## CYCLING OF IMPORTANT NUTRIENTS

Carbon(C), hydrogen($H_2$), oxygen($O_2$),nitrogen($N_2$),Sulphur(S) and pphosphorus (P) are the most important constituents of the body of plants and all the living beings therefore their cycles are described here.

### 1. Carbon Cycle

Carbon is the most significant element in organisms. It is recognised as next to water in their importance to vital phenomena. It is a cabohydrates, fats, proteins like important organic molecules of protoplasm. The source of carbon is the atmosphere and water. Carbon is present in atmosphere mainly in the form of carbon dioxide and thus it cycles in this gaseous phase. Though it is a minor constituent of the atmosphere (0.032%) as compared to oxygen (=21%) and nitrogen (=79%), yet without carbon dioxide no life could exis, for it is vital to the production of carbohydrates through photosynthesis in plants.

$$6CO_2 \xrightarrow{\text{light}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

The final product of photosynthesis i. e., glucose is used for synthesis of other types of carbohydrates, proteins and lipids. These compounds are stored up in plant tissues. The $CO_2$ dissolved in sea water is utilized by the marine animals like protozoans, corals, molluscs etc. for their life. In these animals $CO_2$ is converted into calcium carbonate (CaCO3) which is used for the construction of shells.

$$\underset{}{CO_2 + H_2O} \longrightarrow \underset{\text{Carbonic acid}}{H_2CO_3} \longrightarrow \underset{\text{Bicarbonate}}{HCO_3 + H^+} \longrightarrow \underset{\text{Calcium carbonate}}{CaCO_3 + H^+}$$

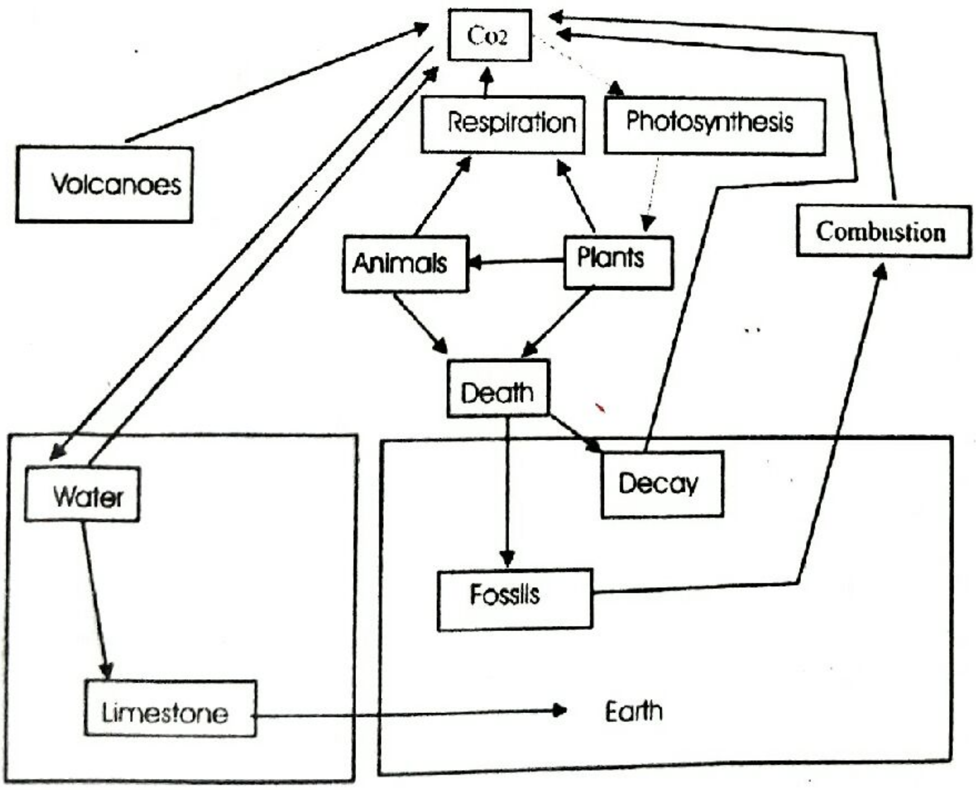



**Fig 2. 6. Carbon cycle in nature**

After the death of marine animals, limestone ($CaCO_3$) stored in the shells is either deposited as sedimentary rocks or dissolved in water to release$CO_2$ by the reversion of above said reactions. A certain proportion of carbon from plants is deposited as coal, carbon from coal returns to air in the form of $CO_2$ through combustion and weathering.

Carbon from atmospheric pool moves to green plants (producers) ,then to animals (consumers) and finally from these to bacteria, fungi and other micro-organisms (decomposers) that return it to the atmosphere through decomposition of dead organic matter. Some of this is also returend to the atmosphere, through respiration at various levels in the food chain. It is estimated that half of the carbon fixed is subsequently returend to the soil in the form of decomposing organic matter.

