



**CHAMPIONING INDOOR AIR QUALITY SOLUTIONS
IN MUMBAI METROPOLITAN REGION (MMR)**



**OCT
06
2021**



2.30 pm to 5.30 pm



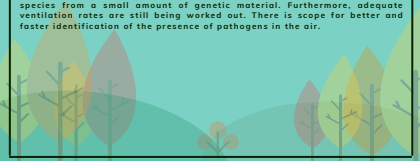
Principal, and Head at CSIR-NEERI Research & Innovation Centre, Mumbai

Mr Goyal outlined CSIR's contribution in the fight against COVID-19 and dwelled upon the airborne nature of the disease. CSIR has been involved in developing drugs, testing methods (nasal swabs, saline gargle, self-testing kits), makeshift hospitals, providing oxygen generators, concentrators, and PPE kits. It was the nodal center for COVID sample testing where it collected and tested more than 1 million samples. Training of private and government labs was taken up for proper testing, quality assurance for accuracy in the testing. Recently NEERI developed a saline gargle method for sample collection which can be used as an alternative method to RT-PCR swabs. Sewage surveillance is another ongoing project.

As a growing body of research shows, the virus can spread from person to person through the air. Additionally, indoor spaces with poor ventilation can contribute to the spread. Detecting the presence of airborne virus particles is further complicated by the mixture of other particles in the air like bio-aerosols, including a large number of floating particles, a significant fraction of which are biological. It only takes a small number of dangerous microbes to create a pandemic. He set the context of the event by describing bio-aerosols, and their potential threat to humans.

WHO suggests the risk of getting COVID-19 is higher in crowded and inadequately ventilated spaces where infected people stand in close proximity to each other for a long period of time. It is crucial to take precautions as respiratory droplets containing the virus spread with greater efficiency in such environments. Understanding and controlling building ventilation can improve the quality of air and reduce the risk of indoor health concerns.

Current techniques that identify microbes in the air are expensive, require specialized equipment & involve long processing steps. They cannot detect a species from a small amount of genetic material. Furthermore, adequate ventilation rates are still being worked out. There is scope for better and faster identification of the presence of pathogens in the air.





Dr. Anup R. Warriar, Senior Consultant - Infectious Diseases & Infection prevention

Dr. Anup presented a review of literature on Indoor Air Quality in healthcare settings and outlined the strategies that need to be adopted by hospitals in the future.

The pandemic brought out the issue of air quality within hospitals to the forefront. Healthcare workers are at greater risk of contracting diseases because of the nature of their work within the hospital setting. There are several parameters and variables which decide the rate and extent of transmission of airborne pathogens. Routine filters used in hospital settings may not provide protection from airborne transmission.

Unlike airborne pathogens which travel long distances across a period of time, aero-disseminated pathogens have the ability to stay in the air for a period of time. Traditionally hospitals use recirculated air and not fresh air. Fresh air composition is limited to 20% of the air circulation. Outdoor pollution can increase the severity of respiratory viral infections. Additionally, there is a risk of chemical exposures within the hospital, which becomes a part of IAQ.

Air quality is more about 'engineering' rather than 'disinfection.' Fogging and fuming alone cannot help with tackling airborne pathogens as a whole. Our focus needs to be on the real time solutions and implementations of the same.

The table given below details how various levels of filtration are required for removal of specific types of pathogens from the air.



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Potential pathogen and its removal by filtration

