Bombay Chamber of Commerce & Industry

# SQ raising the Sustainability Quotient

## Editorial

## Indoor air is considered safe, but is it really?

Indoor air is considered safe by many. But when outdoors, we worry about air pollution from vehicles and industries. Statistics are generally on outdoor air or ambient air. Standards have been set in many countries including India. Some cities have panels connected to real time automatic air quality monitoring stations. We feel safe in enclosed spaces like offices, homes, malls and theatres, air conditioned cars, buses and railway coaches. However, Indoor Air Quality (IAQ) can be just as bad as or even worse than ambient or outdoor air quality.

*Acceptable IAQ is defined by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) in ANSI/ASHRAE standard 62.1 as: "Air in which there are no known contaminants at harmful concentrations and with which a substantial majority (usually 80%) of the people exposed do not express dissatisfaction".*

Emissions emanate from cooking, cigarettes, incense sticks, repellents, paints, seals and coatings – releasing complex pollutants. These include Particulates, Formaldehyde (HCHO), Radon, Toluene, Ammonia, Benzene, 2-furaldehyde, Benzyl alcohol, Monocyclic monoterpenes, Dichloromethane, Ethylhexyl phthalate, to name a few. Most of these "micro-pollutants" are carcinogenic and difficult as well as expensive to monitor. Often buildings which are poorly designed do not maintain adequate ventilation. As a result, micro-pollutants get accumulated – sometimes overshooting the acceptable values.

Traditionally, IAQ has been associated with Sick Building Syndrome (SBS). The World Health Organization (WHO) compiled common reported symptoms into what was defined as SBS. India does not have IAQ standards. Spot studies in 2005 showed high values of CO2 in auditoriums in Vadodara crossing three times the IAQ standard. Indoor pollution levels have been found to be very high, leading to severe respiratory ailments, especially in women and children.

China set standards for IAQ as early as 1976. Korea has IAQ standards even for metro buses! IAQ standards in Japan and Germany cover most of the micro-pollutants listed above. It is a pity that in India we haven't taken IAQ seriously. But is just setting of IAQ standards going to be enough. How can we enforce such standards? The approach will have to be multipronged, focusing on prevention and control. We will need to bring key stakeholders such as architects, paint manufacturers, furniture makers, HVAC manufacturers, green building rating agencies, medical professionals etc. together. A combination of control, reduction (modification) with standards/guidelines may work. There is a need to form a National Association on Indoor Air Quality in India and take on this issue with the Ministry of Environment & Forests on a collective basis.

Experts from Academia and Research Organizations such as IITs, NITs, CSIR-NEERI, EMC, IPCA, ICMR, and University of Delhi came together and formed 'Society for Indoor Environment (SIE)'on 3rd February 2017 under Society registration act 1860.The goal is to bring the issue of IEQ to the forefront and to stimulate action from all stakeholders on implementing technologies and solutions for improving and maintaining IEQ. Read more about the SIE in the updates section of this SQ. Do hope to have your support and participation in SIE. *Write in to me at prasad.modak@emcentre.com*

*- Prasad Modak*

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# Sustainable Building Design: From Energy Centric to Occupant Centric Approach

Radha Goyal[1] and Ashish Jain[2]
[1] Deputy Director, Indian Pollution Control Association, Delhi - 110092
[2] Director, Indian Pollution Control Association, Delhi - 110092

## Background

Indoor environment quality (IEQ) has proven to have high-level impacts on occupant's health, comfort and well-being. It also impacts the productivity and the behavior of occupants. Green building design can play an important role in improving the IEQ vis-a-vis the health, comfort, well-being, performance and behavior of occupants.

However, the current green building design parameters and practices have negative impacts on occupant health, comfort and well-being. They are mostly in favor of building efficiency to make them energy efficient by reducing ventilation rates. Doing so is in conflict with well-being and comfort of occupants as a higher ventilation rate is needed to dispel pollution from the buildings. However, higher ventilation may cause further conflicts if the ambient air is more polluted, as in case of cities like Delhi. It will allow more pollutants to enter into the buildings. Further, there are also conflicts within the comfort and well-being parameters. For example natural ventilation or higher rate of ventilation may also have an adverse effect on acoustic comfort of occupants since it might allow more external background noise to enter the building. Some research studies across the globe on acoustic comfort reveal that the overall comfort and satisfaction of occupants with acoustic comfort is lower in LEED certified green buildings than in buildings that are not certified (Altomonte and Schiavon, 2013). Some of the common green building strategies, such as open plan environments to maximize the use of day lighting and natural ventilation, provide fewer barriers between the sources of noises and occupants leading to poor acoustic comfort(Brill et al., 2001; Lee and Guerin, 2010). Adding to it, the geometry of the indoor space also impacts the acoustic comfort of the space. For instance, the long and narrow kind of buildings may create a bowling alley kind of effect where sound bounces between the two walls creating noise (American Speech-Language-Hearing Association, 2005). In addition to these, there are many more practices in green building design that negatively impact acoustic comfort such as, use of under floor heating leads to elimination of carpets which tend to absorb the sound (Jana Madsen, 2014). The use of harder material for floor and walls in order to help with cleaning is also an important issue. The harder the material, the lesser is its capability to absorb noise, resulting in more noise in the interior space (Field, 2008).

