Review : Health, Comfort and Productivity in the Indoor Environment

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Indoor and Built Environment 1996; 5; 22
DOI: 10.1177/1420326X9600500105

Review

Indoor Built Environment

Indoor Built Environ 1996;5:22–33

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Health, Comfort and Productivity in the Indoor Environment

Key Words
Comfort
Productivity
Sick building syndrome
Allergy
Environmental hypersensitivity

Abstract
Possible sources of indoor air pollutants and their impact on the health, comfort and productivity of the building occupants are discussed from the point of view of a professional building pathologist. The causes and symptoms of sick building syndrome, allergy and environmental illnesses and building-related illnesses are listed in the context of building environments. Finally, the ways in which a solution to the problems caused by indoor air pollution in buildings can be solved and the steps necessary for remediation and prevention measures following the examination of buildings and their occupants, are detailed.

Introduction

An average North American or European man spends 80–90% of his time indoors and the air he breathes is mostly indoor air. The indoor air as well as the temperature, light and sound conditions in our dwellings, offices, schools and other premises are of decisive importance for the health, comfort, morale, productivity and well-being of the occupants. Health and comfort problems associated with indoor air have nevertheless come to constitute a major problem in recent years. The appearance of the sick building problem seems to coincide with the introduction of energy conservation measures, following the oil crisis of the early 70s. A number of influencing factors have been proposed including pollution (ozone, formaldehyde, volatile organic compounds, etc.), inert fibres, microbiological growth (fungi, viruses, bacteria, mites, algae and other allergens), radon and electromagnetic forces.

The allergic substances can be airborne and inhaled as pollen, fungal spores or dust, or they may be ingested in food and drink. Airborne allergens however cause more problems throughout the world than all other forms of allergens combined. People affected complain about fatigue, headache, skin irritation, mucus membrane trouble and smell.

A number of environmental, design and construction factors determine the quality and quantity of allergic components, for example, geographical location, time of the year, time of day, altitude, weather conditions and flora and fauna, shape and configuration, materials and structures, design of ventilation systems, thermal insulation, building tightness, air change and energy.

Building Environments

Buildings can be likened to living organisms. The useful life of a building depends on its internal and external environments, both in terms of longevity of materials and

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1420–326X/96/0051–0022$10.00/0

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Accepted:
September 4, 1995

as an appropriate habitat for its occupants. Buildings work as spatial environmental ecosystems and provide ecological niches and pockets of microclimates in their built environment for the development of building biology and must be understood as a whole. These ecological niches and microclimates in which biological agents live and interact have many dimensions. It is of fundamental importance in the examination of a building to measure as many relevant variables as possible and to characterise the role of biology in these man-made spatial ecosystems, which are part of the larger ecosystem outside. Buildings separate their occupants from hostile external environments and create a better internal environment for them. Therefore buildings can be likened to human skin (a second skin), or an extension of our bodies as the third skin (considering the body as the first skin and clothes as the second skin), which forms a physical barrier to separate the inside from the outside.

The building shell needs to be adaptive, flexible and reactive in order to maintain a relatively constant built environment in circumstances of regularly or cyclically changing external conditions and the varying activities of the occupants. Changing internal environments (both fully controlled 'museum' environments and simpler and more intermittently operated systems) and the effect of this on the fabric and contents of the building must be understood holistically. These changes can be permanent radical change, for example the installation of a new heating system; shifting equilibrium, a progressive change from one state to another; spatial variations, non-uniform environments which result from diverse occupancy, both in space and time; cyclic fluctuations, the control strategies of most heating and ventilation systems; seasonal variations, and violent changes. The building envelope must function in close correspondence with the processes and biorhythms of the body, for example regulation of moisture, breathing and heat balance. These issues have led us to understand the need for the use of ecologically sound materials to design a breathing fabric which balances the sources of moisture with its reservoirs and sinks in the built environment.

The WHO have estimated that as many as 30% of new buildings in the developed world may have problems leading to occupant complaints and illnesses which can lead to lowered morale, loss of productivity and even absence from work. The combined effect on productivity, absence from work and staff turnover is likely to have a considerable economic impact.

The Indoor Environment

The quality of the indoor environment reflects on the health, comfort and productivity of individuals in buildings. The main reason for the lack of awareness of the problems is due to the fact that the effects of indoor air pollution are mostly chronic and long term and not directly and immediately life threatening. However, there is a growing concern about people's dissatisfaction with the air quality in their places of work. In addition, there is evidence that external environmental conditions (e.g. traffic pollution) which may be associated with indoor air quality and sequelae such as asthma and allergies are increasing in the population. The indoor air quality and healthy and comfortable internal environment is the product of interaction of design, construction, use and maintenance of buildings (fig. 1). At present there are no government guidelines or codes of practice with respect to indoor air quality.