## 2. Oxygen Cycle

If you look back at the carbon cycle, you will see that we have also described the oxygen cycle, since these atoms often are combined. Oxygen is present in the carbon dioxide, in the carbohydrates, in water, and as a molecule of two oxygen atoms. Oxygen is released to the atmosphere by autotrophs during photosynthesis and taken up by both autotrophs and heterotrophs during respiration. In fact, all of the oxygen in the atmosphere is *biogenic*; that is, it was released from water through photosynthesis by autotrophs. It took about 2 billion years for autotrophs (mostly cyanobacteria) to raise the oxygen content of the atmosphere to the 21% that it is today; this opened the door for complex organisms such as multicellular animals, which need a lot of oxygen.

## 2. Nitrogen Cycle

Nitrogen exist in a variety of forms in natural systems and its compounds are involved in numerous biological and abiotic processes. Nitrogen, in its gaseous form of N2, makes up almost 78.084% percent of the atmosphere and seems to have a highly complex nutrient cycle in the terrestrial and aquatic ecosystems This constitutes the major storage pool in the complex cycle of nitrogen through ecosystems. It is an important nutrient of plants as an essential constituent of chlorophyll and protiens. It lives freely in the air but plants cannot utilize it from the air. They obtain N2 from ammonium salts, nitrites and nitrates. These compounds are formed from atmospheric N2 by a process called **nitrogen fixation.**

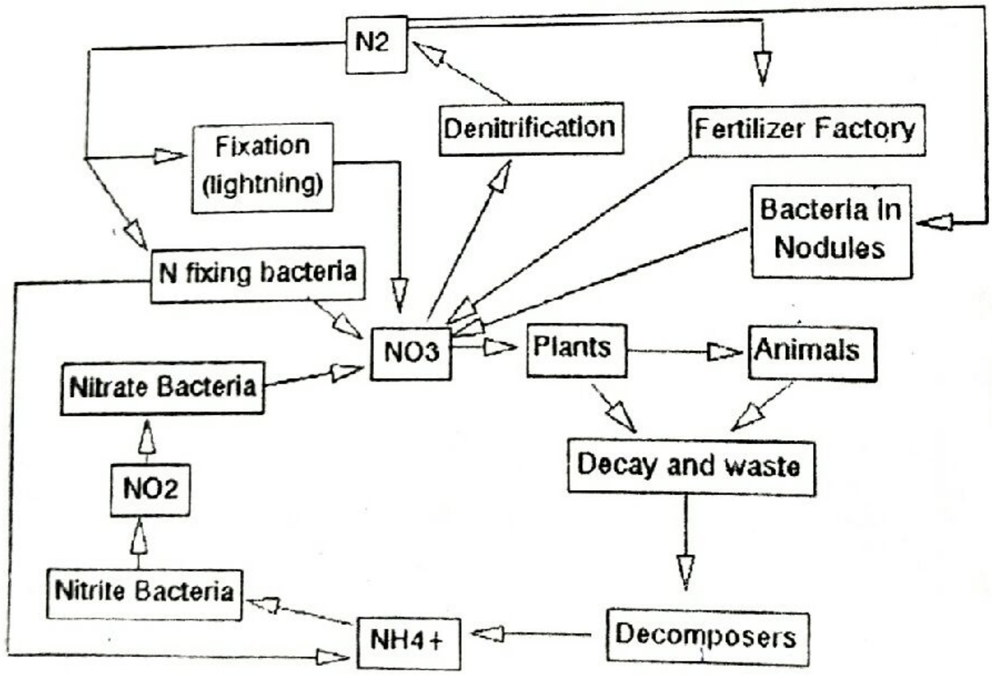



**Fig 2. 7. Nitrogen cycle in nature**

Nitrogen participates in protein synthesis and in the formation of protoplasm nucleic acids, purine and pyrimidine bases, chlorophyll, allkaloids and many coenzymes, in which the N2 is found in the form of organic combinations. The chief sources of nitrogen for plants are nitrates in the soil. The atmospheric nitrogen is fixed symbiotically as well as asymbiotically by a variety of micro-organisms. The chief nitrogen fixers are bacteria belonging to the genus *Rhizobium* found in root nodules of leguminous plants. Asymbiotic nitrogen fixers are some cyanobcteria like *Anabaena, Nostoc* etc, aerobic bacteria like *Azotobacter* and anaerobic bacteria like *Clostridium*. Certain photosynthetic bacteria like *Rhodospirillum* are also nitrogen fixers. Some proportion of atmospheric nitrogen is fixed during lightning also. The fixed atmospheric nitrogen reaches the soil as nitrates, which are taken by plants of manufacture of complex nitrogenous compounds which in turn, are eaten by animals. The dead organic matter formed due to death of plants and animals is decomposed by various types of bacteria, actinomycetes and fungi occurring in the soil and water. This releases nitrogen either in free stage or as ammonia gas in the atmosphere. Ammonia($NH_3$) gas may reach the soil as nitrates through the activity of nitrifying microbes, *Nitrosomonas* and *nitrobacter*. Some nitrates of soil due to activity of denitrifying microbes *Pseudomonas* may also be converted to free nitrogen gas returning to atmosphere. This inorganic nitrogen is again recycled into the organic system upon absorption by higher plants. It is presumed that the fixation of nitrogen by micro-organisms is generally in equilibrium with denitrification.

