Unit I

Environmental and Ecosystem

INTRODUCTION

Environmental chemistry is an inter-disciplinary science involving chemistry, life science, physics, agricultural science, medical science, public health, sociology, etc. It deals with the study of various chemical phenomena in the environment. It is the study of chemical species present in the environment, their sources, reactions, pathways and their fate due to human activities.

The developed countries turned their attention towards environment in the sixties. The concern for the environment reached its climax with the celebration of EARTH DAY in the year 1972 sponsored by the United Nations. Developing countries have been showing interest in the environment from 1972 onwards with the conclusion of the United Nations Conference on Human Environment at Stockholm. Hence at present it is an international concern.

The objective of environmental education is to create awareness among the public in general and students in particular about the environmental issues. At present there are many environmental issues. The man made technosphere is always in combat with the nature's different spheres. Hence an understanding of the basic concepts of environmental chemistry is imperative not only to chemists but to all.

ENVIRONMENTAL SEGMENTS

The environment consists of the following four segments:

1. Lithosphere

2. Hydrosphere

3. Atmosphere

4. Biosphere

LITHOSPHERE

LITHOSPHERE is the outer mantle of the solid earth, consisting of minerals occurring in the crust and the soil. The soil comprises of a complex mixture of minerals, organic matter, air and water. Soil is the most important part of the lithosphere.

HYDROSPHERE

The hydrosphere includes all types of water resources, viz., oceans, seas, rivers, lakes, streams, reservoirs, glaciers, polar ice caps and ground water. About three quarter of the earth's surface is covered with water.

BIOSPHERE

This denotes the realm of living organisms and their interactions with the environment. Biosphere consists of the earth's crust, the atmosphere and various species of life which exists in the zone 600 meters above and 10,000 meters below sea level. The vastness and complexity of the biosphere lead to its division into smaller units called *ecosystems*. An ecosystem consists of plants, animals, and microorganisms which live in a definite zone along with the physical factors such as soil, water and air. The word 'eco' has its origin from the Greek word 'oikos' meaning home. Biosphere is also called as ecosphere.

ATMOSPHERE

The atmosphere is the protective blanket of gases surrounding the earth. It sustains life on earth and. saves it from the dangerous environment of outer space. It transmits only friendly lights while filtering out hostile radiations. The atmosphere extends upto 500 kms above the surface of the earth. The atmosphere plays a vital role in maintaining the heat balance of the earth. The atmospheric temperature varies from -100°C to +1200°C depending upon the altitude: The major components of the atmosphere are nitrogen and oxygen and the minor components are argon, carbon dioxide and some trace gases.

Oxygen in the atmosphere supports life in the earth. Carbon dioxide is essential for photosynthesis. Nitrogen is one of the macronutrients for plants. Atmosphere is a vital carrier of water from oceans to lands as part of the hydrological cycle.

ENVIRONMENT AND ECOSYSTEM

If we study the life processes of plants and animals, including man, we would realize that living organisms are dependent on each other. For example, lion eats cows and the likes for its survival. The cow eats grass for its own survival. Grass requires nourishment from the soil and this nourishment is provided by the matters excreted by animals or by the dead bodies of other plants and animals. Thus every living organism is surrounded by materials and forces which constitute its environment and from which it must derive its needs. A plant, an animal or a microbe requires for its survival a supply of energy, a supply of materials and removal of waste products from its environment. For these basic requirements each living organism is bound to depend on and also to interact with different non-living (abiotic) and living (biotic) components of the environment. Hence, all the organisms both living and non-living are interrelated as well as interdependent.

Plants, animals and microorganisms, together with the environment in which they live, make up an independent unit called the ecosystem, which may be in an ocean, in a forest, in a mountain or even in a desert. The entire zone of land, air and water inhabited by living the organism is known as biosphere.

PRINCIPLES OF ECOLOGY

1. All organisms and the physical environment are interdependent and affect each other.
2. The environment is holococentric, in which, alteration of anyone component affects all the other components too.
3. Each organism has certain limits of tolerance towards various factors of environment and only within these limits the organisms can survive.
4. The environment is modified by the organisms according to their needs. The carrying capacity of the environment determines the size of organisms' population that can survive in that environment.
5. The existence of life depends on the flow of energy through food chains and on the cycling of nutrients. These processes ensure the stability of ecosystem.
6. The nature strives for greater diversity i.e. Greater variety of organisms in a system, which leads to its stability.

DEFINITIONS OF ECOLOGY

Ecology is the study of relation of organisms or group of organisms to their environment.

Ecology is the science of inter-relation between living organisms and their environment.

Ecology could also be defined as the science of interactions and interelations among individuals, populations, and communities with the environment. In short, ecology is environmental biology.

ENVIRONMENT

Environment is "the sum total of every thing that directly influences the organism's chances of survival or reproduction. The intimately local and immediate surrounding of the organism is known as microenvironment. The sum total of the physical and biotic conditions existing external to the organism and its microenvironment is called macro environment. Habitat means the particular place in which the organism (either plants or animals) grows and lives.

The biotic factors controlling the ecosystem could be classified into various component.

They are

1) Producers, (e.g) Plants which synthesis starch.

2) Consumers, (e.g) Man and animals which consume the starch. and

3) decomposers, (e.g) micro organisms which decompose the dead biotic.

The various ecological factors include.

1. Biotic (Living) I factors, and
2. Abiotic (Non-living) factors.

The main abiotic factors are,

a. Climatic factors
b. Medium factors
c. Physical factors
d. Chemical factors

Climatic factors include temperature, light, wind velocity, atmospheric gases, atmospheric humidity, rainfall etc.

Medium factors include soil, water, air and bodies of other organisms in the case of parasites.

Physical factors include fire, pressure, geomagnetism etc.,

Chemical factors include acidity, alkalinity and the availability of inorganic nutrients needed by plants.

Types of Ecosystem

Ecosystem can be divided into two categories.

1. Natural ecosystem
2. Man Engineered ecosystem

Natural ecosystems operate themselves under natural conditions and can further be divided as ***Terrestrial Ecosystem*** and ***Aquatic Ecosystem.***

Terrestrial Ecosystem includes grassland ecosystem, forest ecosystem, desert ecosystem, cropland ecosystem and man engineered ecosystem..

Aquatic Ecosystem includes fresh water ecosystem and marine ecosystem. Fresh water ecosystem may be sub-divided into lotic or running water ecosystem such as river, stream, spring etc and lentic or standing water ecosystem such as pond, lake etc.

Man Engineered Ecosystems are artificial ecosystems maintained artificially by man.

Examples:

a. Cropland ecosystem such as a field of maize, wheat, rice etc.

b. Micro ecosystem such as those made in laboratories for a planned study.

In addition to these ecosystems, ***space ecosystem*** has also been recently recognized.

BIOGEOCHEMICAL CYCLES IN ENVIRONMENT

Biosphere, hydrosphere, lithosphere and atmosphere have profound effect on the living organisms. The hydrosphere supplies water to the organism. Lithosphere supplies minerals and a substratum for support and atmosphere supplies gases. Biosphere as a whole supplies food. The organisms grow and finally return the materials to the biosphere through expiration, excretion and death. The materials in the form of water, carbon, nitrogen, phosphorus, sulphur etc. circulate in the biosphere in characteristic pathways. These paths are generally known as biogeochemical cycles.

Biogeochemical cycles in the environment are the cyclic pathways in which a regular and continuous exchange of elements occurs between the environment and the organisms

'Bio' represents living organisms; 'geo' represents soil environment and 'chemical' means elements such as carbon, sulphur, phosphorus, nitrogen etc. which undergo transition regularly.

Biogeochemical cycles are generally of two types.

a. Sedimentary cycles - In these cycles the main reservoir is the soil and the sedimentary and other rocks of earth's crust. Eg: Sulphur and phosphorus cycles

b. Gaseous cycles : In these cycles the main reservoir of nutrient is the atmosphere and the oceans. Eg: Oxygen, carbon, nitrogen cycles

Both types of cycles involve biotic and abiotic agents. Both are driven by the flow of energy and both are tied to the water cycle or hydrological cycle.

HYDROLOGICAL CYCLE

The hydrological cycle is a continuous natural process which helps in exchange of water between the atmosphere, the land, the water bodies (sea, oceans, lakes etc.) the living plants and animals.

The cycle consists of five parts which provides the world wide water supply. About one third of the solar flux absorbed by the earth's surface is utilized to start the hydrological cycle. This cycle is driven by the evaporative power of solar radiation which requires nearly 15% of the total radiation reaching the outer atmosphere. The hydrological cycle is shown in Fig. 1.1.

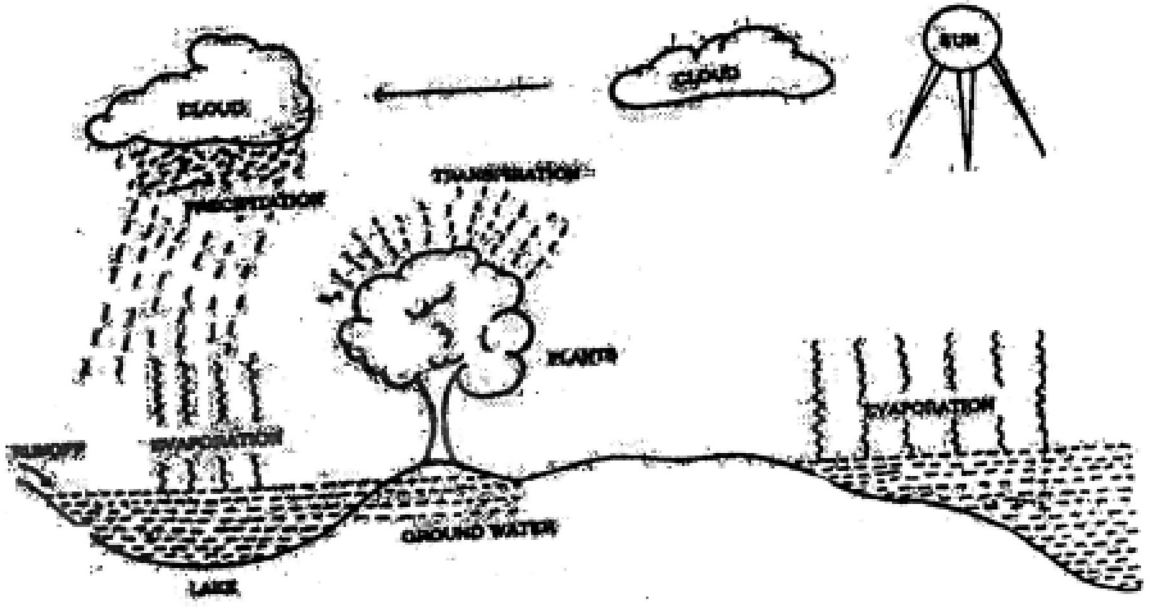


FIG 1.1. THE HYDROLOGICAL CYCLE

Water as rain, hail or snow is precipitated on all land and water surfaces. Water on land surfaces seeps into the soil as ground water. Below the ground water there is a natural water level or water table. The soil below the water table is sustained by the underlying clay and rock strata. Ground water does not remain stationary but moves in various directions. Water also moves up above the water table by capillary action and thereby maintains a continuous supply of water to the surface layer of soil, where it is absorbed by plant roots in the absence of rain. Another important underground water resource is the aquifers. Aquifers exist above the rock strata. From these aquifers water can be pumped to the surface.

All the rain water precipitated on land does not percolate into the soil. Surface water or run-off flows into streams, rivers, lakes and reservoirs. This surface water on the earth is lost by evaporation. Evaporation from the oceans exceeds precipitation by rain into the seas by 10%. This excess 10% moves as water vapour over land surface and thereby balances the hydrological cycle. Plants absorb ground water by capillary action and give off excess water through leaves by the process called transpiration.

The hydrological cycle consists of a balanced continuous process of evaporation, transpiration, precipitation, surface run-off and ground water movements .

CARBON CYCLE

Carbon is an essential constituent of carbohydrates, proteins, fats and other organic compounds. The source of all the fixed carbon in living organisms as ell as in fossil deposits, is carbon dioxide found in the atmosphere and dissolved in the waters of the earth. Green plants use C02 in the process of photosynthesis to make carbohydrates. Thus the green plants lock the radiant energy of the sun in the synthesized food. The evolved oxygen in the process of photosynthesis is used by the living things. All animals including human being depend for their food on plants directly or indirectly. Some of the carbon is returned to the atmosphere in the form of $C0_2$ by plant respiration in which oxidation of glucose take place resulting in the formation of $C0_2$, H_20 and energy. The CO_2 so formed as a by product of plant respiration is, again used by plants in the process of photosynthesis.

Decomposing microorganisms break down dead materials with the release of Carbon back into the carbon cycle. All the carbon of plants, herbivores, carnivores and decomposers is not respired, but some is fermented and some is stored. Carbon compounds such as methane are oxidized to CO_2 by a number of reactions in the atmosphere.

Carbon in sediments may be uncovered by erosion and be oxidized by weathering and combustion. The carbon cycle is shown in Fig .1.2

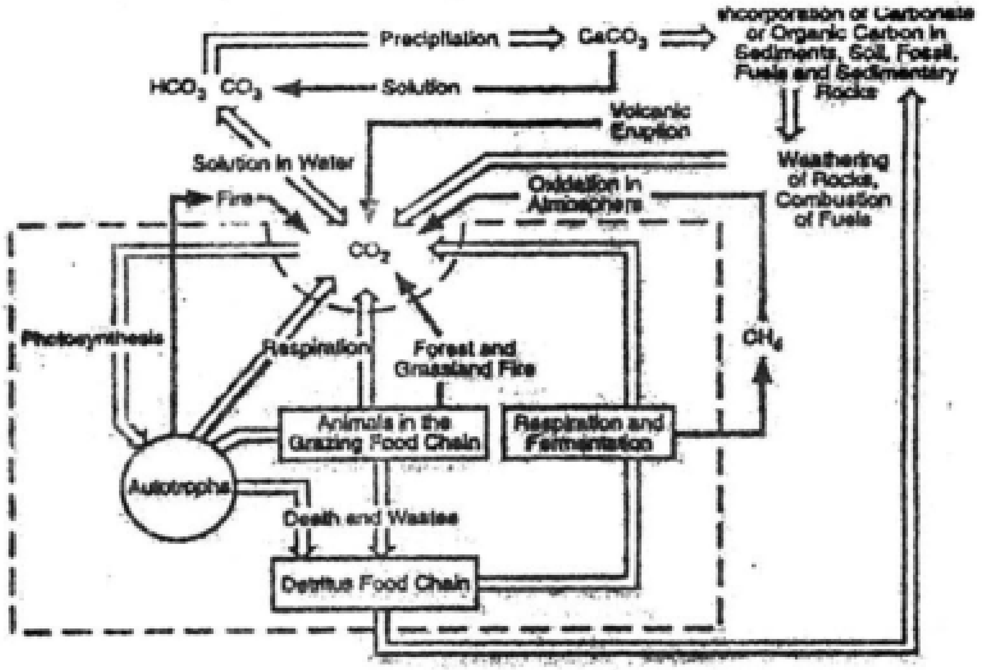


FIG 1.2 CARBON CYCLE

NITROGEN CYCLE

Nitrogen and its compounds are essential for the maintenance of life process in the biosphere., There is continuous exchange of nitrogen within ecosystems operating the nitrogen cycle. The nitrogen cycle is shown in Fig.1.3. Nitrogen cycle is a cycle in which atmospheric nitrogen is converted into its compounds such as nitrates and the combined nitrogen is again constantly passing back to the atmosphere.

Nitrogen in the soil is present in the form of organic nitrogenous substances (found in humus) and inorganic nitrogenous substances such as ammonia, nitrites and nitrates.

Plants utilize this nitrogen to synthesize proteins. These proteins are taken directly or indirectly by animals, and are hydrolysed to amino acids. These are used up to make protoplasm. Excess of amino acids are converted to ammonia, urea and .uric acids by microorganisms present in the soil through the process called ammonification. Faeces, urine, dead plants and dead animals get decomposed by bacteria and fungi. During putrefaction, the nitrogen present in them is converted into ammonia and nitrogen compound which finally reach the soil.

Ammonia and other nitrogen in the soil are oxidized to nitrites by nitrosifying bacteria present in the soil.. These nitrites are further oxidized to nitrates by nitrifying bacteria present in the soil. Nitrogen compounds present in the soil are constantly decomposed into nitrogen by denitrifying bacteria present in the soil. Thus part of nitrogen is returned to atmosphere.

Absorption of nitrogen from the atmosphere is known as nitrogen fixation, There are two types of nitrogen fixation.

1. Non-biological nitrogen fixation
2. Biological nitrogen fixation

Non Biological Nitrogen Fixation

Due to lightning, nitrogen and oxygen in the atmosphere combine to form nitric oxide, which is subsequently oxidized to the dioxide. This combines with rainy water in the presence of oxygen to form nitric acid The nitric acid thus formed reaches the earth to form nitrates which are basic food for the plants.

$$N_2 + O_2 \rightarrow 2NO$$

$$2NO + O_2 \rightarrow 2NO_2$$

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

$$HNO_3 + NH_3 \rightarrow NH_4NO_3$$

$$CaO + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O$$

Biological Nitrogen Fixation

There are some plants which have a special type of nitrogen fixing bacteria called symbiotic bacteria in the nodules of their roots. These bacteria possess the property of converting atmospheric nitrogen into its compounds which the plants can , assimilate as food.

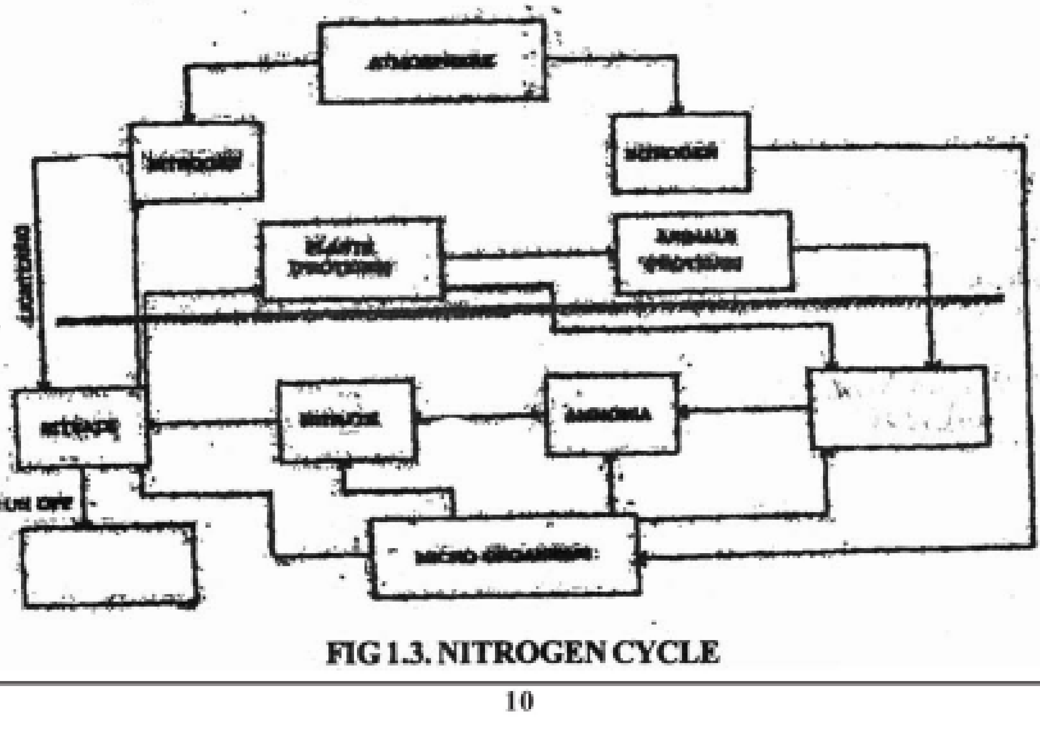


FIG 1.3. NITROGEN CYCLE

Oxygen cycle

Oxygen is a major component of all living organisms. Its adequate supply is vital for sustenance of life in the biosphere. Oxygen needed by most plants, animals and all human beings for aerobic respiration or enzymatic oxidation of organic food which sustains growth and general metabolism. It is absorbed from the environment during aerobic respiration but released by plants during photosynthesis thereby setting up the oxygen cycle. There is also continuous exchange of O_2 between the atmosphere and all water surfaces on the earth. The total amount of O_2 in the biosphere is relatively constant so that the oxygen cycle is stable.

The oxygen cycle is based on the exchange of O_2 among the environmental segments atmosphere, hydrosphere, lithosphere and biosphere. It plays a key role in atmospheric chemistry, geochemical transformation and life processes.

Oxygen contributes largely to the process on the earth's surface. It participates in combustion reactions.

$$C + O_2 \rightarrow CO_2$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Oxygen is consumed in some oxidative weathering processes of minerals.

$$4FeO + O_2 \rightarrow 2Fe_2O_3$$

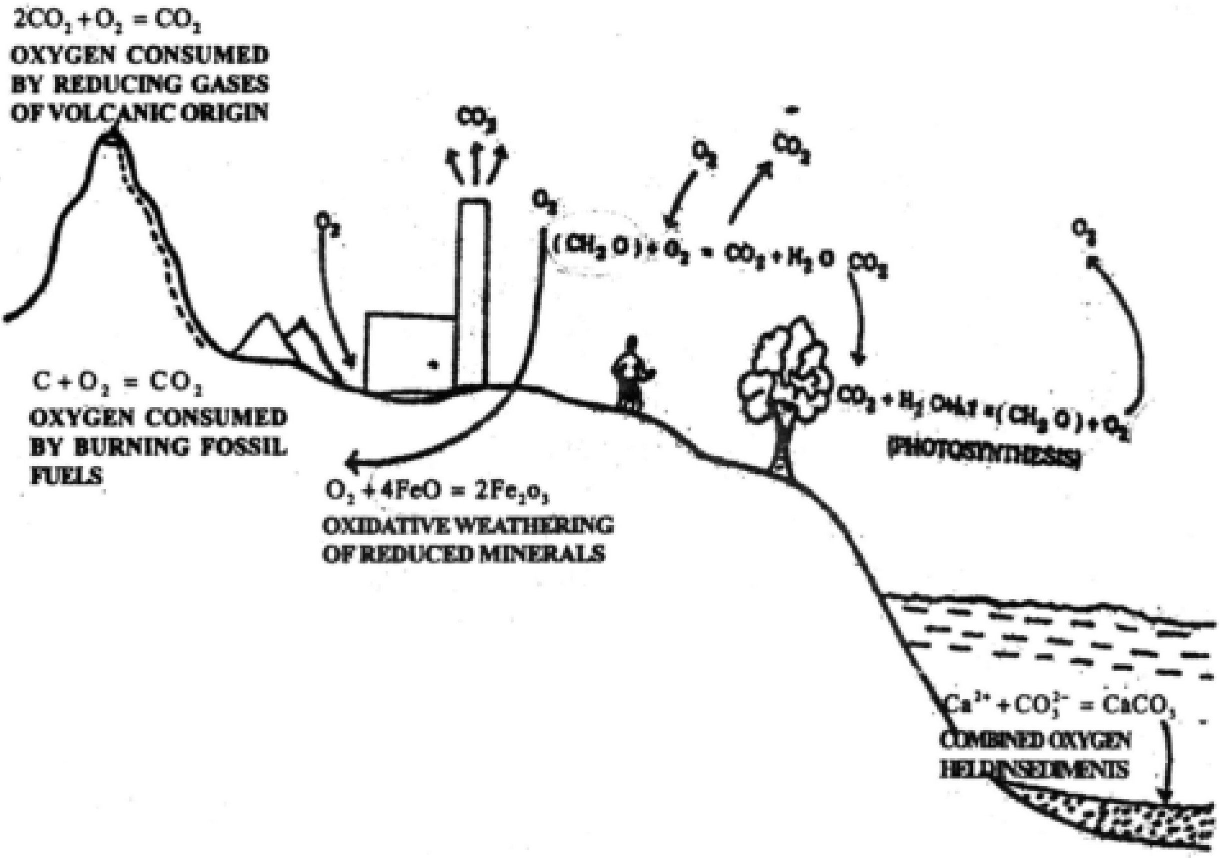
In the primitive stage of the earth, soluble iron (II) consumed bulk 0f O_2 giving large deposits of Fe_2O_3

$$4Fe^{2+} + O_2 + 4H_2O \rightarrow 2Fe_2O_3 + 8H^+$$

Green plants return O_2 to the atmosphere through the process of photosynthesis.

$$6CO_2 + 6H_2O + h\gamma \rightarrow C_6H_{12}O_6 + 6O_2$$

This process was responsible for building the original oxygen stock in the atmosphere and continues to maintain the oxygen balance in the atmosphere. Though combustion of fossil fuels and of reducing gases (CO) from the volcanoes consumes large quantities of O_2, it has little impact on the total oxygen stock in the atmosphere because of the operation of the oxygen cycle. The oxygen cycle is shown in Fig.1.4.



SULPHUR CYCLE

Sulphur cycle may be gaseous cycle and sedimentary cycle because it includes gaseous phase and sedimentary phase. The sedimentary phase of sulphur cycle is long termed. In it sulphur is tied up in organic and inorganic deposits. Sulphur is released from these deposits by weathering and decomposition. The sulphur so released is carried to terrestrial and aquatic ecosystems as a salt solution.

The combustion of fossil fuels, volcanic eruptions, the surface of the oceans and gases released by decomposition are the main sources of sulphur in the atmosphere. In the beginning, sulphur comes in the atmosphere as H_2S which gets oxidized to SO_2. This SO_2 gets dissolved in rainy water to form H_2SO_4 which reaches the earth. Plants absorb the sulphates to form proteins and amino acids. From the producers, sulphur in amino acids enters into the animals. The excess sulphur is excreted in the faeces. Excretion and death carry sulphur back to the soil and also to the bottom of the water bodies, where the organic matter interacts with the bacteria of detritus food chain. Here the protein is degraded to H_2S. In aerobic condition H_2S is oxidized to SO_4^2 certain bacteria.

In anaerobic conditions in the presence of UV light photosynthetic bacteria oxidize H_2S to sulphate.