People have become more aware of environmental pollution, acid rain, depletion of ozone, global warming, additives in food, and chlorofluorocarbons (CFCs), so their awareness of the impact of the places in which they live and work is increasing. The increasing incidence of chronic conditions such as asthma and allergies and the number of people who might be affected by sensitisation, allergies and environmentally triggered asthma has led to new thinking in the building industry. For example, attitudes are changing towards environmentally friendly building design and construction, effective maintenance and ventilation rates, materials from sustainable sources, etc.

The following categories broadly influence the indoor air quality and these categories operate cumulatively, and it is their cocktail effect which is contributing as a risk factor to health in the indoor environment:

- design and construction factors: e.g. office design and layout, poor lighting and ventilation scheme, ergonomics;
- environmental factors: e.g. odour, lighting, temperature, dust, noise, outdoor and indoor environment;
- perceptual and psychological factors: e.g. hysteria and stress due to lack of privacy, or because of lack of control or claustrophobic effects due to sealed construction;
- cultural and organisational factors: e.g. cleanliness, maintenance and management and their relationships with occupants.

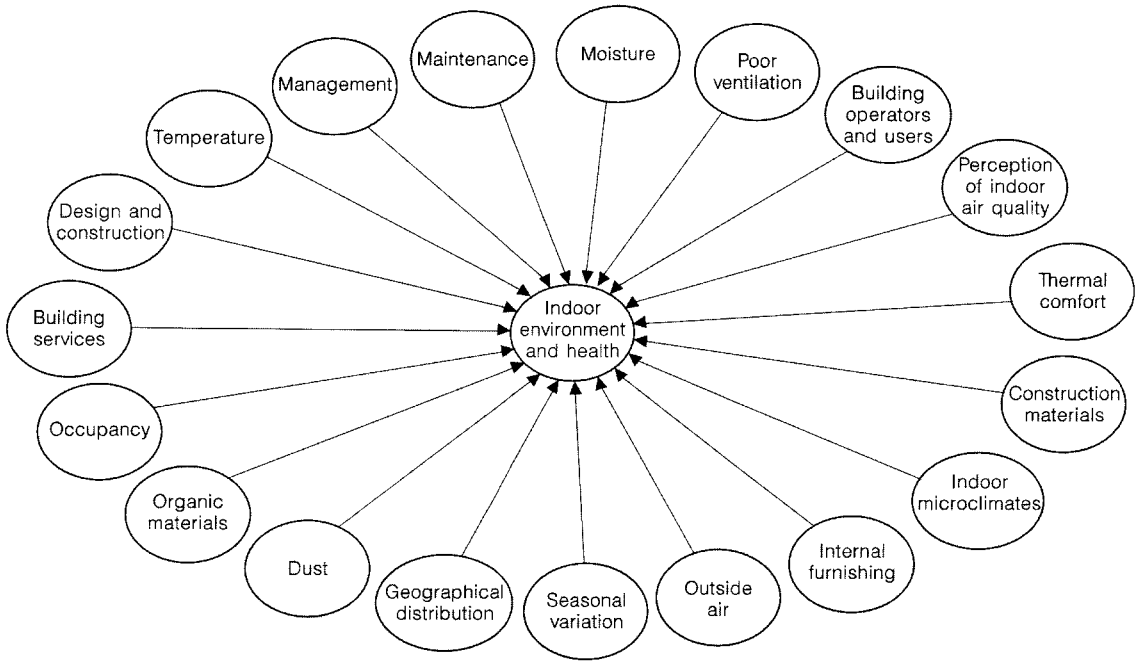

Fig. 1. Factors affecting indoor environment and health.

Indoor Pollution

Pollutants in the indoor environment arise from many sources including the external environment, from whence radon and oxides of sulphur, nitrogen and carbon. The number of potential pollutants in the indoor environment is enormous, for example volatile organic compounds, environmental tobacco smoke, damp and moulds, pollution from the activities of the occupants. Indoor pollution arises from all stages of a building's life and for this reason a multidisciplinary approach to amelioration is necessary. A close dialogue between various disciplines, for example, materials manufacturers, contractors, architects, surveyors, building services engineers, building pathologists and other professionals, financiers and developers, is necessary.

