AIR POLLUTION

By
Bibhabasu Mohanty
Assistant Professor
Department of Civil Engineering
SAL Institute of Technology & Engineering Research

Content

Definition, Composition of atmospheric air, Classification and sources of air pollutants. Effects of air pollution on human, plant and material, Air pollution control methods, equipment and safety.

What is pollution ???

- Pollution is "*change in background conc.*".
- "Any *substance introduced* into the environment that *adversely affects the usefulness* of a resource".
- Pollution happens because no process is 100% efficient; each process produces pollution.

Air pollution

- Air pollution defined as the of *one or more contaminants* or *combinations* in such quantities and of such durations as may be or tend to be *injurious to human, animal or plant life, or property, or which unreasonably interferes with the comfortable enjoyment of life or property or conduct of business*.

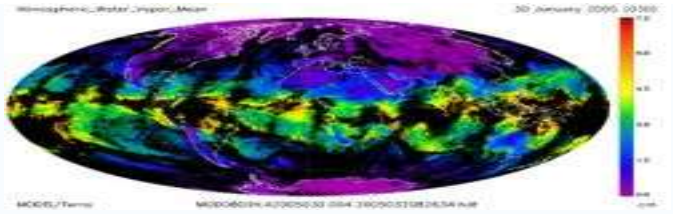
Composition of dry atmosphere, by volume

ppmv: parts per million by volume

Gas	Volume
Nitrogen (N_2)	780,840 ppmv (78.084%)
Oxygen (O_2)	209,460 ppmv (20.946%)
Argon (Ar)	9,340 ppmv (0.9340%)
Carbon dioxide (CO_2)	375 ppmv
Neon (Ne)	18.18 ppmv
Helium (He)	5.24 ppmv
Methane (CH_4)	1.745 ppmv
Krypton (Kr)	1.14 ppmv
Hydrogen (H_2)	0.55 ppmv

Not included in above dry atmosphere:

Water vapor (highly variable)	typically 1%



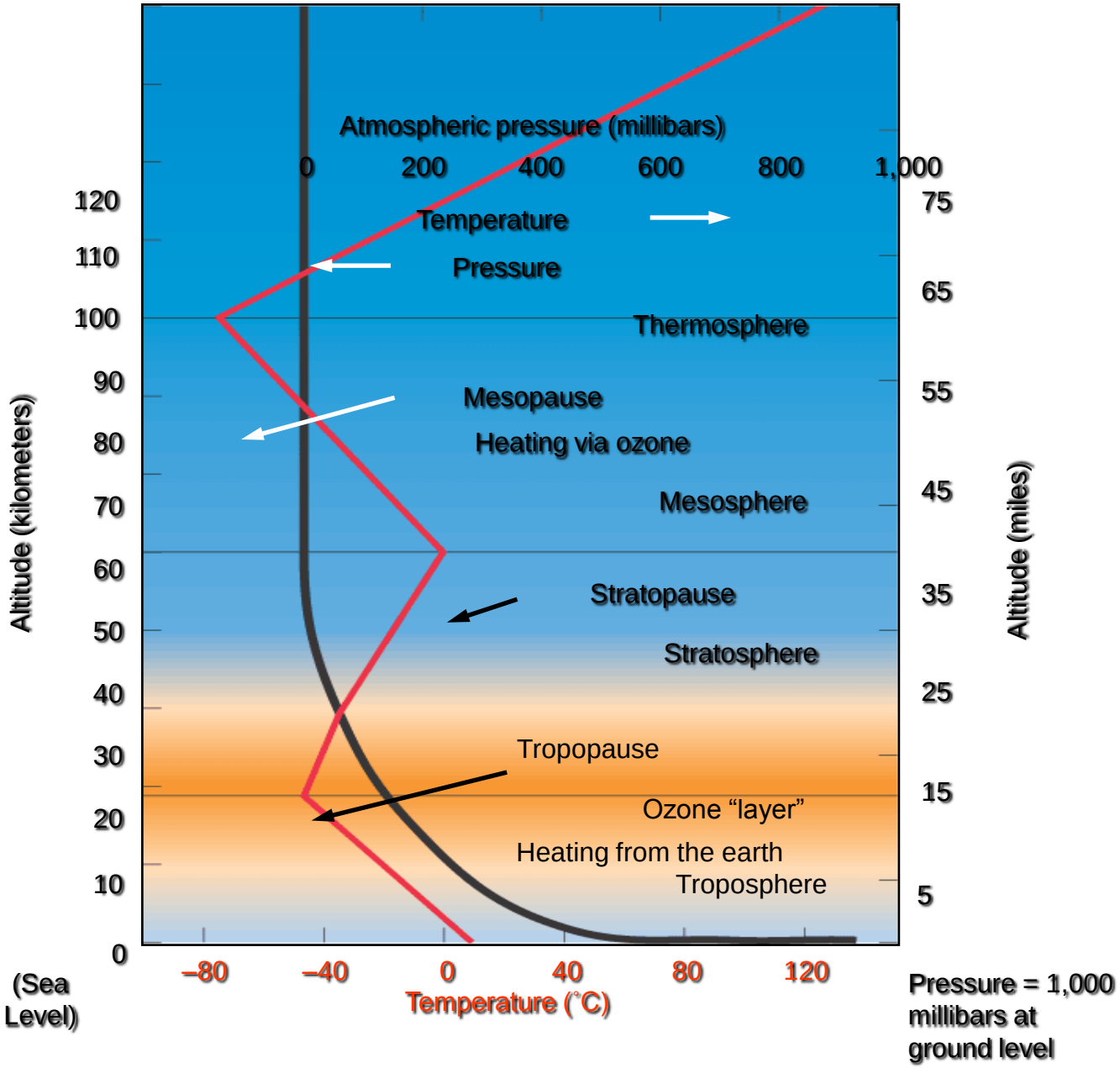
Mean Atmospheric Water Vapor.

Source for figures above: NASA. Carbon dioxide and methane updated (to 1998) by IPCC TAR table 6.1 [1]. The NASA total was 17 ppmv over 100%, and CO_2 was increased here by 15 ppmv. To normalize, N_2 should be reduced by about 25 ppmv and O_2 by about 7 ppmv.

Minor components of air not listed above include:

Gas	Volume
nitrous oxide	0.5 ppmv
xenon	0.09 ppmv
ozone	0.0 to 0.07 ppmv
nitrogen dioxide	0.02 ppmv
iodine	0.01 ppmv
carbon monoxide	trace

