Indoor Air Pollution

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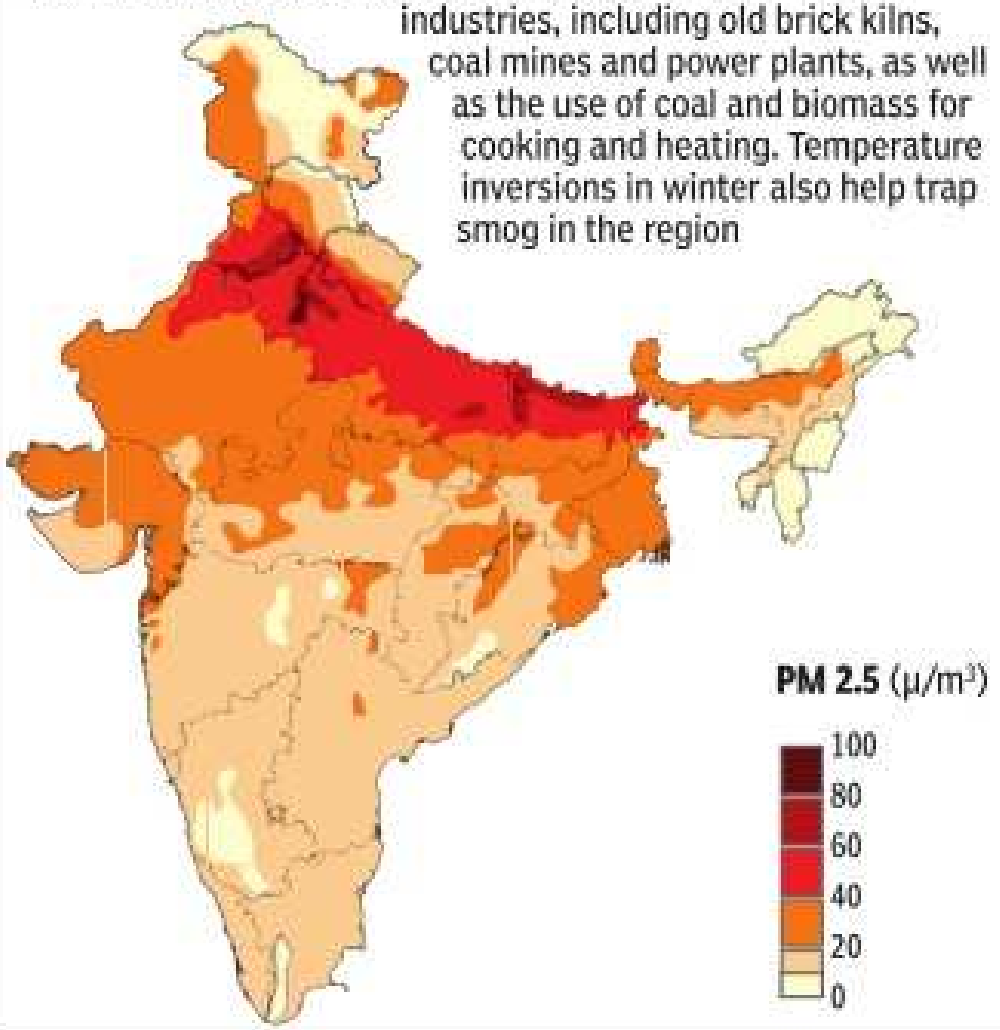
AMBIENT AIR POLLUTION

This satellite-based map from a 2012 study shows ambient levels of fine particulate matter, or PM2.5, across India. Pollution tends to be higher in north India, especially in the Indo-Gangetic basin, thanks to a combination of large population, lots of industries, including old brick kilns, coal mines and power plants, as well as the use of coal and biomass for cooking and heating. Temperature inversions in winter also help trap smog in the region



HOUSEH
POLLUTI
BIG KILL

INDIA

- Exposure to o
and indoor air p
contributed to €
1.2 million de
in 2017 in India
- **Around 84€**
million people
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household air pollution

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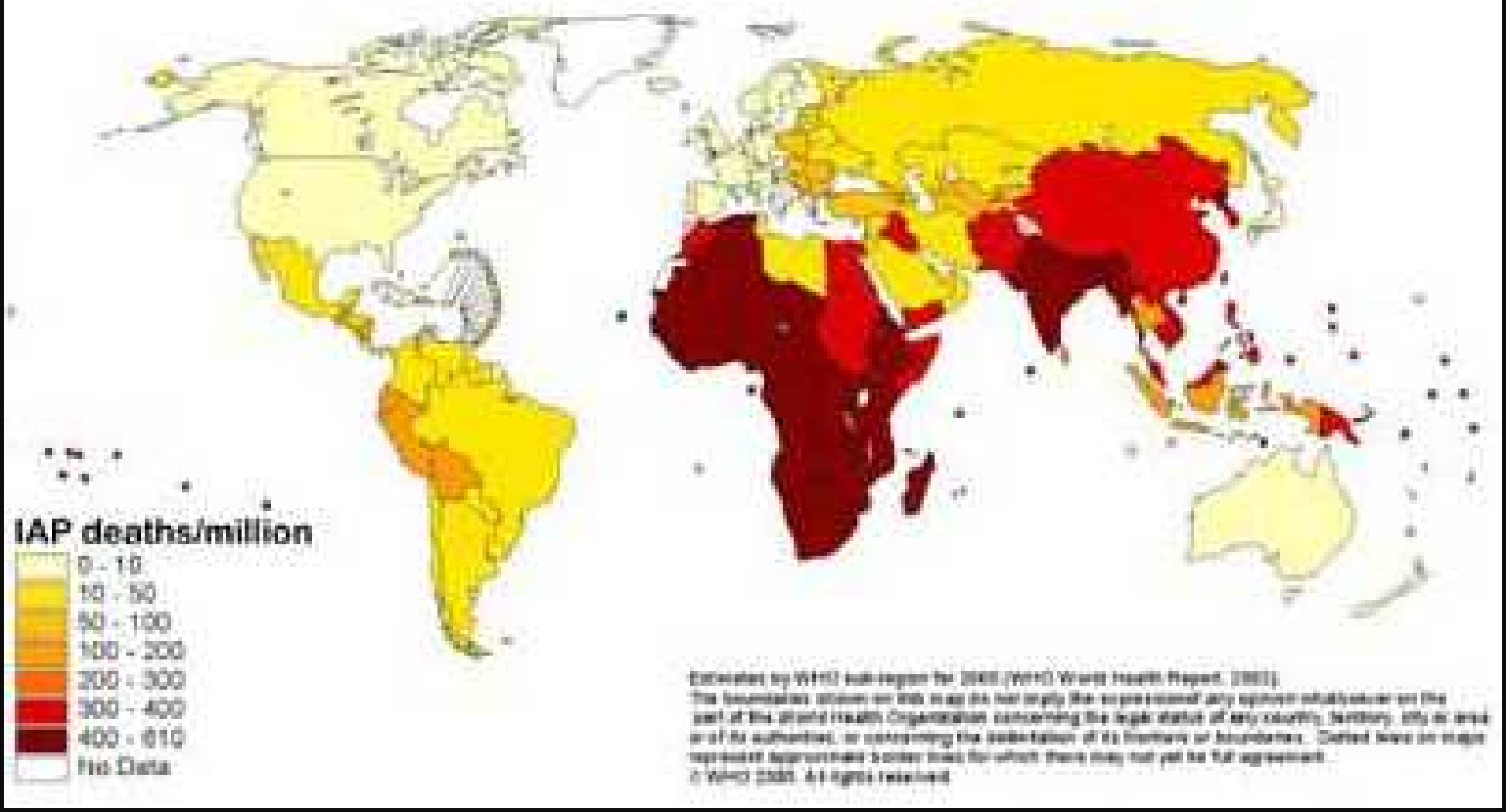
together accounted for
total global pollution

