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Tips for Healthy Cooking - An Environmental Point of View

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The magnitude of indoor air pollution (IAP) contributed by domestic cooking is huge. It is important to consider that the pollutants released in the indoors not only affect the respiratory health of the exposed individuals but also contribute significantly to the outdoor pollution. In recent years much research interest has been focused on carbonaceous component of fine PM, because of the significant role that organic carbon (OC) and elemental carbon (EC) play in visibility reduction and in global climate change (Jacobson, 2000).

- Type and quantity of fuel
- Medium of cooking
- Type of cooking i.e. Roasting, Frying, steaming etc.
- Duration of cooking (quantity of food cooked)
- Efficiency of ventilation

Type of fuel

Fuel type and its quality influences pollutant emissions in several ways. Solid fuels, especially biomass, may be moist, leading to greater likelihood of inefficient, low-temperature combustion zones, which elevates concentration of undesirable indoor air pollutants.

DO YOU KNOW?

Studies show that air can be unhealthy to breathe when people cook in kitchens with poor ventilation.

It has been observed that fine particles and sulfates are contributed to the atmosphere on using cow dung. High concentrations of manganese, potassium, CO, formaldehyde, benzene etc are emitted during burning of biomass. LPG, considered a cleaner urban fuel because it produces no visible emissions, contributes gaseous pollutants such as nitrogen oxides (NO_x), carbon monoxide (CO), organic compounds and small amounts of sulfur dioxide (SO_2) and particulate matter (PM).

Cooking medium

Indian cooking, which involves frequent frying and roasting, generates large amount of inhalable vapors and aerosols. In urban households where fuel combustion sources are minimal, vaporized edible oil and fat nucleate/condense easily during frying, to form particles in the indoor environment (Varghese et al., 2005). These particles have been associated with number of respiratory ailments and lung cancer (Ko et al., 2000). The International Agency for Research on cancer (2006) has classified emissions from high temperature frying as probably carcinogenic to humans. PM and NO_x have been monitored simultaneously and OC EC fractions of PM have been studied, separately during frying and roasting activities and under different ventilation conditions (Kaul, 2011). Maximum value PM ratios ($PM_1/PM_{2.5}$ and $PM_{2.5}/PM_{10}$) have been observed as 0.68 and 0.54, respectively during frying; 0.44 and 0.39, respectively during roasting. This indicates that emission of fine PM is more during frying whereas coarse PM is primarily emitted during roasting. The average OC concentrations for roasting and frying is624.49±438.5 and 881.05±736.87 $\mu g/m^3$, respectively. Maximum 60-minute moving averages of NO_x, $PM_{2.5}$ and PM_{10} have been recorded as 1738.3$\mu g/m^3$, 826 $\mu g/m^3$ and 1687 $\mu g/m^3$ respectively. High values of NO_x and PM persist for long durations in many kitchens, which disperse to other parts of a household as well as to the outdoor environment and can have significant implications for human health.

INDOOR AIR QUALITY FACT #1

The kitchen is a hot spot of indoor air pollution

Type of cooking

Four cooking mediums of soyabean oil, peanut oil, mustard oil and clarified butter(ghee) have been compared for emissions of PM_1, $PM_{2.5}$ and PM_{10} while frying same type and quantity of food. Soyabean oil releases minimum concentration of PM_1 and $PM_{2.5}$ while contribution of particles from clarified butter(ghee) is maximum (Kaul et. al., 2016).

Duration of cooking

As the concentration of PM and NO_x is substantia lit is desirable, even in urban kitchens, that cooks be exposed to the pollutants for shorter durations. It has been observed that cooking generated pollutants decrease lung function and deteriorate respiratory health of the exposed individual (Kaul et. al., 2016). Long exposure to cooking generated pollutants can be very severe for vulnerable individuals and can cause effects similar to those caused by long periods of smoking.

