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MARK THROWER MANAGING EDITOR

The importance of indoor air quality

By Paul Bennett, managing director, BSSEC

Indoor air quality is the degree to which air is pollution free within and around building structures and ultimately affects building occupants' comfort, productivity and health. The effects of poor air quality are felt by occupants for hours or years after exposure. Air quality can therefore have a long-lasting impact on the economy and the environment.

In this CPD article we will consider what the common air pollutants are in buildings, what the health impacts of these air pollutants are on occupants, what regulations and standards are in place to manage air quality and finally what control strategies can be employed to improve air quality in buildings.

The severity of air pollution has long been undervalued and for the first time in the UK air pollution was legally recognised as a cause of a person's death. On the 16th of December 2020 legal history was made when a ruling was made that air pollution was the cause of the death of a nine-year-old girl, Ella Kissi-Debrah. Her February 2013 death certificate has now been legally changed to be caused by acute respiratory failure, severe asthma and air pollution exposure. It is now recognised that she was exposed to nitrogen dioxide (NO_2) and particulate matter (PM) pollution in excess of World Health Organization guidelines, the principal source of which were traffic emissions.

Contamination of air can cause a number of different health problems to building occupants including. To help reduce the risk of such problems an understanding of some of the common indoor pollutants is required.

CO (Carbon Monoxide), NO_2 (Nitrogen Dioxide), and Nitrogen oxide (NOx). This type of air pollution is most commonly found being dissipated from domestic appliances such as, boilers, heaters, fires, stoves and ovens. This is because these appliances typically burn carbon-containing fuels such as coal, coke, gas, kerosene and wood. Alternatively, these emissions derive from close proximity vehicle emissions which may also enter buildings through ventilation systems.

Carbon monoxide can cause chronic effects at low levels such as headaches, dizziness, nausea. It can also cause lethal poisoning at high levels which can ultimately lead to death.

Nitrogen Dioxide can cause inflammation of the airways, reduced lung function and increases the risk of an asthma attack (or asthma attacks). Nitrogen Dioxide can also increase the severity as well as the incidences of respiratory illnesses.

Particulate matter (PM, PM10 or PM2.5). This is essentially matter in the air that is not a gas. This includes natural sources like pollen, sea spray and desert dust. It also includes human-made sources like smoke and dust from vehicle exhausts, brakes and tyres. PM can travel large distances with up to 33 per cent of PM2.5 originating from non-UK sources and around 15 per cent from natural sources. PM is classified according to size, with the smallest particles having the greatest ability to penetrate the body and thus impact on health. PM10 and PM2.5 is less than 10 and 2.5um (micrometres) across and are the main types of PM which are regulated.

Respiratory illnesses

Particulate matter has been linked with a number of respiratory illnesses, including asthma and chronic bronchitis. Long-term exposure can cause premature death from heart disease and lung disease including cancer. Increased incidences of stroke have also been accredited to being exposed to higher concentrations of particulate matter for long periods of time.

Sulphur Dioxide (SO_2) is an acidic gas which can combine with water vapour in the atmosphere to produce acid rain. In indoor environments sulphur dioxide is an irritant that can affect airways, particularly in those who have asthma.

VOCs (Volatile Organic Compounds). VOC pollution arises from cleaning and personal care products such as aerosol sprays, disinfectants, moth repellents and air fresheners. VOCs are also emitted from building materials, for example, in paints, paint strippers and other solvents and certain pressed wood products, as well as soft furnishings such as new carpets and sofas. Moulds and bacteria are also sources of odorous volatile organic compounds in the indoor air that can be amplified by an increase in air humidity.

Volatile Organic Compounds can cause eye, nose and throat discomfort/ irritation, headache and allergic reactions. Higher concentrations of VOC's can cause irritation to the lungs, liver, kidney and the central nervous system.

Non-methane volatile organic compounds (NMVOCs) are organic molecules, which differ widely in their chemical composition but can display similar behaviour in the atmosphere. These include vapours from every-day products used at work or home like petrol, solvents, air fresheners, cleaning products and perfumes.

Carbon dioxide (CO_2). Not only is CO_2 a greenhouse gas that causes climate change it also effects concentration levels. CO_2 is created when large numbers of people gather and exhale in a room. The normal outdoor level of CO_2 is around 400ppm but in a building such as a school classroom this can climb as high as 2,300ppm and at such levels causes fatigue making concentration difficult.

Where CO_2 levels increase concentration levels start to fade at around 950ppm with a 15 per cent loss of concentration to as much as a 50 per cent loss of concentration at 1,400ppm.

Environmental tobacco smoke (ETS) and secondhand smoke (SHS). Tobacco products such as cigarettes, cigars and pipes contains over 4,000 different chemicals, toxic gases and reactive compounds. Smoking at the back door or under a fan will not reduce the harm to occupants of the building caused by secondhand smoke. This is because secondhand smoke can remain in the air for up to five hours after smoking has occurred.

Second-hand smoke puts people at risk of coughs, colds, ear problems, chest infections and potentially death.

