Guidance on Indoor Air Quality

Indoor Air Quality – the good, the bad and the ugly!

Whilst life expectancy is increasing around the world, there is a significant rise in chronic non-communicable diseases, which, coupled with longer life expectancies, put healthcare systems under increasing pressure. The built environment has a significant role to play in this, be it the indoor environments where we spend most of our time, to the way our towns and cities are planned. Beyond supporting our health, the built environment can also contribute to our wellbeing, our enjoyment of a place, how we interact with others, and how we perform in workplaces. Although it is now obvious to many that the health of our planet and the wellbeing of our species are intrinsically linked, buildings cannot be designed uniquely for the pursuit of environmental sustainability objectives, at the expense of the comfort or health of occupants.

Exposure to air pollutants can have both acute and chronic health effects, from mild to severe. The probability and severity of adverse health outcomes is largely dependent on age, pre-existing medical conditions, and individual sensitivity. Poor indoor air quality (IAQ) is largely dependent on outdoor air pollution, however, the indoor environment contains additional sources of air pollutants derived from building materials, consumer products, occupants, and their activities.

UCL Institute for Environmental Design and Engineering, in collaboration with the Department of Chemistry at the University of Cambridge, recently published a report investigating levels of indoor air pollution within London's schools. Researchers examined five primary schools and one nursery and concluded that children living, or going to school, near busy roads were exposed to higher levels of vehicle pollution. Children at these schools had a higher prevalence of childhood asthma and other respiratory issues.

In addition, research published by 'We Design For' consultancy, revealed that indoor air quality within the commercial buildings they tested was actually worse than outdoor air quality. Buildings tested in central and north London, as well as Wycombe were found to be exceeding particulate matter (PM) guidance limits by up to 520%. Data from the study shows indoor air standards in some buildings is failing to comply with WHO guidance and Building Regulations' annual mean limit for nitrogen dioxide (NO_2). More than 60% of the buildings tested had higher levels of harmful NO_2 and PM2.5 inside than outside. Building Regulations state that exposure to NO_2 should not exceed 288 µg/m over a one-hour average, and 40 µg/m over a long-term average. Many buildings are failing to meet these targets, yet there is rarely monitoring in place to measure, record or tackle this invisible issue.

All buildings are required by law, to offer a level of ventilation to help reduce the risk of damp and condensation, prevent the build-up of bacteria, and remove allergens and pollutants. If the air being introduced into commercial offices is not fresh or clean however, the process can become counterproductive. It is suggested that ventilation alone is not a viable solution for tackling indoor air quality, and that recognised industry guidance regarding the control of ventilation systems, and the location of fresh-air intakes, needs to be updated.

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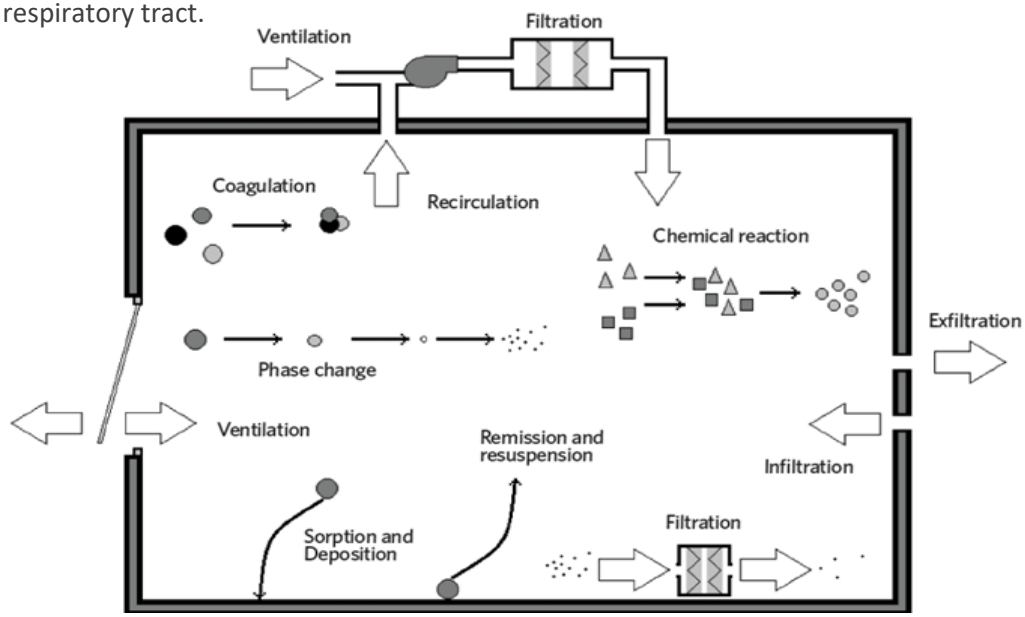
Building materials and systems, along with activities in buildings, can be sources of contaminants harmful to human health. Some materials used to construct and furnish buildings emit harmful gases and harbour biological organisms. Unvented combustion processes for space and food heating, emit gaseous and particulate contaminants, and can be a source of moisture which is a primary driver of biological growth. The presence and concentrations of airborne contaminants are often measured without careful consideration of their relevance. Some are inappropriately grouped together, for example, more than one million volatile organic compounds (VOCs) with unknown toxicities exist, and yet, they are often reported as single values and referred to as Total VOCs (TVOCs).

