Air Pollution and control

Air Pollution and control

Air Pollution

Definition

Addition of chemicals to the atmosphere by natural events or human activities in high enough concentrations to be harmful for living organisms, material property and the enjoyment of these properties

Sources of Air Pollution

- Anthropogenic
  - Stationary
    - Point
    - Area
  - Mobile
    - Line
    - Area
- Natural
  - Stationary
  - Mobile

Types of Air Pollution

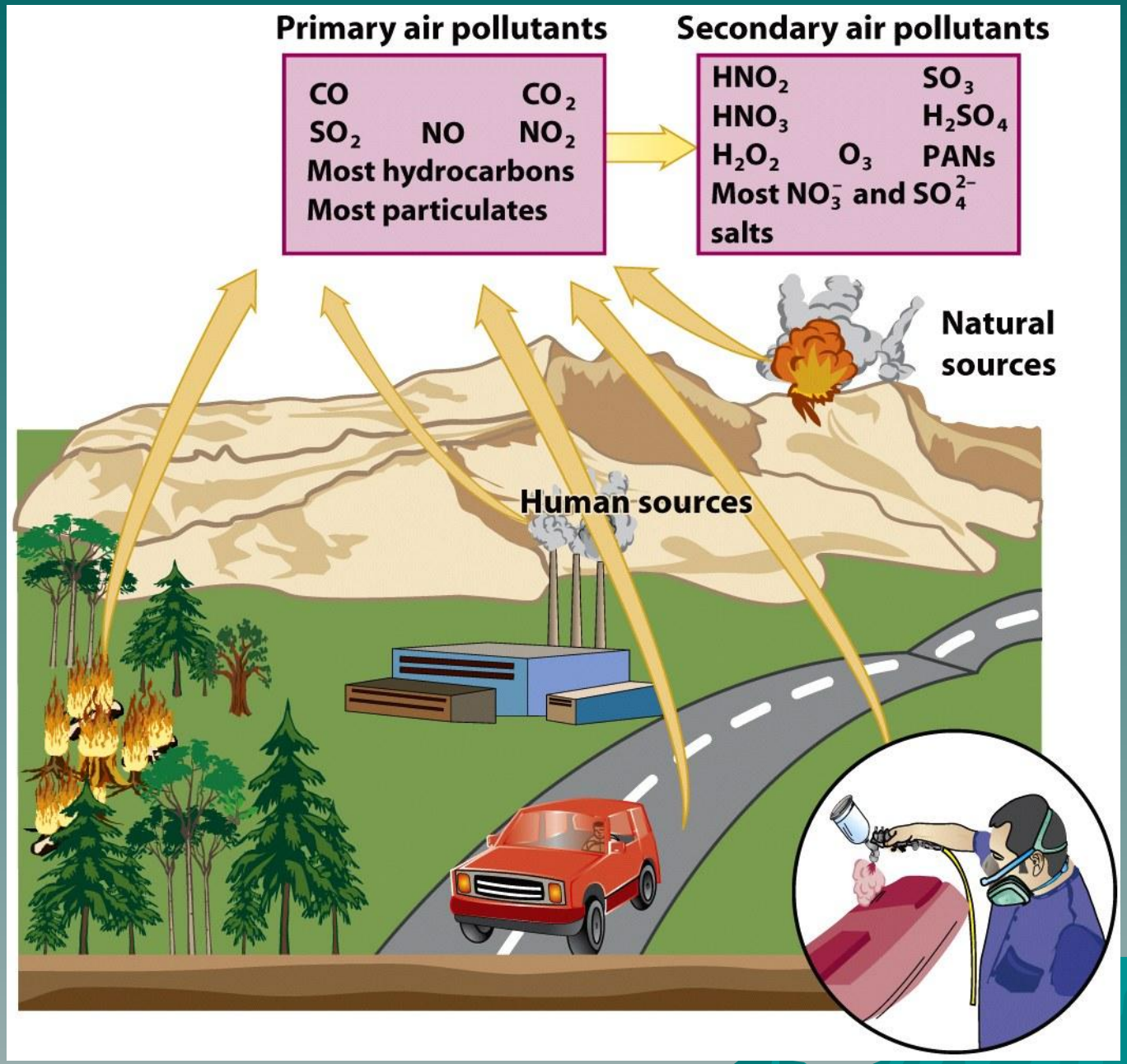
- Natural
  - Volcanos (Smoke , CO_2,SO_2)
  - Dust
  - Forest fires(smoke, CO_2,$No_{x,}$$SO_{x,}$)
  - Wetlands (CH_4)
- Anthropogenic
  - Stationary sources
  - Mobile sources
  - Evaporative sources (volatile liquids)

Types of Air Pollutants

- Based on ***origin***
  - i) Primary Air Pollutant
  - ii) Secondary Air Pollutant
- Based on ***Chemical composition***
  - i) Organic
  - ii) Inorganic
- Based on ***states of matter***
  - i) Particulate matter
  - ii) Gaseous pollutants

Major Air Pollutants

Pollutant	Composition	Primary or Secondary	Characteristics
Particulate matter			
Dust	Variable	Primary	Solid particles
Lead	Pb	Primary	Solid particles
Sulfuric acid	H_2SO_4	Secondary	Liquid droplets
Nitrogen oxides			
Nitrogen dioxide	NO_2	Primary	Reddish-brown gas
Sulfur oxides			
Sulfur dioxide	SO_2	Primary	Colorless gas with strong odor
Carbon oxides			
Carbon monoxide	CO	Primary	Colorless, odorless gas
Carbon dioxide*	CO_2	Primary	Colorless, odorless gas
Hydrocarbons			
Methane	CH_4	Primary	Colorless, odorless gas
Benzene	C_6H_6	Primary	Liquid with sweet smell
Ozone	O_3	Secondary	Pale blue gas with acrid odor
Air toxics			
Chlorine	Cl_2	Primary	Yellow-green gas


Primary air pollutants
CO
CO_2
SO_2
NO
NO_2
Most hydrocarbons
Most particulates
Secondary air pollutants
HNO_2
SO_3
HNO_3
H_2SO_4
H_2O_2
O_3
PANs
Most NO_3^- and SO_4^{2-} salts
Natural sources
Human sources

Primary Air Pollutants

- Oxides of Sulphur
- Oxides of Carbon
- Oxides of Nitrogen
- Volatile Organic Compounds
- Suspended Particulate Matter(SPM)

Pollutant	Sources	Human Health & Welfare Effects
SULPHUR DIOXIDE Basic air pollutant Permissible maximum conc = 50µg/m^3	Refineries, chemical plants, smelting operation Burning of fossil fuels Municipal incineration plants	• Irritant gas, If inhaled affects mucus membranes • Increases the breathing rate leading to bronchial-spasms • Asthma patients are badly affected by SO_2 • Responsible for acidity in fogs, smokes and rain

Pollutant	Sources	Human Health & Welfare Effects
Carbon Monoxide Odorless , colorless gas. CO Permissible maximum conc = $4mg/m^3$ Residential areas	Incomplete combustion of carbon-based fuels in motor vehicle & industrial boilers.	• Reduces the ability of blood to deliver oxygen affecting the cardiovascular & nervous system. • Impairs vision, causes dizziness, & can lead to unconsciousness or death.

Pollutant	Sources	Human Health & Welfare Effects
NOx Chemical interactions between atmospheric nitrogen and oxygen at high temperature Permissible limit (NO_2)-40μ/m^3	• Fuel combustion in motor vehicles & industrial sources. • High temperature burning combining nitrogen & oxygen in the air.	• Respiratory irritant • Aggravates lung & heart problems • Precursor to ozone & acid rain. • Causes brown discoloration of atmosphere • Bronchitis and Pneumonia • Reduced resistance to respiratory infections

Pollutant	Types	Sources	Human Health & Welfare Effects
***Particulate Matter*:** Airborne solid or liquid particles smaller than 10 microns in diameter or smaller than 2.5 microns PM_{10} $PM_{2.5}$ TSPM = 140µg/m^3 RSPM = 60 µg/m^3	Solid – Dust, smoke, fumes Liquid – Mist, fog	• Power plant boilers, steel mills • Chemical plants • Unpaved roads & parking lots • Wood-burning stoves & fireplaces • Automobiles •Pollen grains and spores, fur •Volcanic eruptions	• Aggravates respiratory problems like asthma & emphysema. • Lung tissue damage • Altered defense mechanism • Carry toxic material deep into the respiratory system. • Impairs visibility

Pollutant	Sources	Human Health & Welfare Effects
Lead A toxic heavy metal Pb	Smelters, lead-acid battery manufacturing, incineration of garbage containing lead products, food and water & use of leaded gasoline.	• Toxic to the nervous system, organs, & most levels of body function • Seizures • Mental retardation • Behavioral disorders

Secondary Air Pollutants

- Sulphuric Acid
- Ozone
- Formaldehydes
- Peroxy-acyl-nitrate (PAN)

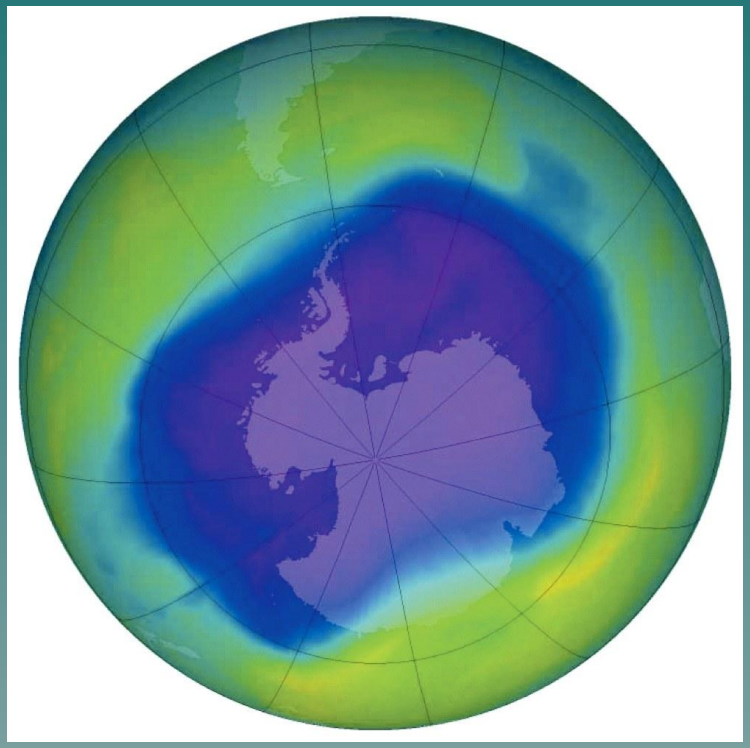
Pollutant	Sources	Human Health & Welfare Effects
Ozone Colorless or bluish gas. O_3	• Emissions of volatile organic compounds (VOC) & nitrogen oxides in the presence of sunlight • Fuel combustion in motor vehicles, gasoline storage & transport, solvents, pains & landfills.	• Irritates mucous membranes, aggravates lung & heart problems • Reduces lung function • Causes burning eyes, sneezing, coughing, and chest discomfort