## Sustainable Building Design: An Occupant Centric Approach

To overcome these issues of green building design, building designers and engineers need to follow the triple bottom line of sustainability, i.e. environmental, economic and social aspects. Considering the occupants experience and performance whilst designing buildings is equally important to building performance. Abalance between the two is essential. Though the relationship between IEQ and well-being of occupants and the relationship of IEQs amongst themselves is quite complex. However, as we spend more than 90% of our daily time indoors, it is important to understand these relationships and to develop a linkage between building sustainability rating systems with comfort of occupants (social) and conservation of natural resources (environmental and economic).

The following probable steps have to be taken to achieve this healthy linkage between building design and the occupant's well-being:

- IEQs and occupant's well-being have to be considered throughout the lifecycle of the building. Decisions made at design, construction, commissioning and maintenance stages have an impact throughout the lifecycle of the building. Overall, it is essential consider*sick building syndrome*, *thermal*, *visual* and *acoustic comfort* parameters.

- A high level of monitoring and control at all stages to ensure that buildings are delivering what they are designed for. Acceptable IEQ with respect to occupant's well-being can be easily achieved if the source control is practiced during the operation of the buildings (Abbaszadeh et al., 2006)

- The concept of passive design should be adopted to combine thermal comfort and sustainable design.

- Design of exterior entrances with permanent entryways will help in capturing dirt particles and prevent particles infiltrating indoor space.

- A balance between energy efficiency and optimal amount of fresh air needs to be ensured by mechanical engineers.

- Materials used in a building affect thermal performance, indoor pollution, visual as well as acoustical comfort. Therefore, materials that do not produce odor or VOCs and can also enhance the sound absorbing ability to eliminate acoustic problems post-occupancy should be selected.

- Providing control to the occupants such as control of lighting through dimming controls, and providing training to raise their awareness will have an impact on the overall satisfaction.

- Following certain strategies, such as higher level of natural ventilation at night in urban buildings as there is lower noise and pollution at that time due to lower traffic and other outdoor activities.

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# ENGINEERING CONTROL OF AIR POLLUTANTS IN INDOOR MICROENVIRONMENTS

*Swapnika Amancha, Shailendra Kumar Sharma, Shiva Nagendra SM**
*Department of Civil Engineering, IIT Madras, Chennai -600 036*
*email: snagendra@iitm.ac.in*

## Background

Indoor air quality (IAQ) has been gaining increasing attention in recent years because we spend more time (80-90%) in the indoor environment. In the past, attention has been focused on outdoor air pollution. Indoor air pollution is typically under-reported and lesser regulated. Most people are aware that outdoor air pollution can impact their health, but indoor air pollution can also have significant, harmful effects [1].

IAQ depends on various factors like indoor sources and sinks; infiltrations and ventilations; design, maintenance and operation of building ventilation systems; moisture and humidity; ambient air quality and meteorological parameters; and occupant perceptions and susceptibilities. In addition, there are many other psychological factors (physical, emotional and mental reactions) that affect perception of IAQ.

Today, concern over the effects on health from poor indoor air quality is increasing. Poor indoor air quality can cause or contribute to the development of infections, lung cancer, and chronic lung diseases such as asthma. In addition, it can cause headaches, dry eyes, nasal congestion, nausea and fatigue. There is consistent evidence that exposure to indoor air pollution increases the risk of pneumonia, acute lower respiratory infections (ALRI), chronic obstructive pulmonary disease (COPD), cataracts and tuberculosis.

Indoor environmental quality can be represented by concentrations of pollutants ($CO_2$, particulate matter, gaseous pollutants etc.), thermal conditions (temperature and relative humidity) that affect the health, comfort (visual and acoustic), and performance and satisfaction of occupants. IAQ is a major concern to businesses, schools, building managers, tenants, and workers because it can impact the health, comfort, well-being, and productivity of the building occupants [2]. Maintaining adequate IAQ in schools and workplaces is a top priority for facility managers and building operating engineers. An essential element for doing so is bringing in outside air so as to dilute indoor air and exhaust pollutants and contaminants along with moisture and odors. The pollutants in indoor environments can actually reach higher levels than those found outdoors [3]. Although several factors contribute to IAQ, fumes and residues from cleaning chemicals currently used in our homes, offices, and schools have a significant negative effect on the air we breathe. Many common cleaners contain dangerous and harmful chemicals that are carcinogens, neurotoxins, hormone disruptors, and reproductive toxins [4].

## Engineering Control

Three basic ways to reduce pollutant concentrations in indoor air are control of emission from source, adequate ventilation system, and air purification. Air purification devices help in controlling levels of airborne particles including those associated with allergens and in some cases, gaseous pollutants. There are various kinds of technologies being used for air cleaning devices; filtration and electrostatic attraction are effective in removing the particles. Researchers propose use of ultraviolet (UV) light for killing microorganisms growing on surfaces. Photo catalytic oxidation (PCO) of volatile organic compounds (VOCs), another Visible or UV light technology are under development, with the potential to destroy gaseous contaminants. Ozone-generating devices sold as air cleaners use UV light or corona discharge and are meant to control indoor air pollutants [5].

