Indoor air quality: Issues and concerns in India

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What is IAQ

The quality of air inside buildings as represented by concentrations of pollutants and thermal (**Temperature and Relative Humidity**) conditions that affect the **health, comfort, and performance of occupants**

IAQ – an area of concern

- Indoor air quality is linked to health of the occupants
- IAQ is an important concern – both rural and urban
- US EPA pointed out that indoor air pollution poses a greater risk than outdoor air pollution - people spend 80-90% of their time indoors (Yu and Browers, 2013)
- Carbon based gaseous pollutants (VOCs) indoors could be 2 to 5 times higher than outdoors
- Presence of air pollutants in indoor environment a global issue due to adverse effects on human health (Tsakas, Siskos and Siskos, 2011)
- Indoor air pollution - ranked among the top five environmental health risks to the public by EPA.
- Indoor air pollution – one of the top 10 death, disease risk factors - India

Pollutants & Sources

Location	Sources	Pollutant
Offices, government buildings	HVAC systems, carpets, painting & polishing , household cleaners, aerosols, insecticides, pesticides and personal care products	Primary: PM, VOCs Additional : CO, NOx, SO2
Parking areas	Vehicular movement	Primary : PM, CO, NOx, HC Additional : SO2, VOCs, PAHs,
Public places such as restaurants, hotels, libraries, shopping malls (misc. sources	HVAC systems, carpets, painting & polishing , insecticides, pesticides, smoking, constriction activities	Primary: PM, VOCs, Nicotine Additional : CO, NOx, SO2
Rural households using biomass	Biomass burning for cooking, heating, waste burning. Kerosene burning for lighting,	Primary: PM, CO, BC Additional : CH4, NMOC

Causal factors

- Inadequate ventilation/air tightness / poorly designed ventilation systems
- High temperature and humidity levels
- Other indoor sources including combustion
- Infiltration of outdoor air contaminants into the indoor
- Use of cleaning products, paints, printers, pesticides and other VOCs generating products

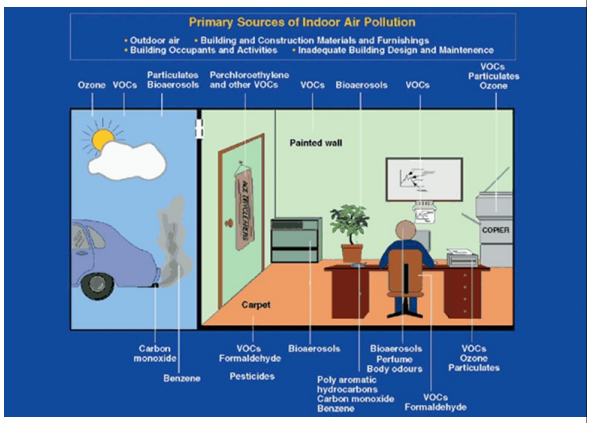
Problems of IAQ

Enclosed space inhabited by humans produce the following effects

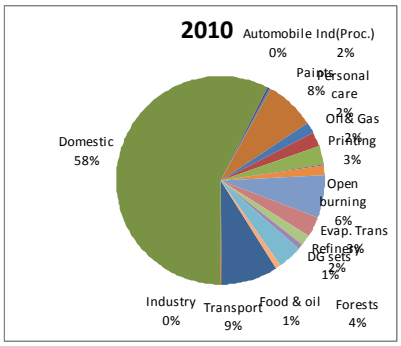
- ⇩ Oxygen level or ⇧ CO_2 level
- Increase in temperature and humidity
- Increase in bio-aerosol and odor
- Accumulation of air pollutants

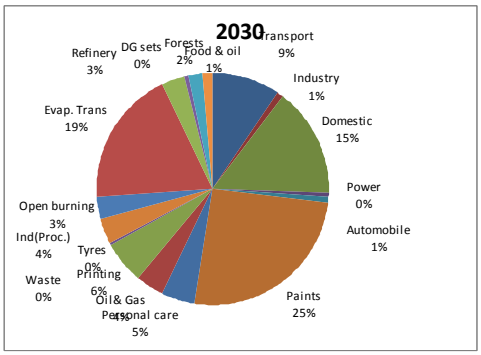
Sources of indoor air pollutants

- Combustion activity
- Furniture
- Chemicals
- Building materials
- Food & Water
- Smoking activity
- Outdoor air pollution