Ozone

- Tropospheric Ozone
  - Man- made pollutant in the lower atmosphere
  - Secondary air pollutant
  - Component of photochemical smog
- Stratospheric Ozone
  - Essential component that screens out UV radiation in the upper atmosphere
  - Man- made pollutants (ex: CFCs) can destroy it

Ozone Depletion in Stratosphere

- Ozone thinning/hole
  - First identified in 1985 over Antarctica
- Caused by
  - human-produced bromine and chlorine containing chemicals
  - Ex: CFCs



Recovery of Ozone Layer

- Montreal Protocol (1987)
  - Reduction of CFCs
- Phase out of all ozone destroying chemicals is underway globally
- Satellite pictures in 2000 indicated that ozone layer was recovering
- Full recovery will not occur until 2050

Urban Air Pollution

- Photochemical Smog (ex: Los Angeles below)
  - Brownish-orange haze formed by chemical reactions involving sunlight, nitrogen oxide, and hydrocarbons

Effects of Air Pollution

- Low level exposure
  - Irritates eyes
  - Causes inflammation of respiratory tract
- Can develop into chronic respiratory diseases

Table 20.2 Health Effects of Several Major Air Pollutants

Pollutant	*Source*	*Effects*
Particulate	Industries, electric power plants, motor vehicles, construction, agriculture	Aggravates respiratory illnesses; long-term exposure may cause increased incidence of chronic conditions such as bronchitis; linked to heart disease; suppresses immune system; some particles, such as heavy metals and organic chemicals, may cause cancer or other tissue damage
Nitrogen oxides	Motor vehicles, industries, heavily fertilized farmland	Irritate respiratory tract; aggravate respiratory conditions such as asthma and chronic bronchitis
Sulfur oxides	Electric power plants and other industries	Irritate respiratory tract; same effects as particulates
Carbon monoxide	Motor vehicles, industries, fireplaces	Reduces blood's ability to transport oxygen; headache and fatigue at lower levels; mental impairment or death at high levels
Ozone	Formed in atmosphere (secondary air pollutant)	Irritates eyes; irritates respiratory tract; produces chest discomfort; aggravates respiratory conditions such as asthma and chronic bronchitis

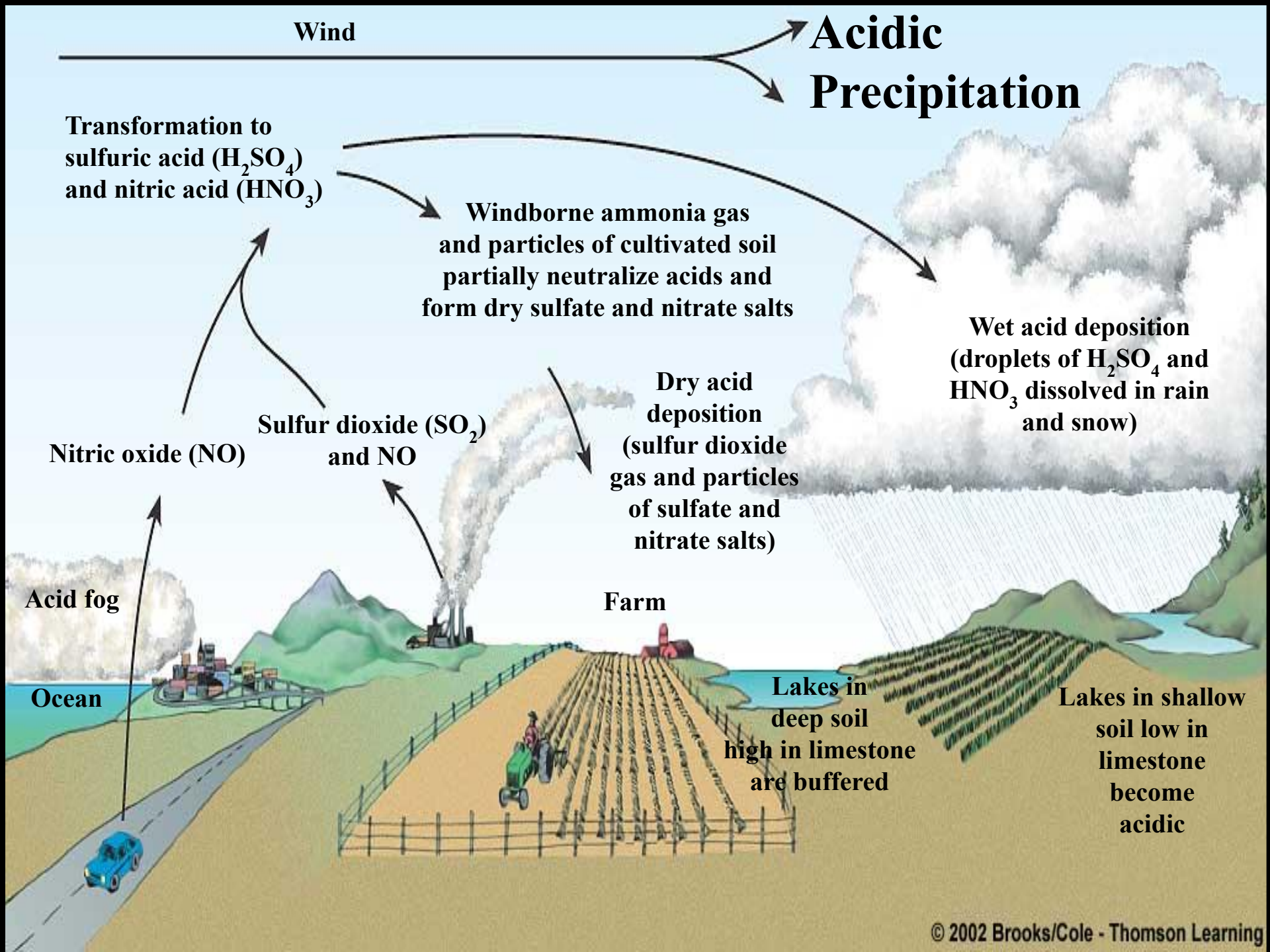
Acid Precipitation (Wet or Dry)

When gas pollutants e.g. sulfur dioxide, nitrogen dioxide dissolve in rain water, various acids are formed.

$CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid)

$SO_2 + H_2O \rightarrow H_2SO_3$ (sulfuric acid)

$NO_2 + H_2O \rightarrow HNO_2$ (nitrous acid) + HNO_3 (nitric acid)


Wind
Acidic Precipitation
Transformation to sulfuric acid (H_2SO_4) and nitric acid (HNO_3)
Windborne ammonia gas and particles of cultivated soil partially neutralize acids and form dry sulfate and nitrate salts
Wet acid deposition (droplets of H_2SO_4 and HNO_3 dissolved in rain and snow)
Dry acid deposition (sulfur dioxide gas and particles of sulfate and nitrate salts)
Nitric oxide (NO)
Sulfur dioxide (SO_2) and NO
Acid fog
Ocean
Farm
Lakes in deep soil high in limestone are buffered
Lakes in shallow soil low in limestone become acidic
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Acidic Precipitation

Primary Pollutants

SO_2

NO_2

Secondary Pollutants

H_2SO_4 sulfuric acid

HNO_2 nitric acid

acidic precipitation

Fossil fuels
Power plants
Industrial emissions
Auto emissions

vegetation
direct toxicity
indirect health effects

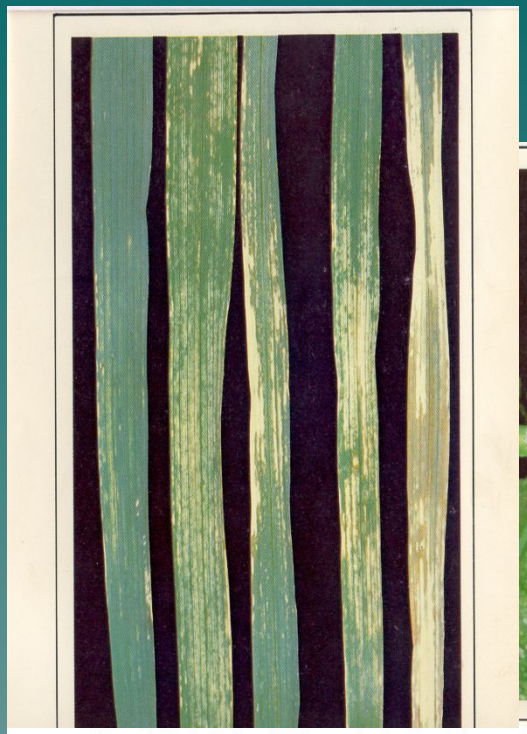
soils
leaching of minerals

sediments
leaching aluminum

Effects of Acid Rain

- Acidic water dissolves the nutrients and helpful minerals in the soil and then washes them away before trees and other plants can use them to grow.
  - weaken trees by damaging their leaves
  - limit the nutrients available to them
- Acid rain also causes the release of substances that are toxic to trees and plants, such as aluminum, into the soil.
- Greatly affects aquatic ecosystem as it can attach to fish gills causing suffocation

Effects of Air pollution on plants and property



Air Pollution Control

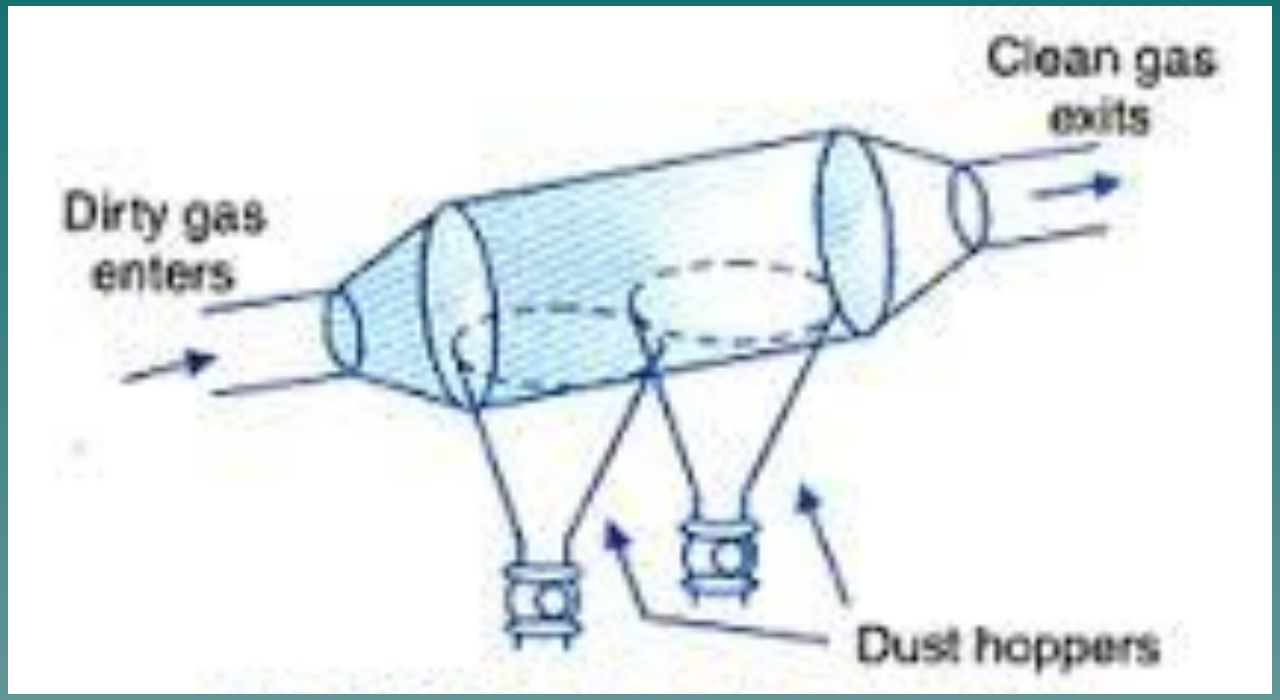
- Natural self cleansing property of environment
  - Dispersion
  - Gravitational settling
  - Absorption
  - Rainout
  - Adsorption