e burden attributable to
s from chronic
e diseases

Introduction

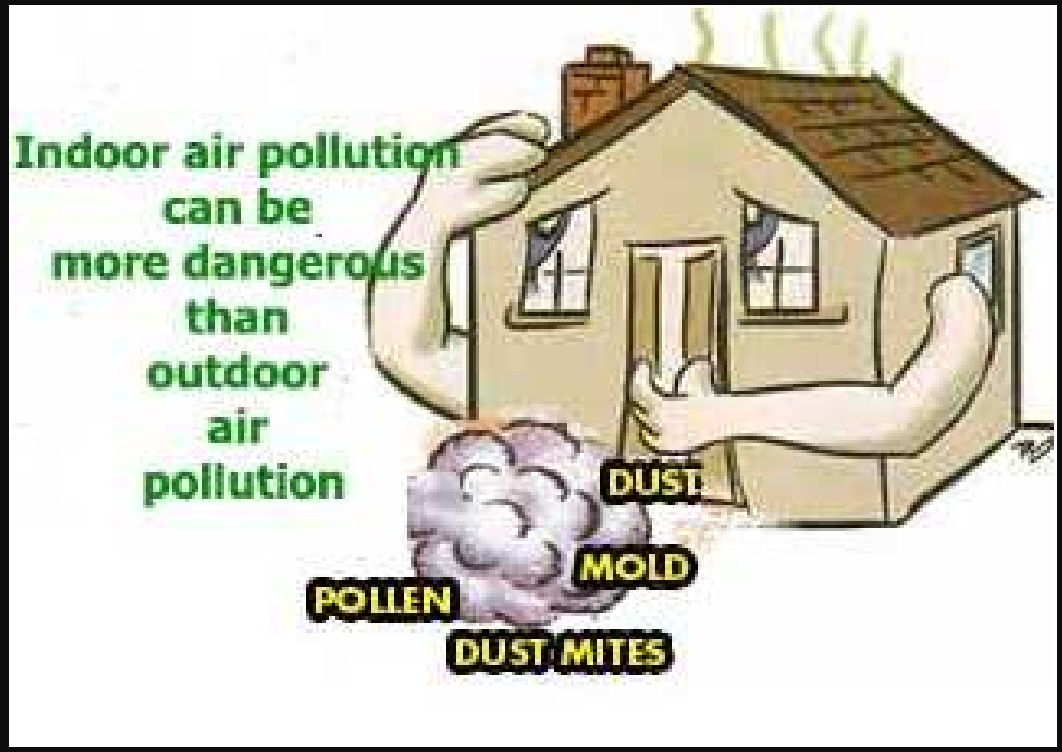
- *Although pollutant concentrations vary significantly from building to building, the levels of some common air pollutants often are greater indoors than outdoors.*
- *Since most people spend more time (70-98%) indoors than outdoors, exposure to indoor air pollutants is an important environmental problem.*
- *Levels of 11 common pollutants generally are 2-5 times higher inside homes and commercial buildings than they are outdoors.*
- *Pollution levels inside cars in traffic-clogged urban areas can be up to 18 times higher than outside levels*
- *Indoor air pollution is a serious problem in developed areas of all countries, mostly because of chemicals used in building materials and products*

Deaths from indoor smoke from solid fuels



Indoor Air Pollution is the term used to describe the amount of contaminants in the air inside a building from sources such as

cigarette smoking,
fuel combustion for heating or cooking,
certain wallboards, carpets, or insulation as well as the geology of the area (radon in soil or rocks beneath the structure)



Indoor Air Pollution--Developed World

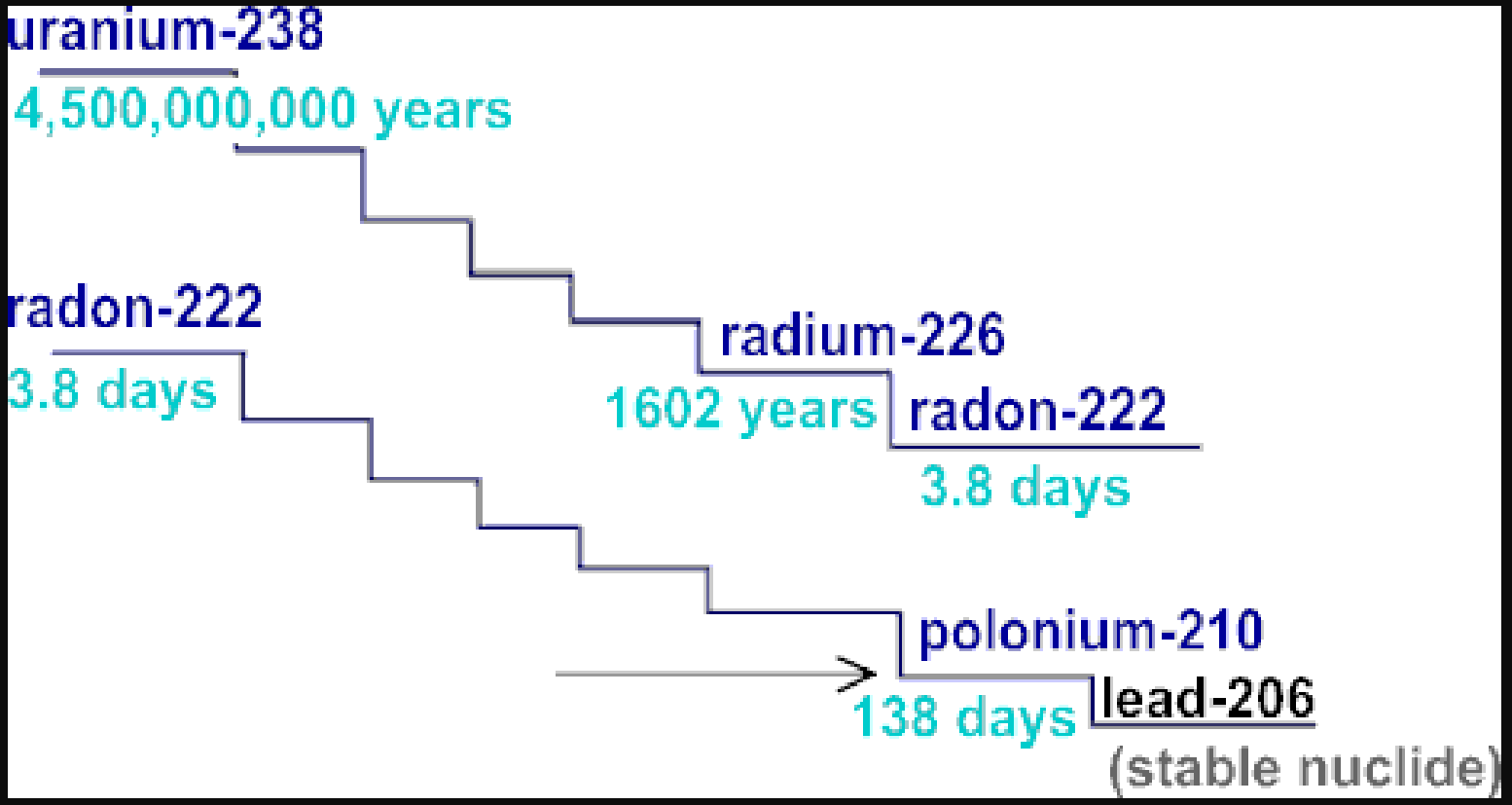
According to the EPA, the 4 most dangerous indoor air pollutants in developed countries are:

- *tobacco smoke*
- *formaldehyde emitted from many building materials and various household products*
- *radioactive radon-222 gas, which can seep into houses from underground rock deposits*
- *very small (ultrafine) particles of various substances in emissions from motor vehicles, coal-burning facilities, wood burning, and forest and grass fires*

What's radon

Radon is a naturally-occurring radioactive but inert gas part of the decay chain that starts with uranium and ends with plumbum .

