ENVIRONMENTAL CHEMISTRY

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Environment

The sum total of all social, economical, biological,physical and chemical factors which constitute the surroundings and influence the life of a living organism in its habitat

- Abiotic or non living component :Lithosphere, hydrosphere, atmosphere
- Biotic or living component : all living organisms
- Energy component : solar energy, geochemical energy, thermoelectrical energy, hydroelectrical energy, nuclear energy etc

Segments of Environment

- **There are four different segment of environment:**

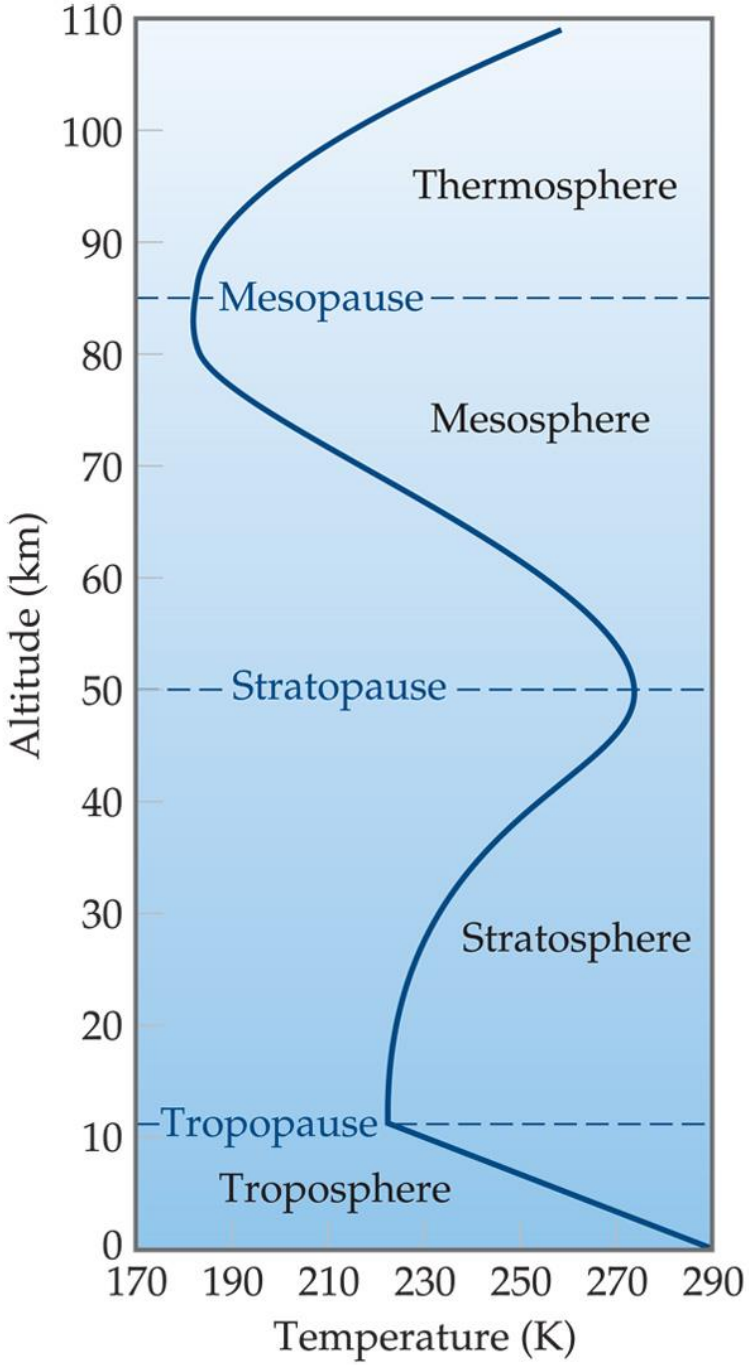
- **1. Atmosphere:**
- The air envelope surrounding the earth is known as Atmosphere. This protective envelop surrounding earth sustain life on earth and protect us from unfriendly environment of outer space. It extends to the height of about 500 km from the earth surface. It consists of life saving gases like O_2 for human beings and animals and CO_2 for plants.

- **2. Hydrosphere:**
- It covers more than 75% of the earth surface either as oceans or as fresh water. Hydrosphere includes sea, rivers, oceans, lakes, ponds, streams etc.
- 97% -Ocean
- 2%- Polar ice caps, Glaciers
- 1%- Fresh water (from rivers,lakes, streams)
- Uses
- 30%-Irrigation
- 50%- Thermal power plants
- 7%- Domestic
- 12%- Industrial

- **3. Lithosphere:**
- It means the mantle of rocks constituting the earth's crust. The solid component of the earth is called Lithosphere, which includes soil, earth, rocks and mountains etc. The lithosphere mainly contains three layers –
- **(a) Inner and Outer Core:**
- Central fluid or vaporised sphere of diameter of about 2500km from the centre.
- **(b) Mantle:**
- It is about 2900-3000 km above the core in molten state.
- **(c) Crust:**
- Outermost solid zone about 8-40 km above mantle

- **4. Biosphere:**
- This segment of environment consists of atmosphere (air- 02, N2, C02) Lithosphere (land- minerals, salts, food, nutrients) and hydrosphere (water- dissolved oxygen, Salts) which influences and support the entire biotic and abiotic life systems.

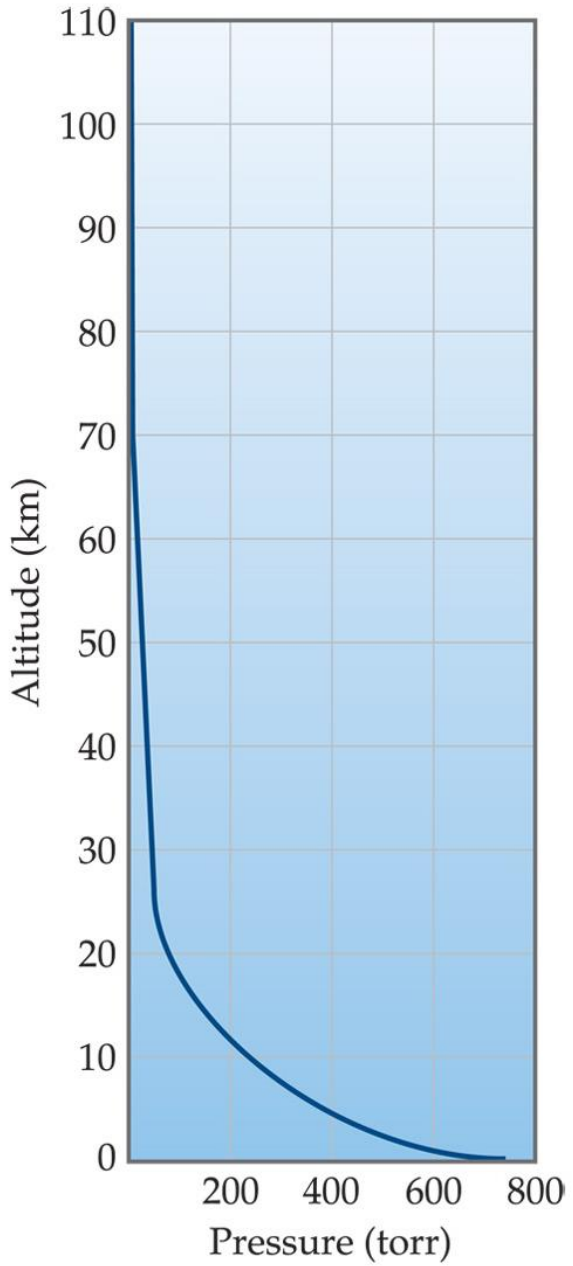
- **Atmosphere**
- General
- physical structure
- chemical composition



- Temperature varies greatly with altitude.
- The profile makes a Z-shape from mesosphere to the ground.

Pressure is highest at the surface and decreases with height.

Fluctuations in pressure are a driving force of weather.



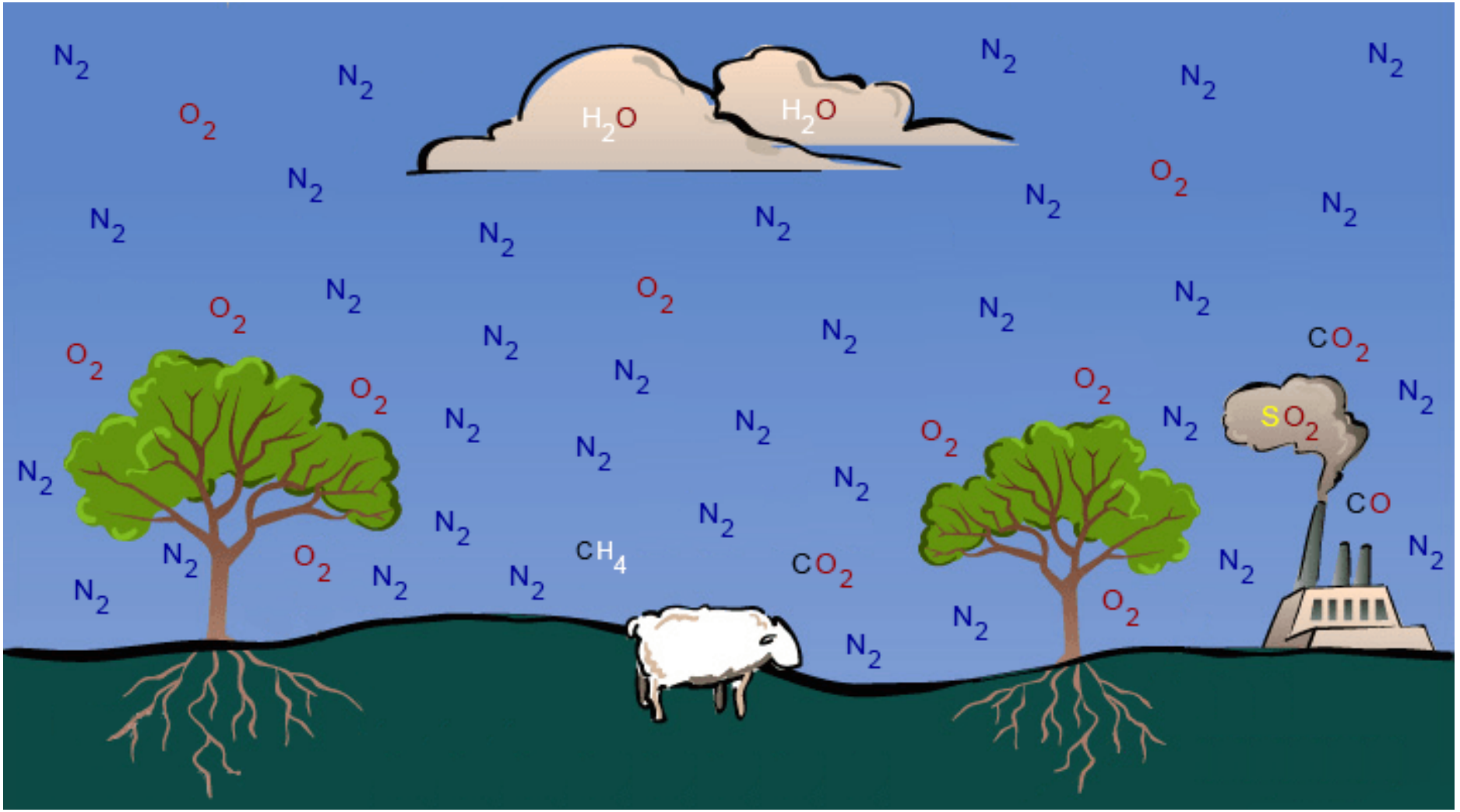
- **Troposphere**
- It is the lowermost layer of the atmosphere.
- The height of this layer is about 11 km on the equator and 8 km on the poles.
- The thickness of the troposphere is greatest at the equator because heat us transported to great heights by strong convectional currents.
- Troposphere contains dust particles and water vapour.
- This is the most important layer of the atmosphere because all kinds of weather changes take place only in this layer.
- The air never remains static in this layer. Therefore this layer is called ‘changing sphere’ or troposphere.
- The environmental temperature decreases with increasing height of the atmosphere. It decreases at the rate of 1 degree Celsius for every 165 m of height. This is called Normal Lapse Rate.
- The zone separating troposphere from the stratosphere is known as tropopause.
- The air temperature at the tropopause is about – 80 degree Celsius over the equator and about – 45 degree Celsius over the poles. The temperature here is nearly constant, and hence, it is called tropopause.