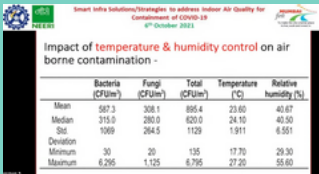
<i>Pseudomonas aeruginosa</i>	Gram -ve bacteria	NC	2,826	99.0
<i>Mycobacterium tuberculosis</i>	Gram -ve bacteria	E	1,488	74.3
<i>Legionella pneumophila</i>	Gram -ve bacteria	NC	1,163	92.3
<i>Haemophilus influenzae</i>	Gram -ve bacteria	E	1,162	41.0
<i>Mycoplasma carolinense</i>	Fungal spore	NC	1,000	99.0
<i>Aspergillus</i>	Fungal spore	NC	999	99.0
<i>Staphylococcus aureus</i>	Gram -ve bacteria	E	679	71.5
<i>Acinetobacter</i>	Gram -ve bacteria	E	347	91.4
<i>Corynebacterium diptheriae</i>	Gram -ve bacteria	E	10	79.0
SARS virus	SARS virus	E	10 (China)	41.7
<i>Haemophilus parainfluenzae</i>	Gram -ve bacteria	E	Common	98.2
<i>Bordetella pertussis</i>	Gram -ve bacteria	NC	Common	79.9
<i>Cryptosporidium parvum</i>	Fungal spore	NC	Common	99.0
<i>Citrobacter freundii</i>	Gram -ve bacteria	E	Rare	94.7

Factors affecting IAQ in a patient's room:

Design factors: the components that characterize the patient room (furniture, finishing).

- Management and cleaning activities: Disinfecting surfaces, cleaning and maintaining ventilation systems.
- Human presence and activities: number of users, their health status and medical activities carried out in the room
- Outdoor and microclimatic factors: outdoor air, solar exposure and other microclimatic parameters.

The picture below depicts the importance of temperature and relative humidity on airborne contamination. As temperature rises the amount of bacteria and fungi found also rises. Hence, hospitals need to focus on maintaining temperature and relative humidity.



There is evidence which proves that when air quality in the hospital is taken care of, the infection rate in the hospital decreases. Overhead/upper air UV radiation when used as part of air disinfection to improve the air quality, it impacts patient outcomes.

The ASHE Monograph on the Environment of Care and Healthcare-Associated Infections, highlights that an engineering perspective needs to be in place. Modern practices of designing healthcare buildings for comfort favors pathogen persistence. The design of centrally air-conditioned buildings disregards the standard ventilation parameters, requirement for sunlight, exchange between air & filtration of air.

Coughing or sneezing transmits the virus into the air which then travels to the people around them. Aerosols can be breathed in by the person even while maintaining social distance. Multiple ways of tackling this can be cleaning and air disinfection, opening up of windows and wearing a mask. Use of Personal protective instruments like masks alone will not be helpful in tackling COVID-19; engineering controls and administration controls, elimination and substitution would be needed.

Steps to monitor ventilation indoors

- A minimum ventilation rate of 4-6 air changes per hour
- Maintaining CO₂ levels below 700 to 800 ppm
- Ventilation rates of 8-12 liters per second per person



WHO has published revised recommendations for achieving the target for IAQ in Covid settings for healthcare organizations. Real time monitoring of adequate ventilation is recommended using exhaled CO₂ measurements. Key recommendations in HVAC have been to ensure ducted return air and disinfect recirculated air.



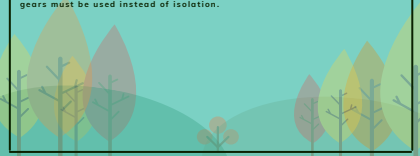
Dr. (Ar.) Roshni U. Yehuda, Practicing Environmental Architect & Academician

Dr Yehuda presented on regulating IAQ in educational institutions and public school buildings; expanding upon the present scenario and the future possibilities.

As increasing number of schools are now fully air conditioned, it becomes important for the management to plan different kinds of spaces, each with a different set of guidelines (educational, assembly, movement, admin, social & essential). Each of these spaces require different kinds of thought processes. The social environment that schools provide is crucial to learning. Reopening school will be a big challenge post pandemic. Hence, having a plan for prevention of transmission is necessary.