There is a very wide range of potential indoor air pollution sources, the effects of which may impinge on human health or the synergetic effect of these factors may be the cause of health-related problems in buildings. The following list covers the broad areas of sources of indoor pollution:

- materials – formaldehyde, solvents and other volatile organic compounds, mineral fibres, radon gas, pesticides and interior furnishings;
- construction – airtightness 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, radon, odour and irritation, emission of gases and outdoor pollution;
- maintenance and management factors – poorly maintained building fabric, controls and cleanliness routine.

Some of these factors warrant examination in more detail.

Materials

The selection of building materials may affect the environment, both externally and within buildings. Some materials that have been used are hazardous or contain hazardous components such as asbestos, solvent and lead-

based paints, timber treatments and formaldehyde, or are environmentally undesirable such as CFCs. The use of these can have a significant impact on the indoor environment and the health and comfort of the occupants. The choice of building materials should not be underestimated in creating a healthy environment.

Among the many factors and products that have to be taken into account are those building materials used for shell and facade construction, sanitary and cosmetic facilities, insulation using fabric (furnishings/carpets) or void foam fillers (which may contain CFCs), asbestos, hardwoods, pipework insulation and its location and protection, paints, volatile organic solvents in many products, furniture, other decoration, the potential problem of static electricity, wood preservatives, concrete sealants.

Of particular importance when a building is being constructed are the impact of the various finishes including wall coverings, carpet backing, carpets, panelling, partitions, furnishings, paints, stains and materials needed to fit them such as flooring and carpet adhesives.

Design and Construction

Poor building design and construction contribute to building-related health problems. The following factors should be taken into consideration to improve the indoor air quality:

- location, orientation, shading, views;
- passive solar heating;
- organisation of space, vertical transportation;
- building use, special industrial processes, number of employees and hours of occupation;
- public transport, vehicle access and parking;
- social facilities: disabled, rest rooms, crèche, canteen, coffee machines, fitness facilities, toilets;
- waste disposal;
- commissioning and initial air change/water control.

Services and Controls

The following criteria relating to water, heating, cooling, humidification and air quality should be taken into consideration for the improvement of health-related problems in buildings:

- domestic water – type of system/storage/showers/delivery temperature designed to CIBSE TM 13/fuel efficiency control strategy/system monitoring/operational strategy/disease control;
- heating – type of system/fuel efficiency control strategy/greenhouse gas emission/location of flue/operational strategy/maintenance;
- cooling – type of system/fuel efficiency control strategy/refrigerant type/refrigerant leak detection/location of pump-down equipment/heat rejection (if wet CIBSE TM 13)/operational strategy/maintenance/adequate access;
- humidification – type (spray, steam, none)/cleaning/condensation/fuel efficiency/operational strategy/maintenance;
- lighting – type of system/switching efficiency/lighting levels/location of luminaires in relation to task/VDUs etc. – operational strategy/maintenance;
- air quality – type of air handling system/fuel efficiency/air – volume change and velocity/relative humidity/location of intakes/adjoining buildings/control strategy/adaptability of system/filtration/quality of materials/operational strategy/maintenance.

Workplace Design

The following categories cover the range of factors involved in contributing to building-related health problems:

- low floor-to-ceiling height;
- large unstructured open plan areas;
- absence of natural light;
- inadequate supply of air to the workstation (occupied zone).

Occupants

A range of potential sources of contaminants can be introduced by occupants or emanate from occupant activities in the indoor environment:

- water vapour;
- carbon dioxide and particulates;
- tobacco smoking;
- emission of a range of organic compounds.

Environmental Factors

- humidity and mould growth;
- noise;
- radon and radon daughters;
- odour and irritation;
- emission of gases;
- outdoor pollution.

Maintenance and Management Factors

- poor maintenance and management;
- poor cleanliness;
- lack of communication;
- cultural aspects.

Table 1. Chemical species found in the indoor environment

Generic type	Physical form	Chemical species	Boiling point range, °C
Inorganic	gas	SO_2, NO_x, CO_x, O_3 chlorine, ammonia	
	liquid	aerosols	
	particulate	heavy metals mineral fibres	
Organic	very volatile organic compounds	formaldehyde, benzene, toluene	<0 to 50–100
	volatile organic compounds	solvents, plasticisers, wood preservatives	50–100 to 240–260
	semi-volatile organic compounds	pesticides, fungicides	240–260 to 380–400
	particulate organic matter	soot, dust	>380

Causal Agents of Illness and Stress

Many factors influence the indoor environment within buildings, including the choice of building materials, infestation by insect pests and other forms of biological organisms, and the efficiency of services equipment. Causal agents of illnesses and stress in buildings may be chemical, physical, biological, psychosomatic or the synergistic effects of one or all of these agents.