The Atmosphere



Source and classification

- Natural
- Man- made or anthropogenic

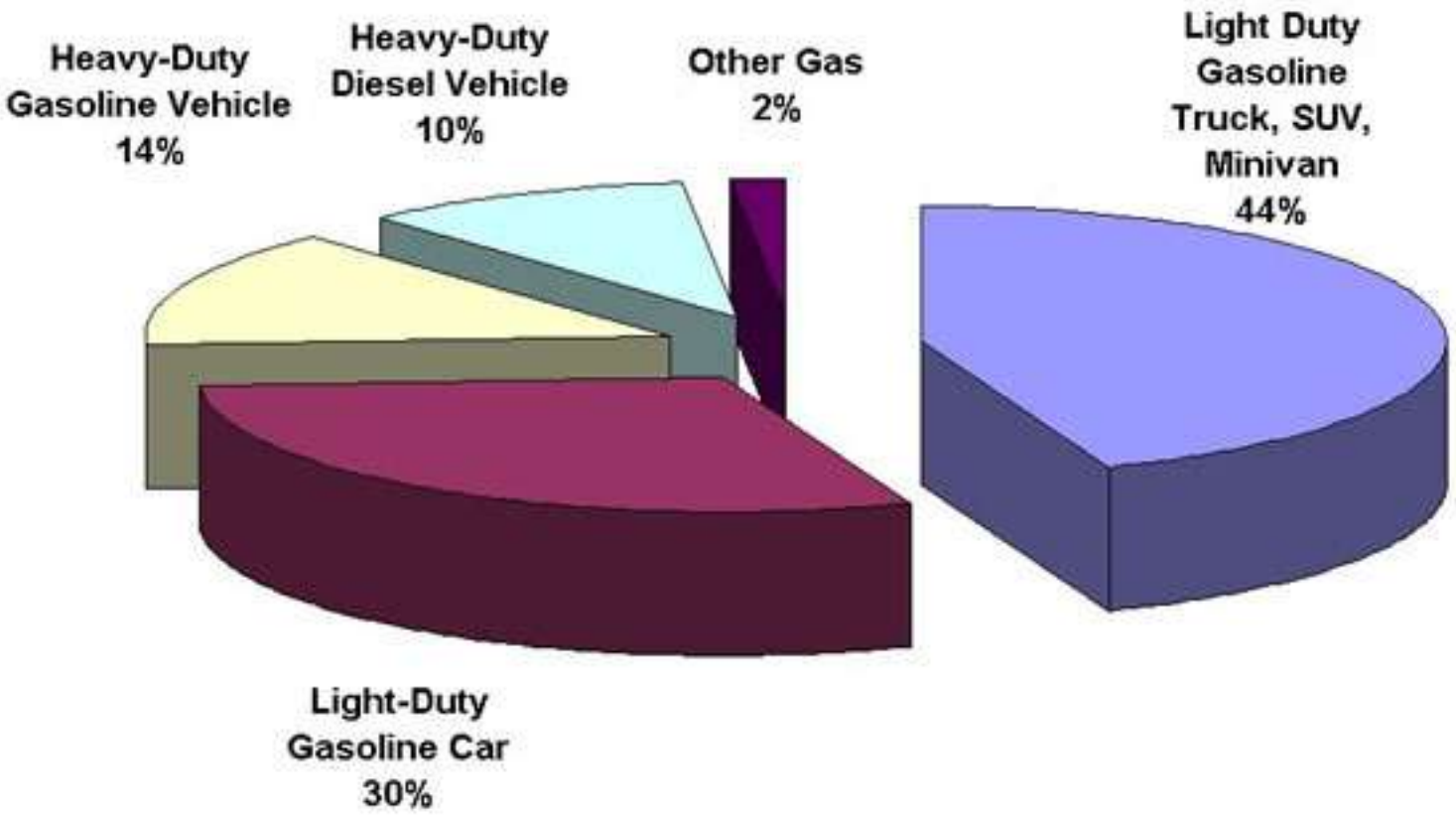
- Natural- pollen grains, volcanic eruptions, forest fires, dust storms, spores, bacteria and other microorganisms.
- Man- made- industrial units, thermal power plants, automobile exhausts, fossil fuel burning, mining, nuclear explosions,

Source and classification

- Stationary
- Mobile

  - Point source- large stationary source
  - Area source- small stationary source and mobile source with indefinite routes
  - Line source- mobile source with definite routes

2005 Air Toxic Emissions from On-Road Mobile Sources (Tox-Weighted)



Air pollutants

- Substance dwelling temporarily or permanently in the air.
- Alters the environment by interfering with the health, the comfort, or the food chain, or by interfering with the property values of people.
- A pollutant can be solid (large or sub-molecular), liquid or gas .
- It may originate from a natural or anthropogenic source (or both).

- It is estimated that anthropogenic sources have changed the composition of global air by less than 0.01%.

- Even a small change can have a significant adverse effect on the climate, ecosystem and species on the planet.

Classification of pollutants

- Pollutants can be grouped into two categories:

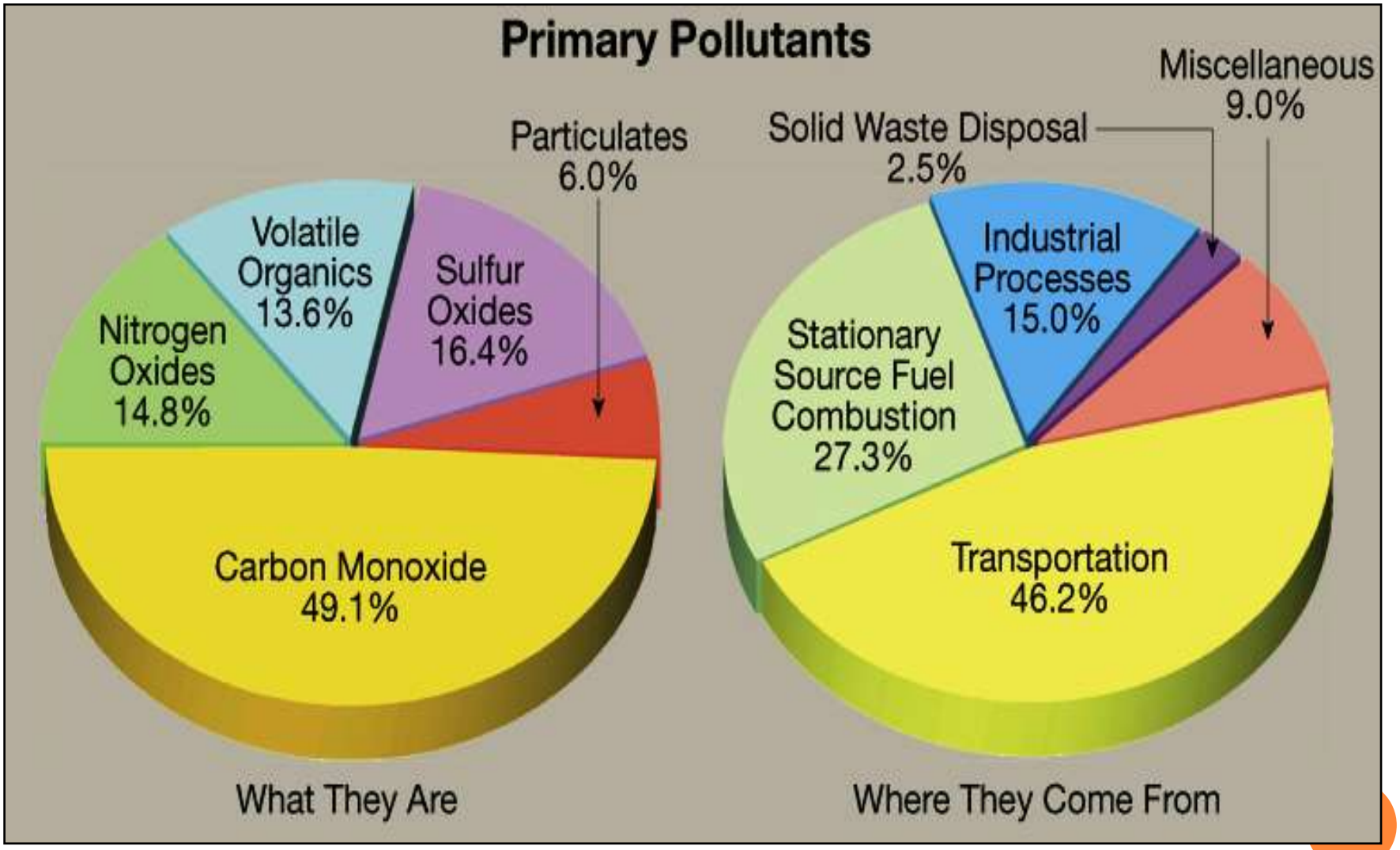
  (1) **primary pollutants**, which are emitted directly from identifiable sources, and