Proper communication and sensitization of students, their parents and teachers is necessary. Counselling and health monitoring should be compulsory. Other measures like medical support, physical distancing, making etc. need to be followed. No-contact temperature checks can be conducted with thermal imaging cameras should be put on premises. Washing hands, sanitizing and staggered timetables should be followed to avoid overcrowding. Dust (PM 2.5 & 10) can also be sources of carrying viruses of any type. ISHRAE guidelines suggest Temperature 24 to 27°C and humidity between 40 to 70°C.

We are likely to see more such viruses as pathogenic or zoonotic species are here to stay and cannot be eliminated in the near future. Human beings are erratic in compliance, hence we will need to devise technical and biological research solutions to tackle the incidence of air borne pathogenic diseases. For example, electrostatic precipitators, consisting of fine mesh aluminum screens that trap negative and positively charged particles can be used whenever there is air movement such as an AC inlet and outlet. This helps in trapping bacteria and viruses in flowing air and reduce exposure to pathogenic material. A non-contact system and protective gears must be used instead of isolation.





Dr. Mala Singh Founder & MD - PEC Greening, India

Dr. Mala presented on the importance and necessity of Indoor Air Quality Solutions. IAQ refers to the air quality within and around a building and its structure; it relates to the health and comfort of building occupants. We spend 90% of our time indoors. Inhaling breath in the same room where an infected person is present releases viruses packaged in small respiratory aerosols that form deep in the lungs. Poor IAQ can adversely affect health leading to immediate effects like irritation of eyes, nose and throat, headache and dizziness. Longer-term effects can include respiratory, heart diseases or cancer. How many pathogens your body can take in depends on how much fresh air is coming into the building. Designing a building in relation to IAQ is possible during the planning stage where we can look into aspects like daylight, indoor air, lighting and pollution.

Passive designing needs to be a part of the initial process for commercial buildings; as existing buildings cannot bring major interventions. Electromechanical equipment can help in the existing buildings. It reduces or removes mechanical cooling, heating, ventilation and lighting demand. It also maximizes the use of 'natural' sources of heating, cooling and ventilation to create comfortable conditions inside the building.

Recommendations to improve IAQ in commercial spaces

-Green housekeeping practices: Ensuring use of green housekeeping chemicals and sanitization. Pollutants from tobacco smoke and dust from sweeping or vacuuming can exacerbate underlying respiratory conditions.

- Keep office equipment separate: Office machines emit indoor air pollutants which are linked to symptoms such as fatigue, headaches and a tight chest. Keeping machinery separate from staff, increasing ventilation to improve the airflow and increase hourly room air exchange.
- Emissions from aged material and furniture: these emissions account for nearly 30% of the total volatile organic compounds which exacerbate allergies and respiratory issues & contribute towards 'sick building syndrome'. Use of green certified carpet is recommended as they are made with more sustainable material.
- Low uses of VOC adhesive, paints and sealants: technical specifications of paints being used in building must be checked to ensure they do not cause further indoor pollution.
- Indoor air safety technology: Treating the air requires specialized technology capable of maintaining high levels of IAQ to help protect the quality of life and performance. For example, disinfecting filtration system (DFS).

Air Quality monitoring should be undertaken by checking and maintaining filters regularly by cleaning frequently to improve its efficiency or by replacing it with new innovative technologies. Removing the excess of humidity from the air by using a dehumidifier or changing the thermostat. Apart from technology, traditionally planting indoor plants absorb CO₂ and also eliminate harmful chemicals like benzene, formaldehyde and trichloroethylene. Regular testing and auditing of buildings is challenging, but it needs to be promoted.



Mr. Pravin Rawool, Asst Vice President & Head - MEP & Internal Services, Godrej & Boyce Mfg. Co. Ltd

Mr. Pravin spoke about smart infra solutions/strategies to address IAQ for containment of Covid-19 and shared initiatives of Godrej and Boyce in relation to IAQ. Recent research indicates that monitoring and controlling IAQ is central to reducing the risk of transmission. There is an intertwined relationship between Health, built environment and comfort. Special focus is required in addressing the air quality in offices as most use centralized air conditioning. When a building is not designed properly (sick building syndrome) it results in poor IAQ.