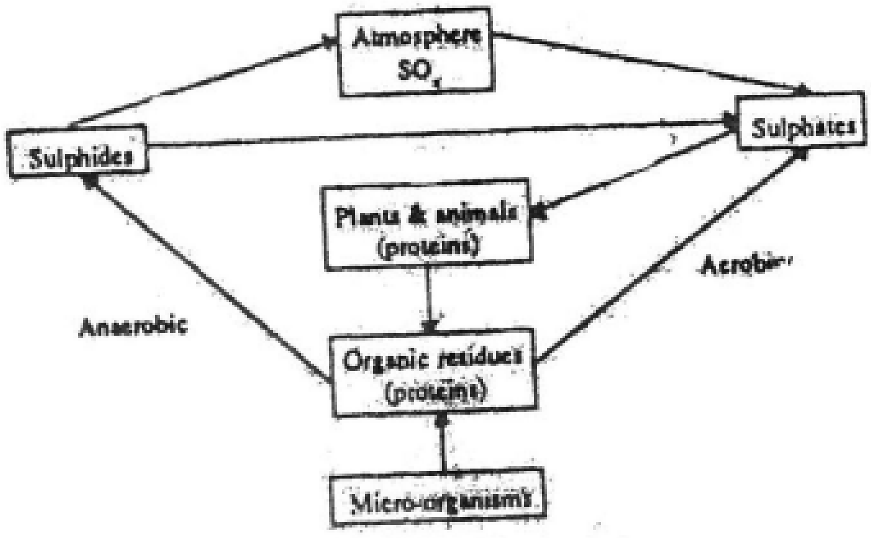


FIG 1.5 SULPHUR CYCLE

PHOSPHORUS CYCLE

Phosphorus is necessary for the growth and maintenance of animal bones and teeth while organo-phosphates are essential for cell division involving the production of DNA and RNA. Plants and animals derive their nutrition via energy metabolic pathways utilizing ATP (adenosine triphosphate).

Phosphate minerals are locked in rocks and soil. where phosphates exist in soluble and insoluble forms. Terrestrial plants absorb inorganic phosphate salts from the soil and convert these into organic phosphate. Animals obtain their phosphates by eating plants. Plants and animals after their death and decay retain phosphates in the soil. which are finally converted to humus by the action of soil microorganisms. Bulk of the phosphate in the soil is fixed to the soil. but part of it is lost by leaching out in to watercourses. (Fig. 1.6).

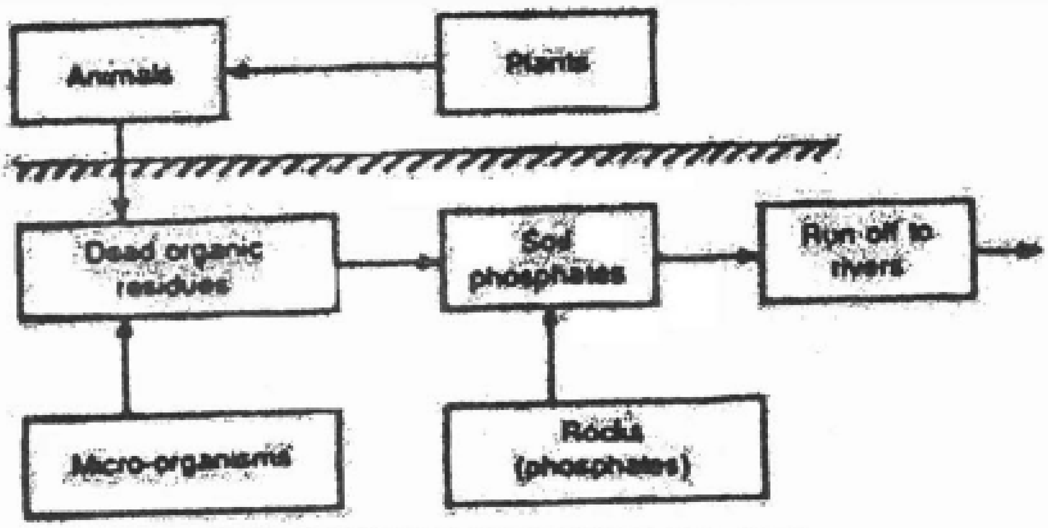


FIG 1.6. PHOSPHORUS CYCLE ON LAND

In fresh water, phytoplanktons, (floating algae) absorb soluble inorganic phosphates and convert them into organophosphates. Algae are the sources of food for zooplankton which in turn are eaten by other aquatic animals. All these forms of life after their death and decay settle to the bottom of water. In due course the organic waste gets decomposed by the action of microorganisms, releasing phosphates into the water body for recycling again.

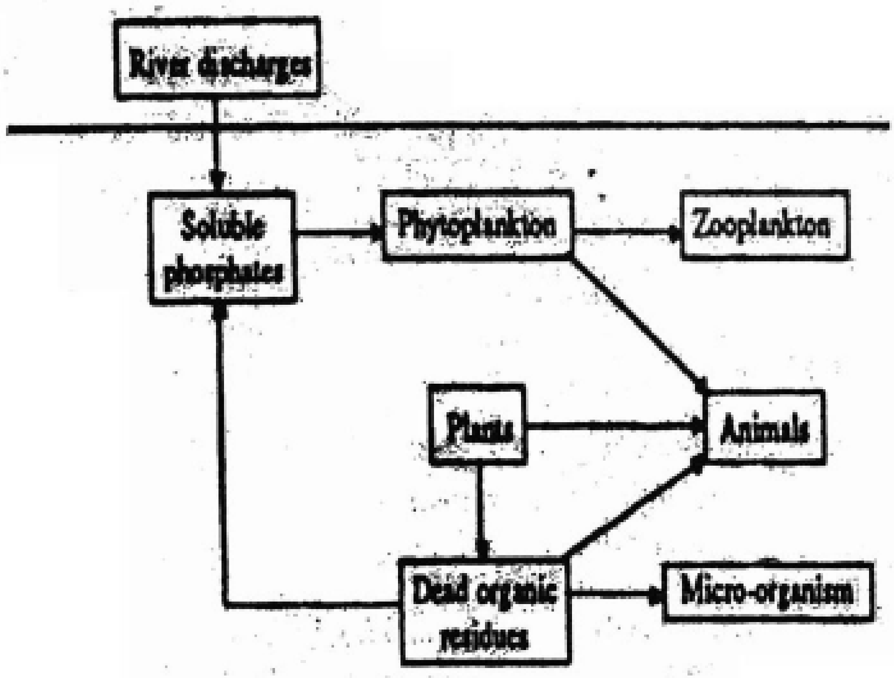


FIG 1.7 PHOSPHORUS CYCLE ON WATER

****

UNIT II

ATMOSPHERE AND AIR POLLUTION

EVOLUTION OF THE ATMOSPHERE

It is believed that evolution of earth took place approximately five billion years ago, when a cloud in the interstellar gas, known as solar nebula, collapsed forming protostars and planetary systems. Out of these clouds of cosmic dust came out earth, sphere of molten rocks. Gases bubbled out of the hot interior forming reducing atmosphere of methane, ammonia, hydrogen cyanide, water vapour, helium and hydrogen etc. that surrounded the earth. These hot gases moved upward, from high to low pressure and caused fall in temperature. Condensation of gases took place and these condensed gases fall upon the surface of the infant earth in the form of rain.

These torrents of rain continued for many million years, since the rains immediately vapourized in the beginning long before they even reached the surface. Gradually the earth got cooled, rain reached the surface and shallow oceans resulted. The rain fall continuous for centuries washed away millions of tons of minerals and some mountain. The rains finally slowed and stopped. The lowest region of the earth's surface had been filled with a chemical soup in which first form of sea and life developed.

Earth's primitive atmosphere was a reducing atmosphere. Hydrogen and helium escaped from the gravitational pull. Gases when subjected to strong ionizing radiation , ionized to positive and negative ions. Negative ions were carried down by the condensed water vapours into the lower part of the cloud, while the positive ions were left in the upper part of the cloud. This vast differences in the electrical potentials produced lightning within the clouds. These electrical discharges made the molecules to unite to form various amino acids. The amino acids produced in the atmosphere continuously precipitated down to the ground forming concentrated solution in ocean water. Even at this stage, the atmosphere was the same reducing atmosphere. These amino acids underwent polymerization. Once polymerization had occurred, he danger of dissolution diminished, since polymers organized into a stable configuration. Because of the formation of hydrophobic bonds, the polymers were surrounded by a hydration shield which protected the polymers from the solvent break. These polymers then assumed a coacervate structure. There are six stages of molecular complexity to the evolution of life. Firstly the formation of simple polypetide chain, then a-helix, next the folded coil, the linked folded coils and finally the linking of different folded coils together with a ribonucleic acid chain.

One of the nucleic acids, perhaps with the aid of a protein, which acted as an enzyme was able to reproduce itself. In a short time each became two, and two became four and then eight and the seas were filled with these "Prelife" forms.

Life did not appear suddenly. It took millions of years. These life forms drew their energy from fermentation of organic matter arising from chemical and photochemical processes. Finally they were capable of producing organic matter by photosynthesis.

$$6CO_2 + 6H_2O + h\gamma \rightarrow C_6H_{12}O_6 + 6O_2 \uparrow$$

This led to the generation of oxygen. Blue green algae may probably be the first members of the plant world (3000 million years ago). With the increase in the supply of oxygen, more complex plants evolved and oxygen-consuming animals increased to maintain the oxygen balance. Gradually oxygen accumulated in the atmosphere which helped the formation of ozone layer to protect life forms from the destructive ultraviolet radiation. Slowly earth became environmentally more hospitable for life. Consequently life forms migrated from the sea to the land.

CHEMICAL COMPOSITION OF ATMOSPHERE

The atmosphere has three main categories of constituents, namely, major, minor and trace. Pollution free dry air at the ground level has following components.

CATEGORY	COMPONENT	PERCENT BY VOLUME	In ppm
MAJOR COMPONENTS	NITROGEN	78.09	78.09×10^4
	OXYGEN	20.94	20.94×10^4
	WATER VAPOUR	0.1-5	$10 \times 10^2 - 5 \times 10^4$
MINOR COMPONENTS	ARGON	9.34×10^{-1}	9.34×10^3
	CARBON DIOXIDE	3.25×10^{-2}	325
TRACE COMPONENTS	NEON	1.82×10^{-3}	18.2
	HELIUM	5.24×10^{-4}	5.24
	METHANE	2×10^{-4}	2.0
	KRYPTON	1.14×10^{-4}	1.14
	NITROUS OXIDE	2.5×10^{-5}	$2.5 \times \ 0^{-1}$
	HYDROGEN	5×10^{-5}	5.0×10^{-1}

XENON	8.7×10^{-8}	8.7×10^{-4}
SULPHUR DIOXIDE	2×10^{-8}	2×10^{-4}
OZONE	TRACE	TRACE
AMMONIA	1×10^{-6}	1×10^{-2}
CARBON MONOXIDE	1.2×10^{-5}	1.2×10^{-1}
NITROGEN DIOXIDE	1×10^{-5}	1×10^{-1}
IODINE	TRACE	TRACE

The density of atmosphere decreases with increasing altitude. The pressure at sea level is I atm which decreases to 3×10^{-7} atm at 100 km above the sea level, while temperature varies from 92°C to 1200°C. Total mass of the atmosphere is 5×10^5 tons which Is one millionth of earth's total mass.

STRUCTURE OF ATMOSPHERE

The atmosphere is divided into four regions, as shown below.

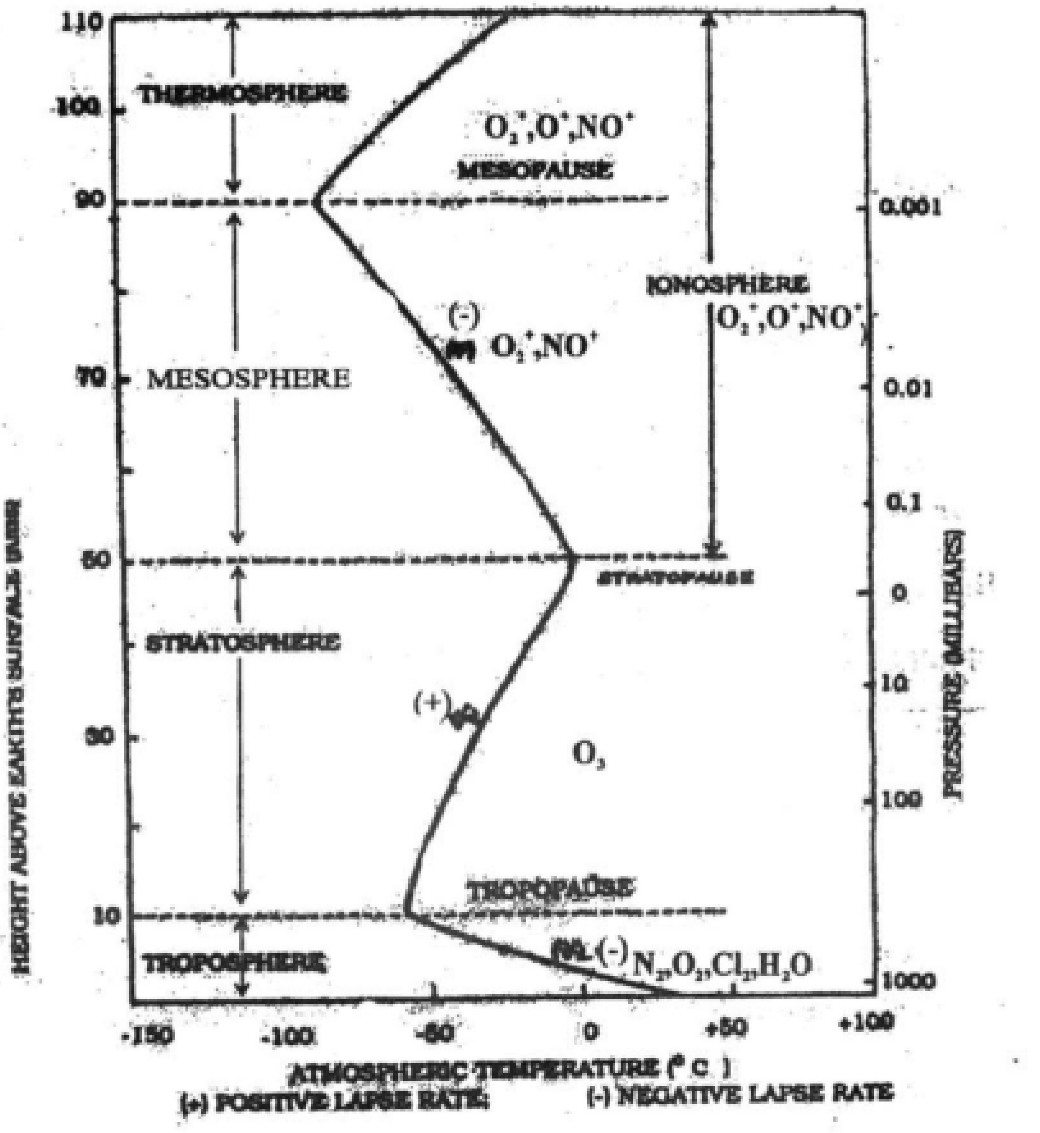
REGION	ALTITUDE RANGE in km	TEMPERATURE RANGE in °C	IMPORTANT CHEMICAL SPECIES
TROPOSPHERE	0-11	15 to - 56	N_2, O_2, CO_2, H_2) vapour
STRATOSPHERE	11- 50	-56 to -2	0_3
MESOSPHERE	50- 85	-2 to -92	O_2^+, NO+
THERMOSPHERE	85 - 500	-92 to 1200	O_2^+, O+, NO+

The troposphere contains 70% of the mass of the atmosphere. Density decreases exponentially as altitude increases. In respect of composition, the troposphere is more or less homogeneous in the absence of air pollution. This is mainly due to the constant circulation of air masses in this region. The water content varies due to the hydrological cycle. The troposphere is a turbulent region due to the global. energy flow arising from imbalances of hating and cooling rates between the equator and the poles.

Temperature in the troposphere decreases uniformly with increasing altitude. The cold layer (-5°C) at the top of the troposphere is called the tropopause, which marks temperature inversion ie transition from negative to positive lapse rate. The change of temperature with altitude is called lapse rate.

The stratosphere is the quiescent layer having a positive lapse rate. The temperature increases with increase in altitude reaching the maximum at -2°C at the upper limit of the stratosphere. The positive lapse in this region is due to presence of ozone in this region. Because of the quiescent nature of this region, molecules and particulates reside in this region for a quite long time Pollutants which reach this region remain there for a long time and pose long term hazards.

The mesosphere shows negative lapse rate i.e. temperature decreases as altitude increases. This is due to low levels of ultraviolet absorbing species like ozone.



In the thermosphere, temperature increases with increasing altitude, giving a positive lapse, maximum temperature, 1200°c. Here the atmospheric gases, say oxygen and nitric oxide, split into atoms and also undergo ionization after the absorption of far ultraviolet radiation.

Since the mesosphere and themosphere contain the ions, both spheres are collectively called as ionosphere.

CHEMICAL AND PHOTOCHEMICAL REACTIONS IN THE ATMOSPHERE

Chemicals in the atmosphere participate in photochemical reactions by absorptions of solar radiations. Such reactions occur even in the absence of chemical catalysts. Different processes are observed under varying atmospheric conditions.

It is noted that the atmosphere is tremendously dynamic system with wide fluctuations of the parameters viz composition, temperature, humidity and intensity of sunlight

O_2 Plays an important role in the troposphere, O_3 plays a key role in the stratosphere

Oxygen and Ozone chemistry

Oxygen plays an important role in the troposphere. The stable form of almost all the elements are oxides. The atmosphere contains gases such as carbon dioxide and sulphur dioxide. The oceans are full of oxides of hydrogen, while the earth's crust contains mainly oxides of silicon, calcium, magnesium, iron and aluminium.

In the upper layer the species of oxygen are O_2, $O^\bullet$, O^+, O_2^+ and O_3.

$$O_2 + h\gamma \rightarrow O^\bullet + O^\bullet$$
$$O_3 + h\gamma \rightarrow O^\bullet + O_2$$
$$O^\bullet + h\gamma \rightarrow O^+ + e$$
$$O_2 + h\gamma \rightarrow O_2^+ + e$$

Ozone is formed by a photochemical reaction

$$O_2 + h\gamma \rightarrow O^\bullet + O^\bullet$$
$$O^\bullet + O_2 + M(N_2 \text{ or } O_2) \rightarrow O_3 + M$$

The third body (m) absorbs the excess energy liberated by the above reaction.

SULPHUR DIOXIDE

Sulphur dioxide absorbs solar radiation in the region 300-400nm, particularly in the lower atmosphere, to produce electronically excited states of SO_2.

$$SO_2 + h\gamma \rightarrow SO_2^\bullet$$

In natural sunlight, at the 5-30 ppm level SO_2 reacts with oxygen and water producing sulphuric acid.

$$SO_2^\bullet + H_2O + \tfrac{1}{2}O_2 \rightarrow H_2SO_4$$

This is promoted by the presence of hydrocarbons and nitrogen oxides which are the key components of photochemical smog.

The free radical $HO^{\bullet}$ present in the photochemical smog also contributed to the oxidation of $S0_2$

$$\begin{aligned} HO^{\bullet} + SO_2 &\rightarrow HOSO_2^{\bullet} \\ HOSO_2^{\bullet} + O_2 &\rightarrow HOSO_2O_2^{\bullet} \\ HOSO_2O_2^{\bullet} + NO &\rightarrow HOSO_2O^{\bullet} + NO \end{aligned}$$

In humid atmospheres $S0_2$ is oxidized by reactions inside water aerosol droplets, in the presence of NH_3 in the presence of catalysts such as Mn(II), Iron (II), Ni(II) etc.

$$NH_3 + SO_2 + H_2O \rightarrow NH_4^{\oplus} + HSO_3^-$$
$$NH_3 + HSO_3^- \rightarrow NH_4^{\oplus} + SO_3^{2-}$$

Solid particles such as soot provide heterogeneous phases catalyzing the oxidation of SO_2. Sulphur dioxide, one of the serious air pollutants is responsible for smog and acid rains.

NITROGEN OXIDES

Oxides of nitrogen in the atmosphere are nitrous oxide, nitric oxide, nitrogen dioxide etc.

Nitrous oxide originates from microbiological processes. At higher altitudes it helps the depletion of ozone.

$$\begin{aligned} N_2O + h\gamma &\rightarrow N_2 + O \\ N_2O + O &\rightarrow NO + NO \\ NO + O_3 &\rightarrow NO_2 + O_2 \end{aligned}$$

Nitric oxide and nitrogen dioxide collectively designated as NO enter the atmosphere mainly from anthropogenic (man made) sources i.e. combustion of fossil fuels etc. The annual global input of NOx is about 86 million tonnes. The NOx originates from microbial action in the earth's surface, which fields N_2O. This N_2O is inert in the troposphere but reacts with O_2 in the stratosphere to form NO which depletes ozone layer.

$$2N_2O + O_2 \rightarrow 4NO$$
$$NO + O_3 \rightarrow NO_2 + O_2$$

NO reacts with OH to produce HNO_2 which is quickly rained out in the troposphere.

Nitrogen dioxide is an important species in the atmosphere. $N0_2$ finally ends up as $HN0_3$.

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

Nitric acid produced is removed as acid rain.

NO_2 further reacts as,

$$2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$$

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

$$2NO_2 + O_3 \rightarrow N_2O_5 + O_2$$

$$N_2O_5 + H_2O \rightarrow 2HNO_3$$

Supersonic aircrafts discharge large quantities of NOx in the stratosphere. Nuclear explosions produce large quantities of NO x in the stratosphere.

GREEN HOUSE GASES AND GLOBAL WARMING

Carbon dioxide, water vapour, methane, chlorofluorocarbons, and nitrous oxide are called green houses gases. Among these gases carbon dioxide is the main green house gas since its contribution is more than 50%.

These gases strongly absorb infrared radiation (14000-25000 nm) and effectively block a large fraction of the earth's emitted radiation. The radiation thus absorbed by these gases is partly re-emitted to the earth's surface. Consequently the surface gets heated up. This phenomenon is called Green House Effect or Global Warming.

Deforestation coupled with increased combustion of fossil fuels have cumulative effect on the net increase in carbon dioxide content. At present the atmosphere has a carbon dioxide content of 356 ppm. Forests are the areas where a great deal of photosynthesis occurs. Forests are a vast reservoir of fixed but readily oxidisable carbon in the form of wood and humus. Thus they serve to maintain a balance in the atmospheric carbon dioxide level. The major sink is the ocean which contains bulk of dissolved carbon dioxide as bicarbonate. Another important sink is the biomass, viz. green plants which consume CO_2 for photosynthesis.

The temperature effects of carbon dioxide and water combine together to have a long range impact on the global climate. When carbon dioxide level increases, surface temperature increases resulting increase in evaporation of surface water, thereby increasing the temperature further. If CO_2 level increases at this level, surface temperature may have a rise of 3°C around 2050 A.D.

Rise in temperature will affect the over all world food production, due to Climatic changes. Biological productivity of the estuaries and oceans will also decrease.

Due to the melting of icecaps, glaciers etc. sea level could rise, submerging coastal cities throught the world. Fertile belts will turn arid.

Without carbon dioxide the earth would be as cold as the moon. If its quantity increases too much, the earth may be as hot as Venus.

The relative contributions of the green house gases are given below.

Carbondioxide = 50%

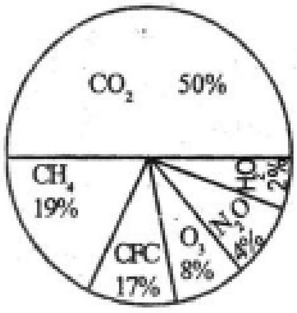
Methane = 19%

Chlorofluorocarbons = 17%

Ozone = 8%

Nitrous Oxide = 4%

Water Vapour = 2%



PHOTOCHEMICAL SMOG

When the automobile exhausts get trapped by stagnant air masses and exposed to intense sunlight, photochemical oxidants are formed in the atmosphere. This gives rise to the phenomenon called photochemical smog which often observed in Los Angels and Denver, USA. Photochemical smog is an oxidizing smog and is characterized by brown fumes which irritate the eyes and lungs and damage the plant life.

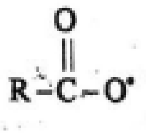
The photochemical smog is formed in the following sequences,

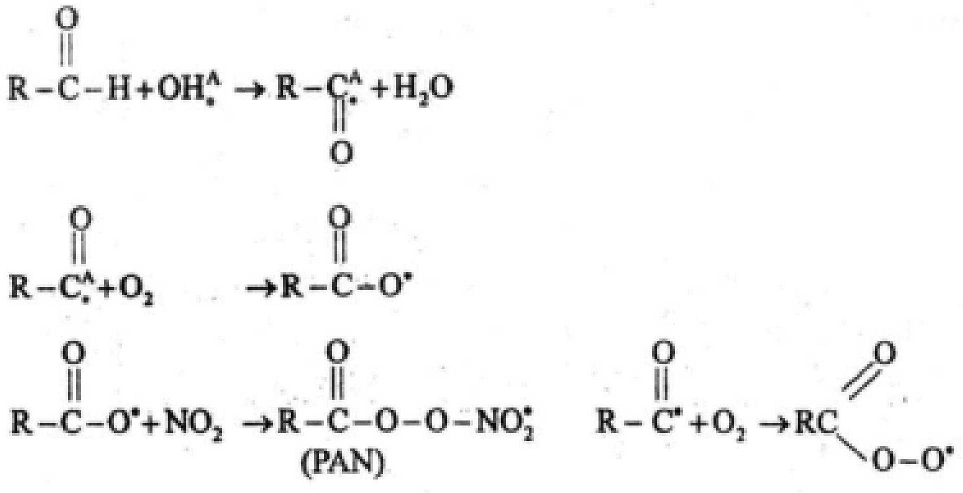
1. $\text{HYDROCARBONS FROM AUTOMOBILES EXHAUSTS} + O_2 \rightarrow RCH_2^{\bullet}$
2. $R - CH_2^{\bullet} + O_2 \rightarrow R - CH_2 - O - O^{\bullet}$
3. $R - CH_2 - O - O^{\bullet} + NO \rightarrow R - CH_2 - O^{\bullet} + NO_2$
4. $R - CH_2 - O^{\bullet} + O_2 \rightarrow R - CHO + H - O - O^{\bullet}$
5. $H - O - O^{\bullet} + NO \rightarrow NO_2 + HO^{\bullet}$
6. $HO^{\bullet} + \text{HYDROCARBON} (R - CH - R) \rightarrow RCH_2^{\bullet}$ etc

The cycle yields 2 molecules of NO_2 and one molecule of RCHO and regenerates the free-radical $RCH_2^{\bullet}$ to start the chain.

Very soon there is rapid build up of smog products.