Uranium-238 Decay Chain

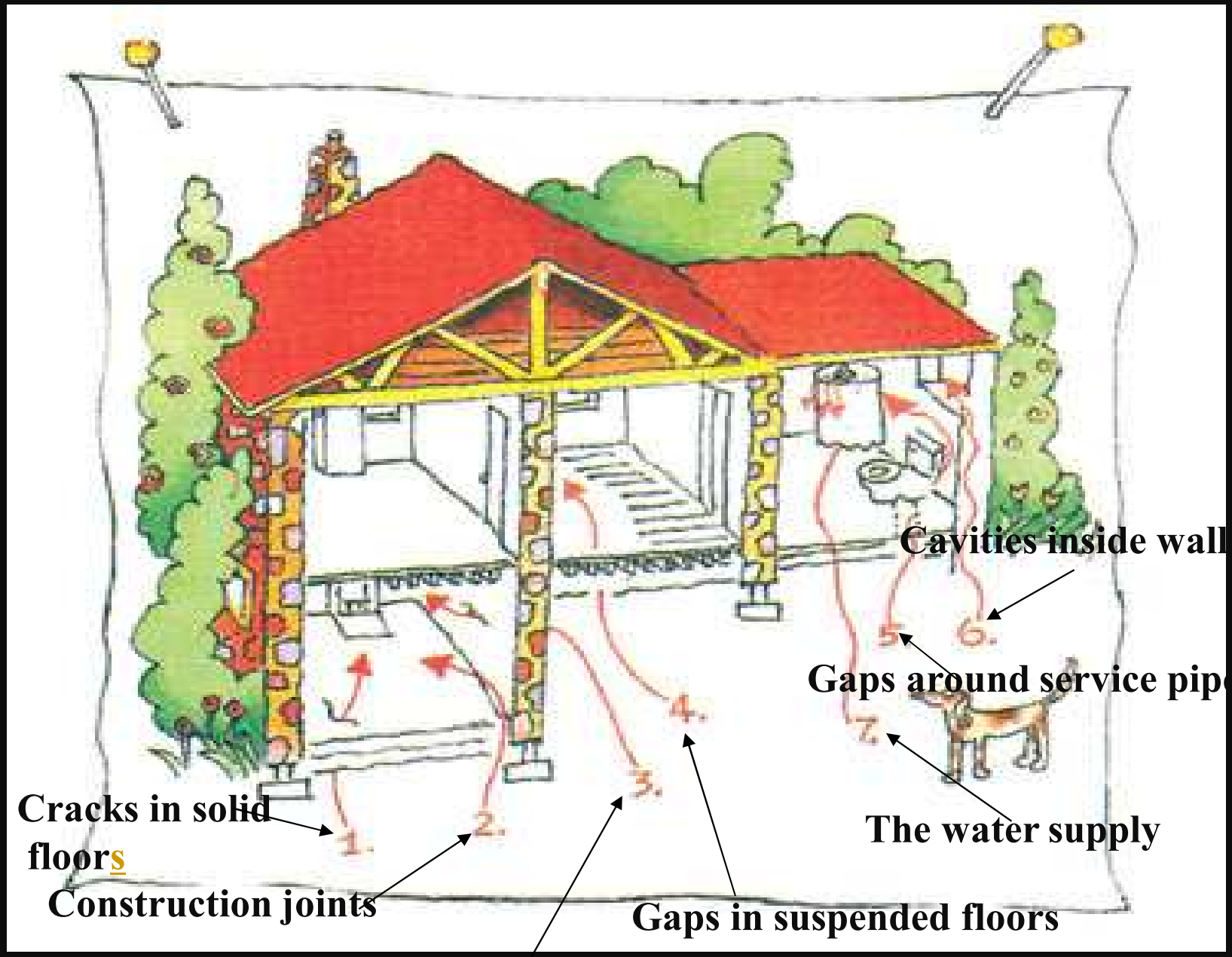


Where does radon come from?

- *Natural source:*
  - *Earth and rock beneath home;*
  - *Well water;*
  - *Outdoor air;*

- *Artificial source:*
  - *Daily life materials: leather; low density plastic (like plastic bags, etc.); paints*
  - *Building materials: gypsum board (sheetrock), concrete block, mortar, sheathing paper (tarpaper), wood paneling, and most insulation.*

How does radon get inside buildings?



Soil

- *How much of radon reaches the surface depends on the uranium content of the underlying earth materials together with their depth and permeability*
- *Enter the lowest level of a building using whatever pathways are available.*
- *For structures with basements or slab-on-grade foundations, the entry points include*
  - *Cracks and pores in floor slabs, walls, and floor-wall joints;*
  - *Openings around sump pumps, floor drains, and pipes penetrating floors and walls.*
  - *Structures with a crawl space between the ground and lowest floor level may be less vulnerable to radon, which tends to escape to the outside air when appropriate vents are installed, but can still admit some of the gas through cracks in the flooring*