Here we report about a portable, low cost, and efficient air purifier we developed at Environmental and Water Resources Engineering Laboratory, Department of Civil Engineering, Indian Institute of Technology Madras. This purifier comprises three stage purification processes. As shown in Figure 1, a fan is fitted at the top to suck in the air, which goes to the first layer and filtered through a muslin fabric bag. The filtered air then passes through the second layer made of activated charcoal produced locally. The high surface area of charcoal leads to excellent adsorption of pollutants. The lighter air with lesser pollutants then passes through the third layer, which a UV light fixed onto the activated charcoal layer. This UV light helps in treatment of bacteria and viruses. This completes the whole cycle of the air purification system. This purifier consumes around 50 watts (W) of energy.

We studied the performance of this air purifier by testing it in a controlled laboratory environment. We found that it was able to remove particulate matter concentrations. Results also showed that it was able to capture volatile organic compounds present in the indoor environment.

*Figure 1: Air purifier developed at IIT Madras*

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# INDOOR ENVIRONMENTAL QUALITY AND OCCUPANT WELL-BEING IN INDIA: A PARADIGM SHIFT

*Priyanka Kulshreshtha and Geetika Mishra*
*Department of Resource Management and Design Application*
*Lady Irwin College, Delhi University, New Delhi*

Just a week back I was asked to review a book for an undergraduate course in environmental science. Since my area of research has been air quality ,I promptly jumped on to the section of air pollution .The author had talked in detail about the treacherous air pollution playing havoc in metro cities of India and provided terrifying data on the mortality rate due to ambient air pollution, which with due respect, I agreed to. However, to my surprise, not a single mention was made about the importance of indoor environmental quality in modern India. This incident is enough to tell us about the level of awareness and status of research on indoor environmental quality in India.

Indoor Environment Quality (IEQ) is one of the important factors for ensuring health, comfort, safety and productivity of the population. It refers to the quality of environment inside the building that is determined by many factors such as indoor air quality (IAQ), thermal comfort, lighting quality, acoustic conditions as well as furniture and space layout. Research has linked the concentration of pollutants indoors with productivity, sense of well being and occupant's health. In the long term, poor IEQ may give rise to a set of symptoms and health problems to the occupants of the building collectively known as Sick Building Syndrome (SBS). The various symptoms associated with SBS are irritation of eyes, nose and throat, headache, cough, wheezing, cognitive disturbances, light sensitivity, gastrointestinal distress and other flu like symptoms. The factors inducing SBS in an enclosed environment could be uncomfortable temperature and humidity, chemical and biological pollution, physical condition, and psycho social status.

The concept of IEQ was born in urban India around the initiation of the term 'green' building brought on by LEED (Leadership in Energy and environmental design) almost a decade ago. Ironically, a study which compared the symptoms of SBS in different categories of LEED certified buildings, concluded that LEED certification had no correlation with the SBS symptoms and making the buildings 'green' did not reduce SBS symptoms(Mohan 2012).