The nitrogenous excretory products like ammonia, urea and uric acid are formed in the animal body by the dissociation of amino acids which are discharged outside in the soil along with the animal urine. Insectivorous plants get $N_2$ by eating insects. The excretory waste products of animals and dead remains of the plants and animals body are also decomposed by decomposers and release free $N_2$ in the form of ammonia in the atmosphere. Some amount of nitrate is lost from the ecosystem by sedimentation. Thus, the nitrogen cycle continues in the atmosphere among green plants, animals and bacteria which are producers consumers and decomposers respectively. The denitrification is performed by the activity of *Thiobacillus denitrificans and Bacillus denitrificans* like bacteria.

## SEDIMENTARY CYCLE

In sedimentary cycles, the main reservoirs are soil and rocks. The elements classified under this cycle do not have a gasous phase (Sulphur cycle is an exception). They are usually found in soil and sediments and sulphur has a gaseous phase in $SO_2$ and $H_2S$, but its resident time in this phase is very small. Plants usually take sulphur from the soil in sulphate form. Bacteria can use elemental sulphur. Some amount of sulphur always forms sediments.Hence,sulphur is included in the sedimentary cycle along with phosphorus. The elements concerned in the sedimentary cycle are earthbound and follow a basic pattern of flow through erosion, sedimentation, mountain building, volcanic activity and biological transport (e.g.,through the excreta of marine birds). Sedimentary cycles are much less perfect than gaseous in that some of the elements may get stuck in certain phase of the cycle. In sedimentary cycle, the cycling of minerals occur in two phaese:

1.Rock cycle and

2.Organic cycle.

The degree of availability of a nutrient depends upon its turnover rate or release from biotic components rather than its concentration in the abiotic environment.For example, in an aquatic ecosystem, the concentration of phosphorus is very poor but the rapaid rate of growth and decay of phytoplanktons and other aquatic plants make the element available for continuous use and cycling

### 1. Phosphorus Cycle

Phosphorus is most important because it is vital component of DNA, RNA and ATP, NADP and in this way related with genetic and energy producing molecules of the life and therefore necessary to all living cells.The phosphorus is sedimentary rock, which is only available to basic cycle in small amounts as a result of weathering. The cycle does not have a major gaseous phase and therefore moves at a very slow pace. The phosphate deposits in the lithosphere represents the major reserve. These phosphorus are weathered and later transported on the soil by wind and water, where they existas inorganic dissolved phosphates.

The basic phosphorus cycle begins with dissolved phosphates which are absorbed by plants for use in making their own tissue. Plants are eaten by animals. Decay bacteria breakdown the tissue of dead animals and plants. Phosphatising bacteria further break down these products and return phosphate to the soil.The water solube phosphates is lost to the deep sediments of the oceans through run-off. About twenty million tonnes of phosphorus are estimated to leach off from land into the ocean per year. The major pathway for returning phosphorus to land is the uplifting of marine sediments which however, is a geologically intemittent process. Some amount of phosphorus is returnedto earth in theform of bird excreta (guano), fish excreta and dead fish.Algae efficiently absorb inorganic phosphate; when they die, most of the absorbed