Controlling Stationary Pollutant

Controlling Particulate Pollution

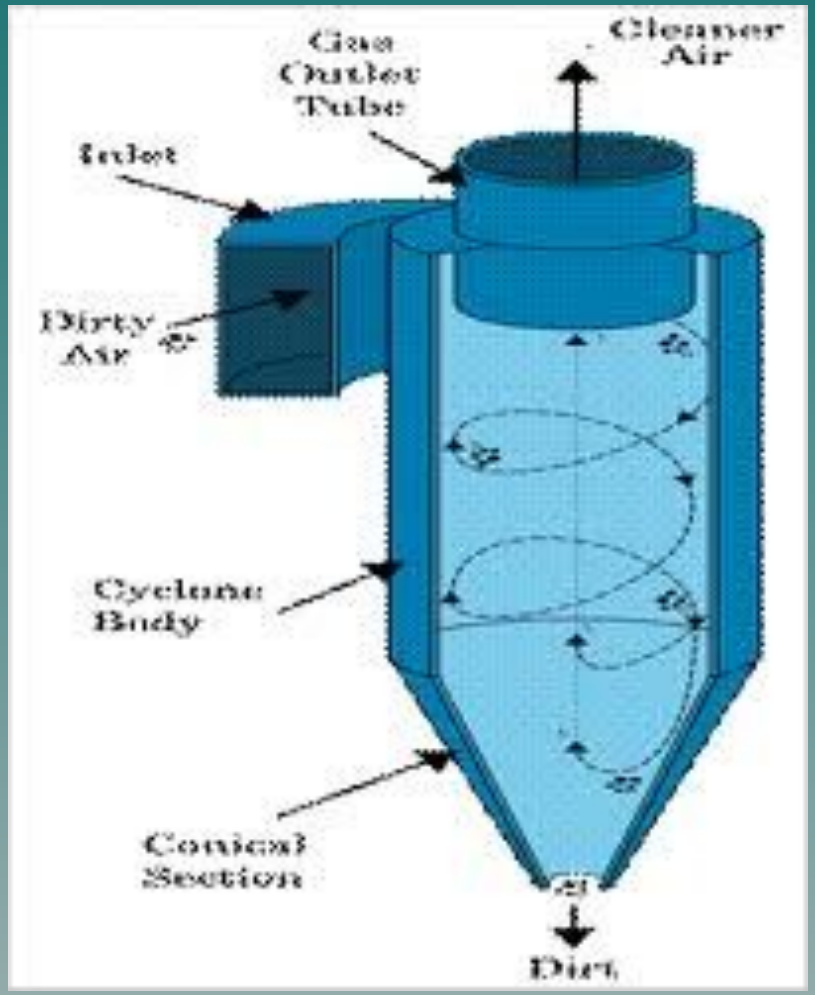
Use of equipments like :

- Settling Chambers
- Cyclone Separators
- Baghouse filters
- Electrostatic Precipitator
- Wet scrubber