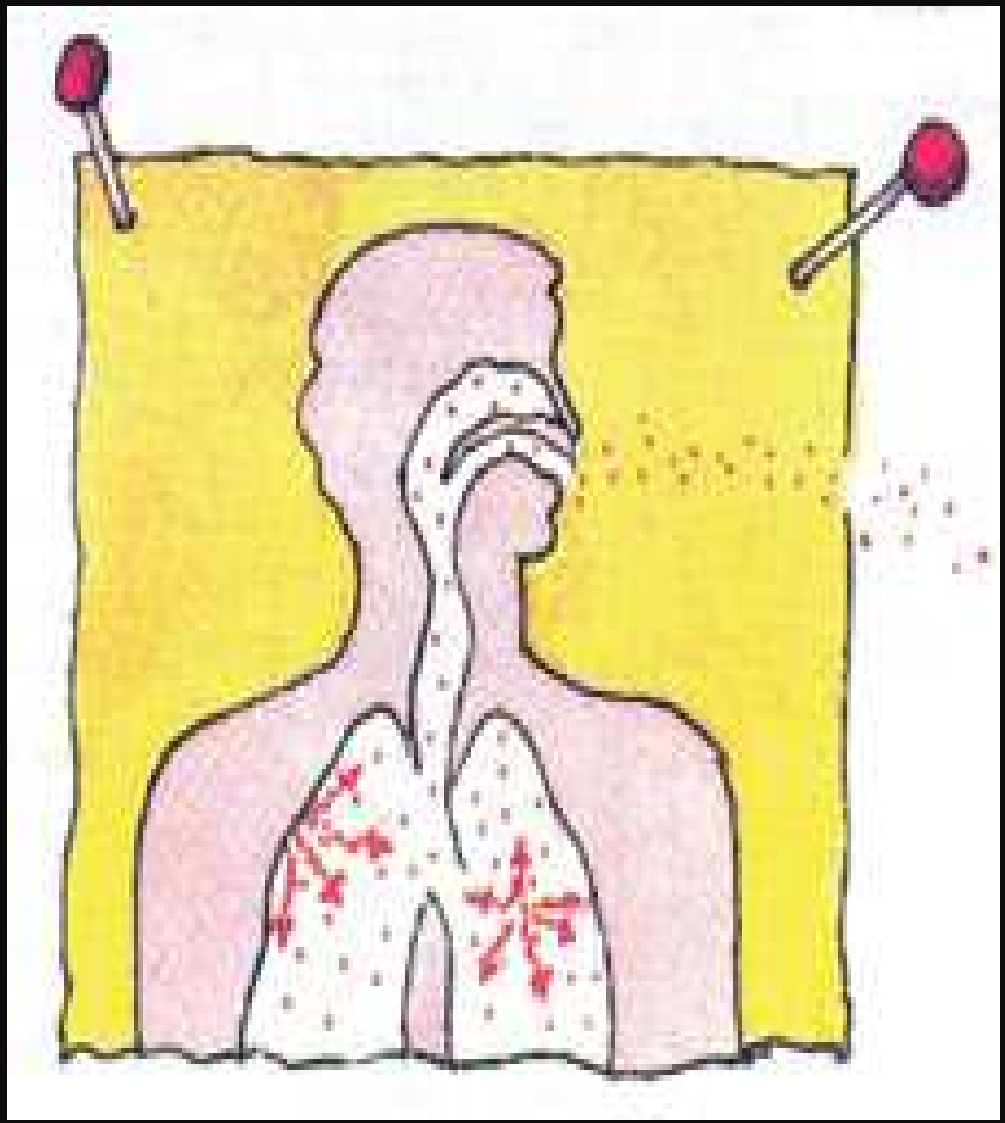
Water

- *This is mainly true for houses in which ground water is used as the main water supply.*
- *Small public water works and private domestic wells often have closed systems and short transit times that do not allow radon to decay to harmless by-products before entering a home.*
- *Once inside, radon escapes from the water to the indoor air as people take showers, wash clothes or dishes, or otherwise use water.*
- *The areas most likely to have problems with radon in ground water are those with have high levels of uranium in the underlying rocks*

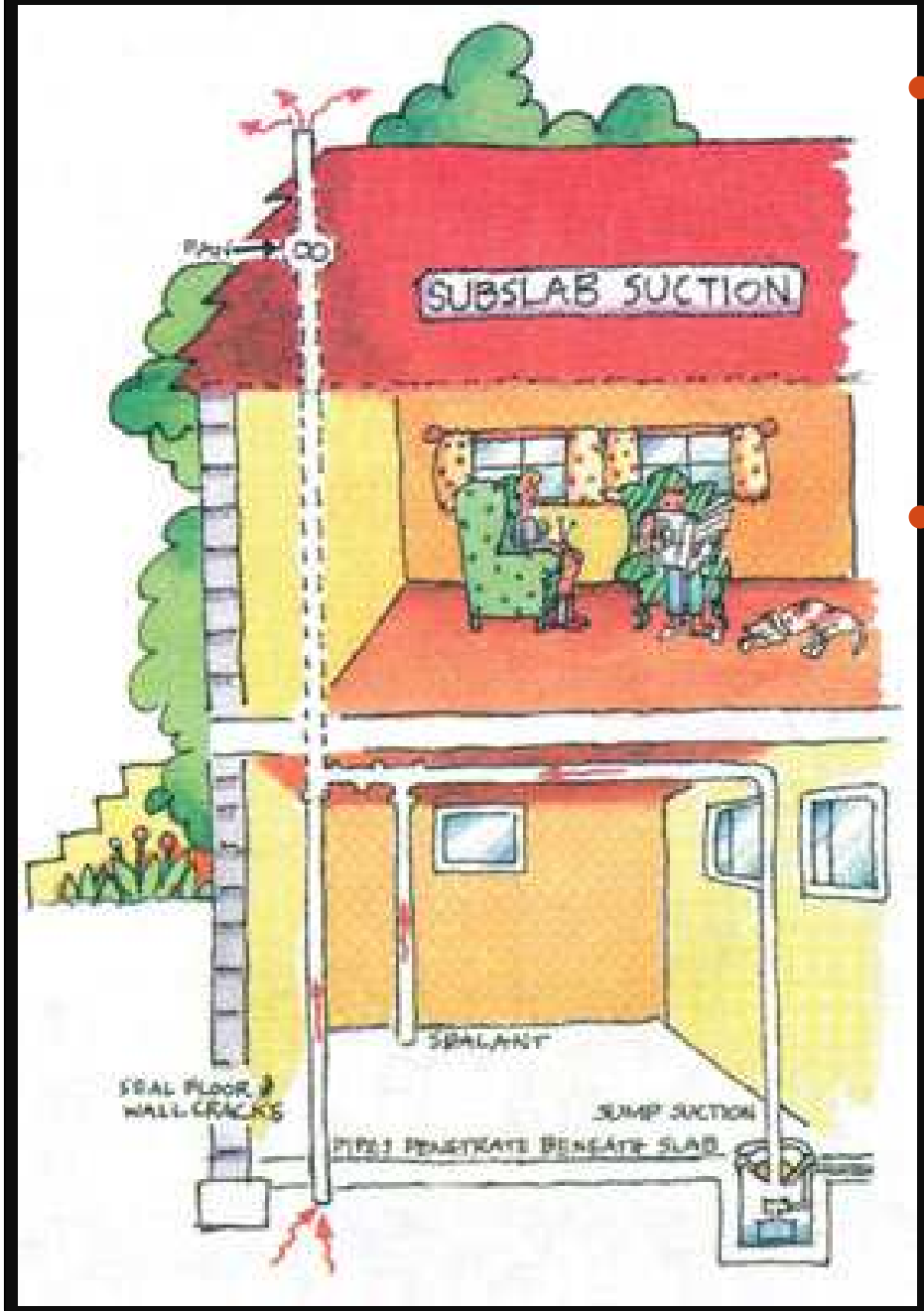
The Risk of Living With Radon

- *Radon gas decays into radioactive particles that can get trapped in lungs when you breathe.*