Chemical

A number of common chemical agents are found in buildings (table 1).

Biological

Biological contamination of indoor environments has received increasing attention in recent years as a possible cause of indoor-air-related illness at home and at work.

The impact of building biology on the built environment is man's commonest problem and can be traced back to biblical times or earlier. Biological agents have not only a serious impact on the maintenance and repair of the national housing stock but also cause great concern about the health of occupants. The main biological factors causing building-related sickness are moulds, fungi, bacteria, viruses, protozoa, pollens, housedust mites, insect pests, algae, pigeons and rodents (table 2). Indoor environments in sealed buildings allow the accumulation and proliferation of micro-organisms and products of their metabolism (i.e. endotoxins and mycotoxins) as well as other volatile organic compounds, all of which are subject to circulation within the indoor air.

Physical

Physical agents can also be identified in the indoor environment (table 3).

Psychosomatic and Psychogenic

- depression,
- anxiety,
- overwork,
- frustration.

Building Health

Indoor environment may influence the health of occupants in buildings in the following three different ways:

- allergy and environmental hypersensitivity;
- sick building syndrome (SBS),
- building-related illnesses.

Sick Building Syndrome

The WHO has defined health as '... the state of complete physical, mental and social well being, and not merely the absence of disease and infirmity'. This should be remembered in any study of SBS which is the name given to a condition in which occupants of a buildings experience symptoms which disappear soon after the affected people leave the building. Other and related terms used are: 'tight building syndrome', 'stuffy office syndrome'. The appearance of SBS symptoms is sometimes associated with inadequate ventilation and if they are prevalent may result in loss of productivity and absenteeism.

Table 2. Biological agents found in the indoor environment

Microbes	viruses	influenza
	bacteria, mycobacteria	endotoxins
		Legionella pneumophila
	fungi, moulds	spores, toxins, mycotoxins,
	mycoplasmas	conidia, hyphae
	thermophylics	*Thermoactinomyces vulgaris*
	actinomycetes	*Saccharopolyspora rectivirgula*
		(Micropolysporum faeni)
Plants	seed plants	pollen
Arthropods	mites	housedust mites
		storage mites
	insects	cockroaches (disease carriers)
Animals	rodents	rats (disease carriers)
	pets	excretions, dander, skin scales, fur, feathers, serum proteins
	birds	disease transmitters
	humans	CO_2, ammonia, disease carriers

Table 3. Physical agents found in the indoor environment

Sensible	temperature, humidity	(at extremes)
	light	glare, flicker
		circadian dis-synchronisation
	noise	printers
	vibration	traffic, trains, aircraft
Insensible	static electricity	–/+ ion imbalance
	electromagnetic radiation	ionising: radon
		non-ionising:
		UV under-/over exposure
		bioelectromagnetic effects

The WHO has identified the following typical symptoms of SBS:

Stuffy nose	Blocked, runny or itchy nose
Dry chest	Dry skin
Chest tightness	Watering or itchy eyes
Lethargy	Headache
Loss of concentration	

SBS is not necessarily the same as building-related illness, or building-associated illness which terms are used to cover the range of ailments which can affect occupants in buildings. Building-related illnesses can be acute, for example: légionnaire's disease, allergies, such as rhinitis and asthma which can be caused by diverse allergens including those from house dust mites, pollen, cat dander and moulds; or they can be chronic as with the asbestos-related diseases.

Comfort and Health

The quality of the built environment is associated with the health, comfort and productivity of the building occupants. For example, perception of an odour is a comfort effect, whereas irritation is usually defined as an acute health effect. Comfort has been defined as that condition of mind which expresses satisfaction with the environment. Of the many days work lost through absenteeism a notable amount is caused by SBS and building-related illnesses which can also lead to low morale, inability to concentrate, eye strain and poor productivity. Careful environmental assessment of building plans and monitoring of the built environment can alert managers to problems before they arise. An independent investigation is required to recommend ways of improving standards, and suggesting strategies for improving the quality of the workplace while minimising the impact of buildings on the environment.

Most comfort standards are based on what is an acceptable level of dissatisfaction among the occupants, normally taken as 20%. That is, 80% of the occupants are satisfied. The use of occupational exposure limits for environmental pollutants is inappropriate when considering comfort since they do not allow for any synergistic or cocktail effect of pollutants or the effect on compromised individuals, e.g. some immune compromised individuals may experience allergic reactions at levels of allergen which normally healthy people may not react to.