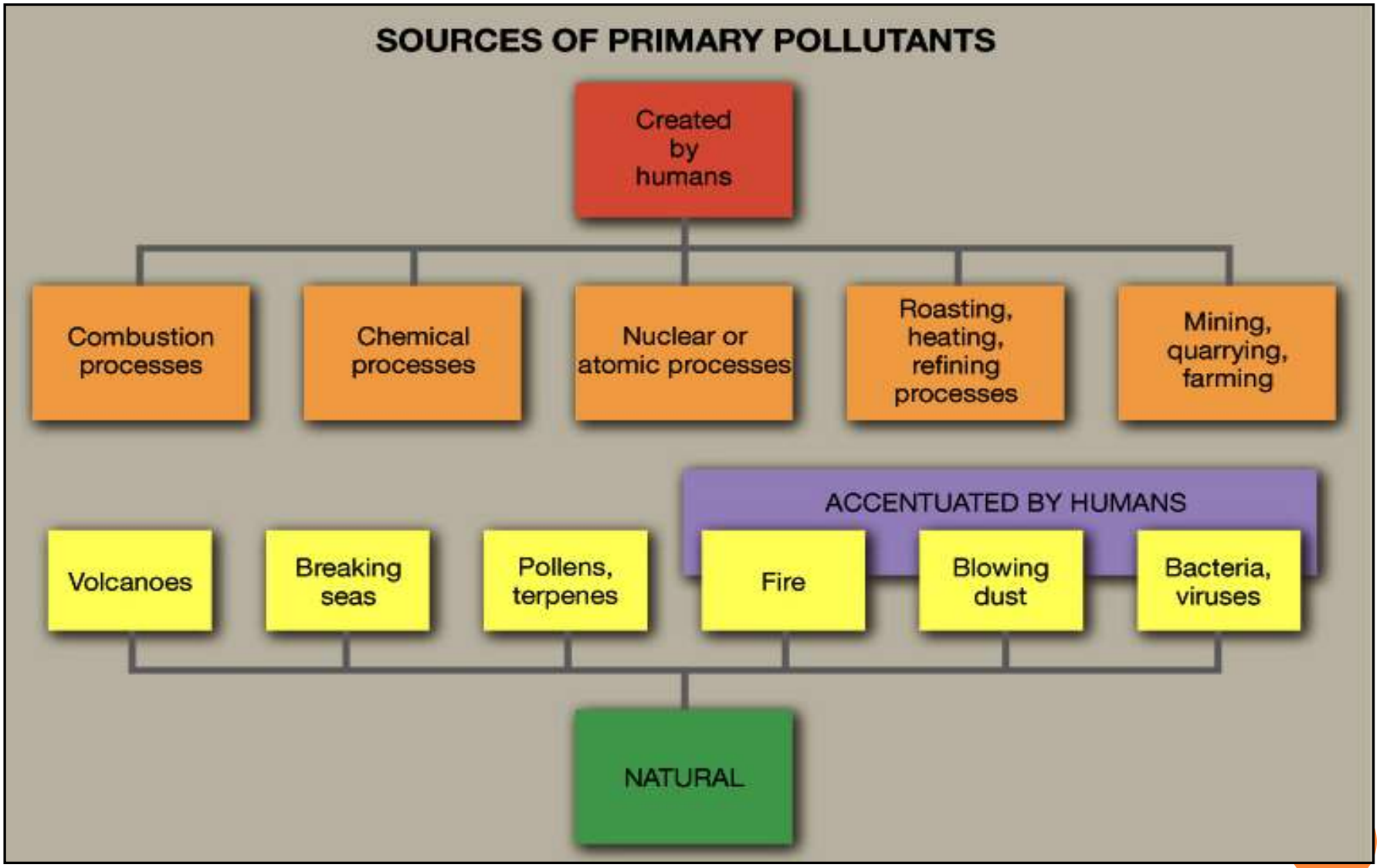
  (2) **secondary pollutants**, which are produced in the atmosphere when certain chemical reactions take place among primary pollutants.

Primary Pollutants

The major primary pollutants include:

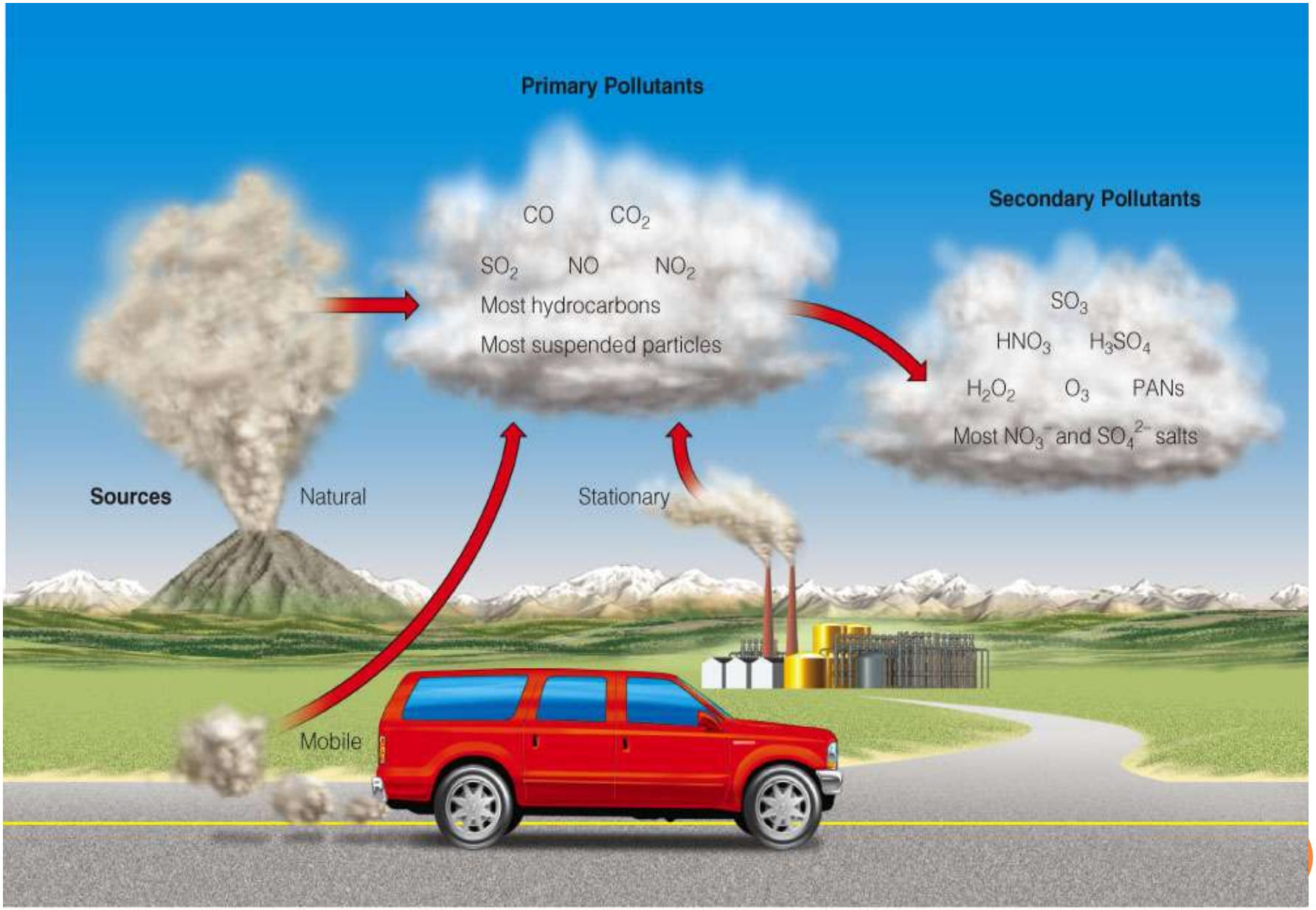
- particulate matter (PM),
- sulfur dioxide,
- nitrogen oxides,
- volatile organic compounds (VOCs),
- carbon monoxide, and
- lead.


Primary Pollutants
Particulates 6.0%
Volatile Organics 13.6%
Sulfur Oxides 16.4%
Nitrogen Oxides 14.8%
Carbon Monoxide 49.1%
What They Are
Miscellaneous 9.0%
Solid Waste Disposal 2.5%
Industrial Processes 15.0%
Stationary Source Fuel Combustion 27.3%
Transportation 46.2%
Where They Come From


SOURCES OF PRIMARY POLLUTANTS
Created by humans
Combustion processes
Chemical processes
Nuclear or atomic processes
Roasting, heating, refining processes
Mining, quarrying, farming
ACCENTUATED BY HUMANS
Volcanoes
Breaking seas
Pollens, terpenes
Fire
Blowing dust
Bacteria, viruses
NATURAL

Secondary Pollutants

- Some primary air pollutants react with one another or with other chemicals to form secondary pollutants.