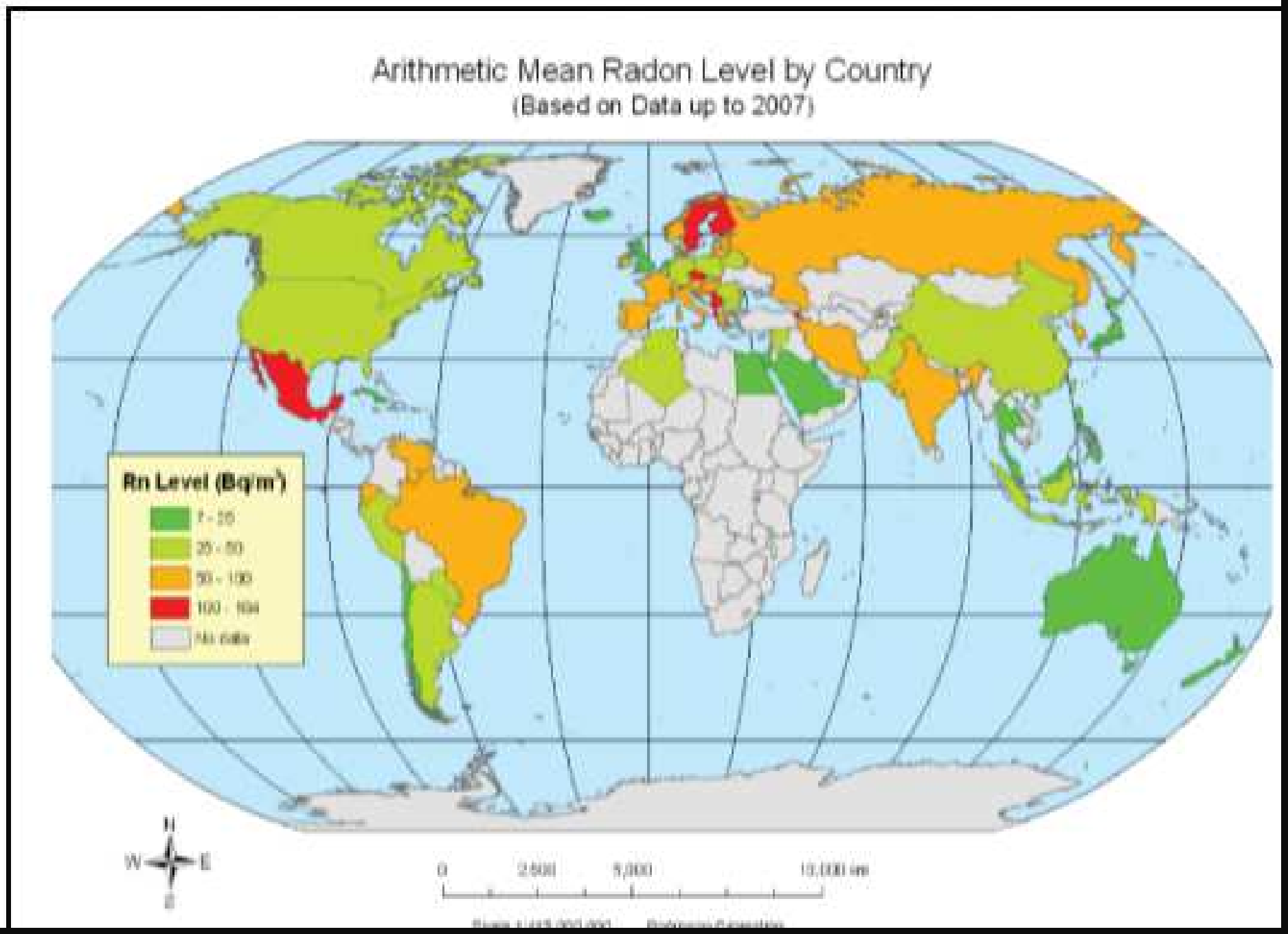
- *As they break down further, these particles release small bursts of energy. This can damage lung tissue and lead to lung cancer over the course of your lifetime.*



How to Lower the Radon Level



- *The most effective way to lower the radon level is set a vent pipe system (SSRRS) and fan, which pulls radon from beneath the house and vents it to the outside.*
- *There are also other ways:*
  - *Test home for radon.*
  - *Careful, while choosing building materials.*
  - *Fill the gaps and cracks in the ground, floor, and walls.*
  - *Pay more attention to the basement and the first floor where there is a high level of radon.*


Arithmetic Mean Radon Level by Country
(Based on Data up to 2007)
Rn Level (Bq/m³)
1 - 25
25 - 50
50 - 100
100 - 184
No data
N
W
E
S
0
2,500
5,000
10,000 km

Major Indoor Pollutants

Pollutant	Source	Health Effects
1, 1, 1-Trichloroethane	*Aerosol sprays*	*Dizziness, breathing irregularities*
Asbestos	*Pipe insulation, ceilings, floor tiles, oven mitts*	*Lung Cancer and asbestosis*
Benzo-a-pyrene	*Tobacco smoke, woodstoves*	*Lung Cancer*
Carbon Monoxide	*Faulty furnaces, cigarette smoke*	*Headache, heartbeat irregularities, death, CO has 250x affinity for hemoglobin than O_2*

http://www.metricmind.com/ac_honda/main.htm

"On the plus side there's no evidence of asbestos."

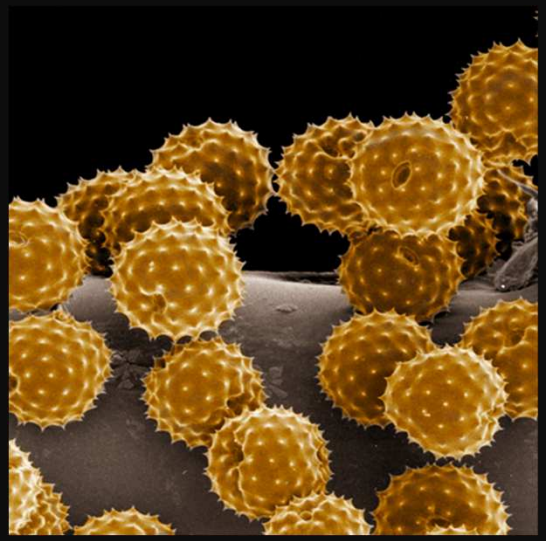
Chloroform	*Pulp and paper mills, water and wastewater plants*	*Cancer*
Formaldehyde	*Paneling, particle board, furniture, carpeting, adhesives*	*Nausea, dizziness, irritation of throat, eyes, and lungs*
Methylene chloride	*Paint strippers and thinner – persistent*	*Nerve disorders, diabetes*
Nitrogen oxides	*Furnaces, stoves, fireplaces and vents*	*Headaches, irritated lungs*
Para-dichlorobenzene	*Air fresheners, mothballs*	*Cancer*

http://www.metricmind.com/ac_honda/main.htm

Radon – 222	*Soil and rock near house foundation, concrete*	*Lung cancer*
Styrene	*Carpets, plastics,*	*Kidney & liver damage*
Tetrachlor-ethylene	*Dry-cleaning fluid*	*Nerve disorders, damage to liver and kidneys, cancer*
Tobacco Smoke	*Cigarettes and other smoking sources*	*Lung cancer and heart disease*
Organic Material (Living Organisms)	*Dust mites, fungal and algal spores, dust (human skin), animal dander, hair, carpet fibers, fur*	*Allergies, coughs, sneezing, eye irritation, sore throats, difficulty breathing*

