ERGOSENSE

The logic and science behind Indoor Air Quality monitoring & management.

Compiled by the research and development team at Ergosense (Pty) Ltd

Introduction

Today more than half of the earth's population lives in cities, and spend most of their time indoors. Therefore, we need the indoor spaces we inhabit to be healthy and comfortable environments that support our wellbeing. To contribute to that support and wellbeing, human psychology looks to the built environment for protection; the buildings where we work and live need to be safe havens.

Indoor environmental quality (IEQ) is one of the core aspects of ensuring that buildings are healthy, safe and comfortable for human occupation. IEQ includes **indoor air quality (IAQ)**, as well as the physical and psychological aspects of life indoors. These include lighting, visual quality, acoustics, thermal comfort, etc.
IAQ is one of the strongest predictors of workplace health, as well as workforce performance. Poor IAQ has been linked to both physical and psychological health symptoms. Additionally, poor IAQ is known to have a significant impact on cognitive functioning and is as one of the leading causes of distractions and decreased productivity.

Historically the focus for improvement has been predominantly on the comfort metrics, specifically temperature. Measuring the other comfort and indoor air quality metrics have been surprisingly limited.

Similarly, the impact of indoor environmental quality on psychological wellbeing and performance of employees in the workplace has been underestimated and consequently received limited attention.

A Harvard Business Review Survey was conducted to understand what employees want most from their workspaces. Surprisingly, it was found that employees want the basics first: better air quality, access to natural light, and the ability to personalize their workspace. Air quality specifically was the biggest influencer of employee performance, happiness, and wellbeing, and was mentioned as the most important factor by 58% of the respondents.

1. Measuring building conditions and evaluating building health

The adage, 'you can't manage what you can't measure' couldn't ring more true in the case of indoor air quality. If you do not have any idea what your building is doing, then how do you know if there is a problem or not? Furthermore, how can you measure any success if you implement remediation plans? It has become critical for buildings to have a baseline from which facilities managers can begin the process of indoor air cleaning measures.

As a first step, building managers should collect real-time data on the important environmental and air quality metrics and continuously monitor fluctuations in their buildings. The upshot? Having robust data allows for an understanding of the building's health and behaviour, and also then provides for immediate responses and adjustments; whether it be to a building's mechanical system or to suggest changes in occupant behaviour.

Furthermore, we must think about preventative, instead of reactive, care. Not all buildings are alike, solutions might be nuanced, and need to be evaluated on a building-by-building basis. This underscores the importance of being informed by accurate real-time and historical data for every building and workspace.

The technology exists that can measure the following important indoor environmental metrics that matter when it comes to maintaining healthy indoor spaces:

- Temperature
- Humidity
- CO2
- TVOCs
- PM Contaminants
- Sound
- Light

1.1. Temperature

1.1.1. Effects on occupants

Conventional wisdom says that finding the ideal office temperature is important to worker productivity: Thermal comfort is the source of one of the most frequent complaints in office environments. In periodic facility satisfaction surveys, **being hot and being cold have consistently been top two complaints about office environments**. We can therefore see a difference of just a few degrees can have a significant impact on how focused and engaged employees are.

Guidline Summary:

cold	<15
cool	15 - 19
temperate	19 - 25
warm	25 - 28
hot	> 28

1.1.2. Managment difficulties

Of course, individual preferences vary, for instance, generally, women prefer a slightly higher temperature. This makes it difficult to please everyone, especially when you have complex buildings or office layouts to contend with.

In addition to an ambient temperature, **the humidity of an environment has a big influence on how people experience it.** The apparent temperature, or "feels like" temperature, is a way to express what the temperature seems like to a person. High humidity levels could feel warmer and low humidity could feel cooler.