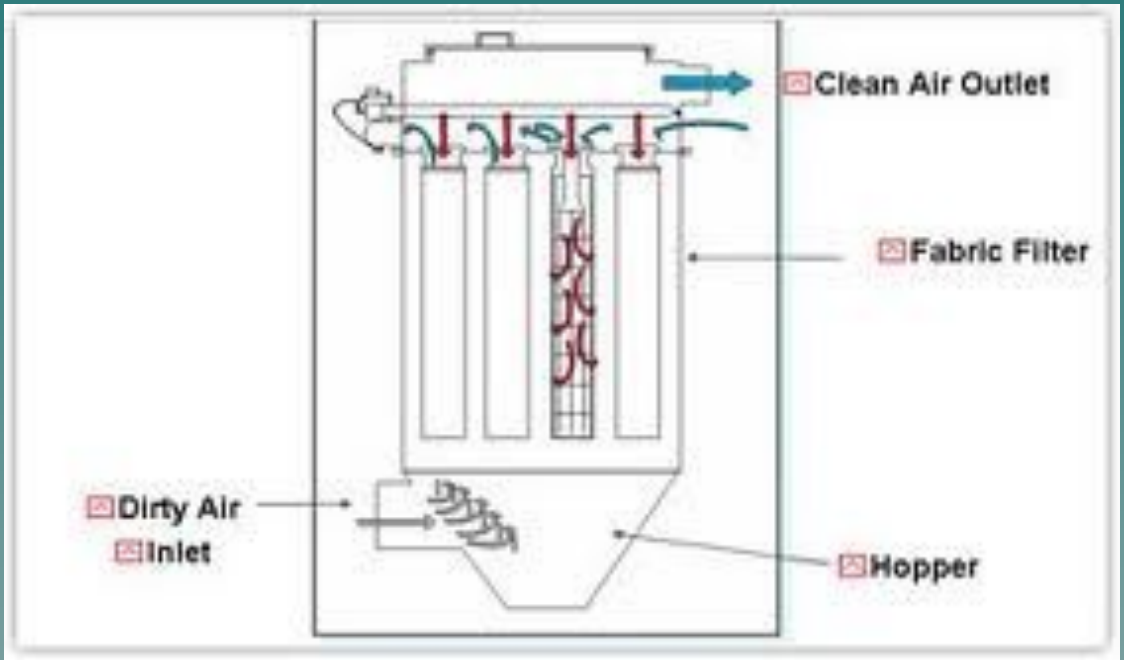


Gravity Settling Chamber

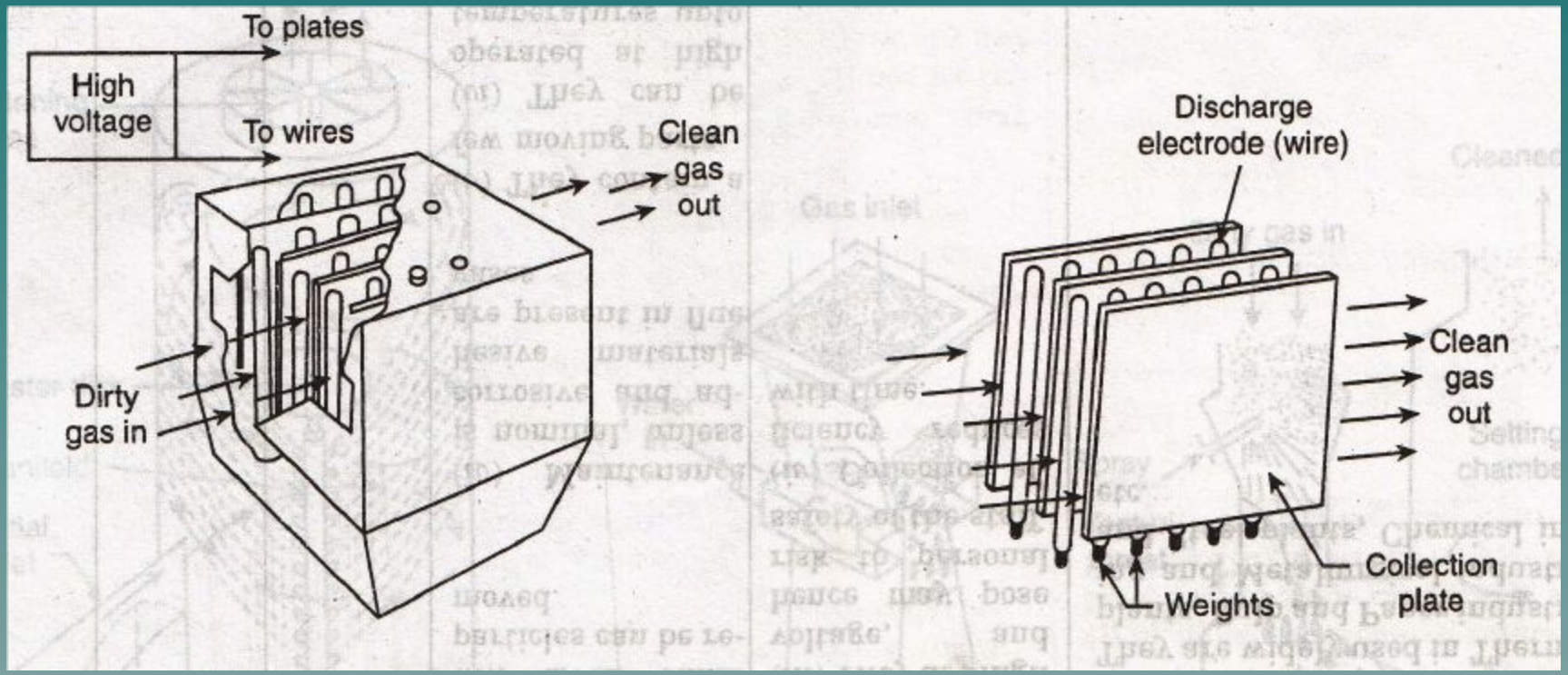
Cyclone Separators



Bag house filter

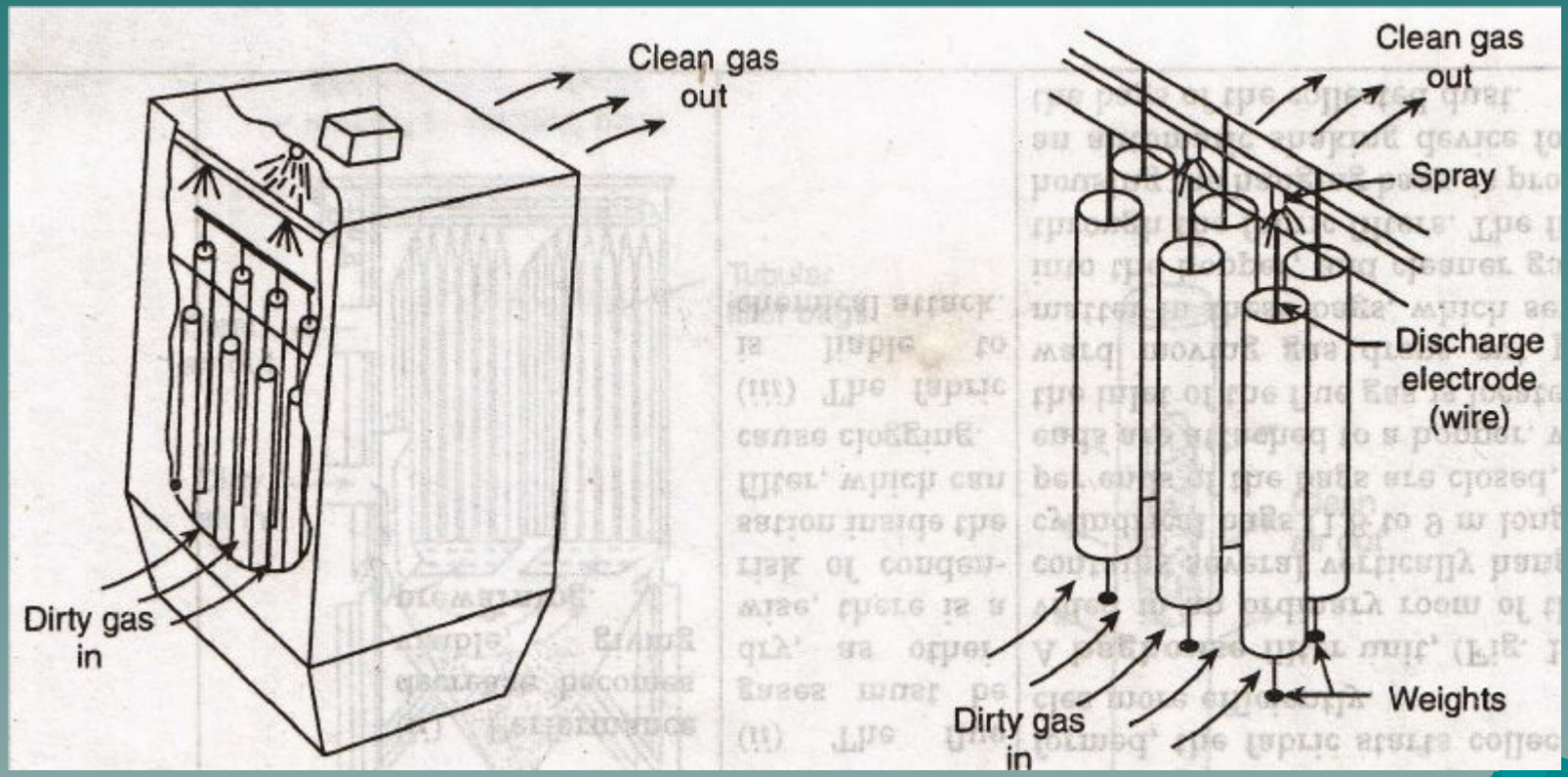


Electrostatic precipitator



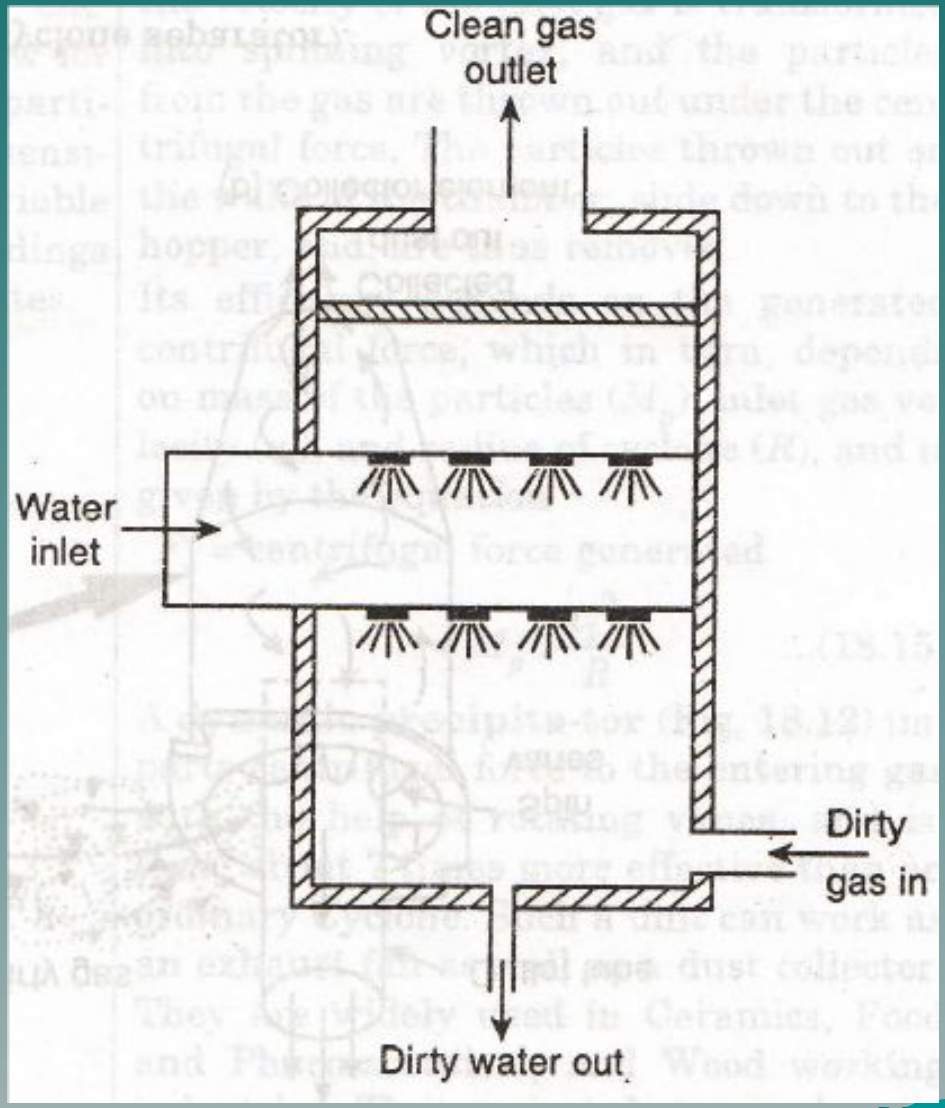
High voltage electrostatic precipitator- plate type

Electrostatic precipitator



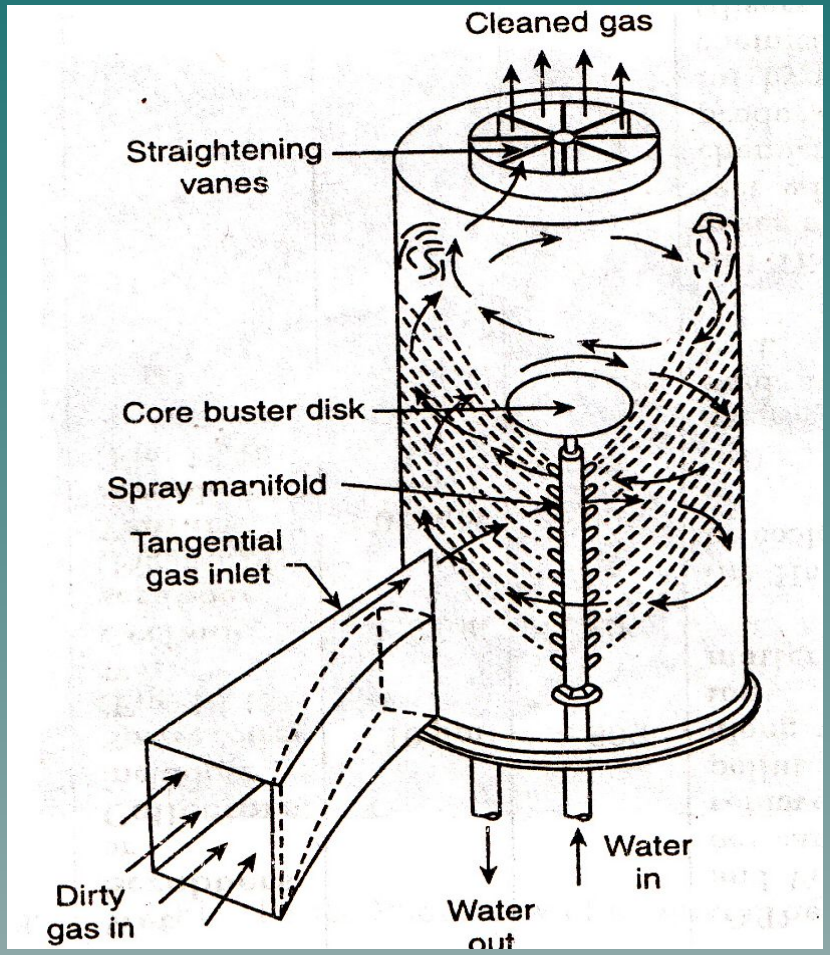
High voltage electrostatic precipitator- tube type

Wet scrubber



Spray Tower *(also used for gaseous pollutant control)*

Wet scrubber



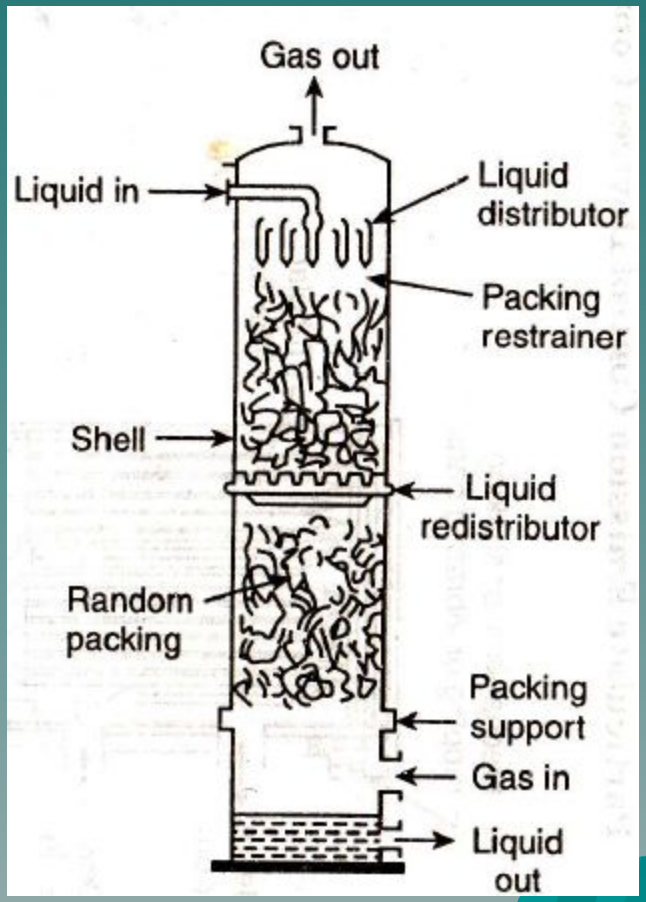
Wet cyclone scrubber

Gaseous pollutant control

- Absorption units
  - Spray tower
  - Plate tower
  - Packed tower
  - Venturi scrubber
- Adsorption units
- Combustion equipments