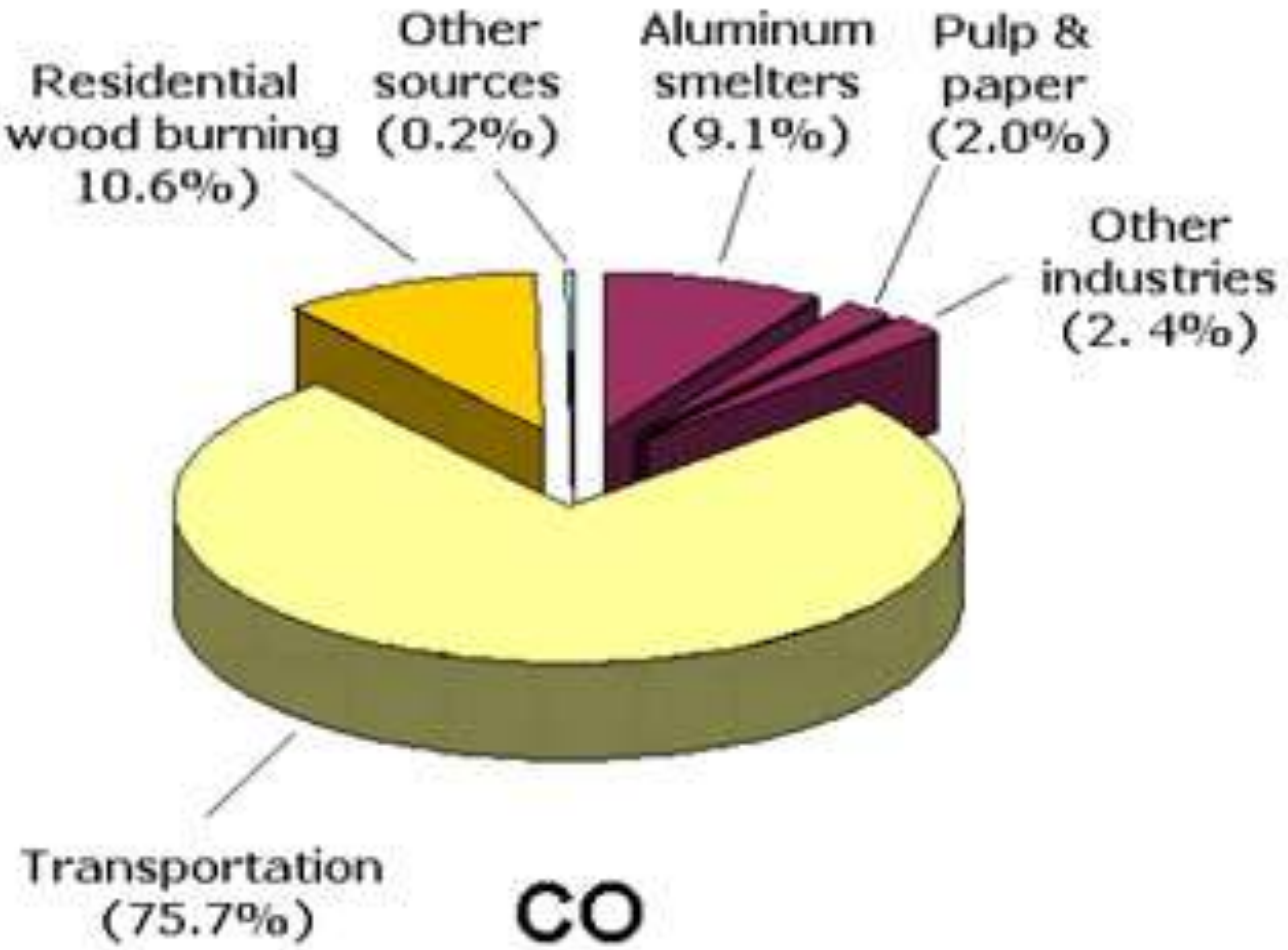


- Atmospheric **sulfuric acid** is one example of a secondary pollutant.
- Air pollution in urban and industrial areas is often called **smog**.
- **Photochemical smog**, a noxious mixture of gases and particles, is produced when strong sunlight triggers **photochemical reactions** in the atmosphere.
- The major component of photochemical smog is **ozone**.

Major Pollutants sources and effects

- Carbon monoxide (CO)- colorless, odorless, tasteless gas.
- No effect at normal conc. (0.1ppm) but higher conc. seriously affect.

- Volcanoes, natural gas emissions, seed germination contribute to CO.
- Transport sector contribute 75% CO.
- Residential wood burning 10%, industrial process 15% CO.


Residential wood burning 10.6%)
Other sources (0.2%)
Aluminum smelters (9.1%)
Pulp & paper (2.0%)
Other industries (2. 4%)
Transportation (75.7%)
CO

Effects:

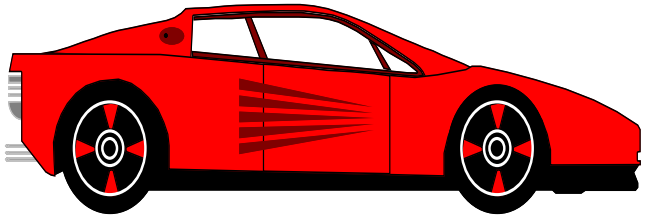
- Reduce oxygen carrying capacity of blood.
- Decrease in vision and causes cardio vascular disorders.

- Carbon dioxide ($C0_2$)- Fossil fuel combustion.
- Jet plane use O_2 and release CO_2.
- Burning

Effects:

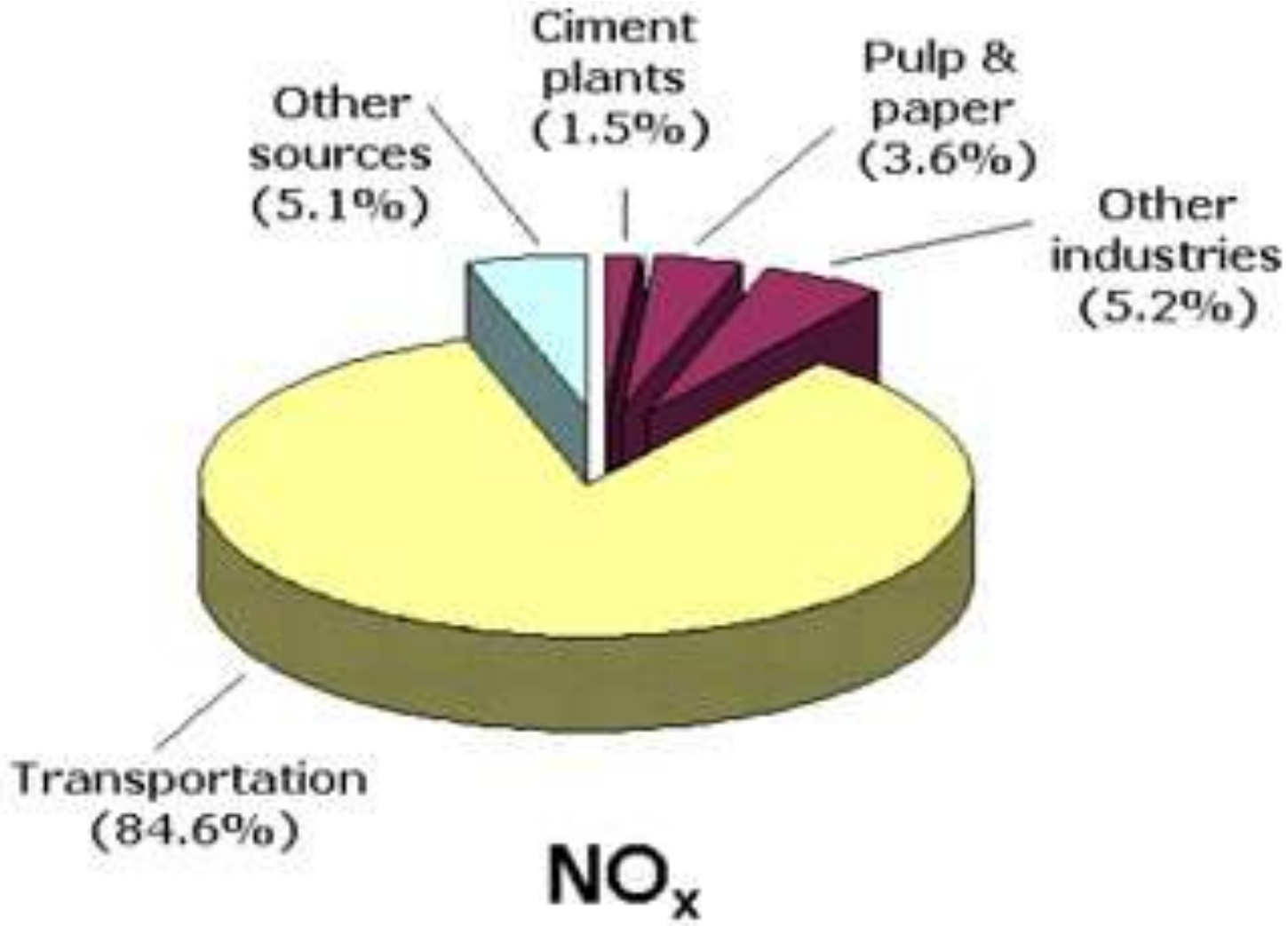
- Causes headache and nausea.
- Effect on climate, increase global temp.

- Oxides of nitrogen – NOx group contains NO, NO_2, N_2O.
- Fuel combustion in automobiles and industries.
- Lightening.
- Forest fires.
- Natural ionizing radiations.