RCHO reacts with $OH^{\bullet}$ leading to the formation of an acyl radical $R - C = O^{\bullet}$

peroxyacyl radical  $R - \overset{\overset{\displaystyle O}{\|}}{C} - O^{\bullet}$ and finally peroxyacyl nitrate (PAN) one of the eye irritants found in the smog



$$R-\overset{O}{\overset{\|}{C}}-H+OH^{\wedge}_{\bullet} \rightarrow R-\underset{O}{\underset{\|}{C}}{}^{\wedge}_{\bullet}+H_2O$$

$$R-\overset{O}{\overset{\|}{C}}{}^{\wedge}_{\bullet}+O_2 \rightarrow R-\overset{O}{\overset{\|}{C}}-O^{\bullet}$$

$$R-\overset{O}{\overset{\|}{C}}-O^{\bullet}+NO_2 \rightarrow \underset{\text{(PAN)}}{R-\overset{O}{\overset{\|}{C}}-O-O-NO_2^{\bullet}} \qquad R-\overset{O}{\overset{\|}{C}}{}^{\bullet}+O_2 \rightarrow R\overset{O}{\overset{\|}{C}}-O-O^{\bullet}$$

i) Reactive hydrocarbons from auto-exhaust interact with O_3 to form a hydrocarbon-free radica $RCH_2^{\bullet}$

ii) $RCH_2^{\bullet}$ rapidly reacts with O_2 to form another free radical ($RCH_2O_2^{\bullet}$).

iii) $RCH_2O_2^{\bullet}$ reacts with NO to produce NO_2 and the free radical $RCH_2O^{\bullet}$

iv) The new free radical inter acts with O_2 to yield a stable aldehyde, RCHO and hydroperoxyl radical $H_2O^{\bullet}$

v) $HO_2^{\bullet}$ then reacts with another molecule of NO to give NO_2 and $HO^{\bullet}$

vi) $HO^{\bullet}$ is extrememly reactive and rapidly reacts with a stabel hydrocarbon RCH_3 to yield H_2O and regenerate the hydrocarbon -free redical $RCH_2^{\bullet}$, thereby completing cycle.

vii) The aldehyde RCHO may initiate another route by interaction with $OH^{\bullet}$ radical, leading to the formation of an acyl radical RC=0, peroxyacyl radical $RCOO_2^{\bullet}$ (by reaction with O_2) and finally peroxyacyl nitrate, PAN.

ACID RAIN

Oxides of nitrogen (NOx) and sulphur (SOx) let out to the atmosphere are converted into $HN0_3$ and H_2S0_4.

$$\begin{aligned} NO+O_3 &\rightarrow NO_2+O_2 \\ NO_2+O_3 &\rightarrow NO_3+O_2 \\ NO_2+NO_3 &\rightarrow N_2O_5 \\ N_2O_5+H_2O &\rightarrow 2HNO_3 \end{aligned}$$

HNO_3 is removed as a precipitate after reaction with bases (NH_3 , particular time)

$$SO_2 + \frac{1}{2}O_2 + H_2O \xrightarrow[\text{soot particles}]{(HC,NOX)} H_2SO_4$$

The presence of hydrocarbons and NOx step up the rate of formation of sulphuric acid. In water droplets, ions such as Mn (II), Fe (II), Ni (II) and Cu (II) and soot particles catalyse the oxidation of $S0_2$.

$HN0_3$ and H_2S0_4 combine with HCl emitted by natural and anthropogenic sources to generate acidic precipitation which is widely known as acid rain.

Acid rain causes severe damages to buildings and sculptural monuments of marble, limestone, slate, mortar etc.

$$\underset{\text{Limestone}}{CaCO_3} + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$$

In Greece and Italy, statues have been damaged by acid rain. The Taj Mahal is one of victims of acid rain.

In 1958 rain in Europe showed a pH of 5.0. By 1962 it was 4.5 in Netherlands. Sweden experienced rainfall with a pH 4.5 in 1966. It damaged the Swedish forests. The pollution sources were emission from U.K and Germany. In Europe the emission rate of sulphur was 70 Metric tons per year.

While 33 - Nation UN conference on acid rain was in session at Stockholm (July 1982) the venue received heavy downpour of acid rain for the entire week. The conference was designed to focus world attention on acid rain, the most potent ecological threat to Scandinavia and Canada, for which U.K and U.S.A are responsible.

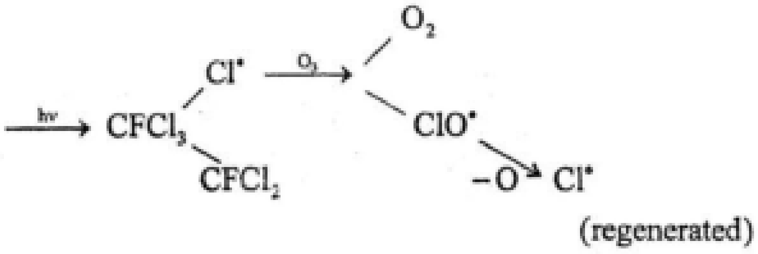
During the conference, sulphur was depositing at the rate of 3.5 g m^{-2}-1 year. 25 per cent of this rain came from U.K depositing 40000 tonnes of sulphur on Sweden. Sweden's 85000 lakes were slowly damaged and 4000 lakes were completely dead. In Canada, trees and lakes are being destroyed by acid rain, 60% of which originates from U.S.A.

H_2S0_4 is the major contributor to acid rain, $HN0_3$ ranked second and HCl third. Acid precipitation shows a correlation with the prior movement of the air mass over major sources of anthropogenic sulphur and nitrogen oxide emissions.

OZONE HOLE

The main cause of ozone depletion is the widespread use of chlorofluorocarbons (CFC). CFCs are used in fridges, freezers, air-conditioners, spray-cans, foams etc. Halons which are used as fire extinguishers do ten times greater damage to the ozone.

Burning of coal and oil and the increasing use of nitrogenous fertilizers are also contributing to the destruction of ozone layer. Ozone is destroyed by NO and N02. Supersonic flights and space shuttles release nitrogen -oxides and chlorides respectively. CFCs under the influence of ultraviolet radiation release chlorine atoms each of which reacts with more than 10^5 molecules of ozone.



CFC - 11 lasts for 74 years and its concentration is doubling every 17 years.

CFC - 12 lasts for about 111 years and its concentration is doubling every 17 years.

CFC - 13 lasts for 90 years

Halon - 1301 lasts for 110 years

The damage by CFCs involves the following steps

1. Release of reactive halogen free radicals from CFCs
2. Free radicals, say $F^\bullet$ and / or $Cl^\bullet$ reacts with ozone molecule

$$O_3 + Cl^\bullet \rightarrow O_2 + Cl-O$$

3. The tiny ice particles catalyse the formation of $Cl-O$
4. The concentration of $Cl-O$ goes on increasing
5. $Cl-O$ reacts with ozone to form oxygen molecule

$$Cl-O+O_3 \rightarrow Cl^\bullet + 2O_2$$

In the early eighties, a large hole in the ozone layer appeared over Antarctica, where ozone level dropped by 30 per cent. Then a similar hole was discovered over the northern hemisphere. Here ozone level decreased by 3 per cent. Each 1 per cent reduction in ozone may cause as much as 6 per cent increase in skin cancer from exposure to UV radiation. The overall reduction in the ozone layer is now estimated to be about 8 per cent.

Montreal Protocol, (1987), signed by 34 countries called for a freeze on the use of CFCs. Since the Montreal Protocol, the ozone layer has been found to disappear at a still faster rate.

EL NINO PHENOMENON

Normally the waters of the Eastern Pacific off Ecuador, Peru and Northern Chile are cold, as much as 10°C cooler than the waters of the Western Pacific. This part of the Eastern Pacific is teeming with fish, since here cold waters, rich in nutrients, well up from the deep ocean. But once in every five to ten years from December to March, the waters of the Eastern Pacific warm up a little (4°C higher than normal) which disrupts the upwelling of the rich cold water. This in turn disrupts the anchovy fishery, key to Peruvian economy. This phenomenon is called El Nino (Spanish term for 'the Christ Child') since it starts in December.

When El Nino occurs, the anchovy fish die for shortage of food, followed by birds that normally feed on the anchovy. Since the Peruvians sell the birds deposit guano (dung) found around its nesting sites as very rich fertilizer, the death of the birds has disastrous effect on Peruvian economy. Peruvian fishery is one of the world's largest by weight. The anchovies are also dried and ground up into fishmeal for animal feed and poultry.

Normally trade winds blow along the equator from the South-East Pacific towards west, pushing warm water out to the sea. When El Nino comes, these trade winds become weak and change direction from west to east. Warm Pacific current starts to blow east. When it reaches the South American coast, it kills coldwater fish. The warm water warms the air, which lowers the atmospheric pressure and torrential storms occurs along Chile's coast reaching as far as California.

This changes the climatic pattern in many parts of the world.

El Nino struck Chile and Peru in 1970s and 1982. In Iquique the port city of Chile, in 1982, heaps of anchovies and sardines lay lifeless on the beaches. More than 100,000 fishermen become jobless.

El Nino caused sand storms in Australia, cyclones in Tahiti, droughts in Africa and floods in California.

El Nino coincides with Southern Oscillation. It is an irregular but recurrent relationship between atmospheric pressures and sea-surface temperature over the South-Eastern Pacific and the Indian Oceans. These two events El Nino and Southern Oscillation are combinely called as ENSO. This lasts for December to December. The most notorious ENSO occurred in 1982. Then, 14 million people were affected due to droughts in Brazil, food production dropped by 4% in India, grain yield reduced by 10 per cent in China, 350 died of starvation in Indonesia and there were floods in Australia, Ecuador, Bolivia and Peru.

PARTICULATES IN ATMOSPHERE

Small solid particles and tiny liquid droplets are termed as particulates. Particulates range in size from a diameter of 0.0002 μ m to a diameter of 500 μ m, with life times varying for a few seconds to several months. The number of particles in the atmosphere ranges from $10^2\ cm^{-3}$ in clean air to more than $10^5\ cm^{-3}$ in polluted air.

Sources of Particulates

Every year 800-2000 million tones of particulate matter are let into the atmosphere. Natural sources are volcanic eruptions, blowing of dust and soil by the wind, spraying of salt and other particles by seas and oceans. Contributions from man-made activities are fly ash from power plants, melters and mining operations, and smoke from incomplete combustion, which is responsible for the emission of 200-450 million tones of particulates every year.

Inorganic particulate matter

Metal oxides are important particles in atmosphere.

They are produced whenever fuels containing metals are burnt. E.g.

$$3FeS_2 + 8O_2 \rightarrow Fe_3O_4 + 6SO_2$$

$$V + 5O_2 \rightarrow 2V_2O_5$$

$CaC0_3$ in the ash is converted to CaO

$$CaCO_3 \rightarrow CaO + CO_2$$

Leadtetraethyl in leaded gasoline reacts with O_2 and . halogenated scavengers dichloroethane and dibromoethane to yield lead halides which are volatile and emerge through the exhaust system, but which condense to form particles.

$$Pb(C_2H_5)_4 + O_2 + C_2H_4Br_2 + C_2H_4Cl_2 \rightarrow CO_2 + H_2O + PbBrCl + PbBr_2 + PbCl_2$$

Till 1975 USA alone dumped 200,000 tonnes of Pb into the atmosphere. As unleaded gasoline are becoming common, these emissions are getting reduced.

S02 in the atmosphere is oxidized to H_2S0_4. This H_2S0_4 droplets react with NH_3, CaO etc. to form salt particles.

$$H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$$
$$H_2SO_4 + CaO \rightarrow CaSO_4 + H_2O$$

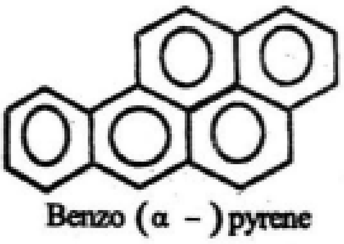
FLY ASH

Bulk of the particulates exists as oxides. These oxides are generated by the combustion of high ash fossil fuels. E.g.

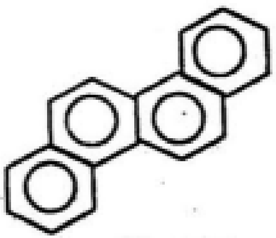
SiO_2, Al_2O_3,K_2O,Fe_2O_3 etc.

Organic Particulate Matter

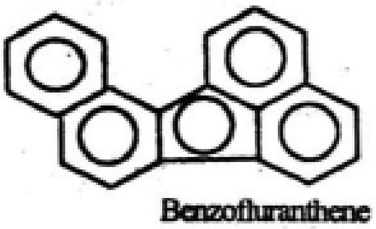
Polycyclic aromatic hydrocarbons (P AH) from an important particulate matter. They are carcinogenic in nature. Some PAH are,



Benzo (α –) pyrene



Chrysene



Benzofluranthene

Most of the PAH compounds are absorbed onto the soot particles.

Effects on Human

Many particulates are carcinogenic. Fine particles(3J.l) penetrate into the deep air passages and stay intact for years. This can cause severe breathing trouble and irritation of the lung capillaries. Coal miners are affected with black-lung disease and asbestos workers are suffering from pulmonary fibrosis

Effects on Materials

Particulates carry toxic substances along with them. Some particulates are corrosive and they damage materials. Around the cement factories leaves are coated with thick dust and the soil is also coated with thick dust which lead to ineffective photosynthesis and soil infertility respectively.

Climate

Particulates influence the climate through the formation of clouds and rain.

Control of Particulate Emission

1. Particulates with a diameter greater than 50 μ can be removed by gravity settling chamber.
2. By the use of spray chambers particulates can be removed.
3. Cyclone collectors are also employed to remove particulates.

RADIOACTIVITY IN ATMOSPHERE

Radioactive pollutants include particulate and electromagnetic radiations which cause chronic cellular damage in man and animals. Cosmic and terrestrial radiation enter into the biosphere and affect the whole biota. The extent of radioactive pollution is expressed in term of various international units.

UNITS OF RADIATION

Curie represents 3.7×10^{10} disintegrations per second.

One Becquerel = One disintegration per second

1 curie = 3.7×10^{10} Becquerel

Rad is the quantity of radiation which results in the absorption of 100 ergs of energy per gram of the absorbing material.

Gray is the SI unit which is equivalent to 100 Rads.

Rem (Roentgen Equivalent Man) is that quantity of ionizing radiation which produces the biological effect equivalent to unit of X-rays or gamma rays.

Exa becquerel	1Ebq = 10^{18} disintegrations per second
Peta becquerel	1PBq = 10^{15} disintegrations per second
Tera becquerel	1TBq = 10^{12} disintegrations per second
Giga becquerel	1GBq = 10^{9} disintegrations per second
Mega becquerel	1MBq = 10^{6} disintegrations per second
Kilo becquerel	1KBq = 10^{3} disintegrations per second

NATURAL SOURCES

1. Cosmic rays enter the atmosphere from outer space. Their quantum depends upon altitude and latitude of a location. People living in high altitudes in the higher latitudes receive more radiation than people living at the sea level do.
2. The earth's crust also contains some radioactive nuclides which continuously emit radiations. For example U-238, Th-234, Ca-226 are present in soil, rocks and natural building materials.
3. Food crops grown in the earth crust and drinking water percolating through soil, also contain some radioactive nuclides such as K-40, C-14 and Rn-222. These nuclides enter the body through food chain.

The annual average background radiation is 105 m rem.

Man made sources

1. X-rays used in medicine penetrate the human body. It has cumulative effect on the body. The average dosage per person is estimated at about 50 m rem per year. According to the finding of a UN committee (1992) there are about 120 cases of disease due to genetic damage from medicinal sources alone.
2. Radioactive fall out resulting from nuclear weapon testing, explosions of nuclear weapons in the air, on the ground, under the ground and under the sea, all contribute to man-made radiation. Considerable amounts of C-14, 8r-19, 1-131, Cs-137 etc. are dispersed in the' atmosphere. These nuclides may undergo further disintegration in the atmosphere and may spread all over the globe. They settle down on the earth's surface as radioactive fall out and contaminate the food chain.
3. The increasing use of radioisotopes in research, industry, medicine and in nuclear reactors are also major sources. The operation of nuclear reactors and nuclear fuel processing units make the largest contribution. The gaseous wastes containing Ar-41, Xe-133, 1-131, Kr-85, H-3 and C-14 are discharged during the operation of the reactors. The liquid wastes consist of H-3, Fe-59 and Co-60 etc. The spent fuel has the gaseous wastes such as H-3, 1-131, Kr-85 etc.

Naturally occurring or man made radiation consists of a, ~, y and X-rays which cause both genetic and rheumatic effects. They cause damage in the germ cells, lethal mutations and genetic deaths etc. These radiations create chronic anemia, bone necrosis, bone sarcoma, skin cancers, erythema, atrophy, pigment changes, fibrosis and cancer.

ANALYSIS OF AIR POLLUTANTS

Analysis of Carbon monoxide

1. Infrared Spectrometry

   It is based on the principle that Co. strongly absorbs infrared radiation at certain wavelengths.. When IR radiation is passed through a long cell (100 cm) containing a trace of CO, part of the energy is absorbed.

2. Gas chromatography

   10 ppm and lower levels of CO can be conveniently measured by gas chromatography with a flame ionization detector. For estimation of lower levels of CO (10 ppm), the sample is subjected to catalytic reduction by H_2 over a Ni catalyst at 360°C and measured with a flame ionization detector.

Analysis of Nitrogen Oxides, NOx

1. Chemiluminescence:

   It is the standard method for NOx analysis based on interaction wiun 0_3 to yield the electronically excited NO_2 molecule which emits radiation in the 600-3000 nm range.

2. Spectrometry:

   NOx-is collected over NaOH solution. The $N0_2$ produced is allowed to react with H3P04, sulpahnilamide and N-(1-napthyl) ethylene diaminedihydrochloride. The resulting reddish purple azo dye is measured at 543 nm.

Analysis of Sulphur dioxide

West - Gaeke spectrophotometric method

SO_2 is collected in a scrubbing solution containing $HgCl_2$ and KCl. The solution is allowed to react with HCHO and then with para-rosanieine hydrochloride. The absorbence of the product red-violet dye is measured at 548 nm.

Analysis of Hydrocarbons

Hydrocarbons can be conveniently collected in an absorption column packed with a very porous styrene – divinyl benzene polymer. Air is sampled and then the sample collector is subsequently heated to desorb the sample for gas chromatographic analysis.

The gas chromatograph, in conjunction with a mass spectrometer (GC / MS) is best suited for identification of low levels of hydrocarbons.

Analysis of particulate matter

Particulate matter can be determined using high volume method, using a high volume sampler. Air is drawn through the filter at a specific rate for a certain time. After the operation is over, the filter is weighed and the difference gives the amount of particulate matter per unit volume of air. Particulate matter from the filter may be extracted with suitable solvent or incinerated or digested before elemental analysis.

CONTROL OF AIR POLLUTION

1. **Zoning**

   Zoning of industries is done based on the type of industries, their functions etc.

2. Air pollution control at source

   Polluting raw materials can be replaced by less polluting materials. Non-essential ingredients can be removed before processing.

Pollution can be reduced by modified procedure. Exhaust hoods and ducts can be used. Pollution can be controlled by modifying the equipments.

3. Installation of controlling devices and equipments
   Dust collectors are used to remove dusts. The commonly used internal separators are gravity settling chambers, cyclones and fabric fitters.
4. By constructing high stacks or chimneys pollutants at higher altitudes can be discharged
5. By planting trees and growing vegetation
6. Odours of gases can be absorbed by passing through beds of activated charcoal or sand or soil.

TCDD ACCIDENT AT SEVESO, ITALY

In the year 1976, an explosion took place in a chemical plant at Seveso, Italy. That plant was manufacturing the herbicide, 2,4,5 - trichloro phenoxy acetate. A white cloud of poisonous gas consisting of 2, 3, 7, 8 - tetrachloro benzodioxin leaked out and engulfed the environment. Everything in and around the plant was contaminated. Nearly 1800 people were evacuated from the affected area. About 200 people including children suffered from skin diseases and related problems. About 1 % of the babies born after the accident were deformed and premature.

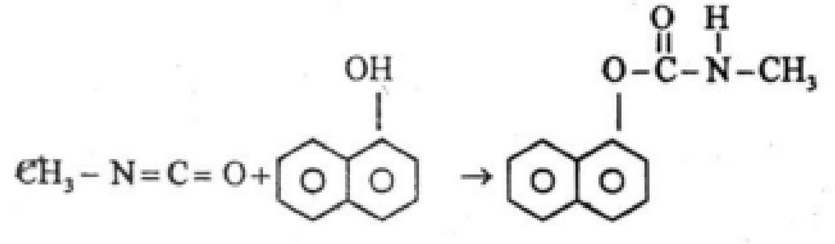
BHOPAL DISASTER

Union Carbide factory, at Bhopal, Madhya Pradesh was manufacturing Carboxyl (Carbamate pesticide) from methyl isocyanate (MIC – CH_3NCO)

Methylamine pumped into a reactor along with phosgene, forms Methyl isocyanate \ which reacts with a. - Naphthol to form 1-Naphthyl- N - methyl carbamate (Carbaryl).

MIC is highly reactive and toxic to the human body.

$$\underset{\text{methylamine}}{CH_3NH_2} + \underset{\text{Phosgene}}{COCl_2} \rightarrow \underset{\text{Methylisocyomate}}{CH_3 - N = C = O} + 2HCl$$



α – Naphthol 1 – Naphthyl – N – methylcarbamate (Carbaryl)

A fateful incident took place on December 3, 1984, at about 11.30 pm, when the workers realized there was MIC leak. As the temperature of the storage tank increased, the pressure went up resulting the opening of the safety valve releasing MIC from the storage tank.

It was a massive MIC leak. The workers tried to turn on the vent gas scrubber to neutralize the gas. The scrubber was out of order. The factory turned on the public siren at 1 a.m. By the time over 50,000 lbs of MIC has been released. People woke up coughing violently and with burning eyes. They fled from their houses. Children unable to walk suffocated and died. Within a week about 10000 people died, 1000 became blind while more than 1 lakh people suffered due to various disorders. Union Carbide was facing over 60 law suits in USA totaling $100 billion on behalf of 150,000 victims. The company settled the matter out of the court by paying $5 million. Even now the legal wrangling rolls on. The people are waiting with infantile faiths,

CHERNOBYL DISASTER

The worst nuclear accident occurred at Chernobyl, Ukraine, USSR (now CIS) on April 28th 1986 at 9 a.m. Explosion occurred through a 4000 - ton steel concrete cover. The reactor core temperature went up to 2000°C. Radioactive fuel and debris hit the surrounding areas. In less than a week radioactive debris and gases drifted over most of Europe.

More than two thousand people died bar. USSR government claimed only two deaths.

Soil, water and vegetation over 60 sq. km area around Chernobyl were severely damaged. The agricultural land in this area will remain radioactive for several decades. Neighbouring countries such as Poland had banned sale of cow milk as there were chances of contamination of grass with Cs-137. Millions of surviving population in the region has high risks of cancer attack.

****

UNIT – III

HYDROSPHERE AND WATER POLLUTION

Water is one of the abundantly available substances in nature. It is an essential constituent of all animal and vegetable matter and forms 75% of the matter of earth's crust. Water accounts for about 70% of the mass of human body. The total amount of water above, below and on the surface of the earth has been estimated to be 1.33x 10^{24} kg which is about 5% of the total mass of the earth.

Sources of Water

The chief sources of water are ground water, surface water, seawater and rainwater. The sources of water which supply water from below the earth's surface are known as sub surface sources or ground water sources or underground sources. The entrance of rainwater into the ground is known as infiltration and the movement of water after entrance is known as percolation.

Earth's surface consists of alternate courses or layers of pervious and impervious soils. The pervious layers are those 'through which water can easily pass, while impervious layers are those through which water cannot pass easily. The pervious layer is called aquifer or water bearing strata. The surface of water in the aquifer is known as water table. Water table level is low in summer and rises in monsoon season.

Under ground water sources are generally found in the form of springs, wells, infiltration wells and infiltration galleries.

Ground water appears at the surface in the form of springs and some springs are hot as they discharge hot water because of the presence of sulphur and other minerals. This spring water is used to cure skin diseases. There are artesian springs in which groundwater comes to the surface under pressure. There are gravity springs which develop because pf the overflowing of the water table. Surface springs are formed when sub-soil water is exposed to the ground surface by the obstruction of an impervious layer. Wells are also classified as shallow wells, tube wells and artesian wells.

The quantity of water remaining on the surface after losses due to evaporation, percolation and transpiration etc is known as surface water. The most important sources of surface water are lakes, ponds, rivers and storage reservoirs. Running water bodies, such as, brooks, streams, rivers etc. are called lotic and stagnant water bodies like ponds, lakes, swamps etc. are called lentic.

A lake is formed due to the collection of water in a natural basin or depression in a mountainous area or in plains. A pond is a man made of standing water but smaller than that of lake.

Large rivers are the principal sources of water supply. Rivers may be perennial as well as non-perennial. In perennial rivers water flows for all the seasons because such rivers are snow fed. The non-perennial rivers are flooded in monsoon and get dried in summer. .

An artificial lake formed by the construction of dam across a valley is known as storage reservoir.

CHARACTERISTICS OF WATER

Water obtained from different sources is associated with a large number of impurities.

The substances contained in natural water can be divided into the following three groups,

1. Suspended materials
2. Colloidal particles
3. Dispersed ions

Suspended materials are particles of sand and clay of different size, remnants of plants and other substances entrained from the surface by rain water or thawed snow and carried into open basins, say, rivers, lakes and ponds. Such substances are present in large excess during floods. Substances of both organic and inorganic origin are present in water in colloidal state. The humic substances present in swamp water impart a yellow or brown tinge. All the organic substances present in water are not in colloidal state. Some of them may be present in the form of true solution.

Of the inorganic substances present in water, iron, silicon, aluminium compounds are in colloidal forms.

Natural water usually contain dispersed ions derived from compounds such as Calcium bicarbonate, Magnesium bicarbonate, Calcium chloride, Magnesium chloride, Calcium sulphate, Magnesium sulphate, Sodium sulphate and Sodium chloride. Nitrite, nitrate and ammonium ions are also present in small quantity. Underground waters contain ferrous compounds also.

All natural water contain gases, of which carbon dioxide and oxygen cause corrosion of metals. Underground waters generally contain more mineral salts, free Carbon dioxide, Calcium and Magnesium salts, iron and manganese salts etc. The temperature of the underground water is always lower than that of the surface water.

WATER POLLUTION - SOURCES AND CLASSIFICATION

Water resources have been the most exploited natural system. Pollution of water bodies is increasing steadily due to rapid population growth, industrial proliferation, urbanizations, increasing living standards and wide spheres of human activities.

Pollution can be defined as 'the alteration in physical, chemical and biological characteristics of water which may cause harmful effects on human and aquatic biota'.

It can also be defined as 'the addition of excess of undesirable substances to water that makes it harmful to man, animal and aquatic life, or otherwise causes significant departures from the normal activities of various living communities in and around water'.

Water pollution disturbs the normal uses of water for irrigation, agriculture, industries, public water supply and aquatic life. Now it is considered in terms of conservations, aesthetics and preservation of natural beauty and resources also.

Water pollution is caused by natural and anthropogenic processes.

In the natural process, the decomposed vegetable, animal and weathered products are brought into main water resources. All these processes are interdependent.