http://www.electricmind.com/ac_bonds/main.htm

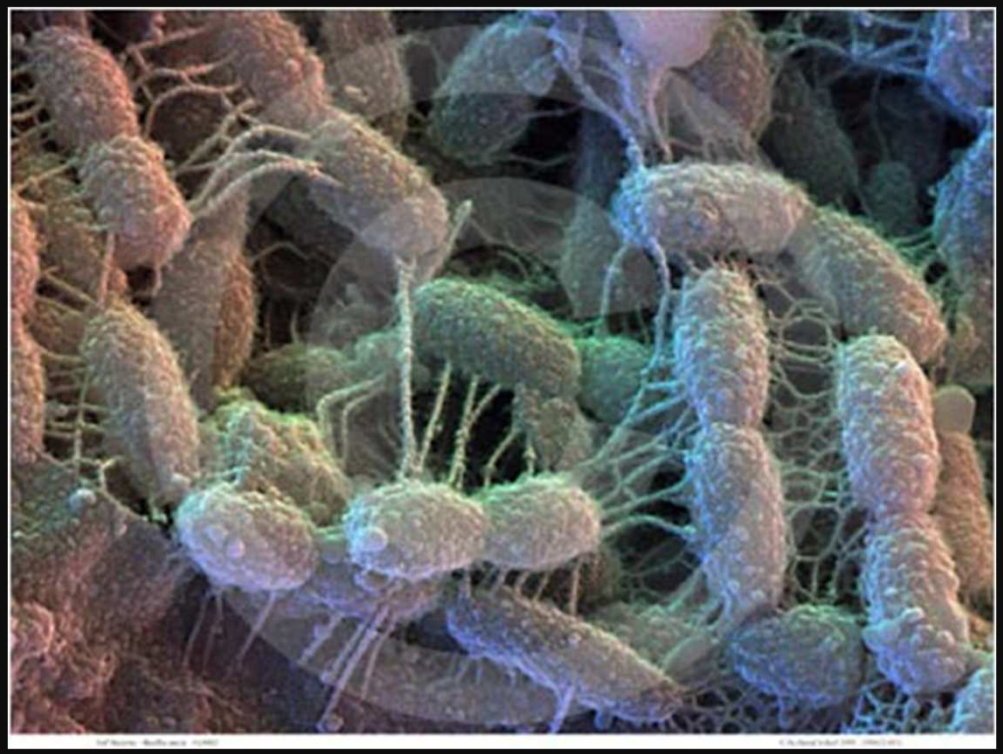
Pollen



Fungal spores

Viruses

Bacteria



Dust Mites

Lead Particulates - Candle Burning

- *The core of candle wicks may contain lead.*
- *Out of the molten wax, lead can be emitted as particulate to the air.*
- *In an EPA study, of 100 sets of candles that appeared to have metal-core wicks, 8% contained lead wicks.*

What is Ventilation??

Why ventilation is needed indoors?

Types of Ventilation

Natural Ventilation :

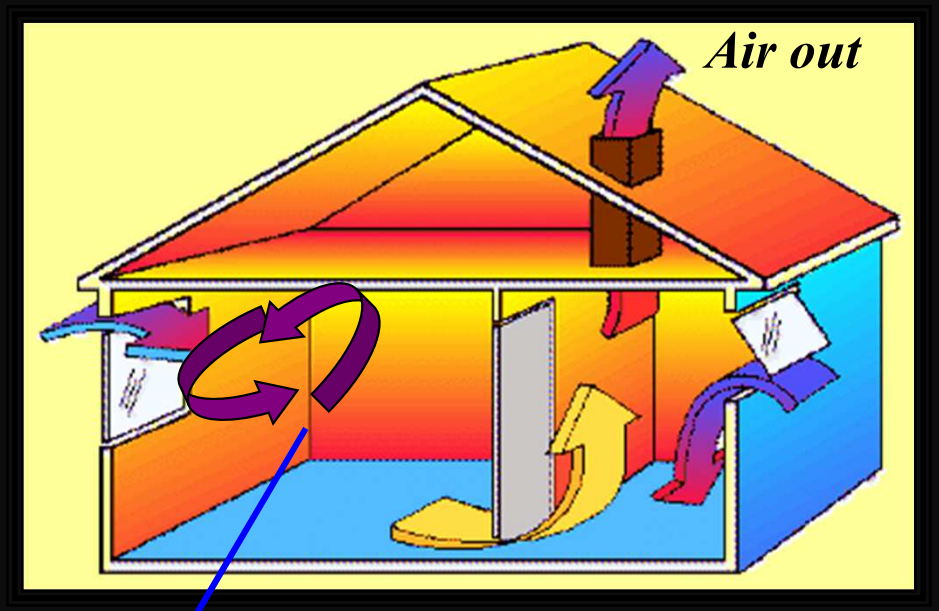
1-It involves flow of outdoor air through windows, cracks and a variety of openings in the buildings.
2-Movement of air from indoor spaces to outdoor.

Limitation - Fairly inefficient as it is NOT UNIFORMLY distributed. -It brings POLLENS & OTHER POLLUTANTS from outside air.

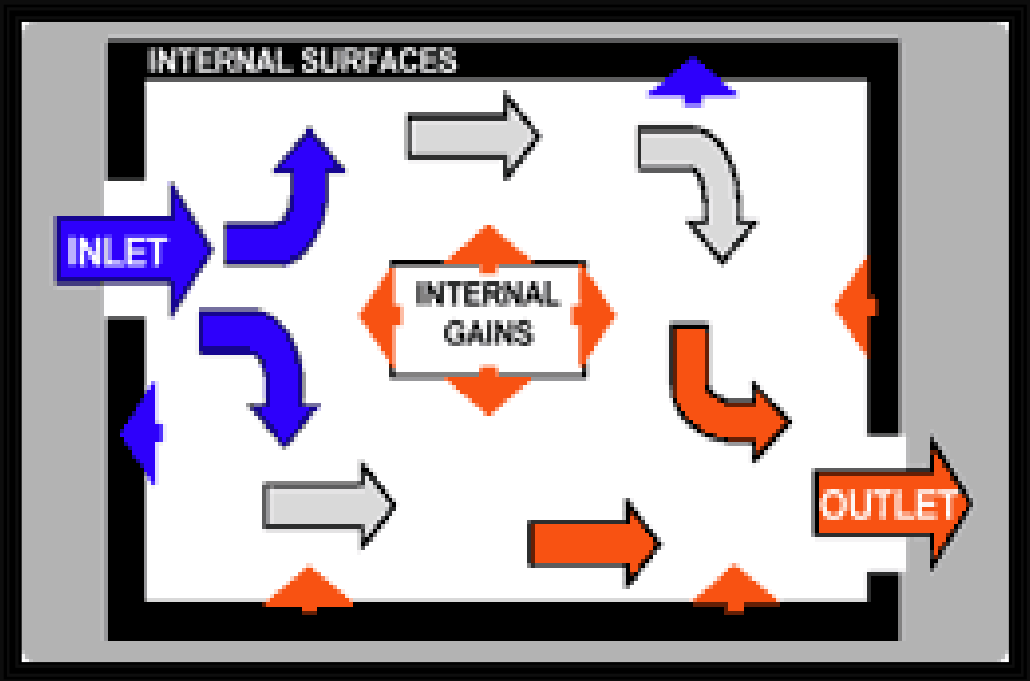
Mechanical ventilation

It involves use of fans and heating / air conditioning equipments.

Air Flow Inside the Buildings



Air flow pattern, when natural ventilation occurs



Air flow, when uniform mixing inside (mechanical ventilation)

Ventilation Measurement

A. In naturally ventilated buildings

- By *Infiltration* measurement. Infiltration is reported as *air change per hour* (ACH) – the average rate at which indoor air is replaced by fresh outdoor air.ACH is a rough guideline for different building conditions, given by ASHRAE. For e.g., in "*air tight buildings"* ACH is 0.1 to 0.2, in "*leaky building"*, ACH is 2.0 to 3.0.
- *Tracer gas technique* is employed to measure infiltration. Non reactive gases, e.g. SF_6/NO are used as tracer gases with the assumption that the loss of tracer gas is only due to ventilation/ exfiltration.