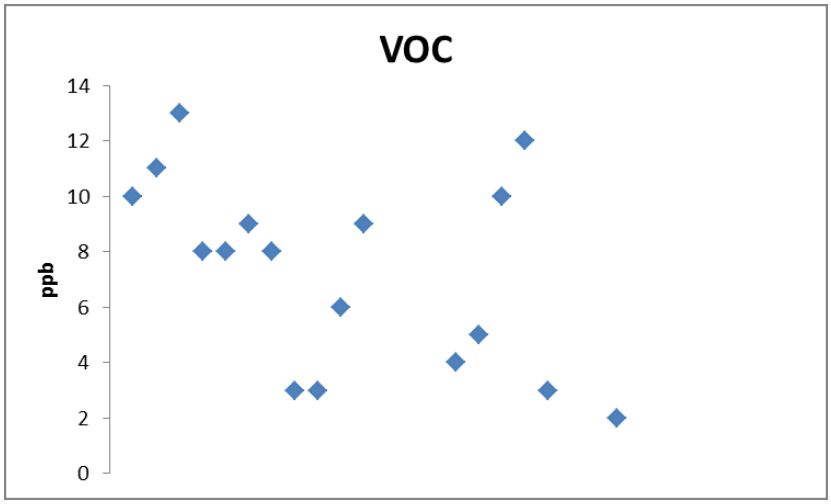
NMVOC emissions in India





- In 2010, paints contribute to 8% NMVOC emissions in India.
- In next 20 years, the share is about to grow to 25%.
- This has implications over outdoor and indoor air quality.

TERI measurements in office buildings



IAP and health

Pollutant	Health effects
NO_2	Type: Immediate: Causes: irritation to the skin, eyes and throat, cough etc
CO	Type: : Immediate; Causes: headache, shortness of breath, higher conc. May cause sudden deaths.
VOCs	Type: : Immediate; Causes: Liver, kidney disorders, irritation to the eyes, nose and throat, skin rashes and respiratory problems.
Formaldehyde	Type: : Immediate; Causes: irritation to the eyes, nose and throat, fatigue, headache, skin allergies, vomiting etc.
RSPM	Type: : Cumulative, Causes: Respiratory Illness (upper and lower), Acute (Asthma) and chronic (COPD), Lung cancer,
Pesticides	Type: : Immediate; Causes: Skin diseases
SO_2	Type: : Immediate; Causes: lung disorders and shortness of breath
Asbestos	Type: : Cumulative; Causes: Lung cancer
O_3	Type: : Immediate; Causes: eyes itch, burn, respiratory disorders, lowers our resistance to colds and pneumonia.

Sick building syndrome (SBS)

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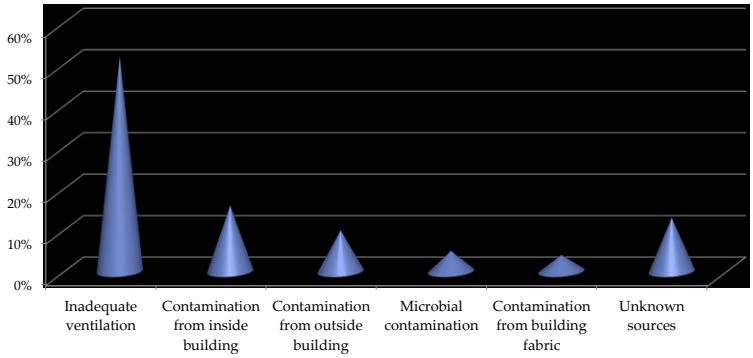
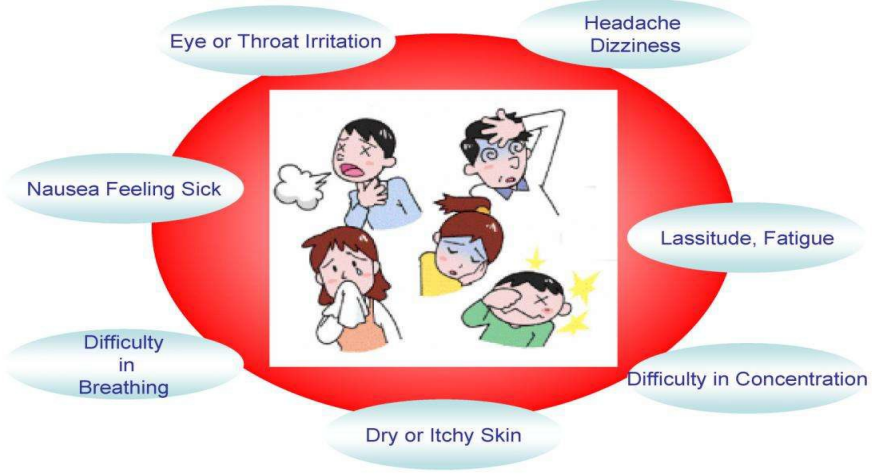
Building occupants experience acute health and comfort effects which is linked to time spent in the building, but no specific illness or cause identified. Not a clinically diagnosable disease.