Airborne Viruses. Airborne disease can spread when people with certain infections cough, sneeze, or talk, throwing nasal and throat secretions into the air.

The rapidly spreading coronavirus, SARS-CoV-2, and the disease it causes, COVID-19, has been responsible for millions of deaths globally in 2020 and 2021. While the coronavirus that causes COVID-19 is not generally considered to be airborne, there may be some situations in which the virus can act like an airborne disease. These include certain clinical settings in which people are receiving intensive medical treatment. In usual situations, SARS-CoV-2 is spread through respiratory droplets after a person coughs or sneezes, but these droplets are larger than what is considered airborne.

Radon. This is a naturally occurring radioactive gas that is emitted from the ground (especially in defined areas - high levels can occur almost anywhere but are more prevailing when the ground is particularly porous and/or rich in uranium). Exposure to radon gas can increase the risk of lung cancer. It is not a serious problem when radon gas is emitted into outdoor air spaces but becomes one when radon gas accumulates in indoor spaces where occupants can be exposed to high concentrations of radon gas.

Exposure to radon can cause increased risks of lung cancer. Some indicators to a heightened radon exposure can be a persistent cough, wheezing, shortness of breath, coughing up blood, chest pain, frequent infections like bronchitis and pneumonia.

Regulators address air quality through guidance, standards and legislation. Examples of the approach that regulators take can be seen below.

Recommended limits

The World Health Organization works towards setting recommended limits for harmful air pollutants in outdoor and indoor settings. This guidance covers concentrations of fine particulates, nitrogen dioxide, sulphur dioxide, carbon monoxide and ozone.

WHO guidelines also cover indoor humidity and mould levels, emissions of gases and chemicals from furnishings and building materials.

Indoor air quality has also been considered in recommendations surrounding household fuel combustion which outlines how to use clean fuel and sets limits on emissions on cooking and heating stoves/ ovens.

The Health and Safety Executive outlines specific substances in their Control of Substances Hazardous to Health (COSHH) which is a legal requirement (2002) that requires employers to control substances that are hazardous to health to protect both themselves and employees. Within this law around 500 substances have been set legally binding workplace exposure limits.

Department for Environment, Food and Rural Affairs (DEFRA) has set The Air Quality Strategy 2007 which provides the policy framework for air quality management and assessment in the UK. The strategy describes the Local Air Quality Management (LAQM) regime that has been established, whereby every authority has to carry out regular reviews and assessments of air quality in its area to identify whether the objectives have been, or will be, achieved at relevant locations, by the applicable date. The objectives for use by local authorities are prescribed within the Air Quality (England) Regulations and the Air Quality (England) (Amendment) Regulations.

The Air Quality Standards Regulations transposes the EU Directive 2008/50/EC into UK law. They set limit values for nitrogen dioxide, PM10 and PM2.5. The limit values for nitrogen dioxide are the same numerical concentrations as the UK objectives, but achievement of these values is a national obligation rather than a local one. There are also differences in where these standards are applied and how they are reported.

DEFRA has headed the "Clean Air Strategy 2019". The Clean Air Strategy sets out the case for action and demonstrates this government's determination to improve air quality. In some cases the goals that have been set are even more ambitious than EU requirements to reduce people's exposure to toxic pollutants

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like nitrogen oxides, ammonia, particulate matter, non-methane volatile organic compounds and sulphur dioxide.

Ban on sale of cars and vans

UK Government has ruled that new conventional petrol and diesel cars and vans will be banned from sale in the UK from 2030 to reduce emissions and reliance on fossil fuels causing climate change. This will open up the market for electric vehicles that are emission free.

The UK Building Regulations provide ventilation standards in buildings. The standard being Approved Document F – Ventilation. The key aspects in relation to air quality include:

- setting ventilation standards for domestic and non-domestic properties; and
- setting maximum acceptable indoor levels for nitrogen dioxide, carbon monoxides and VOCs.

It should be noted that ventilation and air infiltration rates impacts a buildings energy performance and overall efficiency

Building Research Establishment (BRE) has been working on researching the trade-off between airtightness and levels of ventilation. This is a key issue in building development because highly airtight buildings are energy efficient but as a consequence are less well ventilated and therefore are increasingly prone to the accumulation of air pollutants. The demand for energy-efficient buildings is likely to increase in the coming years in response to concerns over sustainable design and climate change. However, BRE is apprehensive that increasing the airtightness of buildings will decrease the buildings' ventilation levels and that this may have an adverse impact on indoor air quality.

Control strategies for reducing the concentration of air pollutants in the indoor environment depend on the type and location of the source and activity. Ventilation with outdoor fresh air will dilute and flush out pollutants derived from indoor sources but will not eliminate them completely. In fact, the incoming ventilation air may itself be polluted from outdoor sources, which will place an additional burden on indoor air. Hence, care needs to be taken in selecting the correct mitigation strategy to provide optimum indoor air quality for health and wellbeing. Mitigation strategies include:

1) Outdoor Pollution Mitigants

- removing source of pollutant e.g. Government policy on diesel cars or a ban on outdoor smoking near to buildings;
- reduction of pollutants e.g. plan new buildings away from roads;
- controlling the ingress of pollutants e.g. via building airtightness;
- intake location and control e.g. sited furthest away from pollutant source like roads and boiler flues; and
- structural ventilation e.g. if radon is present include replacing or adding ventilation bricks in the outside walls or installing a fan in the loft.