Carbon dioxide (CO2) is commonly used as an indicator of poor IAQ, and although it does not negatively affect the health of occupants in the concentrations often found within buildings, it is a marker of human bio-effluents. The presence of CO2 is a direct result of occupancy, occupant activity, gender, age, and physiology, along with combustion, and transport from elsewhere. Without an understanding of these variables, indoor CO2 cannot be used to assess IAQ or ventilation. Additionally, it can never be used to indicate the presence of other important indoor contaminants, such as formaldehyde from building materials, as these emissions are unrelated to CO2 concentrations.

Ventilation standards generally agree that indoor air should be perceived as fresh and pleasant by the majority of occupants, so they set a baseline ventilation requirement of around 8 l.s-1 per person to dilute bio-effluent odours to an acceptable level for anyone entering an occupied room. The standards also attempt to account for other contaminants by increasing the baseline rate to 10 l.s-1 per person, although this increase is not based on specific contaminants.

Ventilation rates in national standards around the world differ by up to four times, and their origins are not always known or documented. Comparisons of measured ventilation rates against those prescribed by national standards suggest there is also a widespread inability to implement them effectively within many buildings.

The ability of ventilation to mitigate these contaminant exposures is limited. Occupants are exposed to contaminants via inhalation, skin absorption, and ingestion. Infections, carried by fomites such as skin cells, hair, clothes, and furniture, can be spread by all three exposure routes. The opening and closing of doors and the action of sitting on furniture can resuspend fine particles, which can be inhaled into the lower respiratory tract. Large droplets produced by breathing, talking, sneezing, and coughing, contain mucus, saliva, cells, and infectious agents that are transmitted over distances of less than one metre, and such particles can be inhaled into the upper respiratory tract.



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Semi-volatile organic compounds (SVOCs), such as those emitted by dry-cleaned clothing or flame retardants, are absorbed through the skin or by food and ingested. Organic allergens, such as those produced by dust mites, are present within carpets and soft furnishings, and are inhaled. On its own, ventilation is insufficient, and fails to deliver acceptable IAQ, especially when contaminant sources are not reduced or eliminated.

Source control has often been identified as the most effective step towards acceptable IAQ. When source control is not possible, local exhaust ventilation can be effective in removing contaminants before they mix in a space. Some contaminants, such as carbon monoxide, are harmful when exposure is acute, so sensors and alarms can be useful for monitoring levels. However, many others require exposures to be chronic before negative health effects occur. Devices indicating the presence of specific contaminants should be used.

There has been a recent surge in activity within the building services sector over standards for IAQ, and there have been calls for the creation of an air-quality standard. Given the pollution levels in London and other densely populated city centres, delivering acceptable and healthy air quality inside a building is challenging, however, there is considerable guidance already available for services engineers delivering projects in urban areas with higher levels of pollution.

IAQ is addressed in detail in CIBSE guides A and B, with further guidance in AM10 Natural Ventilation, TM21 Minimising Pollution at Air Intakes, and KS17, which offers an overview of the topic. CIBSE's updated edition of TM40 Health and Wellbeing in Building Services, is currently the most up-to-date guidance available which addresses air-quality issues.

CIBSE recognises that the built environment's role in public health, wellbeing, comfort, and cognitive performance is attracting increased awareness, and this prompted the revision of the TM40 document which was originally published in 2006. The updated edition includes the latest research linking building factors to comfort, health, and wellbeing. 'Health and wellbeing' is extremely broad in scope, ranging from acute health impacts, comfort and performance, to fulfilment, joy and happiness.

The revised TM40 focuses mainly on the middle ground and on providing best-practice advice on the design, construction, and operation of buildings, to support health, comfort, and wellbeing. Environmental parameters covered in the 2006 document, namely air, humidity, thermal comfort, light, acoustics, electromagnetic fields, and water, are all included in the new edition. Important updates include, the health effects of pollutants from indoor and outdoor sources, the non-visual effects of light, and the potential impact of electromagnetic fields from power lines or wireless technologies.

In the UK and most developed countries, there is not yet a comprehensive and robustly implemented regulatory framework on IAQ, and professionals are advised to refer to WHO guidelines.

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With the introduction of TM40, it is expected that regulations on IAQ will be put in place or reinforced to address the current gap, and deliver buildings that are both energy efficient and which provide healthy comfortable indoor environments.

This is further supported by recent amendments to the Energy Performance of Buildings Directive, which requires national energy regulations to 'optimise health, indoor air quality and comfort levels'.

While engineers are compelled to design for the prevailing conditions, improved outdoor air quality and reduced levels of pollutants will improve the quality of the 'fresh' air used to ventilate buildings. It is therefore essential that the government takes steps to control pollution and meet, or better, the future standards they have set to achieve.

I hope you find this information useful - should you wish to discuss the guidance in greater detail or have any specific operational concerns relevant to your own buildings, please do not hesitate to contact me.

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