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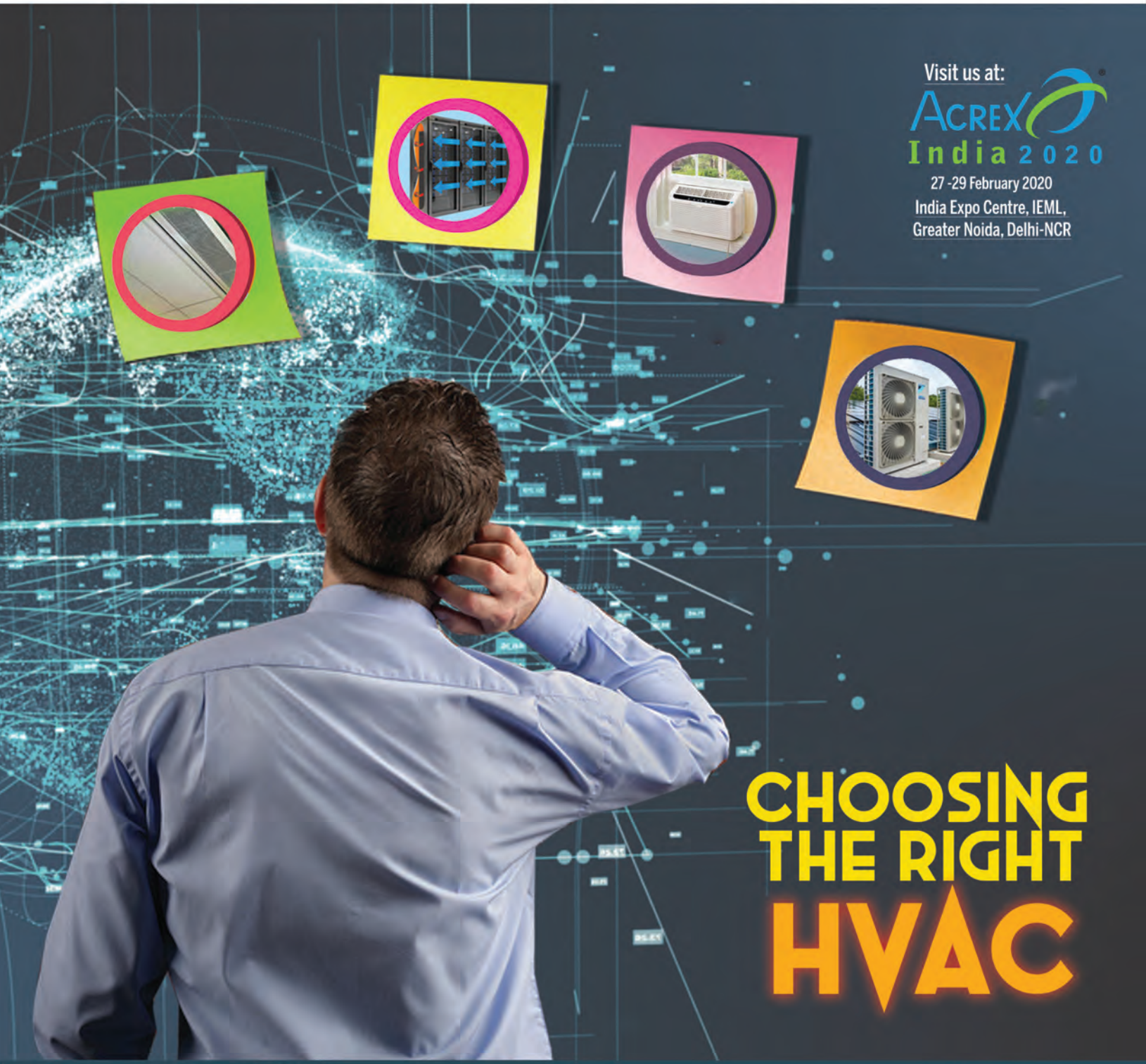

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VOC Emission
and IAQ in Office Spaces

The quality of air within our buildings has a great effect on our bodies. This article explains the impacts of volatile organic compounds on indoor air quality in office buildings.

Sick Building Syndrome (SBS), an ailment known to occur among building occupants, was discovered nearly four decades ago. It comprises a group of loosely associated symptoms known to persist among more than 20 per cent of building occupants with cause(s) not recognisable, and complaints/symptoms relieved after exiting the building. These symptoms include headaches; eye, nose, and throat irritation; a dry cough; dry or itchy skin; dizziness and nausea; difficulty in concentrating; fatigue; and sensitivity to odours. SBS is known to have reduced work productivity and increase absenteeism.

