CHAPTER 11

ENVIRONMENTAL CHEMISTRY

Study of the chemicals, chemical reactions and their effect on the environment is called environmental Chemistry. In environmental Chemistry the causes of pollution, effects of pollution and the techniques and processes used to control the pollution is studied.

In environmental Chemistry we study:

i. The various physical and chemical changes occurring in the environment.
ii. The existence of various chemicals, their sources, their reactions, the mechanism of these reactions.
iii. The effect of chemicals on living organisms including man, animals and plants.
iv. The effects of industrial advancement, deforestation, agricultural wastes, burning of fossil fuels and the use of energy sources on the environmental pollution.

Environment: All things around us is our environment. Everything around us makes our environment. Environment consists of living and non-living things.

Components of the environment: Environment has broadly been classified into four components.

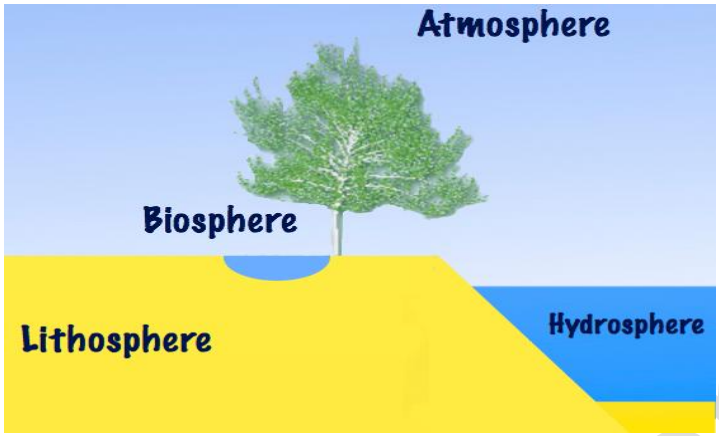
1. Lithosphere: All the solid bodies include in lithosphere like rocks, soil, mountains. Lithosphere consisst of 11 elements. Important chemical species are Oxygen, Silicon, Aluminium, Iron, Calcium, Sodium, Potassium, Magnesium, Sulphur, Barium, Manganese, Chlorine, Chromium, Fluorine, Zirconium, Nickel, Strontium, vanadium etc.

2. Hydrosphere: All the liquid bodies include in hydrosphere like surface water, underground water, water vapours, water in the form of clouds, rain etc.

3. Atmosphere: The gaseous blanket from the earth crust upto 500Km above is atmosphere. It is the envelope of gases surrounding the earth surface. It is a mixture of various gases like nitrogen, oxygen, carbon dioxide, He, Ne, Ar etc.

N_2 = 78% O_2 = 21% CO_2 = 0.03% Ar = 0.9%.

4. Biosphere: It is the region which supports life on earth. All the life and life related factors are grouped in the biosphere. It interchanges materials with human beings, animals and plants. Animals, plants and microorganisms lie in the biosphere in a definite zone and depends on physical factors like soil, water, air etc.



Importance of the Atmosphere

1. It plays a key role to sustain life on earth and save it from hazardous environment of the outer space.
2. It absorbs most of the toxic cosmic rays coming from the outer space.
3. It absorbs harmful radiations such as UV-A, UV-B and UV-C through ozone layer.
4. It maintain the heat balance of the earth through absorption of energy from the sun and re-emitted.
5. It allows the visible radiations coming from the sun as a result we can see.
6. It is the main source of different gases which are essential for life.
7. It is a carrier of water from ocean to land.

Composition of the Atmosphere

Atmosphere is a mixture of gases, liquids and solids.

1. Gases

i. Permanent gases: Nitrogen, oxygen, carbon dioxide and Argon.

ii. Variable gases: Ozone, nitrogen dioxide, carbon monoxide etc.

2. Liquid: Water vapours.

3. Solids: Smoke and dust particles.

Layers or zones or spheres or segments of the atmosphere

Atmosphere is divided into the following spheres.

(1) Troposphere (2) Stratosphere

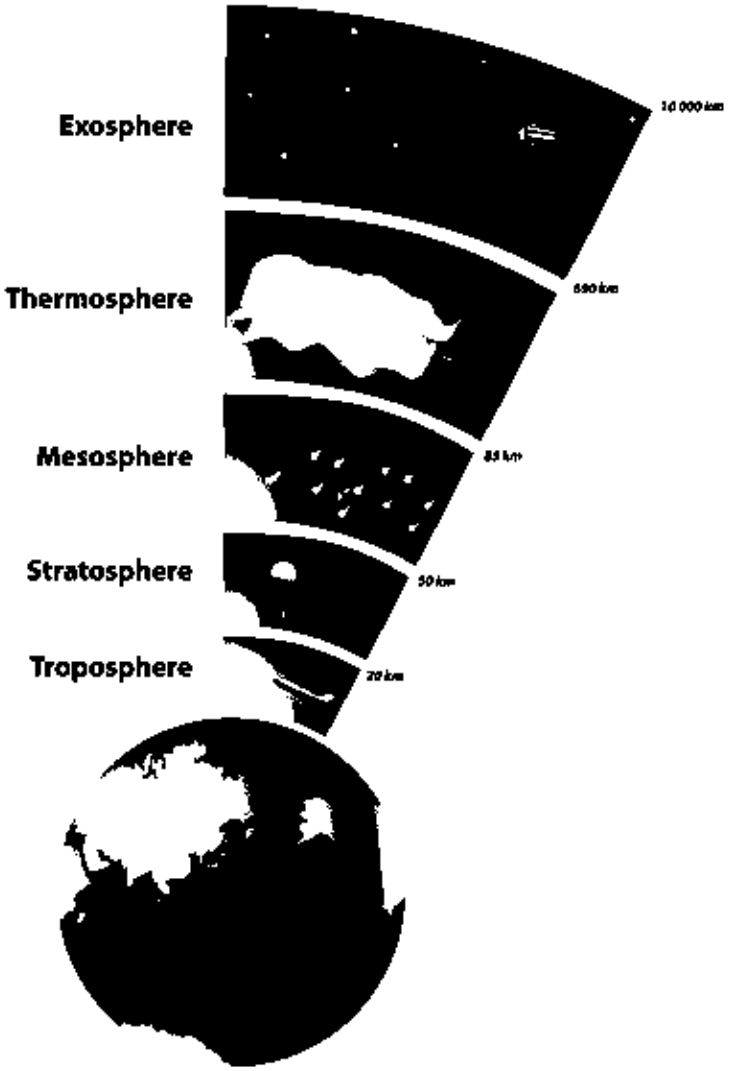
(3) Mesosphere (4) Thermosphere

(5) Magnetosphere (6) Exosphere

Summary of the four spheres of atmosphere is given in the table below.

S.No.	Spheres	Altitude	Temp (C^0)	Important chemical species

		(Km)		
1.	Troposphere	0-11	15 to -56	N_2, O_2, CO_2, H_2O, Ar.
2.	Stratosphere	11-50	-56 to -2	O_3, O_2, N_2.
3.	Mesosphere	50-85	-2 to -92	NO^+, O_2^+.
4.	Thermosphere	85-500	-92 to 1200	NO^+, O_2^+, O, O^+.



Chemistry of the Troposphere

Troposphere extends from the surface of the earth upto11 km. It constitutes about 10% of the atmosphere's height but contain 80% of its mass. The temperature in this region ranges from $15C^o$ to-$56C^o$. The major components of this sphere are N_2,

O_2 CO_2, Arand H_2O. It is a region of much turbulence, due to the global energy flow that results from the imbalances of heating and cooling rates between the equator and the poles. The temperature in the troposphere falls off uniformly with increase in altitude. That's why the air it contains mixes rapidly by convection.

Lapse rate: The change in temperature with height is called lapse rate.

Chemical reactions in the atmosphere

The main chemical species in the atmosphere are N_2, O_2, $H_2O_{(v)}$, O_3, NO^+ and O_2^+ etc.In industrial zones, the atmosphere may also contain the oxides of Sulphur (SO_2 and SO_3), the oxides of Nitrogen (NO, N_2O, NO_2) and the oxides of Carbon (CO and CO_2). The oxides of Sulphur are called as SO_x, the oxides of Nitrogen are called NO_x and the oxides of Carbon are called CO_x. SO_x, NO_x and CO_x are responsible for acid rain.

1. Reactions of SO_x and NO_x, formation of acid rain

$$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$$

$$SO_2 + H_2O + \frac{1}{2}O_2 \longrightarrow H_2SO_4$$

The concentration of the acid thus formed can be quite higher, which ultimately reduce the pH of rain water substantially. This result in producing what is called acid rain.

2. Reaction of CO_2 with the rain water

The CO_2 present in the atmosphere (0.036%) also reacts with the rain water, making it slightly acidic $(pH \cong 5.6)$.

$$H_2O + CO_2 \longrightarrow \underset{\text{Carbonic acid}}{H_2CO_3}$$

3. Reaction of N_2 and O_2 to produce NO

During the lightening and thundering, the reaction between stable molecules of N_2 and O_2 occurs producing NO.

$$N_2 + O_2 \longrightarrow 2NO$$

4. Partial combustion of hydrocarbons

Incomplete combustion of the carbonaceous compounds (hydrocarbons, coal etc.) results in the formation of carbon monoxide.

$$\text{Hydrocarbon} + \text{Limited } O_2 \longrightarrow CO + H_2O + \text{Energy}$$

CO, like other pollutants such as SO_x, NO_x, etc. pollutes the fresh air. At concentration higher than 750 ppm (0.1% of the air), CO may cause loss of consciousness and death occurs quickly.

Many more chemical reactions, occurring in the atmosphere, are involved in the formation of industrial and photochemical smog, similarly the main reaction

occurring in the stratosphere are due to the production and destruction of ozone.

5. Formation of smog (Peroxyacyl nitrate, PAN)

$$NO_2 + h\upsilon \xrightarrow{<400nm} NO_{(g)} + O$$

$$O_2 + O \longrightarrow O_3$$

$$O_3 + NO \longrightarrow NO_2 + O_2$$

$$RH + O_3 \longrightarrow R - \overset{O}{\overset{\|}{C}} - \overset{g}{O}$$

$$R - \overset{O}{\overset{\|}{C}} - \overset{g}{O} + O \longrightarrow R - \overset{O}{\overset{\|}{C}} - \overset{g}{O}O$$

$$CH_3 - \overset{O}{\overset{\|}{C}} - \overset{g}{O}O + NO_2 \longrightarrow CH_3 - \underset{PAN}{\overset{O}{\overset{\|}{C}}} - OONO_2$$

6. Formation of ozone

$$O_2 + h\upsilon \xrightarrow{\lambda=242nm} 2O$$

$$O + O_2 \longrightarrow O_3$$

7. Destruction of ozone

$$O_3 + h\upsilon \longrightarrow O_2 + O$$

$$O_3 + O \longrightarrow 2O_2$$

8. Destruction of ozone by CFCs

$$Cl_2CF_2 + h\upsilon \longrightarrow \dot{C}l + ClCF_2$$

$$\dot{C}l + O_3 \longrightarrow ClO + O_2$$

Air Pollutants and Their Effects

Pollution: The phenomenon in which mixing of the harmful substances with the environment badly effect the natural quality and standard of the environment and make it unfit for animals, plants and humans is called pollution.