Effects:

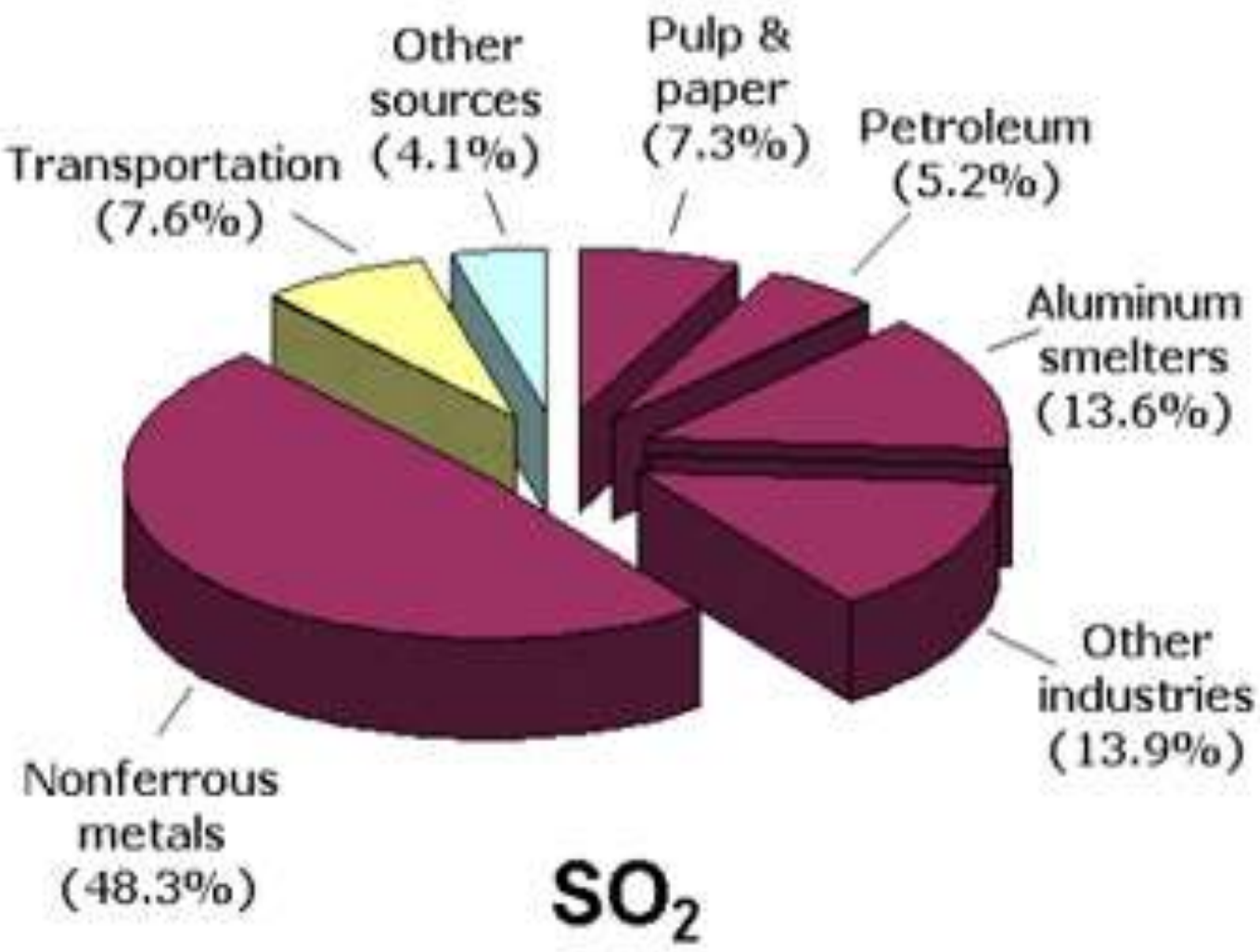
- Reduce blood carrying capacity.
- Causes lung problems.


Ciment plants (1.5%)
Pulp & paper (3.6%)
Other sources (5.1%)
Other industries (5.2%)
Transportation (84.6%)
NO_x

- Oxides of sulphur – generally called SOx, include SO_2, SO_3.
- 67% SOx pollution due to volcanic activities and other natural sources.
- Remaining due to fossil fuel burning, transportation.
- Industrial activities.

Effects:

- Respiratory problems
- Marbles, clothes, paper, leather also affected.
- Plants also heavily affected.


Other sources (4.1%)
Pulp & paper (7.3%)
Transportation (7.6%)
Petroleum (5.2%)
Aluminum smelters (13.6%)
Other industries (13.9%)
Nonferrous metals (48.3%)
SO2

- Hydrocarbons (HC) – these include methane, ethylene, acetylene, terpenes etc.
- Sources include coal fields, natural fires.
- Incomplete combustion
- Forest fires
- Agricultural burning

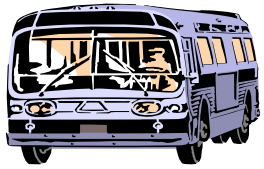
Effects:

- Carcinogenic effect
- Form ozone and PAN which are harmful.
- Damage plants, rubber materials, fabric and paints.

Particulate materials

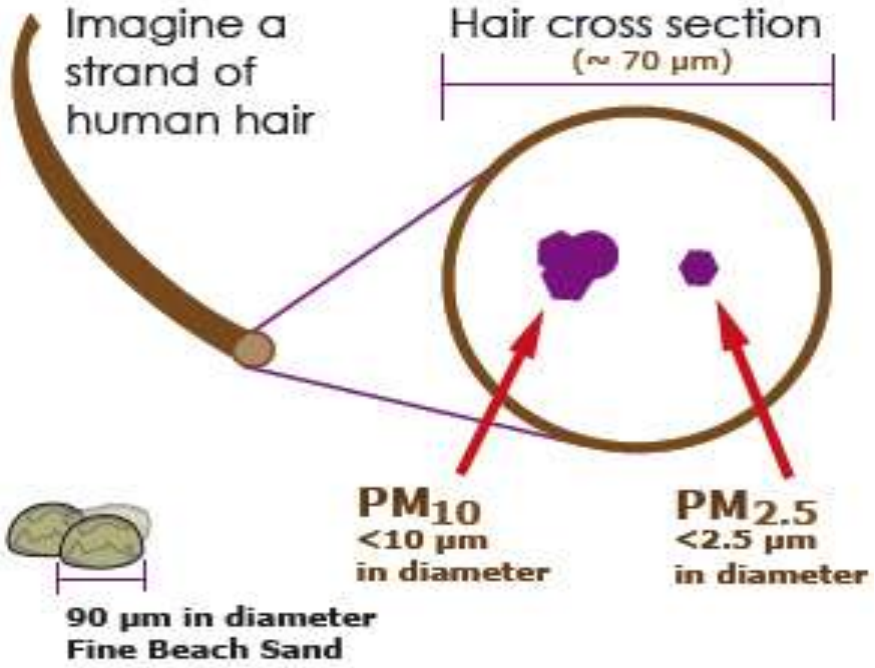
- Particles of different substances suspended in the air
- In the form of solid particles and liquid droplets
- Particles vary widely in size
- Different particulate materials are aerosols, dust, smoke, fumes, mist, fog, fly ash etc.

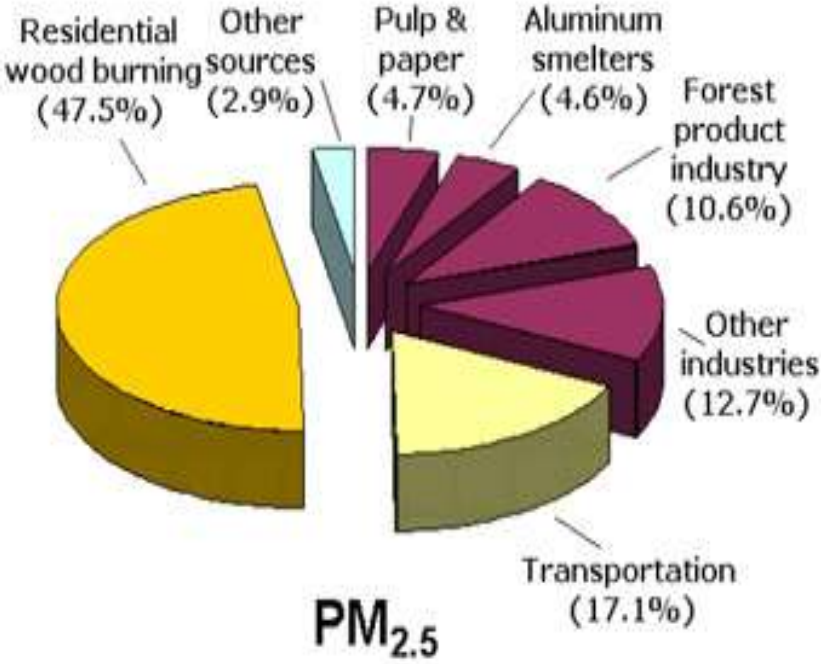
- Fine particles come from a variety of sources:
  - -diesel trucks and buses
  - -construction equipment
  - -power plants
  - -woodstoves
  - -wildfires



- Also, Chemical reactions in the atmosphere can transform gases into fine particles.