90% of our lives are spent indoors and we inhale over 11,000 liters of air each day. Studies show that there is a 9% decrease in productivity with Poor Air Quality. Metrics measuring IAQ and its subsequent health impacts are outlined in the image below:

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Metrics of IAQ and Health Impact

Air Quality	Measurement	Health Impact
PM2.5 and Sulfur dioxide	Air sampling	Respiratory
Particulate matter	Particulate counter	Respiratory and eye irritation
VOC	Gas leak monitors	Upper respiratory (Cough, Sneeze, Runny Nose)
Humidity	Humidity, dry bulb	Eye, mucous membrane and throat irritation
CO2	Air monitoring	Brain impairment (Fatigue)
Radon	Air monitoring	Infestation of radon (Pneumonia)

ISHRAE has mentioned marginally acceptable limits for different parameters of IAQ. AQI is highlighted by the industries.

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Classes of IAQ (ASHRAE 55:2018)

Parameters	Class A	Class B	Class C	Class D
PM2.5	10 µg/m ³	15 µg/m ³	25 µg/m ³	35 µg/m ³
PM10	20 µg/m ³	30 µg/m ³	50 µg/m ³	70 µg/m ³
CO	0.5 ppm	0.7 ppm	1.0 ppm	1.5 ppm
CO2	350 ppm	400 ppm	500 ppm	600 ppm
Relative Humidity	40-60%	30-70%	20-80%	10-90%
Temperature	20-24°C	18-26°C	16-28°C	14-30°C
Radon	1.5 pCi/L	2.0 pCi/L	3.0 pCi/L	4.0 pCi/L
Total Volatile Organic Compound (TVOC)	0.1 ppm	0.2 ppm	0.3 ppm	0.4 ppm
Occupant Satisfaction	100%	80%	60%	40%

Class A: Excellent
Class B: Acceptable
Class C: Marginally Acceptable

IAQ can be improved through filtration, irradiation or high-intensity targeted heating. Filtration refers to air being forced through fibre-based membranes and its efficacy

can vary depending on the filter type. Irradiation uses electromagnetic radiation, to deactivate pathogens but it cannot be used in occupied spaces as the light may be harmful to skin and eyes. Thermal/ high-intensity targeted heating requires air to be exposed to heat for significant periods, thus difficult to apply when there is a continuous flow. Other technologies include ionized purifiers and ozone generators.

ASHRAE recommendations

- Air cleaning technologies can be combined to produce the desired MERV 13- equivalent level of air cleaning to mitigate in the post covid19.
- MERV is the Minimum Efficiency Reporting Value. It is 89% efficient. It has a specific design (pressure drop) and fit. It can cater to the pressure drop. It is important for a retrofitting project.
- In UVGI locations are important. The spread is decided by radiation which is emitted by the UV light. 265 nm is the optimum wavelength for damaging DNA & RNA.

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Industry Recommendations (Post COVID)

Parameters (Required / Good to have)	ASHRAE	ISRAE	REHVA	DEM
Ventilation and Air-Cleaning Strategies	Fresh air intake to be 20% of volume air	4.5 ACPH (2-10)	100% Fresh Air (pass through system)	4.5 ACPH (2-10)
N95 to be operated 1.5hrs before and after the office hrs.	Yes			
Temperature	Not specified	24 °C to 26 °C	24 °C	26 °C
Humidity	40% to 60%	40% to 70%	40% to 60%	40% to 70%
Impress filtration	MERV 13 or higher			Not specified
UVGI (ultraviolet germicidal irradiation)	Yes			
Portable room air cleaners with HEPA filters, particularly in high-risk spaces such as waiting rooms & common areas.	Yes			
Frequent Cleaning & Disinfection of Floors & wall section.	Yes			

Q & A session

A) How can Mumbai's slum population/ low-cost housing residents deal with poor IAQ?

SRA buildings have very little ventilation and open garbage disposal systems. While framing the regulations for SRA building light and ventilation aspects should necessarily be considered.