Pollution is the addition of wrong substances, in wrong amount, at wrong time, at wrong places.

Air pollution is the presence of one or more contiminants in the outdoor atmosphere in such quantity and for such duration which may be or tend to be dangerous to human, plants and animals.

Pollutants: The undesirable substances which affect the standard and quality of the environment are called pollutants. Pollutants may be physical, chemical, biological and radioactive in nature. Pollutants are the substances that on local and regional

scales directly harm animals, plants and humans and their artifacts. Examples are heavy metals, persistent organic pollutants (POP), environmental persistent pharmaceutical pollutants (EPPP), polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs).

Contaminants: Substances which may be physical, biological, chemical or radioactive in nature and present in sufficient concentration that can adversely affect living organisms, through air, water, soil or food are called contiminants. Examples are micro organisms, disinfectants, inorganic chemicals, organic chemicals and radionuclides etc. All the pollutants are contaminants but all the contaminants are not pollutants.

Classification of Air Pollutants

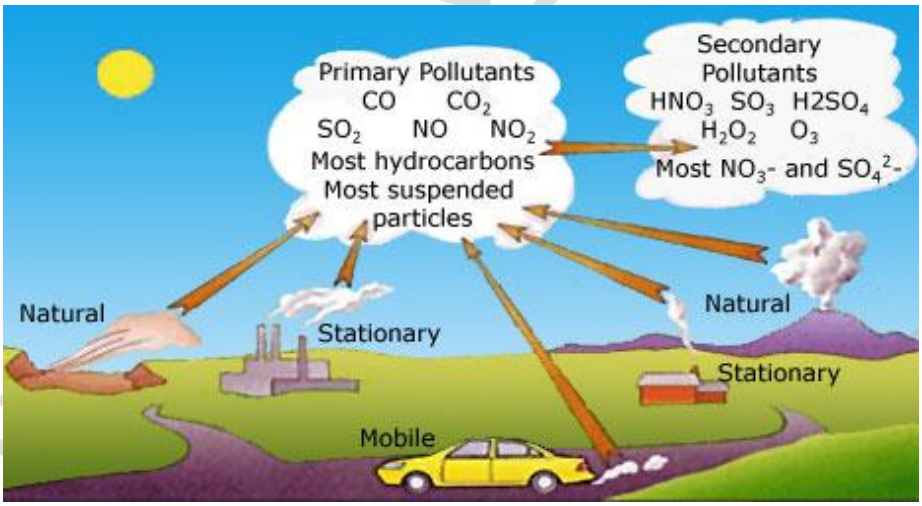
1. Classification according to the origin

i. Primary pollutants

Pollutants which are directly emitted into the atmosphere like CO_x, NO_x, SO_x and hydrocarbons.

ii. Secondary pollutants

These are the pollutants formed by the chemical reactions between primary pollutants and atmospheric constituents. Examples are: ozone, photochemical smog, aldehydes, ketones, peroxybenzol, sulphuric acid, nitric acid, carbonic acid etc.



2. Classification on the basis of chemical nature

i. Organic pollutants: Hydrocarbons, aldehydes, ketones, alcohols, amines.

ii. Inorganic pollutants: CO_x, NO_x, SO_x, H_2S, O_3, fly ash, dusts, H_2SO_4.

3. Classification according to the state/phase

i. Gaseous pollutants: CO_x, NO_x, SO_x, H_2S, O_3.

ii. Particulate pollutants: Finely divided solids or liquids which exist in colloidal

form like, smoke, fumes, dust, mist, fog, smog, sprays and grits.

Major Air Pollutants and their Effects

1. Carbon monoxide (CO)

It is colourless, odourless and toxic gas.

Natural sources of CO: In nature it is formed during volcanic eruption, anaerobic decomposition, seed germination and by oxidation of methane.

Anthropogenic sources: Burning of fossil fuels, industrial and automobile exhausts.

Effects of CO: When the concentration of the CO inhaled, reaches 100 ppm particularly in the closed spaces like tunnels, parking garages etc. It may result in headache, fatigue, loss of judgment, loss of awareness and shortness of breath. The severity of the effects depends on the duration of the exposure and level of exertion. At a concentration higher than 750 ppm (0.1% of the air molecules), loss of consciousness and death occurs quickly.

It is termed as asphyxiating pollution because it can displace (O_2) bound to hemoglobin (Hb).

$$\underset{\text{Oxyhaemoglobin complex}}{HbO_2} + CO \longrightarrow \underset{\text{Carboyhaemoglobin complex}}{COHb} + O_2$$

The Fe binding sites in hemoglobin bind CO 320 times more tightly than O_2.

2. Sulphur dioxide (SO_2)

It is a colourless gas with pungent smell.

Natural sources: Volcanic eruption and oxidation of sulphur compounds.

Anthropogenic sources: Coal burning and smelting of metals,.

Effects of SO_2

1. Irritation of the respiratory tract.
2. Inhibit certain enzymes and stimulate mucous secretion.
3. Its concentration upto 500ppm causes death.
4. Cause breathlessness.
5. Cause pulmonary function disturbance.
6. Damage of skin.
7. Cause gastric disorder.
8. Cause irritation of eyes and lungs.
9. Cause damaging health effects.
10. Contributor to acid rain.
11. Destroy chlorophyll and chloroplast.

3. Oxides of nitrogen

There are eight oxides of nitrogen out of which N_2O, NO and NO_2 are most

important. Although the concentration of N_2O is high than the other two oxides but the other two oxides are more important from pollution point of view.

Natural sources of NO_x: Volcanic eruption and soil bacterial activities.

Anthropogenic sources: Combustion of fossil fuels, coal power plants, industrial exhausts, nitrogeneous fertilizers.

Effects of NO_x

1. Cause of acid rain.
2. Photochemical smog formation.
3. Affect the respiratory tract.
4. Affect heart and eyes.
5. Inhibition of some cellular enzymes.
6. Cause pulmonary fibrosis.
7. Cause inflammation of lungs.
8. Form strong bond with haemoglobin and reduces the oxygen carrying capacity of haemoglobin.
9. Cause ozone layer depletion.
10. Retards plants growth.

4. Volatile organic compounds (VOCs)

Natural sources: Volcanic eruption and anaerobic decomposition.

Manmade sources: Fuel combustion, industrial processes and automobile emissions.

Methane, propane, n-butane, iso-butane, n-pentane, iso-pentane, ethylene, acetylene and toluene etc are VOCs found in the atmosphere. Toxic VOCs are chrysene, benzo alpha pyrene and benzofloranthene.

Effects of VOCs

1. React with constituent of the cells.
2. Some of these are carcinogenic.
3. These are mutagenic as well.
4. Play an important role in the formation of photochemical smog.

5. Ozone as pollutant

Ozone is an allotropic form of oxygen. Ozone mean smell, it was named as ozone due to its irritating odour. Due to manmade activities and photochemical reactions in the troposphere, ozone is produced which act as pollutant. It is quiet harmful at the ground level.

Unit of ozone measurement: The amount of ozone in the atmosphere is expressed in Dobsin Unit (DU) where Imm thickn layer = 100DU. The normal amount of overhead ozone is 350DU. 1DU contain 2.68×10^{20} molecules of ozone per square meter.

Adverse Effects of Ozone

1. It damages eyes.
2. Decreases the elasticity of lung tissues.
3. Increase coughing.

4. Create chest discomfort.
5. Produce cracks in rubber.
6. Destroying plants.
7. Causes respiratory diseases.
8. Reduces the brightness and durability of paints.
9. Causes dyes fading.

Pollutant	Definition	Source	Damaging to:
Aerosols	Suspended liquid or solid particles	Old cosmetics, paint, cleaning supplies	Good, upper atmosphere ozone
Ammonia	Volatile chemical compound	Agricultural production	Human cells, respiratory health
Asbestos	Fibrous, silicate minerals	Building materials, friction products	Respiratory health
Carbon dioxide (CO2)	Gas that traps heat in the atmosphere	Burning fossil fuels	Climate
Carbon monoxide (CO)	Poisonous gas	Incomplete combustion from heaters, furnaces, automobiles	Blood, vision, brain function
Chlorofluorocarbons (CFCs)	Airborne chemical compound	Old aerosols, fire extinguishers,	Good, upper atmosphere ozone
Ground level ozone / smog (O3)	The chemical reaction of O3, NOx, VOCs, and sunlight	Motor vehicles, chemical solvents, industrial emissions	Respiratory health
Hydrochlorfluorocarbons (HCFCs)	Airborne chemicals	Air conditioning and refrigerants	Good, upper atmosphere ozone
Lead	Metal	Dust and soil, old paint, metal processing plant and	Human and animal organs, blood, nervous systems
Mercury	Natural element	Emissions from burning coal or hazardous waste	Human and animal organs, blood, nervous systems
Methane	Gas that traps heat in the atmosphere	Landfills, natural gas systems, coal mining, livestock	Climate
Nitrogen oxides (Nox)	Gas that contributes to smog and traps heat in the atmosphere	Burning fuel	Respiratory health, climate, water ecosystems
Particulate matter (PM)	Tiny, suspended dust and liquid particles	Smoke and Dust; cooking fires in poor countries	Respiratory health, visibility, immune system
Pesticides	Chemical compounds	Agricultural or household pest killers or disinfectants	Respiratory, nervous system, cancer
Propellants	Compressed gas that releases an aerosol	Old cosmetics, paint, cleaning supplies	Good, upper atmosphere ozone
Radon	Natural radioactive gas	Soil, rocks, water	Respiratory health
Refrigerants	Cooling gas	Old refrigerators and air conditioners	Good, upper atmosphere ozone
Sulfur oxide (SO2)	Gas that dissolves easily in water	Burning fuel, gasoline and metal extraction	Buildings, visibility, natural water ways, respiratory health

	MAJOR SOURCES	HEALTH EFFECTS	ENVIRONMENTAL EFFECTS
SO_2	Industry	Respiratory and cardiovascular illness	Precursor to acid rain, which damages lakes, rivers, and trees; damage to cultural relics
NO_x	Vehicles; industry	Respiratory and cardiovascular illness	Nitrogen deposition leading to over-fertilization and eutrophication
PM	Vehicles; industry	Particles penetrate deep into lungs and can enter bloodstream	Visibility
CO	Vehicles	Headaches and fatigue, especially in people with weak cardiovascular health	
Lead	Vehicles (burning leaded gasoline)	Accumulates in bloodstream over time; damages nervous system	Fish/animal kills
Ozone	Formed from reaction of NO_x and VOCs	Respiratory illness	Reduced crop production and forest growth; smog precursor
VOCs	Vehicles; industrial processes	Eye and skin irritation; nausea; headaches; carcinogenic	Smog precursor

Minimizing the automobile pollutants with the help of catalytic converter

The major pollutants present in the atmosphere are automobile emission which contains variety of pollutant generally includes NO_xSO_x and CO_x. These gases disturb the composition of atmosphere and cause air pollution. These effect human health and damage plants.