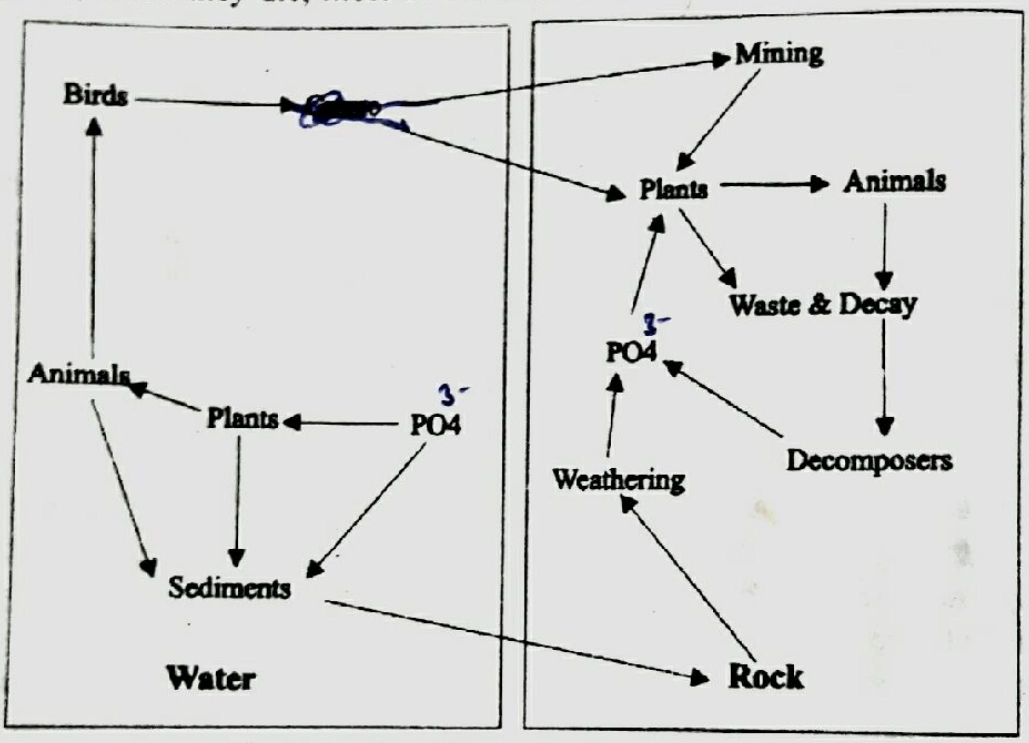



**Fig 2.8. Phosphorus cycle**

phosphate is recycled back into the ambient water. This sort of cycling is calledphosphate is recycled back into the ambient water. This sort of cycling is called **biological cycle or metabolic cycle**. This is quite fast in cycling in respect to geochemical cycling. For example, the cycling of phosphorus in most lakes is quite repaid with a turnover occurring in a few minutes in summer or in a few days in winter. In recent years the excessive use of phosphate fertilizers and the detergents is a problem of global concern as it has been considered responsible for accelearted global eutrophication of water bodies.A generalised phosphorus cycle is being shown below.

## 2. The Sulfur Cycle

Another example of a major biogeochemical cycle of significance to climate and life is the sulfur cycle. Living things require certain safe, low levels of this nutrient. The sulfur cycle can be thought of as beginning with the gas sulfur dioxide ($SO_2$) or the particles of sulfate ($SO_4$) compounds in the air. These compounds either fall out or are rained out of the atmosphere. Plants take up some forms of these compounds and incorporate them into their tissues. Then, as with nitrogen, these organic sulfur compounds are returned to the land or water after the plants die or are consumed by animals. Bacteria are important here as well since they can transform the organic sulfur to hydrogen sulfide gas ($H_2S$). In the oceans, certain phytoplankton can produce a chemical that transforms to $SO_2$ that resides in the atmosphere. These gases can re-enter the atmosphere, water, and soil, and continue the cycle.

In its reduced oxidation state, the nutrient sulfur plays an important part in the structure and function of proteins. In its fully oxidized state, sulfur exists as sulfate and is the major cause of acidity in both natural and polluted rainwater. This link to acidity makes sulfur important to geochemical, atmospheric, and biological processes such as the natural weathering of rocks, acid precipitation, and rates of denitrification. Sulfur is also one of the main elemental cycles most heavily perturbed by human activity. Estimates suggest that emissions of sulfur to the atmosphere from human activity are at least equal or probably larger in magnitude than those from natural processes. Like nitrogen, sulfur can exist in many forms: as gases or sulfuric acid particles. Sulfuric acid particles contribute to the polluting smog that engulfs some industrial centers and cities where many sulfur containing fuels are burned. Such particles floating in air (known as sulfate aerosols) can cause respiratory diseases or cool the climate by reflecting some extra sunlight to space.

