Urban and Indoor Air Quality

1. Urban Air Quality

   Pollutants & Indices

2. Indoor Air Quality

   Radon, VOCs, SVOCs, combustion, PM

3. Air Exchange Rates

China’s pollution puts a dent in its economy

NO2
O3
PM
SO2
CO

Bejing airport at noon
800 flights cancelled

"You literally can see the smog inside a large enough building. The airport terminal, the hotel lobby are large enough that you can no longer see clearly across the room.” John Williamson

Delhi world's most polluted city

TOXIC India slips to 155 among 178 countries on environment performance index, Capital pips Beijing to be city with dirtiest air

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NEW DELHI: It's no surprise that pollution is a perpetual problem in India. But it's definitely disheartening to hear that India has slipped 32 ranks in the global Environment Performance Index (EPI) 2014 to rank a lowly 155 and its capital Delhi has earned the dubious tag of being the world's most polluted city.

A comparative study of 178 countries on nine environmental parameters released earlier this month by the US-based Yale University shows that one of the world's fastest growing economies is a disaster on the environmental front.

What's worse, India's pollution levels could be playing havoc with the health of its citizens. "A bottom performer on nearly every policy issue included in the 2014 EPI, with the exception of forests, fisheries and water resources, India's performance lags most notably in the protection of human health from environmental harm," said a statement issued by Yale.

The study described India's air pollution as the worst in the world, tying with China in terms of the proportion of population exposed to average air pollution levels exceeding World Health Organisation (WHO) thresholds.

A deeper look at the data gathered by a Nasa satellite showed that Delhi had the highest particulate matter (PM) 2.5 pollution levels followed by Beijing. Delhi, with 810 million registered vehicles, has repeatedly beaten the Chinese capital on particulate matter pollution.

The high PM2.5 pollution caused by high vehicle density and industrial emissions is the reason for the dense smog that has been engulfing Delhi during the winter months in the last few years, with adverse health implications. And while Beijing's infamous smog has hogged headlines and prompted government action, even led to the announcement of rewards for cutting back on pollution, the dangers in Delhi have been largely ignored.

According to a study by the Harvard International Review, every two in five persons in Delhi suffer from respiratory ailments. The Lancet's Global Health Burden 2013 report termed air pollution the sixth biggest human killer in India. The WHO last year termed air pollution carcinogenic.

Particles smaller than 2.5 microns in diameter (PM2.5 in shorthand) are fine enough to lodge deep in human lung and blood tissue and cause diseases ranging from stroke to lung cancer, the Yale study said.

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» **BREATHING POISON IN DELHI, P6**

CAPITAL BREATHES UNEASY

Tops global cities with worst air pollution

1. **NEW DELHI**, INDIA
2. **BEIJING**, CHINA
3. **CAIRO**, EGYPT
4. **SANTIAGO**, CHILE
5. **MEXICO CITY**, MEXICO

INDIA SLIPS IN RANK TOO

Is second-most polluted among its neighbours

	2014	2010
Bangladesh	169	139
India	**155**	**123**
Pakistan	148	125
Nepal	139	38
China	118	121
Sri Lanka	69	58

- **Ranking based on 9 parameters:** Health impact, air pollution, water & sanitation, water resources, agriculture, fisheries, forests, biodiversity & habitat, climate change & energy
- On list of 178 countries, India ranks as low as 174 on air pollution, 127 on health impact