The best way to control the emission of these pollutants to the atmosphere is the use of a three way catalytic converter. It has two chambers.

Reducing chamber: In this chamber NO is reduced to $N_2$by hydrogen. Hydrogen is generated at the surface of Rhodium catalyst by the action of water and un-burnt fuel molecules.

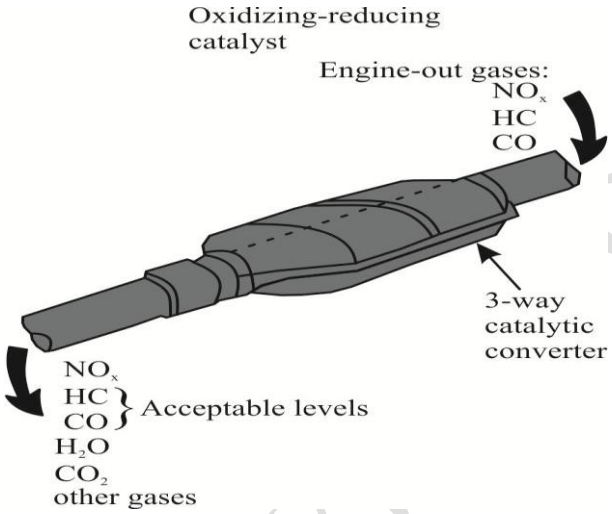
$$HC's + H_2O \longrightarrow H_2 + CO$$
$$2NO + 2H_2 \longrightarrow N_2 + 2H_2O$$

Oxidation Chamber: In the oxidation chamber, air is added and the CO and

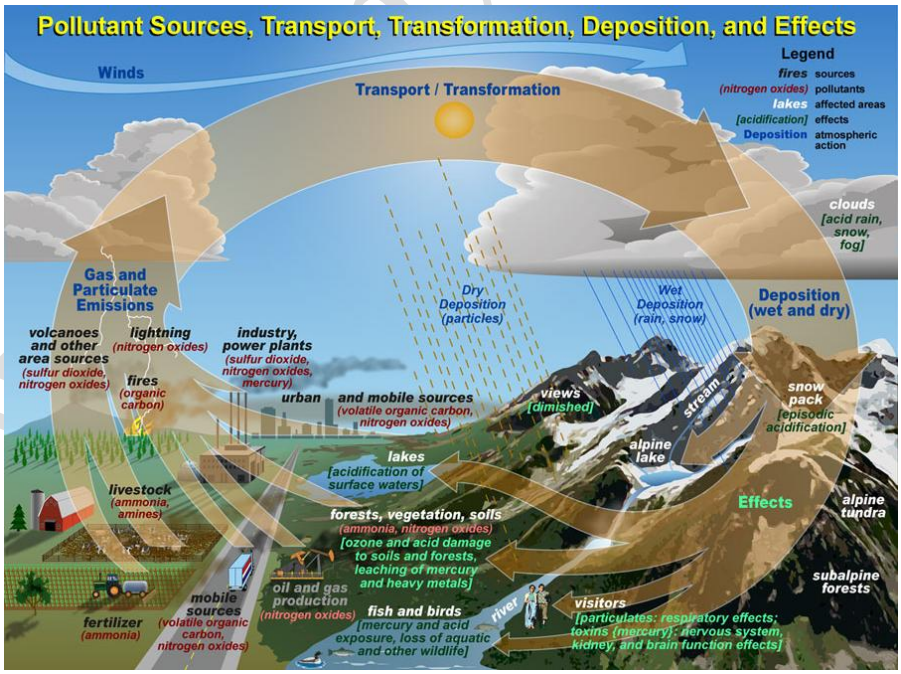
unburned hydrocarbons are oxidized to CO_2 and H_2O at the surface of Pt/Pd catalyst.

$$2CO + O_2 \xrightarrow{Pt/Pd} 2CO_2$$
$$HC's + 2O_2 \xrightarrow{Pt/Pd} CO_2 + 2H_2O$$

The catalytic converter is quite effective in reducing automobile emission of pollutants.



The three-way catalytic converter



Important Terms

Grit: Solid particle having size 70µm.
Dust: Solid particle of diameter usually 100µm.
Fume: Metallic oxides of size 0.03 to 3µm.
Smoke: Solid carbon particles form by the incomplete combustion of carbonaceous matter having size 0.05 to 1µm.
Mist: Liquid particles formed by condensation of vapours having size 0.5 to 1µm.
Spray: Liquid particles form by the atomization of parent liquids.
Aerosole: A suspension of liquid on solid particles usually less than 50µm.
Haze: It is aerosole which restricts visibility. It is smaller in size than fog or mist and having high relative humidity.
Fog: An aerosole of liquid droplets at the ground or near the ground level. It is usually of natural origin. It is a thick cloud of moisture.
Smog: It is the combination of smoke and fog. It is a brown hazy blanket covering the whole city. It reduces visibility and cause increase death rates, particularly in large cities such as Los Angeles, Tokyo, Chicago, Lahore, Faisal Abad and Islamabad etc.

In 1940 in London, it was observed by a Chemist Arie J. Hagen-Smith that the formation of smog occurs.The Problem of smog was first observed in Los Angles.
Types of smog: Smog is of the following two types.

1. Industrial smog

Industrial smog is formed, when exhaust pipes throw smoke and other materials into the air, produced by burning of the fossil fuels such as coal, oil and natural gas. The major products are CO_2, H_2O and smoke (carbon) particles.

The fossil fuel and coal introduce large amounts of combustion products to the atmosphere. Coal is a complex substance made up primarily of carbon containing materials. Its burning produces mostly CO_2.

$$C + O_2 \longrightarrow CO_2$$

CO_2 and H_2O in some ways may be considered pollutants. These cause relatively little trouble. Other minor combustion products are the major pollutants. For instance, most of the fossil fuels contain small amounts of sulphur compounds. These, on combustions, form sulphur dioxide, SO_2.

$$S + O_2 \longrightarrow SO_2$$

The tremendous quantities of coal that are burned for power production and in the blast furnace for making steel release a sizeable SO_2 to the atmosphere which pollute the clean air. SO_2 is an obnoxious pollutant primarily because it gradually reacts further to form sulphur trioxide SO_3. Then in the presence of water or water vapours, droplets of H_2SO_4 are formed as a result of this reaction.

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

H_2SO_4 is corrosive to such diverse materials as building stones and the human respiratory tract.

Another coal-burning power station pollutant is soot, (primarily particles of carbon) which gives smoke its persistent dark colour. The soot also plays its role in the industrial smog. Incomplete combustion of the coal and natural gas may result in the formation carbon monoxide gas or soot. CO is a lethal gas and at a concentration of 750 ppm in air, it may kill a person, if inhaled. At a level of above 100 ppm, carbon monoxide causes nausea, headache and shortness of breath. If exposed for a bit longer period, it causes loss of consciousness. CO plays vital role in the formation of smog. It is evident, that industrial activities are not so great that these can seriously modify the earth's atmosphere, and thus can affect the earth's average temperature and our climates.

2. Photochemical smog

When sunlight act on air pollutants to produce brown hazy fumes, it is called photochemical smog. Photochemical smog can form wherever large quantities of automobile and industrial exhausts are trapped by an inversion layer over a locality that is exposed to sunshine. Photochemical smog is characterized by an accumulation of brown, hazy fumes, containing ozone (O_3) and other oxidants. Nitrogen oxides (NO_x) and volatile hydrocarbons (HC's) photochemical smog, a condition that afflicts an increasing number of cities and their surroundings.

Conditions for Photochemical Smog Formation

1. The atmosphere must be highly polluted with H.Cs and other pollutants.

i. There must be inversion layer with stagnant air mass.

ii. The day must be bright sunny.

Nitrogen dioxide, NO_2 is the only common atmospheric molecule capable of absorbing visible light near the ground level. Its spectrum has maximum absorption at about 400 nm, in the blue region. It is the absorption that gives smoggy air its brown tint. The unstable photo exited NO_2 dissociates to NO and O atoms.

$$NO_2 + h\upsilon \xrightarrow{<400\,nm} NO_{(g)} + O$$

The oxygen atoms (O) react immediately with the surrounding O_2 molecules to produce ozone (O_3).

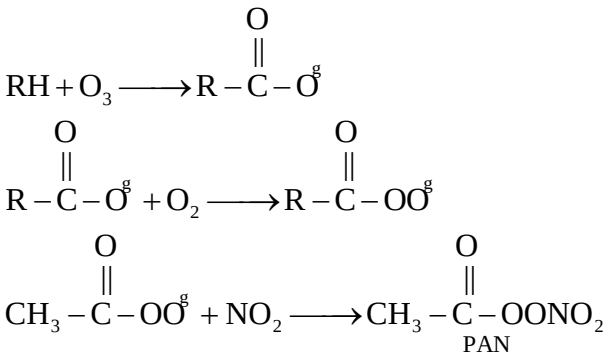
$$O_2 + O \longrightarrow O_3$$

The O_3 can react with NO to regenerate NO_2. A photochemical cycle is thus, established in these reactions. Hydrocarbons are also needed for smog formation. These produce carboxyl radicals by the reaction of O_3 with hydrocarbon.

$$O_3 + NO \longrightarrow NO_2 + O_2$$

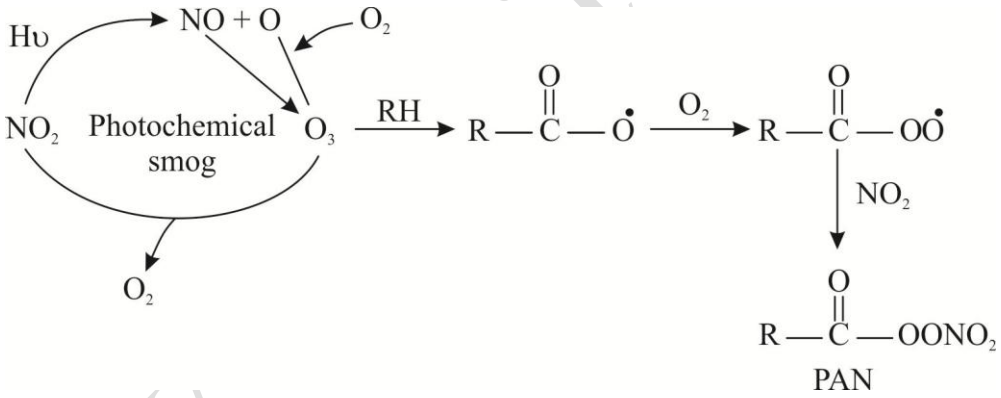
The organic radical react with O_2 and produce acylperoxy radical which react

with NO_2 and produce PAN.