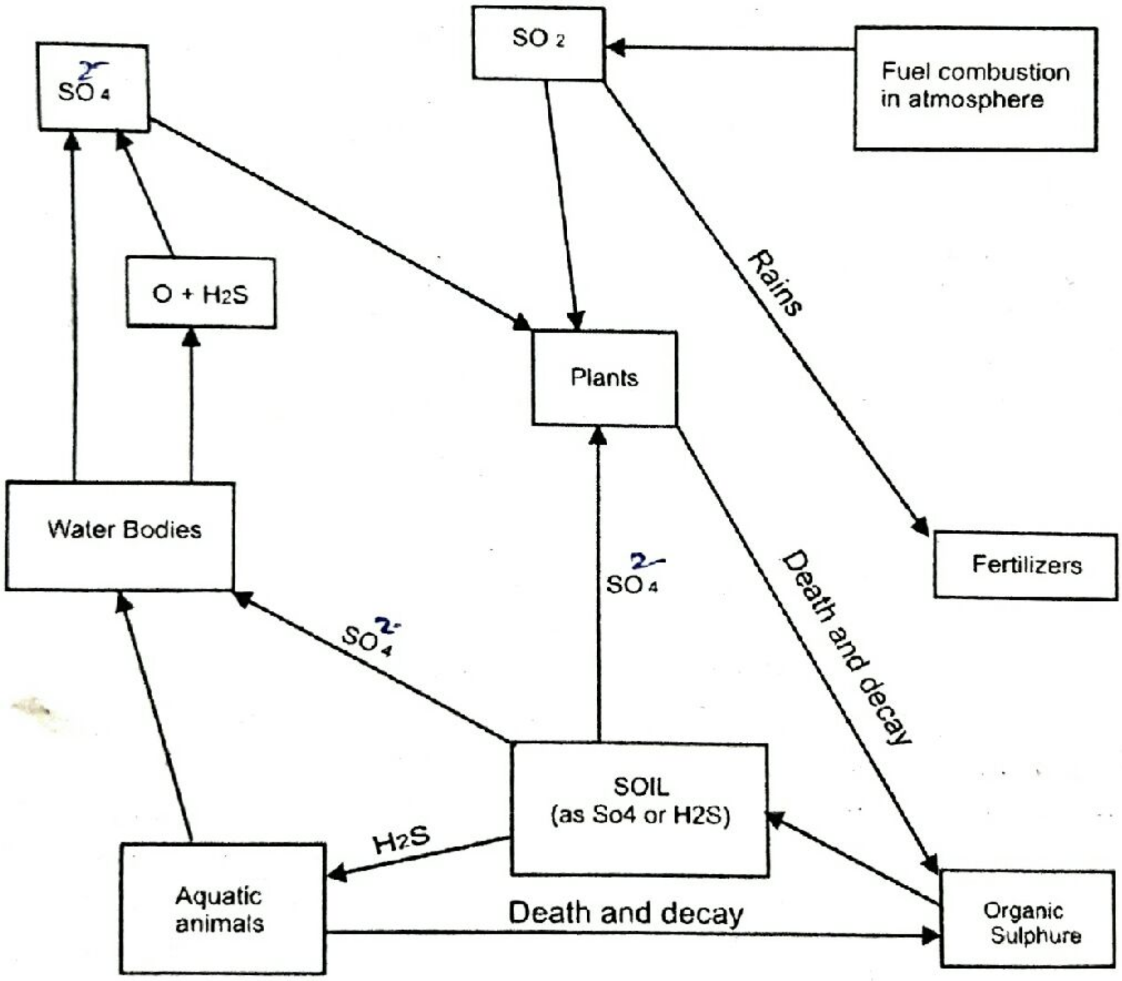



**Fig. 2.9. Sulphur cycle**

The lifetime of most sulfur compounds in the air is relatively short (e.g. days). Superimposed on these fast cycles of sulfur are the extremely slow sedimentary-cycle processes or erosion, sedimentation, and uplift of rocks containing sulfur. In addition, sulfur compounds from volcanoes are intermittently injected into the atmosphere, and a continual stream of these compounds is produced from industrial activities. These compounds mix with water vapor and form sulfuric acid smog. In addition to contributing to acid rain, the sulfuric acid droplets of smog form a haze layer that reflects solar radiation and can cause a cooling of the earth's surface. While many questions remain concerning

## MINERAL RESOURCES

Minerals, being the vital raw material for many basic industries, play an important role in the industrialisation and overall development of nation. Minerals are generally called the "stock" as they are the non-renewable resources. Minerals are the definite chemically bonded substances created through chemical processes between organic and inorganic matters present in the earth's crust. They may be solid or liquid. Since the prosperity of a nation depend upon the proper use of minerals, hence they should be conserved and should not be misused. Govt. should promote the research in this field of mining minerals.

The history is hundreds year old. Iron, steel, copper, zinc, lead, gold, silver, cobalt etc. metals were extracted from minerals in India. But now, building materials coal, iron ore, mangenese ore gold, petroleum, natural gas, copper ore, ilmenite, glass sand, lead and zinc ores, chromite raynite, silmenite, magnesite, gypsom, monazite, beryl, dolomite, bauxite etc. are produced from minerals in India. The minerals from metals like bismuth, cadmium, graphite, platinum, tungsten tin, silver, gold are extracted, are in least quantity.

### Types of minerals

Minerals available in earth crust can be divided into three types

1. Metallic minerals
2. Non-metallic minerals
3. Mineral fuels

Some other classifications of minerals are also given by scientists. They are classified as strategic and critical depending on the use and importance.

**1. Metallic Minerals:** We cannot extract metal directly from minerals. There is difference between minerals and ores. Therefore, for extracting metals, minerals are treated by different processes before extraction. Metallic minerals are generally found in combined state. According to availability of metals, metallic minerals are further divided into following :—

(*a*) Ferrous alloys: Most common metal (which is used largely) is iron. Other than iron are aluminium, lead, zinc, copper etc. All are found in rich quantities, found in native as well as in combined state. Iron pyrite, Lynonite, Haematite, Magnetite are examples of ferro alloys. Certain other metals, non-metals are contaminated with these as impurities.