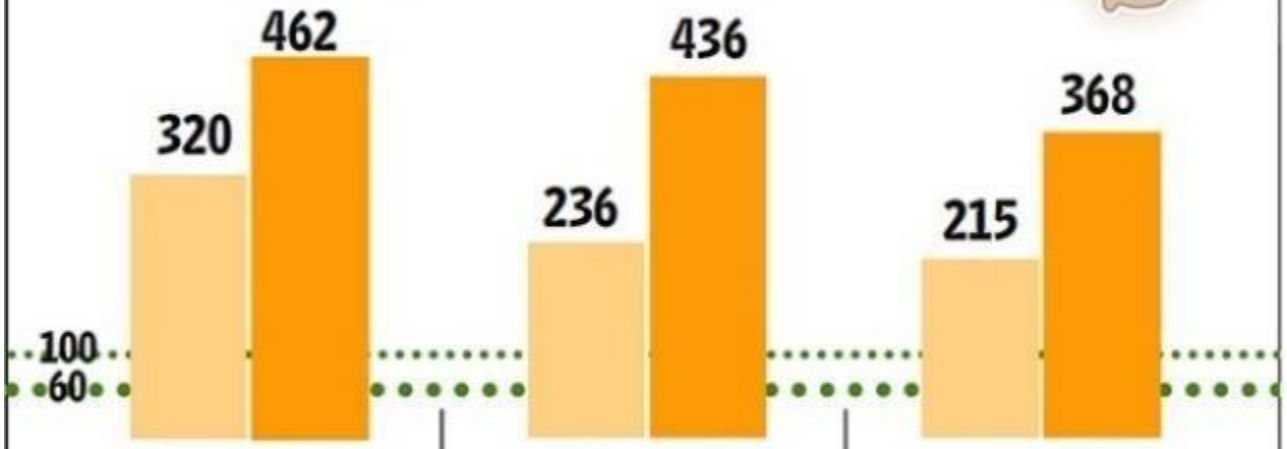
5 CLEANEST COUNTRIES: Switzerland, Luxembourg, Australia, Singapore and Czech Republic

DELHI'S THREE MOST POLLUTED AREAS

Highest level in micrograms per cubic metres

PM2.5 (Particulate matter 2.5 micron size)

PM10 (Particulate matter 10 micron size)



1 Anand Vihar

REASON: Anand Vihar ISBT is the hub for inter-state roadway buses which run on petrol and diesel.

2 RK Puram

REASON: Area is connected to both ring road from sectors 12 and 2. After 10pm it opens for heavy vehicles.

3 Punjabi Bagh

REASON: Location near Haryana border also a disadvantage. Residents say most homes have more than one vehicle.

US EPA Air Quality Index

O_3

PM

CO SO_2

NO_2

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

I = Air Quality Index
C = pollutant concentration
C_{low} = conc breakpoint < C
C_{high} = conc breakpoint > C
I_{low} = index breakpoint for C_{low}
I_{high} = index breakpoint for C_{high}