Peroxy acetyl nitrate (PAN) formed from the peroxy acetyl radical, which is relatively common smog constituent.

The initiation of the cycle depends on the formation of organic radicals, the extent of smog formation depends on the reactivity of hydrocarbons (HC's) with the (O_3) radical. Some HC's produce few radicals, others many more. Formation of photochemical smog is summarized below.



Types of Photochemical Smog

1. London smog

It was observed for the first time in London. It is due tothe presence of reducing agents so it is also called reducing smog.

2. Loss Angelos smog

It was first observed in 1982 which caused a lot of hazards. It is also called oxidizing smog as oxidizing agents were found in the smog.

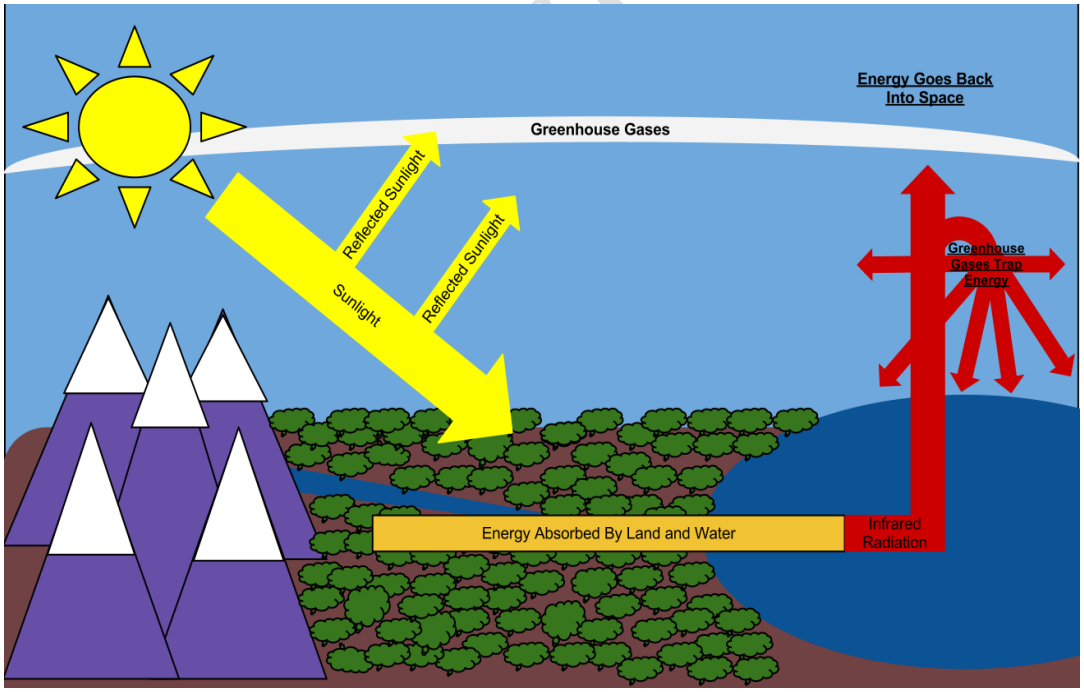
Effects of Photochemical Smog

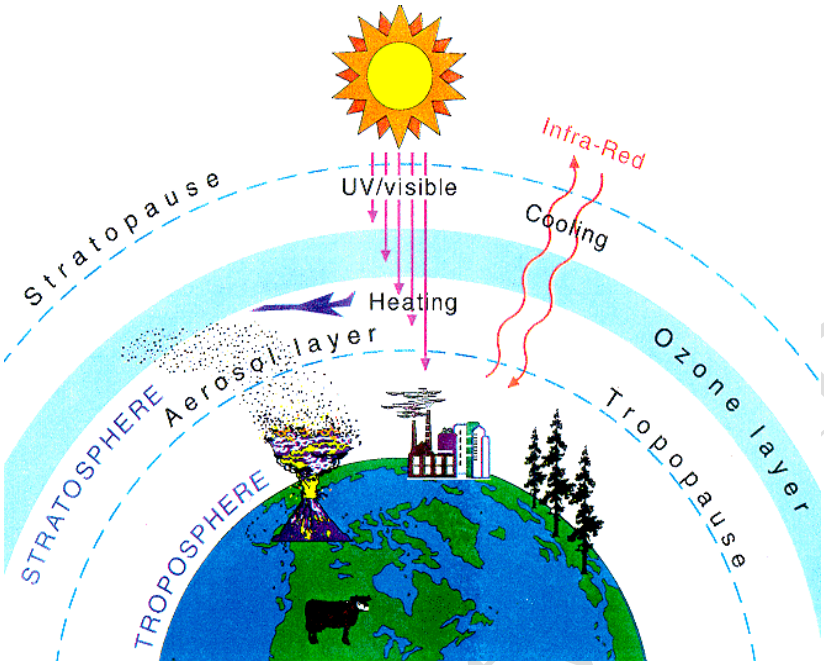
1. It leads to accelerating aging and chromosomal injury.

2. Cause lungs disorders.
3. Cause eye, nose and throat irritation.
4. Cause extreme fatigue and loss of coordination in eyes and minds.
5. Cause pulmonary endema.
6. Cause asthma and bronchitis.
7. The PAN, PPN and PBN present in the smog cause glazing and bronzing of leaves of young plants.

Green House Effect (GHE)

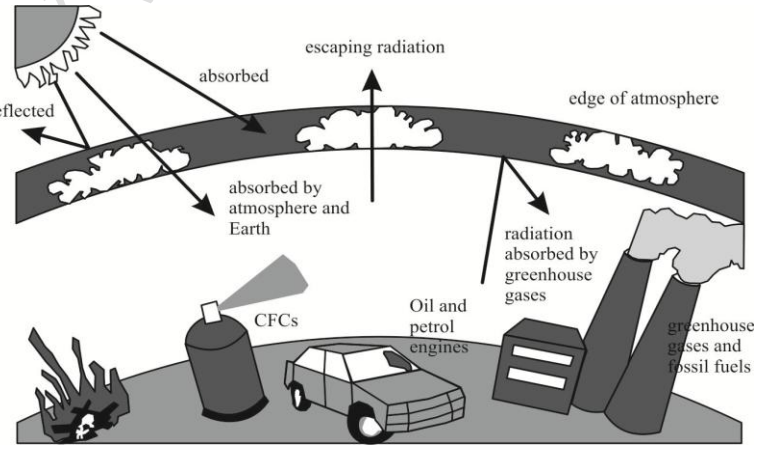
For growth and well nourishment of plants a house with walls and ceiling of clear glass or plastic is made which is called green house. The glass or plastic allow the incoming sunlight of shorter wavelength and do not allow the escape of these radiations back from the earth as these radiations are of longer wavelength and are less energetic. The result is warming of the green house which increases the growth and productivity of plants in it.





Our atmosphere contain CO_2, H_2O, CFCs etc. which act just like that glass or plastic of the green house, these allow the incoming radiations and then prevent its escape. This result in the warming of our atmosphere, this phenomenon is called green house effect or global warming.The increase in the temperature of the earth's surface that is expected to result from an increase in CO_2 in the atmosphere is said to be "green house effect".

Scientists believe that the earth maintains its long-term average temperature as a result of a balance between the heat received from the sun and the heat emitted to space by the earth. The sun like a high-temperature electric light bulb, emits ultraviolet (U.V) and visible radiation. The earth like a cool radiant heater emits mostly infrared (IR) radiation.



Carbon dioxide gas is colourless, and like all the other colourless matter, it does

not absorb visible radiation. Consequently it doesn't absorb much of the sunlight, which is mostly in the visible region that penetrates the outer atmosphere. However, atmosphere richer in CO_2 would capture a larger proportion of the radiation being emitted by the earth's surface. As a result the temperature of the atmosphere and of the earth's surface would gradually increase. CO_2 lets sunlight enter, but prevents the I.R radiation from escaping.

Green house gases: Gases responsible for green house effect and global warming are called green house gases. The major gas contributing 50% to greenhouse effect is CO_2. Other gases (CH_4, CFC's, SO_2, water vapours, ozone and NOx) together contribute the rest of 50%.

Human activities are increasing the atmospheric concentration of CO_2 and other greenhouse gases, thereby altering the way the sun's heat is distributing on the earth's surface and in the atmosphere. In addition, the stratospheric ozone shield, which protects us from the sun's U.V radiation, is threatened by the emission of ozone destroying chemicals. The earth's average temperature is being increased (global warming) which ultimately changes our climates.

Consequences of green house effect and global warming

1. Human health will greatly be affected due to spread of infectious diseases, such as yellow fever, dengue and malaria.
2. There would be rise in sea level, floods and pattern of rain fall.
3. Due to increase in temperature the glaciers and polar ice caps will melt and the sea level rise and many of the islands will sink.
4. One degree rise in temperature will move the plants towards poles upto 90Km and will result in 1/3% loss of food.
5. GHE will disturb the air currents and may lead to storms.
6. It is also a threat for aquatic life.
7. Winter will become short and summer will be long in temperate zones.
8. Evaporation will increase and rainfall will be rapid.

Controlling GHE

1. Green house gases emissions to the atmosphere must be stopped.
2. Deforestation must be discouraged.
3. Plantation and forestation must be encouraged.
4. Scrubbing of the stack gases.
5. Environmental protection agencies (EPA) and environmental regulatory authorities (ERA) must be established.

Acid Rain

The phenomena of acid rain were first observed by an English scientist R. A. Smith in 1853 in the city of Manchester. Initially it was referred as precipitation, which is more acidic then natural rain.

Rain water is slightly acidic (pH = 5.6) due to the absorbed carbon dioxide. When the PH of rain is less than 5.6 it is considered as acid rain. Acid rain is referred to all the precipitations (rain, dew, snow) which have pH less than 5.6.The greater acidity of acid rain is due to the presence of oxides of Carbon, Nitrogen and Sulphur in the atmosphere, which are emitted from the chimneys of industrial plants.