Efficiency of ventilation

Concentration of pollutants varies widely with type of ventilation, habits of using forced ventilation, efficiency/capacity of the ventilation and placement of the stove/burners with respect to the ventilation system provided. It has been observed that exhaust fan and chimney are both effective in removal of coarse particles. However when the emissions are very high due to large quantity of food being fried, ventilation provided by the chimney alone may be inadequate and an additional exhaust fan is desirable. The chimney also seems to have limited capacity to flush out fine particles and gaseous pollutants (Kaul, 2011). These limitations call for an improved design of ventilation system incorporating optimization of strengths of chimney and exhaust fan. It is recommended to install efficient ventilation devices to minimize build-up of pollutants.

Source: Google, Images 2019

Conclusion

Looking at above points it is important to address the issue of pollutant generation during cooking. Various practices that can be adopted to minimise generation of pollutants and mitigate their impact on exposed individuals and environment as a whole are listed below

1. Choose the fuel wisely. In rural areas open burning of solid fuels must be discouraged. In urban areas also lots of cooking fuels/techniques (like LPG, Natural gas, hot plates, microwave etc.) are available which should be used rationally.
2. Select the medium of cooking such that emissions of fine PM is minimum
3. Prefer steaming, boiling, grilling, baking over frying to minimize carbonaceous PM
4. Frying should not be done for prolonged durations. During mass cooking avoid heating large quantity of oil for long time.
5. Avoid contact of oil with hot pan (during making an omelette/parantha etc). No extra oil must burn on pan. Maximum emissions of fine PM occur during this process.
6. Take a break during cooking (especially for cooks in commercial kitchens/hostels etc), to reduce exposure. Asthmatic people can take extra precautions during frying of spices (tadka).
7. Particles can be trapped at source so that their emission to outdoor air is restricted.
8. Choose the ventilation system to integrate the strengths of both, chimney and exhaust fan.
9. Forced ventilation, must be used for entire duration of cooking to prevent dispersion of pollutants to other rooms.
10. The cooks must be monitored for their respiratory health from time to time.

Bioaerosol: In Health and Disease

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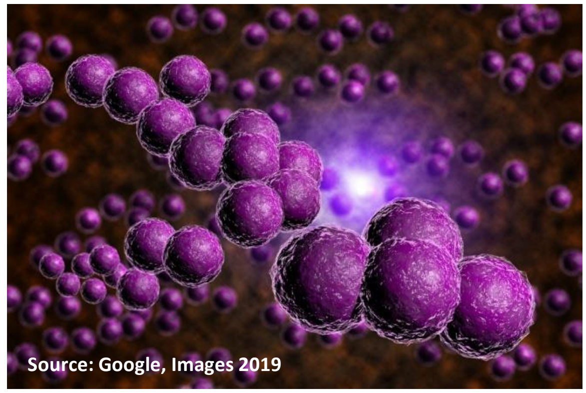
Amidst wide range of human activities, microorganisms in the environment represent a hidden but a dangerous risk factor. Paradoxically, human skin, nasal, mouth are in fact the major sources of microbes. With rapid urbanization and aerial pollution, there is a rising concern of accumulation of microbial burden in form of bioaerosols causing chronic infection in hospital and community. Though the pathogen city of microbes depends on their adaptation to the environment, its survival in form of fomite decides its potential to cause infection. A previously reported study observed repeated attacks of streptococcal pharyngitis amongst soldiers in army barracks which was traced to its rapid transmission through air, dust, blankets, wherein air samples showed 100-1500 streptococci per cubic foot. Another case in point was the demonstration of herpes simplex virus on hot-tub seats resulting in an outbreak . These demonstrations are an assertion that fomites can cause infections, but they are only a first step. When the pathogen is present more frequently or in higher concentration, the association of human infection is further strengthened. In recent years, studies depict that microbial air monitoring and the evaluation of the level of air microbial contamination, at high risk areas, are a basic step towards prevention of disease. Indoor air quality IAQ has received great attention for wellbeing and maintaining safe environment. Indoor air exposure may cause 80-90% of disease. However, problems relating to methodology, monitoring, data interpretation and co relating maximum acceptable levels of contamination require standardization as its association varies at different health care settings. Microbial contamination if exceed permissible level can be hazardous to health. In buildings, the sources of microbial contaminants are people, construction materials, air condensing ventilation, and outdoor air. Often ventilation are considered to re-circulate indoor air along with outdoor air. Other methods like Air handling unit (AHU)is a line of defense for protecting equipment and indoor environment from particulate matter. Filters can treat mix of outdoor air and recirculate indoor air(90%) under control temperature and humidity to supply in indoor spaces. On the contrary, AHU filters too have grown microbes like Schizophylum Rigidoporus, Lentinus, Peniphora and other saprobes.