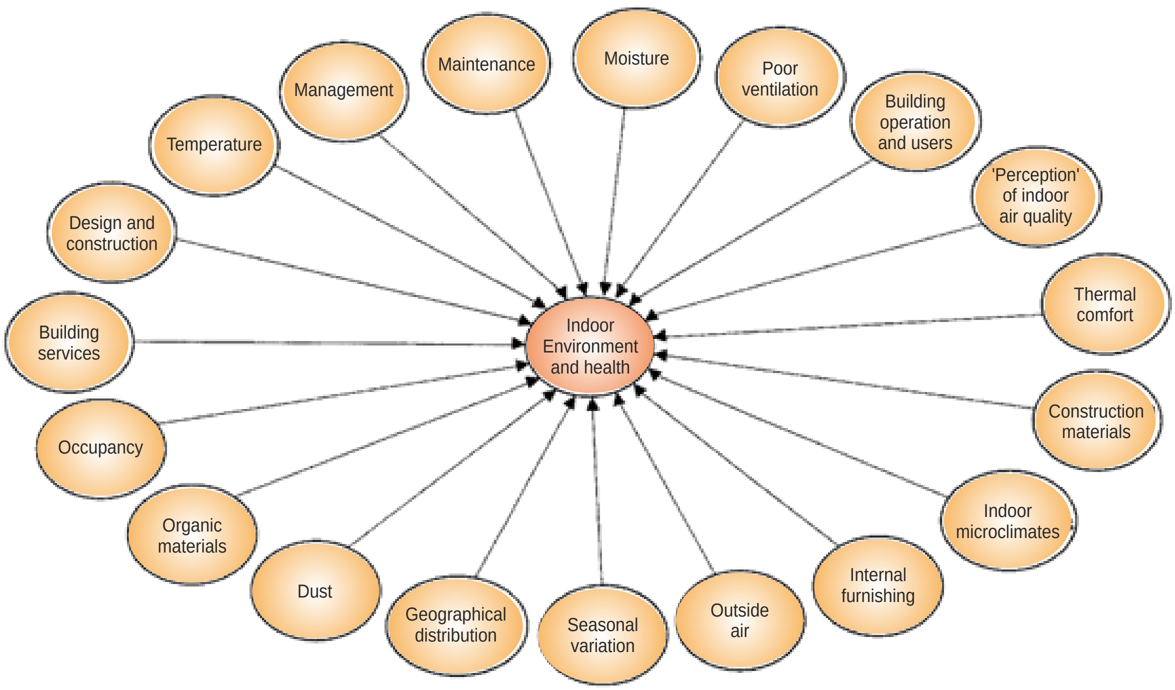


*Fig 1: Factors affecting IEQ and health (Source: Singh J. 1996)*

The thrust areas in IEQ then started concentrating on IAQ, which is a sub-set of IEQ. Some of the pollutants of concern in indoor environment, include respirable suspended particulate matter (RSPM), asbestos, Radon, environmental tobacco smoke (ETS), volatile organic compounds (VOCs) and formaldehyde. It has been proved consistently that children under five years of age in developing countries are at a higher risk of chronic obstructive pulmonary diseases, acute respiratory infections and mortality. In order to ascertain a healthy IAQ, some countries like Canada, Japan, Korea, Singapore, Sweden, UK and USA have established international standards. But, India has no such standards developed for IAQ and sadly, the country's top advisory body, the Planning Commission wants more epidemiological studies to agree on national indoor air pollution norms and are in no hurry to do so despite the fact that about 1.3 million deaths in India are attributed to indoor air pollution. On the other hand, the vulnerability of the population to air pollution related diseases in the Indian sub-continent is very high due to higher exposure to the air pollutants both in the indoors as well as outdoors.

In developing countries like India the major source of energy at the household level is acquired through the burning of coal and biomass in the form of wood, animal dung and crop residues. On a global scale, it is also the largest source of indoor air pollution. In simple cooking stoves, toxic pollutants are emitted in the substantial quantities. Often, the food is cooked in an open combustion scenario and no chimney is used to minimize the indoor suspension of air pollutants. There is no provision of ventilation in the kitchens, especially in the cold climatic conditions. The incomplete combustion of biomass fuels leads to very high levels of indoor air pollution and the most vulnerable are women and children.

Currently India is facing an air quality crisis and research has revealed horrific results that two Indians die every minute due to air pollution. Keeping in mind India's heavy dependence on wood and biomass as domestic fuel, Government of India initiated the National Program on Improved Chulha (NPIC) in 1984-85. It is aimed at popularizing the use of improved cooking devices in rural areas of the country. The secondary objectives of the program involved reducing the drudgery for rural women and to create income-generating opportunities. This has played a role in improving the IAQ of rural households to some extent. In the same way many non-government organizations have worked on the improvement of cook stoves in rural areas. For example, in Bundelkhand 980 improved chimney cook stoves (Sukhad stoves) were distributed resulting in 70% reduction in $CO_2$ concentration and 44% reduction in $PM_{2.5}$ concentration. In urban areas, factors like fuel adulteration, vehicle emission and traffic congestion also contribute to indoor air pollution. As the diffusion is lower, the concentration of pollutants increases and other building factors also add to the ambient pollutants. In terms of air pollution, India is ranked highest amongst the world's most polluted countries.

A major intervention that needs to be brought to the forefront to tackle the problem of indoor air pollution is to sensitize the masses regarding its severity and magnitude. This would enable policymakers to recognize its importance in indoctrinating it as a mandate. More cohort studies need to be carried out to understand the epidemiology of indoor air and relevant impacts to human health. Prevention will be the key rid this menace and placing both ambient air and indoor air as high priority research areas would help address the challenge. Smaller steps, but consistent ones, need to be taken for India to have a national set of standards for healthy indoor air quality.

# INDOOR AIR QUALITY IN HOSTEL KITCHENS: A CASE STUDY

*Nivedita Kaul*, A.B. Gupta[1], Sumit Khandelwal[1]*
*[1]Dept. of Civil Engineering, Malaviya National Institute of Technology Jaipur, Jaipur, Rajasthan (India)*
** Corresponding author email: nkoul.ce@mnit.ac.in*

Domestic cooking is an important source of indoor air pollution (IAP) and is associated with significant morbidity and mortality (Boman et al., 2003). There is strong evidence that use of coal, dung cake, wood and other solid fuels increases the risk of a range of respiratory illnesses (Shen et al., 2009; Mudway et al., 2005; Sumer et al., 2004; Bruce et al., 2000; Boman et al., 2003). Liquefied Petroleum Gas (LPG) is considered a safer fuel compared to wood as far as deterioration of pulmonary functions is concerned (Saha et al., 2005). However, LPG which is predominantly used as a cooking fuel in urban India, emits significant amount of fine particles, $NO_x$ and several other pollutants, which may trigger asthma and other respiratory ailments (Dennekemp, 2001; Wallace et al., 2004; Kumar et al., 2008, Barck et al., 2005). In normal subjects, inhalation of $NO_2$ causes lung inflammation and contributes to exacerbation of respiratory diseases because of its capacity to impair the function of epithelial cells and alveolar macro phages (Barck et al., 2005). Recognizing that the prevalence of gas stoves in urban India is 50-70%, any evidence of a deleterious effect on health, represents a major public health issue. Further, Indian cooking which involves frequent frying and roasting also generates large amounts of inhalable vapors and aerosols that have been associated with a number of respiratory ailments including lung cancer (Ko et al., 2000).