- **Stratosphere**
- Stratosphere is found just above the troposphere.
- It extends up to a height of 50 km.
- The temperature remains almost the same in the lower part of this layer up to the height of 20 km. After this, the temperature increases slowly with the increase in the height. The temperature increases due to the presence of ozone gas in the upper part of this layer.
- Weather related incidents do not take place in this layer. The air blows horizontally here. Therefore this layer is considered ideal for flying of aircraft.
- The upper limit of the stratosphere is known as stratopause.
- One important feature of stratosphere is that it contains a layer of ozone gas.
- The relative thickness of the ozone layer is measured in Dobson Units.
- It is mainly found in the lower portion of the stratosphere, from approximately 20 to 30 km above the earth's surface.
- It contains a high concentration of ozone (O3) in relation to other parts of the atmosphere.
- It is the region of the stratosphere that absorbs most of the sun's ultra-violet radiation

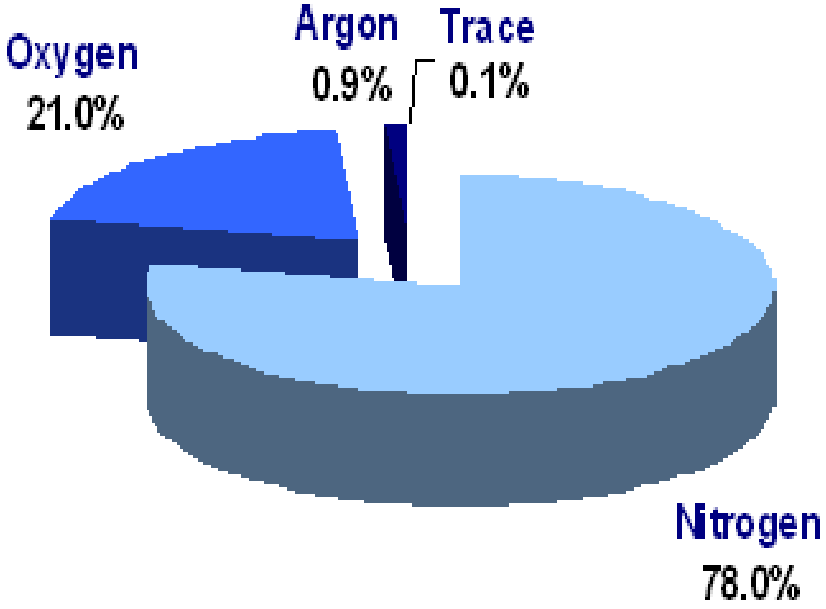
- **Mesosphere**
- It is the third layer of the atmosphere spreading over the stratosphere.
- It extends up to a height of 85 km.
- In this layer, the temperature starts decreasing with increasing altitude and reaches up to – 100 degree Celsius at the height of 80 km
- The upper limit of the mesosphere is known as mesopause.

- **Thermosphere**
- This layer is located between 85 and 500 km above the mesopause.
- It contains electrically charged particles known as ions, and hence, it is known as the **ionosphere**.
- Radio waves transmitted from the earth are reflected back to the earth by this layer and due to this, radio broadcasting has become possible.
- The temperature here starts increasing with heights.

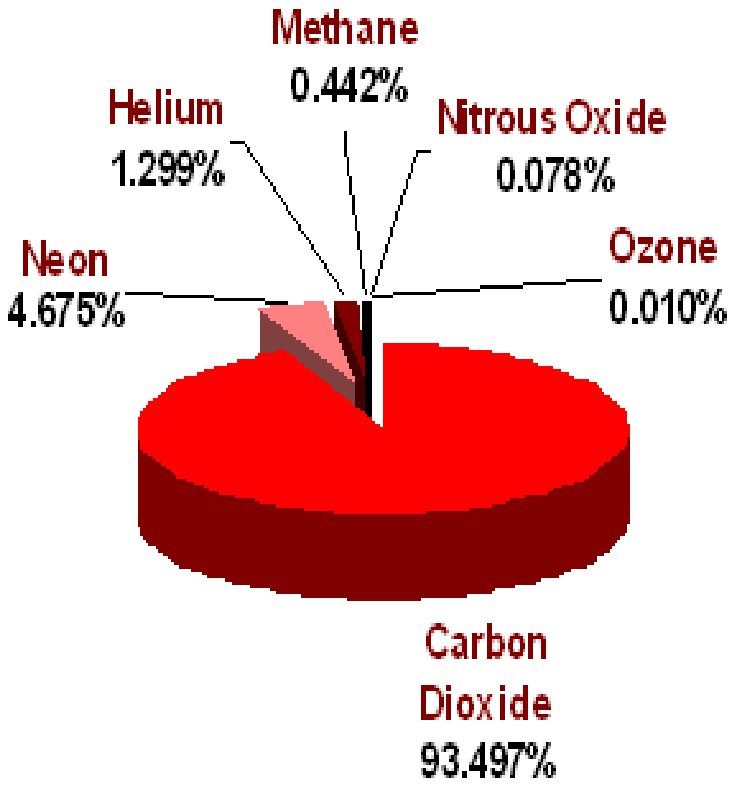
- **Exosphere**
- The exosphere is the uppermost layer of the atmosphere.
- Gases are very sparse in this sphere due to the lack of gravitational force. Therefore, the density of air is very less here.


N_2
O_2
H_2O
H_2O
CH_4
CO_2
SO_2
CO

Atmospheric Composition



Trace Gases



Permanent Gases of the Atmosphere

Constituent	Percent by Volume	Concentration in Parts Per Million (PPM)
Nitrogen (N_2)	78.084	780,840.0
Oxygen (O_2)	20.946	209,460.0
Argon (Ar)	0.934	9,340.0
Carbon dioxide (CO_2)	0.036	360.0
Neon (Ne)	0.00182	18.2
Helium (He)	0.000524	5.24
Krypton (Kr)	0.000114	1.14
Hydrogen (H_2)	0.00005	0.5

Rivers

- Rivers carry dissolved ions they receive from ground water and surface runoff to the sea . The dissolved ions include HCO_3^-, Ca^{++}, SO_4^{2-}, H_4SiO_4, Cl^-, Na^+, Mg^{++}, K^+, PO_4^{3-}. Total dissolved solids in rivers are about 100mg/liter, roughly 20 times the concentration in rain water. Most of the increase is due to weathering of minerals. Rivers also carry small rock fragments and minerals produced in weathering reactions such as clays. These particles, carried mostly in suspension, contain the elements Al, Fe, Si, Ca, K, Mg, Na and P.

Oceans

TABLE 18.6 Ionic Constituents of Seawater Present in Concentrations Greater than 0.001 g/kg (1 ppm)

Ionic Constituent	g/kg Seawater	Concentration (*M*)
Chloride, Cl^-	19.35	0.55
Sodium, Na^+	10.76	0.47
Sulfate, SO_4^{2-}	2.71	0.028
Magnesium, Mg^{2+}	1.29	0.054
Calcium, Ca^{2+}	0.412	0.010
Potassium, K^+	0.40	0.010
Carbon dioxide*	0.106	2.3×10^{-3}
Bromide, Br^-	0.067	8.3×10^{-4}
Boric acid, H_3BO_3	0.027	4.3×10^{-4}
Strontium, Sr^{2+}	0.0079	9.1×10^{-5}
Fluoride, F^-	0.0013	7.0×10^{-5}

*CO_2 is present in seawater as HCO_3^- and CO_3^{2-}.

What is Acid Rain?

- it is a result of air pollution
- sulphur dioxide and nitrogen oxides react with water in clouds and form sulphuric and nitric acid which cause that the rain is acidic
- power stations, factories and cars all burn fuels and therefore they all produce polluting gases

How acidic is acid rain?

