Indoor Air Quality

M Squirrell, B Sc (Hons), MIEH, MRSH, Specialist Environmental Health Officer, *Basildon District Council*

Introduction

Life depends on uninterrupted access to an adequate supply of viable air. To function well we need an environment whose physical, chemical and biological properties are narrowly limited. As such a climate is not provided, we must create an artificial indoor habitat which best fits our needs.

Generally people are exposed to the ambient outdoor air only during a relatively minor portion of their lifetime and therefore, the quality of air within the indoor environment is very important for human health and welfare. The air we breathe indoors is not always 'clean' and relatively little is known about the nature of indoor pollutants.

The outdoor climate, building design, building management and the actions of the buildings occupants determine the indoor environment. Each of these factors is governed by an overwhelming number of variables. Each room in the many millions of buildings, therefore, has its own indoor climate.

Discomfort in the home and the office are not only caused by poor control of heat, humidity and ventilation, or by acute chemical contamination, but also by hardly perceptible concentrations of various other persistent pollutants that singly or combined, over a period of hours or days, can result in a significant accumulated exposure. The resulting dose may be comparable to, or above, occupational hygiene limits but, in many cases, are so low that they are only noticed by allergy sufferers or occupants with high chemical sensitivity, whereas healthier occupants may only experience reduced functions and diffuse symptoms. Recent studies have identified over 250 indoor air components at concentrations between 1 ppb and 1 ppm.

In spite of all the advances in science, engineering medicine and public education, the quality of indoor air is no better now than it was in Roman times.

Examples of indoor air pollutants, their potential effects on health and their sources:

Pollutant	Health Effects	Sources
Asbestos	Carciongenic and respiratory disease	Fire-retardent insulation.
Allergens	Irritation of respiratory system	House dust, mites, animal dander
Carbon Monoxide	Carboxyhaemoglobin poisoning	Fuel burning, tobacco smoke.
Carbon Dioxide	Systemic interference	Metabolic activity, combustion.
Formaldehyde	Irritant to eyes and airways, carcinogenic and systemic effects	Particle board, insulation, Furnishings, tobacco smoke.
Mineral and Synthetic Fibres	Irritant to airways, skin and mucous membranes	Acoustic, thermal and electrical insulation.
Nitric Oxide and Nitrogen Dioxide	Effects of respiratory system	Fuel burning, tobacco smoke.
Organic substances	An irritant and systemic effects	Adhesives, cooking, cosmetics, solvents
Ozone	Irritant to airways and systemic effects	Equipment with electric arcing and UV light sources.
Radon	Carcinogenic effects	Building materials, sub-soil, water
Suspended particulate matter	Irritant to airways	Combustion products including tobacco smoke, household dust.
Water vapour	Allergy arising from promotion of mould growth, possible enhancer of droplet infection leading to respiratory disease.	Biological activity, combustion, evaporation

Sources of air contaminents and their measurement

Indoor air impurities can originate in the outdoor air, from building materials and by the occupants and their activities. The most abundant indoor air contaminents are moisture and combustion gases.

a. **Contaminants primarily generated outdoors**
Since in almost all inhabited spaces there is a continuous air exchange with the exterior, all pollutants present in the outdoor air are also found indoors. These included suspended particulates, sulphur oxides, nitrogen oxides, hydrocarbons, carbon monoxide, photo chemicals, metal contaminents and microbes.

b. **Contaminents generated from building materials**
These include radioactive substances, formaldehyde, asbestos and fungicides from timber preservatives.

c. **Contaminents produced by occupants and their activities**
Occupants introduce by far the largest number of contaminants into the indoor environment. Many compounds used in the industrial workplace can be brought into the home, in connection with hobby or craft activities. Tobacco smoke contains over 841 different chemical components. Metabolic products from the human body include water vapour, carbon dioxide and traces of over 100 other pollutants that can reach noticeable levels in small confined areas. The World Health Organisation expressed concern at the variety and speed of release of indoor contaminents in consumer products, particularly chemicals in personal hygiene articles, solvents and cleaners, biocides, air sprays and hobby and homecraft materials.