2) Indoor Air Pollution Mitigants

- choice of products e.g. by specifying products that have lower levels of VOCs;
- filtration of incoming air to reduce pollution levels e.g. using HEPA filters;
- controlled ventilation rates using mechanical or natural ventilation;
- increased per cent of filtered fresh air versus recycled air;
- regular maintenance of plant and regular air filter changes;
- disinfection and cleaning of air duct lines as older air ducts can contain mould and even dead vermin;
- the use of plants and humidifiers; and
- cleaning air using UV light.

Building services ventilation systems include filters that are used to physically remove particles, and in some cases environmental gaseous pollutants, from the air supply. The UK standards for air filtration are BS EN 779, BS EN 1822 and BS EN 14387 (BSI, 2012a, 2009, 2008) and CIBSE Guide B (CIBSE, 2004). However, air filtration is limited in its performance and is only effective at dealing with the pollutants for which they are designed. For example basic filters are used to remove large particles such as dust but they offer little protection against smaller, respirable particles. These are classified as 'general' or 'G' filters. Higher specification particle filters are classified in increasing order of effectiveness as:

- General ('G' type filters);
- Medium ('M' type filters);
- Fine ('F' type filters);
- Efficient Particulate Air (EPA or 'E' type filters);
- High Efficiency Particulate Air (HEPA or 'H' type filters) and
- Ultra-Low Penetration Air (ULPA or 'U' type filters)

More recently, in addition to the above filters NOx filters and whole-house ventilation systems are becoming a popular choice for domestic ventilation systems where buildings are located close to busy polluting roads.

Ultraviolet germicidal light

Another approach that is being researched for building services applications is the ultraviolet (UV) germicidal light, produced by UV lamps to inactivate the bacteria and viruses present in airborne particles. UV lamps are installed near the ceilings of rooms or in ducts that supply air to rooms. Systems installed in ducts can use UV light to disinfect wet cooling coils and drain pans used for air conditioning systems. These systems can be very effective in reducing the growth of mould and bacteria on the surfaces of coils and drain pans.

UV germicidal lamp systems must be designed to minimise occupant exposure to the harmful ultraviolet light. Studies on the impacts of ultraviolet germicidal systems into people's health has been inconsistent but there is enough evidence of potential health benefits to warrant further research.

It has been noted that ultraviolet germicidal systems would appear to be more effective in reducing respiratory infections when used in crowded spaces.

'The effects of air pollution kill an estimated 7m people across the world every year, according to the World Health Organization. Ambient air pollution accounts for an estimated 4.2m deaths per year due to stroke, heart disease, lung cancer and chronic respiratory diseases'

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ENTRY FORM

INDOOR AIR QUALITY

Please mark your answers below by placing a cross in the box. Don't forget that some questions might have more than one correct answer. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet, return it to the address below. Photocopies are acceptable.

QUESTIONS

1) The World Health Organization estimates that air pollution kills how many people each year?
- ☐ 0.7m
- ☐ 7m
- ☐ 77m
- ☐ 777m

2) Which of the following is an example of Particulate Matter?
- ☐ NOx
- ☐ SO2
- ☐ CO
- ☐ Dust and smoke

3) What is the level of CO2 in normal outdoor air?
- ☐ 950ppm
- ☐ 1,000ppm
- ☐ 400ppm
- ☐ 95ppm

4) What is the level of CO2 in a crowded room that causes a 15 per cent reduction in the ability to concentrate effectively?
- ☐ 950ppm
- ☐ 400ppm
- ☐ 1,400ppm
- ☐ 2,300ppm

5) How many toxic chemicals are released when a person smokes tobacco?
- ☐ 4
- ☐ 40
- ☐ 400
- ☐ 4,000

6) Is COVID-19 an airborne disease?
- ☐ No as respiratory droplets are larger than considered to be fully airborne
- ☐ Yes as scientifically proven
- ☐ Maybe
- ☐ Only in indoor situations

7) Which of the following are health impacts of air pollutions (select all that apply)?
- ☐ Loss of concentration
- ☐ Headaches
- ☐ Lung disease
- ☐ Deaths

8) When is the UK putting a ban all new petrol and diesel engine vehicles?
- ☐ 2035
- ☐ 2025
- ☐ 2030
- ☐ 2050

9) Which one of the following is also known as a high efficiency particulate air filter?
- ☐ Basic
- ☐ General
- ☐ EPA
- ☐ HEPA

10) Are UV lamps 100 per cent effective in disinfecting and cleaning air giving protection against respiratory infections?
- ☐ Yes
- ☐ Results are inconclusive
- ☐ No
- ☐ Only when used with G filters and humidifiers.

PLEASE COMPLETE YOUR DETAILS BELOW IN BLOCK CAPITALS

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