- acidity is measured using a scale called the pH scale. This scale goes from 0 to 14. 0 is the most acidic and 14 is the most alkaline

- unpolluted rain would have a pH value of between 5 and 6. When the air becomes more polluted with nitrogen oxides and sulphur dioxide the acidity can increase to a pH value of 4

The Properties of Acid Rain

- the acid rain can be carried great distances in the atmosphere
- it can take the form of snow, mists and dry dusts
- it can have a serious effect on soil, trees, buildings and water

Effects on Forests

Acid rain

- dissolves and washes away the nutrients and minerals in the soil which help the trees to grow

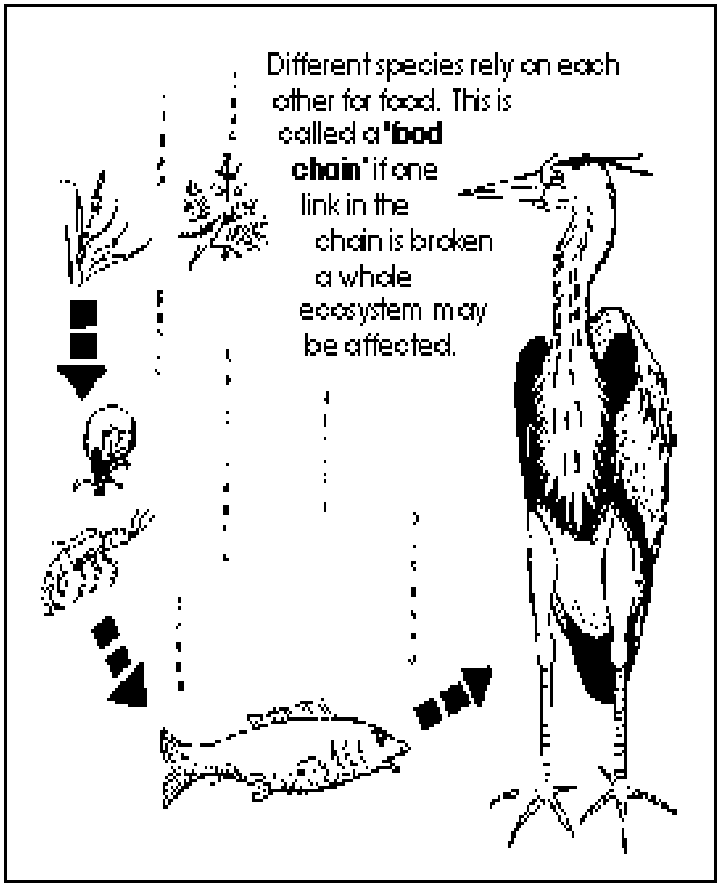
- causes the release of harmful substances such as aluminium into the soil

- wash away the waxy protective coating of leaves, damaging them and preventing them from being able to photosynthesise properly

Effects on Lakes and Rivers

- as the acidity of a lake increases, the water becomes clearer and the numbers of fish and other water animals decrease

- the acidity of the water does not just affect species directly, it also causes toxic substances like aluminium to be released into the water from the soil, harming fish and other aquatic animals



What can be done?

Reduce emissions

- burning fossil fuels is still one of the cheapest ways to produce electricity so people are now researching new ways to burn fuel which don't produce so much pollution

- sulphur can also be 'washed' out of smoke by spraying a mixture of water and powdered limestone into the smokestack

- cars are now fitted with catalytic converters which remove three dangerous chemicals from exhaust gases

Find alternative sources of energy

- scientists are researching different ways to produce energy
- hydroelectric and nuclear power
- solar energy or windmills

What Can We Do?

- we can lower the pollution by using public transport

- we can make an effort to save energy by switching off lights when they are not being used (when less electricity is being used pollution from power plants decreases)

- Sulfur dioxide is a by-product of the burning of coal or oil.
- It reacts with moisture in the air to form sulfuric acid.
- It is primarily responsible for acid rain.

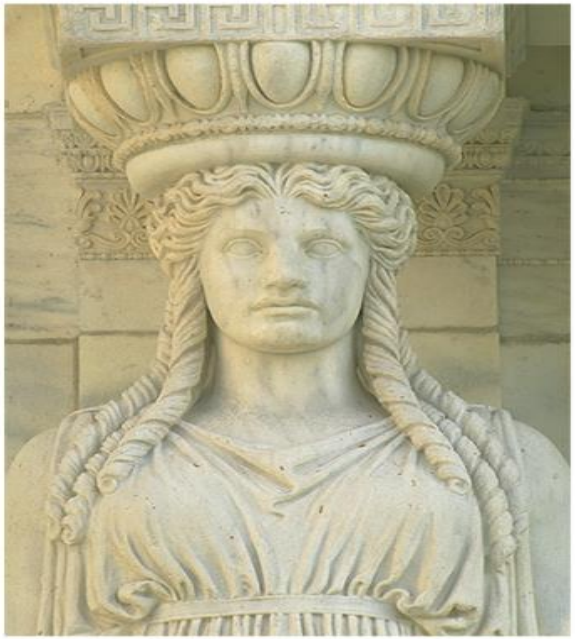
$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$$

$$H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$$

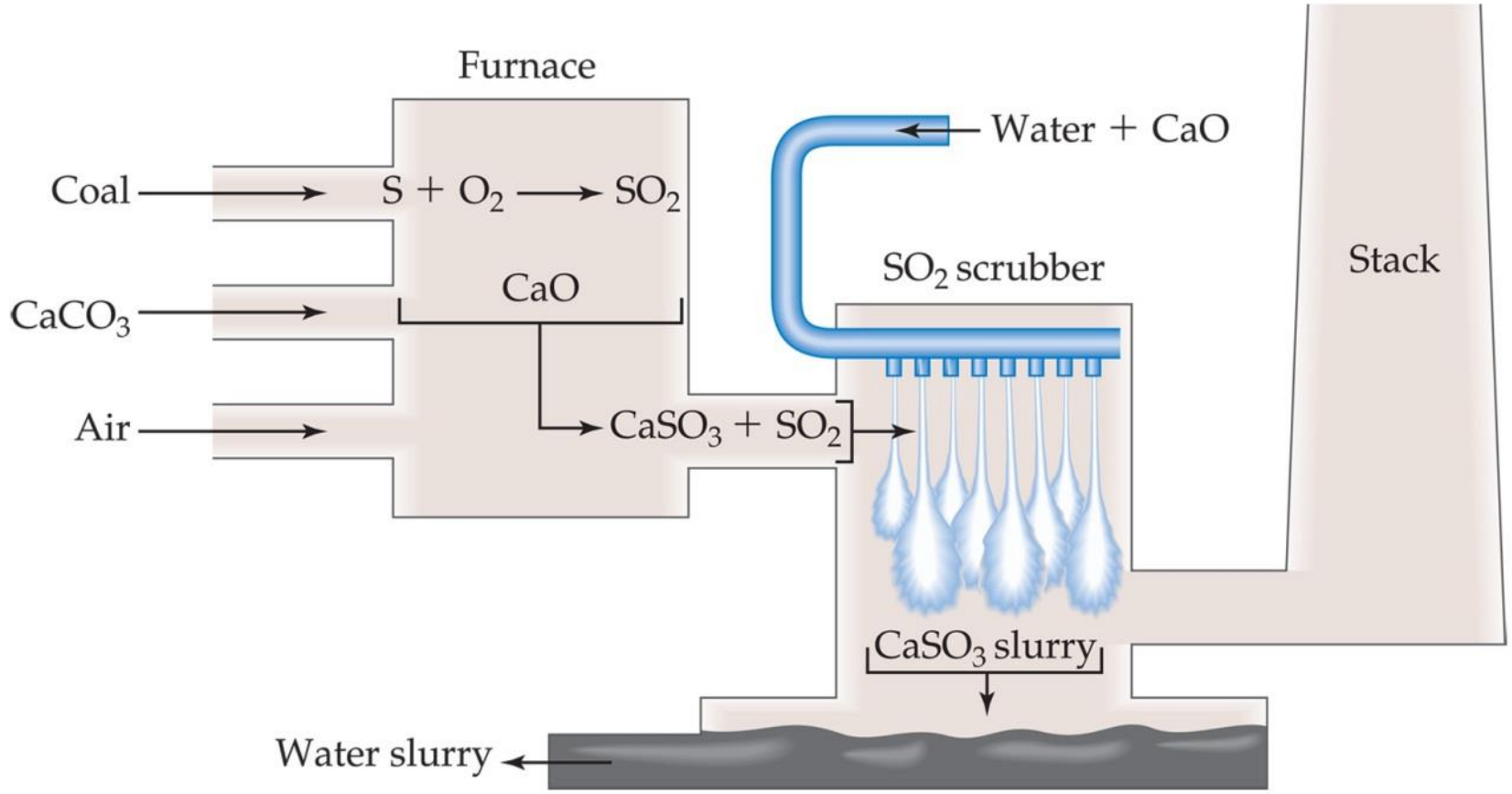
- $NO + O_3 \rightarrow NO_2 + O_2$
- $NO_2 + O_3 \rightarrow NO_3 + O_2$
- $NO_3 + NO_2 \rightarrow N_2O_5$
- $N_2O_5 + H_2O \rightarrow 2HNO_3$

- High acidity in rainfall causes corrosion in building materials.
- Marble and limestone (calcium carbonate) react with the acid; structures made from them erode.

$$CaCO_3(s) + H^+(aq) \rightarrow Ca^{2+}(aq) + HCO_3^-(aq)$$



SO_2 can be removed by injecting powdered limestone which is converted to calcium oxide.The CaO reacts with SO_2 to form a precipitate of calcium sulfite.



Air Pollution

A **pollutant** is a substance or energy introduced into the environment that has undesired effects, or adversely affects the usefulness of a resource. A pollutant may cause long- or short-term damage by changing the growth rate of plant or animal species, or by interfering with human amenities, comfort, health, or property values. Some pollutants are biodegradable and therefore will not persist in the environment in the long term.

Primary & **Secondary pollutant**

A **primary pollutant** is an air **pollutant** emitted directly from a source. A **secondary pollutant** is not directly emitted as such, but forms when other **pollutants**(**primary pollutants**) react in the atmosphere.

- Any visible or invisible particle or gas found in the air that is not part of the original, normal composition.