The problematic trend of sick buildings, which began in the western world, can be traced back to the oil embargo in the 1970s. The new energy efficient buildings built then were sealed and insulated from the external environment. The National Aeronautics and Space Administration (NASA), Washington, DC, reports that these sealed buildings have less exchange of fresh outdoor air for stale indoor air causing higher concentrations of toxic chemicals in indoor environments, brought about by emissions from a great variety of building components and materials.

Table 1: Classes of indoor air pollutants	
Pollutant Class	Typical Examples
Combustion products	Carbon monoxide, nitrogen dioxide, sulphur dioxide, carbon dioxide, tobacco smoke components
Volatile organic chemicals	Pesticide and fungicide components, alcohols, benzene, esters, chloroform
Respirable particulates	Asbestos, fibre glass, inorganic and organic dusts, frayed materials, pollen
Respiratory products	Water vapour, carbon dioxide, Water vapour, carbon dioxide
Biologics and bio-aerosols	Moulds and fungi, bacteria, viruses, nonviable microbial particulates
Radionuclide	Radon, radon progeny
Odours	Odours associated with any of the above
(Source – Hong Kong University Department of Architecture, IAQ Lecture series)	

Such office spaces are now rapidly mushrooming in commercial buildings in Indian cities. These buildings are often sealed glass envelopes that are incapable of breathing. The environment inside is often devoid of vital oxygen, natural light and ventilation, and still worse, laden with harmful gases such as Nitrogen Di-oxide, Volatile Organic Compounds (VOCs), ozone, hazardous chemicals and disease-causing microorganisms that are released and contained within the building's envelope. SBS has the potential to develop into a serious and expensive liability when these toxins become concentrated inside sealed buildings.

Indoor air pollutants that contribute to SBS can be broadly classified as biological and chemical contaminants, particulate matter, combustion gases, VOCs, radionuclide and bio-aerosols. Table 1 provides the different classes of indoor air pollutants.

Why is Indoor Air Quality (IAQ) Important in Offices?

ASHRAE (American Society for Heating Refrigeration and Air Conditioning Engineers) defines IAQ through concentrations of air pollutants that are known or suspected to affect people's comfort, environmental satisfaction, health, work or productivity.

Typical sources of contaminants unique to indoor environments in offices include VOCs and suspended particulate matter from paints, carpets, office equipment, floor and surface cleaning agents, ceiling, furniture and pesticides; bio-aerosols and micro-organisms from furnishings, human activities (bio-effluents); and build-up of gases such as carbon di-oxide and carbon monoxide from poor ventilation.

Health effects from indoor air pollutants may be acute or chronic and, experienced soon after exposure or, possibly, years later. Immediate effects may show up after a single exposure or repeated exposures. These include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable. Sometimes the treatment is simply eliminating the person's exposure to the source of the pollution, if it can be identified. Symptoms of some diseases, including asthma, hypersensitivity pneumonitis, and humidifier fever, may also show up soon after exposure to some indoor air pollutants (The Inside Story – A Guide to Indoor Air Quality, US Environmental Protection Agency, 2012).