Source: Google, Images 2019

Agent & Host

Bioaerosol have been described as particulate of size varying from .02-100um.The respirable fraction(<3.3um) are mainly responsible for causing airways disturbances. Though susceptibility to the pathogens is highly variable, the inhalation dose will characterize the risk of clinical disease, while biologically effective dose is the amount of pollutant interacting with the target site which is likely to influence the mechanism of pathogenesis. Most bacteria existing in fomites are gram positive cocci and bacilli (belonging to family Bacillaceae) ,the commonest flora observed in the environment. The remainder microbial flora constitute gram-negative bacilli or fungi. Gram-positive cocci constitute a higher proportion of the organisms in operating rooms; gram-positive bacilli in the laundry and waste storage areas; and gram-negative bacilli are relatively high in corridors.The common microbes with airborne transmission are *Staphylococcus aureus*-disseminated by squamous cells .


Source: Google, Images 2019

Hospital air contains approx 0.02 cfu/cubic foot air, hence chances of transmission of microbes by gowns and masks to other HCW and even to the patients is high. Gram negative bacilli are more hand borne than air borne or from nebulizersand hydro pulping system leading torespirartory infections. Aerosol generating room can carry *Legionella* or aspergillus spores present in unfiltered air, these may often lead to nasopharyngeal colonization and respiratory manifestations. Though non-pathogenic but when reside or colonize with host microbial flora can transfer gene resulting in accumulation of multi drug resistant (MDR) bugs. Bioaerosol facilitate transmission of antibiotic resistant gene to host.Most infections under the influence of bioaerosol are categorized as toxic, infectious or allergic, sick building syndrome (SBS)or asthma. Several factors like host immune response ,dose intensity ,duration,seasonalvariation,airconditioning,occupant'sactivities,humidity and virulence will determine the outcome of bioaerosol exposure. Bioaerosol can potentially settle on any surface ,on equipments, or can even cause food spoilage at processing and packaging units

Thus maintaining high level of indoor air quality in hospital, prevents patient to patient, visitor to patient, patient to health care worker (HCW) and HCW to patient spread of infection. The rapidly acquiring TB, measles, chicken pox, respiratory syncitial virus and influenza infections can cause sporadic outbreaks to large scale epidemics. Fungal agents like aspergillus, penicillium trichoderma, alternaria, rhizopus can attack books and favor bio deterioration Thus microclimatic condition can influence the growth of many micro-organisms and affect the quality of air. IAQ is applicable to classrooms, libraries, university cafeteria, lecture halls where movement of people, students are a constant source of air contamination. In a study air sample of assayed twice, once in the morning and once afternoon the indoor/ outdoor (I/O) ratio of fungi if found more than 1 is considered as endogenous whilst <1 is exogenous source of indoor air contamination. Fungal spores are air borne unsuspectedly continuous exposure to bioaerosols can have an impact on the health, hence IAQ assessment is a useful tool to monitor trends in infections occurring in such areas.

DO YOU KNOW?

The air in 1 in 15 homes may be contaminated with elevated levels of an odorless natural gas that's the second-greatest cause of lung cancer.

Bioaerosol is composed of two phases (a) gaseous phase, and (b) particulate phase which acts as a vehicle to carry pathogens. The composition can be a complex mixture of bacteria, mould, yeast or pollen ferns and mosses or biopolymers of chitin, DNA, polysaccride and cellulose. Insects, plant debris and decaying biomass may also be a component of bioaerosol. The relevance in food processing units has led to stringent sampling and assessment techniques of bioaerosols..