The oxides of Carbon, Nitrogen and Sulphur emitted within the atmosphere react with the moisture in the air or rain water to form carbonic acid, nitric acid and sulphuric acid.

$$H_2O + CO_2 \longrightarrow \underset{\text{Carbonic acid}}{H_2CO_3}$$

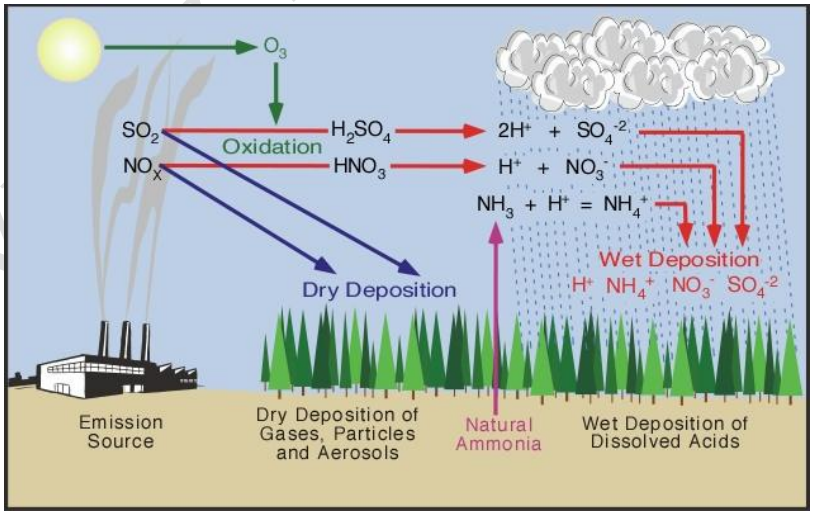
$$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$$

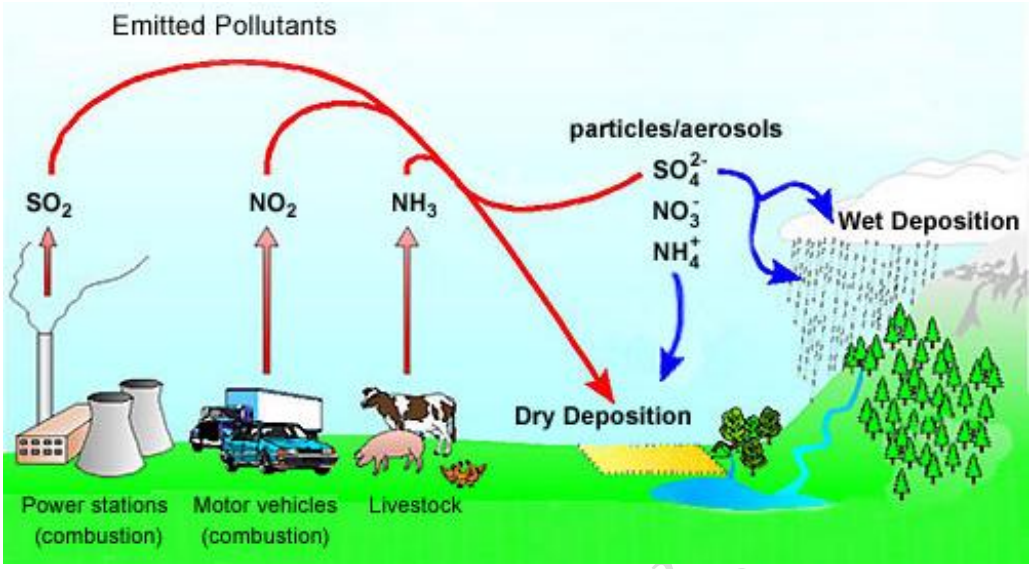
$$SO_2 + H_2O + \frac{1}{2}O_2 \longrightarrow H_2SO_4$$

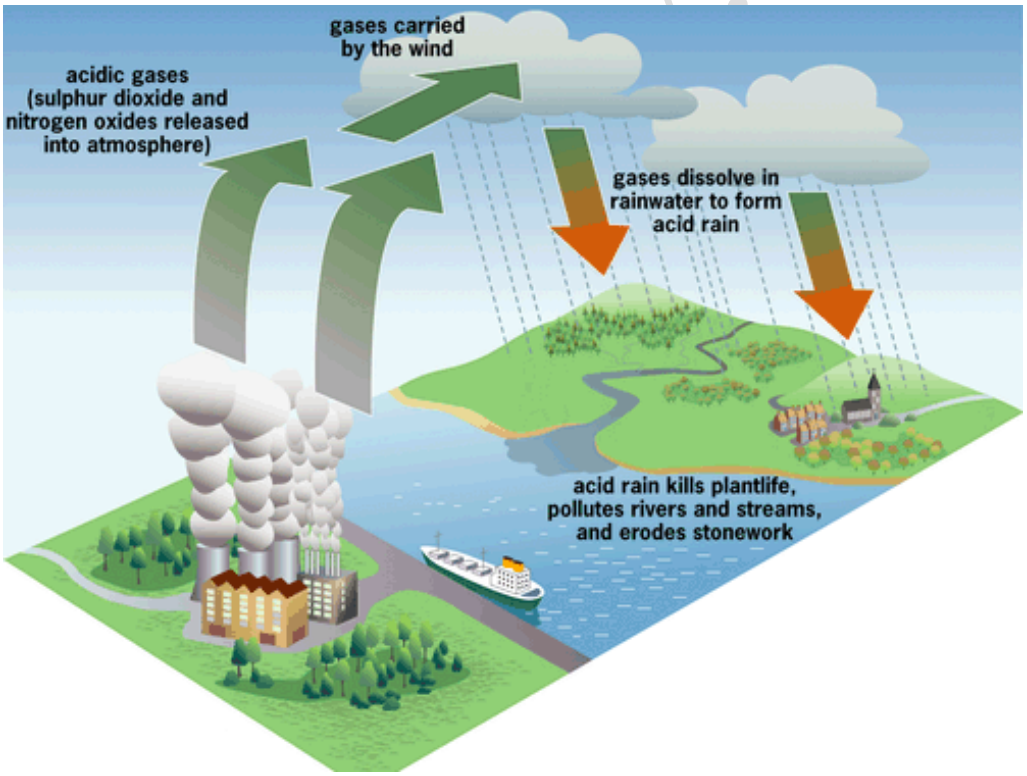
In polluted areas, the concentrations of these acids can be much higher and can reduce the pH of rain water substantially over extended regions, producing what is known as "acid rain". Acid rain can fall quite far from the sources of pollution, due to long-range atmospheric transport. In particular, acid rain is a serious problem for areas down-wind of coal-fired power plants.

Causes of Acid Rain

1. Sulphur dioxide and sulphur trioxide.
2. Nitric oxide and nitrogen dioxide.
3. Organic compounds like formic acid, acetic acid, pyrovic acid, oxalic acid etc. which comes from vegetation.







Effects of Acid rain: Acidrain on one hand is a serious threat to the human life as it contaminates the drinking water and on the other hand is a pressing problem for plants, animals, aquatic life and building material. Heavy metals e.g. Cu, Hg and Pb are also dissolved by acid rain producing various toxic effects.

1. Effects on Materials: The acid rain causes excessive damage to building and sculptures, materials of marble and lime stone due to the acid rain these materials are corroded and weathered.

$$CaCO_{3(s)} + H_2SO_{4(aq)} \longrightarrow CaSO_{4(ppt)} + CO_2 + H_2O$$

2. Effects on Aquatic Life: The acid rain increases the acidity of lakes and rivers thus causing damage to the aquatic life. The fishes are mainly affected by this acidity. High acidity results in killing of fishes reduce their growth and cause reproductive failure.

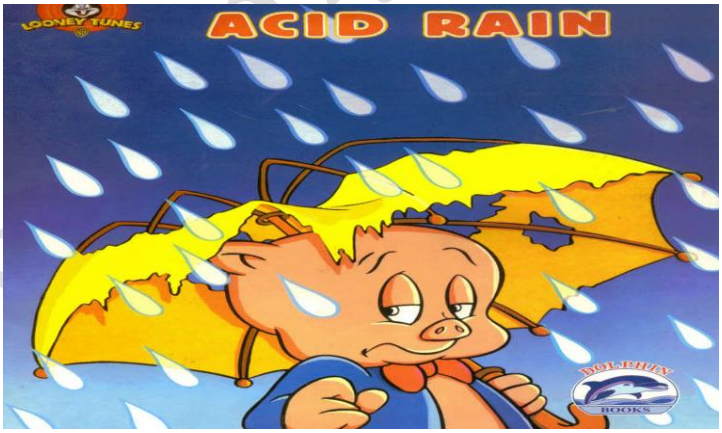
3. Effects on plants: Green algae and many forms of beneficial bacteria which are essential for aquatic life are killed due to high acidity of the rain.It affects the process of photosynthesis. Cause injury to plants barks, leaves and flowers.

4. Effects on soil: Acidrain increase the acidity of soil and effect the ion exchange reactions in soil.It causes corrosion and weathering of soil.The acidity of the rain usually increases the rate of decomposition of matter. This results in the accumulation of organic matter in water, which in turn increases the water pollution.

5. Effects on Human: In Human the acid rain causes lungs, eyes, skin and hair diseases. Gastric disorders occurby drinking acid rain water.

6. Effects on microbes: Some important soil nitrogen fixation bacteria are directly affected by acid rain.

7. Corrosive effects: Acid rain causes corrosion of steel, Zinc, paints, automobile coatings, bridges and pipe lines.



Controlling of Acid rain: Acid rain can be controlled by the following processes.

1. By reducing the combustion of fossil fuels.
2. Removing sulphur from fuel before burning.
3. Using substitutes of fossil fuels.
4. Use of modified exhaust systems.

Chemistry of the Stratosphere

Stratosphere is the second layer of the atmosphere. It extended from 11 to 50 km. Temperature of the stratosphere ranges from -56C^o to -2C^o. The important constituent of this region is Ozone (O_3) However N_2 and O_2 are also present up to some extent. The temperature of this sphere increases with increasing altitudes. Ozone is present in this sphere, which act as protective screen for survival of life on earth from injurious effects of ultraviolet radiations.

Ozone

Ozone is an allotropic form of oxygen. The existence of ozone in the atmosphere was first discovered by a German Chemist in 1840. It is a bluish gas. It has characteristic smell. It is slightly soluble in water. It can be liquefied at -112^{o}C. It is a toxic gas and cause respiratory irritation.

Formation of Ozone

The formation of ozone requires both oxygen atoms and oxygen molecules. Ozone is formed in the stratosphere when O_2 molecules absorb solar energy (radiation). The U.V photons of the sun have enough energy to split O_2 molecules into oxygen atoms high in the atmosphere.

$$O_2 + h\upsilon \xrightarrow{\lambda < 242nm} 2O$$

(The symbol "hυ" is used for photon and $\lambda < 242$nm indicates the wave length range in which photons can induce the reaction).

The oxygen atoms produced in the reaction, then combine with oxygen molecules to form ozone.

$$O + O_2 \longrightarrow O_3$$

At low altitudes, there are ample oxygen molecules but few unattached oxygen atoms. At high altitudes free oxygen atoms are more prevalent but there are few oxygen molecules. Conditions most suitable for ozone formation are found at intermediate altitudes, where both oxygen molecules and free oxygen atoms are present.