How small is PM?

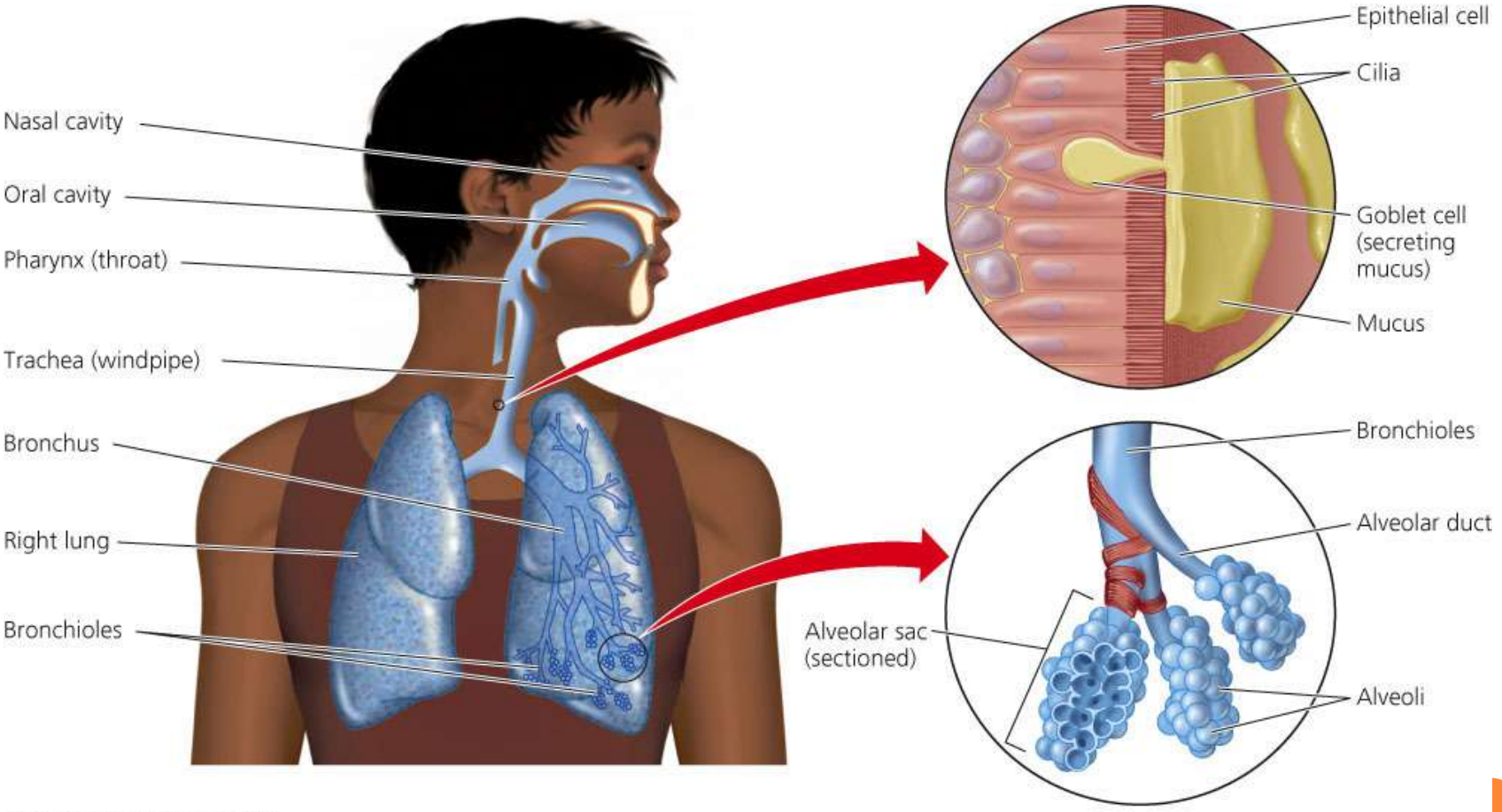




Effects:

- Premature death
- Aggravated asthma
- Acute respiratory symptoms
- Chronic bronchitis
- Decreased lung function (shortness of breath)
- People with existing heart and lung disease, as well as the elderly and children, are particularly at risk

Effects of air pollution on human



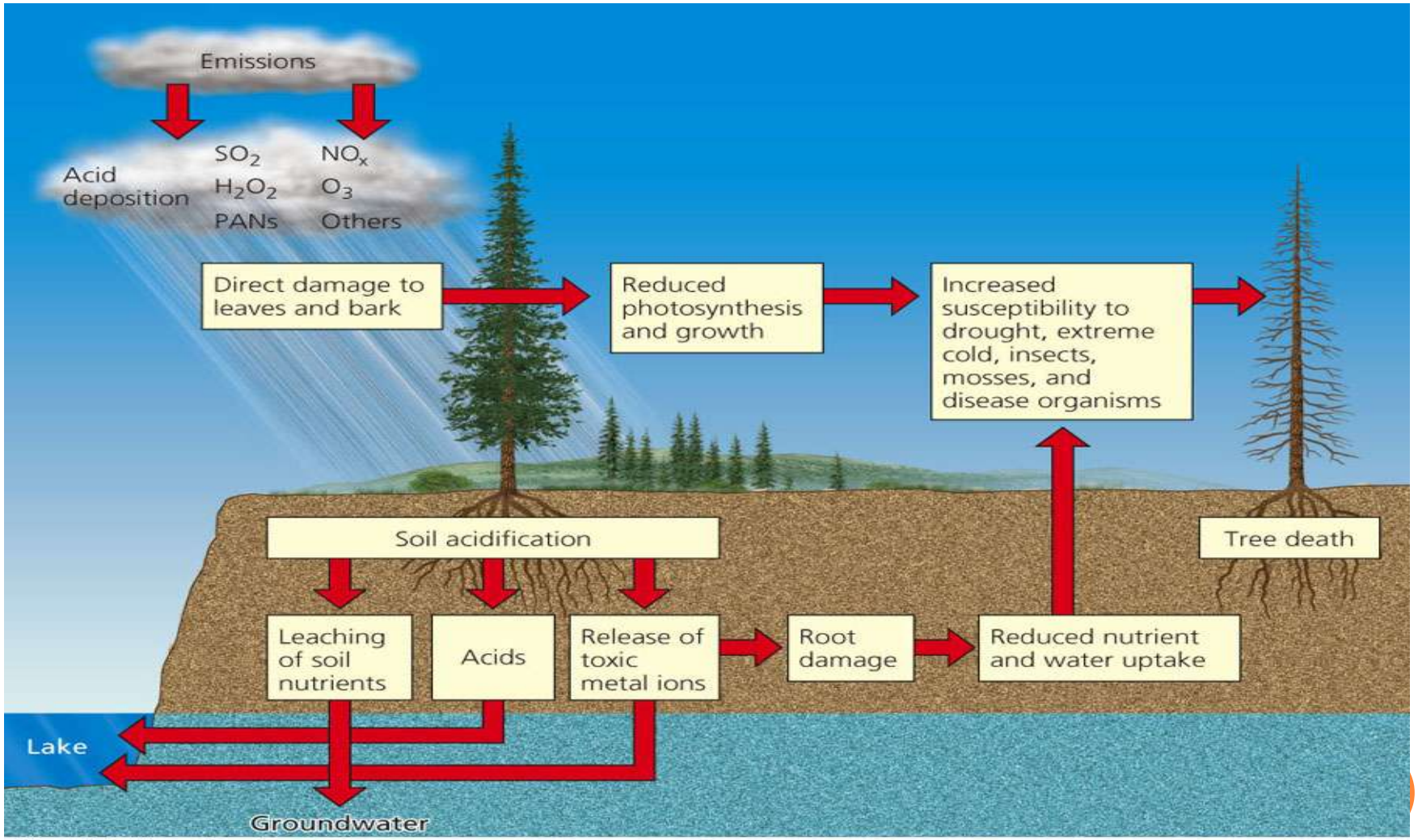
- around 30-40% of cases of asthma and 20-30% of all respiratory disease.
- effect our health in many ways with both short term and long term effect.
- Short term effect are: irritation to nose, eye, throat, bronchitis, headache etc.
- Long term affect are: lung disease, chronic respiratory problem, damage to heart, brain, eyes etc.
- Eye irritation due to NOx, O_3, PAN, particulates.
- Nose and throat due to SO_2, NOx etc.