Siegmann & Sattler (1996) have also reported that poly cyclic aromatic hydrocarbons (PAH) concentrations in fumes from hot cooking oil are high and because they are dissolved in respirable droplets, they may pose a serious cancer risk to exposed persons. Health effects of prolonged exposure to combustion generated pollutants depend on the type of fuel and stove used, adequacy of ventilation, cooking practices, duration of exposure, toxicology of pollutants and susceptibility of the individual.

Studying PM and $NO_x$ interactions in the kitchen indoor environment is essential in view of their synergistic impact on human respiratory health. Simultaneous emission of PM and $NO_x$ has been studied separately during frying and roasting activities and under different ventilation conditions, in 13 hostel kitchens of India by our group (Kaul et al., 2014a; Kaul et al., 2016)). Maximum value of $PM_1/PM_{2.5}$ and $PM_{2.5}/PM_{10}$ was 0.68 and 0.54 during frying and 0.44 and 0.39 during roasting respectively. This indicates that emission of fine PM is more during frying whereas coarse PM is primarily emitted during roasting. Maximum 60-minute moving averages of $PM_{2.5}$ and $PM_{10}$ have been recorded as 826 $\mu g/m^3$ and 1687 $\mu g/m^3$, respectively. HKs are an important source of prolonged exposure to high $NO_x$ ($NO_2$) concentration, due to use of multiple burners for a long time and average concentrations as high as 1400.8±860.5 $\mu g/m^3$ have been recorded in them. It has been observed that the average one hour concentration of $NO_2$ exceeds the WHO guidelines of indoor air quality in several kitchens. High values of $NO_x$ and PM persist for long durations in many kitchens, which can have significant implications for human health (Biyani et al., 2009).

Our studies further assessed the effect of poor indoor air quality in exacerbation of respiratory disorders among exposed individuals in these kitchens (Kaul et al., 2014b). Significant increase in prevalence of cough and impairment of lung functions has been found among cooks, when compared to non-cooks. Significant difference has been found in the prevalence of cough among smoker and non-smoker non-cooks (p=0.03). However, no such difference is observed in smoker and non-smoker cooks, suggesting that kitchen pollutants and smoking have a similar effect on the respiratory system. Comparison of lung functions like average FEV1% predicted and average FVC% predicted of cooks (90.6% and 82.6% respectively) and non-cooks (93.7% and 86.2 % respectively) also shows significant difference.

Considering the high pollution load from fuel and cooking practices as well as the long cooking duration, indoor air pollution from LPG can be regarded as one of the important environmental and public health problems in India. Study of cooking generated fine particles and $NO_x$, their accumulation in the indoor air and effects on exposed individuals are rarely perceived as an occupational hazard and have thus been grossly neglected. Our studies have indicated that a judicious combination of exhaust fan and electric chimney(Kaul, 2011)may provide an effective ventilation for kitchen indoors and can provide succour to millions of women cooks across the country.

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# Protocol for evaluation of Sorption properties of building materials for VOCs in Indoor Environment

*Mukesh Khare, Sunil Gulia, Sumanth Chinthala*
*Civil Engineering Department, Indian Institute of Technology Delhi*

## Introduction

The Indoor air quality in buildings is dependent on both the nature of air movement within the building systems and the nature and location of contaminant sources. Emission of pollutants like volatile organic compounds (VOCs) have direct influence on people's well-being and health. High exposure of VOCs concentration may cause conjunctival irritation, nose and throat discomfort headache, allergic skin reaction, dyspnea declines in serum cholinesterase levels, nausea, emesis, epistaxis, fatigue and dizziness (USEPA, 2017). Higher concentration of indoor air pollutants cause various health problems that may result into 'sick building syndrome'. The Indoor air pollutants can originate from outdoor sources (e.g., traffic and other forms of combustion (CO, NOx, SOx) or from indoor sources, such as occupants and their activities, tobacco smoke, electronic equipment, cleaning products or heating, ventilating, air-conditioning (HVAC) systems and building and furnishing materials. The indoor sources of VOCs may be paints, wood preservatives, aerosol sprays, cleansers and disinfectants, moth repellents and air fresheners, stored fuels and automotive products and building materials (USEPA, 2017). The VOCs emission from building materials, especially those from the viewpoint of energy conservation, is one of the major sources of indoor air pollution which needs to be accessed accurately (Yang et al., 2001, Xu and Zhang, 2003).

However, building materials can also influence the transport and the removal of indoor VOCs by sorption and desorption. The re-emission (desorption) of sorbed VOCs may increase the VOC concentrations in the indoor environment for months or years after a source event (Tichenor et al., 1991, Zhang et al., 2002). The adsorption and desorption properties of a material may influence the chemical properties of VOCs in the form of strength of interaction (van der Waals) between material and pollutant (interaction between two polar molecules, between polar and nonpolar molecules, and dipole/induced-dipole interactions between non -polar molecules). The material surface roughness can strongly affect the sorption capacity of the material. The greater the specific area, the larger the equilibrium coefficient which results in higher adsorption capacity of materials. Additionally, temperature, relative humidity and air velocity can also influence the sorption properties of the material.

The current strategies to reduce formaldehyde emissions from building materials are derived from reducing the use of formaldehyde at the product manufacturing stage (i.e. through the use of novel formaldehyde free resins for the panels industry). Additionally, the suppression of VOCs may be achieved by ventilation, the specification of low emission materials or the use of materials with high air purification properties, all of which improve IAQ. The present article provide an integrated approach based on monitoring and modelling to evaluate the adsorption and desorption properties of building materials for VOCs.