Methodology

Counting microbes in the air is not an easy task. Many different methods are in use for measuring microbial air contamination which are : the count of colony forming units per cubic meter of air (cfu/m3) on settle plates; measurement of a chemical component of the microbial cells/m3 of air; the count under the microscope. At the moment, the only effective means of quantifying air borne microbes is limited to the count ofcfu. The cfu count is the most important parameter, as it measures the live micro-organisms which can multiply. Environmental sampling can be performed to provide overview of microclimate and microbiological parameters. In recent years, level of air microbial contamination in hospitals and community have been identified as risk factors for causing Hospital associated infections(HAI) and community acquired infections (CAI) , hence monitoring is a basic step towards protection. Air samples can be collected in two ways either by active air samplers or by passive air sampling (settle plates).

Active Air sampling

An active air sampler can collect a known volume of air blown on to a nutrient medium by different techniques. It mainly gives an advantage of rapid sample collection. Its main drawback is the difficulty in sterilizing the device, expensive, variable results, poor provision of calibration of the sampler , air exhaust disturbs the airflow ,a certain number of microbes are inactivated due to inappropriate temperature and environmental conditions. The Anderson cascade impactor has a cut off from 7- 0.65um @ 28.3 L of air /min.

Passive air sampling: Settle Plates

The gravitational sampling is considered a non-quantitative collection method, affected by the size and shape of particles and by the motion of the surrounding environment.

The petri plates containing a solid nutrient agar or blood agar are left open to air for a given period of time, at least for one hour. Microbes carried by inert particles fall onto the surface of the culture plate, at an average deposition rate of 0.46 cm/s. After incubation at 37°C for 24 hours for bacterial isolation and 7 days for fungal growth after an exposure time of one hour is ideal for monitoring air contamination. The petri plates are placed 1 meter above the floor and one meter away from the wall. At least one plate is kept on or near the OT table. Colonies on the plate represent in number, proportional to the level of microbial contamination of the air.

The major drawback with this method is, it gives a relative estimate compared to counts obtained by other quantitative methods.It is also time consuming and precautions have to be taken to prevent trafficking around the area of assessment which may give erroneous results.

Settle plates are not preferred for quantitative estimations of the microbial contamination levels of critical environments like operating theatres. Though several resource poor health care settings are using settle plate method, Humphreys affirms that in agar settle plates, although inexpensive and convenient, are unsuitable because this method is not quantitative and selectively collects larger air particles. Since air sampling in the operating room measures microbial fallout rather than air-suspended microbes, hence it still remains the method of choice to determine the bacterial load, nearest the operative tables. Its advantages include low cost, available everywhere, no formal training required, many samples can be taken.

In a recent paper Friberg *et al*. proposed that settle plates showing bacterial surface contamination are both a more practical and a more relevant indicator of actual wound contamination rate than air counts.

As per the current British standard bacteriological standard for ultraclean operating room air a count of less than _10 cfu/m3

Table.1 Showing Total Microbial Count

Environment at Risk	Maximum acceptable Level of IMA
Very High (Ultra Clean Room)	5
High(Clean Room)	25
Medium (Day care facilities etc.)	50
Low	75

WHO states **CFU<1000/m3** as microbial load permissible in office. Its worth noting that certain organism like *Gamella* isolated in hospitals environment and reported as commensal, can cause URTI in patients as it is capable of forming biofilm which may inhibit entry of antibiotics. While *Bacilluscereus* isolated from environment are intrinsically resistant to several antibiotics. Eventually the microbial drug resistance can be delivered via horizontal transfer , transformation , transduction, conjugation, pilus, genetic recombination. Indiscriminate usage of antibiotics in agriculture and animal husbandry has led to the emergence of MDR isolates known as "Environment pollution".