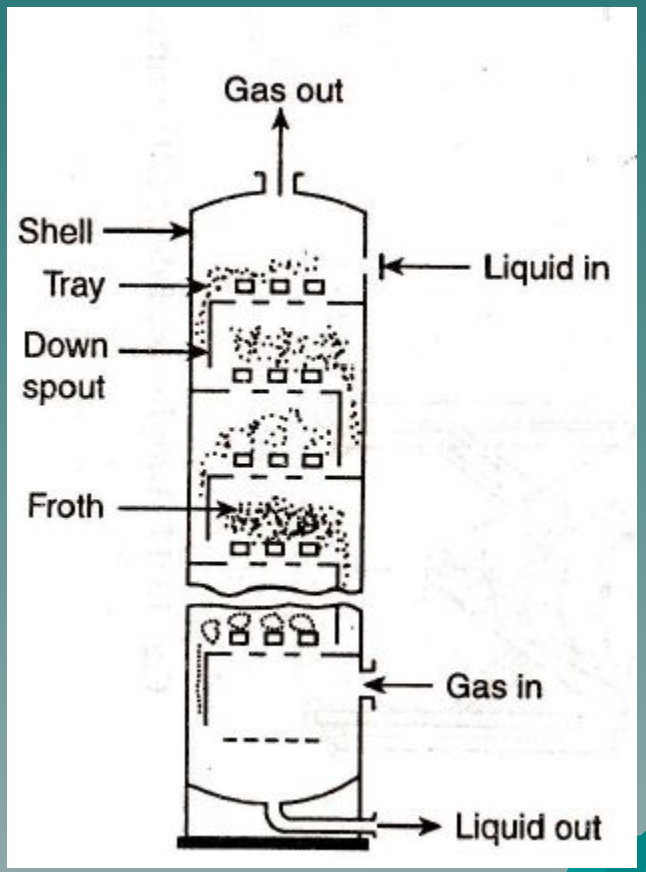
Gaseous pollutant control

- Absorption units
  - Packed towers



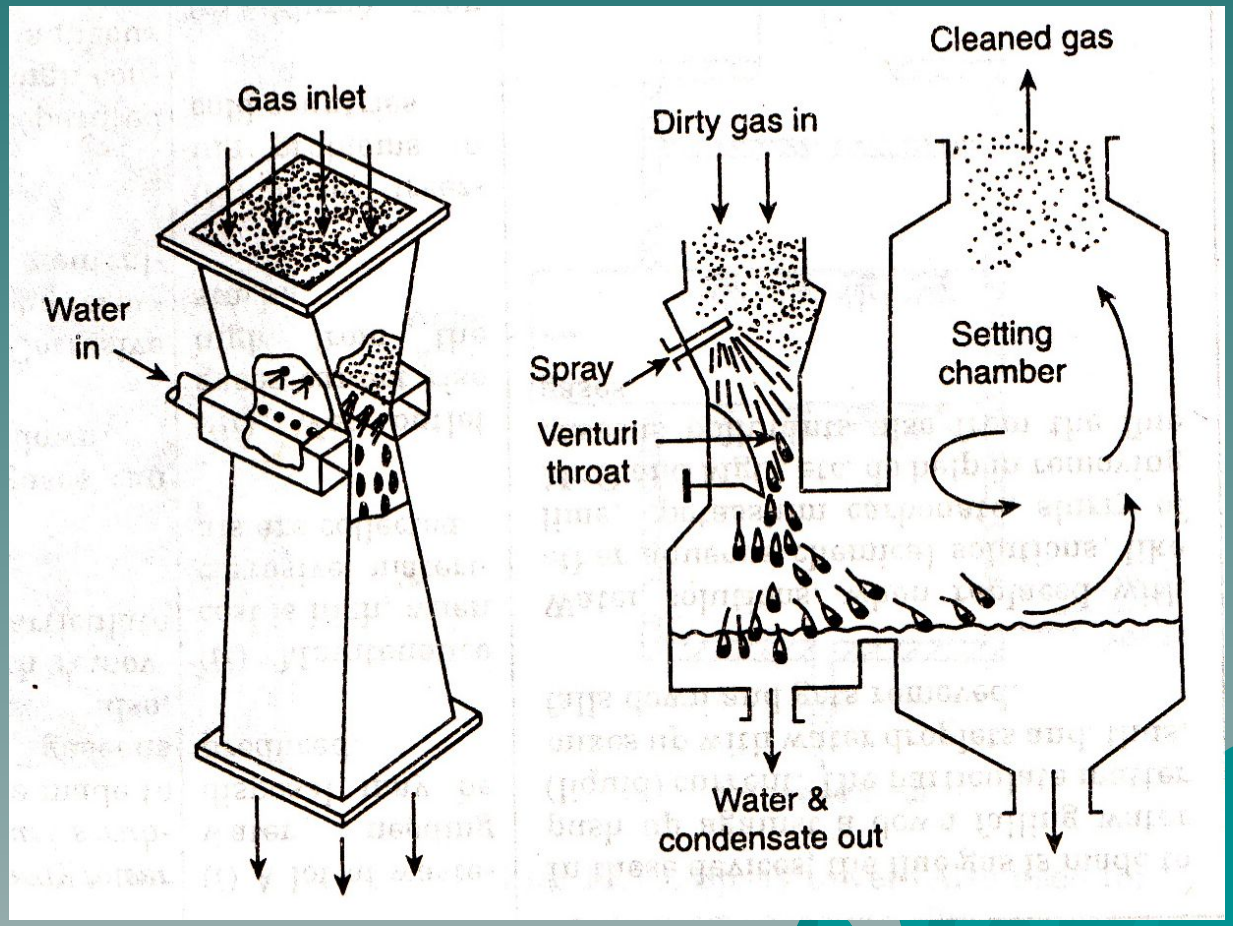
Gaseous pollutant control

- Absorption units
  - Plate towers



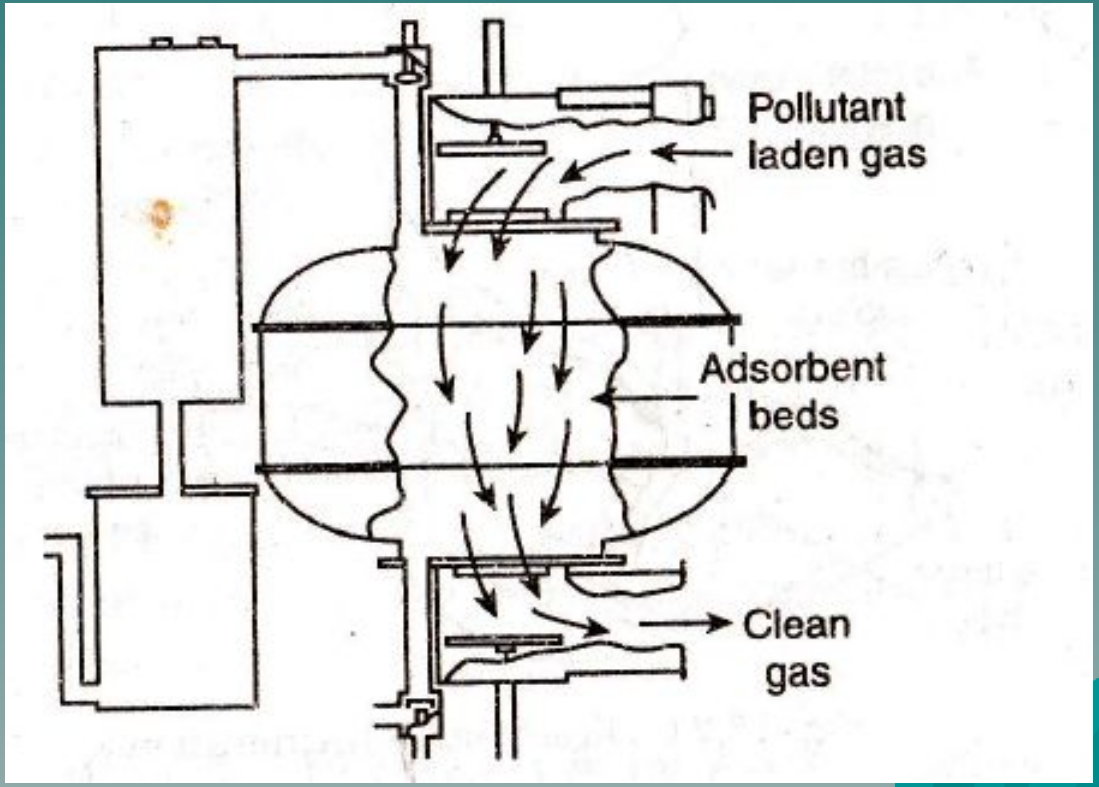
Gaseous pollutant control

- Absorption unit
  - Venturi scrubber *(also for particulate pollutant control)*