In any study of a building, the health and comfort aspects should be addressed as below:

- advise and give guidance on environmental design, control and maintenance;
- make an environmental assessment and carry out monitoring;
- examine air and water quality control;
- examine the building services design and review if necessary;
- make an energy efficiency assessment;
- undertake simulation-based problem solving.

Health and comfort in the built environment are a cross-disciplinary issue involving various engineers and scientists who between them are expert in the requirements for health, comfort, air conditioning, and environmental control.

Regulations and Standards

There is no separate body for environmental laws applicable to buildings in England and Wales. However, The Environmental Protection Act (EPA) 1990 and the Water Resources Act 1991 consider environment and pollution. Occupationally, things are more controlled: the indoor air quality and the health and comfort in the workplace environment depend upon a number of factors in the life cycle of the building. For example, legislation relating to the planning stage (development of plans, environmental assessment), contaminated land, construction (building regulation, noise, air pollution and statutory nuisances, interaction with health and safety legislation), occupied buildings, demolition and future developments.

The workplace and the environment are now regulated by several acts of Parliament, the control of substances hazardous to health (COSHH), and various building regulations, HSE, EPA and CIBSE guidelines. The recent HSE-approved code of practice for *Legionella* for example requires employers and others to:

- identify and assess the sources of risk;
- prepare a scheme for preventing or controlling the risk;
- keep records of its implementation.

Employers now have to show that they have exercised due diligence in the operation of their offices and buildings.

Risk Assessment

External and internal environmental conditions for the purposes of risk assessment should be investigated using appropriate instrumentation. This may include the use of several monitoring systems including a full weather station. There are a variety of instruments which can be used to measure the environmental parameters in the built environment. These range from simple hand-held capacitance and moisture meters to computational fluid dynamics code flow vent using tracer gases and infra-red photoacoustic detectors. 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 review.

Data from measuring physical and biological parameters in a building can be interpreted to identify the cause and effect of a problem. These data, combined with observation of the occupants' activities, building design, materials, finish and maintenance, can lead to a better assessment of risks to occupants. Reactions to environmental factors and ill health associated with buildings are so varied that it is difficult to establish that symptoms are caused by any specific factor measured. However, it would be reasonable to say, for example, that high level of fungal spores in buildings, particularly of types which are known to cause serious health effects (e.g. *Aspergillus flavus, A. parasiticus* and *Stachybotrys* sp.) should be considered a potential risk for disease and a potential cause for non-specific building-related complaints. To back-up such a diagnosis, the measurement of moisture, relative humidity, microventilation and salt content could help in an assessment of potential fungal activity. Alternatively, the data could be combined with the known level and extent of fungal activity and knowledge of the building's design and construction to undertake a risk assessment for indoor health problems related to fungal growth.

Remediation and Prevention Measures

There are health implications from the use of certain building materials, the type of building design and construction, and maintenance and management schedules.

Remedial and preventative measures should focus on the selection of materials with minimum indoor pollution impact. For example, wherever possible, the use of pesticides, fungicides, solvent-based paints, timber treatment chemicals, asbestos, and substances such as CFCs which could contribute to ozone depletion, should be avoided.

Solutions for reducing indoor air pollution should be addressed as follows:

- buildings – improve poor aspects of design and construction, the surroundings of the building and its services and furnishings;
- materials – these are best controlled at source through the use of low-volatility, non-toxic materials;
- indoor environment – improve through organisation and management of indoor pollution sources and related factors;
- disinfection and cleaning of air distribution systems and improved air filtration;
- increase building user awareness;
- improve maintenance and management procedures.

There can be more specific controls applied at the sites where people are working:

- local environment control (workstation control);
- improvements in organisational function and culture overall to alleviate stressful situations at individual workstations;
- control of lumina intensity/or provide improved natural day lighting;
- increases in the rate at which fresh air is supplied.

The success of these measures can be found by studying occupant response, although it is necessary to identify individual behavioural factors and their state of mental and psychological health. Certain specific measures such as the use of aromatherapy or negative-air ionisation could be tried or, less contentiously, the use of plants.

Whatever remedies to improve indoor air quality are tried they should always be with end user needs in mind and be flexible, robust and controllable.