Causes of SBS



EPA

Symptoms of SBS



Effect of temperature, RH and CO2

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Temperature

- Has a direct impact on **perceived comfort** and, in turn, **concentration** and **productivity**
- As per **ASHRAE Standard 55**, the recommended temperature ranges perceived as "**comfortable**" are 73 to 79°F(22.8 to 26.1°C) in the summer and 68 to 74.5°F (20.0 to 23.6°C) in the winter.

Relative humidity

- Too high RH can contribute to the growth and spread of biological contaminants and people think it feels 'sticky'
- RH below 25% - increased discomfort and drying of skin and mucous membrane
- As per **ASHRAE Standard 55**, indoor humidity levels should be maintained between **30 percent and 65 percent** for **optimum comfort**.

CO_2

- **Provides good indication of ventilation rates**
- **Generated in indoor primarily through human metabolism**
- **CO_2 build up in indoor is attributed to in-efficient or non-functioning of ventilation system**
- **As per ASHRAE, above 1000ppm CO_2 –requires adjustment of building's ventilation system**
- **Building shows SBS symptoms if CO_2 concentration > 1000 ppm**

IAQ standards and guidelines

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1. Canada
2. Singapore
3. UK
4. Germany
5. USA
6. China
7. India??

Summary of guidelines

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Parameter	WHO guideline value*	ASHRAE**	OSHA***	NAAQS/EPA (2000)****
PM_{10}	50µg/m³ (24-hr mean)	--	15mg/m³ (total)	150µg/m³ (24-hr)
$PM_{2.5}$	25µg/m³ (24-hr mean)	--	5mg/m³(resp.)	65µg/m³ (24-hr)
SO_2	20µg/m³ (24-hr mean)	--	5ppm (8-hr)	140ppb (24-hr) 75ppb (1-yr)
NO_2	200µg/m³ (1-hr) 40µg/m³(annual mean)	--	5ppm (8-hr)	53ppb (annual) 100ppb (1-hr)
CO	10ppm (8-hr)	9ppm (8-hr)	50ppm (8-hr)	9ppm (8-hr)
CO_2	--	1000ppm (8-hr)	5000ppm	
Humidity	--	30% - 65%	--	
Temperature	--	68°F – 74.5°F (20-23.6°C)(winter) 73°F – 79F° 22.8-26.1°C)(summer)	--	

*** Occupational Safety and Health Administration Permissible Exposure Limit — this level is a time-weighted average and is an enforceable standard that must not be exceeded during any eight-hour work shift of a 40-hour work week

** ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers Inc.) Standard 55

* WHO air quality guidelines global update 2005 and WHO guideline value for the "classical" air pollutants (WHO 1999a

**** The National Ambient Air Quality Standards (NAAQS) were developed by the U.S.

Environmental Protection Agency (EPA) under the Clean Air Act (last amended in 1990). These enforceable standards were developed for outdoor air quality, but they are also applicable for indoor air contaminant levels. The concentrations are set conservatively in order to protect the most sensitive individuals, such children, the elderly, and those with asthma.