The instruments for monitoring and measuring contaminents are in a state of rapid evolution. Techniques for analysis are now five to six orders of magnitude more sensitive than they were five years ago for many air impurities. On the other hand, the measurement of chemicals such as CO_2 and conceptually simple quantities such as humidity, which affects every other physical, chemical and biological property of air remains tedious and subject to large systematic and instrumental errors.

Although much past and current investigation on indoor air quality has been excellent, the available data must be considered exploratory because there are no recognised or validated standard methods for monitoring and analysis of non-occupational indoor air. During the last ten years, the emphasis has shifted from wet chemistry lab methods to real-time monitoring linked with a computer to introduce as many physio-chemical properties of the contaminant being measured as possible. Analytical and sampling methods for the work environment are relatively reliable. They were specifically developed for measuring the upper range at which toxic substances are tolerable at work for a healthy adult group exposed for five, eight hour working days, a week. They are optimized for reliability at levels ten times higher than those considered safe for the 'general' indoor population, which includes children, the elderly and people whose health is poor; all of whom spend most of their time indoors without the daily sixteen hour recovery periods available to workers.

What are the problems?

In recent years problems have been created by mechanical ventilation systems, reduced ventilation rates and standards, and the need to increase the quality of air-tightness in a building based on energy conservation. This has tended to lower ventilation rates and focused attention on to what was going on in the home. The main contaminents are relatively well known; these include asbestos, formaldehyde, lead, microbes (allergens), radon and pesticides, but the major indoor air problems are combustion gases, smoke from tobacco and water vapour. The main areas of concern when assessing the problems of contaminents are as follows:

a. What contaminants need to be dealt with?

b. What are the typical concentrations?

c. What are the effects of the contaminents on the
   (i) health and comfort of individuals?
   (ii) fabric of the building?
   (iii) dose-response relationships?

d. Knowledge of the source? ie, emission rates, variation with time, identification of 'hot-spots' within the indoor environment.

e. What instrumentation and methodologies should be used?

Concentrations of contaminents depends on the size and nature of the source, the size of the building, the ventilation rate and many other factors. Comparisons of concentration levels are not meaningful unless methodologies have been standardised. At present the measured indoor concentrations are sporadic values or average values at best and do not represent the actual breathing-level dose that a person inhales. This gap will soon be filled because reliable personal monitoring equipment is now available for a number of pollutants. However, data for each contaminent can only be correctly interpreted if a complete analysis of potential synergens is available. Any exposure level modelling will depend on data from at least five parameters; human activity, pollutant strength, indoor characteristics, structural characteristics and monitoring constraints.

General medical knowledge on the effects of contaminents on human health is increasing. Information must be derived from exposure studies of selected groups, or by analysis of general population responses to ambient exposure. The analysis of such data is incredibly complex, particularly for low exposure levels which gives rise to tremendous statistical challenges. Assessment of problems should not only be directed to protecting and prolonging the health of occupants but also to protecting the fabric of the building. For example; water vapour is an important contaminent in indoor air but its main effect is on the fabric of the building both by superficial and interstitial condensation.

What research is currently being carried out?
One of the main difficulties with carrying out effective research into indoor air quality is that the subject covers such a wide range of scientific disciplines from medical researchers to heating and ventilation engineers and this is leading to a large amount of unco-ordinated research. These various disciplines should be drawn together in an attempt to solve some of the problems. Internationally the Swedish Council for Building Research arranged a conference in Stockholm where over 900 scientific papers were submitted, which underlines the overwhelming number of factors that are related to indoor air quality. Nearer home, Vent-Axia Ltd, recently organised a seminar where people from related fields within the UK assembled and hopefully further meetings will be arranged.