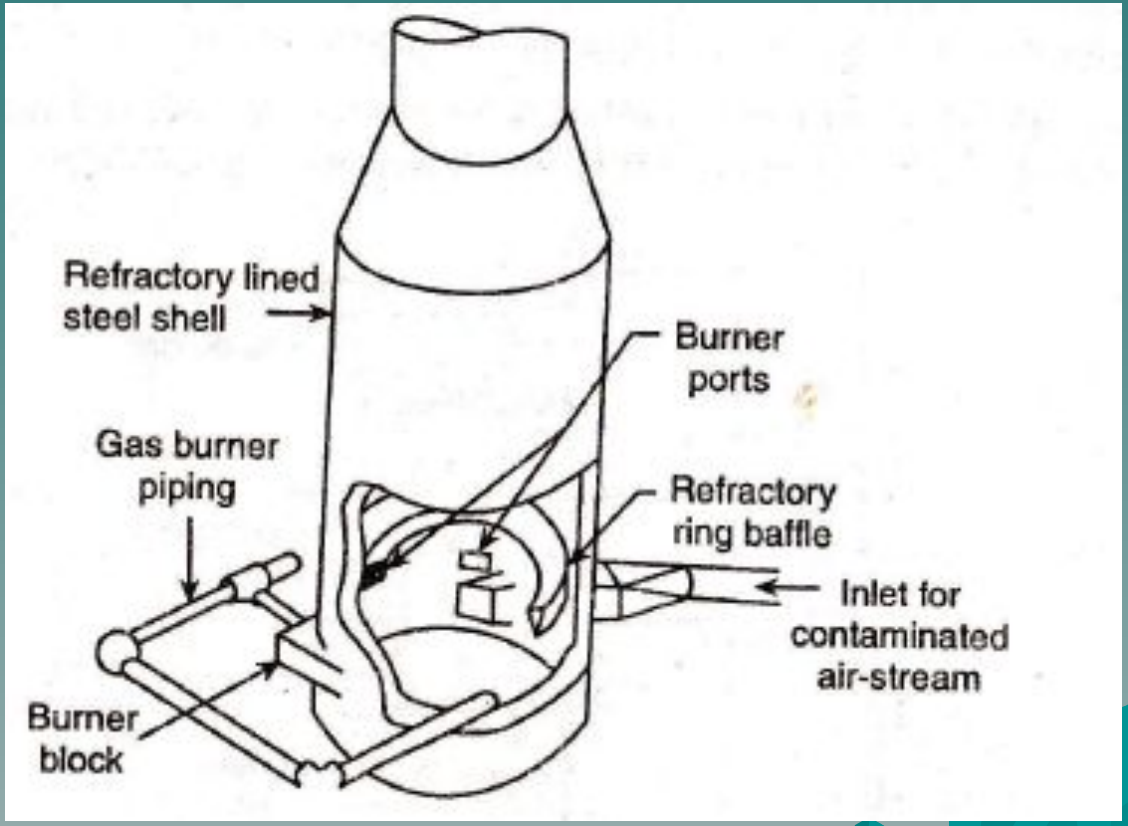
Gaseous pollutant control

- Adsorption unit



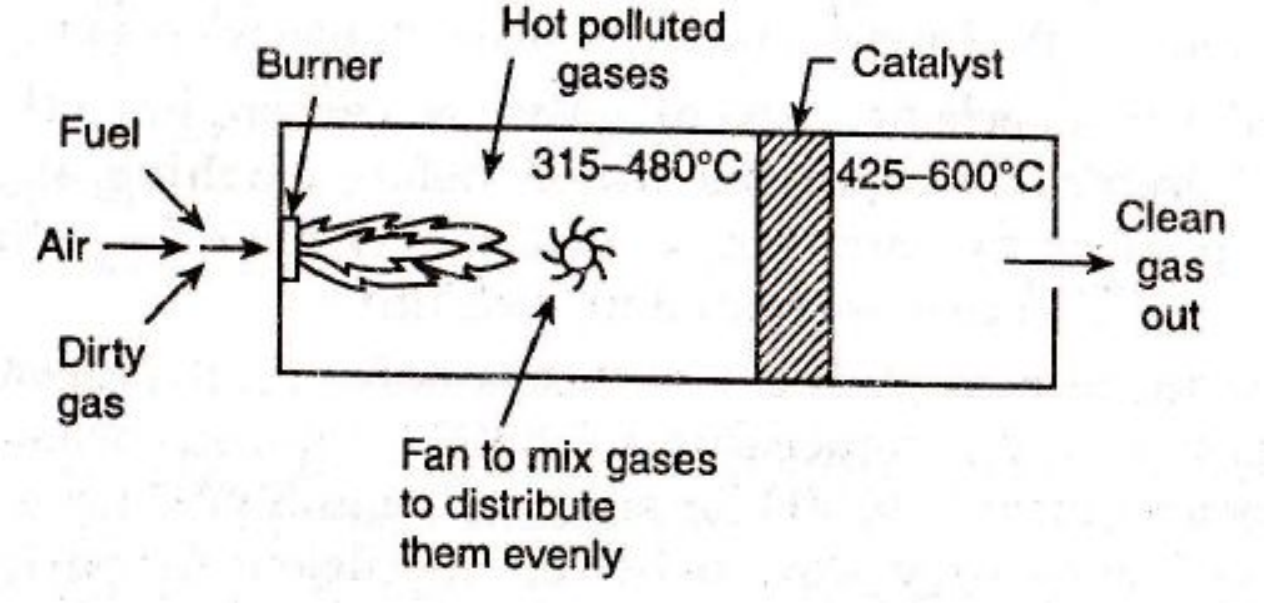
Gaseous pollutant control

- Direct flame incineration



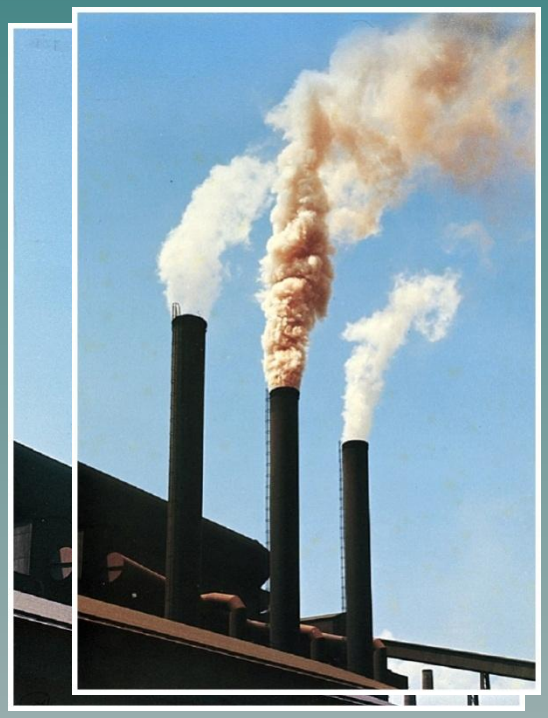
Gaseous pollutant control

- Catalytic incineration



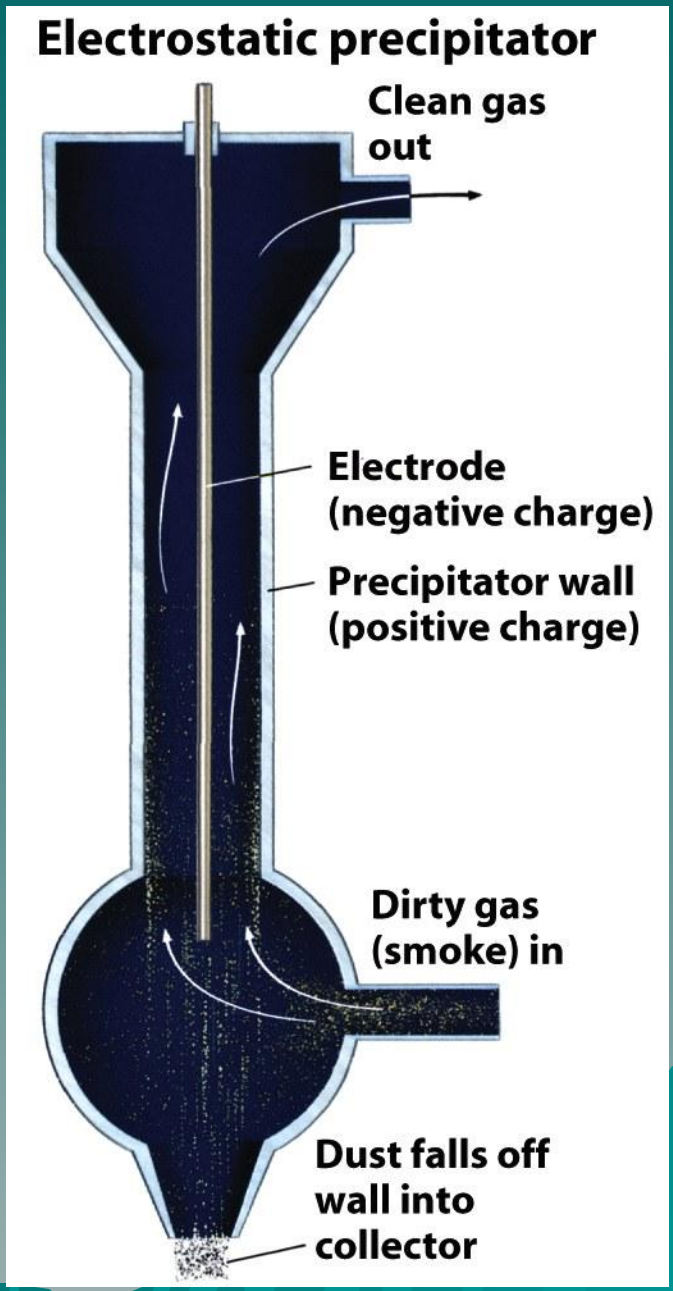
Controlling Air Pollution

- Smokestacks with electrostatic precipitator (right)



Without Electrostatic precipitator

With Electrostatic precipitator



Air quality in India

CLASSIFICATION OF CITIES AS PER AQI- 2002

Critical pollution: Jodhpur, Agra, Kanpur, Kolkata, Lucknow, Dehradoon, Pune, Delhi, Raipur, Solapur, Varanasi, Jamshedpur, Jamnagar

Heavy pollution: Ahmedabad, Baroda, Chandigarh, Jaipur, Kota, Patna, Surat, Vapi, Udaipur

Moderate pollution: Nagpur, Nasik, Panaji, Bangalore, Chennai, Mumbai, Mysore, Hyderabad, Coimbatore, Madurai