Anthropogenic processes include effiluents from industrial, agricultural, urban, domestic, radioactive, and mining sources.

Water Pollution can be classified mainly into four categories. They are

1. **Physical** pollution of water
2. **Chemical** pollution of water .
3. **Biological** pollution of water
4. **Physiological** pollution of water

1. Physical pollution of water brings about changes in water with regard to its colour, Odour, density, taste, turbidity and thermal properties etc. Colour change is not harmful unless it is associated with a toxic chemical. Turbidity mainly arises from colloidal matter, fine suspended particles and soil erosion. Turbidity due to bacterial contamination of sewage is most serious. Odour is caused by both chemical agents and biological agents. Fishy odour is due to organic amines, wormy smell due to phosphorus compounds, rotten egg smell due to H_2S and earthy odour is due to humus.
2. The chemical pollution is due to the presence of inorganic and organic chemicals. E.g. Acids, alkalies, fertilizers, pesticides etc.
3. Biological pollution is due to the presence of pathogenic bacteria, certain fungi, pathogenic protozoa, viruses, parasitic worms etc.
4. Physiological pollution is caused by several chemical agents such as chlorine, SulPhur dioxide, hydrogen sulphide, ketones, phenols, amines, mercaptans and hydroxy benzenes. USPHS (United States Public Health Drinking Water Standard) has laid down the limits only 0.002 ppm of these substances.

1. Chlorinated hydrocarbons
2. Organophosphates
3. Carbamates
4. Chlorophenoxy acids

Chlorinated hydro carbons :

Aldrin, Dieldrin, Chlordane, Lindane, DDT, Toxaphene, Hepachlor, Endrin, Methoxychlor etc.

Organo phosphates:

Malathion, Parathion, Methyl parathion, Diazinon.

Carbamates :

Carbaryl (Sevin), Baygon, Dimetilan

Chlorophenoxy acids:

2,4 - D - (2,4 - dichloro phenoxy acetic acid)

2,4,5 - T - (2, 4, 5 - trichloro phenoxy acetic acid)

In soil a pesticide may be (i) absorbed by the soil (ii) leached by rainwater (iii) picked up plants and animals (iv) evaporated either directly or with water vapour or (v) carried away by wind. Anyhow the sum total of the pesticide in the environment as a whole remains the same. The biodegradation of pesticides in aquatic and terrestrial environments is important for environmental quality. Majority of the pesticides are biodegradable. Some of them are degradable, but unfortunately the degraded products are more toxic than the parent compounds.

Eg. DDE (Dichloro diphenyl dichloro ethylene),the degraded product from DDT is more toxic than DDT.

Detergents also cause water pollution. Detergents are Cleaning-agents which contain surfactants (which lower the surface tension of the liquid in which it is dissolved and it give a stable emulsion or suspension with the soil particles which need removal), builders (added to detergents to form alkaline solution which provides optimum medium for the function of surfactant) and other ingredients. Both the surfactants and builders of the detergents cause water pollution. The most popular builder sodium tri-poly phosphate $Na_5P_3O_{16}$ causes eutrophication also.

Oil pollution is also a matter of concern. The. total annual influx of petroleum hydrocarbons into the oceans is about 10 million metric tons. Oil tanker accidents cause massive oil pollution in the seas. In 1967 about 100,000 tones of oil was poured into the sea after the oil tanker, Torry Canyon got wrecked on the Ollard Rock near Land End, England. In 1977 the Amco Cadiz oil lost its entire range of 223,000 tons of oil on the Brittany Coast. The 1991 Gulf war unleashed about 200 million gallons of oil in the Persian Gulf and 700 oil wells burning in Kuwait over 10 months had disastrous effect on the environment.

1. Chlorinated hydrocarbons
2. Organophosphates
3. Carbamates
4. Chlorophenoxy acids

Chlorinated hydro carbons :

Aldrin, Dieldrin, Chlordane, Lindane, DDT, Toxaphene, Hepachlor, Endrin, Methoxychlor etc.

Organo phosphates:

Malathion, Parathion, Methyl parathion, Diazinon.

Carbamates :

Carbaryl (Sevin), Baygon, Dimetilan

Chlorophenoxy acids:

2,4 - D	-	(2,4 - dichloro phenoxy acetic acid)
2,4,5 - T	-	(2, 4, 5 - trichloro phenoxy acetic acid)

In soil a pesticide may be (i) absorbed by the soil (ii) leached by rainwater (iii) picked up plants and animals (iv) evaporated either directly or with water vapour or (v) carried away by wind. Anyhow the sum total of the pesticide in the environment as a whole remains the same. The biodegradation of pesticides in aquatic and terrestrial environments is important for environmental quality. Majority of the pesticides are biodegradable. Some of them are degradable, but unfortunately the degraded products are more toxic than the parent compounds.

Eg. DDE (Dichloro diphenyl dichloro ethylene),the degraded product from DDT is more toxic than DDT.

Detergents also cause water pollution. Detergents are Cleaning-agents which contain surfactants (which lower the surface tension of the liquid in which it is dissolved and it give a stable emulsion or suspension with the soil particles which need removal), builders (added to detergents to form alkaline solution which provides optimum medium for the function of surfactant) and other ingredients. Both the surfactants and builders of the detergents cause water pollution. The most popular builder sodium tri-poly phosphate $Na_5P_3O_{16}$ causes eutrophication also.

Oil pollution is also a matter of concern. The. total annual influx of petroleum hydrocarbons into the oceans is about 10 million metric tons. Oil tanker accidents cause massive oil pollution in the seas. In 1967 about 100,000 tones of oil was poured into the sea after the oil tanker, Torry Canyon got wrecked on the Ollard Rock near Land End, England. In 1977 the Amco Cadiz oil lost its entire range of 223,000 tons of oil on the Brittany Coast. The 1991 Gulf war unleashed about 200 million gallons of oil in the Persian Gulf and 700 oil wells burning in Kuwait over 10 months had disastrous effect on the environment.

The overall effects of oil on marine organisms are (i) direct lethal toxicity (ii) disruption of physiological or behavioural activities and (iii) changes in biological habitats.

Inorganic Pollutants

Inorganic pollutants include inorganic salts, mineral acids, finely divided metals or metal compounds, trace elements, organometallic compounds etc. These pollutants enter water bodies from municipal and industrial wastes and urban run off. These chemicals are able to kill or injure fish and other aquatic life and can interfere with the suitability of water for drinking or industrial use.

The most toxic among the trace elements are the heavy metals such as Hg, Cd, Pb and metalloids as As, Sb and Se. The heavy metals have great affinity for sulphur and they attack the sulphur hydrogen bonds in enzymes. Carboxyl group and amino groups in amino acids are also affected by the heavy metal ions. The transport phenomenon across the cell wall is also affected by these heavy metal ions. They also precipitate phosphate bio-compounds or catalyse their decomposition. This heavy metal pollution is due to street dust, domestic sewage and industrial effluents.

Another problem is acid mine drainage. Coal mines discharge substantial quantities of H_2S0_4 and Fe(OH)3 into local streams through seepage. The steam beds, contaminated with acid mine water, are often coated with odd yellow deposit of amorphous semi gelatinous $Fe(OH)_3$ H_2S0_4 of acid mine destroys aquatic life in water bodies.

Sediments and suspended particles are also important repositories for trace metals such as Cr, Cu, Mo, Ni, Co and Mn.

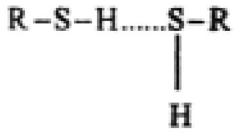
Radioactive pollutants

Radioactive pollutants enter into the aquatic environment through a variety of sources given below.

(i) Use of radioactive materials in nuclear weapons.
(ii) From nuclear power plants and nuclear reactors.
(iii) Mining and processing of ores to produce radioisotopes.
(iv) Radioactive fall out from nuclear bombs.
(v) Emission from the industrial use of nuclear energy.
(vi) Leakage from underground nuclear detonations.
(vii) Use of radioisotopes in medicine, industry, agriculture and research operations.

Uranium ore contains 2 to 5 pounds of U_30_8 per ton. Large amount of ore are processed for extraction of uranium. Only a few grams are useful for Uranium extraction while large quantities of 'uranium tailings' are produced which enter into water bodies.

Radioactive contaminants deposit on surface water and ground water. This water consumed by plants acts as medium for radioactivity. The radio contaminants from vegetation are passed on to animals and finally to man. The radioactive materials react with proteins by breaking the hydrogen bonds in



$$\begin{array}{l} R-S-H......\underset{\displaystyle H}{\underset{|}{S}}-R \end{array}$$

Ionizing radiations in water result in cellular damage. The water molecule in the cell gives $H^{\bullet}$ and OH . These free radicals react with various molecules.

Radionuclides occurring in water bodies from leaching of minerals or reactors include Ra-226, Sr-90, K-40, Ba-140, Kr-85, Co-60, Mn-54, Pu-239, 1-131, Cs-137, U-236, Zr-95, Y-91, Nb-95 and Ru-103. Among these some are soluble in water, and they enter into biological cycle causing health hazards. Zr-65 accumulates in oysters, Fe-55 in fishes while Sr-90 which is chemically similar to Ca, enters into man in bones and teeth. Rn-222, Ra-226 and Th-232 accumulate dangerously in man causing several physiological, somatic and genetic disorders. It can cause birth abnormalities, blood changes and mutation defects.

SAMPLING

The relevance of a chemical analysis depends on the sampling programme. An ideal sample should be valid and representative. Collection of samples through random selection ensures them to be representative.

The important factors for any sampling programme are (a) frequency of sample collection, (b) total number of samples (c) size of each sample, (d) sites of sample collection (e) method of sample collection (f) data to be collected with each sample and (g) transportation and care of samples.

There are two types of sampling. They are spot sampling and composite sampling. Spot samples or grab samples are discrete portions of water samples taken at a given time. Composite samples are essentially weighted series of grab samples, the volume of each being proportional to the rate of flow of the water stream at the time and site of sample collection. For accurate analysis, it is desirable to allow a short time interval between sampling and analysis. Temperature, pH and dissolved gases must be determined in the field and as quickly as possible after sampling.

Redox reactions are likely to cause large errors in analysis. Soluble iron (II) and manganese (II) are oxidized to insoluble iron (III) and manganese (III) compounds as anaerobic water sample absorbs oxygen from the atmosphere. Microbial activity reduces phenol, increases BOD and COD values and reduces Cr (IV) to Cr (III). These problems can be solved through preservation techniques. Prior to preservation it is equally important to preconcentrate the samples because many of the pollutants are present in very small quantities.

Carbon adsorption method

This is a common technique. A large volume of water, say, 1000 gallons, is passed over activated carbon. The adsorbed organic matter is extracted from the dried carbon with $CHCl_3$ followed by alcohol.

The solvents are evaporated and the weights of the extracts are expressed as μ g/1 of carbon-chloroform extract (CCE) and carbon-alcohol extract (CAE). The chloroform extract contains organic pollutants such as phenols and oils. By using other separation techniques, carboxylic acids, phenols, sulphuric acids, pesticides, etc. can be identified.

This technique has some drawbacks. Some reactions may occur on the carbon surface, some compounds get evaporated during drying and some compounds are not completely extracted.

Freeze Concentration Method

The water sample on freezing produces very pure crystals of ice leaving water -soluble impurities in a liquid phase of much reduced volume. This process minimizes the loss of volatile compounds.

Solvent extraction

This technique is useful in the separation of material which are soluble in organic solvents; which are immiscible in water. When an organic material is more soluble in organic solvent than in water, it may be concentrated into a small amount of volume of organic solvent by the process of solvent extraction. By this method chlorinated pesticides can be isolated. Parts per billion $(\mu g/l)$ quantities of Co (II), Fe (III), Pb(II), Ni(II) and Zn(II) in saline water can be determined by this method.

Ion exchange

Ion exchange chromatography has extensively been used for the concentration and the separation of metal ions from natural and wastewaters. The ions are first concentrated on a suitable ion exchange column and then selectively eluted to be measured polarographically, spectrophotometrically, radiometrically etc.

For analysis of suspended solid for metals, the solid is collected from 100 ml of well mixed sample on a 0.45) μ m membrane filter. After filtration, the membrane filter is transferred to a beaker and digested in hot con. HNO_3. The sample is diluted to a fixed volume and then subsequently analysed by AAS.

PRESERVATION

It is essential to protect samples from changes in composition and deterioration. Preservation is essential to retard biological action, hydrolysis of chemical compounds etc. There are various preservation technique for different parameters.

WATER QUALITY PARAMETERS AND STANDARDS

Parameters	US PH Standard	ISI Standard (IS: 2296- 963)
Colour, odour, taste	Colourless	-
	Odourless	-
	Tasteless	
Inorganic Chemicals		
pH	6.0-8.5	6.0-9.0
Specific conductance	300 mmho cm^{-1}	-
Dissolved oxygen (D.O)	4.0-6.0 (ppm)	3.0
Total dissolved solids	500	-
Suspended solid	5.0	-
Chloride	250	600
Sulphate	250	1000
Cyanide	0.05	0.01
Nitrate + nitrite	<10	-
Fluoride	1.5	3.0
Phosphate	0.1	-
Sulphide	0.1 mg L^{-1} (Ppb)	-
Ammonia	0.5	-
Boron	1.0	-
Calcium	100	-
Magnesium	30	-
Arsenic	0.05	0.2

Barium	1.0	-
Cadmium	0.01	-
Chromium (VI)	0.05	0.05
Copper	1.0	-
Iron (filterable)	<0.3	
Lead	<0.05	0.01
Manganese	<0.05	-
Mercury	0.001	-
Selenium	0.01	0.05
Silver	0.05	-
Uranium	5.0	-
Zinc	5.5	-
Organics		
COD	4.0	
Carbon $CHCl_3$ extract (CCE)	0.15	
Methylene blue active substances	0.5	
Phenols	0.001	0.005
Pesticides (total)	0.005	
Polycyclic aromatic hydrocarbons (P AH)	0.2 ppb (0.002ppm)	
Surfactants	200	
Radioactivity[3]		
Gross beta	1000pc/L	

Radium - 226	3 pc/L	
Strontium - 90	10 pc/L	
Bacteriological parameters		
Coliform cells/1000 ml	100	< 5000
Total bacteria count / 100 ml.	1 x 10^6	

USPH = UNITED STATES PUBLIC HEALTH DRINKING WATER STANDARD.

ISI - INDIAN STANDARD INSTITUTION

DETERMINATION OF WATER QUALITY PARAMETERS

HYDROGEN ION CONCENTRATION (pH)

It is used to express the intensity of acidic or alkaline condition of the water sample. pH can be measured using a pH meter. Before use it can be standardized with a pH 4.0 solution prepared by dissolving 1.012g anhydrous potassium hydrogen phthalate in 100 ml distilled water.

ELECTRIAL CONDUCTIVITY

Electrical conductivity can be measured using conductivity bridge. . Its unit is micro mhos/cm or micro Siemens / cm^3.

SUSPENDED SOLIDS

500 ml of the sample is filtered through a dried preweighed Gooch crucible. It is washed with distilled water. The crucible is dried and then cooled in a decicator. The increase in weight gives the weight of the suspended solids.

DISSOLVED SOLIDS

Filter the sample in a Gooch crucible. 500 ml of the filtered water is dried to 50ml in a beaker. This is transferred to a weighed platinum dish and evaporated to dryness. The increase in weight gives the weight of dissolved solids.

$$\text{Weight of solids(in gm)} \times \frac{10^6}{500} = \text{ppm dissolved solids}$$

ALKALINITY

Alkalinity of water is due to the presence of bicarbonates, carbonates and hydroxide ions. These can be estimated separately by titration against standard acid using phenolphthalein and methyl orange indicators. The estimation is based on the following reactions.

$$\left.\begin{array}{l}\left.\begin{array}{l}\text{(i)}\ {}^{-}OH+H^{+} \rightarrow H_2O \\ \text{(ii)}\ CO_3^{2-}+H^{+} \rightarrow HCO_3^{-}\end{array}\right]P \\ \text{(iii)}\ HCO_3^{-}+H^{+} \rightarrow H_2O+CO_2\end{array}\right]M$$

The titration upto phenolphthalein end point marks the completion of reaotions (i) and (ii) only. This volume of acid corresponds to ^{-}OH ions plus one - half of CO_3^{2-} ions. Titration of water against acid using methyl orange end point marks the completion of reactions (i), (ii) and (iii). The amount of acid used after phenolphthalein end point corresponds to one half of carbonates plus the whole of bicarbonates. The total volume of acid used corresponds to ^{-}OH ions, CO_3^{2-} ions and HCO_3^{-} ions.

The possible combinations of ions causing alkalinity in water are :

(i) ^{-}OH alone

(ii) CO_3^{2-} alone

(iii) HCO_3^{-} alone

(iv) ^{-}OH + CO_3^{2-}

(v) HCO_3^{-} + CO_3^{2-}

The possibility of ^{-}OH + CO_3^{2-} is ruled out, since they combine to form CO_3^{2-} instantaneously.

$$^{-}OH + HCO_3^{-} \rightarrow H_2O + CO_3^{2-}$$

Pipette out X ml of the water sample into a clean conical flask. Add one or two drops of phenolphthalein. Titrate this against a standard acid taken in the burette. The just disappearance of the pink colour is the end point. To the same solution add one or two drops of methylorange. Continue the titration, till the colour changes from yellow to pink.

Let the volume of acid used for phenolphthalein end point $= V_1$ ml

and the volume of acid used for methylorange end point $= V_2$ml

Phenolphthalein alkalinity (in terms of $CaCO_3$ equivalent) =

$$P = \frac{V_1 \times N \times 50 \times 1000}{X} = 50000 \times \frac{V_1 \times N}{X} \text{ppm}$$

Where V_1 = Volume of acid

N = Normality of acid

X = Volume of the water sample

Methyl orange alkalinity (in terms of $CaCO_3$ equivalent) =

$$M = \frac{(V_1 + V_2) \times N \times 50 \times 1000}{X}$$

$$= 50000 \times \frac{(V_1 + V_2) \times N}{X} \text{ppm}$$

When P = 0, both ^-OH and CO_3^{2-} are absent. The alkalinity is only due to HCO_3^-

i.e. when P = O, $HCO_3^- = M$

When p = ½ M, only CO_3^{2-} is present. Half of CO_3^{2-} is neutralized with phenolphthalein and complete neutralization takes place with methylorange indicator.

At phenolphthalein level the reaction is

$$CO_3^{2-} + H^+ \rightarrow HCO_3^-$$

At methyl orange level,

$$HCO_3^- + H^+ \rightarrow H_2O + CO_2$$

Thus alkalinity due to CO_3^{2-} = 2P.

When P = M, only ^-OH is present.

Thus alkalinity due to $^-OH = P = M$.

When P > ½ M. In this case CO_3^{2-} and ^-OH are present.

Half of $CO_3^{2-} = M - P$

Alkalinity due complete CO_3^{2-} = 2 (M - P)

Alkalinity due to ^-OH = M -2 (M - P)

= M - 2M + 2P = 2P - M

When P > ½ M In this case CO_3^{2-} and HCO_3^- are present

Here alkalinity due to CO_3^{2-} = 2P

Alkalinity due to HCO_3^- = M - 2P

ALKALINITY	^-OH(ppm)	HCO_3^{2-} (ppm)	HC03 (ppm)
P = 0	0	0	M
P > ½ M	0	2P	0
P=M	P=M	0	0
P > ½ M	2 P-M	2 (M -P)	0
P > ½ M	0	2P	M - 2P

Free Carbon dioxide

The amount of free carbon dioxide is determined by titrating 100 ml of the sample with 0.025N, NaOH solution using phenolphthalein as indicator. The end point is the appearance of permanent pink colour.

Free carbon dioxide (mg/1) = Volume of 0.025 N NaOH x 10

Dissolved Oxygen

The measurement of dissolved oxygen (D.O) is very much important, since D.O is a measure of the ability of the water body to support aquatic life.

The amount of Oxygen dissolved in unit volume of a sample of water is known as Dissolved oxygen (D.O). It is expressed in mg/l or ppm.

It may also be defined as the number of parts by weight of oxygen present in million (10^6) parts by weight of water.

1ppm = 1mg/1

The water sample is taken in a 150 ml container. To this add 2 ml of manganous sulphate and 2 ml of alkaline potassium iodide solutions. The precipitate formed is allowed to settle down. Then 2 ml of conc. H_2SO_4 is added to dissolve the precipitate completely. 100 ml of this solution is taken in a conical flask and titrated against 0.025 N sodium thiosulphate solution using starch as indicator. The end point is the disappearance of the blue colour. From the volume of this consumed, D.O can be calculated.

1 ml of 1N thio = 0.008 gm of oxygen [thio = sodium thiosulphate]

$$\text{D.O in ppm} = \frac{V \times N \times 0.008 \times 10^6}{X}$$

V = Volume of the consumed

N = Normality of thio'

X = volume of the water sample

If volume of water sample, X = 100ml, and normality of thio 0.025, then,

$$D.O = \frac{V \times 0.025 \times 0.008 \times 10^6}{100}$$

$$= V \times 2$$

$$\text{D.O in ppm} = \text{Volume of } 0.025N \text{ Thio} \times 2$$

Biochemical oxygen demand

The quantity of oxygen consumed by the microorganism to break down the organic matter in a water sample over a period of five days at 20°C is referred to as the Biochemical Oxygen Demand.

It is defined as the number of parts by weight of oxygen required by the micro organisms to break down the organic matter present in million parts by weight of the water sample over a period of 5 days at 20°C.

The D.O content of the water is determined as usual. Another sample of water is incubated for five days at 20°C. After five days the D.O. content is measured. Then B.O.D (mg/1) = D.O before incubation - D.O after incubation.

Chemical Oxygen demand

The organic matter present in a sample of water is measured in terms of Chemical Oxygen Demand. It is defined as the amount of oxygen (in mg) required by the organic matter present in a known volume (in litres) of water for its oxidation by a strong oxidizing agent such as acidified $K_2Cr_20_7$.

A known volume of water sample is taken in a round-bottomed flask. To this add a known excess volume of standard $K_2Cr_2O_7$ and dil H_2S0_4 and a little amount of Ag_2So_4 and $HgS0_4$ and reflux for 2 hrs. The unreacted $K_2Cr_2O_7$ is then titrated against standard ferrous ammonium sulphate using Ferroin as indicator.

The difference between the dichromate added and the dichromate remaining unreacted gives the amount of dichromate consumed for the oxidation of the organic matters. From this COD can be calculated.

$$\text{1ml of 1N } K_2Cr_2O_7 = 0.008 \text{ gm of oxygen}$$

$$\text{COD in ppm} = \frac{V \times N \times 0.008 \times 106}{X}$$

$$V = \text{Volume of } K_2Cr_2O_7 \text{ consumed}$$

N = Normality of $K_2Cr_2O_7$

X = Volume of water sample taken

$$COD = \frac{(V_1 - V_2) \times N \times 0.008 \times 106}{X}$$

V_1 = Volume of ferrous ammonium sulphate in the blank environment

V_2 = Volume of ferrous ammonium sulphate in the test environment

N = Normality of ferrous ammonium sulphate

X = Volume of the water sample

Ammonia

To a 100 ml sample add a little NaOH to neutralize the acid and then add 1ml 10% $ZnSO_4 . 7H_2O$ followed by 1ml of 10% NaOH. Stir and filter. Collect the middle fraction, add 1 drop of 50% EDTA, mix well and add 2ml of Nessler's reagent. Shake well. Measure the resulting yellow colour at 420 nm.

NITRATE AND NITRITE

Take 500ml sample, add 50 ml of 10% NaOH and evaporate to about 200 ml. Cool and add 3g Devarda's alloy and then 30 ml of 10% NaOH and distil. Collect the distillate in a receiver containing 200ml of 0.2 NH_2SO_4 for one hour. Make up the volume to 250 ml. Take 5 - 10ml in a 50 ml volumetric flask and reduce the pH to 4.5. Add 2ml of Nessler's reagent and, measure the optical density at 424 nm, using a spectrophotometer.

CHLORIDE

To a 100 ml sample water add 1ml of 5% K_2CrO_4 solution. Titrate against 0.0282 N $AgNO_3$ to a permanent reddish tinge.

1 ml of 0.025 N $AgNO_3$ = 1 mg Cl

Free Chlorine

Take 500 ml of the sample. Add 5ml of acetic acid to obtain pH 3.0 - 4.0 and 1g KI. Mix thoroughly. Titrate against 0.025N $Na_2S_2O_3$ using starch as indicator.

1 ml of 0.025 N $Na_2S_2O_3$ = 0.4 mg Cl_2

FLUORIDE

To a 100 ml sample add 1 drop of $NaAs0_2$ (5g/l) to remove residual chloride. Add 5ml acid Zirconyl. - Alizarin reagent. Mix thoroughly and compare the samples and standards after 1 hr using spectrophotometer .

CYANIDE

Take 250-500 ml sample in a distillation flask. Add 500 ml18 N H_2S0_4 and 20m151% $MgCl_2$. $6H_20$. Reflux for 1 hr. Collect the HCN gas in 500 ml of 1 N NaOH in gas washer. Measure the cyanide content by spectrophotometric method. The distillate is treated with Chloromine-T at pH<8 then mixed with pyridine-narbutric acid and then measured at 578 nm.

SULPHIDE

Take 500ml sample. Add 1 ml of 2N Zinc acetate and 2 ml of 1 N NaOH. Add 20 ml of 18 N $H_2SO_4$and distil the solution into 200 ml of2.2% zinc acetate. Add excess of 0.05 NI_2 and acidify with H_3PO_4. After 10 mts, titrate against 0.05 N $Na_2S_2O_3$ using starch as indicator.

$$1\text{ml of } 0{,}05 \text{ N } I_2 \equiv 0{,}85 \text{ mg } H_2S$$

SULPHATE

Sulphate is precipitated in HCl medium as $BaS0_4$ by adding $BaCl_2$. The ppt is washed, dried and ignited and weighed as $BaS0_4$.

PHOSPHATE

Take.100 ml sample in a beaker. Digest with 1 ml con. H_2S0_4 and 5 ml con. HNO_3 and evaporate to dryness. Repeat digestion and evaporation. Leach the residue with 5ml of 5N HNO_3 and transfer to a 50ml volumetric flask. Add 5ml of 10% ammonium molybdate, and then 5ml of 0.25% ammonium vanadate. Make up to known volume. Measure the absorbance at 460 nm. It can be compared with a standard solution.

TOTAL HARDNESS

Take 20-50 ml of the sample in a conical flask. Add 5ml pH 10 buffer. Add two drops of 1.4% Erichrome Black T and titrate with 0.01 M EDTA solution till the solution changes its colour from reddish tinge to blue.

$$1\text{ml } 0.01 \text{ MEDTA} \equiv 1.0 \text{ mg } CaC0_3$$

This gives total hardness

CALCIUM HARDNESS

To a 100ml sample add sufficient KOH" to bring the pH to 12 and precipitate Mg^2+ as Mg(OH)2 Add 5 drops of muroxide indicator and titrate with 0.05 M EDT A solution till the colour changes from orange to violet.