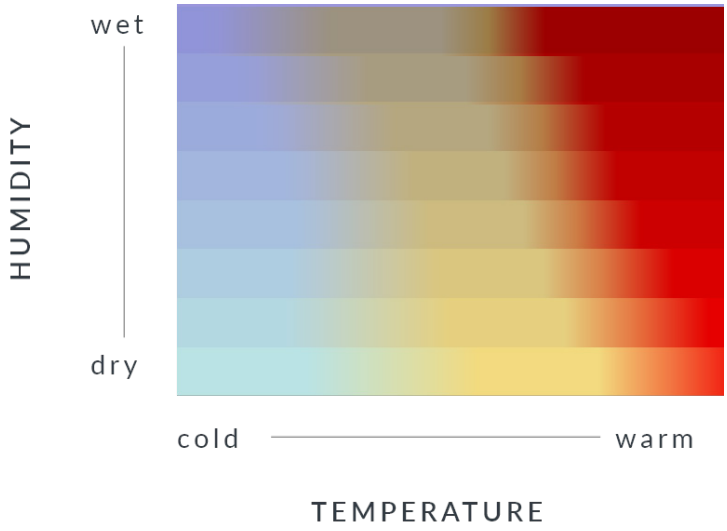


Diagram illustrating the temperature shifting effects of humidity on apparent temperature.

"The term "thermal comfort" refers to a condition that is governed by many environmental and human factors; in other words, physiological, physical, and sociopsychological factors."

- Mujeebu (2020)

1.1.3. Recommended levels

Available research found that keeping the office temperature between **21 and 23 degrees Celsius** would be best for the majority of workers in a "typical" office environment. The U.S. Occupational Safety and Health Administration (OSHA) doesn't mandate employers to maintain specific temperatures in the workplace, but it recommends that employers keep the thermostat between **20 and 24 degrees Celsius**.

1.2. Humidity

1.2.1. Effects on occupants

The relative humidity level plays a significant role in determining the quality of indoor environments – impacting both the health and comfort of occupants.

According to the American Industrial Hygiene Association (AIHA), **uncontrolled humidity levels are one of the main factors for poor indoor air quality (IAQ).** Overly low or high relative humidity can introduce a range of **respiratory issues, irritated skin and eyes, reduced mental focus, and general discomfort** – resulting in productivity loss and health issues.

When the air is too muggy it can make occupants feel irritable and psychologically inhibited. By contrast, the air that is too dry can make employees susceptible to pathogens by drying out their mucous membranes. It can also make them susceptible to nosebleeds and chronic respiratory or sinus issues.

Moreover, very high indoor humidity is associated with increased growth of micro-organisms such as mould and infectious bacteria (Institute of Medicine, 2004). At the same time, viruses survive much longer when humidity levels are low, therefore airborne pathogens are effectively given free rein in drier conditions. This increases the risk of illness flashing through the building. The greatest benefit that you may obtain from dialling in the perfect humidity levels is a decrease in sickness.

Guidline Summary:

Safest range:
40% - 60%

Did you know? Carpets are roughly 10% more humid than the space it is in. It acts as a sink for pollutants as well. Maintaining and cleaning carpets is therefore a vital aspect of insuring a safer IEQ.

1.2.3. Recommended levels

The U.S. Occupational Safety and Health Administration recommend that offices maintain a relative humidity level between 40% and 60%.

1.3. CO2

1.3.1. CO2 basics

Carbon dioxide is a natural component of air, and in indoor environments, the source is usually the building's occupants - the people. Humans exhale carbon dioxide, therefore the levels of CO2 correlate with human metabolic activity. Indoor CO2 levels are a clear indicator of the adequacy of outdoor air ventilation relative to indoor occupant density.

1.3.2. Effects on occupants

It is well documented that carbon dioxide levels have a significant **impact on the cognitive functioning and productivity** of workers. CO2 at levels that are unusually high indoors may cause occupants to **grow drowsy, to get headaches, or to function at lower activity levels.**

According to a new study from the Harvard, researchers found that cognitive performance scores for the participants who worked in the green+ environments were, on average, double those of participants who worked in conventional environments.

Measuring nine cognitive function domains researchers found that the largest improvements occurred in the crucial areas such as responding to a crisis or developing strategy.