## Methodology

The methods of studying characteristics of VOC sources and sinks mainly fall into two categories: experimental investigation and emission modeling (Zhu et al., 2001, Zhao et al., 2002). In principle, the experimental measurements provide the most realistic results than the modeling results. However, it require expensive and well-controlled instrumentation. The experiments are setup using a small-scale or a full scale stainless steel or glass chamber to measure the sorption properties of a test material. The tests are usually conducted under a set of specific environmental conditions (e.g., 25oC, 50% RH, and 1 ACH). The experiments are generally completed in two phases, the dynamic adsorption phase and the dynamic desorption phase. Figure 1 shows a general experimental setup of a small scale chamber.

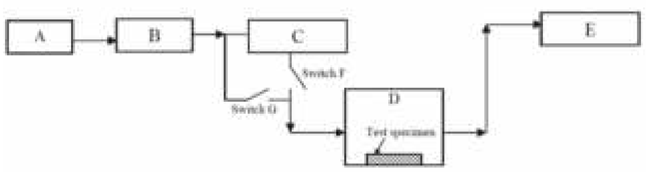


*Figure 1: Experimental setup of a small scale chamber (Zhang et al., 2002)*

Where

A: Clean air supply system; B: Airflow, temperature and humidity controller; C: Temperature controlled VOC generator (e.g. VOC permeation tubes); D: Test chamber assembly; E: Air sampling system at the chamber exhaust.

In adsorption phase, the compounds generated from the pollutant generator (C) are carried by the conditioned, clean air from the conditioner (B) to the chamber containing the test specimen. The pollutants concentration in the chamber is measured by analyzing air samples taken from the chamber exhaust (E). After the system reaches an apparent equilibrium (the concentrations at the chamber exhaust does not increase any more), the dynamic desorption phase starts whereby the pollutant supply is stopped and the chamber is continuously flushed out by the clean air.

Owing to the limitation of the experimental approach, many researchers have addressed the importance of simulating VOC emissions from building materials and furnishings using mathematical models. In literature, the sorption model are generally two types, i.e., first order adsorption/desorption rate models and equilibrium-interface models (Zhang et al., 2002). The linear Langmuir model is probably the most widely used sorption model. It is based on physisorption process and considers only the relatively fast surface sorption process. It does not consider the slow diffusion of pollutant inside the material. The linear Langmuir model is described by following equation (Tichenor et al., 1991).

$$\frac{aM}{dt} = k_a C - k_d M \text{ ----------------(1)}$$

Where,

dM/dt = net mass rate of change of VOCs adsorbed on the material surface (µg $m^{-2}$ $h^{-1}$); C =concentration in chamber (µg/$m^3$); $k_a$ = adsorption rate coefficient (m $h^{-1}$); $k_d$ = desorption rate coefficient ($h^{-1}$); M =mass of pollutant per unit area on material surface (µg $m^{-2}$).

It is difficult to measure the value of $k_a$ and $k_d$ through experiments. However, researchers used statistical tools to estimate the value of these coefficients based on monitoring data of concentration and emission rate.

## Case study

This method has been used to evaluate the adsorption and desorption properties of medium density board (MDF) for VOCs like Toluene, Limonene and Dodecane. The VOCs concentration has been monitored by using experimental setup for 2 litre micro test chamber as described in Figure 1 in Building Research Establishment (BRE), UK laboratory as part of ongoing ECO-SEE project (www.eco-see.eu). The $k_a$ and $k_d$ coefficients values have been estimated using the least square curve fitting method. For this, a curve-fitting software SCIENTIST (Micromath Software, 2015) has been used to estimate $k_a$ and $k_d$ values by fitting the Langmuir equation with experimental VOC values in the adsorption and desorption phase (Figure 2). Table 1 describes the experimental data used for curve fitting to estimate $k_a$ and $k_d$ values. The dosing concentration of toluene, limonene and dodecane were 2169, 2397 and 2754 µg/$m^3$ respectively. The surface area of the MDF, test specimens were 0.016 $m^2$.

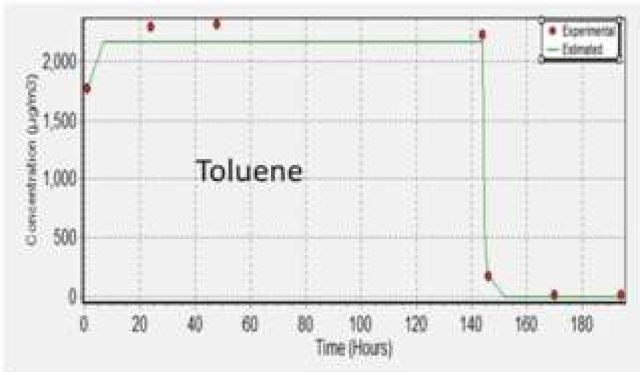


*Figure 2: Curve fitting plots of toluene for MDF - an example*

Table 1. Experimental data and estimated $k_a$ and $k_d$ values

| S. N. | Parameters | Control MDF | | |
|---|---|---|---|---|
| | | Toluene | Limonene | Dodecane |
| 1 | Chamber Volume, $V_0$ ($m^3$) | 0.002 | 0.002 | 0.002 |
| 2 | ACH, $N_0$ (1/h) | 6 | 6 | 6 |
| 3 | Sink Area, $A_0$ ($m^2$) | 0.016 | 0.016 | 0.016 |
| 4 | Dosing concentration, $C_0$ (µg/$m^3$) | 2169 | 2397 | 2754 |
| 5 | T_stop (Hours) | 144 | 144 | 144 |
| 6 | Estimated ($k_a$), m/h | 0.398 | 0.2 | 0.297 |
| 7 | Estimated ($k_d$) 1/h | 1.297 | 0.382 | 0.2 |