- Gaseous pollutants like H_2S, SO_2, NO_2 and hydrocarbons cause odor nuisance.
- Irritation of respiration tract caused by SOx, NOx, CO, O_3.
- Increase in mortality.
- High conc. of SO_2, NO_2 and SPM causes bronchitis and asthma.
- CO and NO react with haemoglobin and reduce O_2 carrying capacity of blood.
- Heavy metals like lead can cause poisoning. High conc. cause damage to liver and kidney.

Factors affecting human health

- Nature of the pollutants
- Concentration of the pollutants
- Duration of exposure
- State of health of receptor
- Age group of the receptor

Effects of air pollution on plant

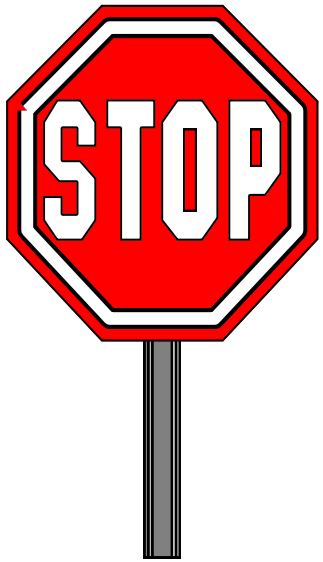


- Decrease yield in agriculture.
- Suppressed growth of vegetables.
- Leaf injury and damage to young plants.
- Decreased growth rate and increased death rate.

Effects of air pollution on materials

- Corrosion of metals due to SO_2 in presence of oxygen and moisture is converted into H_2SO_4 acid.
- H_2SO_4 acid react with limestone, marble and other building materials to cause deterioration.
- Soiling and eroding of building materials.
- SO_2, O_3, H_2S and aerosols damage protective coating and paints of the surface.
- O_3 and PAN causes cracking of rubber and various electrical insulations.
- Deterioration of art work due to SPM.

Air pollution control



- Cannot be fully prevented but can be controlled.

1. Preventative measures
2. Control measures using equipments.

Preventative measures (source control)

- Selection of suitable fuel. (Low sulphur coal in power plant, using of CNG)
- Modification in industrial process.
- Selection of suitable site and zoning for industrial unit.

Control measures

- When source control not possible some measures taken to prevent pollution.
- Collecting pollutants by using equipments.
- Destroying the pollutants by thermal or catalytic combustion.
- Changing the pollutants to less toxic form.
- By releasing the pollutants through tall chimneys for greater dispersion.

Preventation by laws

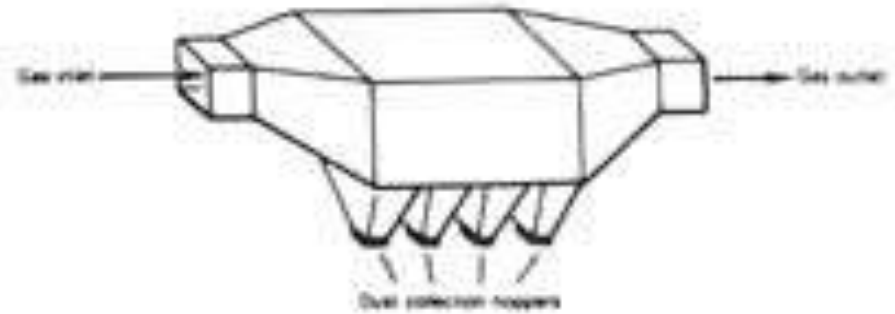
- Various laws has been established for the menace of air pollution.
- Air (Prevention & control of pollution) Act,1981.
- Air (Prevention & control of pollution) Amendment Act,1987.
- Motor vehicle Act, 1988.
- Air (Prevention & control of pollution) Union Territories Rules, 1983.
- Environment Protection Act, 1986.

The government is trying to

- remove the use of leaded petrol, a major cause of air pollution.
- the industrial acts are implemented to control the harmful emission of gases.
- the natural management team work to minimize the effect of various natural disaster like forest fire, volcanic eruption that are causes of air pollution.

Air pollution controlling equipments

- Gravitational settling chamber



Settling Chamber

- Used to remove particles with size greater than 50 µm.
- Velocity of flue gas reduced in large chamber.
- Particles settle under gravitational force.

Advantages

- Low initial cost.
- Easy to design.
- Low pressure drop.
- Low maintenance cost.
- Dry and continuous disposal of solid particulates.

Disadvantages

- Require large space.
- Less collection efficiency.
- Only larger size particles can be collected.

Cyclone separator

- Centrifugal force is utilized to separate the particulate matter.
- It can remove 10 to 50 μm particle size.
- Used mostly in industries.

Advantages

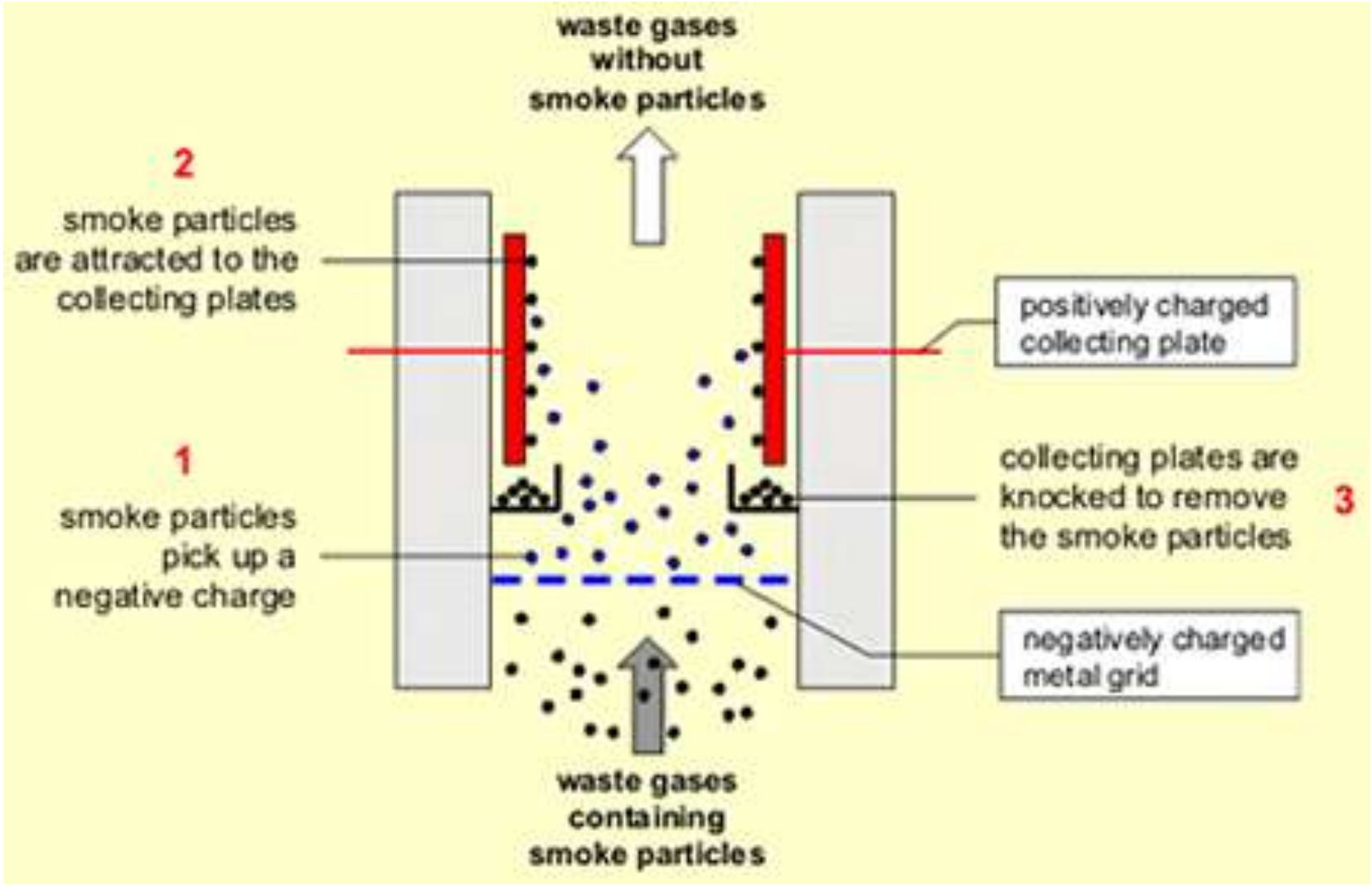
- Low initial cost.
- Require less floor area.
- Simple construction and maintenance.
- Can handle large volume of gas at high temp.