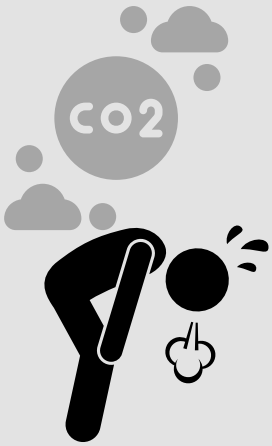
1.3.3. Recommended levels

The normal concentration of CO2 in outdoor air is between 300 and 400 ppm. Indoor levels are typically quite a bit higher, due primarily to the concentration of exhaled air from the people in the building. CO2 levels in office buildings typically range between 350 to 2500 ppm. It has been demonstrated that levels above 1000 ppm tend to result in health complaints, and a general guideline is that levels should be below 800 ppm to ensure everyone's comfort and ability to function optimally.

Guidline Summary:

keep average levels below 800ppm.

The (acute) maximum should not surpass the 1500ppm mark.



1.4. TVOC

1.4.1. What are TVOCs?

Volatile organic compounds, (VOCs) are organic chemical compounds whose composition makes it possible for them to evaporate under normal indoor atmospheric conditions. VOCs are a nearly unavoidable byproduct of our daily lives and are exceedingly common in our indoor environments, as it is released by many of the products surrounding us day-to-day, including some cleaning solutions.

Due to the wide range of organic chemical compounds that fall under the umbrella of VOCs, the term Total Volatile Organic Compounds or TVOCs is used to simplify reporting when these compounds are present in ambient air.

1.4.2. Effects on occupants

The health effects of exposure to VOCs range from **sensory irritation, headaches and nausea** at low/medium levels of exposure, to frank toxic effects at high exposure levels. The latter may include serious health issues including **neurotoxic, organotoxic and carcinogenic effects.**

In addition to the obvious health risks, studies have found that relatively high levels of VOC exposure also have a direct impact on cognitive performance and employee productivity. One study by the Harvard School of Public Health even suggested a **13% decrease in productivity for every 500µg/m3 increase in VOC.**

1.4.3. Recommended levels

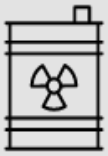
Acceptable levels of VOCs range between 0.3 to 0.5 mg/m3. When levels increase to 1 mg/m3 or more, it is concerning and should be addressed. A suggested threshold for TVOC in indoor environments is 200 PPB (Parts Per Billion).

Guidline Summary:

Average levels should be < 200 ppb

Direct exposure: Short-term (hours) exposure should not exeed 40ppb

Long-term (weeks) exposure should not exeed 100ppb



1.5. Particulate matter (PM)

1.5.1. What is particulate matter?

Particulate Matter (PM) – also known as atmospheric aerosol particles, atmospheric particulate matter, particulates, or suspended particulate matter (SPM) – are microscopic particles of solid or liquid matter suspended in the air. The term aerosol commonly refers to the particulate/air mixture, as opposed to the particulate matter alone. Sources of particulate matter can be natural or anthropogenic.

Particulate matter is **the most harmful form of air pollution due to their ability to penetrate deep into the lungs, bloodstreams and brain, causing severe health problems**. The effects of inhaling particulate matter have been widely studied in humans and animals and include **asthma, lung cancer, respiratory diseases, cardiovascular disease, premature delivery, birth defects, low birth weight, and premature death.**

Types of atmospheric particles include :

- suspended particulate matter with diameter bigger than 10 µm
- inhalable coarse particles (**PM10**) with a diameter of 10 µm or less
- fine particles (**PM2.5**) with a diameter of 2.5 µm or less
- ultrafine particles (**PM 0.1**) with a diameter of 0.1 µm or less.