Microbial Assessment

Enclosed air monitoring is measured by index of microbial air contamination (IMA). The IMA proves to be valuable at places where contamination or infection is high. IMA > 1000 are found in dirty, uncontrolled areas but if such a count is near habitation or where people reside then it warrants lowering of the counts. The following are the different ways of assessing contamination level:

a. CFU/m^3on settle plates
b. Chemical components off microbial cells/m^3air(ATP, DNA, Enzyme)
c. Neubear chamber
d. Flow Cytometry /FISH
e. Automatic Cell Counter

In hospital settings OTs, ICUs, minor OTs IMA< 25 is considered acceptable, while in high risk zones like neuro surgery OT, joint replacement surgical units, transplant units etc should maintain IMA at 5.

DO YOU KNOW?

The EPA Ranks Indoor Air Pollution as a Top 5 Environmental Danger

Microbial identification still remains a challenge. The bioaerosol environment is dynamic, hence association with clinical condition with microbial burden entails careful monitoring for establishing a causal relationship. Advance technology and molecular identification by qPCR and next generation sequencing to differentiate pathogens from saprophytes are tools, essential for bioaerosol research.

The potential ability of the pathogen to proliferate in the fomite, requires demonstration, largely as a function of the size of the inoculum, to cause infection. Besides hospitals, buildings are at constant risk of microbial colonization. When microbiological agents are present in low concentrations, and no pathogens are found among them, they usually pose no hazard to humans. The problem of contamination arises when the level of microbiological contamination exceeds the certain limit which is considered "normal" for a particular environment. Ventilation systems are a technical solution aimed at improving the indoor air quality. Apart from their health-oriented applications, modern ventilation systems reduce the microbiological contamination of the air. However, with time, they may get contaminated and may become a source . Analysis of the obtained results indicated that at workplaces in office buildings, the type of ventilation systems has a significant impact on the air quality It has been observed that rooms with natural ventilation, the recorded total bioaerosol concentrations were significantly higher (approx1.6×103 cfu/m3)than those in air-conditioned or mechanically ventilated premises (Kruskal-Wallis test: in both cases $p < 0.01$). No significant differences were found for the concentrations of microorganisms between air-conditioned and mechanically ventilated spaces. The highest species diversity has been reported in the rooms with natural ventilation, The most prevalent microorganisms in the indoor air were Gram-positive cocci 40%, followed by filamentous fungi 25% and endospore-forming Gram-positive bacilli 15%).

Conclusion

Researcher found beneficial role of silver nanoparticle (AgNPs) with Titania – Chitosan (TiO2-CS) bed filters installed inthe ventilation systems of hospital wards where up to 88% of bacteria and 97% of fungi were removed within 30 minutes, establishing promising potentials in bioaerosol purification. Though guidelines consider the microbial air monitoring as a futile task in hospital settings and rather adopt strict sterilization and disinfection policies to reduce HAI, on the contrary it would be of immense benefit to use it as an indicator of clean environment and use it as a tool to monitor microbial air contamination in high risk areas .

Volatile Organic Compounds in Indoor Environment: Challenges and Solution

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Increasing indoor air pollution levels and the related health effects are a major concern throughout the world. Indoor air pollution from solid fuels accounted for 3.5 million (2.7 million to 4.4 million) deaths and 4.5% (3.4–5.3) of global disability-adjusted life years in 2010. In India alone, approximately 1.04 million premature deaths and 31.4 million disability-adjusted life years (DALYs) are caused due to indoor air pollution (Balakrishnan et al., 2014). Indoor air pollutants can originate from outdoor sources i.e., traffic and other forms of combustion or from indoor sources i.e., occupants and their activities, tobacco smoke, electronic equipment, cleaning products, air-conditioning (HVAC) systems, building and furnishing materials etc. The indoor air pollutants are particulate matters (PM_{10}, $PM_{2.5}$ and $PM_{1.0}$) organic and inorganic gases, bio-aerosols and volatile organic compounds (VOCs) (Khare et al., 2000).