Natural: forest fires, pollen, dust storm

Unnatural: man-made; coal, wood and other fuels used in cars, homes, and factories for energy

5 Major Pollutants:

1..) Carbon Monoxide

2.) Sulfur Dioxide

3.) Nitrogen Dioxide

4.) Particulate Matter

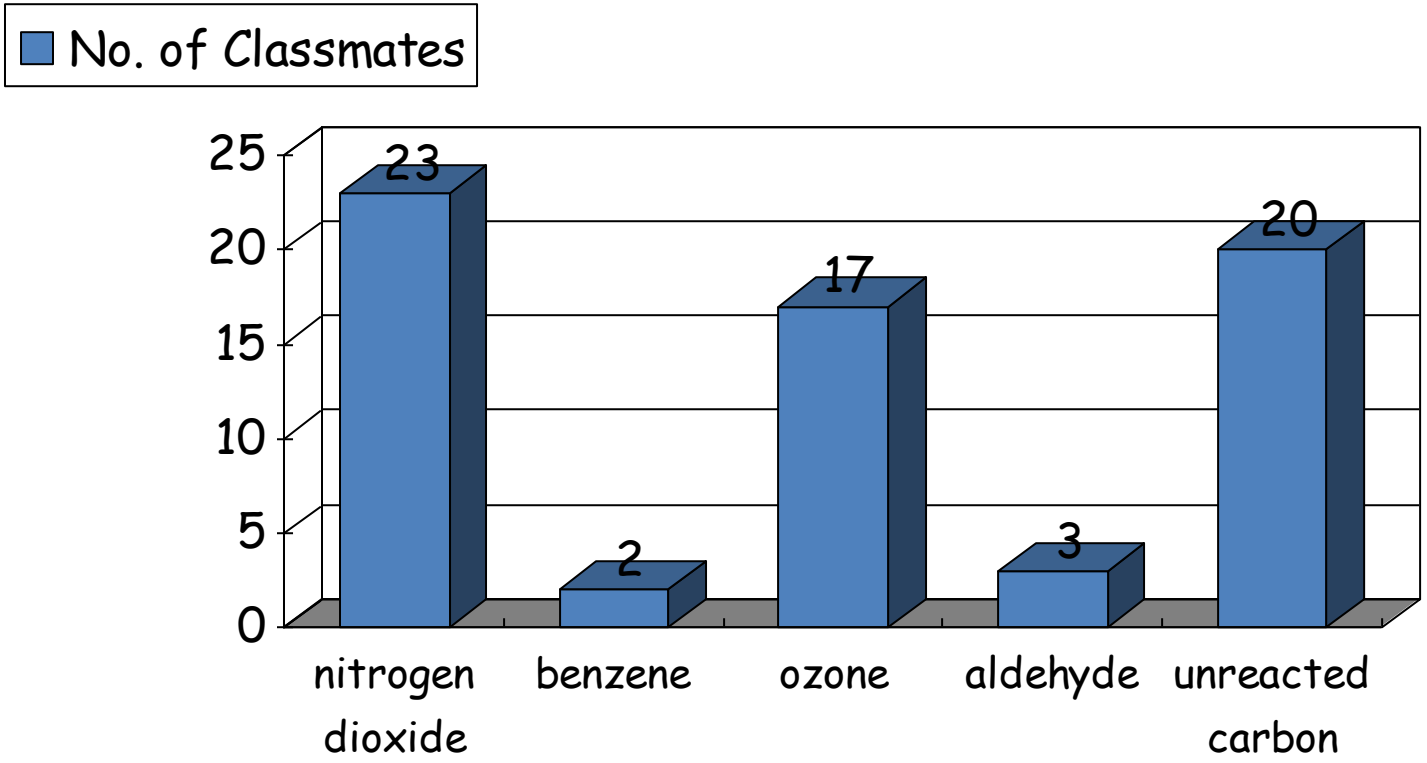
5.) Ground Level Ozone

Table 1: Sources, Health and Welfare Effects for Criteria Pollutants				
Pollutant	**Description**	**Sources**	**Health Effects**	**Welfare Effects**
Carbon Monoxide (CO)	Colorless, odorless gas	Motor vehicle exhaust, indoor sources include kerosene or wood burning stoves.	Headaches, reduced mental alertness, heart attack, cardiovascular diseases, impaired fetal development, death.	Contribute to the formation of smog.
Sulfur Dioxide (SO_2)	Colorless gas that dissolves in water vapor to form acid, and interact with other gases and particles in the air.	Coal-fired power plants, petroleum refineries, manufacture of sulfuric acid and smelting of ores containing sulfur.	Eye irritation, wheezing, chest tightness, shortness of breath, lung damage.	Contribute to the formation of acid rain, visibility impairment, plant and water damage, aesthetic damage.
Nitrogen Dioxide (NO_2)	Reddish brown, highly reactive gas.	Motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.	Susceptibility to respiratory infections, irritation of the lung and respiratory symptoms (e.g., cough, chest pain, difficulty breathing).	Contribute to the formation of smog, acid rain, water quality deterioration, global warming, and visibility impairment.
Ozone (O_3)	Gaseous pollutant when it is formed in the troposphere.	Vehicle exhaust and certain other fumes. Formed from other air pollutants in the presence of sunlight.	Eye and throat irritation, coughing, respiratory tract problems, asthma, lung damage.	Plant and ecosystem damage.
Lead (Pb)	Metallic element	Metal refineries, lead smelters, battery manufacturers, iron and steel producers.	Anemia, high blood pressure, brain and kidney damage, neurological disorders, cancer, lowered IQ.	Affects animals and plants, affects aquatic ecosystems.
Particulate Matter (PM)	Very small particles of soot, dust, or other matter, including tiny droplets of liquids.	Diesel engines, power plants, industries, windblown dust, wood stoves.	Eye irritation, asthma, bronchitis, lung damage, cancer, heavy metal poisoning, cardiovascular effects.	Visibility impairment, atmospheric deposition, aesthetic damage.


SMOG

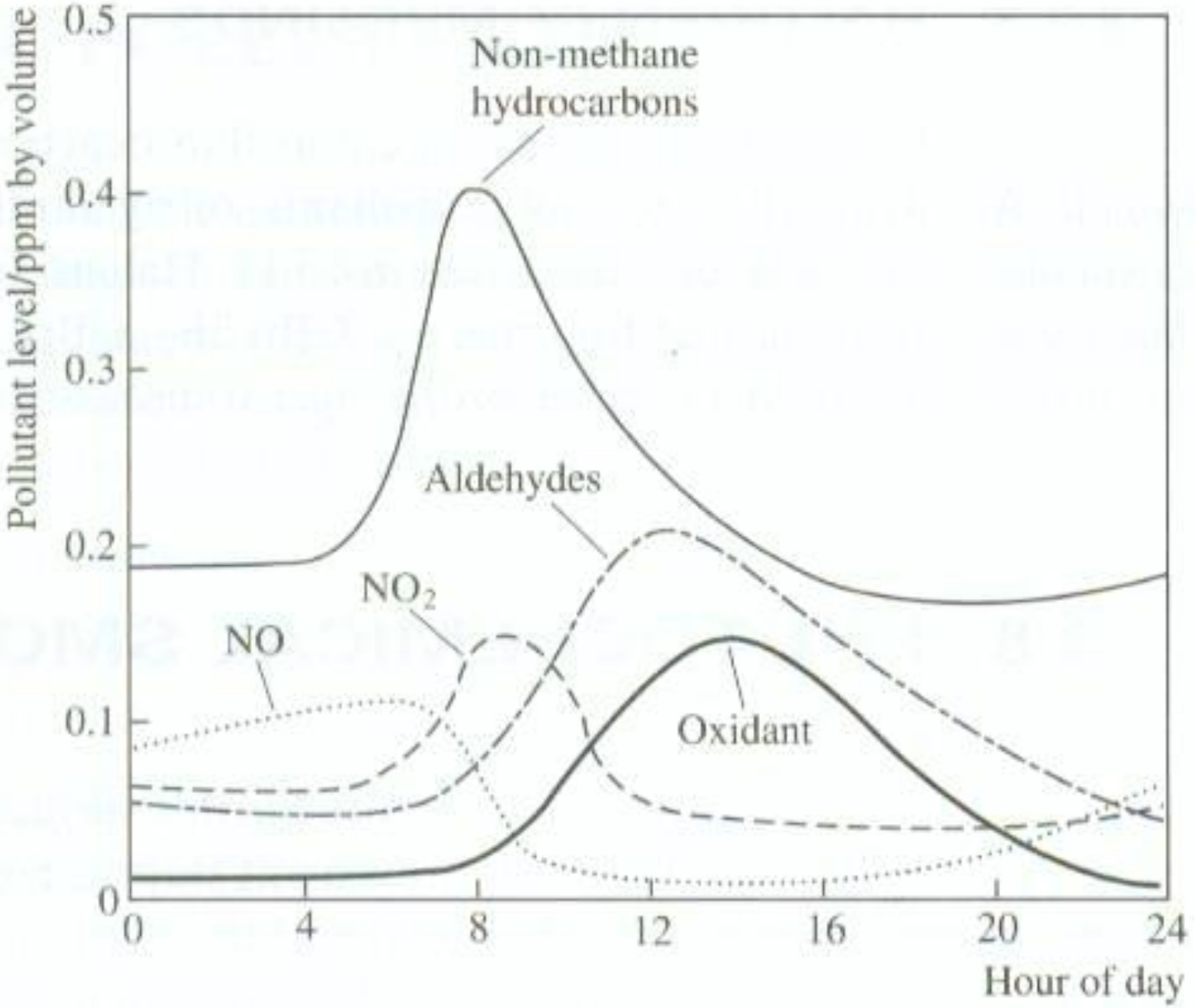
- Combination of gases with water vapor and dust
    - Combination of words smoke and fog
        - Forms when heat and sunlight react gases (photochemical smog)
            - Occurs often with heavy traffic, high temperatures, and calm winds

Photochemical smog is a mixture of pollutants, what are they?