Building Health Questionnaire

In order to identify and assess the building-related health problems, it is necessary to use a questionnaire. The questionnaire should aim at covering 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. Examples of questionnaires used by Oscar Faber are given in the Appendix and in summary below. In practice these have proved to be helpful in identifying some of the causes and symptoms and the information gained from them may be useful to prepare a scheme for preventing and controlling the risk.

Summary of Questionnaires

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

The questionnaire may consist of 20–30 questions, depending upon the type, size and location of the building.

Questionnaire 2

This questionnaire mainly aimed at management and organisational cultural aspects and also the role of individuals in the organisation, for example:

I work on floor 1, 2, 3?		
By window	Yes	No
By a door	**Yes**	**No**
Near a machine	Yes	No

and flexibility, manageability and accessibility of space, conditions around the workstation.

This questionnaire may consist of 30–40 questions, depending upon the size, function and complexity of the organisation.

Questionnaire 3

This questionnaire 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 symptoms 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.

Control Methods

The ultimate goal of total eradication of causal agents of illnesses and stress from buildings is practically impossible to attain. However, it is possible to make some progress remembering that preventative methods are preferred to remedial chemical solutions. It is a fact of life that the remedial approach does so often involve a consid-

erable reliance on the use of chemicals and extensive exposure of the building fabric to them. This can have a detrimental effect on the health of the building fabric and its occupants and be environmentally damaging. Therefore, environmental control strategies are preferred which are based on the sound understanding of the construction details of the building coupled with a detailed knowledge of the putative causal agents of illnesses and stresses to which building's occupants are exposed.

The most important factors can be summarised as follows:

- avoidance of problems through the use of less hazardous building materials;
- source removal, which includes the removal of breeding grounds for bioaerosols in, for example, humidifiers, or the banning of smoking;
- similarly look for and remove contaminant or pollutant reservoirs, institute good housekeeping and implement dust suppression practices;
- the isolation of a contaminant or a pollution source from occupants, e.g. by containment, encapsulation, shielding and sealing;
- check and repair furnaces, flues, heat exchangers particularly with regard to leaks of carbon monoxide and other gases;
- ventilate under floor spaces and ensure the effectiveness of cross ventilation. Ventilate all cavities, voids, concealed spaces, roof voids, wall voids, etc.;
- check dampness in walls, e.g. rising damp and condensation to avoid mould and decay organisms;
- in the case of new buildings look to the design criteria – new design and construction should have an emphasis on the effectiveness of ventilation, thermal comfort, lighting and maintenance needs.

Cleaning and Maintenance

Management of the buildings facilities and the institution of effective cleaning and maintenance regimes 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;
- cooling coils, condenser trays and water trays;
- ducting;
- wet cooling towers;
- air washers/humidifiers;
- mechanical operation.

Remediation

If the problems still persist after preventative maintenance and cleaning regimes and environmental control strategies, then certain more drastic remedial actions are necessary:

- increase the ventilation rates to purge out pollutants;
- remove pollution sources:
  eliminate smoking;
  to kill house dust mites use treatment with liquid nitrogen;
  vacuum clean with high efficiency filtering;
  steam cleaning, for example chairs and carpets;
  biocide treatment of cooling towers.

Health and comfort in the built environment is a cross-disciplinary issue which may involve input from a variety of sources including engineers, scientists, other experts in air-conditioning or environmental control. To ensure health and comfort in the workplace, employers should where necessary seek advice and guidance on environmental design, control and maintenance; take steps to assess and monitor the environment in and around the building; monitor the quality of the air and water coming into the building; ensure that the building services are adequately designed and reviewed; and carry out energy efficiency assessments.

The indoor air quality has a measurable impact on the health, comfort and productivity of the building occupants. Of the many days now lost through sickness, a considerable amount is caused by building-related illnesses, sick building syndrome and allergy and environmental illnesses. Careful environmental assessment of building plans, monitoring the built environment, can alert managers to problems before they arise.