The $k_a$ and $k_d$ values of 0.398 m/h and 1.297 1/h, respectively of MDF for toluene indicate that MDF re-emits toluene suddenly in the chamber. It behaves similarly with limonene, having $k_a$ and $k_d$ values of 0.200 m/h and 0.382 1/h respectively. However, values of $k_a$ (0.297 m/h) are higher when compared to $k_d$ values (0.20 1/h) for dodecane, which indicates that MDF adsorbs dodecane rapidly and re-emits it slowly during desorption phase. It indicates that MDF behaves as a sink for dodecane (Gulia et al., 2016).

The results obtained above have been validated using a 30$m^3$ chamber constructed in Building Research Establishment, London. The flow rate in the chamber has been controlled through various control mechanisms. The material has been placed on a wall perpendicular to the wall where inlet and outlets are located. The inlet and outlet of the chamber have been located in the opposite walls. The flow patterns and the concentration of the pollutants in the 30$m^3$ have been simulated using the software FLUENT in order to check the performance of the material in the full scale model (Chinthala et al, 2016).

Building construction materials play an important role in defining indoor air pollution levels. The materials with high adsorption capacity may capture VOCs and thus reduce the ambient indoor concentration levels; however, materials possessing high desorption capacity may re-emit the IAPs suddenly and thus increase indoor concentrations. This approach can be used to evaluate the adsorption and desorption properties of bio based materials in Indian conditions which help to define the material as Source or Sink for VOCs. The protocol shall be developed by incorporating the results of 2L chambers, 30m$^3$ chamber and real size test house data as shown in the figure 3.

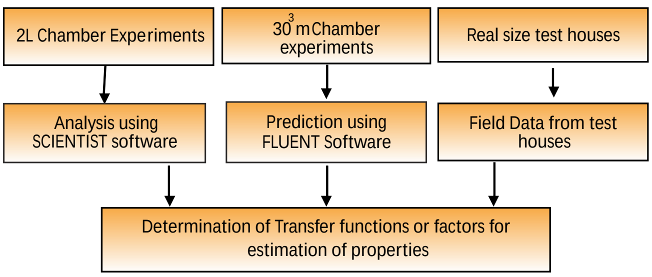


*Figure 3: Protocol for evaluating the sorption properties of building materials for VOCs in Indoor Environment*

*ACKNOWLEDGEMENTS*

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## Launch of Society for Indoor Environment (SIE), the first of its kind in India!

Air pollution in India is a major environmental and public health concern. Air pollution is recognized as the 5th and indoor air pollution (IAP) as second largest killer in India as per Global burden of disease report.

People spend more than 90% of their time indoors. IAP has been linked to Sick Building Syndrome (SBS). SBS severely affects health of people and productivity in offices. Unfortunately, Indoor Environmental Quality (IEQ) is not given its due importance in India.

To address this, Experts from Academia and Research Organizations such as IITs, NITs, CSIR-NEERI, EMC, IPCA, ICMR, University of Delhi) came together and formed "Society for Indoor Environment (SIE)". SIE was incepted on 3rd February 2017 under Society registration act 1860. SIE was set up with following objectives:

I. To facilitate local, urban/rural, regional, national, international and interdisciplinary communication and information exchange by publishing and fostering publication on indoor environmental quality.

ii. To organize Seminars, Meetings, Press-Conferences and other lawful gatherings from time to time.

iii. To organize/conduct research & development in IEQ to fill the gaps and provide sustainable solutions for the welfare of society.

iv. To involve in environmental education and dissemination in the fields of indoor environmental science, technology and policy with schools, colleges and other educational institutes.

v. To take up effective, reasonable and lawful steps for the solution of the problems relating to environment protection.

vi. To organize training, workshops and seminars to bring together different stakeholders (scientists, technologists, engineers, architects, lawyers, epidemiologist, activists and others) to interact and share their knowledge in IEQ.

vii. To develop guidelines, which will help architects, contractors, and building owners and operators to move beyond current practice to provide "Acceptable IEQ."

viii. To work for the preparation and implementation of IAQ Standards in India and other developing countries.

ix. To work on IAQ-sensitive practices in building and system design, construction, commissioning, and operation and maintenance (O&M) throughout the life of a building.

x. To Act as a knowledge resource for Green Buildings.

xi. To publish Books, Chairs, Illustrations, Journal, Magazines, Periodicals, News Letter/Papers and other publications on the subjected issues.