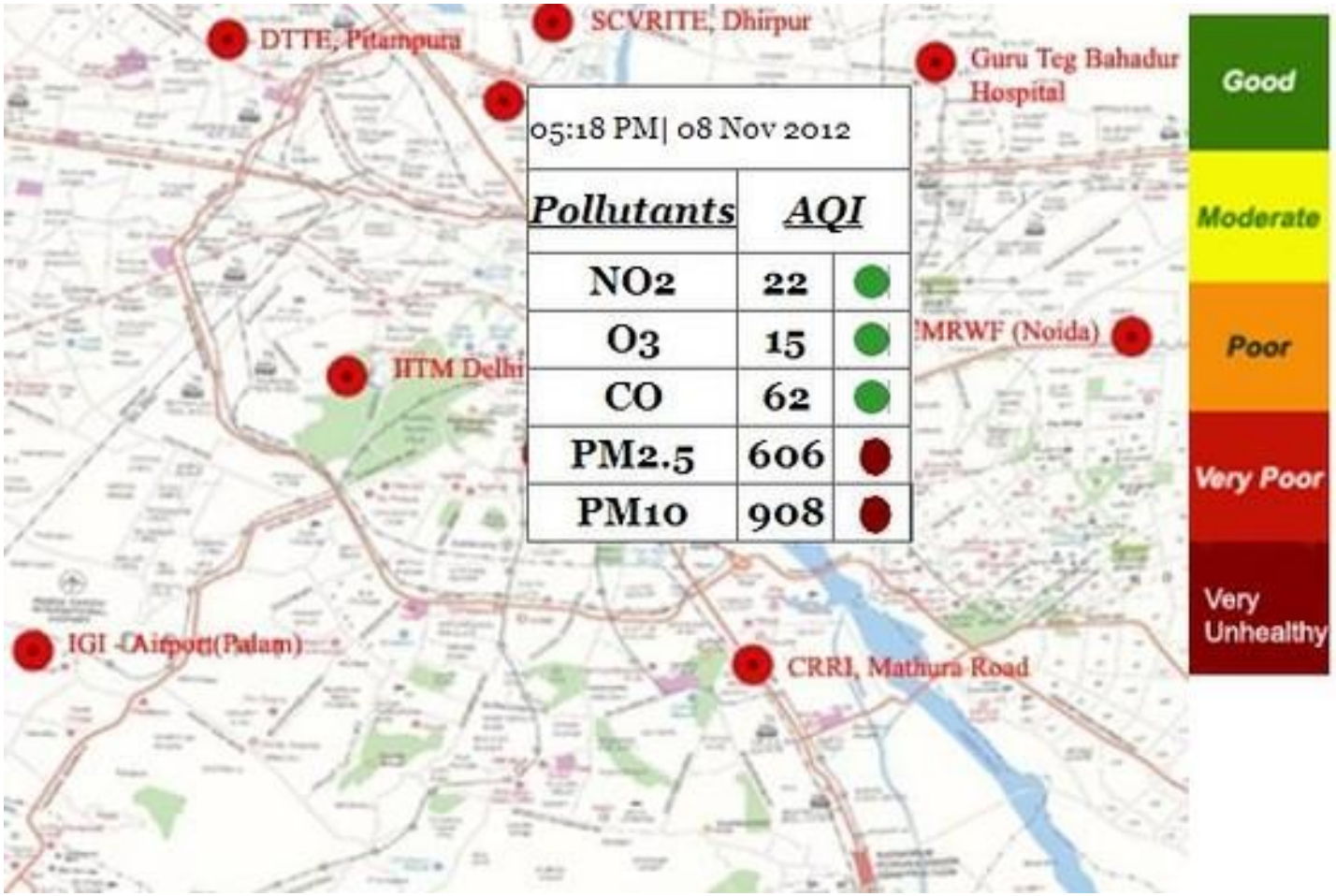
EPA's breakpoint table for PM2.5

Category	PM2.5 (ug/m^3)	Index Value
Good	0 – 12.0	0 - 50
Moderate	12.1-35.4	51-100
Unhealthy*	35.5-55.4	101-150
Unhealthy	55.5-150.4	151-200
Very unhealthy	150.5-250.4	201-300
Hazardous	250.5-350.4	301-400
Hazardous	350.5-500.4	401-500

http://www.airnow.gov/index.cfm?action=resources.conc_aqi_calc

Real-time AQI – China Air

AQI New Delhi



Multi-Pollution Index (MPI)