1ml 0.01 MEDTA = 0.4008 mg Ca.

Magnesium hardness = Total hardness - Calcium hardness

ARSENIC (AAS method)

To a 50 ml sample add 10 ml of con. $HN0_3$ and 12 ml 18N H_2S0_4. Evaporate. Add small amounts of conc. $HN0_3$ time to time. Cool. Add 25 ml water, 1 ml $HCl0_4$ and again evaporate. Cool add 40 ml con. HCl and make up to 100 ml. Take 25 ml aliquot, add 1ml of 20% KI and 0.5 ml $SnCl_2$ To this add 1.5 ml Zn slurry. Measure the AsH3 peak at 193.7 nm.

CADMIUM

Directly aspirate into an air-acetylene flame of an AAS and measure at 229 nm. For low levels of Cd, extract the chelate with ammonium pyroline dithiocarbamate into methyl isobutyl ketone. Aspirate the organic extract into air - acetylene flame and record the absorbance.

Chromium

Follow the same procedure as under Cd and measure absorbance at 358 nm.

Copper

Copper solution can be directly aspirated into air-acetylene of an atomic absorption spectrophotometer and measured at 325 nm.

Iron

Use the same procedure as described under Cd. Measure the absorbance at 248.3 nm.

Lead

Use the same method as that of Cadmium and measure at 283.3 nm after direct aspiration into an air-acetylene flame. For lower concentration of lead, follow the same method as that for Cd, viz. chelation with ammonium pyrrolidine dithiocarbamate, extraction into methyl isobutyl ketone (MIBK) and aspiration of the MIBK extract into AAS with air - C_2H_2 flame.

Manganese

Manganese solution can be directly aspirated into air-acetylene of an atomic absorption spectra photometer and measured at 525 nm.

Zinc

Follow the same procedure as described for Cadmium. The absorbance is measured at 213.9nm.

Escherichia Coliform (E.Coli)

Take 0.1 ml of diluted (10^2 - 10^4 times) sample and incubate in eosine - methylene blue-agar medium at 37°± 1°C for 48 hrs. A pink to red colour with metallic surface sheet develops. Count the number of coliform colonies and express as colony counts / 100 ml sample.

Total Bacteria

Incubate 0.1 ml of diluted sample (10^2 - 10^4 times) in tryptone glucose - agar medium at 35°±0.5°C for 48 hrs. Count the number of colonies and express as number of counts / 100 ml sample.

FLUOROSIS

The presence of fluoride in water and food is almost universal and therefore its intake in the diet virtually becomes inevitable. It is well known that fluoride provides important public health benefits by effectively preventing dental cavities. Drinking water with a concentration of 0.7 to 1.2 ppm is the optimally beneficial level for preventing dental caries. The permissible level prescribed for fluoride content in drinking water by WHO is 1.0 ppm. The excess of fluoride ion intake beyond the prescribed limit leads to dental and skeletal fluorosis, which is a serious, public health problem in many areas of the world. Caused by ingesting excessive amounts of fluoride, fluorosis a well-defined clinical entity is characterized by dental mottling, skeletal and other non-skeletal manifestation.

Dental fluorosis was first reported by Eager in 1901 and skeletal involvement owing to fluoride 'was reported by Moller and Gudjonsson in the year 1932. Roholm described industrial fluorosis in 1937. In the same time in India an attempt was made first by Short et al. to describe skeletal fluorosis because of excessive intake of fluoride containing water.

The principal sources of fluoride intake in man are water, edible vegetables, tea, coffee, marine animals and industrial dusts. The most common fluorine bearing minerals which constitute the natural source for fluoride in drinking water are fluorite, apatite, rock phosphate and topaz. Addition of such "high fluoride" foods like polished peas, rice, tea and fish may raise the daily average intake of 2 mg and above. Food originating in contaminated area contains much higher fluoride levels than food grown in non-polluted areas. Dental fluorosis is also caused by polluted air when coal is burnt in the houses and industries. The native people of South Atlantic Island are having fluorosis. They consume water with 0.2 ppm fluoride only but fish with 7 ppm of fluoride. Tea and spinach contain the highest amounts of fluoride in plant origin while in animal origin marine fish ranks the highest. Teflon coated cooking vessels may raise the. fluoride content of food. Cereals from plants which intake fluoridated water, contain approximately 4-6 ppm of fluoride as contrasted with less than one half this amount in cereals from plants which take non-flouridated water.

Fluorine in atmospheric air is present in the form of gas (HF) and aerosol particles. Fluorine compounds present in Super phosphates, aluminium smelters, steel, glass, brick, ceramic, limestone and cryolite, pollute the atmospheric air in the form of gas and aerosol particles. The pollution of air, water and food are caused by the vast expansion of the use of fluorine and its compounds such as fluoride containing drugs, anaesthetics, tooth-pastes etc.

The chief factors for the formation of dental fluorosis depends on the concentration of fluoride .in drinking water. and food when the teeth are developed. Fluoride is taken up most rapidly into the teeth during the phases of growth and development. Fluoride appears to act in three ways: (1) the incorporation of fluoride into the enamel crystals in the form of fluoroapatite, reduces their solubility during acid attack (2) fluoride promotes re-mineralization of early enamel lesions and (3) the presence of fluoride inhibits acid production by the plague bacteria.

Dean classified dental fluorosis into seven categories,

1) Normal

2) Questionable

3) Very mild

4) Mild

5) Moderate

6) Moderately severe

7) Severe

Endemic skeletal fluorosis is a chronic metabolic bone and joint disease caused by ingesting large amounts of fluoride through water and food. Early symptoms are generally referable to muscalo skeletal system. Next stage they develop rheumatic complaints. They complain of pain and stiffness of spine. Subsequently the joints of both limbs become similarly affected. In later stages stiffness of the spine increases, movements become limited. The patients loose their ability to walk as crippling deformities, contractures and neurological complications appear.

In addition to skeletal and dental fluorosis, other organs also have been affected by excessive ingestion of fluoride. Some of the organs affected by fluoride are,

Thyroid glands, Kidney, lungs, brain, heart, speen and liver

DEFLUORIDATION

Fluorides are necessary for men and animals in small doses, because fluorine is a component of bones and teeth. But excess of fluorine in water or air is poisonous. It destroys enamel of the teeth and makes the bones brittle. Fluorine gets accumulated in the body even if it is introduced in trace amounts. Chronic poisoning due to fluorine causes loss of appetite, cachexia, structural changes in the bone tissues and teeth. It affects the joints, kidneys, liver, heart, adrenal glands, testes and thyroid glands. Fluorine also destroys the enzymes involved in the metabolism, due to its combination with metals such as copper, iron, manganese, zinc etc. which are the part of enzymes. Fluoride enters 'human and animal body mainly through water. Hence water containing increased doses 'of fluoride should be defluoridated. Water is defluoridated by binding fluoride ion with chemical reagents or by its sorption on various materials.

When water is treated with aluminium sulphate, fluoride presents in it forms a sparingly soluble AlF_3 which is precipitated with $Al(OH)_3$. The quantity of aluminium sulphate required to defluoridate water depends on the pH of the medium. In neutral medium the requirement of $Al_2(SO_4)_3$ is 30-40 times higher than in acid medium. Hence this method is complicated and expensive.

Defluoridation ,of water with magnesium salt is carried out with adding lime which increases the pH of water to 10.2 - 10.3. Under this condition magnesium hydroxide is formed.

$$MgCl_2 + Ca(OH)_2 \rightarrow CaCl_2 + Mg(OH)_2$$

Magnesium hydroxide reacts with fluoride to form insoluble basic oxyfluoride of magnesium.

$$Mg(OH)_2 + NaF \rightarrow Mg(OH)F \downarrow + NaOH$$

This method decreases the fluoride concentration from 5 to 1 mg/litre

Water can be defluoridated using calcium phosphate which is pretreated with 10% NaOH solution.

$$2Ca_3(PO_4)_2 + 3NaOH \rightarrow Ca_5(OH)(PO_4)_3 + Ca(OH)_2 + Na_3PO_4$$

$$Ca_5(OH)(PO_4)_3 + NaF \rightarrow Ca_5F(PO_4)_3 \downarrow + NaOH$$

This method is employed if the fluoride concentration is not less than 10 mg/litre. The requirement of calcium phosphate is about 10 mg per one mg of fluoride removed.

In sorption method, strongly basic anion exchange resins, special activated coals, magnesia sorbent, activated alumina etc. have also been used for the removal of fluoride from water.

The effective material is activated alumina. Commercial alumina is calcined twice 800°C with intermediate cooling 'and wetting with 15% soda solution. The depth of the sorbent bed should be about 2 metres. The alumina is regenerated with a 2% solution of NaOH with subsequent neutralization of excess of alkali with 0.5% HCl solution. Fluoride ion is retained on the surface of alumina.

WATER TREATMENT PROCESSES AND PRESERVATION

Rivers, lakes, streams etc. are the various natural sources of water. Water from these sources contains large number of impurities. The impurities present in water vary from place to place. Treatment of water obtained from different sources is essential so that it can be safely used for municipal, laundry, boiler and industrial purposes. Water from the natural sources may contain physical, chemical and biological impurities.

Physical impurities impart colour, taste, odour and turbidity to water. Chemical impurities cause hardness and water pollution. Metals and gases cause corrosion of pipes and fittings. Bacteriological impurities spread diseases like cholera, typhoid, diarrhoea, dysentery etc.

The treatment of water has the following objectives,

a. Removal of colour, objectionable odour and taste.

b. Removal of dissolved objectionable gases, dissolved and suspended impurities and harmful minerals.

c. Removal of dissolved and suspended organic impurities

d. Removal of pathogenic bacteria

e. Making water safe for drinking, domestic and other purposes.

Removal of coarse, dispersed and colloidal impurities

Removal of coarse, dispersed and colloidal impurities from water is known as clarification. Coarse dispersed solids may be removed from water either by filtration or by sedimentation. In filtration the water is clarified by passing it through a porous material, which retains coarse impurities on its surface and in pores. A large number of clarification filters have been employed for the clarification of water. They are single flow closed pressure filters, open type mechanical filters, horizontal closed pressure filters, multiple mechanical filters, chamber type filters etc. The most common type of clarifying filter is single flow closed pressure filter. This is the simplest form of filters. A part of it is filled with the material constituting the filtering bed on top of which the filter is filled with water to be clarified. Closed pressure filters operate under the pressure created by the pumps delivering the water to be clarified.

Filtration of water is done in order to remove colloidal and suspended matter remaining after sedimentation and to remove bacterial load. In the process of sedimentation solid particles are allowed to settle by gravity on the bottom of the tank in which water is undergoing clarification. Sedimentation takes a long time. The main principle of sedimentation is to allow water to rest or flow at a very slow velocity so that heavy particles settle down.

The process of filtration usually consists in allowing the water to pass through thick layers of sand called media which act as stainers. There are four ways of explaining the theory of filtration.

1. Sand contains voids. The suspended particles which are unable to pass through the voids of sand grains are retained and removed.
2. The impurities and sand particles attract each other.
3. The microorganisms form a film around the sand particles. These films contain large colonies of microorganisms or bacteria. They feed on the organic impurities present in the water and convert them into harmless compounds.
4. Sand particles and the particles of impurities carry electrical charges of opposite sign. They attract each other and get neutralized.

COAGULATION OF WATER

Sedimentation is not sufficient to remove all the suspended matter. The process of consolidation of colloidal particles is called coagulation. In water treatment process, coagulation means the treatment of water with reagents so as to remove colloidal and coarse dispersed impurities. Reagents used or coagulation are called coagulants. In water treatment technology ferrous sulphate ($FeS0_4.7H_20$), aluminium sulphate ($Al_2(S0_4)_3.18H_20$) and ferric chloride ($FeCl_3$) are used as coagulants. The process of coagulation depends upon various factors, such as pH, amount of coagulant used, water temperature etc.

When aluminium compounds are used, pH may be within 5 and 7. With iron compounds, pH may be between 8 and 10. The requirement of aluminium sulphate and ferrous oxide are 0.2 - 1.0 and 0.1 - 0.5 milli equivalents per litre respectively. The most favourable temperature is 303 - 313 K. Mixed coagulants, consisting of aluminium sulphate and ferric chloride are generally used for industrial effluents.

FLOCCULANTS

The process of coagulation can be intensified by adding special reagents known as flocculants. Flocculants work probably by neutralizing the charge on the colloidal, particles and by destroying the protective properties of some colloids. The particles of the flocculant are adsorbed on the dispersed particles and on coagulant flakes to convert them into particles of reasonably large size and high stability. The time required to clarify water is thus decreased. Starch, sodium polyalginate, polyacrylamide, maleic anhydride, activated silica etc. are used as flocculants.

STERILISATION AND DISINFECTION OF WATER

Coagulation and filtration remove suspended solids and decrease bacteriological contamination partly. Complete disinfection is carried out by chemical reagents which kill pathogenic bacteria or microorganisms. There are chemical and physical methods for sterilization.

CHEMICAL METHODS

PRECIPITATION METHOD

Certain impurities present in water can be easily precipitated by adding suitable reagents, such as alum, soda ash, lime etc.

AERATION

Aeration is performed by two methods, natural aeration and artificial aeration. Natural aeration takes place in rivers, streams, falls etc. Artificial aeration is carried out by spraying water in the form of spray or fountain. Aeration promotes taste and removes odour. It increases the oxygen content and gives freshness, and removes $C0_2$ from water. It also removes H_2S and other volatile substances which are responsible for bad taste and odour. Aeration removes impurities of Fe and Mn.

OZONISATION

The plant consists of a tower made of enamelled iron, and divided into several compartments by means of perforated celluloid partitions. The tower is provided with two inlets at the bottom and one outlet at the top. The ozonized oxygen and water are allowed to pass through separate inlets provided at the bottom and the sterilized water is collected from the outlet at the top. The perforated partition breaks up the gas and water stream into minute bubbles, as a result of which intimate contact between gas and water is effected.

The 'bactericidal action of ozone is associated with its high oxidation potential and the ease with which it passes through the cell membranes of microbes. Ozone oxidizes the organic substances in the microbe cell in order to kill it. It works on bacteria more quickly an chlorine. If one ml of water contains 274-325 E. coli type bacteria, 86% are killed by an application of 1 mg/l of ozone and 2 mg/l fully disinfects water. The dose of ozone required depends on the degree of pollution and usually varies from 0.5 to 4.0 mg/l. Turbid water requires more ozone.

Ozone sterilizes, bleaches, decolourises and deodourises water. Excess of ozone causes no danger, because it decomposes into oxygen. It causes no irritation to mucous membrane. It improves the taste also. But ozonisation is highly expensive.

SILVER ION METHOD (OLIGO DYNAMICS)

There are various views on the bactericidal action of silver. The silver ions interfere with the metabolism of bacteria and thus kill them. Another view is, the silver ions penetrate inside the microbial cell and destroy its protoplasm. According to a third view, the silver ions are adsorbed on a microbial cell and act like a catalyst in accelerating the oxidation of plasma by atmospheric oxygen. The bacterial action of silver is affected by the presence of various impurities in natural waters. Silver water is prepared separately and then added to the treated water. This method is used to disinfect water in sanatoria, hospitals and ships etc. This water can be used to can foods, to treat artesian and common wells, pipes and also for medicinal purposes. The silver treatment of water is effective in cases where water does not contain much salt or suspended matter.

Copper also possesses oligodynamic properties. Industrial water can be treated by electrolytic dissociation of copper.

CHLORINATION

Chlorination is the best and the cheapest method of sterilization of water. It is the most effective method in checking pathogenic microorganisms. Chlorination can be carried out directly in the liquid form or as bleaching powder. Excess of chlorine is removed by sulphite antichlor. Chlorine reacts with water to form hypochlorous acid and nascent oxygen. Both are powerful germicides.

$$\begin{aligned} Cl_2 + H_2O &\rightarrow HOCl + HCl \\ HOCl &\rightarrow HCl + [O] \end{aligned}$$

HOCl reacts with bacterial enzymes to interfere with the metabolism inside the cell. Organic impurities are destroyed by chlorine. Humins are converted to $C0_2$, Fe^{2+} is oxidized to Fe^{3+}, Mn^{2+} is oxidized to Mn^{4+} and stable suspensions are converted into unstable ores because of decomposition of protective colloids. When chlorine compounds are added to water, they are hydrolysed to give HOCl.

$$2CaOCl_2 + 2H_2O \rightleftharpoons CaCl_2 + Ca(OH)_2 + 2HOCl$$

$$NaOCl + H_2CO_3 \rightarrow NaHCO_3 + HOCl$$

$$NaOCl + H_2O \rightleftharpoons NaOH + HOCl$$

$$Ca(OCl)_2 + 2H_2O \rightleftharpoons Ca(OH)_2 + 2HOCl$$

Bleaching Powder Method

After removing organic matter, suspended impurities etc., water is mixed with required amount of bleaching powder and the mixture is allowed to stand for several hours for the completion of sterilization.

$$CaOCl_2 + H_2O \rightarrow Ca(OH)_2 + Cl_2$$

$$Cl_2 + H_2O \rightarrow HOCl + HCl$$
$$HOCl \rightarrow HCl + [O]$$

Both HOCl and nascent oxygen are powerful germicides. Calculated amount of bleaching powder should be used, because excess of it gives bad odour and disagreeable taste while less than required quantity will not be effective.

On standing bleaching powder undergoes auto oxidation as,

$$6CaOCl_2 \rightarrow 5CaCl_2 + Ca(ClO_3)_2$$

Available chlorine in bleaching powder decreases on storage.

CHLORINE DIOXIDE

ClO_2 is also used to remove bacteria. It oxidizes phenols to quinone and maleic acid which do not give unpleasant odour. It can be prepared by passing Cl_2 gas through. sodium chlorite.

$$2NaClO_2 + Cl_2 \rightarrow 2NaCl + 2ClO_2$$

or

$$2NaClO_2 + 4HCl \rightarrow 2NaCl + 4ClO_2 + 2H_2O$$

IODINE METHOD

In swimming pools water is iodinated. The concentration of iodine solution increases with temperature. Water can also be disinfected by organic iodine compounds known as iodophores.

In villages, the well water is sterilized by adding calculated amount of potassium permanganate.

PHYSICAL METHODS

BOILING

Boiling of water for about 15-30 mts destroys all disease producing bacteria and algae. It removes all the dissolved gases and gives a flat taste. For large volume of water this method is not suitable.

Exposure to sunlight and ultraviolet light:

This is the latest method. Sunlight is helpful in destroying bacteria, but it cannot penetrate deep. Sterilization with U.V rays is carried out by exposing water to ultra violet rays. Wavelengths from 2000 to 2950 A have the strongest effect and so this region is called bacterial region. The UV rays kill the vegetative forms of bacteria, protozoa and viruses. Water should be treated with ultraviolet rays only after it has passed all other stages of treatment.

IRRADIATION WITH ULTRASOUND

Frequencies over 20,000 Hz are called ultrasonic. Ultrasound kills animal and plant cells, protozoa and microorganisms. Hydras, infusoria, cyclops, nonogenetic flukes and other organisms are sensitive to ultrasound. Ultrasound destroys large organisms which are detrimental to the drinking and industrial water supply.

Some case studies of water pollution.

All the water resources have been polluted and exploited due to increasing population, industrialization, urbanization, increasing living standards and broad spheres of human activities.

Major Indian rivers, such as Ganga, Yamuna, Tapti, Narmada, Sone, Chambal, Daha, Damodar, Krishna, Cauvery, Brahmaputra, Mahi and other medium and minor,or rivers are severely polluted.

Ganga the most sacred river of India, which is regarded as the cradle of Indian Civilization, travels nearly 2525 km through U.P, Bihar and West Bengal supporting about 40 million people. The rivet Ganga starts from Gangotri in the Himalayas and joins in the Bay of Bengal at Ganga Sagar. Once the purest water of Ganga is now polluted at number of places by domestic and municipal and industrial wastes.

It is estimated that about 1200 million litres of waste water is released into Ganga from about 29 major cities, 23 medium cities and 48 towns, which are situated at the banks of Ganga. At Varanasi it "receives the largest amount of biological and chemical pollutants. About 60 million litres of untreated sewage are dumped into it every day. It receives ashes of about 40,000 human bodies, about 10,000 incompletely burnt dead human and animal bodies annually. The main sources of pollution of Ganga at Kanpur in UP are jute, chemical, metal and surgical industries, tanneries, textile mills and a great bulk of domestic sewage. Near Meerut, river Ganga is heavily contaminated with nitrates, fluoride and manganese.

There are more than 150 industries flanking both sides of Hoogly river. In the 120 km stretch from one end of greater Calcutta to another, there are about 270 outlets of untreated water to the river Hoogly. The water quality of Hoogly river is much worse than the fourth grade unfit water as specified by World Health Organization.

In Mumbai and the Kalyan belt, millions of litres of sewage and industrial effluents are being discharged into the sea and watercourses without any treatment. The D.O. level in the Ganga at Kanpur and in the Hoogly river near Calcutta is much below the optimum level of 3 to 4 ppm. Gomati at Kanpur is badly polluted, its D.O being 4 ppm at many points.

The Damodar Valley from Durgapur to Asannol forms the largest industrial complex in West Bengal. The Indian Iron and Steel Company (TISCO) and Bengal Paper Mills (BPM) discharge their waste directly into the Damodar river. In Durgapur, the Tamla Nalah carries effluents of most of the industries and meets the Damodar river. The Durgapur Steel Plant also discharges part of its effluents in Damodar river. Thus Damodar river is used as the sink for industrial and domestic wastes.

Yamuna is receiving 60% of the untreated domestic sewage, industrial effluents, fly ash and other chemicals in Delhi alone. The river has also lost free flowing that has self-cleaning properties. There should be no ammonia in drinking water. But in some places Yamuna water has 1.8 mg/l of ammonia.

Tanneries in Vaniambadi, Ambur and Ranipet area of Tamil Nadu are discharging untreated effluents in the Palar river. Several acres of land had been affected by this water.

River Thamraparani at Tirunelveli District of Tamil Nadu is polluted due to paper mills situated at its banks. Another Thamraparani at Kanyakumari District is the victim of brick kiln.

Periyar is dying a slow death. Nearly 437000 tons of sand is being mined every day. The river is choked with clay. Periyar's water becomes salty because of seawater intrusion. Salt water introduces in Aluva and chemicals enter at Kalady and Chowwara. The Neyyar, Bharathapuzha and Pamba known as Southern Ganga are also polluted.

The Naini Lake in Nainital, Ambazari Lake of Nagpur, Powai Lake in Maharashtra, Pushkar Lake in Rajasthan, Chilka Lake in Orissa, Dal Lake of Sri Nagar are all polluted. The wate of these lakes contain high nitrate concentration. Migrating birds pollute the water by dropping enormous amount of excreta. Huge quantities of sewage are dumped. Most of the lakes are enriched with nutrients resulting in high eutrophic condition.

****

UNIT - IV

LITHOSPHERE AND SOIL POLLUION

CHEMICAL COMPOSITION

Lithosphere means the mantle of rocks constituting the earth's crust. The earth is a cold, &pherical solid planet of the solar system, which spins on its own axis and revolves round the sun at a certain constant distance. The solid component of the earth is called lithosphere which includes mainly soil, rocks, mountains etc. The lithosphere mainly contains three layers, crust, mantle and outer and inner core. The core is the central fluid or vapourised sphere having diameter of about 2500 km from the centre. Core is composed of nickel iron. The mantle extends about 2900-3000 km above the core and is in the molten state. The outer-most solid zone of the earth is known as crust. It is about 8-40 km above the mantle. The surface of the crust is covered with the soil. Soil is environmentally the most significant part of the lithosphere.

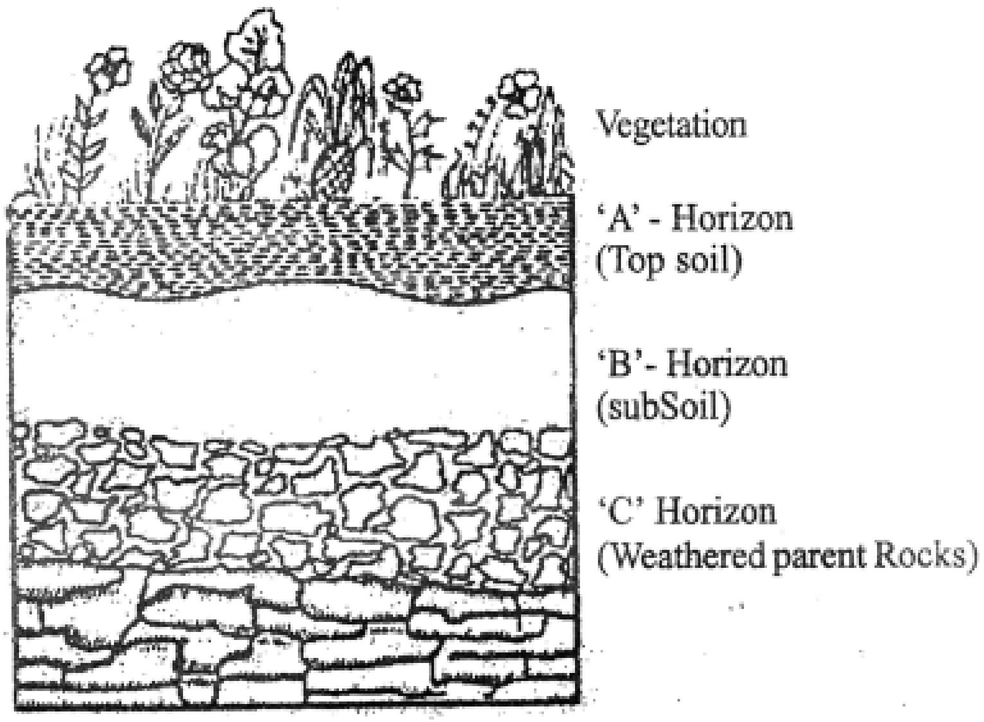
Soil is the upper most part of the earth's crust and is a mixture of organic as well as weathered rock materials necessary for the growth of plants. The organic matter and weathered rock materials are formed through the physical, chemical and biological processes occurring slowly for a long period.

Soil is a storehouse of minerals, a reservoir of water, a conserver of soil fertility, a producer of vegetative crops and a home of wild life and livestock. The soil is'one of the most important ecological factors called edaphic factor. The science which deals with the study of soil is called soil science, pedology or edaphology.

There are layers of soil one over the other in progressive state of maturity. Such a vertical section of the soil is called soil profile. These soil profiles are made up of horizontal layers called horizons. These horizons vary in thickness, colour, texture, structure, acidity, porosity and composition. Soils have four horizons - an organic or O-horizon and three mineral horizons (A, Band C horizons).