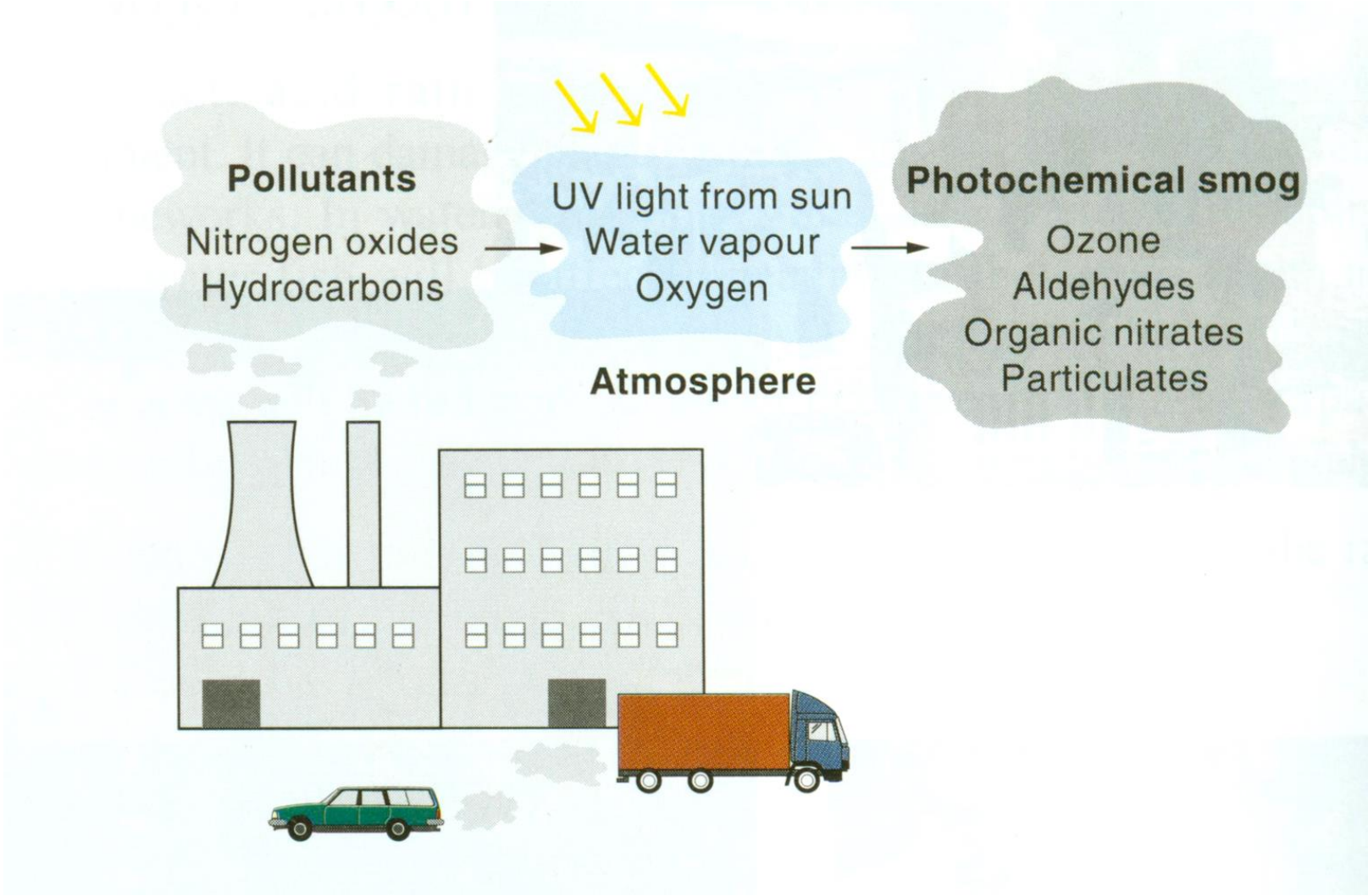


Composition

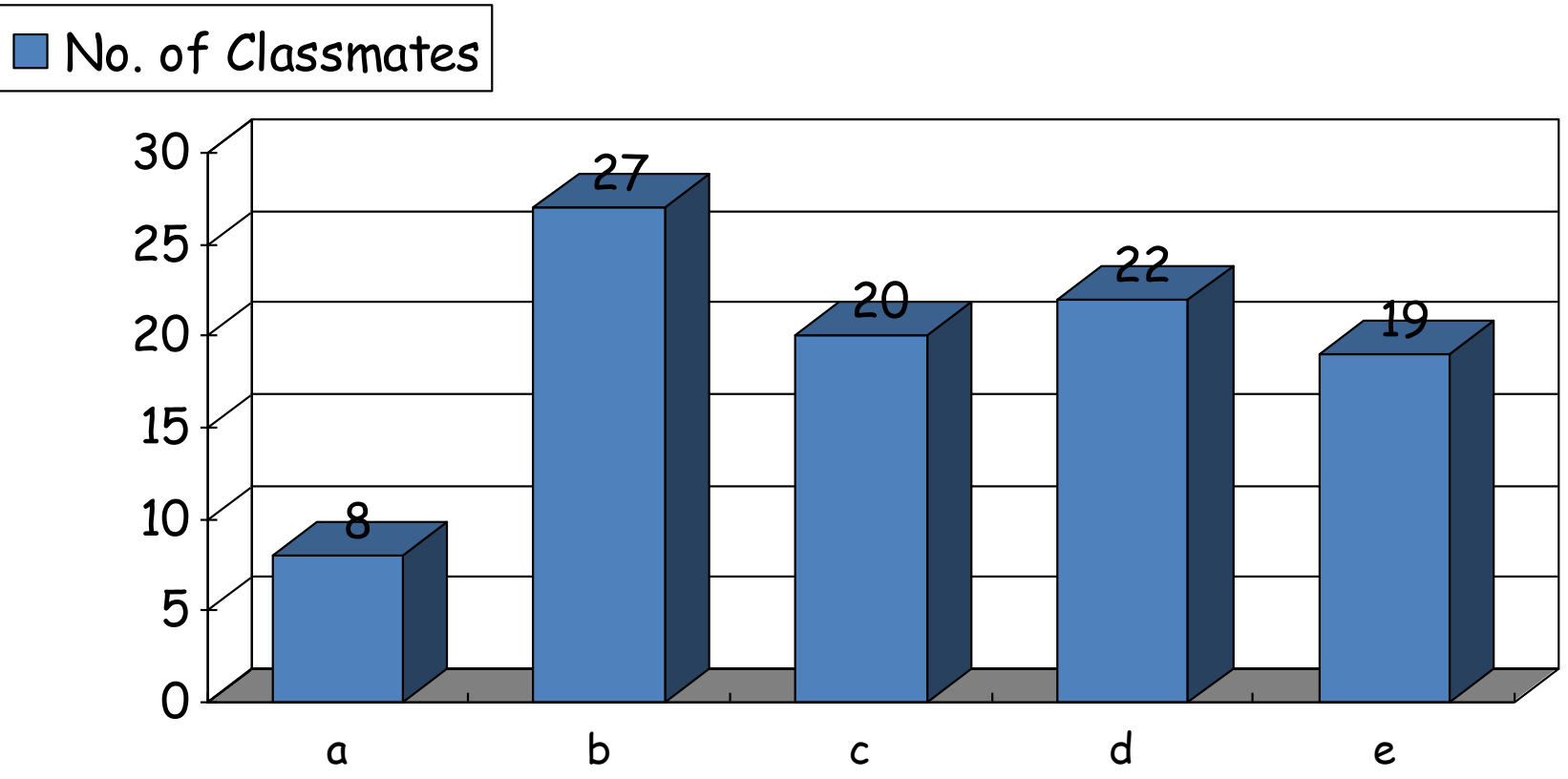
- Nitrogen oxides
- Ozone
- Aldehydes
- Unreacted carbon
- Particular matter
- Peroxyaceyl nitrate (PAN)


Pollutant level/ppm by volume
0.5
0.4
0.3
0.2
0.1
0
Non-methane
hydrocarbons
Aldehydes
NO2
NO
Oxidant
0
4
8
12
16
20
24
Hour of day

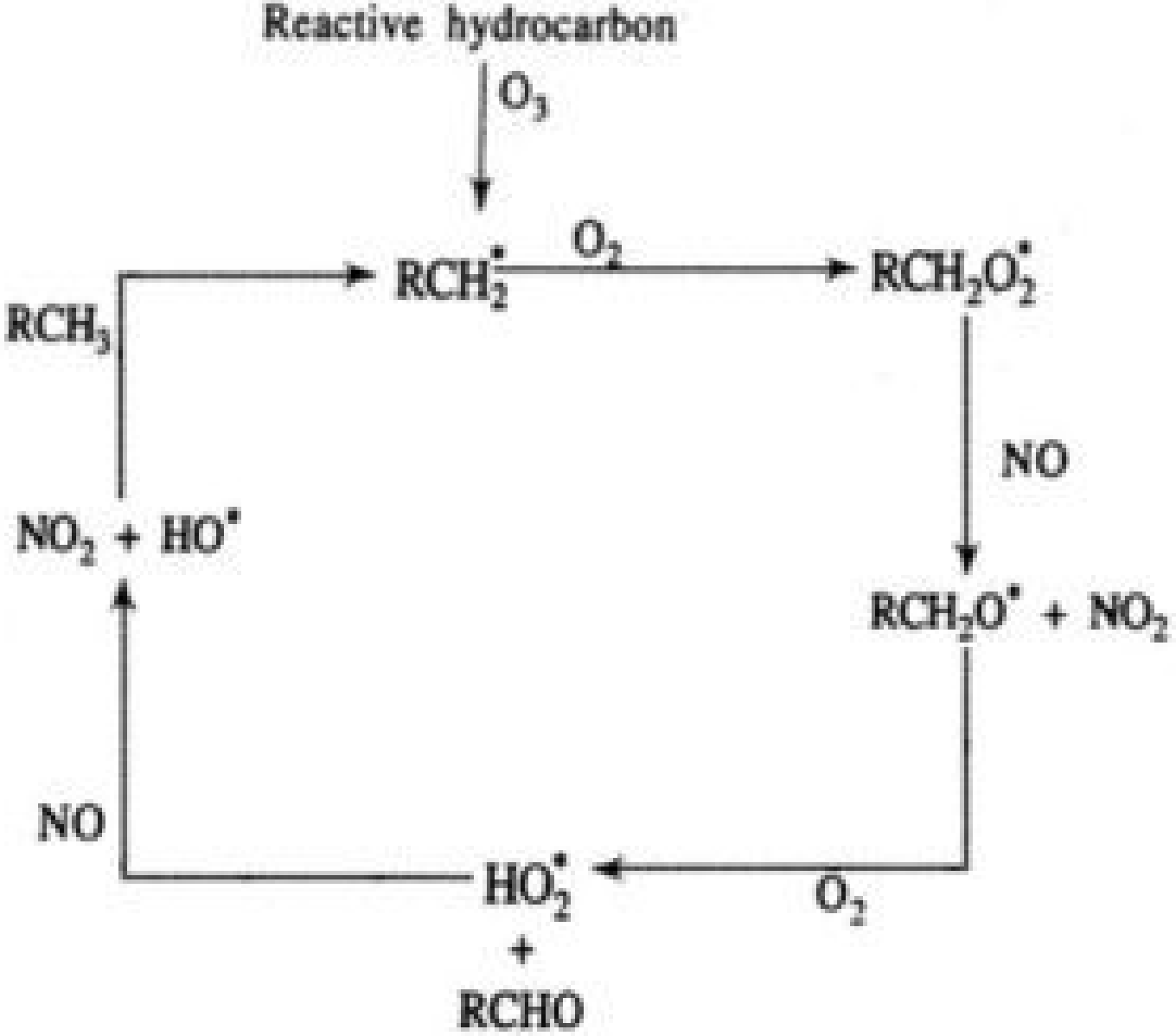
Formation


Pollutants
Nitrogen oxides
Hydrocarbons
UV light from sun
Water vapour
Oxygen
Photochemical smog
Ozone
Aldehydes
Organic nitrates
Particulates
Atmosphere