(*b*) Non-ferrous alloys: The minerals/alloys of this type contain the metals like titanium, antimony, arsenic, beryllium, copper, zirconium, cerium, lithium etc. These metals are costlier than proceeding metals. Here the iron found as an impurities.

(*c*) The minerals/alloys containing very least quantity of metals whose extraction is costlier. These metals are generally used in jewellary eg. gold, platinum, silver, irridium etc.

**2. Non-metallic minerals :** Minerals, whose yield products are other than metals comes in this head. They are called the non-metals. They are further divided on the basis of physical and chemical properties. Graphite, pyrolusite, dolomite quartz, kaoline, fire clay, felspar, mica, asbestos, gypsom fluorite, chrome/red ochre, lime stone, borax, phosphorite, ilmanite, flint, dymond, calcite, sand stone. stones like phylite, cyanite, lime stone, ruby, sapphire. Emarald, amber, spodumene etc. are the examples of non-metallic minerals.

**3. Mineral fuels :** These include the materials used to provide energy, for example coal, natural gas, fossil fuels and petroleum etc. These are the important source of energy, hence they have tremendous importance for mankind.

Coal is the most commonly available fuel which is used as domestic as well as industrial fuel. It is of different type i.e. Anthracite, Bituminous, Lignite etc. The type and quality of the coal depend upon the percentage of carbon present in them. It is the principal source of energy in world. It is used in various ways in different industries like cement, glass, railways, textile, sugar, paper, steel etc. It is also largely used in domestic way. USA, China, Britain, Germany, South Africa, Australia are richest coal containing countries in world.

Petroleum is used in the manufacture of large number of petro-chemicals. It is drilled out from the sources as crude oil. Crude oil is refined before use as petrol, diesel, kerosine etc.

**Minerals in nature :** The man is using minerals since long. From lacs of year back primitive man was using flint, quartiz etc. for preparation of their tools. This was called "stone age". Later they use metals therefore, the period was named after as "copper age", "bronze age", and "iron age". Now present age is "machine age" because machines are prepared from minerals and they run by mineral fuels.

The formation of mineral deposits is a very slow geo-chemical or biological process, which takes millions of years to develop mineral deposits. Most of the minerals are widely distributed in earth's crust. Studies shows that, there are number of ways by which mineral deposits are formed. They are

1. Molten rock materials, which is a complex collection of a number of substances, when cooled, the crystallization of different minerals takes at different temperatures. These are settled in different bands, giving the mineral deposits.

2. Sodium chloride, gypsom, salt peter etc. Water soluble minerals are obtained by evaporation of lake/sea water. The compounds of iron and manganese as chemical sediments are also formed by precipitation from lake or sea water.

3. Deposits of minerals like asbestos, talc, graphite etc. are formed intense heat and pressures inside earth's crust.

4. When the pH, temperature, solubilities are changes, the rock materials in solution/ suspension are deposited in sufficient amounts to form mineral deposits as water current slow down.