Guidline Summary:

PM2.5:

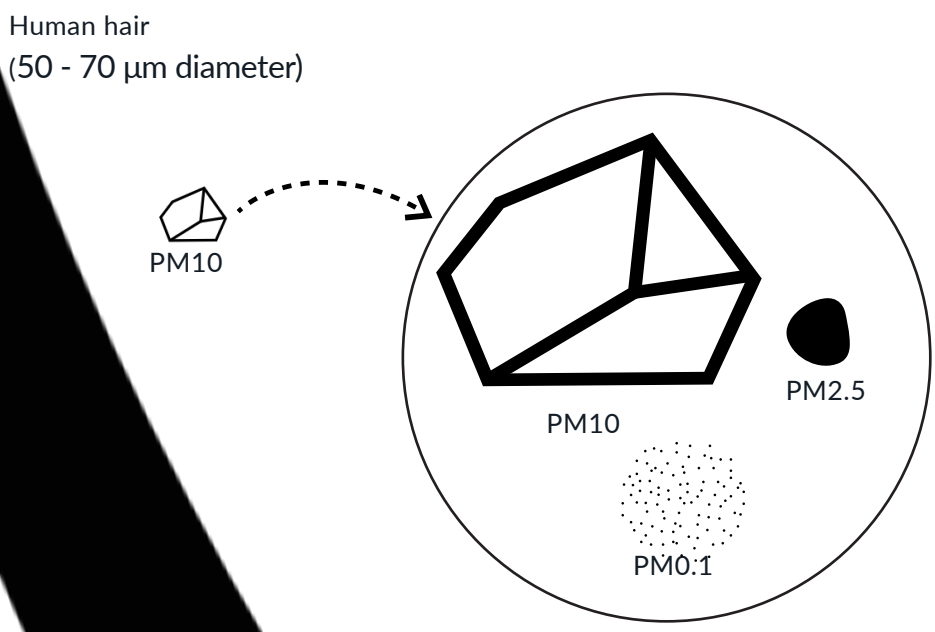
10 µg/m3 (annual mean)

25 µg/m3 (24-hour mean)

PM10:

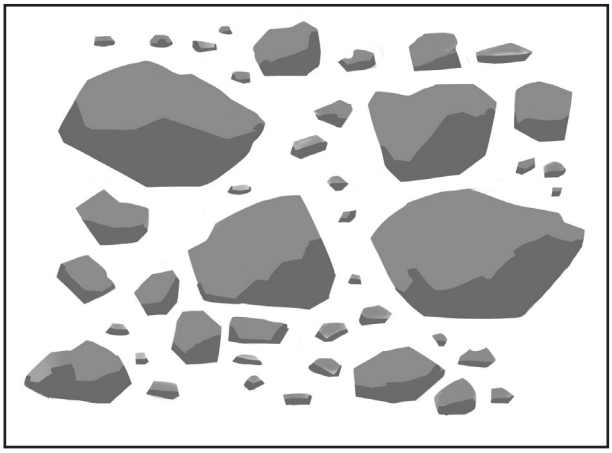
20 µg/m3 (annual mean)

50 µg/m3 (24-hour mean)



1.5.2. Mass vs Count

PM are measured in count and by mass. The two measurements are used to gauge which type of particles and prevalent and how much.



Total PM captured

The particles pass a series of consecutive filters to be measured, hence the larger PM size measurement contains the measurements of the smaller sizes as well. The result of the above PM measurement would be:

	mass: (µg/m3)	count:
PM10	95	36
PM2.5	55	32
PM0.1	15	28

With these values the following can be determined:

		mass: (µg/m3)	count:
PM10:		40	4
PM2.5:		40	4
PM0.1:		15	28

Captured PM ordered to show the relationship between mass and count measurements

1.5.3. Effects on occupants

PM2.5 is of particular concern as it can penetrate to alveoli, the gas exchange area in the lungs, and hence the circulatory system. Because of the small size, **ultrafine particulate matter (PM0.1) can enter deep into our lungs and may pass through cell membranes and migrate into other organs, including the brain,** and do all manner of harm.