The Volatile Organic Compounds (VOCs) include substances of organic origin found in the air in gaseous and vaporous form. VOCs categorize in to very-VOCs (such as formaldehyde), VOCs (such as benzene, fragrance compounds), semi-VOCs (such as PAHs, flame retardants). The indoor sources of VOC include household products, fragranced consumer products, off gassing of building materials, floor and wall coverings, paints and adhesives, deodorizers, fuel evaporation, and bleach use and some combustion processes (e.g., cooking, smoking). These are the dominant sources and contributes approximately more than 70% of total measured indoor VOCs. Human activities such as cooking, cleaning and smoking also contribute to VOCs in the indoor environment.

Research studies reported that VOCs varies in indoor environment of residences and office premises (Baek et al., 1997; Brickus et al., 1998). Besides indoor sources, industrial emissions, exhaust from diesel and gasoline driven vehicles are some of the anthropogenic sources of VOCs in the outdoor environment which contribute to indoor VOCs (Nelson and Quigley, 1983). One of the major source of these VOCs are construction and finishing materials in Indoor (Yang et al., 2001). The major sources of formaldehyde are from particleboard, fibreboard, and plywood. Additionally, building materials can also affect the transport and the removal of indoor VOCs by its adsorption and desorption properties. Re-emission of adsorbed VOCs is also responsible for increase the VOC concentrations in the indoor environment for months or years after a source event (Tichenor et al., 1991, Zhang et al., 2002). Formaldehyde concentrations are higher in residential buildings compared with office buildings because of the relatively large ratio of pressed wood products to air volume in homes.

DO YOU KNOW?

All types of printers/copiers emit high levels of toner particles, VOCs with other hazardous pollutants.

Park et al.2006 found that indoor levels of TVOC (120 -328 μg/m^3) and HCHO (88- 134 μg/m^3), mainly emitted from wooden materials, were significantly higher in new residential buildings than in older ones. Kim et al. 2010 also found a significant increase in the levels of TVOC (517 - 1,920 μg/m^3) and HCHO (209 - 457 μg/m^3) in new buildings, and these increases were associated with the use of building materials (adhesives, coatings, or paint) and the purchase of new furniture. They concluded that the levels of TVOC and HCHO exceeded all existing recommended levels found in domestic and international guidelines, which indicates that these air pollutants were primarily emitted from indoor environments, not outdoor environments. Kabir et al. 2010 observed that no level of indoor air pollutants exceeded a Korean guideline in child care buildings, medical buildings, or elementary schools, but some of pollutants (HCHO, PM_{10} and bio-aerosol) were relatively higher in the summer season than in other seasons.

DO YOU KNOW?

VOCs are the toxic fumes that off-gas from manmade items

The ability of organic chemicals to cause health effects varies greatly from those that are highly toxic to those with no known health effect. As with other pollutants, the extent and nature of the health effect will depend on many factors, including the level of exposure and length of time exposed. The common symptom of VOCs exposure are Eye and respiratory tract irritation; headaches; loss of coordination; nausea; damage to liver, kidney, and central nervous system; dizziness; visual disorders; and memory impairment. At present, not much is known about what health effects occur from the levels of organics usually found in homes. In spite of relatively low concentration, emission of VOCs can provoke sick building syndrome through the irritation of sensory systems, neurotoxic effects, skin irritation, nonspecific hypersensitivity reactions, odour and taste sensations. Some of VOCs such as benzene, styrene, tetrachloroethylene, 1,1,1,- trichloroethane, trichloroethylene, dichlorobenzene, methylene chloride, and chloroform can induce mutagenic or carcinogenic effects (Paul H., 2002).

The concentration of total volatile organic compounds (TVOCs) determine the human response: concentration of TVOCs < 0.20 mg/m^3 is found to be comfortable; the range 0.20-3.00 mg/m^3 means the irritation; the range 3.00-25.00 mg/m^3 is acutely uncomfortable; concentrations > 25.00 mg/m^3 correspond to toxic action on human organism (Hunter and Oyama, 2000).