Disadvantages

- Requires large head room.
- Less efficiency for smaller particles (<10μm).
- Sensitive to variable dust load and flow rate.

Electrostatic precipitators

- Works on the principle of electrical charging of particulate Matter (-ve) and collecting it in a +ve charged surface.
- 99% efficiency.
- Can remove particle size range of 0.1 μm to 1 μm.


waste gases without smoke particles
2
smoke particles are attracted to the collecting plates
positively charged collecting plate
1
smoke particles pick up a negative charge
collecting plates are knocked to remove the smoke particles
3
negatively charged metal grid
waste gases containing smoke particles

Advantages

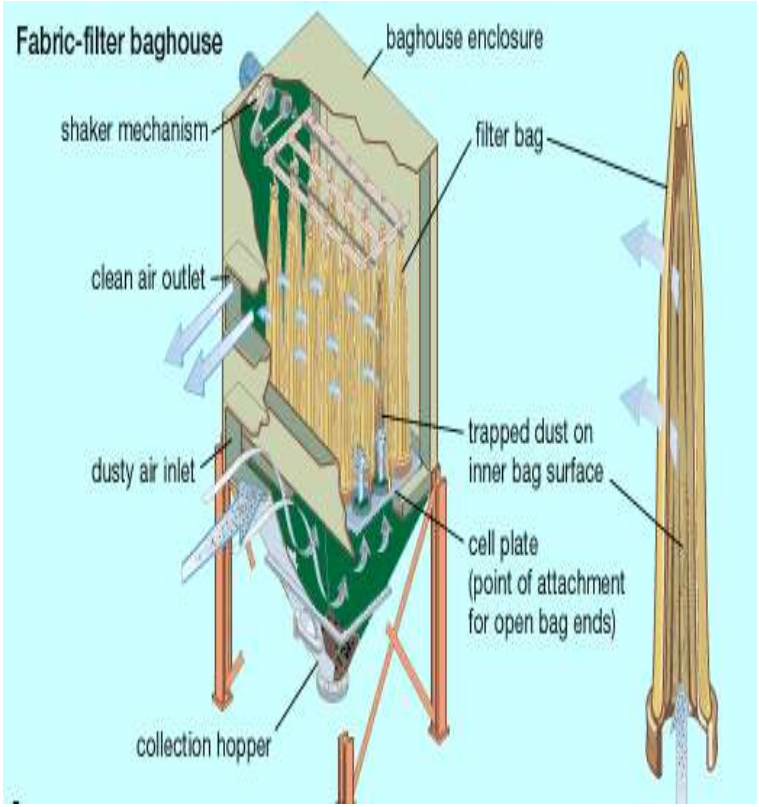
- High collection efficiency.
- Particles may be collected dry or wet.
- Can be operated at high temp. (300-450˚c).
- Maintenance is normal.
- Few moving parts.

Disadvantages

- High initial cost.
- Require high voltage.
- Collection efficiency reduce with time.
- Space requirement is more.
- Possible of explosion during collection of combustible gases or particulates.

Fabric filters

- Flue gas is allowed to pass through a woven Fabric, which filters out Particulate matter.
- Small particles are retained on the fabric.
- Remove particles up to 1 μm.
- Its efficiency up to 99%.



Advantages

- Higher collection efficiency for smaller than 10 μm particle size.
- Performance decrease becomes visible, giving prewarning.
- Normal power consumption.

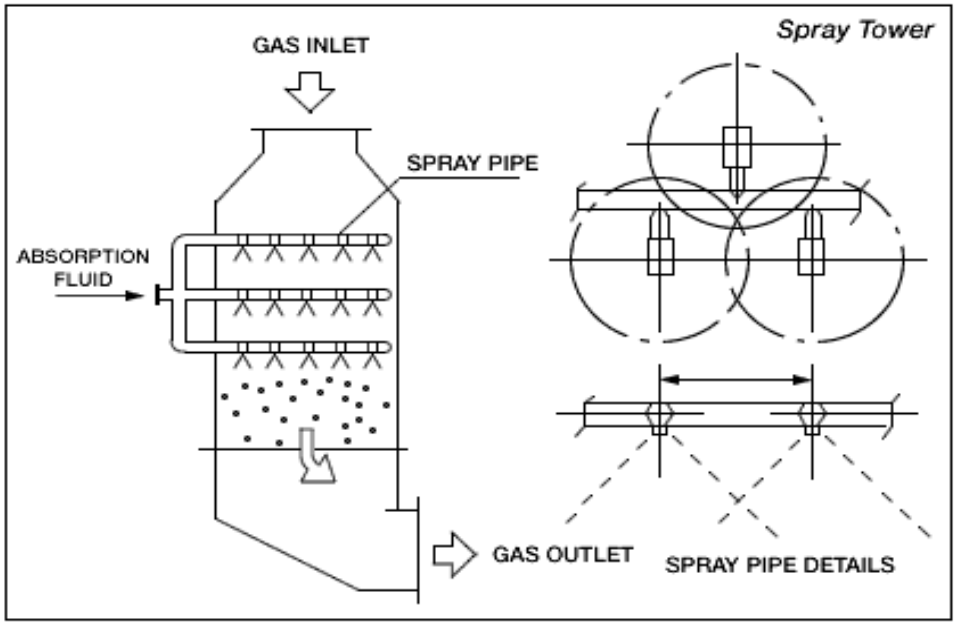
Disadvantages

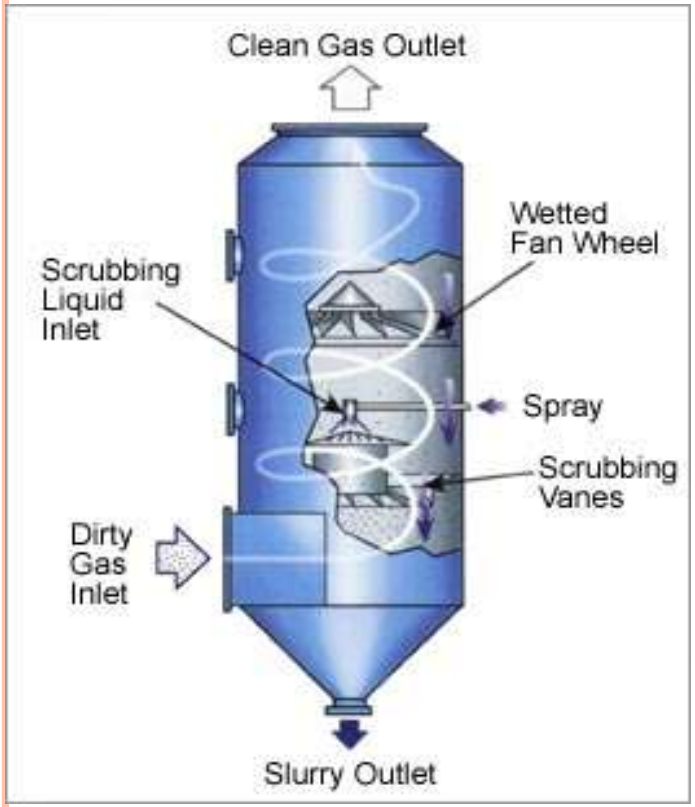
- High temp. gases need to be cooled.
- High maintenance and fabric replacement cost.
- Large size equipment.
- Fabric is liable to chemical attack.

Scrubbers

- Particulate matters are incorporated into liquid droplets and removed from the gas stream.
- Different types of scrubbers are-
    - Spray tower
    - Venturi scrubber
    - Cyclone scrubber
- Flue gas made to push up against a down falling water current.
- Particulate matter mix up with water thus falls down and gets removed.

Spray tower





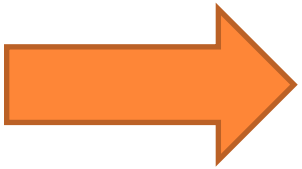
Cyclone scrubber

Advantages

- Simultaneously remove particulates and gaseous pollutants.
- Hot gases can be cooled down.
- Corrosive gases can be recovered and neutralize.

Disadvantages

- Lot of waste waters produced.
- Poses freezing problem in cold countries.
- Maintenance cost is high when corrosive materials are collected.



THANK U ALL…