Destruction of Ozone

Ozone is also destroyed by solar radiation. When O_3 absorbs solar U.V photons it dissociates into O_2 and O.

$$O_3 + h\upsilon \longrightarrow O_2 + O$$

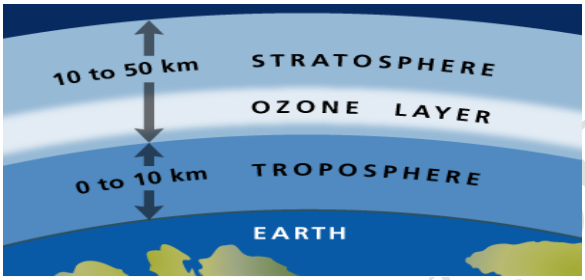
Also when O_3 encounters a free oxygen atom (O), the two can combine to form two O_2 molecules.

$$O_3 + O \longrightarrow 2O_2$$

The concentration of O_3 depends on the relative rate of the formation and destruction reactions.

Ozone Layer

Ozone is present in a layer form in the stratosphere at 25 to 30Km above. This portion of the stratosphere is also called ozonosphere. Ozone layer acts as a protective shield for living organisms. It provides protection from toxic radiations which are carcinogenic and mutagenic.



Ozone Layer Depletion

The formation of holes in the ozone layer is called ozone layer depletion. Decrease in the thickness of ozone layer below 280DU is called ozone layer depletion. This depletion is due to human activities. Ozone layer depletion was first reported in 1885 by Joseph Farman.The possible ozone depletion is due to photochemical reactions which are taking place in the atmosphere. Ozone is usually destroyed by the oxides of nitrogen which destroy 30-50% of the ozone in the stratosphere.

Sources of Ozone Layer Depletion

1. Oxides of nitrogen.
2. Atomic oxygen.
3. Chloroflourocarbons (CFCs).
   CFC-11 called Freon 11, which is $CFCl_3$.
   CFC-12 called Freon 12, which is CF_2Cl_2.
   CFC-22 called Freon 22, which is CHF_2Cl.
4. Reactive hydroxyl radicals.

Certain manmade organic compounds like CFCs (Freon gases) and bromine containing halons which are widely used in refrigerators, air conditioners, blowing agents for plastic foams, propellants for aerosol sprays and solvent for cleansing microelectronic components. The halons are used as fire extinguishers. The heavy bromine containing molecules provide a blanket of the gas that effectively smothers flames. The CFCs and halons are highly stable, easy to produce and easy to store, non-toxic and inflammable so these are enormously used for these applications. These

compounds are also called mericals. These are when released to the troposphere; these are not subjected to oxidation and not destroyed by the action of U.V photons. The absorbing U.V photons break the weakest bond in the molecules either C-Cl or C-Br.

$$CFCl_3 + h\upsilon \rightarrow CFCl_2 + \dot{C}l$$

The released chlorine or bromine destroys the ozone by the following reactions.

$$\dot{C}l + O_3 \rightarrow \dot{C}lO + O_2$$

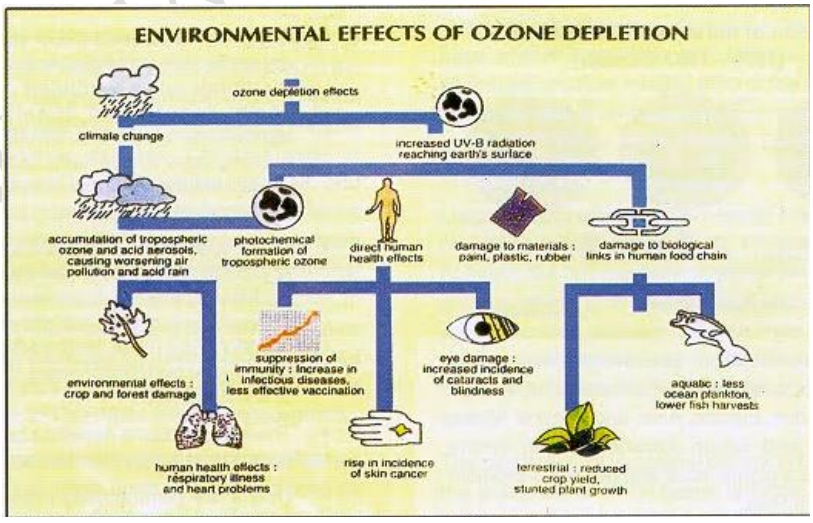
$$\dot{C}lO + O_3 \rightarrow \dot{C}l + 2O_2$$

A single chlorine free radical can destroy upto 100000 ozone molecules.

Range of ozone layer is from 380 to 400DU. If this thickness falls between 260 to 280DU then is called ozone hole and the ozone layer is said to be depleted.

Effects of Ozone Layer Depletion

1. UV-B radiations cause skin cancer when these pass from the holes in ozone towards earth.
2. UV-B radiations also cause decreased eye sight.
3. UV-C radiations destroy DNA and RNA.
4. Cause grooves appearance on face.
5. Cause dermatological effects.
6. Cause sun burn.
7. Cause Lashmania.
8. Cause eye cancer in cattles.
9. Effects the growth and reproduction in plants.
10. Cause global warming.



Protection from these Effects

1. To minimize the escape of pollutants responsible for ozone layer depletion.
2. The holes in ozone layer can be repaired by the use of high altitude balloons of ozone gas and spreading that ozone in the stratosphere.
3. Wearing of full clothes, hats, caps and dopatta.
4. To wear tightly weaved clothes.
5. To be sun wise.

Substitutes of CFCs

Hydrochloroflourocarbons (HCFCs) and hydrofluoric carbons (HFCs) can be used as substitutes for CFCs. The presence of C-H bonds allows the HCFCs and HFCs to be attacked by the OH radicals and are destroyed in the stratosphere. Compared to CFCs, these compounds also show less reactivity, good insulating and solvent characteristics, fire suppression and boiling points suitable for use in refrigerator.

Water Pollution

Any unwanted interferences chemical, physical or biological in nature which adversely affects the quality and standard of natural water and make it unfit for drinking and other use are called water pollutants and the phenomenon is called water pollution.

Water is of great importance to life, life is water based as everything has been created from water. Surface water and its quality is of great importance for human health and for aquatic ecosystem. Aquatic animals cannot exist for few minutes without water. The available water for use is surface and ground water which is continuously being spoiled by live stock wastes, agriculture, pesticides, oil leaks, industrial effluents, municipal sewage, mining, power plants etc.

Types of Water Pollutants

Water pollutants may be of the following types.

1. **Physical pollutants:** Solid debris, mud, sand, stones, twigs, plastics, papers etc.
2. **Biological pollutants:** Viruses, bacteria, fungi, algae etc.
3. **Chemical pollutants:** Fertilizers, pesticides, metals, aromatics, oils, etc.
4. **Radioactive pollutants:** Radioactive elements from mining of uranium ores,

nuclear explosions, research areas, tracer technological techniques, radiotherapy centers, weapons and nuclear power plants are hazardous.

Classification of Water Pollutants

Water pollutants may broadly be of two types, suspended solids and sediments and dissolved solids.

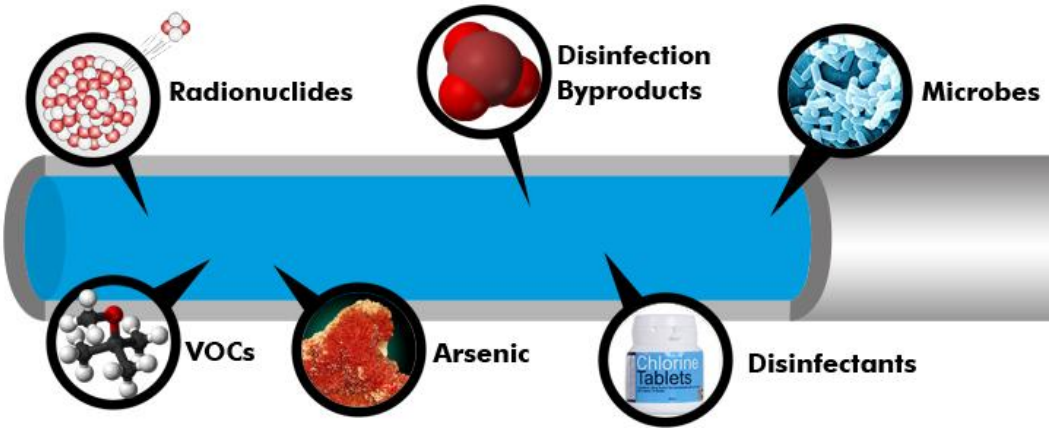
1. Suspended solids and sediments

i. Filterable: Which are of larger size and can be filtered easily.

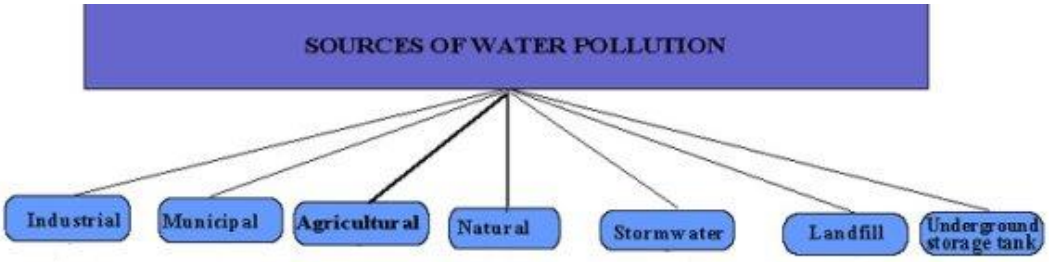
ii. Non-filterable: These are smaller colloidal particles of microscopic size. These give turbid and cloudy appearance to water. These can be detected in water by passing a beam of light through the water and observing the scattering of light these produce, the appearance is just like a beam of light passing through smoky or foggy air. This phenomenon is called ***Tindal effect***.

2. Dissolved solids

The dissolved solid material, present in water, may either be organic or inorganic. The dissolved organic compounds, acting as impurities, enter into water as a result of the growth and the death of aquatic plants, such as algae. Others are contributed by sewage from domestic sewage systems and by industrial wastes. The total amount of organic substances can be estimated from the amount of oxygen or any other chemical oxidizing agent, needed to oxidize these substances to CO_2 and H_2O.The dissolved inorganic materials present in water are mostly salts. These on one hand are essential for human body, but on the other hand, if their concentrations are greater than about 500 ppm, they make water unfit for drinking, and such water is considered to be polluted. The most common salts present in water are carbonates, bicarbonates, sulphates and sulphides of calcium and magnesium. Hardness of water depends primarily on the Ca^{+2} and Mg^{+2} ions contents.



Sources of Water Pollution



1. Industrial effluents

The industrial waste–water pollution is a serious problem in many countries. Many industries used water as coolant or as process water. So the industrial effluents wastewater is always contaminated with toxic chemicals depending on the nature of the raw material used in the industry.