The prevention and amelioration of indoor environmental pollution begin with the control of the sources. Environmentally friendly building materials must be developed and used to construct "healthy buildings," basically preventing indoor environmental contamination and creating a healthy and comfortable living environment. Researchers (Lee et al., 2005; Huang et al., 1996; Wu et al., 2004) have suggested various solutions for reduction of Indoor VOCs in the past. Some of the solutions are i) use of multilayer flooring material to reduce sick house syndrome; ii) utilization the eco-material without harmful gases and reducing or removing them through the additional treatment to the building materials; iii) development of new types of fiber panels and coatings as potential low-emitting alternative materials; iv) water-based products that can be introduced to the wood coating industry to replace the high VOCs and high hazardous air pollutant materials; v)removal of trace VOCs using ionization and electric migration of ions; vi) Increase ventilation during use of products that emit VOCs;vii) Do not store opened containers of unused paints and similar materials within building.

It is inferred that VOCs is one of the significant indoor air pollutants and can affect the human health. The major sources of VOCs are indoor construction and finishing materials. It is suggested that reduce the VOCs at sources by replacing the alternative eco-friendly materials, if not possible to control at sources, then reduce exposure by using a sealant on all exposed surfaces of panelling and other furnishings.

Need for Monitoring Indoor Environmental Quality in Schools

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Importance of excellence in education has been recognized world over. Good academic institutes, schools and colleges not only nurture students academically but also provide them right quality of learning environment to foster their holistic development. Several international and national research groups have recognized importance of Indoor Environmental Quality (IEQ) and its role on protecting health and well-being of students and staff.

The distinguishing feature of school buildings is that they inhabit large number of students, wherein, occupancy sometimes reaches up to 4-5 times more than any other places like home or office buildings. Also, children spend a considerable time inside their classrooms ranging from 6-7 hours daily. Thus, it becomes a prime obligation of the academic institutes to promote healthy learning environment in classrooms to enhance productivity and performance of school children. IEQ in classrooms comprises of number of parameters as given in Fig. 1. Poor IEQ is often linked with direct (like neurological effects) or indirect negative health consequences (poor concentration, dizziness, sleepiness etc.) affecting students' concentration and learning (Norback et al., 1990). Hence, maintaining the recommended IEQ through improved ventilation rates, optimum temperature and humidity, controlled acoustical conditions and adequate lighting may enhance learning process in schools.

Figure1: Indoor Environmental Quality Parameters

Realizing the vulnerability of the young children studying in schools located in highly polluted urban areas like Delhi, the research study was conducted to assess the IEQ in classrooms of Air-Conditioned (AC) and Naturally Ventilated (NV) private schools located in Delhi. Both, Quantitative as well as qualitative data was gathered to gauge the real picture of the existing IEQ conditions in these schools. The data gathered showed poor plight of schools, wherein, the schools did not meet/ maintain the recommended IEQ as suggested by national and international agencies like Central Pollution Control Board, India and World Health Organization (WHO).AC schools provided partial protection from higher ambient particulate pollution due to closed doors and windows. However, this led to problem of increased accumulation of carbon dioxide (CO_2) inside classrooms due to higher occupancy and poor ventilation techniques implemented in these schools.

On the other hand, even though NV schools had good ventilation but they were found to be more vulnerable to ambient particulate pollution.

DO YOU KNOW?

Use of Non-Dust chalk can reduce the concentration of particulate matter

It was also observed that different seasons; ventilations techniques; ambient pollutants levels; use of chalkboard and other classroom activities; movement of occupants; opening and closing of doors and windows; and lastly the classroom occupancy affected the concentrations of $PM_{2.5}$, PM_{10} and CO_2 inside the classrooms. The results highlighted that students complained of occurrence of large number of Sick Building Syndrome Symptoms during classroom occupancy which might have occurred due to exposure to poor IEQ in classrooms.

Classroom lighting turned out to be the most important and significant parameter affecting speed and accuracy of task completion of students and hence, it must be given due importance while designing classrooms.