Appendix

Questionnaire 1

		Yes	No
	Heating and Ventilation		
1.	Is the winter temperature within your work space usually comfortable?	☐	☐
2.	Is the summer temperature within your work space usually comfortable?	☐	☐
3.	Is the temperature during the morning usually comfortable?	☐	☐
4.	Is the temperature during the afternoon usually comfortable?	☐	☐
5.	Do you notice any uncomfortable draughts?	☐	☐
6.	Would you describe the air within your work space as fresh?	☐	☐
	Noise Levels		
7.	Are you able to work without being disturbed by the background noise?	☐	☐
8.	Are you able to hold telephone- or work-related conversations without being interrupted by background noise?	☐	☐
	Lighting		
9.	When viewing your screen in a usual sitting position, is it free of reflections from windows or interior lights (switch off your display if you are not sure. Make sure the interior lights are switched on)?	☐	☐
10.	Do you have sufficient light at your desk during the day-time?	☐	☐
11.	Do you have sufficient light at your desk during the hours of darkness?	☐	☐
	Furniture		
12.	Is your chair comfortable to sit in?	☐	☐
13.	Does your desk have sufficient leg room (e.g. are there any pedestal units in the wrong place, can you move about your desk?)	☐	☐
14.	Does your desk have sufficient storage space?	☐	☐
	Room Layout		
15.	Can people walk past your desk without you moving from your normal sitting position?	☐	☐
16.	Do you feel you have sufficient space to work in?	☐	☐
17.	Can you work without being disturbed by any kind of distraction located within hearing or seeing distance?	☐	☐
	Personal Health		
18.	At the end of a typical working day is your back usually free of aches or pains?	☐	☐
19.	At the end of a typical working day are you usually free of tired eyes or headaches?	☐	☐
20.	During a typical working week are your arms and hands, either during work or at home, free of aches or pains?	☐	☐

Questionnaire 2

1. I work on floor (1, 2, etc) ☐ _____ by a window ☐ by a door ☐ near a machine (e.g. PC, typewriter, photocopier, coffee machine) ☐

2. From my work place I can see plants ☐ cannot see plants ☐

3. My position in the library is

Director/Chief	☐	Trainee	☐
Associate/Deputy	☐	Secretary	☐
Services Dept.	☐	Tech. Clerk	☐
Receptionist	☐	Contractor Worker	☐
Other	☐		

4. I am male ☐ female ☐ and age under 30 ☐ 30–35 ☐ over 45 ☐

(Please Circle)

5.	Overall my working environment is	excellent	1	2	3	4	5	bad
6.	I am managed:	well	1	2	3	4	5	badly
7.	I manage others:	well	1	2	3	4	5	badly
8.	I manage my work:	well	1	2	3	4	5	badly

Questionnaire 2 (continued)

9.	The nature of my work is:	interesting, stimulating & enjoyable	1	2	3	4	5	boring and uninteresting
10.	The amount of work I have to do is:	excessive	1	2	3	4	5	insufficient
11.	My furniture is:	comfortable	1	2	3	4	5	uncomfortable
12.	The quipment I work with is:	used easily	1	2	3	4	5	with difficulty
13.	The colour I see most in my environment is	black:brown:blue:green:red:yellow:white						
14.	The space I use is:	sufficient	1	2	3	4	5	insufficient
15.	My out of work activities (sports, drinking, travel to/from home) interfere with my work:	always	1	2	3	4	5	never
16.	My work place is:	safe	1	2	3	4	5	unsafe
17.	The air in my work place smells:	good	1	2	3	4	5	bad
18.	I smoke:	frequently	1	2	3	4	5	never
19.	The humidity is:	too high	1	2	3	4	5	too low
20.	The air is:	still	1	2	3	4	5	draughty
21.	The air seems:	clear	1	2	3	4	5	stuffy
22.	The noise in my environment is	pleasant	1	2	3	4	5	unpleasant
23.	My immediate colleagues are friendly & helpful	always	1	2	3	4	5	never
24.	My manager is friendly & helpful	always	1	2	3	4	5	never
25.	The atmosphere is:	too hot	1	2	3	4	5	too cold
26.	The light on my work is:	too bright	1	2	3	4	5	too dark
27.	The light generally in the room is:	too bright	1	2	3	4	5	too dark
28.	The view (other than my work) I see most is:	good	1	2	3	4	5	bad
29.	Overall my health is:	excellent	1	2	3	4	5	poor
30.	I would like to be able to control my working environment	totally	1	2	3	4	5	not at all

A further comment on my working conditions is: _____

A further comment on the questionnaire is: _____

Questionnaire 3

1. Symptoms experienced and estimated duration:

	0–24 h	<1 week	1–4 weeks	>4 weeks		0–24 h	<1 week	1–4 weeks	>4 weeks
Headache	☐	☐	☐	☐	Flue-like symptoms	☐	☐	☐	☐
Eye irritation	☐	☐	☐	☐	Fever	☐	☐	☐	☐
Nose irritation	☐	☐	☐	☐	Fatigue, malaise, lethargy	☐	☐	☐	☐
Throat irritation; upper respiratory	☐	☐	☐	☐	Drowsiness	☐	☐	☐	☐
Dry mouth	☐	☐	☐	☐	Dizziness or faintness	☐	☐	☐	☐
Backache	☐	☐	☐	☐	Difficulty concentrating	☐	☐	☐	☐
Shortness of breath	☐	☐	☐	☐	Skin dryness, rash, irritation	☐	☐	☐	☐
Chest pains	☐	☐	☐	☐	Too hot	☐	☐	☐	☐
Nausea	☐	☐	☐	☐	Too cold	☐	☐	☐	☐