In 2013, a study involving 312,944 people in nine European countries revealed that there was no safe level of particulates and that **for every increase of 10 µg/m3 in PM10, the lung cancer rate rose 22%. The smaller PM2.5 were particularly deadly, with a 36% increase in lung cancer per 10 µg/m3** as it can penetrate deeper into the lungs. Worldwide exposure to **PM2.5 contributed to 4.1 million deaths from heart disease and stroke, lung cancer, chronic lung disease, and respiratory infections in 2016.** Overall, ambient particulate matter ranks as the sixth leading risk factor for premature deaths globally.

Other than the impact on the global population from a health perspective, the current calculations of the societal cost of air pollution may be substantially underestimated. A growing body of evidence in health sciences suggests that exposure to poor air quality may also have **harmful immediate and lasting impacts on the human brain,** ultimately lowering individuals' cognitive abilities (Underwood, 2017). Exposure to air pollution alone has been shown to have severe **health consequences which may translate into adverse effects on human capital formation and labour market outcomes in the short and long run** (Graff Zivin and Neidell, 2013, 2018). These physiological effects on human cognition may have severe consequences for individual performance in complex cognitive tasks.

A recent study by Künn et al at Maastricht University studied the impact of indoor air quality on the cognitive performance of individuals using data from official chess tournaments. The results show that poor indoor air quality hampers cognitive performance significantly. The study found that an **increase in the indoor concentration of fine particulate matter (PM2.5) by 10 µg/m3 increases a player's probability of making an erroneous move by 26.3%.** The impact increases in both magnitude and statistical significance with rising time pressure. The study found clear evidence suggesting a short-term and transitory effect of fine particulate matter on cognition.

Quantifying the benefits of improving air quality has to expand beyond major health impacts that result in hospitalizations or deaths, and additionally take into account more subtle effects on labour productivity and human capital accumulation.

1.5.4. Recommended levels

WHO Guidelines for the annual and 24 hour mean levels for PM concentration respectively are:

PM2.5:

10 µg/m3 (annual mean)
25 µg/m3 (24-hour mean)

PM10:

20 µg/m3 (annual mean)
50 µg/m3 (24-hour mean)

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1.6. Light

1.6.1. Effects on occupants

Human comfort issues have always been the focus of green buildings. Especially, lighting (visual sense), acoustics (auditory sense), and temperature and humidity (thermal sense) have led major discussions in providing human comfort in green buildings. Lighting in our living and workplaces is critically important for our ability to accomplish tasks efficiently and safely. Also, proper light levels prevent eye strain, which allows us to work comfortably for longer periods.

1.6.2. Recommended levels

Visual comfort strategies for workplace health mainly address lighting for visual acuity, glare control, and quality of lighting. To provide sufficient lighting level, 300 lux is recommended for general areas and 300–500 lux for computer workstations.

Guidline Summary:

300–500 lux

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1.7. Sound

1.7.1. Ambient environment

Auditory comfort has been a major discussion in the modern workplace. Open-plan offices have become a prevalent office type in the contemporary workplace due to efficient real estate management. The importance of open environments has been emphasized to facilitate interaction and collaboration in the innovation economy.

1.7.2. Effects on occupants

However, the downside of an open environment is excessive noise that causes **annoyance, stress, and physical fatigue,** not to mention the **loss of concentration and productivity.**

High-noise environments are proven to be detrimental to a person's mental health and stress levels. In particular, loud sounds and prolonged exposure to noise can trigger psychological responses in the body, including **spikes in a person's heart rate and blood pressure**. In addition to causing mental health and mood issues, prolonged noise exposure can have a direct impact on a person's ability to do their job well. In a study by Joshua Dean at MIT, he found that noise can have a significant impact on productivity by impeding cognitive function in employees.

1.7.3. Recommended levels

In an office building, the recommended sound levels are between 30 and 65dB, and for open-plan offices, the recommended levels are 40-45dB.

Guidline Summary:

safe area:
30 - 65dB

Did you know? The biggest culprit in noise pollution is road traffic, and the leading cause of permanent hearing loss due to expose to too high sound levels are personal audio devices, like headphones

2. COVID 19 - understanding viral infection potential in indoors environments

The direct impact that air quality and other indoor environmental factors have on human's health, comfort, productivity has been well researched in the past. Based on these studies clear guideline has been established for indoor environments (as discusses in the preceding sections of this document).