Figure 2: Indoor Environmental Quality (IEQ) monitoring

A need was felt for campaigns and training programmes for school children and their families, school staff, professionals, policy makers and the general public at large for creating awareness about their indoor environment and possible risks associated with it. Based on the findings from the study, certain suggestions are formulated to improve IEQ in schools such as:

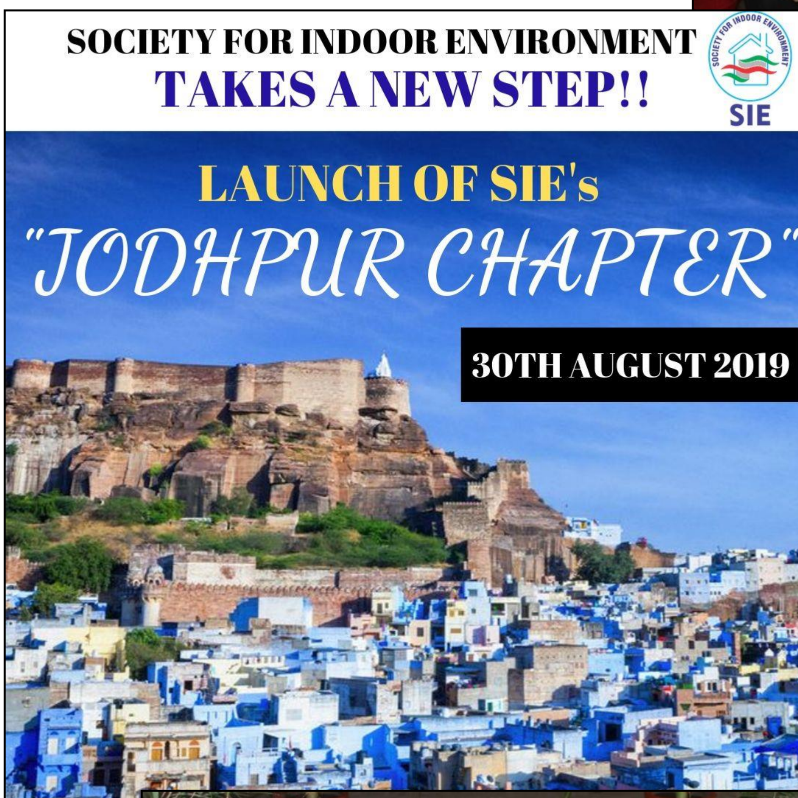
- Operate exhaust fans and ACs together for at least half an hour before the entry of students to remove already settled dust and previously accumulated CO_2.
- Filters of AC systems should be changed/ cleaned regularly.
- As AC is required only for 4-5 months in Indian climate, schools must have operable

windows so that if the need arises, they may be opened and closed to control ventilation.

- Daily cleaning procedure including brooming, mopping and dusting during pre and post school hours must be followed.
- Schools must create buffer zone between pollution sourcesand classrooms by judiciously planting more trees and creating green cover.
- Schools must cover bare soil playgrounds with grass to avoid resuspension of dust.
- Schools are advised to use dustless chalks or white boards for instructions.
- Children must wear masks during alarmingly high pollution periods like winters.
- Installingsensors inside the classrooms will help to raise awareness among students and teachers about indoor environmental conditions. CO_2 sensors, if installed in classrooms, would potentially motivate occupants to increase ventilation rates.
- Classroom walls may be constructed using sound proof building material like red hollow bricks or autoclaved aerated cement blocks. This will also help in providing thermal insulation.
- Provide illuminance between 300-500 lux on desks as well as over instruction board.
- Size of windows may be defined, based on the floor area and minimum WFR should be 1:10 to provide adequate daylight inside the classroom.
- Adequate provisions must be made to control glare produced by direct sunlight using venetian blinds/ curtains and non-glossy instruction boards.
- Lighter colours may be used on walls and ceiling for enhanced reflectance of light.

EVENTS & HAPPENINGS


Society for Indoor Environment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