What are the disadvantages of having photochemical smog?



a. headaches b. eye, nose and throat irritation c. impaired lung function
d. coughing and wheeling e. damaging plants

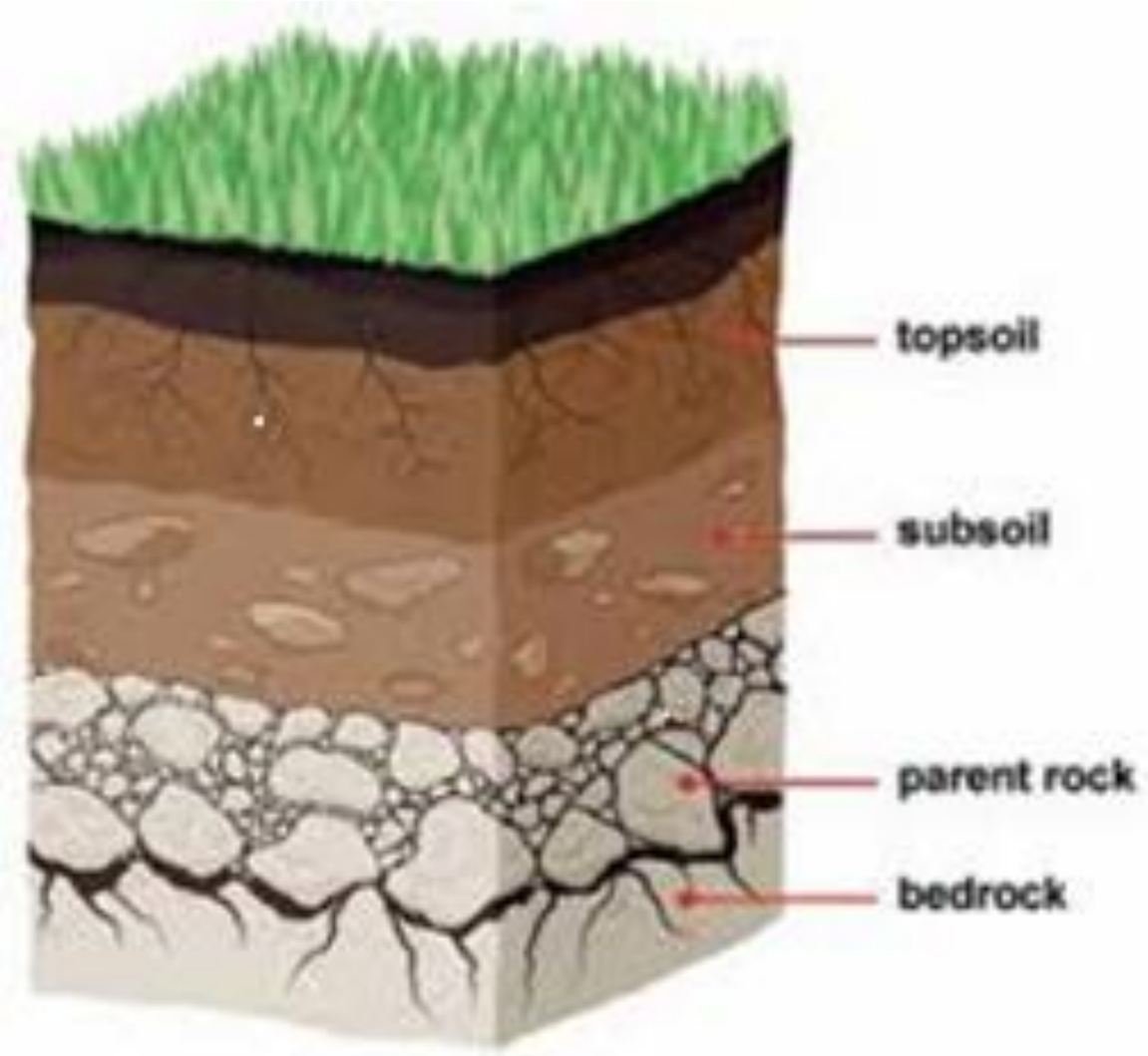

Reactive hydrocarbon
O_3
$RCH_2^{\bullet}$
O_2
$RCH_2O_2^{\bullet}$
RCH_3
NO
$NO_2 + HO^{\bullet}$
$RCH_2O^{\bullet} + NO_2$
NO
$HO_2^{\bullet}$
O_2
+
RCHO

- Its effects……

- 1st smog related deaths were in London in 1873; death toll 500 people; can you imagine how much worse the atmosphere is now?!
- Limits visibility
- Decreases UV radiation
- Yellow/black color over cities
- Causes respiratory problems and bronchial related deaths

- **Formation of Soil**
- The soil has taken thousands of years to form. Soil formation takes place in the following ways:
- Big rocks break down into smaller rocks by continuous action of wind and rain. It takes many years for these rocks to break down into smaller rocks.
- Rocks are mainly broken by two types of weathering- physical weathering and chemical weathering. A number of natural force, called agents, work to break down the parent rock into tiny particles of soil. These agents include wind, water, the sun's heat, and plants and animals.
- These pieces get further broken down to form sand and silt and, ultimately, into finer particles and the process continues. This process is very slow. It takes thousands of years to form a just 1cm layer of soil. These fine particles form the top layer of the soil.

- **Horizons of the Soil**
- A soil consists of the following horizons:
- **1. Horizon A or Topsoil**
- It is also called humus layer, which is rich in organic material. This layer consists of decomposed material and organic matter. This is the reason, the topsoil has dark brown color. The humus makes the topsoil soft, porous to hold enough air and water. In this layer, the seeds germinate and roots of the plants grow. Many living organisms like earthworms, millipedes, and centipedes, bacteria and fungi are found in this layer of soil.
- **2. Horizon B or Subsoil**
- Just below the topsoil lies another layer called subsoil or horizon-B. It is comparatively harder and compact than topsoil. It is lighter in color than the topsoil because there is less humus in this layer. This layer is less organic but is rich in minerals brought down from the topsoil. It contains metal salts, especially iron oxide in a large proportion. Farmers often mix horizon-A and horizon-B when ploughing their fields.
- **3. Bedrock or Horizon C**
- Bedrock is also known as parent rock and lies just below the subsoil. It contains no organic matter and made up of stones and rocks, so it is very hard..


topsoil
subsoil
parent rock
bedrock

Question For You

- Q. What is humus layer in the soil?
- Ans: It is also called topsoil or horizon A, which is rich in organic material.This layer consists of decomposed material and organic matter. This is the reason, the topsoil has dark brown color. The humus makes the topsoil soft, porous to hold enough air and water. In this layer, the seeds germinate and roots of the plants grow. Many living organisms like earthworms, millipedes, and centipedes, bacteria, and fungi are found in this layer of soil.

- **Types of Soil**
- There are three basic types of soil: sand, silt and clay. But, most soils are composed of a combination of the different types. How they mix will determine the texture of the soil, or, in other words, how the soil looks and feels.
- **Sand** within soil is actually small particles of weathered rock. Sand is fairly coarse and loose so water is able to drain through it easily. While this is good for drainage, it is not good for growing plants because sandy soil will not hold water or nutrients.
- **Silt** can be thought of as fine sand, and it will hold water better than sand. If you were to hold a handful of dry silt in your hand, it would feel almost like flour. If you were to add water to the silt in your hand, it would do a fair job of holding the water and feels slick and smooth.

- **Clay soil** – are heavy soils that benefit from high nutrients. Clay soils remain wet and cold in winter and dry out in summer. These soils are made of over 25 percent clay, and because of the spaces found between clay particles, clay soils hold a high amount of water. Because these soils drain slowly and take longer to warm up in summer, combined with drying out and cracking in summer, they can often test gardeners.

- **Peat soil** – are high in organic matter and retain a large amount of moisture. This type of soil is very rarely found in a garden and often imported into a garden to provide an optimum soil base for planting.
- **Chalk soil** – can be either light or heavy but always highly alkaline due to the calcium carbonate or lime within its structure. As these soils are alkaline they will not support the growth of ericaceous plants that require acidic soils to grow. If a chalky soil shows signs of visible white lumps then they can't be acidified and gardeners should be resigned to only choose plants that prefer an alkaline soil..
- **Loam soil** – are a mixture of sand, silt and clay that are combined to avoid the negative effects of each type. These soils are fertile, easy to work with and provide good drainage. Depending on their predominant composition they can be either sandy or clay loam. As the soils are a perfect balance of soil particles, they are considered to be a gardeners best friend, but still benefit from topping up with additional organic matter.

What is Weathering?

- Rocks, minerals, soils normally change their structure under the action or influence of certain environmental forces. Biological activity, extreme weather, and agents of erosion such as water, wind and ice are examples of environmental forces that influences the continuous breakdown, wearing away and loosening of rocks and soils. This is what is termed as weathering.

- Weathering processes are of three main types: mechanical, organic and chemical weathering.

- **Mechanical or Physical Weathering**
- Mechanical weathering is also known as physical weathering. Mechanical weathering is the physical breakdown of rocks into smaller and smaller pieces. It happens when water enters the pores and cracks of rocks, then freezes.

- Once the frozen water is within the rocks, it expands by about 10% thereby opening the cracks a bit wider. The pressure acting within the rocks is estimated at 30,000 pounds per square inch at -7.6°F. Over time, this pressure alongside the changes in weather makes the rock split off, and bigger rocks are broken into smaller fragments.

- **Organic or Biological Weathering**
- Organic or biological weathering refers to the same thing. It is the disintegration of rocks as a result of the action by living organisms. Trees and other plants can wear away rocks since as they penetrate into the soil and as their roots get bigger, they exert pressure on rocks and makes the cracks wider and deeper. Eventually, the plants break the rocks apart. Some plants also grow within the fissures in the rocks which lead to widening of the fissures and then eventual disintegration.

- Microscopic organisms like algae, moss, lichens and bacteria can grow on the surface of the rocks and produce chemicals that have the potential of breaking down the outer layer of the rock. They eat away the surface of the rocks. These microscopic organisms also bring about moist chemical micro-environments which encourage the chemical and physical breakdown of the rock surfaces. The amount of biological activity depends upon how much life is in that area. Burrowing animals such as moles, squirrels and rabbits can speed up the development of fissures.