B) Does CO2 as ventilation coefficient measurement give false sense of safety indoors?

There are two aspects to this issue. Firstly, location where the sensor is placed will decide how well it can assess the room. Secondly, all aspects of indoor air quality cannot be determined by CO2 levels alone. It's easier to measure CO2 as it gives us a good idea of the crowd in a limited space,- but it cannot be the only measure.

C) Are indoor plants helpful or harmful?

Indoor plants have been planted in an office by P.V. Mittal in Delhi and their case studies show that indoor plants are helpful for the indoor environment. Also there are many global case studies for proving the same. In a research study on "What kind of VOCs are found in open offices' " by Rachna Sansad, NEERI & Godrej Interio, they found that VOCs were reduced by indoor plants.

D) Was cost a key factor for Godrej's new initiatives relating to its filtration methods?

Cleaner environment and safety of people is the priority of Godrej. It was paramount and vital to enhance the level of safety for the people. So, cost was not our biggest concern. We had an in-house team for consultation and value engineering, which helped us a lot. For example, the UVGI the mounting brackets i.e. the fabrication was done in the factory itself. Hence, the installation charges were less.

E) Should lack of proactive participation of industrial & commercial facilities in maintaining IAQ be penalized. If not, what incentives could be introduced?

Looking at the pre-covid situation, air quality was more focused on comfort and productivity whereas in the post-covid era, it is focused on health. The key difference is that the air quality has been center staged. Certification of IGBC, UIGBC, Wellness worked as incentives to the developers/commercial establishments. In Maharashtra, DCR came into effect in December 2020 as an incentive. Auditing buildings can also help keeping check.



Speakers profile

- **Dr. Anup R. Warriar**

Dr Anup R Warriar is an accomplished physician practicing exclusively in the area of infectious diseases and infection prevention since 2008. His focus areas have been evaluation and management of prolonged/undiagnosed fevers, complicated tropical infections, treatment of drug resistant infections, infections in the ICU and HIV Medicine.

He also has many years of teaching experience and has mentored many graduate and post-graduate trainees to take up Infectious diseases as their sub-specialty.

- **Dr. (Ar.) Roshni U. Yehuda**

Dr. (Ar.) Roshni U. Yehuda is a Practicing Environmental Architect & Academician. She is president of the Institute of Environmental Architecture and Research. Dr. Roshni has a Ph.D in Resource Management and is a qualified master trainer and panel expert on the energy conservation building board of India. She is a trainer for sustainability education academy in Australia and Co-Chairman of the ASSOCHAM GEM Maharashtra chapter. She is also the director of Roshni Udyavar & Associates, Mumbai & adviser in environment and sustainability for science and technology in Pune. She is principal investigator in the department of science and technology for government of India Research Project on Energy Efficient and ECBC-compliant opaque wall assembly. From 2003 to 2017, she headed the Rachana Sansad's Institute of Environmental Architecture, a postgraduate department of the Academy of Architecture, Mumbai. She has more than 20 years of academic and professional experience.

- **Dr. Mala Singh**

Dr. Mala is a Founder & MD of PEC Greening India. She is an IGBC Accredited Professional and has worked as a sustainability consultant for more than 500 large green building projects. She is an alumni of IIT Roorkee & GRIHA Certified Professional. She is on the advisory board of various government committees & prestigious association to empower sustainability. She is the Co-Chairman of IGBC Mumbai chapter and Chairperson of Sustainability Focus.

- **Mr. Pravin Rawool**

Mr. Pravin has done his Masters of Engineering from Walchand College of engineering and an MBA from Great Lakes Institute of Management. He is a certified professional in Group Corporate Renewal from Imperial College London. He is AVP & Business Head at Godrej & Boyce Manufacturing & Co Ltd. He has 19 years of diverse experience in managing operation and maintenance of industrial processes, project management, energy management and MEP services. He has presented many technical papers at various national and international conferences.