Control Methods

Preventive methods are preferred to remedial chemical solutions. The concept of eradication of causal agents of illnesses and stress from buildings is practically impossible. The remedial approach often involves considerable reliance on the use of chemicals and extensive exposure of the building fabric. This could have a detrimental effect on the health of the building fabric and its occupants and is environmentally damaging.

### Environmental Control Strategies

Environmental control strategies are preferred which are based on the sound understanding of the construction details and in depth knowledge of the causal agents of illnesses and stress, including their environmental requirement.

### Source Removal

Include removal of breeding grounds for bioaerosols (that is control of relative humidity and water vapour) and e.g. banning of smoking.

### Avoidance

Use of less hazardous materials.

### Isolation

Isolation of a contaminant or a source from exposure to occupants, e.g. by contaminant encapsulation, shielding and sealing.

### Design Criteria

New design and construction should have an emphasis on the effectiveness of ventilation, thermal comfort, lighting and maintenance needs.

### Reservoirs

Remove contaminant or pollutant reservoirs, institute good housekeeping and dust suppression practices.

### Checks

Check and repair furnaces, flues, and heat exchangers for leaks of CO (carbon monoxide) and other gases.

### Ventilation

Ventilate under floor spaces and ensure the effectiveness of cross ventilation. Ventilate all cavities, voids, concealed spaces, roof voids, wall voids, etc.

### Damp and Decay

Check dampness in walls, e.g. rising damp and condensation, to avoid mould and decay organisms.

## Cleaning and Maintenance

Facilities management and the institution of effective cleaning and maintenance regime are by far the best policy to reduce indoor air pollution. For example, regular cleaning and maintenance of the following components in the air-conditioned building are of fundamental importance.

**Air handling Unit**

Filters (Filtration efficiency is important and also the seal on the filters should be verified).

**Cooling Coils**

Condenser trays and water trays.

**Ducting**

Wet cooling towers, Air washer's humidifiers, and Mechanical operation.

**Filter the Contaminants**

Dilution ventilation, increase ventilation to purge out pollutants

**Remove the Source**

Eliminate smoking, Treatment with liquid nitrogen – to kill house dust mites Vacuum cleaning with high efficiency filtering, Steam cleaning – for example chairs and carpets, Biocide treatment of cooling towers.

## Health and Comfort

Occupational exposure limits do not take into account the synergetic or cocktail effect of pollutants nor the fact that more sensitive individuals may experience allergic reactions which normally healthy individuals may not.

Health and comfort in the built environment is a multi-disciplinary issue which may involve input from a variety of sources including engineers, architects, medical and health scientists, pschychologists, other experts in air conditioning or environmental control. To ensure health and comfort in the workplace, employers should: - seek advice and guidance on environmental design, control and maintenance – assess and monitor the environment – monitor air and water quality control – ensure that building services are adequately designed and reviewed – carry out regular assessment of biological contaminants and environmental performance including energy efficiency assessments.

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