The upper most horizon of soil profile is called horizon - 0 or littler zone. It is not usually present in the soils of deserts, grasslands and cultivated field, but present in soils of forests.

Underlying the littler zone is the topsoil or horizon A which has several inches of thickness. This is the layer of maximum biological activity in the soil and contains bulk of the organic matter. Hence it is of considerable importance for vegetation cover and agricultural crops. Metal ions and clay particles in the A-horizon are subject to considerable leaching. Reckless deforestation over the years has led to considerable loss of topsoil which means loss of agricultural production. The next layer is the B horizon subsoil. It receives materials - organic matter, salts or clay particles leached from the topsoil. The next layer, C horizon is composed of weathered parent rocks from which the soil originated. A prodective soil consists of 45% minerals, 25% soil water,25% soil air, 5% organic matter.



Soil Profile

Due to the small size of soil particles and presence of small capillaries and pores in the soil, the water phase depends on the soil solid matter. Water presents in large spaces in soil is relatively more available to plants and readily drains away. But water held in small pores or between the unit layers of clay particles is bound more strongly. Soil rich in organic matter may hold large amount of water compared to other soils.

About 35% of the volume of a typical soil consists of air-filled pores. The decay of organic matter in the soil consumes O_2 and produces CO_2. Hence the soil may contain 15% O_2 and more of CO_2.

The minerals in the soil are essentially silicate minerals, 74.3% of which consists of silicon and oxygen. The common elements in soil are oxygen 46.6%, silicon 27.7%, aluminium 8.1 %, iron 5.0%, calcium 3.6%t sodium 2.8%, potassium 2.6% and magnesium 2.1 %.

Among the silicates, orthoclase ($k_2Al_2Si_6O_{16}$) albite ($NaAlSi_3O_8$) and epidote ($4Ca0.3\,(AlFe)_2 0_3.6SiO_2.H_2O$) are common. Iron oxide and magnetite oxides and titanium oxides are abundant. Calcium carbonate is also common.

The clay minerals in soils are secondary minerals, essentially hydrated aluminium and iron silicates. Organic matter consists of polysaccharides, amino-sugars, nucleotides, organic sulphur and phosphorus compounds. The humic materials constitute the most important class of complexing agents. Some soil fungi yield citric acid and other cheating organic acids.

MICRO AND MACRO NUTRIENTS IN SOIL

For plants, the essential micronutrients are boron, chlorine, sodium, copper, iron, manganese, zinc, vanadium and molybdenum. These elements are required at trace levels and, if present at higher levels, have a toxic effect. Most of these serve as essential components in enzymes. Some of them, such as chlorine, manganese, iron, zinc and vanadium are likely to take part in photosynthesis.

The essential macronutrients are carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, potassium, calcium and magnesium. The atmosphere and water are the sources of carbon, hydrogen and oxygen. Nitrogen may be obtained by some plants directly from the atmosphere through nitrogen fixing bacteria. The other essential macronutrients are obtained from the soil. Nitrogen, phosphorus and potassium are commonly added to soil as fertilizers.

Calcium deficiency in soil is due to calcium uptake by plants, leaching by carbonic acid in acidic soils, and competition with high levels of sodium, potassium and magnesium in alkaline soils. Calcium deficient soils are generally treated with lime. Magnesium deficiency in soil is caused by high levels of calcium and sodium or potassium.

The nitrogen content in soil is mostly of organic nature (90%) resulting from the decay of dead plants and animals, plant residues, faeces, urine of animals etc. It is hydrolysed to $NH_4^{\oplus}$ which can be oxidized to $N03^-$ by natural processes in soil. Nitrogen bound to soil humus is responsible for maintaining soil fertility.

In acidic soils, the orthophosphate ions are either precipitated or sorbed by cations, viz. Al^{3+}, Fe^{3+} etc. In alkaline soils the following reactions occur with $CaC0_3$, whereby hydroxyapatite is precipitated.

$$6HPO_4^{2-} + 10CaCO_3 + 4H_2O \rightarrow Ca_{10}(PO_4)_6(OH)_2 \downarrow + 10HCO_3^- + 2OH^-$$

Potassium is relatively abundant in earth's crust. But most of it is not accessible to plants. Only clay minerals in soil containing exchangeable potassium make it available to plants.

POLLUTION BY FERTILIZERS

Nowadays agriculturists heavily use artificial fertilizers which generally contain one or more of the plant nutrients i.e. nitrogen, phosphorus and potassium. Pollution problems arise due to excessive application of fertilizers. The excess fertilizers contaminate the soil with their impurities. Consequently the water present in the soil also gets polluted. Generally fertilizers are retained by the soil, but there are possibilities for the nitrates to be washed out. These nitrates cause undesirable effect on the water quality of the low land lakes or rivers creating numerous health hazards. If phosphate exceeds 10 ppm and nitrate 300 ppm in water, it results in eutrophication, choking the whole stretch of aquatic ecosystem. The accelerated multiplication of undesirable algae occurs when the nutrients are in excess, as a result of over-fertilization. These undesirable algal species as they multiply, grow and die, the dissolved oxygen in the water bodies depletes leading to anoxic conditions. The dominant species often is the blue green algae whose degradation products are toxic and impart bad odours and tastes to the water.

POLLUTION BY PESTICIDES

Pesticide is a general term for insecticides, acaricides, rodenticides, molluscides, herbicides, fungicides, etc. There are four structural classes of pesticides. They are;

1. Chlorinated hydrocarbons (DDT, BHC etc.)
2. Organo Phosphate (Malathion, Parathion etc)
3. Carbomates (Sevin, Baygon etc)
4. Chlorophenoxy acids (2,4-D, 2,4,5-T)

   (2,4 - dichlorophenoxy acetic acid and
   2,4,5 -triochlorophenoxy acetic acid)

The chlorinated hydrocarbon pesticides on land destroys the soil fauna reducing the productivity of the soil. Birds are most affected because of aerial sprays of insecticides like DDT as their nests and feeding sites are near the fields which are sprayed. Birds pick up food from soil, especially when the ground is wet. Thus there is an indirect source of insecticides for birds as they feed on burrowing animals like earthworms which take a large amount of. soil which has been sprayed willi insecticides

In birds DDT causes thinning of eggshells and loss of productivity as it depresses the activity of the female and male sex harmones like estrogen and testosterone.

The chlorinated hydrocarbon insecticides cause mutations of DNA molecules in man and livestock. They are mainly Central Nervous System (CNS) poisons and elicit a variety of CNS symptoms in man. They also affect the vital organs of the body. They cause degenerative alterations in liver and kidney. DDT is carcinogenic to man. DDT and BHC leave lot of residual toxicity in vegetables, grains and plants.

The organophosphates are actually toxic and affects the CNS, causing nausea, abdominal pain, diarrhoea, respiratory problems, lung edema, fall in blood pressure, drowsiness, mental confusion, fever, convulsions, paralysis, coma, heart attack etc.

The export of agricultural commodities to developed countries has also suffered because of pesticide contamination. The remnants of the pesticides may get absorbed by the soil particles which may contaminate root crops grown in soils. These pesticide residues coexist within the biological system with other forms of life.

POLLUTION BY PLASTICS

Over the last few years, plastics have become indispensable. The plastic is nonbiodegradable. The plastic bags block the sewage, affecting health and hygiene. They accumulate all over the street, roads, public places and can remain in the ground for 'decades, thus preventing water from seeping into the soil and obstructing photosynthesis and air circulation. Consequently ,soil productivity is retarded and vegetation is adversely affected. Many stray animals and cattle may die after consuming the polythene bags. Polythene bags have caused havoc in 1996 in Italy, killing sea turtles, dolphins and many other marine creatures.

The real culprit. of the plastic world is polyvinyl chloride (PVC). PVC cannot be disposed of safely. It cannot be recycled beyond a point. When PVC is burnt, carcinogenic dioxins are let out. Dioxins cause genetic defects, deformed reproductive organs, lowered sperm counts, cancer counts. etc. PVC is used for flooring, wallpaper, curtains, tablecloth, electric wiring, shoes, toys etc,. Hence none of us can escape from its toxic effect. The slow release of PVC such as lead and cadmium are neuro-toxic and kidney-toxic respectively

Delhi's garbage consists of up to' 30% plastic bags. We take in barium (green plastics), lead (black plastics) and chromium (red) salts unknowingly with our packed foodstuffs, vegetables and fruits. As the bonds in plastic are impossible to break down through physical or chemical processes, they are non- bio - degradable.

Plastic toys are also health hazards. Soft toys are made from PVC, mixed with phthalates. The phthalates are probable carcinogens. Some phthalates can produce tumours and other chronic affects and can cause potential damage to kidney and liver.

POLLUTION BY HEAVY METAL COMPOUNDS

The most commonly anticipated problem at present is the contamination of soil with toxic materials such as mercury, chloride, nitrate, zinc, iron, cadmium etc. which have significant adverse effects on crop productivity. Mercury behaves as a cumulative poison which chronically affects the entire planet.

The toxic metals may be absorbed by plants grown in contaminated soil which then accumulate in animals eating those plants reaching to chronic toxic levels. Most of the heavy metals become quite insoluble in soil at pH·6 or more. Cadmium being highly soluble than other heavy metals, is a frequent contaminant. Other metals such .as Ni, Cu, Mo, and Zn are also soluble but to a lesser extent.

Heavy metal pollution causes increasing rate of maternal mortality, kidney and liver related diseases, birth abnormalities and cancer. Women have many pregnancy problems toxaema, haemorrhages, kidney and liver related diseases. The level of sick born is high. A high percentage of children are born with asphyxia. This is because of the fact that high levels of metals like Mn, Pb, Sr, Cd and other metals have been found in the' placenta and in the blood. These metals can cause brain damage, genetic disorders, endo trinal diseases among the new borns.

The problem is largely due to exposure to heavy metals. Synthetic chemicals and fertilizers are sources of heavy metals which are added to the soil deliberately or as an impurity. Pb and Cd, the common trace metals in rock phosphate, also occur in super phosphate fertilizers. Toxic selenium species get less readily oxidized so it cannot be easily removed *from* the soil by weathering. Today various trace elements such as Fe, Co, Ni, Cu, Zn, Ba, Pb, V, Mn, As, Hg, Mo, Si etc., are added to the soil in one or other forms. Mn and Fe oxides have a tendency to concentrate trace metals by isomorphous replacement of ions. Presence of high levels of Na, Mg and K causes calcium deficiency in soil. Magnesium deficiency in soil has been attributed to high concentrations of Ca, Na and K which have been added as fertilizers. Excess of sulphur in soil may be absorbed by plant leaves as sulphur dioxide injuring plant tissues. Mg, Fe, Zn and V if present in excess pose lethal effects on crop production. Metallic contaminants in soil are considered to be the indestructible poisons.

PLANTS AS INDICATORS OF SOIL POLLUTION

Certain plants can withstand the presence of heavy metals in higher concentration e.g. silene plants to Zn, liver worts and mosses to Cu, Serpentina to Cr and Ni, Festuca species to Pb and Acidophilic grasses to Al. Some plants species can be of diagnostic value as they reveal the quality of substrate on which they grow and are called as soil indicator plants.

Grasses like Deschampsia flexuora, Calluna Vulgaris, Sarothomus Scoparis are indicators of acidic soil.

Plant species like Suaeda microphylla, Haloxylon aphyllum etc., indicate the alkaline soil.

Several plants like Wolffa, Chara, Utricularia grow well in polluted waters, while Anthoxanthum, Agrotis, Festuca etc. are used as indicators of Zn, Cu, Pb, Al respectively. Leaf cabbage indicates accumulation of polycylic hydrocarbons in the soil.

TREATMENT AND ABATEMENT PROCEDURES FOR SOIL POLLUTION

Soil pollution can be controlled by following certain practices and techniques. They are,

1. Control of sewage, domestic and industrial wastes.
2. Eco-farming and eco-technology
3. Biotechnology
4. Integrated Nutrient Management
5. Genetic Resource Management
6. Land use systems
7. Integrated Pest Management

Control of Sewage, Domestic and Industrial Wastes

Soil pollutants such as sewage can be decomposed by natural processes i.e. by the action of micro-organisms as bacteria, fungi, protozoa and other microbes. Biodegradable wastes can be composted where fungi and bacteria play major roles.

Dumping solid waste is a popular and inexpensive way of getting rid of wastes. There are disadvantages also. The waste should be properly disposed Off.

From the waste useful products can be recovered. Gobar gas plants based on anaerobic fermentation of organic wastes can be erected. Biogas slurry can be used as manures. Gobar gas plants provide enriched manure and improve local sanitation. In advanced cities where underground facilities exist, sewage gas may be utilized. Sewage gas is a mixture of methane and carbon dioxide. From this methane gas can be separated out, compressed and filled in cylinders and can be .used for heating purposes.

Bacteria can be used to convert toxic compounds into either useful industrial products or harmless wastes. This process is known as BIOREMEDIATION. Solid waste is compressed similar to that of producing farm manure. The technique involves. microbial help to turn municipal waste into fertilizers or soil-reinforcing products. Now several genetically engineered bacterial strains are available to decompose complex organic compounds which were so far considered to be non-biodegradable .

Some of the waste components can be easily recycled and reused. Recycling of paper, plastics glass, metals and organics is the main issue today..

Previously recycling of old papers generated low graded papers. Now Japan recycles 40% of the unwanted papers into new high-grade paper. Recovery of one ton of paper saves about 17 trees.

There are different types of plastic materials, viz. bottles, carry bags, rain coats etc. Now scientists are designing a compatibilizer molecule which stick together these different plastic molecules making the recycled plastic very durable. Research is going on to recycle glass, metal or organic waste effectively.

ECO FARMING AND ECO TECHNOLOGY

Soil erosion and depletion of soil fertility should be arrested. All attempts should be made to use renewable source of energy. The soil should be nursed back to health. . The cropping patterns should be changed to maximize ecologically productive efficiency.

BIOTECHNOLOGY

Biotechnology can influence biofertilizers. Biotechnology has great promise for conservation. and utilization of biodiversity, waste recycling and bioremediation.. Biotechnology is being widely Used for developing new and value added products.

Integrated Nutrient Management (INM)

The concept of INM is for optimization of the effects of all available sources of plant nutrients to improve soil fertility.

The soil is treated as a living system for promoting all the function - s4pportive, buffering and storehouse of nutrient and water supply. Bacterial fertilizers such as Rhizobium and Azospirrillium can be used. Each farmer can prepare his vermi compost on his farm and apply it to the soil.

Genetic Resource Management

Collection, conservation and sustainable use of plant genetic resources assume greater importance to sustain productivity in view of the ever growing population and changed international scenario. Characterisation, evaluation, conservation and utilization of horticulture, medicinal, aromatic and other commercially exploitable germplasms are required. Molecular tagging and characterization of genes of economic importance in plant, animal, fish and microbial resources is required to underscore specific traits which can be used for resource upgradation.

Land Use Systems

Efforts are underway to develop agro- forestry models for different regions. Land use systems have been developed for desert areas involving suitable trees, grasses and legumes. Suitable location, suitable crop production technologies have been developed for tillage, seeding, weed control, water and fertilizer application and crop management for enhanced productivity. Based on soil and rainfall, potential areas for mono-cropping, inter cropping and double cropping has been delineated in various dry farming zones.

Integrated Pest Management (IPM)

The government should atleast ban or restrict those pesticides which have already been banned or restricted in other countries for toxicological or other reasons. Insecticide pollution can be controlled by using degradable insecticides like organic phosphates, using short-lived chemical pesticides and using biological control methods instead of insecticides. Predators can be used against pest and to control weeds. Parasites like calcid warps can control many pests. Sterilization of male insects can be done by exposing them to gamma rays. Hormonal stimulants such as juvanile hormones that prevent insects from completing their life cycles can be used. Decoy plants i.e. low value crops can be cultivated as they attract pests from high value crops. Rotation and diversification of crops can also be practiced.

All these measures are the components of IPM system.

NATURAL RESOURCES

MINERAL RESOURCES: METALS AND NON METALS

Mining and processing of minerals and ores involve major environmental concerns, including disturbance of land, air, pollution from dust and smelter emission and water pollution from disrupted aquifers.

The rate of depletion of resource is measured by two parameters - per capita mining and per capita consumption. Per capita mining is calculated by dividing the amount of resource mined by the population. Per capita consumption is obtained by dividing the amount of resource actually processed by the population. It is a better index of the standard of living of the population.

World's Mineral Reserves

Resources	Reserve (tons)	Occurring as	Per capita mining, kg	Per capita Consumption, kg
Al	1.1 x 10^9	Al_20_3, nH_20	15.1	2.8
Sb	3.6 x 10^6	Sb_2S_3	14.8 g	17.3g
Asbestos	-	-	1.0	0.9
Cr	4.4 x 10^9	$Fe Cr_2 0_4$	0.7	0.5
Coal	4.7 x 10^{12}	-	580	624
Co	2.2 X 10^6	$CUC0_2S_4$	-	5.6 g
Cu	280 X 10^6	$CuFe S_2CU_2S$	1.6	1.5
Au	11 x 10^3	Au	0.4 g	0.4 g
Fe	88 x 10^9	Fe_20_3, Fe_30_4	110	109
Pb	82 x 10^6	PbS, $PbC0_3$	3.8	0.8
Mn	635 x 10^6	$Mn0_2$, $Mn_20_3 H_2O$	2.0	2.2
Hg	115 x" 10^3	HgS, Hg	2.6 g	2.2 g
Mo	5.2 X 10^6	MOS_2	20.7 g	18.5 g
Ni	68 x 10^6.	(Fe, Ni)S	145 g	135 g
Petroleum	54.1 x 10^9	-	582	471
Phosphate	19.8 x 10^9.	$Ca_3(P0_4)_3(F,CI,OH)$	23	3.2
Potash	98.9 x 10^9	KCI, $KMgCl_2 6 H_2O$	4.6	3.6
Ag	171 x 10^3	Ag, Ag_2S, Ag_3AsS_3	-	-
Sn	4.76 x 10^6	$Sn0_2$	50.6 g	70.5

Ti	310×10^6	TiO_2FeTi0_3	-	375 g
W	$3 X 10^6$	$Ca W0_4, (Fe, Mn)W0_4$	-	-
U	$749 X 10^3$	U_30_8	-	4.8 g
Zn	112×10^6	ZnS,ZnO	1.5	1.4

The world percapita mining figures indicate that coal, petroleum, iron ore, Aluminium and phosphate rock are mined to the maximum extent. The demand on resources is not equitably distributed over the entire population. This is reflected in the contrast between the per capita mining figures for the Asian and North American sub-continent. USA imports substantial quantities of most of the resources so that its per capita consumption figure exceeds its per capita mining figure.

As far as metal resources are concerned, they may be grouped under two heads, nonferrous metals and ferrous metals plus Aluminium.

	Average Reserve	Average Per Capita Consumption
Group 1. Metals (non ferrous)	0.05 x 109 tonnes	0.42 Kg
Group 2 Metals (ferrous + Al)	11.8 x 109 tonnes	14.4 Kg
Ratio : Group 2 / Group 1	210/1	34/1

The group 1 metals are Au, Hg, Sn, Ag, Zn, Pb, W, U, Cu and Sb whereas the group 2 metals are Mo, Mn, Al, Co, Ni, Ti, Fe, Cr and K.

The major non-metal resources include asbestos, carbonates, chlorine, granite, oxygen, phosphate, potash, sand, gravel, sodium compounds and water.

Asbestos, the carbonates of calcium and magnesium, gravel, granite etc. constitute the common and the most widely used building materials. As in the case of metals,. the environmental aspects of many of these minerals are quite important. Even the extraction of ordinary rock and gravel has impact on the environment.

Ch_2, NaCl, Mg are the major representatives of the group of resources with a vast reserve - ocean.

The fertilizers, phosphate and potash have low depletion rates. This is because large deposits, both of phosphate rock, occurring as $Ca_3(P0_4)_2$ and KCI are widespread through out the world.

FUEL AND ENERGY RESOURCES COAL

Coal denotes a large range of solid fossil fuel derived from partial degradation of plants. Chemically, coal is a complex material exhibiting a typical composition $C_{100} H_{85} S_{2}. N_{1}.5,O_{2.5}$ Coal constitutes the major primary source of energy. It is called as black diamond. The power sector is the largest consumer. The other major consumers are steel, cement, railways, fertilizers and the domestic sectors. Coal has a number of non-energy uses. It is the mother of several chemicals.

Coal is stratified and formed by the burial of partially decomposed vegetation in past geological ages. The long and slow change-over initiated and promoted by the heat of the earth's interior and the pressure of the standing mass of the crust above, continued in the absence of air- for more than 300 millions of years converting the plants to coal. There are different types of coal.

a) **Anthracite (86 - 88% fixed carbon).**

b) **Bituminous coals - low volatile type (78-86% fixed carbon), medium volatile type (69-78% fixed carbon), and high volatile type (<69 fixed carbon).**

c) **Sub - Bituminous coals or Black Lignite**

d) **Pulverised coal**

Anthrocite has a high heating or calorific value. It is the most prized among solid fuels. In India it is found in Himalayan hills.

Coal can be transformed to gaseous, liquid, or low - sulphur, low-ash solid fuels which are less polluting than coal. During World War II, Germany developed a major coal - based synthetic petroleum industry that reached a peak capacity of 100000 barrels per day in 1944. In South Africa, a plant now converts about 10000 tons of coal per day to synthetic petroleum. A typical second-generation coal conversion plant - synthanes gastification plant - has been developed in the USA with a capacity of 72 tons per day of coal. The gaseous products from bituminous coal in a synthane gastifier are CO, H_2, $C0_2$, H_20, CH_4 and H_2S.

The quality of coal is upgraded by the hydrogenation process which removes ash from coal. High-grade ash-free coal is produced as Solvent Refined Coal (SRC) by suspending pulverized coal in a solvent and treating with hydrogen.

Methanol is a liquid fuel which can be produced from coal.

PETROLEUM

Petroleum is one of the most important liquid fuels in the world. The aviation gasoline, petrol, diesel, greases, lubricants, kerosene oil etc, are all obtained from crude petroleum oil.

Petroleum (Petra = rock, oleum = oil) is also known as rock oil or mineral oil. It occurs below the surface of the earth at a depth 500-15000 ft. The biggest oil producing country in the world is USA.

According to Mendeleff, petroleum is of inorganic orgin and is formed by the hydrogenation and polymerization of hydrocarbons. According to Engler, petroleum is of organic origin and is formed by the destruction of dead animals, fishes etc.

According to modem view, natural petroleum is formed due to the decomposition of animals as well as vegetables. At some places the petroleum is of animal origin and at other it is of vegetable origin.

According to one theory, it takes place by means of bacterial decomposition followed by physical and chemical changes while according to another view, it is formed from organic matter by the catalytic activity of certain natural inorganic compounds. According to third view, the formation of petroleum is also helped by radioactive rays.

Most of the constituents are straight chain paraffins and aromatic hydrocarbons like. benzene, toluene, naphthalene etc. It has also sulphur compounds and nitrogen compounds. The disagreeable odour is due to sulphur compounds.

The crude petroleum may be divided into three classes called bases

1. **Paraffine base :**

   If the residue obtained after the removal of volatile compounds of crude oil is rich in paraffin or wax, the petroleum is called paraffin base.

2. **Asphalt or Naphthene Base:**

   If the residue obtained is rich in naphthenes it is classified as asphalt or naphthene base.

3. **Intermediate base :**

   If the residue left after removing volatile compounds contains both paraffins and naphthenes, it is called intermediate base.

NATURAL GAS

Natural gas is a mixture of methane, ethane, propane, butanes, pentanes, carbon dioxide, nitrogen etc. Natural gas is found in the vicinity of coalmines or oil fields. It is also found associated with petroleum in nature. The natural gas derived from oil wells may be either dry or wet. When there is no oil, the gas is said to be dry. When it occurs with petroleum it is called wet gas. The dry gas consists of mainly methane. The wet variety consists of a mixture of methane and higher hydrocarbons. The calorific value of wet gas is higher than dry gas.

Various bye products from the raw natural gas are of great industrial importance. Some of them include methane, ethane, propane, butane and liquid petroleum gas (LPG). Natural gas is fed to the nearby cities in pipes and transported to several places in the liquid form (LPG) in cylinders.

The natural gas contains undesirable water and hydrogen sulphide, which must be removed before it is transported for various uses. There are various treatments to remove water and hydrogen sulphide. If nitrogen is present it should also be removed before use.

The gas obtained by anaerobic. fermentation of organic matter in sewage is also called sewage natural gas. It contains 70 per cent of methane and 30 per cent of carbon dioxide. The gobar gas obtained by microbiological fermentation of cow dung is another form of natural gas, which is rich in methane.

SOLAR ENERGY

The sun offers an ideal energy source, unlimited in supply, inexpensive, which does not add to earth's total heat burden and does not produce pollutants. Solar energy is so abundant that, with a collection efficiency of only 10%, less than 5% of the United States surface area could provide the country's energy. needs. The major disadvantage is that sunlight is diffuse and intermittent. The necessary technology for harnessing and storing solar energy is expensive at present. But with rising fuel prices and the end of petroleum deposits in sight, the economic balance is bound to let in favour of solar energy. For these reasons there is now considerable activity in the development of solar technology which is likely to cut down costs.

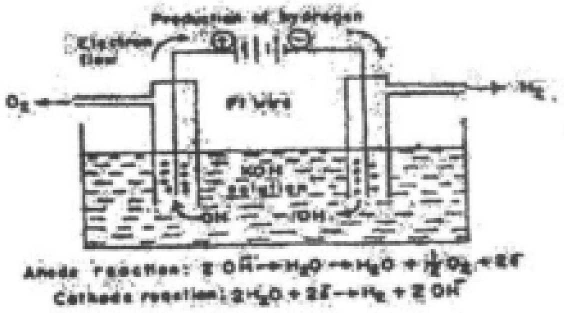
The most convenient application of solar energy is in heating buildings and providing hot water which, in developed countries like USA, consumes 20-25% of the fuel supply.

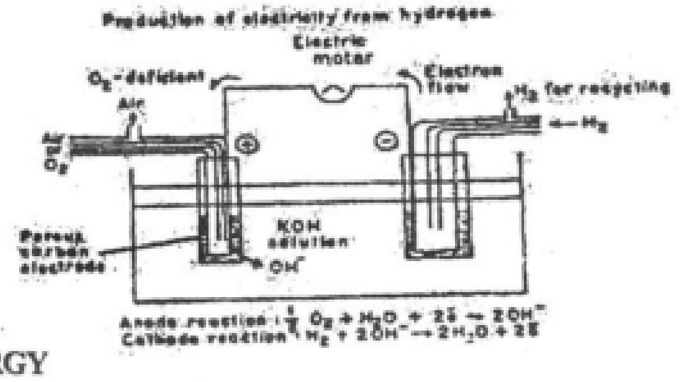
Sunlight is collected on plates in the roof and the heat transferred to a circulating water system. Sunlight may be directly converted into electricity through the photo- voltaic effect. Light is absorbed in a material with the generation of positive and negative charges which are collected at the electrodes at either side. The silicon solar cell, developed for the space programme, consists of a sandwich of n-type and p-type silicon semi conducts - the charge separation is developed acrpss the junction between them, p-type Si conducts +ve charges while n-type Si conducts -ve charges. The Si produced electricity is very costly, since high grade Si is required. With the innovation in manufacturing process and more advanced technology the prices are likely to be reduced.