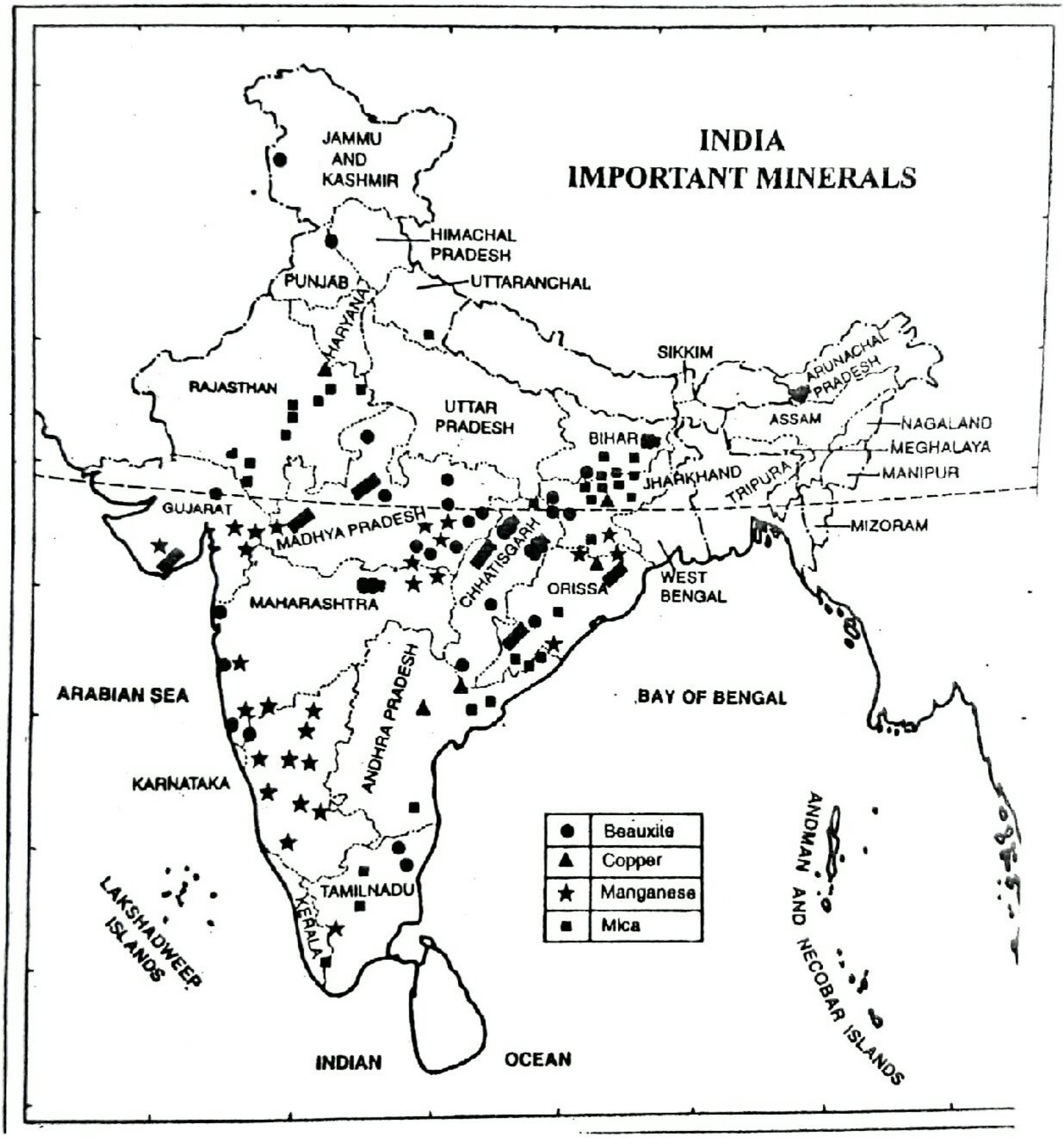
5. Mineral deposits are also formed by oxidation and reduction reactions.

6. Formation of mineral deposits are also take place by micro-organisms. It is mainly autotrophic bacteria which are involved in mineralization reactions.

There are also other views for formation of mineral deposits. When the plants, dead animals, wild life & other ecosystems are accumulated below in earth. Biological process convert them in to mineral deposits.

**Mineral resources of India :** India has sufficient quantities of iron, aluminium, titanium, copper, lead, zinc ores. India is fairly rich in mineral resources. We possess good deposits of most of mineral elements which we needed in large quantities. However, other economically important minerals are not present in sufficient quantities. Iron minerals, which are most important ingredient of today's economy are found in sufficient quantity in our country. We presently exporting it to other countries. The similar case is for aluminium also. Our cou ranks Vth among the aluminium rich countries of the world. At present we have suffic aluminium stock for the domestic market. We are exporting to other countries as well.

Zinc, lead ore reserves in India are estimated to be about 390 million tons. Good qualit these elements minerals/ores are being depleted at a fast rate.




India has a large number of economically useful minerals and they constitute one-quart the world's known mineral resources. About two-thirds of its **Iron deposits** lies in a belt Orissa and Bihar border. Other haemaite deposits are found in Madhya Pradesh, Karna Maharashtra and Goa. Magnetite Iron-ore is found in Tamilnadu, Bihar and Himachal.

India has the world's largest **deposits of coal.** Bituminous coal is found in Jharia and Bokaro in Bihar and Raniganj in West Bengal. Lignite coals are found in Neyveli in Tamilnadu.

Next to Russia, India has the largest supply of **Manganese.** The manganese mining areas are Madhya Pradesh, Maharashtra and Bihar-Orissa area. **Chromite deposits** are found in Bihar, Cuttack district in Orissa, Krishna district in Andhra and Mysore and Hassan in Karnataka. **Bauxite deposits** are found in western Bihar, southwest Kashmir, Central Tamilnadu, and parts of Kerala, U.P. Maharashtra and Karnataka.

India also produces third quarters of the world's **mica.** Belts of high quality mica are, Bihar, Andhra and Rajasthan. **Gypsum** reserves are in Tamilnadu and Rajasthan. **Nickel ore** is found in Cuttack in Bihar and Mayurbanj in Orissa. **Ilmenite** reserves are in Kerala and along the east and the west coastal beaches.

**Silimanite reserves** are in Sonapahar of Meghalaya and in Pipra in M.P. **Copper ore** bearing areas are Agnigundala in Andhra, Singhbhum in Bihar, Khetri and Dartiba in Rajasthan and parts of Sikkim and Karnataka.

The Ramagiri field in Andhra, Kolar and Hutti in Karnataka are the important **gold mines.**

The Panna **diamond belt** is the only diamond producing area in the country, which covers the districts of Panna, Chhatarpur and Satna in Madhya Pradesh, as well as some parts of Banda in Uttar Pradesh.