- Chemical weathering pertains to the changes in rock structure under the action or influence of chemical reactions. There are hundreds of natural chemical processes and reactions within the rocks the change the composition and the structure of the rocks over time. Temperature and, especially, moisture are critical for chemical weathering. Chemical weathering, therefore, occurs more quickly in hot, humid climatic regions.

Types of Chemical Weathering

1. Hydrolysis

- Hydrolysis is the chemical reactions caused by water. Water reacts with the rock and alters the size and chemical compositions of the minerals, lessening their resistance to weathering. Whenever minerals are hydrolyzed, crystal rocks and clay minerals such as calcium, potassium, and sodium ions are produced.

2. Carbonation

- Carbonation is the mixing of water with carbon dioxide to make carbonic acid. Carbonation takes place when the rock minerals react with weak carbonic acid formed when water combines with carbon dioxide in the atmosphere. Carbonic acid acts on the rock by breaking down and dissolving its mineral contents. The dissolved materials are washed away by ground water, and the soluble ions are stored in the groundwater supply. Rocks such as limestone and feldspar experience this type of chemical weathering more. This type of weathering is important in the formation of caves.

3. Dissolution

- Dissolution equally means leaching. It is the process by which the rocks are dissolved when exposed to rainwater. Limestone and rock salts are particularly the rocks that form solvent solutions when exposed to rainwater, surface waters, or even ground water. Upon dissolving, the minerals in the rocks become ion solutions in the water which are then washed away.

4. Oxidation

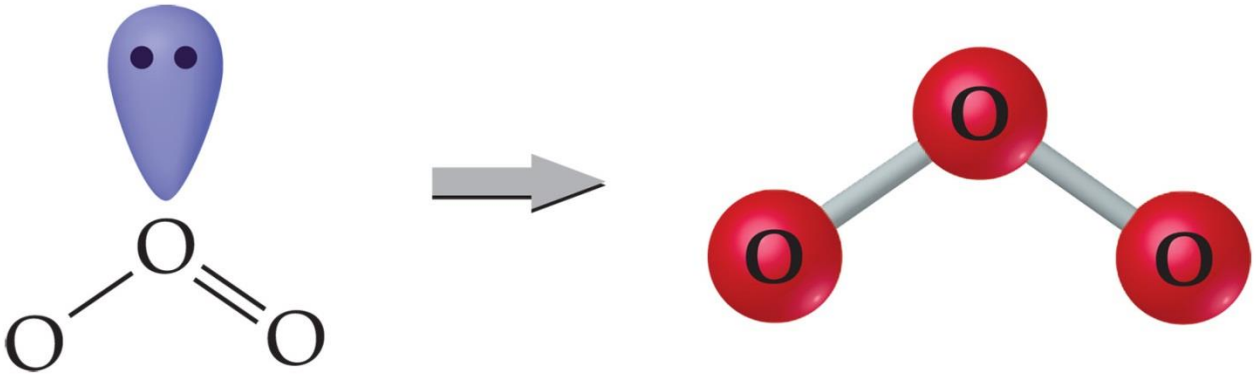
- Oxidation is another type of chemical weathering. Oxidation is also known as rusting. It is the process whereby the rock minerals lose one or more ions or atoms in the presence of oxygen. When minerals in the rock oxidize, they become less resistant to weathering. Oxygen combines with other substances via the oxidation process giving rise to the ion or atom lose.

- **Greenhouse effect**, a warming of Earth's surface and troposphere (the lowest layer of the atmosphere) caused by the presence of water vapour, carbon dioxide, methane, and certain other gases in the air. Of those gases, known as greenhouse gases, water vapour has the largest effect.

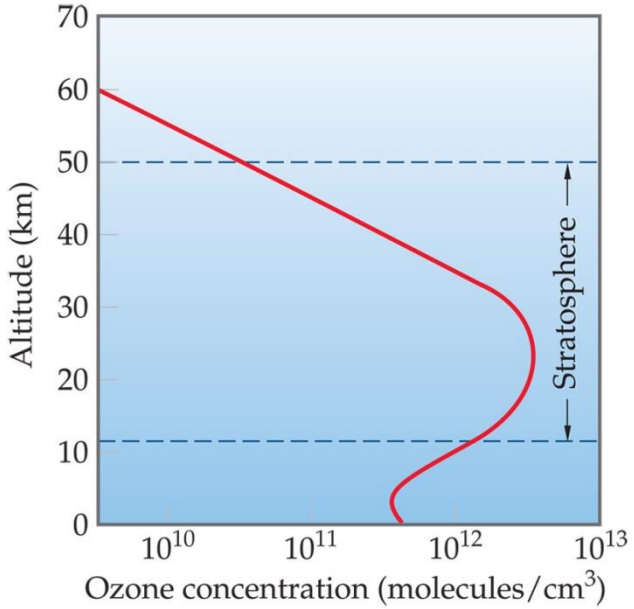
Ozone

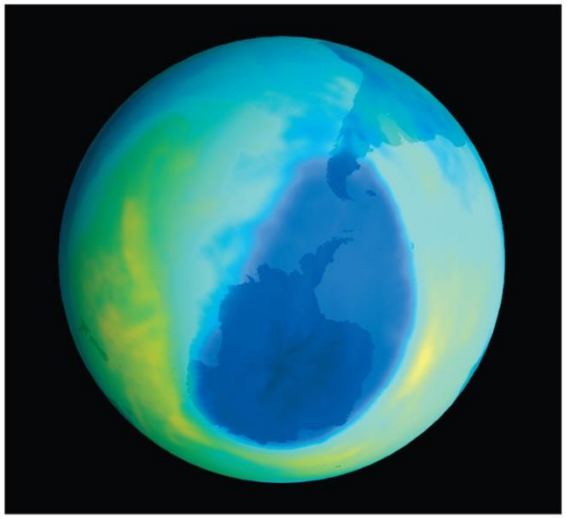
- Ozone absorbs much of the radiation between 240 and 310 nm.
- It forms from reaction of molecular oxygen with the oxygen atoms produced in the upper atmosphere by photodissociation (< 242 nm).

$$O + O_2 \longrightarrow O_3$$



Ozone Depletion





In 1974 Rowland and Molina (Nobel Prize, 1995) discovered that chlorine from chlorofluorocarbons (CFCs) may be depleting the supply of ozone in the upper atmosphere.

Chlorofluorocarbons

CFCs were used for years as aerosol propellants and refrigerants.

Mostly = $CFCl_3$, CF_2Cl_2.

They are not water soluble (so they do not get washed out of the atmosphere by rain)

and are quite unreactive (so they are not degraded naturally).

Chlorofluorocarbons

- The C—Cl bond is easily broken, though, when the molecule absorbs radiation with a wavelength between 190 and 225 nm.
- The chlorine atoms formed react with ozone:

$$Cl + O_3 \longrightarrow ClO + O_2$$

Movie…

Chlorofluorocarbons

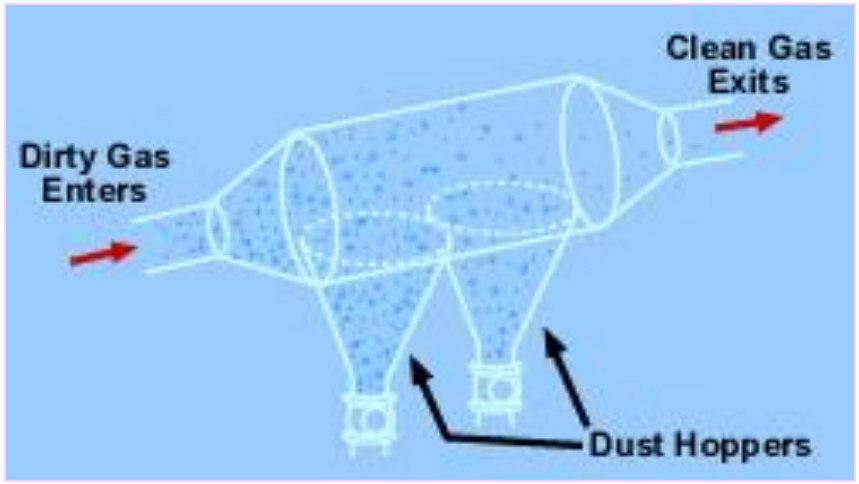
In spite of the fact that the use of CFCs in now banned in over 100 countries, ozone depletion will continue for some time because of the tremendously unreactive nature of CFCs.

Source Control Technology

- Air quality management sets the tools to control air pollutant emissions.
- Control measurements describes the equipment, processes or actions used to reduce air pollution.
- The extent of pollution reduction varies among technologies and measures.
- The selection of control technologies depends on environmental, engineering, economic factors and pollutant type.

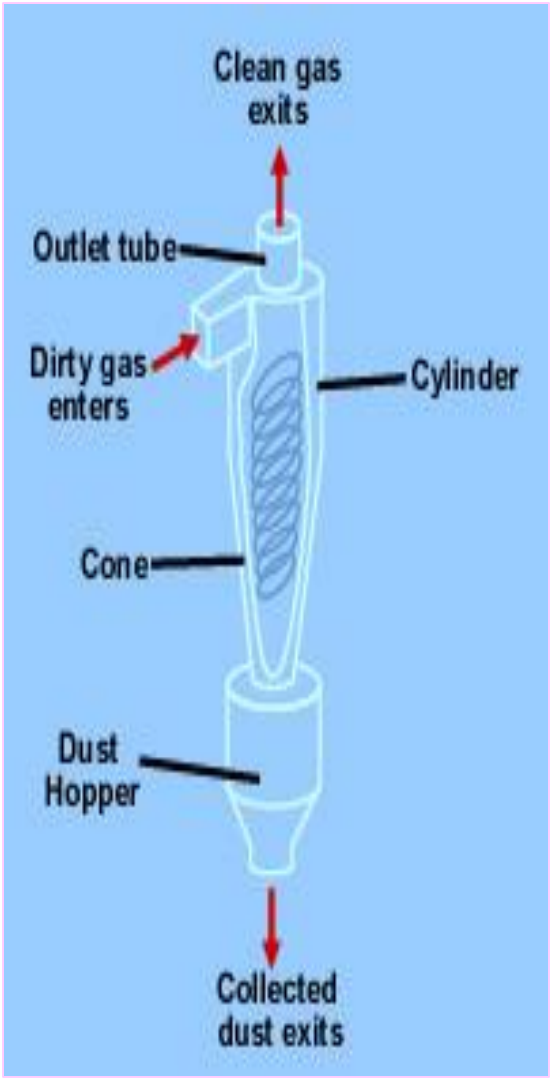
Settling Chambers

- Settling chambers use the force of gravity to remove solid particles.
- The gas stream enters a chamber where the velocity of the gas is reduced. Large particles drop out of the gas and are recollected in hoppers. Because settling chambers are effective in removing only larger particles, they are used in conjunction with a more efficient control device.



