M. Sc. Semester-III, Paper: CC-12 (4)
Unit-1 Environmental Chemistry (Contd.)

⇒ Phosphorus/Phosphate cycle:

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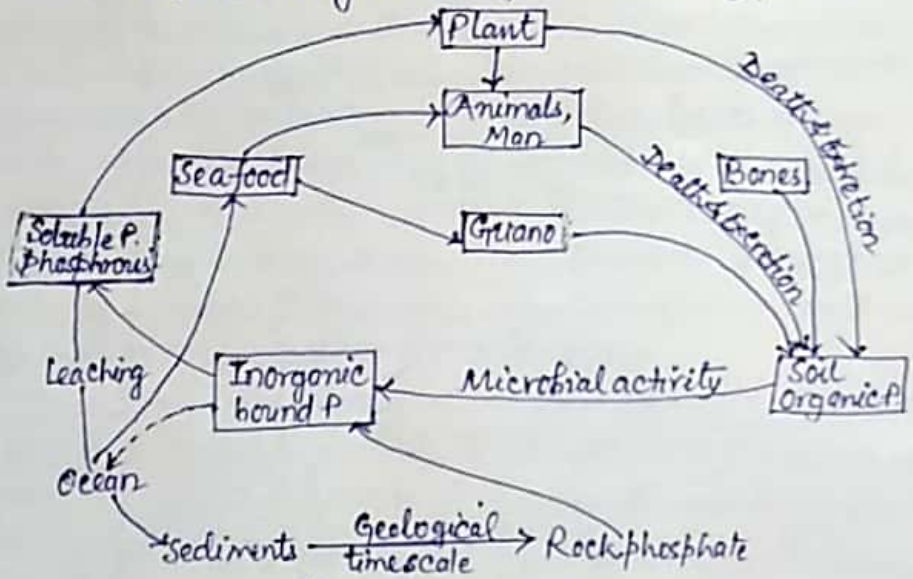
Phosphorus is the second most important and vital element for growth of plants and animals. It is a component of nucleic acids, ATP, NADP, phospholipids etc. All of them are highly important for the functioning of organic systems. ATP is energy currency of living cells. It can store and release small amount of energy for performing various activities of the cells. Phosphorus occurs in the soil as phosphorite [$Ca_3(PO_4)_2$], fluorapatite [$CaF_2 \cdot 3Ca_3(PO_4)_2$], iron phosphate or aluminium phosphate minerals. Weathering of rocks adds phosphate to soil and water. However, in the soil, the mineral is almost always critical. Therefore, it is added to the soil as fertilizer consisting of rock phosphate, bone meal, fish meal, mud from lakes and shallow sea beds, guano and phosphate rich industrial wastes. Inorganic phosphate usually occurs in the insoluble form. It is dissolved by excretions of micro-organisms and the roots. The dissolved fraction is absorbed by plants and converted to organic form. Organic phosphorus is returned to soil through death and excretion of animals, which get phosphate by eating plants. It is acted upon by the decomposers, some microscopic animals and phosphatising bacteria. Phosphorus is released in the inorganic state for utilization by plants.



[Phosphorus Cycle]

Several industrial wastes contain inorganic phosphates. phosphates are also used in many detergents. Along with fertilizer rich field wash and sewage water, they are forced to ponds, lakes, streams, rivers and oceans. Excess phosphates settle down at the bottom as sediments. A lot of soil phosphate is also lost through leaching. The leached and other forms of phosphate sediments go out of circulation. They become available only after long geological periods when the sediments come to the earth surface as constituent of rocks.

Streams take out about 20 million tonnes of phosphorus per year to the oceans, of which it return only 6 million tonnes of P to land in the form of fish catch, sea weed collection and guano. Guano is excrement of marine birds often deposited on islands, e.g. near cost of Peru.

Green plants take P & N in form of salts (fertilizers) from soil and combine them with glucose to yield proteins, fats and carbohydrates. Thus, green plants are also the source of fats and proteins. In these transformations, bacteria and fungi also play an important role as decomposers. They act upon the dead bodies of animals and plants. Due to decomposition of these phosphate and phosphonic acid are released. These compounds present in the urine of animals pass down in the soil-water.