HYDROGEN ENERGY

Hydrogen is a good choice among all the alternate fuel options. The chemical storage in the form of H2 is an attractive energy storage. The gas is generated directly by electrolysis of H_20. Electricity is passed between electrodes immersed in a conducting aqueous solution. H_2 is generated at the cathode and 0_2 at the anode. The energy stored in H_2 can then be converted into electricity using the reverse of the electrolytic cell, called fuel cell. H_2 is oxidized at the cathodes, where electrons are produced, and passed through the circuit to the anode. where O_2 is reduced. The overall efficiency of this conversion and reconversion is quite lower to various energy barriers connected with the electrode processes. Electrochemical research is going on to lower the energy barriers.

If energy is stored in the form of H_2, the energy transport problem would be solved. H_2 can be transported by pipeline and it is less expensive than electrical transmission over large distances. In remote area H_2 can be generated and be transported to urban centres. These considerations have given rise to the concept of the hydrogen economy in which H_2 will be the main energy currency. It can be consumed directly for electrical generation and heating and can be used to synthesize liquid fuels.





TIDAL ENERGY

The term tide is used for the periodic rise and fall of water of the oceans influenced by sun and moon. It is due to the gravitational pull on ocean water by the sun and moon. Tidal flow consists of the vertical motion of the rise and fall of water level and a horizontal movement in the tidal currents towards and away from the shore.

Tides and wave contains large energy. Hydroelectric plants can work using tides and waves. During high tide, the height of the tide, is above that of tidal basin and the turbine units operate and generate power. During low tide the height of the tide is lower than that of the tidal basin and water is allowed to flow out to drive the turbine unit. The turbine unit does not operate if the tide level and the basin level are equal.

The total global tidal energy potential is around three million mega watts, out of which India can generate 40000 MW from its coastlines. In 1966, France constructed the first major tidal plant for electrical generation. In India the prospective sites are Gulf of Kutch, Sunderlands, Lakshadweep Islands and Andaman and Nicobar Islands. India could intensify work on OCEAN THERMAL ENERGY CON-

VERSION (OTEC) and wave energy. Total OTEC potential in India is about 50,000 MW. India will be the first country to have a power plant OTEC technology. A 100 MW floating station is set up in Tamil Nadu. This (Rs.750 crore) plant will be precursor to a series of six plants that are likely to be set up in the country along different coast lines.

Wave Energy

Artificial bays on the beach can effectively be used to generate power from wave energy. A wave reflector has been developed in Australia for this purpose. The reflector consists of a large parabolic bay that focuses a wide front of waves onto a single point. The principle is the same as used by satellite dishes to transmit radio and television signals to a receiver. A chamber has been used over the focus. The other end of the chamber is a turbine. When the waves reach the reflector, they are concentrated and amplified. After being hit by the waves the turbine spins in only one direction. A 40m x 20m parabolic bay can produce nearly 250 KW of energy everyday.

WIND ENERGY

Moving air is known, as wind. The wind has energy. The energy is because of its high speed. Wind energy emerges as the most advantageous alternate energy. Wind energy involves no harm to the environment. Wind power station consumes no raw material and does not give off waste gases or waste materials. It is a cheap source of energy, technologically simple to manage and environmental friendly. In India, the wind power is of great significance as there are large' coastal, hill and desert areas where wind energy can be usefully exploited. Present day wind technology can be broadly classified into three types.

a. Wind pumps, which use mechanical energy derived from the wind energy.

b. Wind energy generators (WEG) which convert wind energy into electricity with the help of turbo generators.

c. Wind-electric battery chargers which produce electricity and store it in batteries.

The harnessing technology of wind energy is simple. The strike of the blowing wind on specially designed blades of a wind mill's rotor causes both to rotate. This rotation, which is the mechanical energy, when coupled to a turbine, drives the power generator. The wind energy thus delivers on the' spot, small quantities of energy which is free from pollution and environmental degradation. An ideal wind speed is to be in the range of 4.0 to 25 m/sec. The Indian sub continent is a high wind speed zone with energy potential of 20000 MW. Wind power generators are installed only in identified windy areas. Power transfer from the place of generation to the consumption point through the state grid is known as wheeling. The power generated by the wind mill is fed to the grid at the site and an equal quantity can be drawn by the owner from the grid at the place of choice within the state. The electricity board charges 2% for such wheeling. A wind power generator of 200 KW / 250 KW generates at an average of 6-7 lakh units annually, depending upon the wind velocity.

Denmark, Spain, Germany and USA have emerged as leaders in wind energy development, the European Wind Energy Association has set a target of 40,000 MW by 2010 and 1,00,000 MW by 2020. Within the developing countries, the largest wind industry is in India. The Washington based World Watch Institute (WWI) recognizes India as Wind Super Power. In terms of total installed capacity, India ranks fourth in the world after Germany, Denmark and United States.

Large areas having annual average wind speed in excess of 20 km /hr are available in Tamil Nadu, Andhra Pradesh, Kerala, Karnataka and the coastal areas of Gujarat and Maharashtra. High wind potential of the order of 3000 MW has been observed in Thoothukudy, Tirunelveli and Kanyakumari districts of Tamil Nadu. Muppandal in Kanyakumari district has the highest wind speed. After Tamil Nadu, Gujarat comes next in wind energy generation, when the potential areas are Mandvi, Okha, Okha Madhi, Navi Bander, Dhank and Kukma.

VERMICOMPOST FERTILISERS

Vermi means earthworms and culture means farming. Vermiculture means farming of . earthworms. Earthworm is one of the greatest forces of the nature in the continuous renewal and maintenance of the "all important top soil layer" upon which all life depends.

In 1881, Charles Darwin wrote about earthworms, "It may be doubted if there are other animals, which have played so important a part in the history of the world as have these lowly creatures". He further said, "the plough is one of the most ancient and most valuable man's inventions; but long before it existed, the land was regularly ploughed, and still continues to be thus ploughed by earthworm".

There are about 3000 varieties of earthworms. They have been formally classified into main three types, based on their life styles and burrowing habits. They are Aneciques, Endoges and Epiges.

Vermi composting is the process of converting organic waste into vermin-compost fertilizer through the action of epigeic earthworm species. Before the worms can digest the waste, partial decomposition is essential. The mesophilic and thermophilic stages where heat is generated in the compost pile can destroy the worms. Once these stages are passed, the pile cools down and worms can be introduced.

Vermi compost is the cast or excreta of epigeic earthworm species which have been cultured on animal dung and other organic wastes.

The worm's gut is like a bioreactor in which a number of different microbes reside. These enhance soil fertility. More important, an earthworm's blood shows a much greater affinity for oxygen than human haemoglobin. This creates a high oxygen atmosphere within the worm, and microbial activity is stepped up : the microbial density in the worm's gut is about 1000 times greater than that in surrounding soil.

Vermi composting technology can be used for urban and rural waste recycling i.e. conversion of organic waste into manure. This manure Can be used in agriculture, horticulture etc. or as an inoculum for improving and maintaining soil fertility. A few species of earthworms are used for the treatment of industrial wastes. Earthworm polycultures are used for improving soil quality by turning and mixing of the soil. Earthworm protein can be used as feed for livestock.

There are two methods for producing vermicompost. They are ***Pit*** or ***Container method and Heap method.*** There is no significant difference in the quality of the manure produced by either ofthese methods.

BIO-FERTILISERS

Bio-fertllizers are important components of integrated Nutrient Management. Biofertilizers such as Rhizobium, Azopirillum, phosphate bacteria, blue green algae etc., are renewable and environment friendly. These are presently being used in quantities between 8 to 10 tons per year. One ton of bacterial fertilizers covers about 1000 hectares of cropped area with the potential of supplying 25-30 kg nutrients per hectare.

Rhizobium bacteria are important bio-inoculators. Almost 40 m ha. are cropped to legumes which have a mutually beneficial or symbiotic association with rhizobia. Under good growth conditions, rhizobia can fix up to 300 kg nitrogen per hectare per year. Rhizobium is effective for leguminous crops.

Azospirillum bacteria are growing very near the roots. They are found near roots and hence nitrogen is supplied to the plants easily. These bacteria are also nitrogen-fixing type. Azospirillum helps in nitrogen fixation and supply to crops like wheat, paddy, maize, cotton, sugarcane, fruit crops and vegetables. Azospirillum can be mixed with the seeds, or the saplings can be drenched with Azospirillum solution, or it can be applied in the field prior to seeding or sapling or it can be applied in the nursery.

Phosphate bacteria or phosphate solubilising bacteria help in making available soil phosphorous to the plants. It helps to have healthy tissues, reproduction, and good yield. These bacteria convert non-available and insoluble phosphate into soluble phosphates and thus help the plants to uptake them.

Blue green algae (BGA) are the potentially important fertilizers for wet land rice cultivation. It can be grown as green manure while the inoculum of blue green algae is less bulky and easy to handle. Blue green algae supply not only nitrogen to the crops but some amino acids also.

****

UNIT - V

ENVIRONMENTAL RESTORATION

Waste is a valuable raw material located at a wrong place. It can be converted into useful products. Any country with limited resources should not ignore any kind of resource material. National waste can contribute significantly towards national wealth. Wastes are of various types. For example,

1. ***Agricultural and Forestry Wastes*** - These include non - edible oil seeds, wastes from fruits and vegetables, rice husks, tea waste etc.
2. ***Animal wastes*** - These include slaughter-house wastes, animal carcasses, fishery wastes, leather and wool wastes etc.
3. ***Industrial and Mineral wastes*** - These include bagasse and press mud from sugar factories, blast furnace slag, coal ash, fly ash, mica wastes, metal scraps, wastes from pulp, paper mills, distilleries etc.
4. ***Community wastes*** - These include wastes including sweepings, garbage, kitchen waste, night soil, etc.

WASTE DISPOSAL AND THEIR MANAGEMENT BY CHEMICAL AND BIOLOGICAL METHODS

With rapid industrialization, urbanization and population growth, the waste management becomes an ordeal. Dumping the waste as a waste has two fold negative implications. On the one hand, it pollutes the air, water and the land resulting in diseases and destruction of human habitat, on the other hand it deprives us of a powerful resource material for producing energy, electricity and manure etc.

Municipal solid waste (MSW) is a problem due to urbanization and urban migration. About 40% urban population is poor and live in slums or footpaths without basic amenities and sanitation facilities.

Our country's population has been estimated to be 1250 millions by 2015. The urban population is expected to group 470 millions by 2015. Urban solid waste management is going to be a tough problem to our country.

The piles of urban solid wastes are growing at a faster rate. Solid wastes from Indian cities contain high proportion of organic matter and also have high moisture content. The food contents attract flies and rodents. The decomposition of waste causes foul smell.

Indian MSW has huge hidden energy potential that can be harnessed by making use of suitable technologies. Keeping in view the power potential from municipal solid waste, the Nonconventional Energy Development Agency (NEDA) has been chalking out programmes to generate power from MSW.

Analysis of waste samples collected from various parts of India gave the following composition of the waste.

Vegetable / Compostible matter	:	50 - 65%
Sand / Fine earth	:	30 - 40 %
Paper / card board	:	5.25%
Metals	:	0,6 - 1.0%
Plastic items	:	0.6 - 0.9 %
Glass, ceramics etc	:	0.1 - 0.7%

Major parts of the plastic, paper and metallic contents are taken away by rag pickers and used for recycling. The final disposal of wastes can be carried out by several methods such as sanitary land filling, incineration and composting.

In developing countries the most common practise is uncontrolled dumping. The capacity of existing dumps has reached its limits with the rapid growth in population. Rapid industrialization hardly leaves places for dumps.

Another technique is incineration. Incineration lets out dangerous carcinogens like dioxins, furans etc. They cause foetal and reproductive damage also.

Incineration has now been blamed for its devastating side effects, including releasing of a cocktail of pollutants into the atmosphere. Another major problem is the disposal of incinerator ash, which contains, bottom ash as well as fly ash. This ash is highly toxic because of the presence of heavy metals, dioxins and furans. If the ash is dumped into landfills, it will result in ground water pollution because of leaching. In Chennai at the Akash Colony in Anna Nagar, an eco-friendly incinerator has been commissioned. The equipment costs about Rs.20000/-.

Composting is another technology. It involves a process of biological degradation where the presence of oxygen leads to organic wastes being converted into CO_2 and compost. ***Biogas*** production is an alternative method successfully used in India.

An ***anaerobic digestion*** process based on biotechnology has also been developed to treat the solid waste and produce methane and organic manure. The process consists of five phases.

1. Pretreatment and segregation
2. Anaerobic digestion
3. Recovery of organic manure
4. Effluent treatment and disposal
5. Power generation

First, wood, stones and other inorganic solids are separated by hand picking. The refuge is then washed with a stream of water. Organic matter along with fine particles of sand is pumped into the anaerobic reactor in the form of a slurry, where the organic matter undergoes anaerobic decomposition and biogas is produced. The effluent from the reactor is subjected to dewatering. The solid waste coming out from the reactor contains stabilized organic matter with biomass. These solids can be used as environment friendly organic manure because they have excellent fertilizer value. The effluent is subjected to aeration that renders it harmless and suitable for disposal. The biogas thus produced contains 55-65% CH_4. About 150 tons of solid waste has been found to produce 14000 cubic metres of biogas which can generate 1.2 MW of power and 45 tons of organic manure.

Vermiculture is also another bio-technique for converting the solid wastes such as sewage sludge, domestic waste or agricultural waste into compost.

Recycling is also an eco-friendly technique through which waste can be converted in wealth.

Reclamation of wastelands is done through landfills and composting. The domestic and industrial wastes are embedded within the sub-soil surface layers of wastelands. The compost is formed which increases the soil fertility.

RECYCLING

Conservation of resource is generally known as recycling. A product at the end of its life is converted into another useful product. The process of creating a new product from the waste is also extremely efficient, producing virtually no waste or unwarranted by product.

The advantages of recycling are,

a. It reduces our reliance on landfills and incineration.
b. It protects our environment and our health
c. It conserves natural resources

Once our society had been a throw away society, now slowly it is becoming a sustainable society. In UK the major campaign is Warmth. and Energy from Refuse. The energy thus obtained is known as ***Dustbin Energy***. Refuse derived fuel (RDF) is also becoming common.

Wealth from Agricultural Waste:

1. Microcrystalline cellulose (MCC) can be used for making clothes, paper and food. A new method of preparing MCC from groundnut shells available in plenty in India has been developed. 6 kg of groundnut shell can produce 1.5 kg of MCC.

2. Agricultural cellulosic wastes such as bagasse, corncobs alfalfa etc., can be converted into glucose.

3. Indian Plywood Research Institute, Bangalore has developed a technology for manufacturing boards from rice husk. This board is resistant to termites and has high decay resistance. It is resistant to fire, water and durable.

4. Tomato and Potato peels can be used in making adhesives.

5. Waste eating microbes can be used for decomposing dead leaves, household vegetable and fruit wastes etc and converting them into fertilizers.

6. Jute fibres and wastes are used by Calcutta based Jute Research Institute to make special papers and boards.

7. Jute fibres and wastes are used by Calcutta based Jute Research Institute to make special papers and boards.

8. Furfural which is produced commercially by the reaction of corncobs with sulphuric acid, is the basic material used for the synthesis of nitro furans, which are important germicides used for cattle diseases. Bacteria causing typhoid, gastro-enteritis, diarrhoea can be controlled by nitrofurans.

9. Zein, left over when corn is turned into ethanol can be converted into plasticised resins.

7. A UK based company ICI is making paint from starch derived from wheat, potatoes and maize.

8, Banana leaves can now be converted into the energy rich fuel. There are two methods for the purpose. One method known as pellitisation or briquetting involves crushing banana leaves into powder and adding a binder to convert into fuel pellets. In the second method known as biomethanation, leaves are digested by anaerobic process in the presence of methane producing bacteria to produce methane.

WEALTH FROM PLASTIC WASTE

1. A firm in U.K is making fuel from dirty, mixed plastic-wastes which is the hardest of all waste products.

2. A plant in Bottrop in Germany has developed a technology of converting assorted plastic wastes into oil.

3. Honda, the Japanese company is going to produce floor tiles and decorative housing materials from deformed plastic components.

4. The Brasher Boot Company, a British concern makes jacket from recycled polyethylene terephthalate (PET) a plastic used in soft drink bottles. Except the zip and the thread the rest of the jacket is made from recycled plastics.
5. A Company in France makes yarn from recycled mineral water bottles.
6. Tons of plastic cups are collected from beverage vending machines and pulped and manufactured into pencils with lead inside. Rulers, note-trays and ball point pen casings can also be made from used plastic cups.
7. Nissan Motor Company of Japan is going to recycle PET bottles for use in vehicle sound absorption material. Five bottles will be enough for sound insulation for one vehicle.

WEALTH FROM FLY ASH

1. Central Fuel Research Institute, Dhanbad is utilizing fly ash to make building blocks.
2. In South India fly ash is used for making bricks and cement. Fal-G made from fly ash, lime and calcinated gypsum is cheaper than conventional clay bricks.
3. Scientists from RRL, Bhopal developed Fly Ash Jute Reinforced Polymer from fly ash, natural geo-fibre and a polymer called acrolite - 572.

WEALTH FROM MISCELLANEOUS WASTES

1. Central Leather Institute (Chennai) and RRL in Trivandrum have developed a technique to convert chrome sludge into bricks.
2. An Indian Scientist suggests tube lights can be used to purify drinking water.
3. Gandhigram Rural Institute has developed a technology to convert used bulbs and tube lights into conical flasks and chemical apparatus.

CONSERVATION OF FORESTS

A plant community predominantly of trees and other vegetation usually with a closed canopy is called forest. The word jungle is used to describe a collection of trees, shrubs etc. that are not grown in a regular manner.

Importance of forests

The forests of a country make a natural asset of immense value. Forests are the sources of timber, wood fuel, bamboos, medicinal plants etc. They guard against soil erosion, floods and damage of watersheds. They provide shelter to wild life. The forest cover lowers the maximum temperature and raises the minimum temperature.

There are more than 15000 known floral species in India. As many as 328 families of plants are found in India.

Essential oils are obtained from a variety of forest plants. Drugs, camphor, spices, poisons, insecticides, dyes, gums, resins etc are some of the important products from the forest. Plants-derived medicines are worth 40 billion dollars the world over.

One of the most effective ways of preventing global warming is to plant more trees and that too in huge quantities. The main green house gas CO_2 is converted by trees in to life saving oxygen through the process of photosynthesis. In fact trees are the ideal sinks to trap CO_2. Carbon dioxide depletes the ozone layer also. Thus trees protect the ozone layer by consuming CO_2.

Forest Cover

The total forest area of the world was estimated to be 7000 million hectares in 1900. By 1975 it was 2890 million hectares. If the trend continued it may be 2370 million hectares by 2000. The major reduction is in tropics and sub tropics because of rapid growth in population in this area. The tropical rain forest was 1600 million hectares in 1900 and 940 million hectares by 1975. In India around 3000 BC about 80% of the country was covered by forests. Now it is reduced to 22.7%. The National Forest Policy recommends the forest cover should be 33%. Visual interpretation of Land-sat imagery showed the forest cover is 19.4%. Area with dense forest is only 11.7%. The forest cover of our country is 640,107 km^2 (19.4%).

Deforestation

Indiscriminate felling of trees, is a worldwide phenomenon. A forest of the size of Cuba is being destroyed every year. But no one can escape from the adverse effects of deforestation. The main reasons for deforestation are,

1. Over population
2. Increased timber requirements
3. Increase in agricultural crop lands
4. Construction of dams, power stations, roads, railways etc.

During colonial period, teak was exported to Britain. Pines were exported for making railway sleepers. Before political colonization, the British colonized our forests. Virgin forests of Doon Valley were cleared for British settlers. Horticulture is also responsible for the deforestation in India.

Delhi's forests are shrinking at an alarming rate. Muthupettai (Tamil Nadu) has lost a total mangrove area of 12,425 ha. for prawn culture. Himalayas is under serious threat of being wiped out. in near future.

Conservation of forests

Conservation is the most efficient and most beneficial utilization of natural resources and is one of the most significant applications of ecology. Conservation is mainly concerned with the management of the natural resources of the earth, preservation and protection from destructive influences and misuses etc.

The important measures that can be taken for the conservation of forest are :

1. The trees, if cut down for timber or other uses, should be matched with planting more trees.
2. The use of fire wood and wood charcoal should be discouraged. Biogas plants and chulhas may be popularized.
3. The rate of reforestation should be much greater than the rate of deforestation.
4. Social forestry programmes should be undertaken seriously. Thus wastelands can be properly utilized to produce firewood, fodder etc.
5. Afforestation should be undertaken in a big scale.
6. The agro-forestry programme should be encouraged.
7. The urban- forestry programme in which small gardens, kitchen gardens and maintaining fruit trees and flowers in house compounds should be encouraged.
8. Big trees and trees of aesthetic value should be planted along the roads,
9. Regeneration and tending of forest crop should be adopted.

Mining and construction of mega dams also contribute to deforestation, in large scale. They also cause the loss of flora, and fauna and dislocation of the tribal people. Instead, large number of smaller dams can be constructed.

Large scale planting of trees in deserts can be done employing the Jaltripti device designed by Central Arid Zone Research Institute, Jodhpur.

The population growth is to blame for 80% deforestation in India and Africa. Forestlands are converted to agricultural lands, roads, buildings etc., to meet the growing demands due to growing population. Population control is a must for earth.

Forest conservation programme can made more effective by educating the public and enacting stringent laws against unmindful deforestation.

CONSERVATION OF WILD LIFE

A wild animal is one that lives without the help and care of man

Eg. Lions, Tigers, Leopard, Bears, Monkeys, Elephants, Fox etc.

According to ecologists, both .animals (fauna) as well as plant. ,flora) are included in wild life.

Indian wild life is incomparable in its variety. In India there are more than 120 families of vertebrates. There are more than 400 species of mammals, 1200 species of birds, more than 350 species of reptiles and more than 29,70,000 species of insects.

Knowledge of animals is a part of our culture. Wild life plays an important as well as vital role in unraveling many mysteries of nature. Wild life is the soul of man and it renders him a healthy environment. They maintain nature's balance very effectively and that too at no cost.

Reasons for depletion of wild life

1. Tall grasses, forest vegetations etc. those are used by wild animals as their shelters and covers are destroyed by man.
2. Deforestation for cultivation, construction of dams, power stations, highways, railways etc. which reduces the area for the free movements of wild animals.
3. By destruction of wild· plants, man is depriving the wild animals of their food. Uncontrolled grazing by domestic animals in the forests also deprives the wild animals of their usual food.
4. Noise pollution adversely affects the wild animals
5. Polluted river water and other water bodies also affect the wild animals.
6. Natural calamities such as flood, drought, epidemics, fire, earthquake also affect the wild animals.
7. Poaching is another major cause of depletion of wild life. The worst victims of poaching are elephants, tigers, musk deer, rhinoceros etc.

EFFECTS OF, WILDLIFE DEPLETION

The death of even a single animal or the damage of even, a bunch of grass disturbs the ecological balance of nature. Man cuts tall, grasses for himself. These destroy natural habitats of various animals and food for herbivores. As a result herbivores die of starvation. Carnivores die due to lack of shelter. When the herbivores population shrinks, the predator species suffer. In the absence of natural prey the predators either die or turn their attention towards the cattle and man in the inland.

WILDLIFE CONSERVATION

Conservation of wild life is an essential part of environment. Wild life management is very old in India. Vedas contain hymns in praise of animals. They have linked some animals with the specific God or Goddess as the best way of conservation of wild life. Snake has been associated with Shiva, swan with Saraswathy, lion with Parvathy etc. Chanakya imposed heavy penalties for killing birds, deers etc. Mughal emperors created hunting reserves, called "Shikar Gaha" for the protection of game animals. During 18th and 19th centuries the British rulers and some Indian princess caused ruthless destruction of Indian wild life.

Law should be passed to protect the endangered species and severe punishment should be given to those hunters who indulge in illegal and senseless killings and the poachers who hunt them out for personal gains. Natural habitat of wild animals should be carefully protected. Veterinary efforts should be made in order to save wild animals from epidemics. Public should be educated about the advantages of wild animals. Research on wild life should be encouraged in order to know better about the biology and behaviour of wild animals.

In our country so many projects have been launched to protect the wild life.

Eg. Project Tiger, launched on 1973

Project Elephant, launched on 1991

Gir Lion Project (1972)

The Crocodile Project 1975 etc.

THE STATE OF GLOBAL ENVIRONMENT

Population and Health

World population doubled in 40 years between 1950 and 1990 to cross five billion. The developed countries account for 1.5 billion and developing countries 3.5 billion. By 2010 the population will grow to 7 billion. World population is growing by 92 million each year.

Population in the developed countries is growing by 0.5 per cent per year and in developing countries by 2.0 per cent per year. Infant mortality is one of the most tragic indicators of poverty. There are still 34 developing countries where more than 1 in 1 0 infants die. In these countries, one in three children is malnourished, 1.2 billion people lack safe water, 3 million children die annually, 1 million women die each year, 1 billion adults cannot read or write and more than 100 million children of primary school age are not in school.

WATER

Because of rapid industrialization and growing urbanization most of the water bodies are polluted. No country can escape from this blame. In 1990 nearly 1 billion people were without access to safe drinking water while in 2010 this number may rise to 1.5 billion. In developing countries 60 per cent of population belongs to this category

The maximum demand for water is in industrialized countries those practise irrigation. An average North American uses 70 times more water than an average African. Agriculture consumes 60 per cent of water; 23 per cent is used by industry and domestic uses account for only 8 per cent.

In developed countries water pollution is mainly caused by industry and agriculture. Nitrate levels in the European rivers monitored by GEMS (UN Global Environmental Monitoring System) are, on average, 45 times higher than in unpolluted rivers. Phosphates and pesticides also cause widespread pollution, which is not confined to pesticide levels, in some Tanzanian, Colombian and Malaysian rivers and are higher than those found in Europe.