Wastes from some Typical Industries

i. Paper Industry: The chemicals generated by the paper industries include non-degradable organic (Cellulose), wood chips, barks, alkalies, phenols and chlorine bases substance.

ii. Chemical processing industries: Alkalies, acids, phenols, detergents, soaps, silicates etc. are added to water.

iii. Plastic and rubber industries: H.Cs, brines, oils, acids, bases, heavy metals etc. are added to water.

iv. Electroplating Industry: This industry generates dissolved and particulate compounds of heavy metals, Chromium, Nickel, Zinc, Cadmium,Lead, Steel, Iron and Titanium oxides etc. All these metal are toxic to aquatic life and microorganism. The effluents contain CH_3Cl H_2SO_4, HNO_3 etc. and heavy metals.

v. Petroleum Industry: The petroleum chemical industry generates pollutants like phenols, pitch, salts, cyanides, alkalies, acids and mineral oils. Phenol is highly toxic and irritant in mature. It is carcinogenic in nature.

vi. Coal industries: Sulphuric acid, char, sand, stones etc are introduced to water.

vii. Textile Industry: The wastewaters of this industry are colored pigments, alkalies, greases, fibers, heavy metals, poly vinyl alcohols and softeners. This water is unfit for agriculture and for aquatic life.

viii. Leather Industry: The effluents of this industry contain NaCl, dirt, soluble proteins and suspended solids. This waste may cause anesthesia and related problems.

ix. Food processing industries: Fats, proteins, lactoses, furs, feathers etc. are introduced to the water.

x. Tanning industries: Provide effluents like phenols, limes, hoofs, horns, hairs, proteins, bloods, tannins, heavy metals and oils which give bad odour and colour to

water.

Pollution Caused by Metals: Metals that are released by various industries to pollute water mainly include Arsenic, Mercury, Lead and Cadmium.

Pollution caused by inorganic salts: Like carbonates, bicarbonates, sulphates and sulphides cause water pollution.

Pollution caused by organic compounds: Benzene, toluene, xylene and phenol etc are introduced to water which are so much toxic.

(a) **Arsenic:** Smelting of gold, lead, copper, iron and nickel ores are the main sources of arsenic pollution. Arsenic in drinking water is a slow poison. It decolorizes the skin (keratoses) which leads to cancer.

(b) **Mercury:** Mercury toxicity is associated with almost entirely with eating fish. Sulphate reducing bacteria in sediments generate methyl mercury and release it into the water above, where it is absorbed by fish from the water passing across their gills or from their food supply. The poisoning of mercury causes numbness of limbs, blurring, loss of vision, loss of hearing and loss of muscle coordination.

(c) **Lead:** Leaded paints, leaded gasoline and lead solder (to seal food and drinks in cans) are the main sources of lead pollution. Lead poisons many thousands of people yearly. Once absorbed in the body, lead enters the blood stream and moves from there to soft tissues. Higher exposures produce anemia. It also inhibits the enzymes involved in the biosynthesis of haemoglobin.

(d) **Cadmium:** Cadmium inputs to soils and ultimately to surface waters are mainly from airborne deposition (wet plus dry) and from commercial phosphate fertilizers which contain cadmium as a natural constituent of phosphate ore. Chronic exposure to cadmium causes heart and lung diseases (including lung cancer at high levels), immune system suppression and liver and kidney diseases.

2. Domestic waste water

Domestic or Municipal waste water is the one of the major cause of fresh water pollution. Most of the effluents discharge from municipality waste receives no treatment.

Domestic water mainly contains soaps and detergents. Synthetic washing powder has drastic effect on the water sources.

Residue of detergents cause wide spread pollution including large aggregate of bubbles and foams, due to which the dissolved oxygen level is reduced.The water quality is also at risk due to presence of phosphate, which is widely used in detergents formation.

Effect on fresh water: The effects of the domestic waste water on the fresh water are

summarized as under**.**

- The presence of detergent in the wastewater usually causes the eutrophication of lakes.
- It will also cause turbidity.
- It is always a good source for pathogens, causing variety of diseases.
- It also contains nitrogenous waste, which imparts bad smell to the fresh water.
- It contains soap and detergents, which affects the wild life.
- It also contains suspended matter, which cut off sunlight and affects the aquatic life

3. Agricultural wastes

Fertilizers, pesticides, herbicides, germicides, insecticides, fungicides etc create extremely high potential of water pollution. Inorganic fertilizers increases the sulphates, phosphates, nitrates and chlorides concentration of water. The main nitrate hazard is "blue baby syndrome" a condition of respiratory failure in babbies.

4. Hot water from thermal power plants

The heavy machinery and power plants get heated when frequently and continuously used for making various industrial products. Some parts of the plants are heated due to friction when they are in contact with each others. For high efficiency and to elongate their life time, these parts (components) must be cooled. This is done with cold water. The cooling of power plants and other machinery by circulating water, raises the temperature of the water. When this water enters the fresh water, it causes pollution called "thermal pollution".

Thermal pollution has adverse effects on the biota of the receiving waters. The high-temperature water, when mixed with cold water, increases the solubility of many pollutants (organic and inorganic), salts, ions, causing the water to be more easily polluted, thus affecting the quality of water and make it unfit for drinking and public use.

5. Petroleum spills

Petroleum cause severe water pollution. Oil spills from tankers and ships effect birds, fishes and microorganisms. The feathers of diving birds get clogged with oils. Sea weeds and mollusks also get damaged. The cell membranes of a large number of microorganisms are also damaged.

Water Quality Parameters

The water quality parameters decide whether or not the given sample of water is fit for drinking.Drinking water must qualify the following parameters or qualities.

1. It must be colourless.
2. It must be tasteless.
3. It must be odourless.

4. It must be free of turbidity causing agents like suspended solids, dissolved solids, chlorides, sulphates, phosphates etc.
5. Turbidity must not exceed 10ppm.
6. It must be free from disease causing bacteria.
7. It must have no conductivity.
8. It must be free of hardness.
9. Its temperature must be in the range of 36 to 40^{o}F.
10. Its pH must be in the range of 7 to 8.5.
11. It must have proper amount of dissolved oxygen for the survival of aquatic life. The dissolved oxygen must be from 4 to 8ppm. If the DO value is less than 4 the water is said to be polluted.
12. Its BOD must be less than 80mg/Liter.
13. Its COD must be less than 150mg/Liter.

Total Suspended solids (TSS): The amount of solids which are removed by means of filtration is termed as suspended solids. It causes the turbidity of water.

Total dissolved solids (TDS): The amount of dissolved solids in water can be determined by evaporating the water sample which will leave behind the residue in solid form. The DS can be used as a parameter for water quality. If the amount of DS is greater the water quality will be low. The amount of DS in drinking water must not exceed 3500µg/litre.

Biological Oxygen Demand (BOD)

It is the amount of dissolved oxygen needed by aerobic biological organisms in a water sample to break down organic materials present in a given water sample at certain temperature over a specific time period. It is determined in five days so it is also called five days test. First oxygen is determined in water and then after five days its amount is determined again. The decrease in the amount of oxygen in five days is called BOD. The microbes utilize oxygen for their metabolic activities and these oxidize organic matter in water. So the value of BOD is the amount of oxygen consumed as a result of biological oxidation of dissolved organic matter in a sample of water. A small value of BOD means pure water. The maximum BOD for normal water is 80mg/Liter.

Chemical Oxygen Demand (COD)

It is the amount of oxygen required for the chemical oxidation of the organic matter present in a water sample. Water is treated with strong oxidizing agent like potassium dichromate. The organic matter in water is oxidized while the remaining dichromate is determined volumetrically. The value of COD is a direct measure of the chemically oxidizable matter in water. The value of COD is always greater than BOD

for a water sample. Greater COD indicate more pollution and smaller COD indicate pure water. The maximum COD for non-polluted water is 150mg/Liter.

Waste water treatment: Purifying the polluted water require a number of steps and number of processes to be carried out.

1. Screening or filtration
2. Sedimentation
3. Coagulation/flocculation
4. Removal of hardness
5. Aeration
6. Chlorination
7. Passing through charcoal beds
8. Addition of fluorine compounds

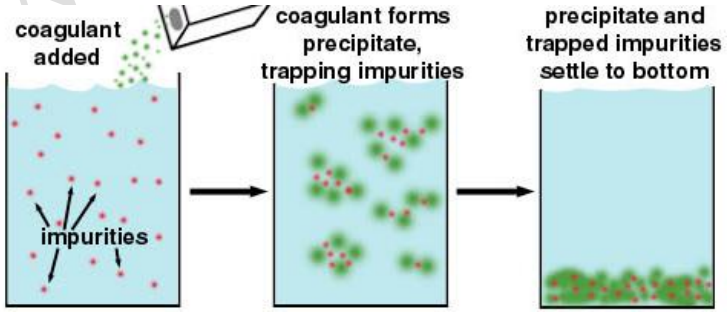
1. Screening or filtration: In this step, the undissolved floating and visible solid materials present in water are removed. Coarse objects are removed by running the water through screens bars or filters.

2. Sedimentation: The small floating suspended materials can be removed when water is added to sedimentation tanks and kept as such for some time. On resting the small particles will settle at the bottom under the action of gravity and are removed.

3. Flocculation/coagulation: This technique is used for the removal of finely divided suspended solids and othe colloidal particles. The finer, colloidal particles that make water turbid cannot be removed by simple filtration. So a flocculating agent that is a substance that forms large gelatinous particles is added. The common flocculating agent is Aluminiumsulphate ($Al_2(SO_4)_3$) often referred to as alum, some lime($Ca(OH)_2$) is generally added so that precipitate of Aluminium hydroxide ($Al(OH)_3$) must form which has gelatinous form.

$$Al_2(SO_4)_3 + 3Ca(OH)_2 \longrightarrow 2Al(OH)_3 \ (PPT) + 2CaSO_4$$

This precipitate traps both inorganic solid particles and bacteria in the large curd like particles. These particles are then easily removed by filtration through a sand-bed or charcoal.



4. Removal of dissolved solids: Dissolved solids are removed by ion exchange process. In this process cation exchangers and anion exchangers are used. Zeolites, resins and mixture of feldspar, china clay and soda ash are used as natural ion

exchangers.

5. Removal of hardness: The hardness of water is due to the presence of chlorides, sulphates and bicarbonates of calcium and magnesium. Hard water is treated with washing soda to convert the chlorides, sulphates and bicarbonates of Ca and Mg to carbonates which are not responsible for hardness. Temporary heating can be removed by simple heating while permanent hardness can be removed by Clark,s method or zeolite method.