*Please visit the website at http://societyforindoorenvironment.net/ and write to prasad.modak@emcentre.com*

## Training Programs on Air Quality Management in 2017

Pollution Control Boards (PCBs), Urban Local Bodies (ULBs) and Industries have been generating large amounts of data through Continuous Emission Monitoring Systems (EMS) and Automatic Air Quality Monitoring Stations (AQMS). Currently, data analysis and interpretation is not carried out rigorously. Annual reports of averages data is rarely available in full. A major constraint is the low technical capability of the scientific staff in data analysis, interpretation and action planning. Application of advanced statistical analysis is critical in diagnosis of air quality data as it provides a bases for prioritization and preparation of air quality management programs.

Two training programs have been conceived over a duration of 2 days each for 25 to a maximum of 30 participants. The focus is on data analytics, update on monitoring instrumentation, air quality modelling and preparation of air quality management plans.

Who Should Participate?

- Staff of the PCB at HQ as well as Regional Offices
- Scientists & Engineers from large manufacturing companies and power plants
- Engineers from companies that offer monitoring instrumentation
- Professors/Researchers/Students
- Scientific Research Bodies
- Environmental NGOs

*Email tausif.farooqui@emcentre.com*
*for more details Please visit http://www.cpcb.nic.in/Proto-Ind_AirPollution_June2014.pdf the CPCB draft monitoring guidelines for Indoor Air Pollution as of June 2014.*

*Kindly send your comments/suggestions to: Prof. Mukesh Khare, mukeshk@civil.iitd.ac.in and Dr. D. Saha, mailcpcb@gmail.com*

# Indoor Plants for Air Quality Improvement

The following infographic created by Lovethegarden.com on indoor plants that help improve the indoor air quality.


# State of Global Air

Find both, the report as well as an interactive global map showing information on air quality and the related burden on health across countries based on recent data (2015) to provide a comprehensive picture of global air pollution and health levels and trends (since 1990). https://www.stateofglobalair.org/

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*For more details Please visit : http://www.cpcb.nic.in/Proto-Ind_AirPollution_June2014.pdf the CPCB draft monitoring guidelines for Indoor Air Pollution as of June 2014.*

*Kindly send your comments/suggestions to: Prof. Mukesh Khare, mukeshk@civil.iitd.ac.in and Dr. D. Saha, mailcpcb@gmail.com*

# Sustainability Committee Activities

## The Practical session on Fire Safety and Protection

Bombay Chamber of commerce & Industry organized a session on the practical aspects of Fire Safety Awareness on 2nd February 2017.

Key areas of precautions to be taken to avoid fire and steps to be taken after the fire incident were discussed. The methodology utilised for the session were group exercises, practical demonstrations & practice, evacuation drill, brainstorming and discussions on office fires incidents. The reasons and possible precautions during day to day operations were discussed at length. During the practical session the trainer tried to empower the participants with basic steps on how to be fire safe.

Speakers:

- Mr. Amol Jadhav, Manager Rallies India Limited,
- Mr. Prashant Sansare, General Manager – Health Safety & Environment, Arkema Chemicals India Pvt. Ltd.,
- Mr. D. G. Ahire, former Dy. Chief Warden, Civil Defence.

## Seminar on Workplace Wellness

The corporate leaders have started understanding the importance of employee satisfaction, employee health and believe that workplace wellness is a business case. Employers know that potential candidates are looking for jobs with good packages which include excellent health and safety facilities in the organization. Workplace wellness strategy of the organisation, benefits both employers and employees. To address the need of the industry Bombay Chamber organized Seminar on Workplace Wellness on March 10, 2017.

Key Content and Speakers:

- Are we truly prepared to handle medical emergency in Offices? – Dr. Madhav Rege, Occupational Health Consultant Corporate Health Services, Tata Motors
- Stress at Workplace - - Dr. S. Sivaramakrishnan, Former Chief Medical Officer, Siemens Ltd.
- Prevention & Management of Non-Communicable Diseases and Vaccination Program for Seasonal Infections - Dr. Chaitanya Gulvady, Vice President- Health, Siemens Ltd.
- Spirituality & Corporate Executives , Sister Deepa B K, Brahma Kumaris Business & Industries Wing.
- Medical Check Up-Business Gimmick or Necessity - Dr. Hemant Haldavnekar , Heads Occupational Health Services, BARC.
- Indoor Air Quality - Mr. Amit Raiyani, Sr. Industrial Hygienist, Reliance Industries Ltd.
- Optimal Nutrition and Exercises - Ms. Natasha Vora, Project Manager, Nurture Health Solutions

## Training Courses offered by the Chamber

Bombay Chamber of Commerce and Industry is 178 years old organisation, an oldest Chamber in the Country. It has been understood that the Sustainability of the business is dependent on the human resource of the organisation. The corporate are investing on their very important Human Resource to enhance their knowledge and skills. As a service to the members and potential members, the Chamber is offering following training courses.

(1) Women Safety and Self Defence (2) Road and Travel Safety (3) Office Safety (4) Fire Safety

(5) Corporate Social Responsibility for Business Sustainability

We are sure of corporate will take advantage of the opportunity.

*For more details contact:*

*Ms. Usha Maheshwari , Additonal Director / Ms. Aneeha Neeraja Rajan, Assistant Manager*

*Tel.:022 61200214 / 227 Email: sustainability@bombaychamber.com / csr@bombaychamber.com*