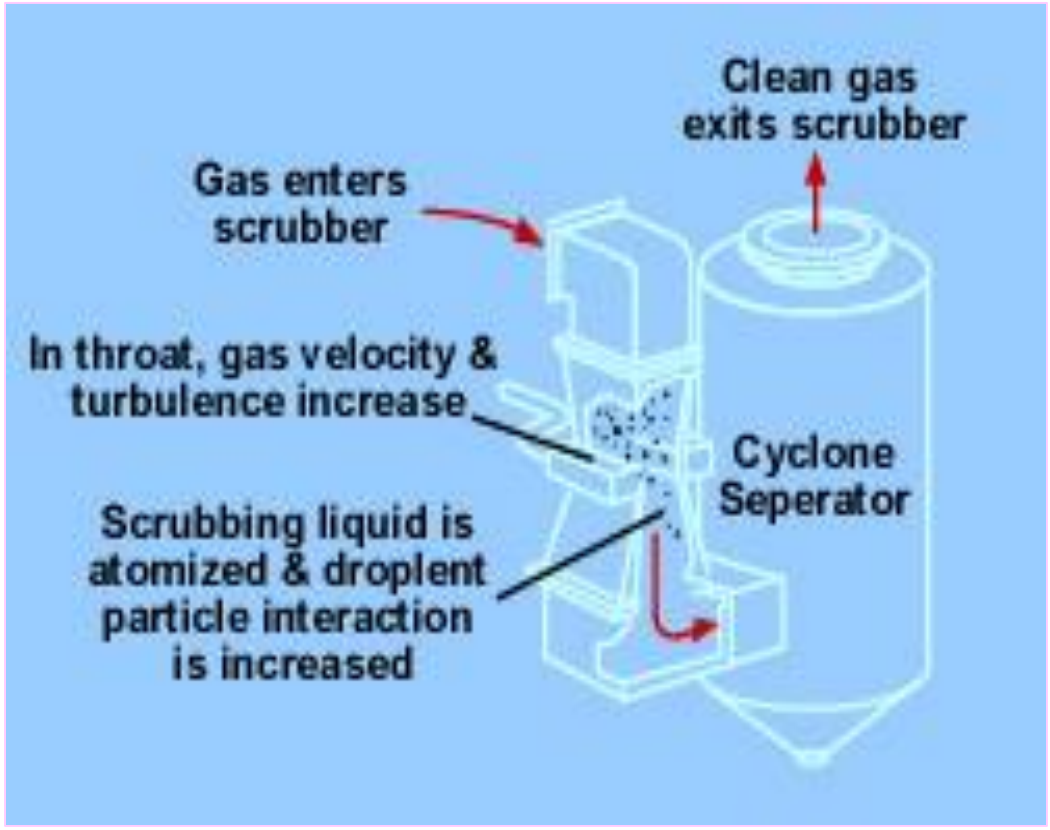
Cyclones

- The general principle of inertia separation is that the particulate-laden gas is forced to change direction. As gas changes direction, the inertia of the particles causes them to continue in the original direction and be separated from the gas stream.
- The walls of the cyclone narrow toward the bottom of the unit, allowing the particles to be collected in a hopper.
- The cleaner air leaves the cyclone through the top of the chamber, flowing upward in a spiral vortex, formed within a downward moving spiral.
- Cyclones are efficient in removing large particles but are not as efficient with smaller particles. For this reason, they are used with other particulate control devices.



Venturi Scrubbers

- Venturi scrubbers use a liquid stream to remove solid particles.
- In the venturi scrubber, gas laden with particulate matter passes through a short tube with flared ends and a constricted middle.
- This constriction causes the gas stream to speed up when the pressure is increased.

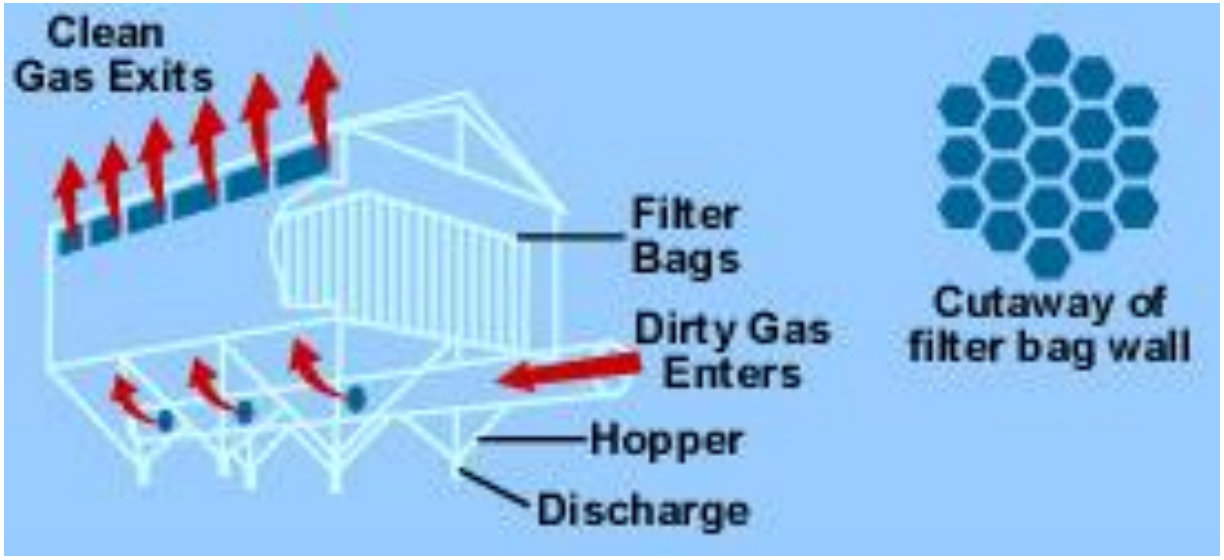


Conti….

- The difference in velocity and pressure resulting from the constriction causes the particles and water to mix and combine.
- The reduced velocity at the expanded section of the throat allows the droplets of water containing the particles to drop out of the gas stream.
- Venturi scrubbers are effective in removing small particles, with removal efficiencies of up to 99 percent.
- One drawback of this device, however, is the production of wastewater.

Fabric filters

- Fabric filters, or baghouses, remove dust from a gas stream by passing the stream through a porous fabric. The fabric filter is efficient at removing fine particles and can exceed efficiencies of 99 percent in most applications.



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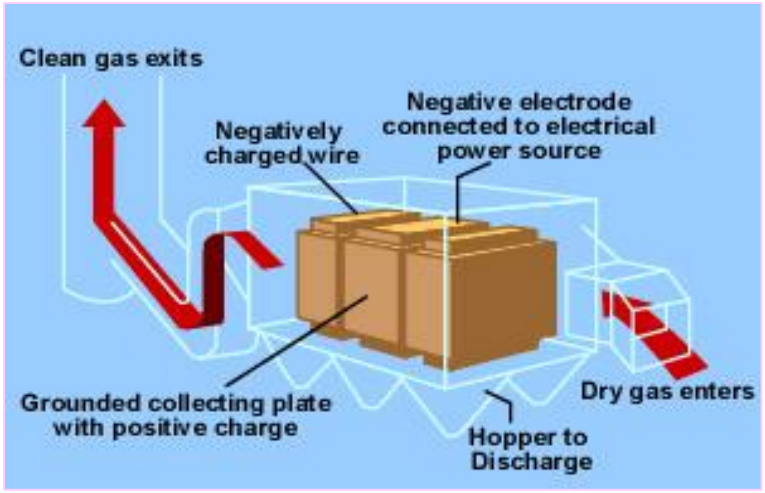
- The selection of the fiber material and fabric construction is important to baghouse performance.

- The fiber material from which the fabric is made must have adequate strength characteristics at the maximum gas temperature expected and adequate chemical compatibility with both the gas and the collected dust.

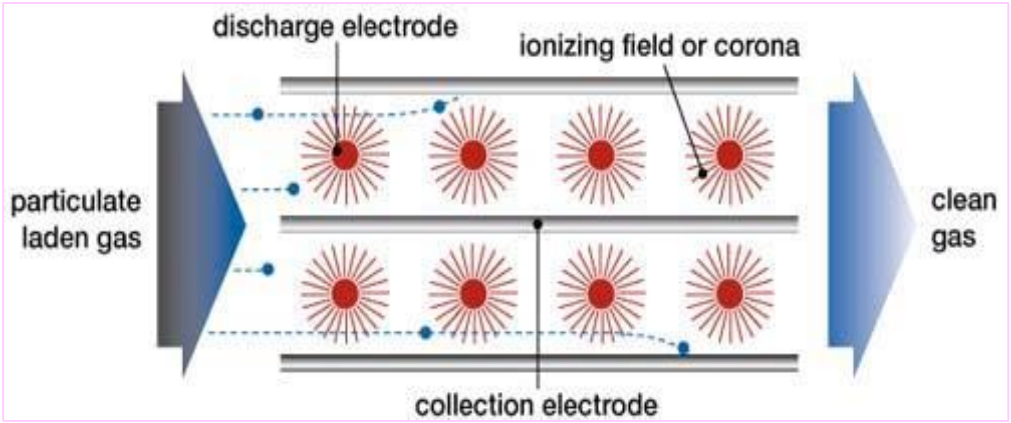
- One disadvantage of the fabric filter is that high-temperature gases often have to be cooled before contacting the filter medium.

Electrostatic Precipitators (ESPs)

- An ESP is a particle control device that uses electrical forces to move the particles out of the flowing gas stream and onto collector plates.



- The ESP places electrical charges on the particles, causing them to be attracted to oppositely charged metal plates located in the precipitator.



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- The particles are removed from the plates by "rapping" and collected in a hopper located below the unit.
- The removal efficiencies for ESPs are highly variable; however, for very small particles alone, the removal efficiency is about 99 percent.
- Electrostatic precipitators are not only used in utility applications but also other industries (for other exhaust gas particles) such as cement (dust), pulp & paper (salt cake & lime dust), petrochemicals (sulfuric acid mist), and steel (dust & fumes).

- Ride your bike

- Tell your friends and family about pollution

- Make sure your parents get pollution checks on their cars

- Ride the school bus