$$MPI = (1/n) \left[\Sigma \{(AC_i - GC_i)/GC_i\} \right]$$

where

AC_i is actual concentration for pollutant i

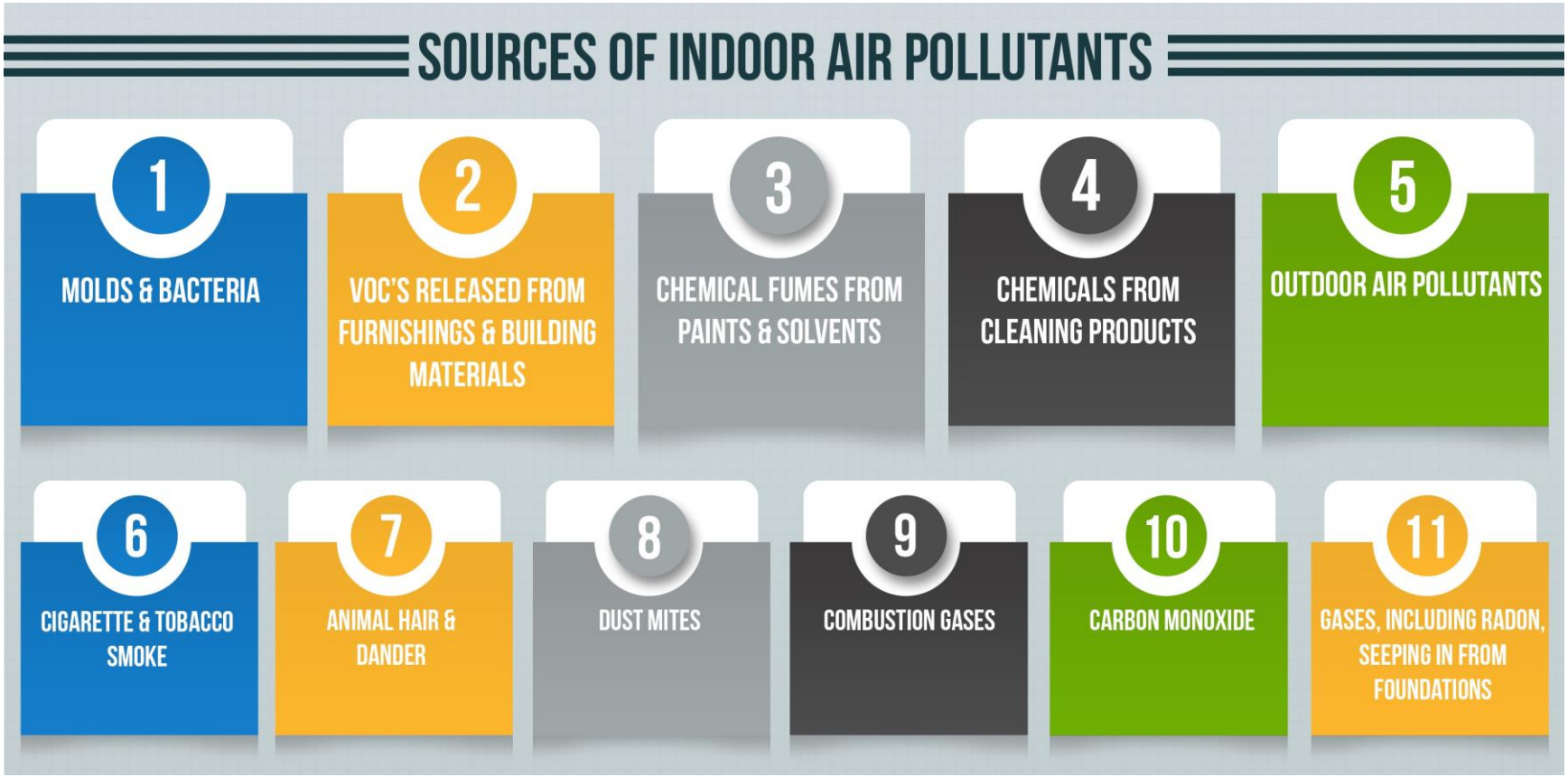
and

GC_i is guideline value for pollutant i

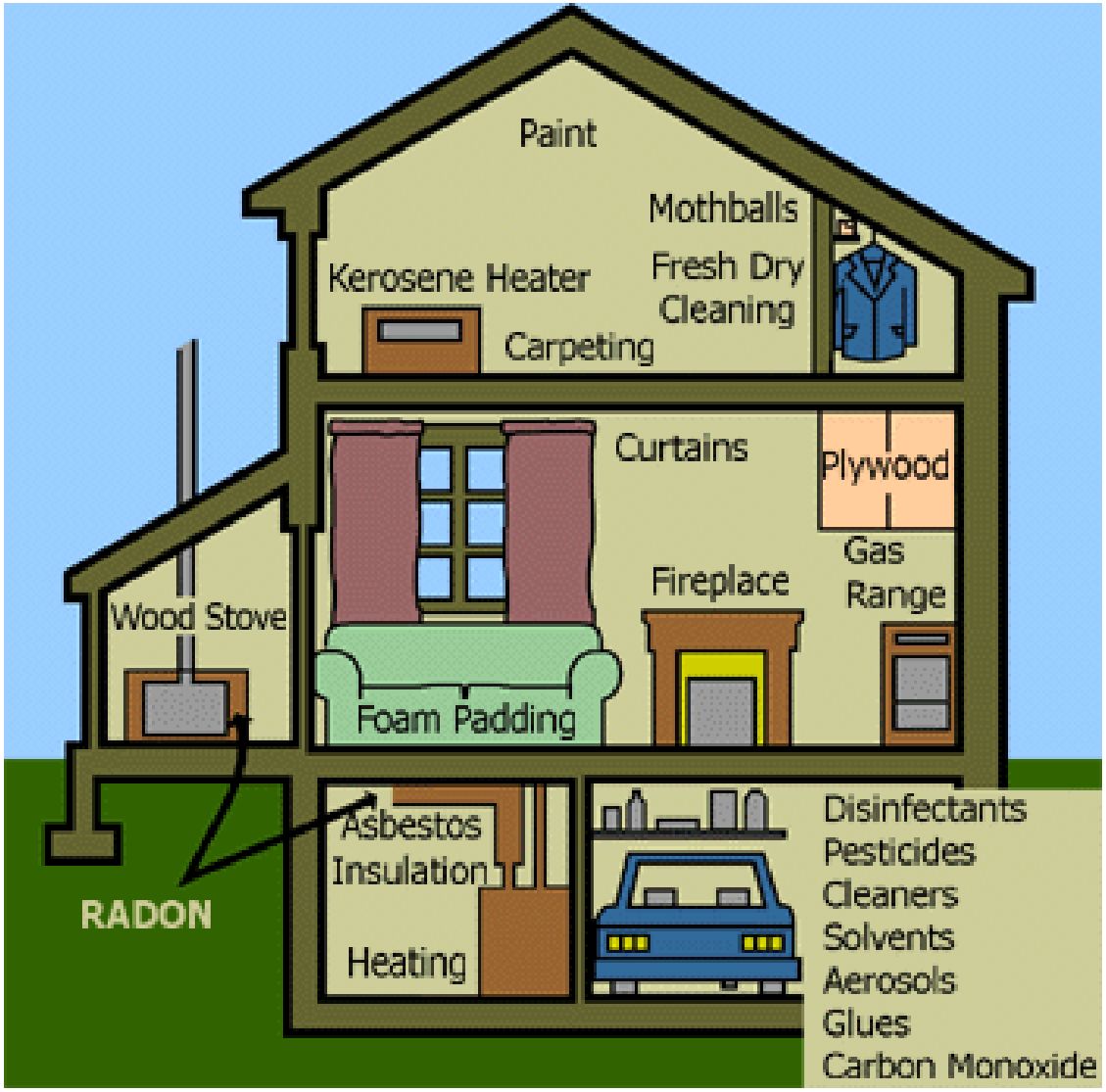
and

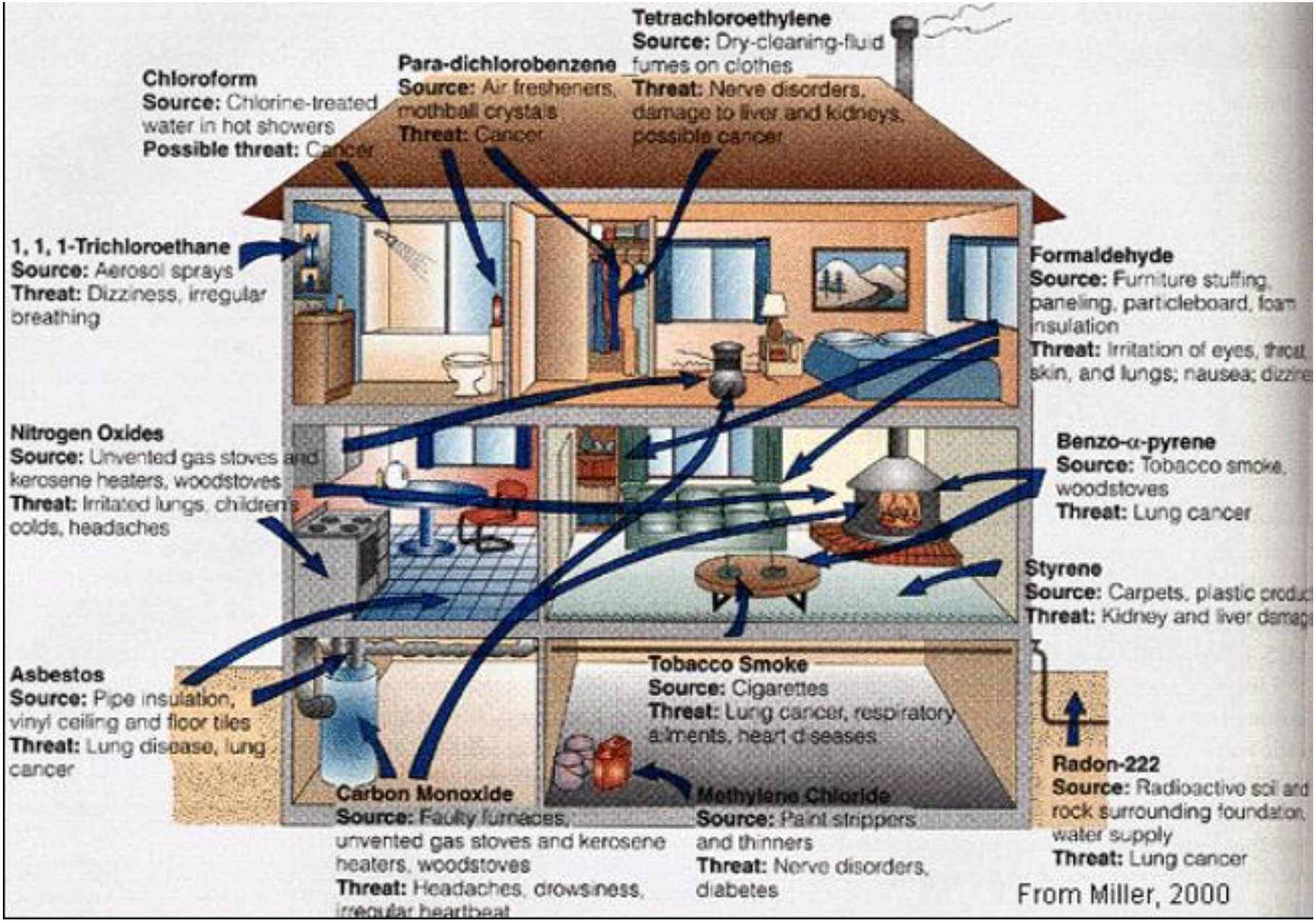
n is number of pollutants used in the index

2. Indoor Air


SOURCES OF INDOOR AIR POLLUTANTS
1
MOLDS & BACTERIA
2
VOC'S RELEASED FROM FURNISHINGS & BUILDING MATERIALS
3
CHEMICAL FUMES FROM PAINTS & SOLVENTS
4