**Petroleum deposits** are found in Assam and Gujarat. Fresh reserves were located off Mumbai. The potential oil bearing areas are Assam, Tripura, Manipur, West Bengal, Punjab, Himachal, Kutch and the Andamans.

India also possesses the all-too valuable nuclear **uranium** as well as some varieties of **rare earths.**

A quarter of all mining is carried out in the southern part of Orissa. Gold, silver and diamonds make up a small part of other natural resources available in India. The gemstones are found in Rajasthan. Major portion of the energy in India is generated from coal. It is estimated that India has around 120 billion tons of coal in reserve, enough to last for around 120 years. Huge reserves of the petroleum have been found off the coast of Maharashtra and Gujarat and M.P. Electrical energy generated by hydroelectric power, coal and nuclear energy. Half of the hydroelectric power is generated by snow field reservoirs high up in the Himalayas. In Madhya Pradesh important minerals like diamond, tin ore, coal, copper ore, alexandrite, iron ore, dolomite, rock phosphate, manganese ore, lime stone, granite, marble, corumdum, pyrophylite, diaspore, Bauxite etc. are found in different quantities. Chhatisgarh (new state of M.P.) is rich in minerals and forest products.

## Environmental effects of extracting and using mineral resources

Mining, minerals and mineral based industry indeed play an extremely important role in the development of mankind. The total geographical area of India i.e. 329 million hectares constitute 2.4% of the world land area. Out of this about 82500 hectares is sustaining mining activities of some kind or the other. As the mining activity grows, the per capita availability of land is declining at a very high rate. The extra emphasis on mining and minerals is directly related to growing population and better standard of living.

The environment means the surroundings. The components of environment include soil, water, air, land, landscape, and living creatures. The environment is more damaging by open cast mining than underground mining. Not only environment, mining also effects human health. Over exploitation causes the wastage of mineral wealth and derelict of land. Mineral deposits should not be over exploited because they are non-renewable. Derelict land is that land which has been abandoned as useless. Dereliction is the result of thoughtless, uncontrolled ruthless exploitation of natural resources. This land is the permanent damage not usable for agriculture. There ar following environmental effects of mining—

(*i*) Land degradation due to lowering of the surface levels at some places and creation of larg mounds at other places;

(*ii*) Deforestation in the mining areas, i.e., the loss of valuable cover resulting in th possibility of enhancement of soil-erosion;

(*iii*) The loss of top and sub-soil;

(*iv*) Adverse effect on ground water table. The local water table is lowered as a result opencast mining. The replenishment of acquifers is adversely affected as the mined o terrains are completely dismembered of acquiducts leading to acquifers. As a result th affluent discharge of rain water is increased leaving the water-table completely or parti unrecharged. This also increases the salinity of remaining ground water;

(*v*) Due to increased discharge of rain water passing ~~through the terrains,~~ disturbed by surfac mining, the local drainage system is polluted, which on joining the main drainage featur affects it also;

(*vi*) The frequency of land slides increases substantially as a combined result of factors stated above;

(*vii*) The erosion of soil is enhanced;

(*viii*) The agricultural lands are affected by silt and the fine material mined but not recovered, also clogs the surface water channels;

(*ix*) The disturbance caused adversely affects the well-balanced pH and diminishes t regenerative qualities of soil, etc.;

(*x*) The disturbance caused to the floral and faunal population is immense;

(*xi*) The heavy earth-moving machinery and blasting cause problems of noise, vibration a the release of noxious gases in the atmosphere;

(*xii*) The aesthetic damage caused to the landscape reduces its recreational value;

(*xiii*) Mine drainage has polluted streams, rivers, lakes even seas;

(*xiv*) Fumes from smelters damage forests and spread pollution over large area (air pollution)

(*xv*) Mining and mineral based industries with their effluents create pollution problem Asbestos, cement and other chemical industries are very hazardous. People are n supposed to live in surrounding areas;

(*xvi*) Mining causes the reduction of forests i.e. deforestation. Thus flora and fauna are al destroyed. Wild life also effected. Land becomes barren and this results in increas incidents of land slides;

(*xvii*) The people related with mining and extraction effected by polluted environment (Dust poisonous gases) lead to skin and lung diseases;

(*xviii*) Mining affects the sub segments of the environment like forests, vegetation, soil cov humus and ground water. Dust and toxic gases indirectly affects air, humidity, temperatu

(*xix*) Deforestation and climatic change results poor rainfall and affects flora & fauna.

## WORLD FOOD PROBLEM

Before the 21st century, it was felt that world food production is not sufficient for the pres population. Food production was less because people were using the old techniques, seed e Later on when population pressure starts, the new ways of food production, using fertilize pesticides, insecticides etc. are discovered to increase the yield. In 1999 International Fo Policy Research Institute (IFPRI) reported the increase in world food consumption by 20 discussing the impact of this on both developed and developing countries. The report consid