6. Chlorination: Chlorine or bleaching powder is frequently used to purify water. The chlorine treatment is very effective in killing the pathogens that may cause serious water borne diseases such as typhoid and cholera. Chlorination is the widely used method to disinfect water for longer duration of time. The reactions involved are:

$$H_2O + Cl_2 \longrightarrow HCl + HOCl$$

HOCl is weak acid and partially dissociates.

$$HOCl \longrightarrow [O] + HCl$$

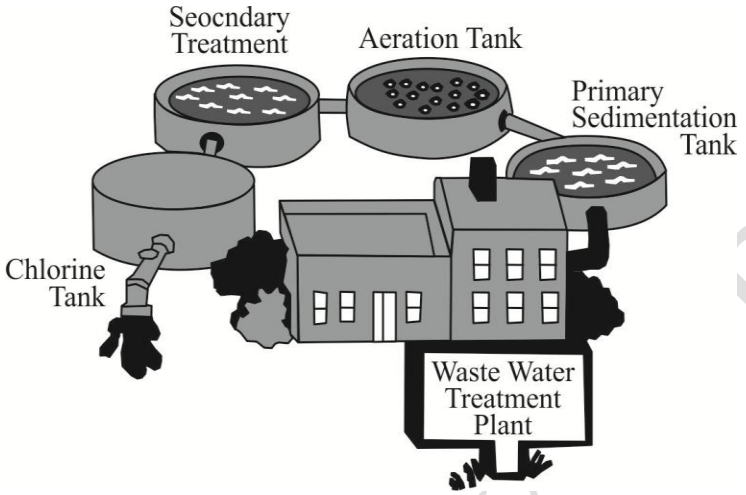
The nascent oxygen destroys the disease causing microbes.

Microbes are also killed by UV radiations passed through the water sample. Copper sulphate treatment also causes the precipitation of microbes.

7. Aeration or oxygenation: Water is aerated to remove odour and taste from it and to adjust its oxygen level. Aeration tanks, aerated lagoons, oxidation ditches and waterfalls are used for aeration of water.

8. Passing through the activated charcoal beds: Activated charcoal removes the fine organics which are not oxidized by microbes. Colour, odour and taste is also removed when the water is passed through charcoal beds. Ammonia also removes colour, odour and taste from water.

9. Addition of fluorine compounds: A fluoride compound is added in some plants, to help fight tooth decay. The result of thorough water treatment operation is water that is as good as new.



Natural Water Eutrophication

The enrichment of water with nutrients especially phosphates and nitrates is called eutrophication. These typically promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the oxygen of available water, causing the death of other organisms, such as fish. It is a natural phenomenon in which dead bodies of organisms accumulate in the lakes and filling of the lakes occurs and marshy conditions arise. Eutrophication is considered as water pollution process as aquatic life is affected.

Green Chemistry or Sustainable Chemistry

Green Chemistry is the utilization of a set of principles thatwill help to reduce the use and generation of hazardous substances during the manufacture and application of chemical products.Green Chemistry is the use of chemistry for pollution prevention by environmentally conscious design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry, also called sustainable chemistry, is a philosophy of chemical research and engineering that minimizes the use and generation of hazardous substances. Green Chemistry offers a strategic pathway to build a sustainable future. Green Chemistry is the way to provide the things we benefit from today in a clean and sustainable way that does not harm the life.

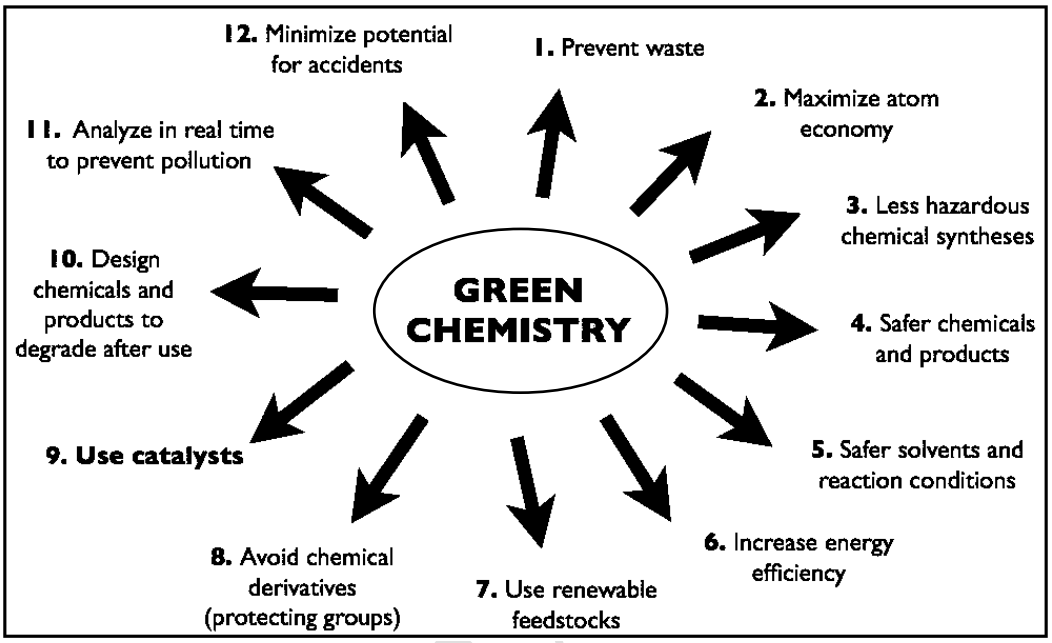
The concept of Green Chemistry was coined by Paul Anestas of America. He enunciated twelve principles of Green chemistry in 1994 towards ideal synthetic methods to save natural resources.

Twelve Basic Principals of Green Chemistry: The basic principles of "Green Chemistry" are the following:

1. Preventing wastes.
2. Maximizing atom economy.
3. Designing less hazardous chemical synthesis.
4. Designing safer chemicals and products.
5. Using safer solvents and reaction conditions.
6. Increasing energy efficiency.
7. Using renewable feed stocks (raw materials).
8. Avoiding chemical derivatives.
9. Using catalysis and not stoichiometric reagents.
10. Designing degradable chemicals and products.
11. Analysis in real time to prevent pollution.
12. Minimizing the potential for accidents.

$$\%\text{Atom economy} = \frac{\text{Formula weight of the product}}{\text{Sum of the formula weights of all the reactants}} \times 100$$

Good atom economy means most of the atoms of the reactants are incorporated into the desired products and only small amounts of unwanted byproducts are formed and hence lesser problems of waste disposal or waste treatment. Atom economy is a method of expressing the efficiency of a particular reaction.



EXERCISE

Q.1. Choose the correct one.

(i) Which one of the following is not a secondary pollutant?

(a) Ozone (b) H_2CO_3

(c) H_2SO_4 (d)✓ CO_2

(ii) Pollutants have adverse effect over

(a) Biosphere (b) Ecosystem

(c) Hydrosphere (d)✓ All

(iii) Ozone layer in upper atmosphere is being destroyed by.

(a)✓ Chlorofluoro Carbons (b) SO_2

(c) Smog (d) Photochemical Oxidant

(iv) Drained sewage has B.O.D.

` (a)✓ More than that of water (b) Less than that of water

(c) Equal to that of water (d) None of above

(v) Photochemical smog is primarily caused by

(a) CO (b) CO_2

(c) O_3 (d)✓ NO_2

(vi) Result of ozone hole is
(a) Acid rain (b) Global warming
(c) Increased amount of CO_2 (d)✓ Greater exposure of earth to U.V

(vii) Which one of the following substances is not present in acid rain?
(a) H_2SO_4 (b) HNO_3
(c) H_2SO_3 (d)✓ CH_3COOH

(viii) Photochemical oxidant PAN is formed by
(a)✓ The action of oxide of nitrogen on hydrocarbons in presence if sunlight
(b) Action of carbon dioxide on hydrocarbon in presence of sunlight
(c) Action of hydrogen sulphide on hydro carbon in presence of sunlight
(d) Action of SO_2 and hydro carbons.

(ix) Which compound is base for corrosion resistance paints
(a) White lead (b) Red lead
(c) Lead chromate (d)✓ All of these

(x) The temperature (C^o) range of troposphere is
(a)✓ 15 to -56 (b) 56 to -2
(c) -2 to -92 (d) -92 to 1200

SHORT QUESTIONS

Q.2. Short Questions:

(1) Why is acid rain considered as a threat to historical monuments?

Ans. The historical monuments like unique statues, famous buildings, bridges and other objects are either made up of marble (carbonates) and metals. The pH of acid rain is lower so it corrodes the metals, marbles etc. and damage/fad away/tornish the colours also like that of Taj Mahal in India. The marble building in Washington DC have pock marks due to acid rain. That's why acid rain is considered as threat for historical monuments.

$$CaCO_{3(s)} + H_2SO_{4(aq)} \longrightarrow CaSO_{4(ppt)} + CO_2 + H_2O$$

(2) Define the following:
(a) Contaminants **(b) Pollutant**
(c) Eutrophication **(d) Acid rain**
(e) B.O.D **(f) Smog**

Ans. Given in the theory.

(3) What is the importance of dissolved oxygen in water?

Ans. The amount of dissolved oxygen plays a very important role in aquatic life. It is used for respiration and for the decomposition of organic matter. It also determines the quality of water whether it is fit or unfit for drinking. From the DO we can calculate the BOD and COD values.

(4) What methods are employed for control of SO_2 pollution?

Ans. The SO_2 emissions are controlled when the coal or petroleum is desulphurized first by desulphurization processes. A spray dry absorber process is also used in which the flue gas is passed through large chambers where an atomized lime and water mixture (calcium hydroxide) is sprayed. The calcium hydroxide react with SO_2 and produce a dry particulate material composed of calcium sulphate, calcium sulphite and unreacted calcium oxide (lime). The particulate is then captured and removed.

(5) What are the applications of Green Chemistry?

Ans. Given in the theory.

(6) Name four major greenhouse gases.

Ans. The major greenhouse gases areCO_2, CH_4, H_2O (vapours), nitrous oxide, ozone, CFCs etc.

(7) Out of CFC's and CO_2 which one has higher potential to cause global warming and why?

Ans. $CO_2$is the major global warmer gas. It is produced during the combustion process of any organic material accumulate and form a blanket in the atmosphere trapping the heat and cause global warming. CFCs are present in lesser amount and cause ozone layer depletion and global warming also but to a lesser extent.

(8) Why does the rain water normally have pH of about 5.6? When does it become acid rain?

Ans. The pH of natural water is less than 7 it is due to the absorption of carbon dioxide, sulphur dioxide and nitrogen dioxide present in the air. Carbonic acid, sulphuric acid and nitric acid are formed which lowers the pH of rain water to 5.6. if

the pH of rain water is below 5.6 then it is called acid rain, it is due to the absorption of larger amount of oxides of S, C and N.

LONG QUESTIONS

Q.3. Long Questions:

(1) 'Green Chemistry is a new route to the protection of environment'. Comment on it.

Ans. Given in the theory.

(2) What is greenhouse effect? How is it causing global warming?

Ans. Given in the theory.

(3) What is meant by atmosphere? Explain the various layers of atmosphere.

Ans. Given in the theory.

(4) Define air pollutants and discuss its effects.

Ans. Given in the theory.

(5) (a) What is role of ozone layer in upper atmosphere?
(b) What will happen if ozone is no more present in upper atmosphere?

Ans. Given in the theory.

(6) What is water pollution? What are the main sources of water pollution?

Ans. Given in the theory.

(7) Write note on the following.
(a) Acid rain **(b) Smog**
(c) Water treatment **(d) Chemistry of stratosphere**

Ans. Given in the theory.