CHEMICALS FROM CLEANING PRODUCTS
5
OUTDOOR AIR POLLUTANTS
6
CIGARETTE & TOBACCO SMOKE
7
ANIMAL HAIR & DANDER
8
DUST MITES
9
COMBUSTION GASES
10
CARBON MONOXIDE
11
GASES, INCLUDING RADON, SEEPING IN FROM FOUNDATIONS

Sources


Paint
Mothballs
Kerosene Heater
Fresh Dry Cleaning
Carpeting
Curtains
Plywood
Gas Range
Fireplace
Wood Stove
Foam Padding
Asbestos Insulation
Heating
RADON
Disinfectants
Pesticides
Cleaners
Solvents
Aerosols
Glues
Carbon Monoxide



From Miller, 2000

Indoor air quality

- Composition and exchange of outdoor air
- Indoor materials (construction, consumer goods)
- Indoor activities (cooking, heating, smoking)

→CO, CO_2, NOx, VOCs, PM, Rn

Specific S/VOCs of concern: H_2CO, BTEX, halocarbons, PAHs, PBDEs, PCBs, phthalates

3. Air Changes per Hour (ach)

Older homes and buildings ach ~ 1 hr^{-1}

Newer homes and buildings ach ~ 0.1-0.5 hr^{-1}

(i.e., one air exchange every 10 – 2 hrs)

'ach' is a first order rate constant ($time^{-1}$) → k_e

Residence time of indoor air ($\tau_e = 1/k_e$)