B. In mechanically ventilated buildings

- ACH is measured by CO_2 concentration. It is a good *surrogate index* to determine the proper ventilation in HVAC buildings. ASHRAE model for measuring infiltration in HVAC buildings is –

$$Q = G/ C_i – Ca$$

Minimum recommended ventilation rate (Q) by ASHRAE is *8L/sec. per person* to maintain the *indoor concentration of CO_2 as 700 ppm*.

Parameters for Natural Ventilation

Air Flow- occurs mainly due to two driving forces

Pressure Gradient *– Difference in outdoor and indoor pressure (varies with building shape, size, openings, wind direction, local environmental densities, neighbour building's configuration, topography etc.)*

Temperature Gradient *(Buoyancy Forces)- when the inside air temperature is higher than outside air, the warm air at floor surface starts rising and the cool air starts entering as a result of vaccum created at floor surface. This effect is called as "Stack Effect".*

Parameters for Mechanical Ventilation

Infiltration air, Exfiltration air, Recirculated air, Exhaust air, Makeup air

What Causes Indoor Air Pollution??
(4 ways)

1. Air Tightness in Buildings

Causes inadequate supply of fresh air, as a result, negative pressure develops, which causes:

- *Ground level pollutants, e.g. CO, Radon etc. to be drawn inside the buildings.*
- *Release of odor (Bio-aerosols) and other pollutants.*
- *Pull outside polluted air from vents, cracks and openings and increase dust, pollen etc.*
- *Causes "Sick Building Syndrome".*

Sick Building Syndrome

- *A sickness produced by indoor pollution w/ general & nonspecific symptoms*
  - *Ex. dizziness, headaches, coughing, sneezing, nausea, burning eyes, chronic fatigue, irritability, eye/nose/throat irritation, dry skin, nasal congestion, difficulty breathing, nose bleeds, flu-like symptoms*
    - *persistent set of symptoms in >20% population*
    - *complaints/Symptoms relieved after exiting building*
- *New buildings are more commonly "sick" than old ones because of reduced air exchange.*
  - *Can be solved with low-toxicity building materials & good ventilation*

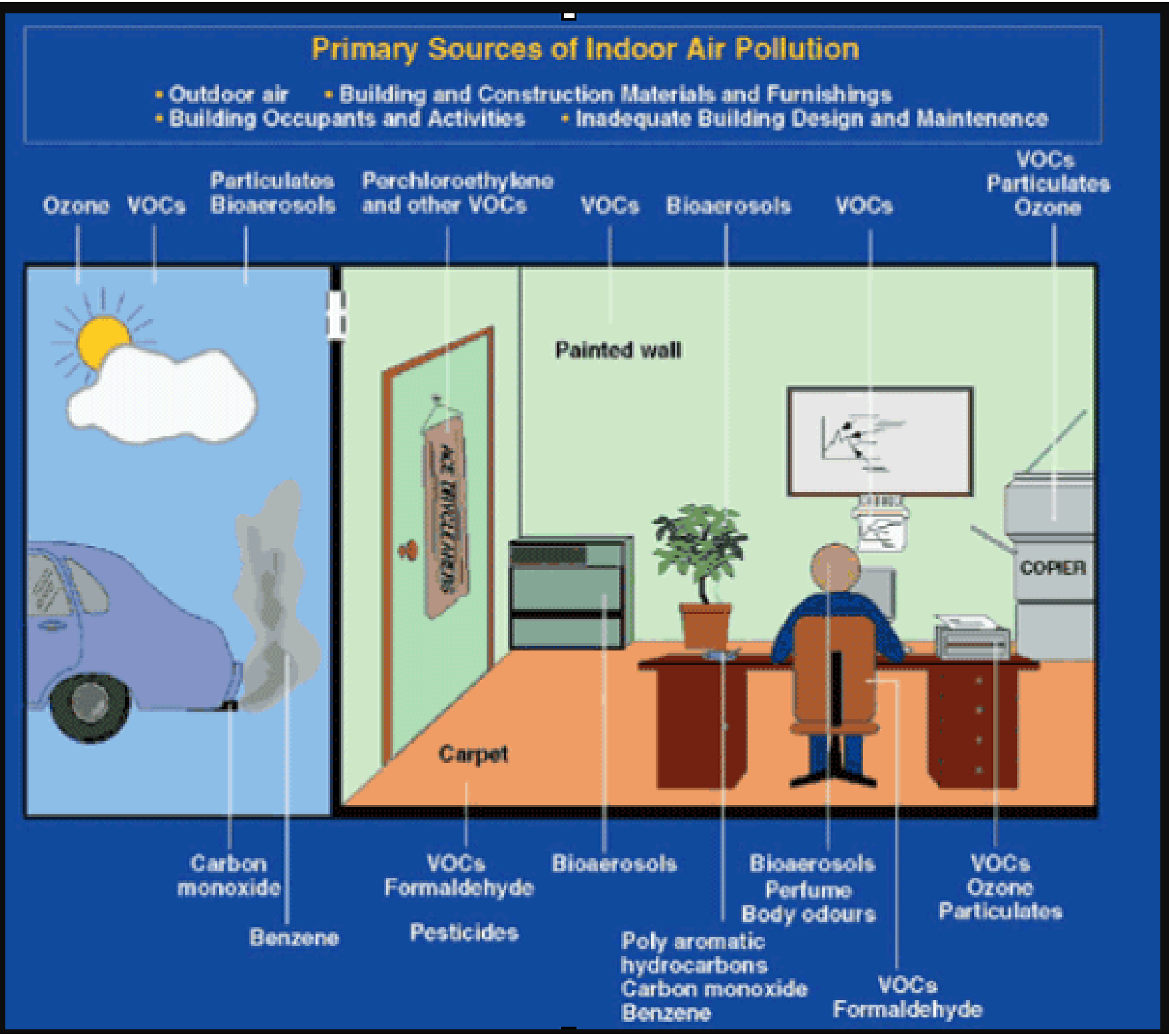
What Causes Indoor Air Pollution??