The Building Research Establishment is studying a number of indoor pollutants including radon, formaldehyde, water vapour and fungal spores and are also looking at the existing standards and requirements for ventilation and air quality.

My own work at present is mainly involved with literature surveys and meeting research bodies; hopefully with improved laboratory and monitoring facilities I will be able to undertake investigations into a number of related topics.

What are the aims and possible remedies?
The aim of indoor quality control is to provide a comfortable habitat for the building's occupants and this requires 'clean-air', a temperature between 68 and 79°F (20-27°C), a room humidity of 40-60 per cent and an air movement between 0.15 and 0.3m/s. The success depends on the design and management of the structure and the activities of the building's occupants (the most difficult to control).

In trying to improve design, the following factors should be considered:

a. location of the building in relation to air currents,
b. neighbouring buildings and landscaping
c. architectural design and
d. choice of building materials to provide the most desirable temperature, humidity and air movements at all times of the day and year with the minimum of interference by the occupants. Control of contaminents already existing can be controlled in three main ways:
    1. by substitution eg, replacement of asbestos and lead
    2. control at source eg, sealing of floors to prevent high levels of radon and adjustment of cooker burners to prevent CO being produced.
    3. effective ventilation so as to 'dilute' airborne contaminents.

Economics and practicalities will decide which of the methods would be appropriate.

Occupants' behaviour is the most difficult aspect to control, houses really need to have fool-proof designs so that ventilation systems in particular cannot be tampered with. People's attitudes and modern design; for example, sealing double glazing units, have meant that windows cannot be relied upon as a means of ventilating rooms. Methods of ventilation have to be designed which cannot be blocked off by occupants. This obviously brings into question the effectiveness of ventilation and adequate mixing that can be achieved under the Building Regulations (openable window area/one twentieth floor area standard). If new ventilation criteria are going to be introduced care must be taken so that any new standards can be easily enforced without the need for complicated equipment and staff resources. How can ventilation be improved in existing properties? Fitting of new ventilation systems? Education of occupants? Improved Institute of Heating and Ventilating Engineers guidelines? or mandatory requirements? In Sweden if they do not have mechanical ventilation, they have to provide a 150mm vent from the kitchen and bathroom to the roof for winter ventilation.

Conclusions and Recommendations
With regard to improved ventilation, further work is required to decide what would be a 'reasonable' ventilation rate for new and future years and how best it can be achieved in new and existing buildings. Environmental Health Officers and other groups cannot promote greater public awareness until we have a better understanding of what is reasonable and how it can best be achieved.

In this general paper I cannot comment on every individual contaminant but I feel the following contaminents deserve mentioning. Although there is still no conclusive evidence of health problems of such materials as man-made mineral fibres, their widespread use for insulation justifies a lot more research to provide a sounder basis for evaluation. Formaldehyde has still not been given a 'clean bill' of health and further work should be undertaken by the medical profession. I feel that while this doubt still exists, stricter controls of its use should be introduced, particularly with regard to imported materials containing formaldehyde and notification of installation of urea-formaldehyde foam to Environmental Health Departments. Greater effort is required to limit the number of consumer products that release contaminents into the indoor atmosphere.

With the large number of recent deaths due to fire in homes, more control is required on building materials and furnishings that release smoke and toxic gases in the event of fire.

More vigorous efforts are required to curtail smoking in public places, particularly restaurants, cinemas, theatres and public houses, also education of parents warning them of the dangers to children and non-smokers by smoking in the confined area of the home.

In summarising, there is a great need for sensible co-ordinated anticipatory research to provide a good solid foundation to identify problems and to provide factual evidence. Until such information becomes available, it will be difficult to assess fully the impact that contamination of the indoor atmosphere is having on the health and welfare of occupants.

References
Euro Reports and Studies 21
Indoor Air Quality, Beet Meyer
Indoor Pollution, S Battersby MJ June 84
Royal Commission on Environmental Pollution 10th Report

The views expressed are personal and do no necessarily represent the policy of Basildon Council.