Questionnaire 3 (continued)

Describe symptoms checked above in more detail:

2. Symptom patterns:
   Symptoms occur ☐ intermittently ☐ continually
   If intermittent,
   How often # _____/(day, week, month) [circle one]
   How long do symptoms last (several minutes, several hours, all day, all week)?
   What months of the year have the symptoms been experienced? (Circle all that apply)
   All the time/Any time/a.m./p.m.

	Yes	No
Do symptoms vary in intensity?	☐	☐
If yes, when is problem greatest? _____		
Do any of the following apply?		
Wear contact lenses	☐	☐
Operate visual display terminal at least 10% of the day	☐	☐
Operate copier at least 10% of the day	☐	☐
Engage in intensive paper handling especially carbonless sensitive paper	☐	☐
Use special office equipment	☐	☐
If yes, specify _____		
Are symptoms experienced away from work?	☐	☐
Previous work locations?	☐	☐
At home?	☐	☐

3. What are the weather conditions when your symptoms are most apt to appear? Or at worst?
   ☐ Calm, mild ☐ Windy ☐ Cold
   ☐ Rainy, stormy ☐ Hot, humid ☐ Dry

4. Are there any specific work activities you engage in just prior to experiencing these symptoms? Are they more apt to happen in a certain work area?

5. How would you describe conditions around your work area? (Check terms, or terms similar to those, used by the person.)

stuffy	too smoky	too dry
too drafty	too much glare	too bright
too humid	too much noise	poor light
feet too cold	back too cold	back too hot

6. Have you noticed any unpleasant odour(s)?
   Describe: _____

	Yes	No
7. Is smoking allowed in the work area?	☐	☐
Do you smoke?	☐	☐
Are you bothered by smoke?	☐	☐
8. Have you sought medical attention related to the symptoms?	☐	☐
9. What do you think causes your symptoms?	☐	☐

Date: _____

Time questionnaire was completed: _____

The questionnaire took about _____ minutes to complete.

DO NOT SIGN

Thank you for completing the questionnaire.

Further Reading

1 House of Commons Environment Committee. Indoor Pollution, 6th Report. London, HMSO, 1991.
2 Berglund B, Lindvall T, Mansson L: Healthy Building '88. Stockholm, Swedish Council of Building Research, 1988, p 445.
3 Curwell S, March C, Venables R: Buildings and Health: The Rosehaught Guide. London, RIBA, 1990.
4 Miller J: Fungi as contaminants in indoor air. Indoor Environ 1990:5;51–64.
5 Gravesen S, Larson L, Gyntelbert F, Skov P: The role of potential immunogenic components of dust (MOD) in the sick building syndrome. Indoor Air 1990:1;9–14.
6 Burge P: Building sickness – a medical approach to causes. Indoor Air 1990;5:3–14.
7 Walker B: A building aware of our needs. Building Services 1990;Dec:35–36.
8 Waubke NV, Kusterle W: Mould infestations in residential buildings. 1st Symposium on Mould Infestations, Innsbruck, Jan 1990.
9 Morey A, Morey PR, Feeley JC Sr, Offey JA: Biological Contaminants in the Indoor Environment. Philadelphia, ASTM, 1990.
10 Kuehn KA, Garrison R, Robertson L, Koehn RD, Johnson AL, Rea WJ: Identification of airborne microfungal populations from home environments within the Dallas Fort Worth (Texas) region. Indoor Environ 1992;1:285–292.
11 Garratt J, Nowak F: Tackling Condensation, a Guide to Causes of and Remedies for Surface Condensation and Mould in Traditional Housing. Garson, Watford, Building Research Establishment, 1991, p 100.
12 Singh J, Walker B: Allergy problems in Buildings. Lancaster, Quay Publishing, in press.
13 Singh J: Building Mycology, Management of Health and Decay in Buildings. London, E & FN Spon, 1994.
14 Singh J: Indoor air quality in buildings. Office. Crona, Health & Safety Briefing, 1994.
15 Singh J: Biological contaminants in the built environment and their health implications. Building Res Information 1993;1:216–224.