However, in the wake of the global pandemic caused by COVID-19, during 2020 we have seen seismic changes to the way we live and work. As workplaces around the world sit empty, business leaders and buildings owners are frantically searching for answers.

How can we safely reopen these spaces, while keeping our employees safe from the spread of this deadly virus?

Other than the traditions offices and workspaces, the places that people need to visit as a matter of necessity - such as hospitals and shopping malls, and schools and educational institutions – also needs to be as safe as possible at all times. Amidst the COVID-19 pandemic, we need more than ever, to understand the critical role of indoor environmental quality, and specifically air quality plays in our quality of life and health. How do we discern if conditions in indoor environments might be ripe for viral survivability and spread?

Currently, there is no continuous air quality monitor that can detect viruses itself. A virus is too small, no continuous monitoring sensor can measure at the level on granularity to identify specific viruses. Viruses are usually much smaller than bacteria with the vast majority being submicroscopic, generally ranging in size from 0.005 µm to 0.300 µm. Coronary viruses are spherical particles between 0.06 micron and 0.14 micron in diameter, with COVID-19 averaging about 0.125 micron, measured by electron microscope (Zhu et al, 2020).

A significant amount of research has been conducted on the complexities of airborne pathogens, how infections happen, the effects of air pollution, and also why certain conditions are hospitable for specifically viral survivability. Based on these studies, we can look at several of the indoor environmental parameters that help us understand air quality and get a view of infection potential for viruses. Air quality monitors gather data which can be used to determine the risk of potential infection in a certain space and whether it would be beneficial to implement some type of remediation action.

The five environmental and air quality parameters that have a role to play in determining the risk of COVID-19 surviving and spreading in indoor spaces are:

- PM (particulate matter)
- Temperature
- Humidity
- Co2 levels
- TVOCs (Total Volatile Organic Compounds)

2.1. Particulate Matter (PM) and contaminated air

2.1.1 How they relate

Airborne particles of biological origin including bacteria, fungi and viruses, are commonly present in the air we breathe. Any respiratory pathogens able to remain viable (infectious) after aerosolization and air transport are a potential cause of respiratory disease, and they are often associated with other substances to form 'complex particles' (Tang 2009). Virus-containing aerosols can be formed through natural occurrences, for example, sneezing by an individual harbouring a respiratory virus infection, or through mechanical means, for example, when air currents around contaminated surfaces disperse the viruses into the air (Verreault et al. 2008)

The dimensions of aerosolized virus particles vary widely, ranging from nanometre (e.g. 'naked' virus particles) to micrometre (e.g. viruses associated with nonviable particles) (Gerone et al. 1966). Once airborne, small particles containing virus(es) can remain airborne for long periods, allowing for their transport to other locations. Overall, smaller particles that contain respiratory viruses are potentially more dangerous because they stay airborne longer (and thus the risk for acquiring an infection is prolonged), and they get inhaled into the lower lungs, potentially causing diseases with more severe outcomes.

To date, several scientific studies focused on virus diffusion among humans demonstrated that increased incidence of infection is related to airborne particulate matter (PM) concentration levels. It is known that PM fractions (e.g., PM2.5 and PM10) serve as a carrier for several chemical and biologic pollutants, viruses included.

2.1.2. Recent research

Recent events and consequent studies suggested that high concentrations of PM of air pollution might favour the spread of COVID 19. Scientific works from around the globe have discussed the likelihood that high concentrations of PM may have been one of the major causes for the important outbreak that has hit several industrialised regions such as Wuhan and northern Italy. As a result, a cascade of works based on data analysis has emerged from around the world as to address the question at hand.

PM and COVID-19 infection risk

On 20 March 2020, Setti et all published a study at the Italian Society of Environmental Medicine (SIMA), in which they found a linear relationship between PM10 levels above 50 microns / m3 and the rate of spread of COVID-19 in Italy. These results are fully consistent with scientific studies on the spread of viruses and bacteria in the population by suspended particles, which correlate the incidence of viral infections with the levels of atmospheric particles (PM10 and PM2.5). (Ciencewicki J. et al., 2007; Sedlmaier N., et al., 2009).