Low pollution: Cochin, Shillong, Pondicherry, Salem

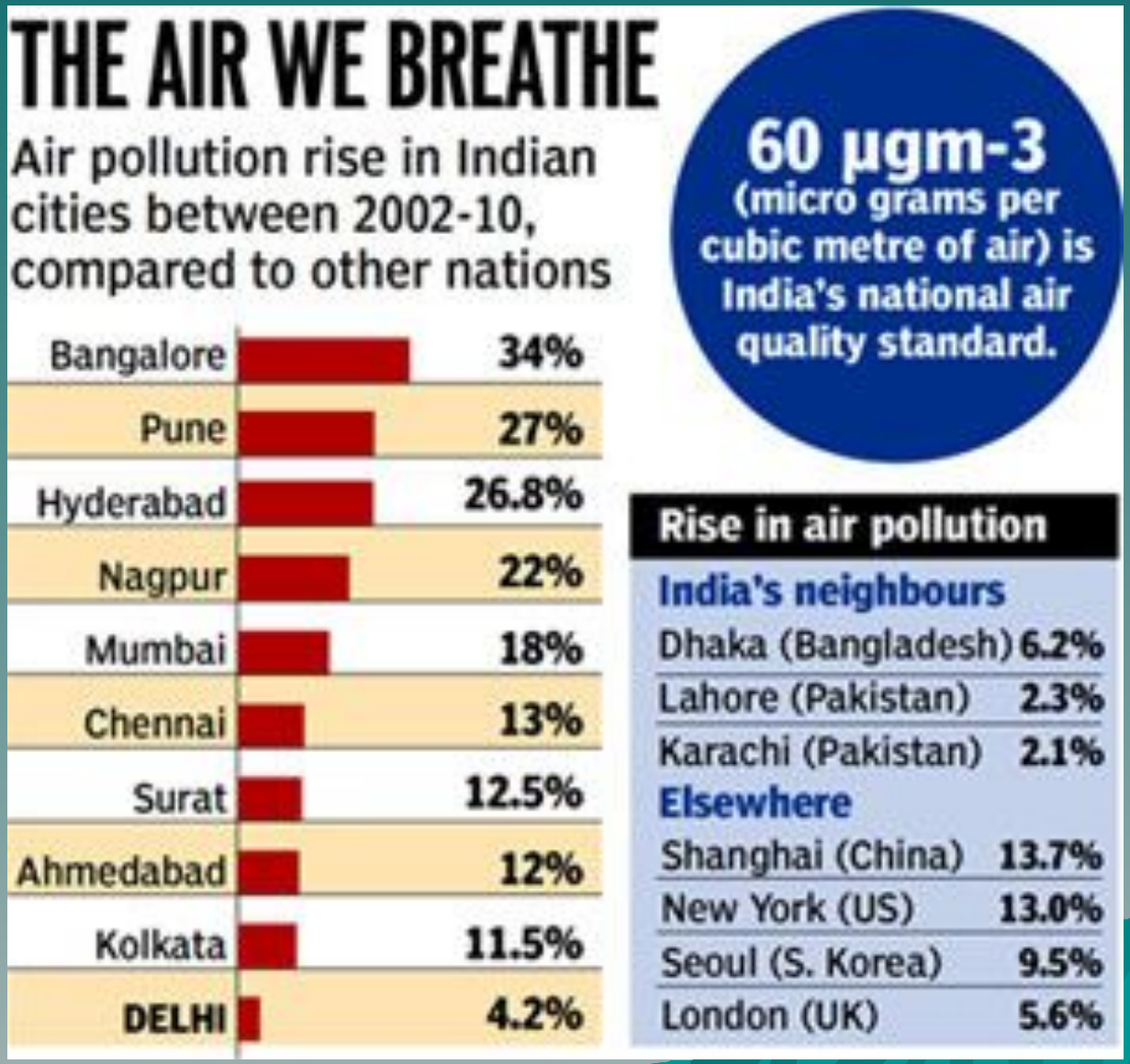
Air quality in India

- With a view to ascertain the ambient air quality at various locations, a monitoring network has been established comprising of 295 stations covering 98 cities/towns in 29 States and three Union Territories under the Air (Prevention and Control of Pollution) Act, 1981, as amended in 1988.

Air quality in India

- Under this programme, four criteria air pollutants viz. Sulphur dioxide (SO_2), oxides of nitrogen (NOx), Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM) are regularly monitored at all the locations.

Indian Scenario for RSPM



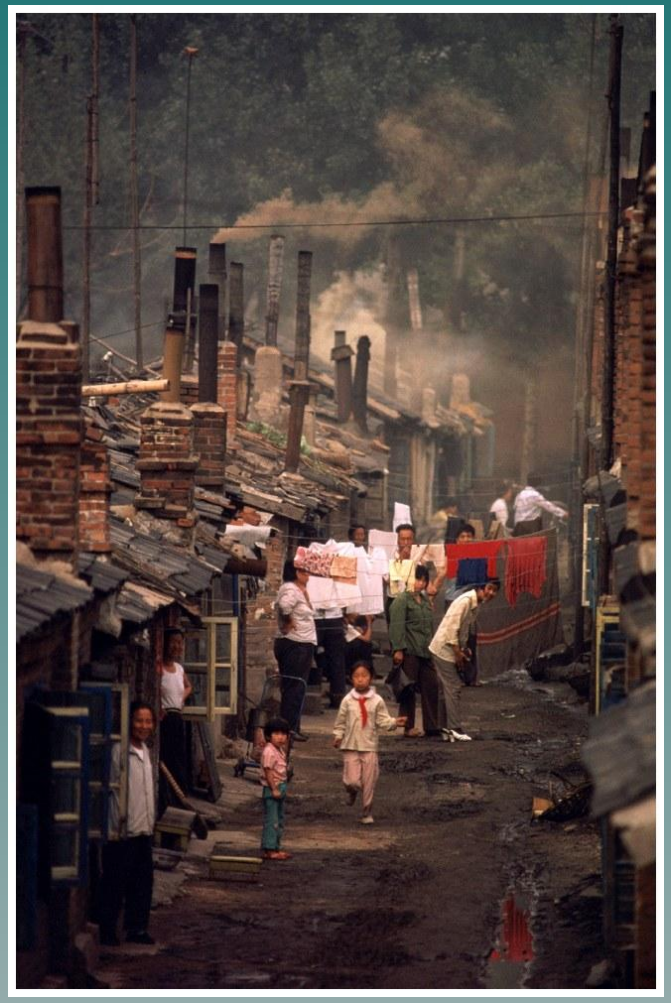
Air quality in India

- Additional parameters such as respirable lead and other toxic trace matters and polycyclic aromatic hydrocarbons are also being monitored in 10 metro cities of the country. The ambient air quality is monitored by Central Pollution Control Board (CPCB) through the National Air Quality Monitoring Programme in coordination with the State Pollution Control Boards, Pollution Control Committees and some of the universities and research institutes. The data, thus generated, are transmitted to CPCB for scrutinization, analysis, compilation and publication as a consolidated report.

Other Ways to Improve Air Quality

- Reduce sulfur content in gasoline as Sulfur clogs catalytic converters
- Require emission standards for all passenger vehicles
  - Including SUVs, trucks and minivans
- Require emission testing for all vehicles
  - Including diesel

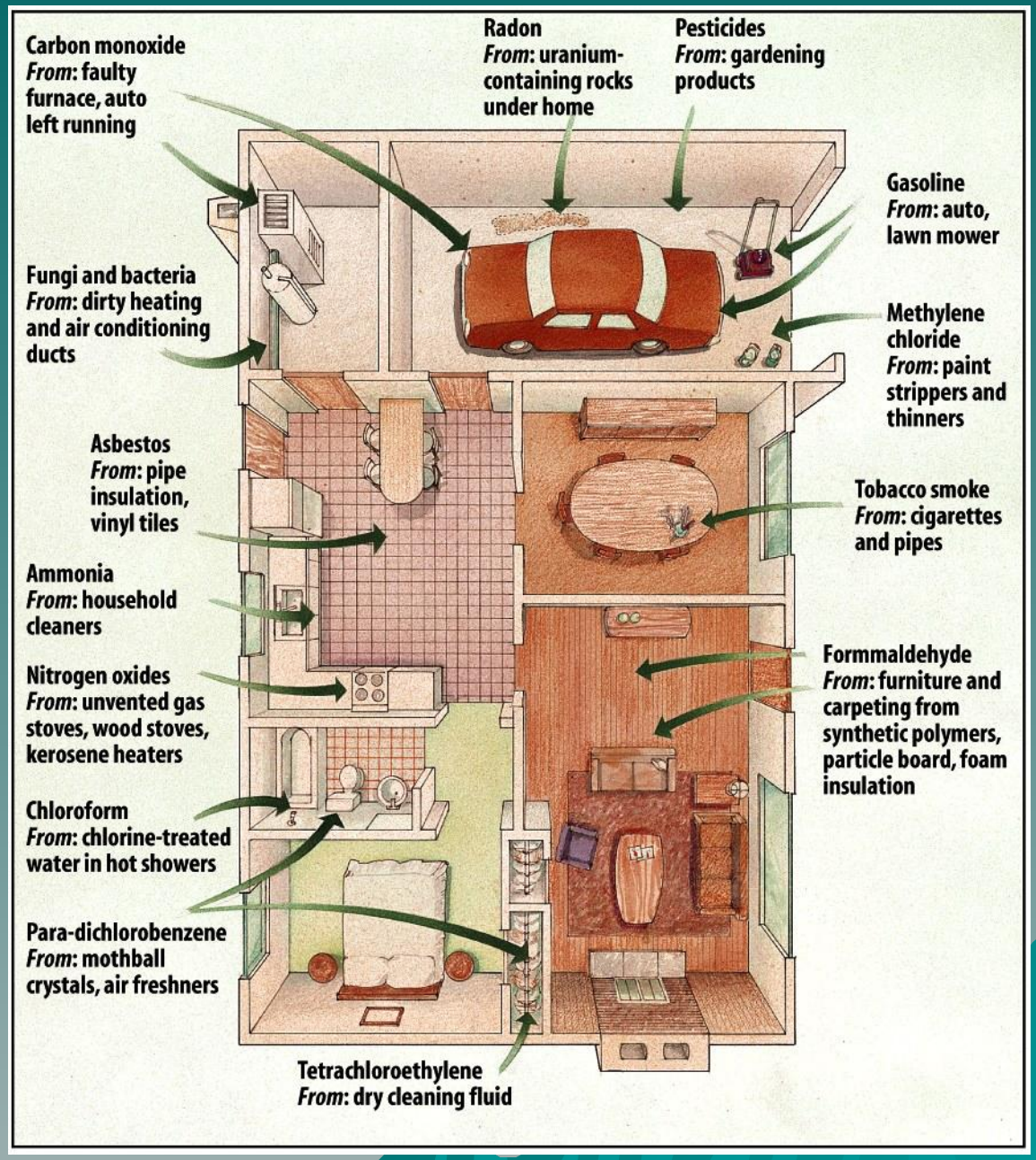
Air Pollution Around the World



- Air quality is deteriorating rapidly in developing countries
- Shenyang, China
  - Residents only see sunlight a few weeks each year
- Developing countries have older cars
  - Still use leaded gasoline
- 5 worst cities in world
  - Beijing, China; Mexico City, Mexico; Shanghai, China; Tehran, Iran; and Calcutta, India

Indoor Air Pollution

- Pollutants can be 5-100X greater than outdoors
- Most common:
  - Radon, cigarette smoke, carbon monoxide, nitrogen dioxide, formaldehyde pesticides, lead, cleaning solvents, ozone, and asbestos



What are some sources of indoor air pollution?