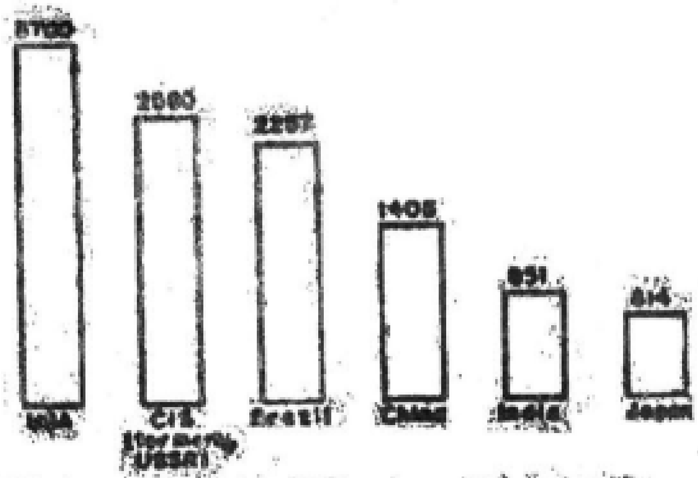
Another important issue is the widespread degradation of aquatic habitats; the coral reefs are among the more vulnerable ecosystems. Recent studies have revealed that due to water pollution and damage from fishing activities, the reefs in 90 out of 190 countries had degraded. In Philippines which shelters the world's most diverse reefs, only 6 per cent of the reefs are in good condition.

Coastal marine pollution is indicated by the spread of algal blooms, oil pollution and a decline in the quality and quantity of marine food. More than half the people of developing countries obtain more than 30 per cent of their protein from marine fish. Sewage and nitrate fertilizers are responsible for algal blooms known as red tides. These deplete the water of oxygen, producing "dead-zones". One such zone, of 4000 km^2 has been observed near the mouth of the Mississippi. Some red tides include algae which produce toxins; Japan's Inland Sea now suffers from some 200 toxic red tides each year.

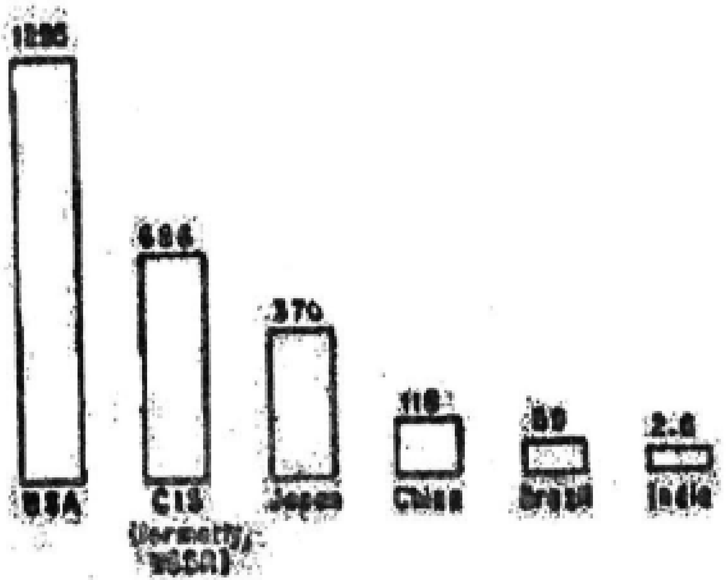
AIR

There are four notorious air pollutants : oxides of sulphur SOx emitted by power stations and industries; oxides of nitrogen NOx emitted by power stations, industries and vehicles; CO emitted due to incomplete combustion by vehicles; and soot and dust, known as suspended particulate matter (SPM) resulting from combustion of fuels.

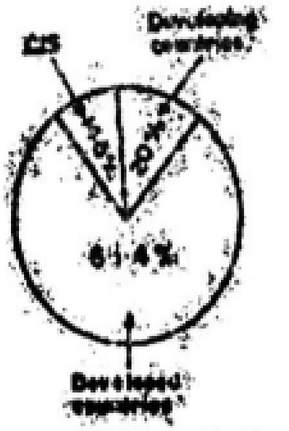
Developed countries have started to act and invest heavily to protect their atmosphere. Consequently emissions of SOx in these countries reduced from 65 to 40 million tons a year over the last two decades. But these emissions have increased in the developing countries from 48 to 59 million tons.



Green house gas emission, in million tons CO_2 by different countries



CFC Consumption in million Tons of CO_2 by different countries



Regionwise share of CO_2 emission

GEMS after monitoring 75 countries reports that the air quality was acceptable in 27 cities, marginal in 11 (London, New York, Hong Kong etc) and unacceptable in 16 cities (Madrid, Paris, Rio de Janeiro). Dust and soot levels were acceptable in 8 cities, marginal in 10 and unacceptable in 23 cities (Bangkok, Rio de Janeiro, Tehran etc). Among Indian cities Kolkota has the worst 'record of air pollution followed by Mumbai.

According to GEMS" report about 900 million urban residents are exposed to unhealthy levels of SOx and more than one million people are exposed to dust and soot

In Europe and USA acid rain is common. Thousands of lakes have been ruined, and aquatic flora and fauna in these lakes have been destroyed in USA, Canada, Scandinavia and Scotland. This Pattern is emerging in Brazil, China, India, Jamaica and Zambia.

LAND AND TREES

Annually 25 billion' tons of topsoil is lost from farmland by erosion.' In. USA cropland loss is 44 per cent due to soil erosion. In El Salvador 77 per cent land is eroded. Nepal has lost 38 per cent of its fields due to land degradation.

Dry lands that cover 47 per cent of the world's land area are 'the worst victims of soil erosion. The loss of crop land has ruined the lives of hundred of millions of small scale fanners. Forests are vanishing at the rate of 16.8 million hectares a year. Millions of people have been forced to leave their homes in Central America, the Caribbean, Africa, Asia and Java due to deforestation.

The dense Amazonian forests of Brazil, the massive timber ranges of Malaysia, the bush jungle of Ghana, the Himalayan forests are being denuded. Deforestation in the hills causes avalanches and flooding in the plain during monsoon. When the Himalayas were dense, Bangladesh. suffered. a major flood about twice in a century - now the frequency is one in four years. . Deforestation is responsible in the increase in $C0_2$ level that contributes to global warning.

Species at risk

Forests are important. bio-reserves. Most .of the 1700 million hectares of tropical forestries in bio diversity are located in poor' countries. They cover only 7 per cent of the land surface, but they nurture 50 per cent. of the world's flora and fauna. In a 15 hectare patch of rain forest in Brunei, 700 species of trees have been identified, the number being the same as in the whole of North America. .

There are about 30 million species on Earth, of which about 1.5 million are on record. Of this 750,000 are insects, 41000 are vertebrates and 25000 are plants; the rest are invertebrates, fungi and microorganisms. Most of the species .are found near the equator. Species diversity is at its peak in tropical forests and coral reefs. India has more than 120 families of terrestrial vertibrates, 400 species of mammals, 1200 species of birds and nearly 30,00,000 species of insects.

In three decades about 25 per cent of the Earth's species may become extinct. Another 20 per cent of the species may be eliminated by 2020. The important reason is deforestation. When varieties of plants or animals are destroyed, the genetic diversity within the species also is reduced.

Industry, Energy and Waste

Industries consume 37 per cent of the world's energy and emit 50 per cent of the world's C02, 90 per cent of SOx and almost all the hazardous chemicals. Every year industries produce 2100 million tons of solid waste and 340 million tons of hazardous waste. In developing countries big as well as small industries discharge waste untreated.

Radioactive waste is another concern. The earth has a stock pile of 1 million tons of highly potent radioactive wastes.

The average person in a developed country consumes 15 times more energy than the man in a poor country.

TRANSPORT

Over the past two years the length of motorways nearly doubled in developed countries. Transport consumes 30 per cent of world's energy and produces 60 per cent of CO, 42 per cent of NO x and 40 per cent of hydrocarbon.

But there is hope for new cleaner road transport. One third of Brazil's cars run on Pure ethanol. In several countries natural gas is being used. In Italy alone 3 lakh cars run on natural gas. Use of unleaded petrol has curtailed lead emission by 87 per cent.

Conclusion.

In 1971 when Edgar Mitchell flew to the moon on board Apollo-14, his first glimpse of earth from space sent him into rhapsody. "It looks like a sparkling blue and white jewel ... laced with slowly swirling veils of white ... like a small pearl in a thick black sea of mystery".

Twenty one years later i.e. in 1992, if Mitchell was sent back into space, even with special spectacles that allowed him to see the invisible gases of the earth's atmosphere, a vastly different sight would greet him. He would see giant punctures or holes in the protective ozone layer over Antarctica and North America. Seeing the dirty clouds of CO_2 and $S0_2$, diminished green cover and filth on water, he would have radioed back, "What on Earth have We Done".

THE EARTH SUMMIT, 1992

The global concern led to the holding of the first UN conference on Human Environment from June 5 to June 10, 1972 at Stockholm which set up the ongoing United Nations Environment Programme (UNEP). The United Nation Conference on Environment and Development (UNCED) or the Earth Summit at Rio de Janeiro. the capital of Brazil, from June 3 to June 14, 1992 marks the 20th anniversary of

Stockholm Conference and the founding of the UNEP. This was attended by 40,000 delegates including 150 heads of states, 7000 media persons, 1200 women, a large delegation from industries, thousands of officials, and 20000 NGO (Non Government Organisation) representatives.

The impact of Science and Technology on environment in the post industrial revolution period has been assessed over the last two decades. Now environment has become a major foreign policy issue .. Earth's ecological ills cannot be treated as separate from issues such as foreign debt, trade, unemployment and inequality. The developed and developing countries were divided on the issue .as to who should pay for cleaning up the ecological mess that the earth faces.

The nations realigned themselves into North-South environmental blocs. China, India, Pakistan and third world nations united under the group 77 banner while the developed countries -grouped under the group 7 or the Organisation of Economic Co-operation and Development (OECD). The Chinese representative expressed the feeling of the South Bloc: "The developed countries are the major polluters and they must accept moral responsibility and pay for it". The logic is very clear. The North has been able to achieve a higher GNP (Gross National Product) largely by abusing non-renewable natural resources to sustain an extravagant life style. The North has only 16% of world population, but consumes 60% of world's food, 70% of world energy resources and 80% wood.

The North Bloc is of the opinion that poverty and population explosion in the South are the major causes for the earth's degradation.

The North and South Blocs blamed each other for the present ecological mess.

Issues that divided North and South at the Earth Summit

Issue	North	South
Greenhouse Gas Emissions	Want a 20 per cent cut in green house gas emissions by 2005 and also a.major shift from use of coal and wood for energy.	South blame the North for excessive emissions over last 50 years and want them to reduce it. Opposed to any cut in its own emission as it affects their development.
Forests	Want a legally binding convention that severely restricts deforestation especially in the tropical countries which are rich .in biodiversity	Opposed to ban on deforestation as it would encroach on their national Sovereignty. The North must compensate for conservation and share profits if species are used for research .
Population	Population explosion and poverty major causes for deforestation	Blame the North for over consumption of resources. The

	and water pollution. Want steps taken to control population	North is responsibel for consuming 60 percent of world's energy resources
Technology transfer	Technology development is commercial and those who want to utilize it must pay for it	Want technology transfer cheaply for cleaning up the polluants and for improving energy efficiency.
Finance	Dislike mandatory contribution Existing UN mechanisms, viz Global Environment Facility (GEF) or World Bank should be used to distribute aid	Want firm commitments on aid for environmental issues. Insist on a new institution whose functioning is transparent and democratic
Degradation	Admit that industrialization process caused it but don't want to pay for polluting the earth in the past.	North is responsible for all the pollution in the past. Must pay for the entire cleaning up process

The summit didnot yield the desired result, namely signing of two treaties at the summit

1. Curtailment of green house gas emission by 20 per cent by 2000.
2. Conservation and management of biodiversity.

USA which accounts for 22 per cent of $C0_2$ emission was unwilling to accept any target date. For all nations it would change their economy and industrial agenda. South Bloc viewed any limitation on their $C0_2$ emission as a check to their economic progress. Germany had unilaterally committed itself to a 25 per cent cut in $C0_2$ emission by 2005.

Because of bitter controversy, the second treaty on biodiversity could not be signed. This treaty meant an agreement to preserve the living natural resources - plants, animals, microbes with options to use the resource for human welfare through the frontiers of biotechnology. The gene-rich countries (South Bloc) in the tropics are poor but willing to share their enormous biodiversity and want a share' of biotechnology. But the technology - rich countries (North Bloc), particularly USA, were not willing to share their biotechnology. The Biodiversity Treaty was finally signed by 167 nations with some amendments in December 1993.

The UNCED Secretariat, was keen for the implementation of Agenda 21. Agenda 21 was an action plan to tackle all the major environmental and developmental problems confronting the South. The cost was estimated as 625 billion dollars annually. The South already spends 200 billion dollars annually on such activities but must raise' 300 billion dollars from their' own resources. UNCED expects rich countries to contribute 125 billion dollars annually. They already spend 50 billion dollars on foreign aid and will now have to enhance the amount by 75 billion dollars. But no such commitment was forthcoming. The North has set up the Global Environmental Facility (GEF) with an initial corpus fund of 1 billion dollars 'to tackle urgent environmental problems like global warming, ozone depletion and conserving forests. The fund will be administered through the World Bank and the United Nations Development Programme.

The Earth Summit was not successful as consensus could not be reached regarding major treaties, which were not signed by all the nations. But the summit generated worldwide interest and provided a framework for the nations to negotiate in future.

Participation of Voluntary Agencies in Environmental Protection

The number of voluntary agencies, community groups, academic societies and corporate entities (Non Governmental Organisations - NGOs) involved in environmental protection has increased considerably in the last few years. Green Peace an organization involved in environmental issues is becoming popular and powerful throughout the world. This organization is very active in many European countries. In our country also there are more than thousand non governmental organizations interested in environmental issues.

CHIPKO MOVEMENT

In 1960 from the point of view of border security a vast network of road was constructed in the ***Alaknanda*** catchment area in the mid-Himalayas. Projects of various types were also taken up in these areas. This led to the vast destruction of forests in the region of the Alaknanda, the main tributary of Ganga, and its feeders such as the Rishi Ganga, the Dhak rivulet, the Patalganga, the Garudganga, the Birohi and the Mandakini. Over 16,000 hectares of the catchment area of these rivers had forest cover and between 1960 and 1969 many thousand trees were cut. This resulted in upper soil erosion, devastating flood and choking of canals by silt. The common people were the victims. It was here the Dasholi Gram Sarajya Mandal (DGSM), Gopeshwar stepped in. Thus was born the Chipko movement. On April 24, 1973 this movement began in Mandal near Gopeshwar. When the Forest Department officials and contractors came to fell trees, the Chipko workers reached the forest with the local people and hugged the trees to save them ..

In 1974, the Chipko volunteers, especially women (Mahila Mangal Dal of Rini Village) embraced the trees and saved the Nanda Devi sanctuary. Later this Chipko movement was organized and implemented in Gopeshwar, Bheundar, Joshimath and Chancharidhar. The movement has been educating the local people about afforestation by organizing regular conservation camps - known as eco-camps. Voluntary agencies, students, youths and experts participate in these camps. Afforestation is done by "shramdan" by the participants. The Chipko movement stops felling trees, saves the jungle and involves people in greater issues of ecology and environment. This movement has the fortune of getting the patronage of Sunderlal Bahuguna.

APPIKO MOVEMENT

Karnataka's Uttara Kannada is known as the "forest district". The British cultivated pepper and cardamom in this district and they called this area the "pepper queen". At the time of Independence, 82 per cent of the land area of the district was covered by forests. Forest based industries were set up in this area. First came a plywood factory followed by a paper unit. Then came big dams submerging vast tracts of forests. The Forest Department continued the colonial forest policy and converted the primeval tropical forests into monoculture teak and eucalyptus plantations. In 1983-84, the area had only 20 per cent forest cover.

Topsoil was washed away, hydrology was affected, percolation didn't take place and the ecological balance was destroyed.

Villagers of Balegadde, decided to launch the Chipko movement, popularized by Sunderlal Bahuguna. Bahuguna was invited and the people took an oath to protect the trees by embracing them. Thus was born the *Appiko* movement. In Kannada Appiko means 'to hug'. In September 1983, when the axe-men came for felling to the Kalase forests, people embraced the trees and thus the Appiko-movement was launched.

Appiko activists organized padayatras, camps, folk dances and slide shows to create mass awareness. They use "Yakshagana" a form of folk dance to convey environmental message. The movement spread to Coorg, Dakshina Kannada and Shimoga districts.

The Appiko movement has three main objectives, known as ***Ulisu*** (to conserve); ***belesu*** (to grow) and ***balasu*** (rational use).

Appiko movement has created a mass awakening about conservation in South India particularly in Kannada, to save the Western Ghats.

Narmada Bachao An dolan

There is a plan to build 30 massive dams on the river Narmada, and the project is a Rs.9000 crore multipurpose one. Of these major dams, two important dams are, the Sardar Sarovar Project in Bharuch district of Gujarat and the Indira Sagar Project in Khandwa district of Madhya Pradesh. These projects could submerge almost as much area as they are meant to irrigate. Millions of people will be uprooted from their place and they have to be rehabilitated.

To oppose these projects an effective and vociferous anti-dam movement was launched by Baba Amte with the name Narmada Bachao Andolan (NBA). This movement has won the Right Livelyhood Award, popularly known as the alternate Nobel Prize for the year 1991.

To push through their anti-dam point of view, NBA activists have lobbied in India and abroad. They have petitioned the World Bank, the principal financier of the project. Now this movement gets support from people like social activist Mehta Patkar and Booker Prize winner Arundati Roy.

ANTI TEHRI DAM MOVEMENT

There is a plan to build a 260.5 metre high Tehri dam at a cost of Rs.4000 crore on the Bhagirathi in the Garhwal - Himalayas. It will generate 2400 MW electricity, irrigate 2.7 lakh hectares of lands, and help 140 industrial cities. Experts feel the project is not only unsafe, but doubt about rehabilitation, water shed management, disaster planning etc. They fear so many villages and cities will be submerged. People of this area launched an anti-dam movement under the patronage of Sunderlal Bahuguna, a famous environmentalist.

VIVEKANANDA KENDRA

Vivekananda Kendra, Kanyakumari through its unit NARDEP (Natural Resources Development Programme) is bringing out so many publications to educate the people on environmental issues. Kendra organizes camps to popularize vermiculture, biofertilisers, biogas, traditional construction methods etc.

So many organizations are actively participating in environmental work. Kerala Sastra Sahitya Parishad (KSSP), Centre for Environment Education (CEE), Ahmedabad, Tamil Nadu and Pondicherry Science Forum (TNSF and PSF), C.P.Ramaswamy Iyer Foundation (CPR Foundation) Chennai, M.S.Swaminathan Foundation, Chennai etc. are doing active service to create environmental awareness among the people.

THE ENVIRONMENT (PROTECTION) ACT, 1986 (EPA)

The State's responsibility with regard to environmental protection has been laid down under Article 48-A of our Constitution, which reads as follows:

"The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country".

Environmental protection is a fundamental duty of every citizen of this country under Article 51A(g) of our Constitution which reads as follows:

"It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

The Environmental Protection Act (1986) is a fresh enactment with a broad sweep to prevent, control and abate all types of environmental pollution and particularly lay down procedures and safeguards for manufacture and handling of hazardous substances.

According to Section 2 of E.P.A,

a. "Environment" includes water, air and land and the inter-relationship which exists among and between' water, air and land, and human beings, other living creatures, plants, microorganisms and property.

b. "Environmental pollutant" means any solid, liquid or gaseous substance present in such concentration as may be, or tend to be, injurious to environment.

c. "Environmental pollution" means the presence in the environment of any environmental pollutant.

d. "Hazardous substance" means any substance or preparation which, by reason of its chemical or physico-chemical properties or handling, is liable to cause harm to human beings, other living creatures, plants, microorganisms, property or the environment.

Power of Central Government under E.P.A for the protection and improvement of environment -

1. Subject to the provisions of this Act, the Central Government shall have the power to take all such measures as- it deems necessary or expedient for the purpose of protecting and improving the quality of the environment pollution.

2. In particular, and without prejudice to the generality of the provisions of sub-section(I), such measures may include measures with respect to all or any of the following matters, namely:

i) Co-ordination of actions by the State Government, officers and other authorities.

   a) Under this Act, or the rules made thereunder.

   b) Under any other law for the time being in force which is relatable to the objects of this Act.

ii) Planning and execution of a nationwide programme for the prevention, control and abatement of environmental pollution.

iii) Laying down standards for the quality of environment in its various aspects.

iv) Laying down standards for emission or discharge of environmental pollutants from various sources whatsoever.

ıded that different standards for emission or discharge may be laid down under this clause from ıfferent sources having regard to the quality or composition of the emission or discharge of environmental pollutants from such sources.

v) Restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards.

vi) Laying down procedures and safeguards for the prevention of accidents which may cause environmental pollution and remedial measures for such accidents.

vii) Laying down procedures and safeguards for the handling or hazardous substances.

viii) Examination of such manufacturing processes, materials and substances as are likely to cause environmental pollution.

ix) Carrying out and sponsoring investigations and research relating to problems of environmental pollution.

x) Inspection of any premises, plant, equipment, machinery, manufacturing or other processes, materials or substances and giving, by order, of such directions to such authorities, officers or persons as it may consider necessary to take steps for the prevention, control and abatement of environmental pollution.

xi) Establishment or recognition of environmental laboratories and institutes to carry out the functions entrusted to such environmental laboratories and the institutes under this Act.

xii) Collection and dissemination of information in respect of matters relating to environmental pollution.

xiii) Preparation of manuals, codes or guides relating to the prevention, control and abatement of environmental pollution.

xiv) Such other matters as the Central Government deems necessary or expedient for the purpose of securing the effective implementation of the provisions of this Act.

3. The Central Government may, if it consider it necessary or expedient so to do for the purposes of this Act, by order published in the Official Gazette, constitute an authority or authorities by such name or names as may be specified in the order for the purpose of exercising and performing such of the powers and functions (including the power to issue directions under Section 5) of the Central Government under this Act and for taking measures with respect to such of the matters referred to in sub section (2) as may be mentioned in the order and subject to the supervision and control of the Central Government and the provisions of such order, such authority or authorities may exercise the powers or perform the functions or take the measures so mentioned in the order as if such authority or authorities had been empowered by this Act to exercise those powers or perform those functions or take such measures.

Rules to regulate environmental pollution

1. The Central Government may, by notification in the Official Gazette make rules in respect of all or any of the matters referred to in Section 3.
2. In particular and without prejudice to the generality of the foregoing power, such rules may provide' for all or any of the following matters, namely:
    - a) The standards of quality of air, water or soil for various areas and purposes.
    - b) The maximum allowable limits of concentration of various environmental pollutants (including noise) for different areas.
    - c) The procedures and safe guards for the handling of hazardous substances.
    - d) The prohibition and restrictions on the handling of hazardous substances in different areas.
    - e) The prohibition and restrictions on the location of the industries and carrying on processes and operations in different areas.
    - f) The procedures and safeguards for the prevention of accidents which may cause environmental pollution and for providing for remedial measures for such accidents.

Under the E.P.A. Environment includes water, air and land.

The sources of land pollution are :

i. The unintended or incidental pollution of soil with man made chemicals.

ii. The spent material from mining, or processing etc.

iii. The discharge of sewage or waste water from urban areas on the land used for agricultural purposes, particularly that adjoining urban areas.

iv. The indiscriminate disposal of solid waste (refuse)

Requirements those are to be fulfilled under the E.P.A by persons carrying on any industry, operation etc.

According to Section 7, no person carrying on any industry, operation or process shall discharge or emit or permit to be discharged or emitted any environmental pollutant in excess of such standards as may be prescribed.

According to Section 8, no person shall handle or cause to be handled any hazardous substance except in accordance with such procedure and after complying with such safeguards as may be prescribed.

Penalties for violations under the E.P.A.

1. Whoever fails to comply with or contravenes any of the provision of this Act, or the rules made or orders or directions issued there under, shall, in respect of each such failure or contravention, be punishable with imprisonment for a term which may extend to five years or with fine which may extend to one lakh rupees, or with both, and in case the failure or contravention continues, with additional fine which may extend to five thousand rupees for every day during which such failure or contravention continues after the conviction for the first such failure or contravention.

2. If the failure or contravention referred to in sub section(I) continues beyond a period of one year after the date of conviction, the offender shall be punishable with imprisonment for a term which may extend to seven years.

Restriction the E.P.A imposes on private citizens with respect to courts taking cognizance of offences under the E.P.A. 1986.

Under this Act no court shall take cognizance of any offence except on a complaint made by any person who has given notice of not less than sixty days, in the manner prescribed, of the alleged offence and of his intention to make a complaint, to the Central Government or the authority or officer authorized as aforesaid.

Effect of Section 24 of the E.P.A with respect to other laws that also deal with environmental protection.

According to Section 24, where any act or omission constitutes an offence punishable under this Act and also under any other Act then the offender found guilty of such offence shall be liable to be punished under the other Act and not under this Act.

Notifications and Rules under the Environment (Protection) Act, 1986

Hazardous Wastes (Management and Handling) Rules, 1989

Manufacture, Storage and Import of Hazardous Chemical Rules, 1989

Manufacture, Use, Import, Export and Storage of Hazardous Microorganism Genetically Engineered Organizations or Cells Rules, 1989

Coastal Regulation Zone Notification, 1991

Scheme of Labeling of environment Friendly Products (Ecomarks), 1992

Notification on Environemental Auditing, 1992

Notification on Environemental Impact Assessment, 1994

Notification on Public Hearing, 1994

Bio-medical Waste (Management and Handling) Rules, 1998

Recycled Plastics Manufacture and Usage Rules, 1999

Notification on Dumping and Disposal of Fly ash, 1999

Noise Pollution (Regulation and Control) Rules, 2000

Under a 1992 amendment to the Environment Protection Rules, Rule 14 requires all industries to obtain consent under the Air and Water Pollution Control Acts to furnish an annual Environment Statement covering quantities of pollutants discharged, hazardous and solid wastes generated, their characteristics and pollution abatement measures to the State Pollution Control Boards.

M.Sc. DEGREE EXAMINATION, APRIL 2004.

First Year - Non - Semester . Chemistry

Paper IV ENVIRONMENTAL CHEMISTRY

(For those who joined in July 2003 and afterwards)

Time: Three hours Maximum: 100 mar

PART A - (10 x 2 = 20 marks)

Answer All questions.

1. What are the various environmental segments? Name them.
2. Account for the positive and negative lapse rate obtained in different atmospheric regions
3. How acid rain is produced? Explain.
4. Describe any one air pollution episode.
5. What is meant by defluoridation? How it is being carried out?
6. Describe the methods of preserving water samples for metal ion analysis.
7. "Plants act as indicators of soil pollution" - Justify.
8. How fuels are classified? Explain with examples.
9. Explain about the recently held earth summit.
10. What are the salient features of Environmental Act 1986?

PART B - (5 x 6 = 30 marks)

Answer All questions.

11. a) Sketch carbon cycle and explain it

(OR)

b) Write notes on earth's radiation balance.