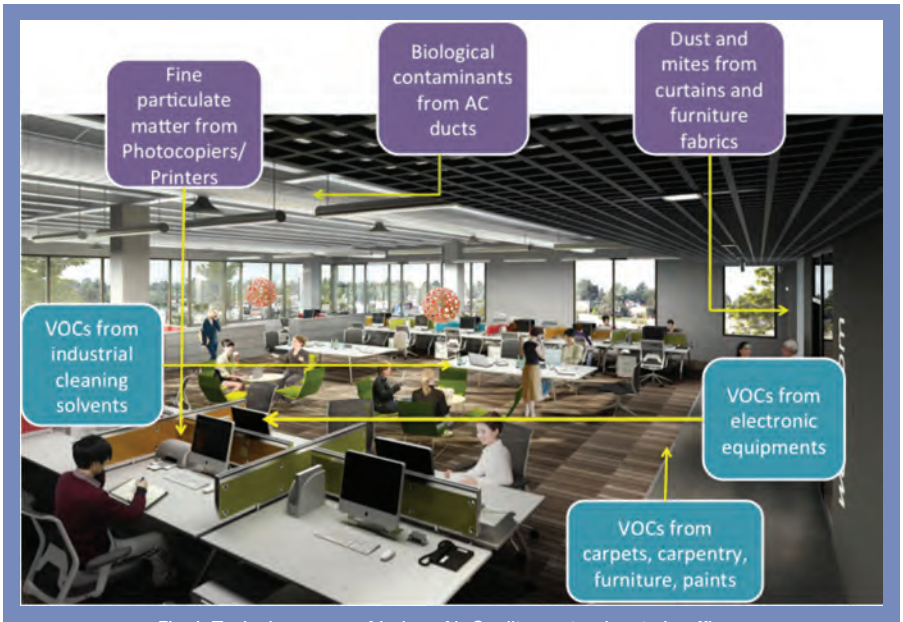

Fig. I: Typical sources of Indoor Air Quality contaminants in offices

Volatile Organic Compounds (VOCs)

VOCs are a large and diverse family of chemicals that contain carbon and hydrogen. VOCs are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals some of which may have short and long-term adverse health effects. A VOC is any organic compound having an initial boiling point less than or equal to 250-degree C (482-degree F) measured at a standard atmospheric pressure of 101.3 kPa and can do damage to visual or auditory senses.

VOCs are sometimes categorised by the ease they will be emitted. For

Sl	Case 'A'		Case 'B'		Case 'C'		Case 'D'	
	Name of Material	Percentage	Name of Material	Percentage	Name of Material	Percentage	Name of Material	Percentage
1	Laminate	25.08	Paint	28.06	Paint	26.58	Paint	32.13
2	Paint	18.26	Gypsum Ceiling	19.14	Gypsum Ceiling	19.38	Gypsum Ceiling	19.60
3	Kota flooring (considered as Carpet)	17.7	Metal powder coated paint	14.91	Carpet	13.08	Carpet	16.19
4	Gypsum Ceiling	15.34	Carpet	19.14	Laminate	7.14	Laminate	10.45
5	Metal powder coated paint	5.93	Laminate	6.11	Metal powder coated paint	3.92	Veneer-Melamine polished	2.85
6	Fabric	6.93	Fabric	5.01	Fabric	5.40	Fabric	2.96

example, the World Health Organization (WHO) categorises indoor organic pollutants as very volatile, volatile, and semi-volatile. The higher the volatility (lower the boiling point), the more likely the compound will be emitted from a product or surface into the air. Very volatile organic compounds (VVOCs) are so volatile that they are difficult to measure and are found almost entirely as gases in the air rather than in materials or on surfaces.

IAQ Standards Related to VOCs

At the international level, many organisations have set up standards for IAQ. These include Greenguard, BIFMA, NIOSH, EPA and WHO. The Greenguard acceptable limits for TVOC is $\leq$ 0.5 mg/m3 and for formaldehyde is $\leq$ 0.05 ppm. BIFMA provides individual VOC concentration limits at 336 hours. For example, the maximum allowable concentration of formaldehyde in workstations as per BIFMA is 17 mg/ m3 and the maximum allowable concentration of formaldehyde for open plan office as per BIFMA is 11mg/m3.

VOCs in Modern Open Offices

Modern offices have many sources of VOCs. Typical sources include volatiles and particulates from building materials, furnishings, appliances, office equipment, office/residential cleaning supplies, human activities (bio-effluents), tobacco smoke, biological organisms, and pesticides.

A study conducted by Rachana Sansad's Insitute of Environmental Architecture in collaboration with Godrej Interio included 4 modern air-conditioned open plan layout offices with more than 100 workstations in Mumbai. The proportion of various exposed surfaces in the office was ascertained using methodology specified by BIFMA, and the proportion of various VOC emitting surfaces was calculated. The results are summarised in Table 2.

From the Table 2, the five most prevalent materials contributing to VOC emissions, were enlisted. The results showed that on an average, painted surface comprised 26 per cent, gypsum ceiling comprised 18 per cent, carpet 17 per cent, laminate 12 per cent and fabric 5 per cent of the total exposed surface in office interiors.

What Can be Done?

Measurement of TVOCs in indoor office environment is the first step towards reducing and eliminating VOC emissions. Understanding the nature of emissions and their levels with respect to standards provides valuable information to product designers. Steps can be taken in the design process to eliminate VOC emitting materials and sources in furniture and product manufacture through Life Cycle Analysis (LCA) of the products. Some recommendations are suggested below:

- Finding alternatives to meet low VOC requirements as per standards of BIFMA, Greenguard and WHO
- Use low VOC adhesives in carpet tiles, laminates or any other interior product
- Reduce VOC contents in Primer
- De-gassing of furniture prior to dispatch. ■

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