The Italian experience indicates a direct relationship between higher levels of particulate matter PM10-2.5 and higher levels of COVID -19. It found that at average PM10 levels of 350 µg/m3, the infection rate will be twice as high as at levels below 50 µg/. This is also the first evidence that SARS-CoV-2 RNA can be present on PM, thus suggesting possible use as an indicator of epidemic recurrence.

Historic PM exposure and COVID-19 mortality risk increase

Another study published in April 2020 by Wu et al, looked at that exposure to air pollution and COVID-19 mortality rates in the United States in a nationwide cross-sectional. Data sources COVID-19 death counts were collected for more than 3,000 counties in the United States (representing 98% of the population) up to April 22, 2020, from Johns Hopkins University, Center for Systems Science and Engineering Coronavirus Resource Center.

Results found that an increase of only 1 µg/m in PM is associated with an 8% increase in the COVID-19 death rate, and concluded that a small increase in long-term exposure to PM leads to a large increase in the COVID-19 death rate.

Extended PM exposure and decrease in defence against COVID-19 virus

Recent work by Conticini et al. stated that communities living in polluted areas (such as Lombardy and Emilia Romagna) are more predisposed to die of Covid-19 because of weakened health status. They claimed that a subject's exposure to both PM2.5 and PM10 leads to systemic inflammation. This leads to a chronic inflammatory stimulus that weakens the cilia and upper airways defences and facilitates virus invasion by allowing virus reaching lower airways.

PM exposure and infection risk

Travaglio et al. analyzed data collected in England and showed positive associations/ correlations between the exposure to different air pollutants and the number of COVID-19 infections and fatalities.

COVID-19 fatality and PM count correlation

Ogen (2020) recently analysed data from 66 administrative regions in France, Spain, Italy, and Germany, and found that the highest COVID-19 deaths in these regions were associated with five regions of Northern Italy that also corresponded with the highest levels of atmospheric air pollution. Cole et al (2020) estimate the same relationship using Netherlands municipality data and find PM2.5 positively associated with COVID-19 cases, hospitalization, and deaths.

Conclusion

Worryingly, research links both long and short-term exposure to PM2.5 to a higher incidence of death from COVID-19. Additionally, it has also been established that PM fractions (e.g., PM2.5 and PM10) serve as a carrier for several chemical and biologic pollutants, viruses, COVID -19 included. Without any doubt, these studies put into light a correlation between air pollutants and COVID-19 cases.

2.2. Temperature and humidity

2.2.1 Virus survivability conditions

There is a body of evidence that connects virus survivability with cool, dry temperatures. Viruses tend to prefer cold and dry conditions - that's why scientists put them in freezers to maintain them. At the same time, the opposite is true for the human immune system; it doesn't perform at its best if exposed to prolonged cold, dry conditions. For example, sitting in a dry office space for eight hours a day, every day, is likely going to challenge your mucociliary function. Your nose and mucous membranes are going to be too dry and that might just open the door for infection.

2.2.2. Role in infection rate

A study by Ward et al (2020) found that dry air appears to favour the spread of COVID-19, and concluded that for a 1 per cent decrease in relative humidity, COVID-19 cases might increase by 7-8 per cent. The estimate is about a 2-fold increase in COVID-19 cases for a 10 per cent drop in relative humidity. Professor Ward said there are biological reasons why humidity matters in the transmission of airborne viruses. "When the humidity is lower, the air is drier and it makes the aerosols smaller," he said, adding that aerosols are smaller than droplets. "When you sneeze and cough those smaller infectious aerosols can stay suspended in the air for longer. That increases the exposure for other people. When the air is humid and the aerosols are larger and heavier, they fall and hit surfaces quicker.