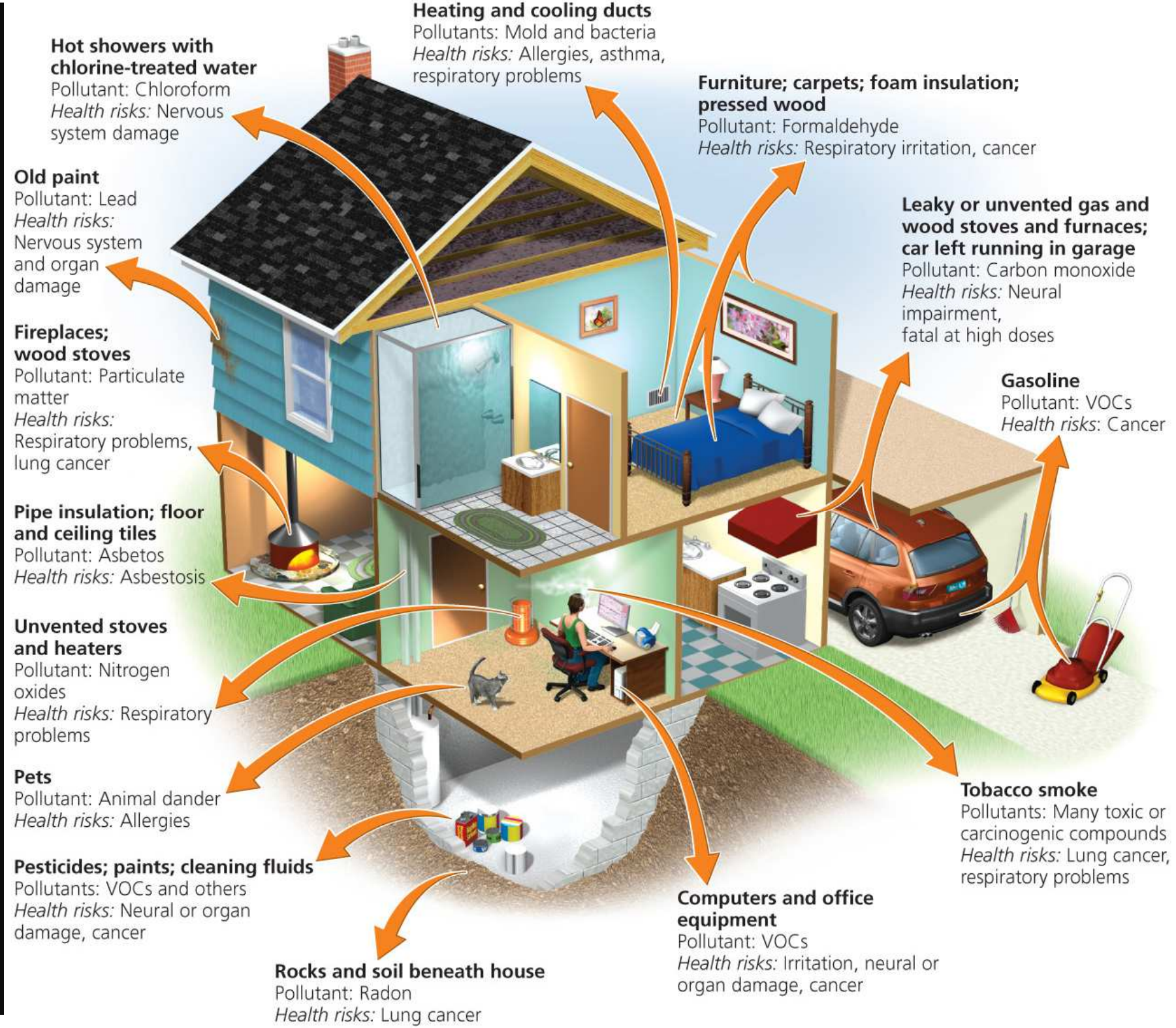
2. Poorly Designed Air Conditioning Systems

Results into the production of fungi, molds and other sickness causing microbes.

Problems of IAQ Enclosed spaces inhabited by humans produce following effects-

- *Reduction in oxygen level of spaces.*
- *Increase in CO2 level.*
- *Increase in temperature.*
- *Increase in humidity*
- *Increase in Bioaerosols and odor*


Primary Sources of Indoor Air Pollution
• Outdoor air
• Building and Construction Materials and Furnishings
• Building Occupants and Activities
• Inadequate Building Design and Maintenence
Ozone
VOCs
Particulates
Bioaerosols
Perchloroethylene
and other VOCs
VOCs
Bioaerosols
VOCs
VOCs
Particulates
Ozone
Painted wall
COPIER
Carpet
Carbon
monoxide
Benzene
VOCs
Formaldehyde
Pesticides
Bioaerosols
Poly aromatic
hydrocarbons
Carbon monoxide
Benzene
Bioaerosols
Perfume
Body odours
VOCs
Formaldehyde
VOCs
Ozone
Particulates


Heating and cooling ducts
Pollutants: Mold and bacteria
Health risks: Allergies, asthma, respiratory problems
Hot showers with chlorine-treated water
Pollutant: Chloroform
Health risks: Nervous system damage
Furniture; carpets; foam insulation; pressed wood
Pollutant: Formaldehyde
Health risks: Respiratory irritation, cancer
Old paint
Pollutant: Lead
Health risks: Nervous system and organ damage
Leaky or unvented gas and wood stoves and furnaces; car left running in garage
Pollutant: Carbon monoxide
Health risks: Neural impairment, fatal at high doses
Fireplaces; wood stoves
Pollutant: Particulate matter
Health risks: Respiratory problems, lung cancer
Gasoline
Pollutant: VOCs
Health risks: Cancer
Pipe insulation; floor and ceiling tiles
Pollutant: Asbetos
Health risks: Asbestosis
Unvented stoves and heaters
Pollutant: Nitrogen oxides
Health risks: Respiratory problems
Pets
Pollutant: Animal dander
Health risks: Allergies
Tobacco smoke
Pollutants: Many toxic or carcinogenic compounds
Health risks: Lung cancer, respiratory problems
Pesticides; paints; cleaning fluids
Pollutants: VOCs and others
Health risks: Neural or organ damage, cancer
Computers and office equipment
Pollutant: VOCs
Health risks: Irritation, neural or organ damage, cancer
Rocks and soil beneath house
Pollutant: Radon
Health risks: Lung cancer

Parameters Affecting IAQ

- *Rate of exchange of air from outdoors (ventilation)*
- *Concentration of pollutants in outdoor air*
- *Rate of emission from sources indoors*
- *Rate of removal of pollutants (Sinks)*
- *Indoor temperature*
- *Indoor humidity*
- *Age of indoor structure*
- *Type of foundation soil*

Control of Indoor Air Pollution

Basic approaches to control indoor air pollution include source control, source isolation, increased ventilation, dehumidification, and the use of filters.
Possible sources of contamination are eliminated in a source-control strategy.

Examples include banning smoking in public buildings.
Source-isolation strategy is used in situations where a source cannot be completely eliminated. For instance, copy machine areas, food service stations, and bathrooms are often separately vented outside buildings to avoid the recirculation of return air.
Low humidity should be maintained inside a house to limit the growth of such bacteria

We can reduce indoor air pollution

- *The amount of air available (for mixing of indoor & outdoor air) to dilute pollutants is an important indicator of the likely contaminant concentration*
  - *Indoor air can mix with outside air by 3 mechanisms*
    - *infiltration*
    - *natural ventilation*
    - *forced ventilation*

Mixing of Indoor & Outdoor Air

- *Infiltration*
  - *natural air exchange that occurs between a building & its environment when doors & windows are closed*
    - *leakage through holes or openings in the building*
      - *Influenced by:*
        - *pressure differentials inside & outside the building*
        - *temperature differentials inside & outside of bldg*
          - *~in winter, warm air inside wants to rise → exits through cracks in ceiling & draws in outside air*
        - *how fast wind is blowing*

Mixing of Indoor & Outdoor Air

- *Natural ventilation*
  - *air exchange that occurs when windows or doors are opened to increase air circulation*

- *Forced ventilation*
  - *mechanical air handling systems used to induce air exchange using fans & blowers*

https://twitter.com/pnrazdan/status/1060427540957868032

https://urbanemissions.info/india-air-quality/india-ambient-monitoring-data/

https://www.radon.com/radon_facts/