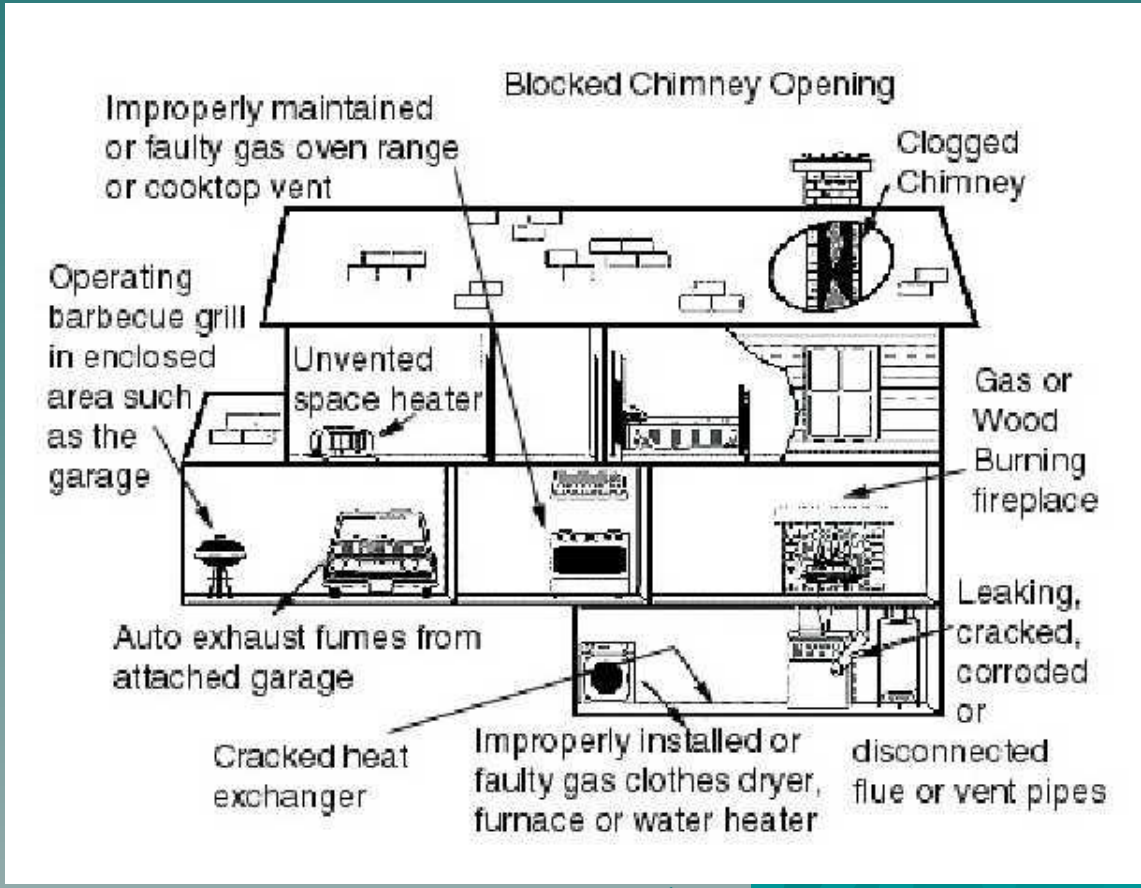
1. Cigarette smoke
   - Deadliest indoor air pollutant
   - Contain formaldehyde, carbon monoxide
   - Causes lung cancer, emphysema
   - Second hand smoke may be worse due to particulates that come from tip.

What are some sources of indoor air pollution?

2. Mold
   - Moisture in vents, carpets
   - Allergy symptoms, breathing problems, headache, fatigue

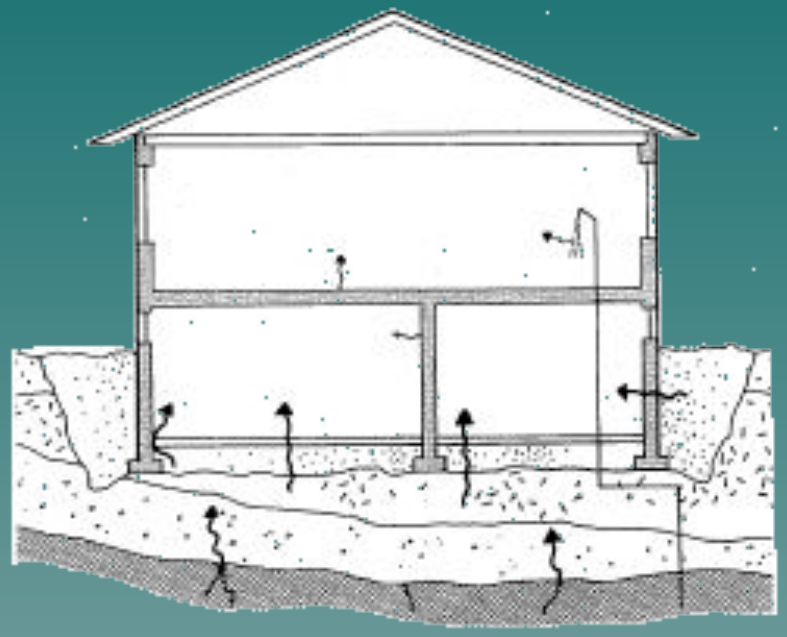
What are some sources of indoor air pollution?

3. Carbon monoxide
   - Malfunctioning furnace, gas appliances, cars
   - Blood cannot carry oxygen
   - Feel sleepy, nausea, dizzy, cause death.



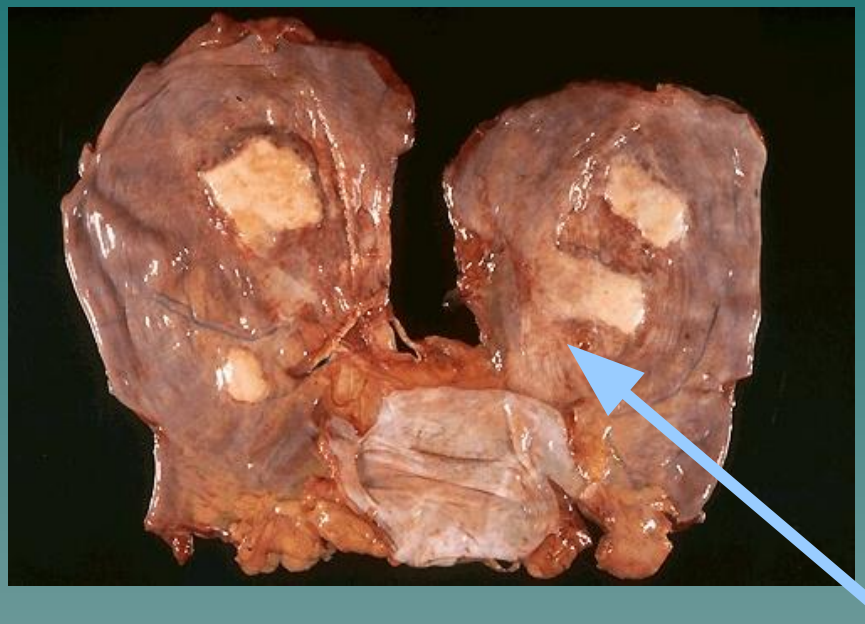
What are some sources of indoor air pollution?

4. Radon
   - Colorless, odorless, radioactive gas
   - Comes from soil under basements
   - Long term exposure can cause lung cancer
   - Fix cracks in floor or walls to prevent influx of radon
   - Install ventilation fan in basement to blow radon out.

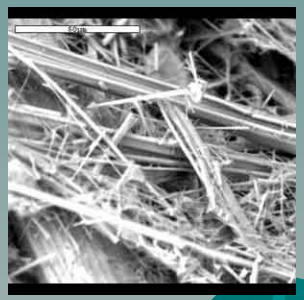


What are some sources of indoor air pollution?

5. Asbestos
   - Roofing, flooring, insulation, brakes
   - Harmless unless disturbed or deteriorates
   - Can cause asbestosis (scarring of lungs) and mesothelioma (type of lung cancer)

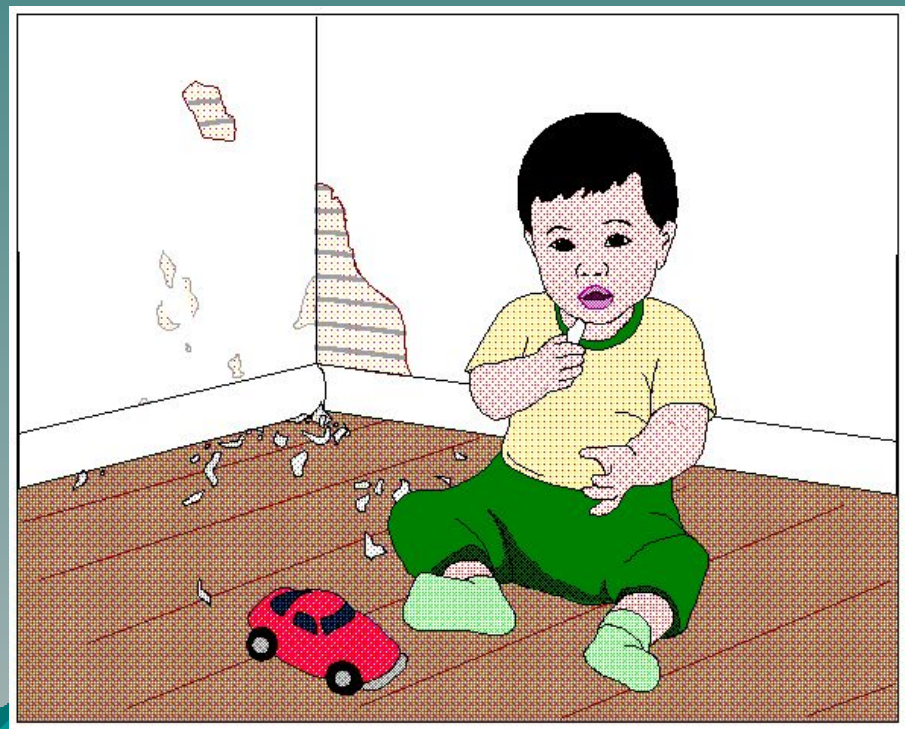


Plaque build up (scarring) in lung with asbestosis



What are some sources of indoor air pollution?

6. Lead
   - Old homes, toys, lead crystal dishes
   - Causes behavior & learning problems, slow growth, hearing problems, headaches

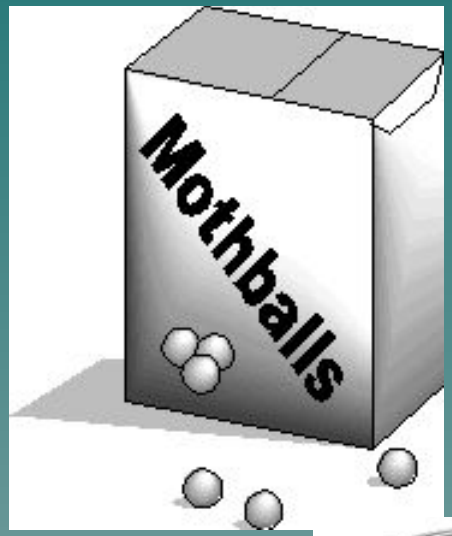


What are some sources of indoor air pollution?

7. Formaldehyde
   - Pressed wood, paneling, particle board, glue, deodorizers
   - Respiratory irritation, fatigue, skin rash, known to cause cancer

What are some sources of indoor air pollution?

8. VOC's
   - Paradichlorobenzene- mothballs, insecticides
   - PERC- dry cleaned clothes
   - Benzene- paints, cigarettes
   - Causes respiratory problems, headaches, loss of coordination, nausea, organ damage, cancer



Solutions to Indoor air pollution

- Source Control
- Ensure proper ventilation
- Ensure proper air filtration/cleaning
- Replace Old Filters
- Quit smoking or Smoke Outside (to reduce your life span)
- Avoid Painting, Spraying Combustible products indoors (or near ventilation units)
- Maintain clean roof, gutters, storm drainage
- Reduce and Remove Moisture
- Leave Asbestos Up To The Professionals