Comparison of Regulations & Guidelines Pertinent to Indoor Environments

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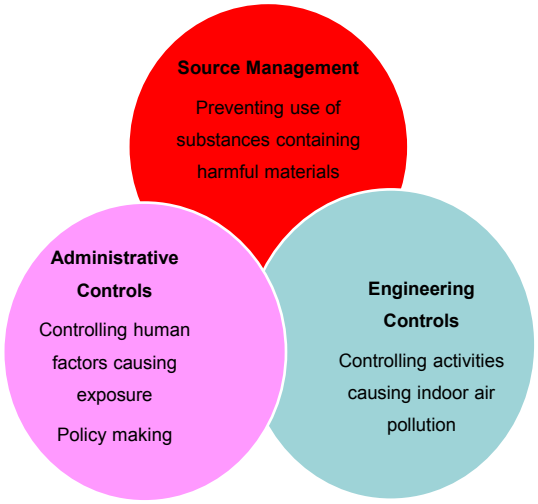
	Enforceable and/or Regulatory Levels			Non-Enforced Guidelines and Reference Levels			
	NAAQS/EPA (Ref. B-4)	OSHA (Ref. B-5)	MAK (Ref. B-2)	Canadian (Ref. B-8)	WHO/Europe (Ref. B-11)	NIOSH (Ref. B-13)	ACGIH (Ref. B-1)
Carbon dioxide		5,000 ppm	5,000 ppm 10,000 ppm [1 h]	3,500 ppm [L]		5,000 ppm 30,000 ppm [15 min]	5,000 ppm 30,000 ppm [15 min]
Carbon monoxide [c]	9 ppm [g] 35 ppm [1 h] [g]	50 ppm	30 ppm 60 ppm [30 min]	11 ppm [8 h] 25 ppm [1 h]	90 ppm [15 min] 50 ppm [30 min] 25 ppm [1 h] 10 ppm [8 h]	35 ppm 200 ppm [C]	25 ppm
Formaldehyde[h]		0.75 ppm 2 ppm [15 min]	0.3 ppm 1 ppm[i]	0.1 ppm [L] 0.05 ppm [L] [b]	0.1 mg/m³ (0.081 ppm) [30 min][p]	0.016 ppm 0.1 ppm [15 min]	0.3 ppm [C]
Lead	1.5 µg/m³ [3 months]	0.05 mg/m³	0.1 mg/m³ 1 mg/m³ [30 min]	Minimize exposure	0.5 µg/m³ [1 yr]	0.1 mg/m³ [10 h]	0.05 mg/m³
Nitrogen dioxide	0.05 ppm [1 yr]	5 ppm [C]	5 ppm 10 ppm [5 min]	0.05 ppm 0.25 ppm [1 h]	0.1 ppm[1 h] 0.004 ppm [1 yr]	1 ppm [15 min]	3 ppm 5 ppm [15 min]
Ozone	0.12 ppm [1 h][g] 0.08 ppm	0.1 ppm	j	0.12 ppm [1 h]	0.064 ppm (120 µg/m³) [8 h]	0.1 ppm [C]	0.05 ppm[k] 0.08 ppm[l] 0.1 ppm[m] 0.2 ppm[n]
Particles[c] <2.5 µm MMAD[d]	15 µg/m³[1 yr][o] 65 µg/m³ [24 h][o]	5 mg/m³	1.5 mg/m³ for <4 µm	0.1 mg/m³ [1 h] 0.040 mg/m³ [L]			3 mg/m³
Particles[c]<10 µm MMAD[d]	50 µg/m³[1 yr][o] 150 µg/m³ [24 h][o]		4 mg/m³				10 mg/m³
Radon	See Table B-2[f]				2.7 pCi/L [1yr]		
Sulfur dioxide	0.03 ppm [1 yr] 0.14 ppm [24 h] [g]	5 ppm	0.5 ppm 1 ppm [i]	0.38 ppm [5 min] 0.019 ppm	0.048 ppm [24 h] 0.012 ppm [1 yr]	2 ppm 5 ppm [15 min]	2 ppm 5 ppm [15 min]
Total Particles[c]		15mg/m³					

*Unless otherwise specified, values are given in parts per million (ppm)
*Where no time is specified, the averaging time is eight hours.

Mitigation strategies



1. Source management

- Lot of indoor air pollutants directly linked to items of daily use
  - **Cleaning items (low VOC products)**
  - **Fuels and cook-stoves (Clean fuels)**
  - **Building materials and furnishings (low VOC products)**
- Building occupants may be the source of pollutants - perfumes or colognes, cigarette smoke (OSHA, 2011)

2. Administrative controls

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Work schedules	• Eliminate or reduce the amount of time a worker is exposed to a pollutant • Reduce the amount of chemicals being used by or near workers • Control the location of chemical use
Education and Awareness	• Inform about the sources and effects of pollutants • Inform about proper operation of ventilation system • Awareness about clean alternatives, mitigation solutions
Housekeeping	• Prevent dirt from entering the environment • Dispose garbage timely • Store food properly • Choose cleaning products, methods that minimize introduction of pollutants into the building

3. Engineering controls

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- HVAC (heating, ventilation, and air conditioning systems) control and management
- IAQ improving plants
- Air purifiers

Interventions required

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- National standards and/or guidelines on indoor air quality
- Verifying claims of products – certifications
- Evaluation of important existing buildings
- GRIHA Rating evaluation to be included in building projects
- Improving outdoor air quality will help in improving IAQ also.

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Thank you