2.2.3. Other threats to respiratory health

At the same time, as outlined in the WHO guidelines for ventilation in buildings it is important to understand that too high indoor humidity is associated with increased growth of microorganisms such as mould and bacteria (Institute of Medicine, 2004).

2.2.4. Recommended levels

The standard recommended ranges for office environments for temperature and humidity should be maintained (Temp 22-24C, Humidity 40% to 60%) for risk of viral survivability not to increase. Colder and drier conditions should certainly be avoided.

2.3. Indoor levels of CO2

2.3.1 CO2 as indicator

Humans are the main indoor source of carbon dioxide (CO2) in most buildings. CO2 is a sign of stagnant air that has been expired from people's mouths and lungs. By proxy, CO2 levels can alert us to over-crowded spaces with too little outdoor or cleaned air.

2.3.2. Increase in air-borne time-period

United States Environmental Protection Agency (EPA) published a statement confirming evidence that the COVID 19 virus can remain airborne for longer times and further distances than originally thought. In addition to close contact with infected people and contaminated surfaces, the spread of COVID-19 may also occur via airborne particles in indoor environments, in some circumstances beyond the 2 m (about 6 ft) range.

Unventilated air has a huge role to play in the viral Index. In addition to sneezing and coughing, viruses get release into the air through normal breathing. If people are infected, they will exhale not only CO2 but viruses as well. If you have sick people in the space, one can deduce that there are airborne virus particles in there too.

ASHRAE (American Society for Heating, Refrigerating, and Air Conditioning Engineers) released a statement recently on the airborne transmission of COVID-19:

> *Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.*

2.3.3 Recommendations

To limit the possible transmission of viruses that become airborne as a result of human respiration, it is recommended that CO2 levels be kept below the accepted norm of 1000ppm, and preferably as low as 800ppm

2.4. Exposure to VOCs

2.4.1. Knock-on effect

Of course, it isn't just COVID-19 itself that is jeopardizing our health – the virus has triggered indirect risks and consequences too. It led to a hike in indoor air pollution within our homes and workplaces. And this was partly because we were cooking and cleaning more than ever within a confined space. Now, as we figure out how we can safely return to the workplace, we need to be mindful that our enhanced, COVID-secure cleaning regimen may have an impact on the air we breathe there too.

2.4.2. Displaced health risks

We are all washing our hands and hyper-cleaning our surfaces, and in some cases, those staff who are responsible for cleaning are potentially being exposed to a new quantity of VOCs. While cleaning used to happen after the building was closed, when occupants had vacated the premises, we are now literally wiping down surfaces on top of people. "But by continuously monitoring the levels of TVOCs in a space, we can alert ourselves when we may be putting the occupants in a more precarious position. The last thing we want to do is increase our exposure to harmful VOCs, and monitoring will tell us when the levels are high and require further inspection. If a VOCs from industrial cleaners that contain chemicals of concern is accumulating in an enclosed space, then that might need attention. This is the responsibility of every employer to protect their occupants, maintenance and cleaning staff as long term exposure to harmful VOCs can be detrimental to the health of individuals.

2.4.3. Recommended levels

It is recommended that VOCs levels be kept between 0.3 to 0.5 mg/m3 or 200 PPB.

The future of the indoor & work-space

So, as we try to work out how to give our employees peace of mind, what does the future of the indoor & workplace look like? Of course, it's highly likely that people occupying a space- whether an office, restaurant, shop, lecture hall – will demand transparency, so they know the air quality is being closely monitored and controlled.

"People will want the buildings they inhabit to support their wellbeing more than ever before," says Anjanette Green, the Director of Standards Development at RESET, "That's not a nice-to-have, it's a must-have. Life as we know it has changed and the spaces we inhabit need to prioritise our health and wellbeing. I'm talking about real changes that will fundamentally help people remain safe. And this isn't just about COVID-19, because there will be more emergencies in the future – perhaps another pandemic, smoke from raging wildfires or increased air pollution caused by global warming. "Increasingly, we will rely on our buildings to protect us, and that means we need to start using building data to drive our course of action and create better, more holistic reactions, no matter what the event."

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