There is a continuous depletion of phosphorus from cyclic pool due to leaching in the soil, excessive drainage to sea, formation of bones teeth and other forms of extremely slowly degradable phosphorus compds. Only a small quantity of P is replenished naturally. Therefore, phosphorus has an incomplete nutrient cycle.

⟹ Carbon cycle:

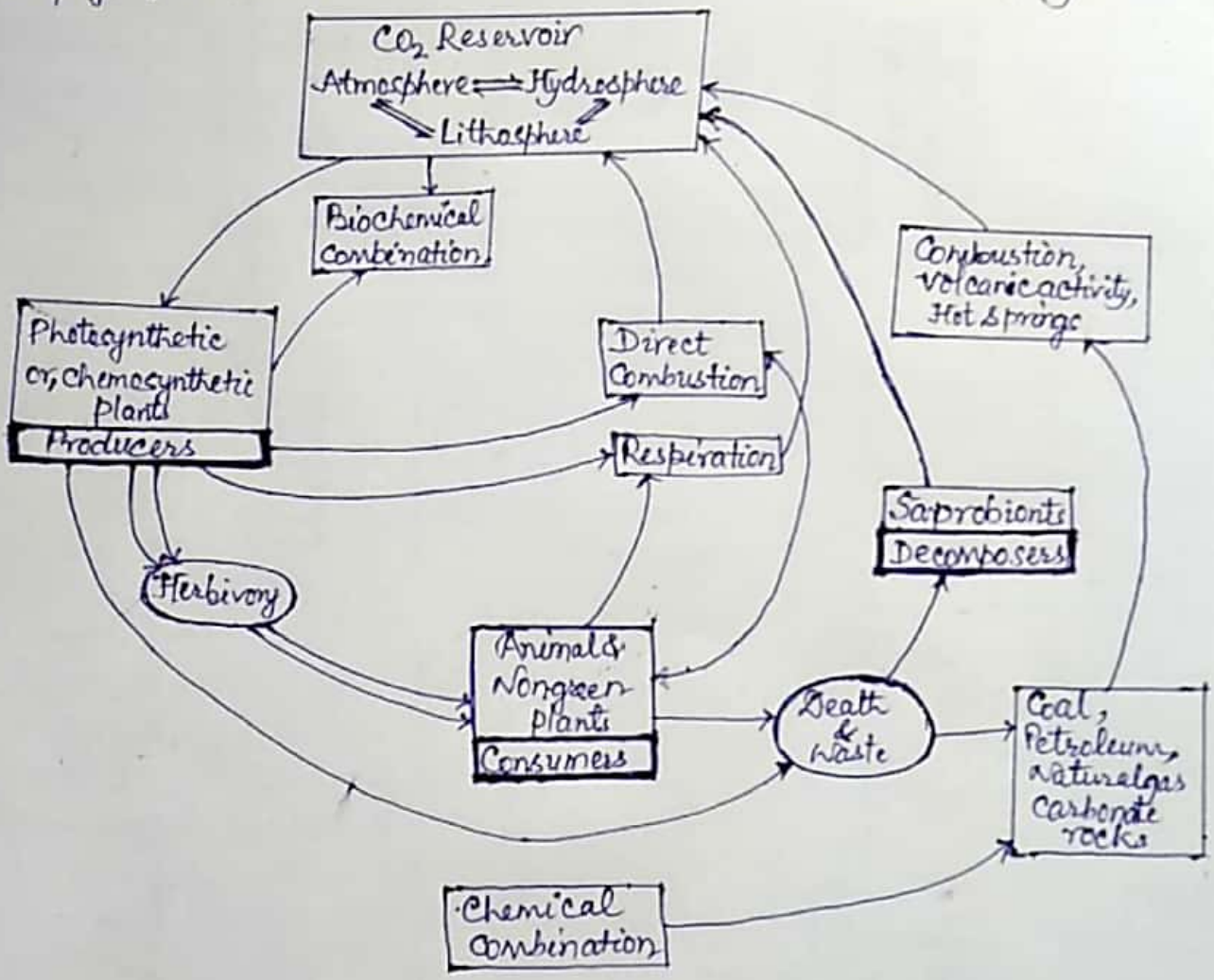
Carbon containing parts of the earth, its atmosphere, lithosphere and hydrosphere, are collectively called carbosphere. Carbon is essential component of all organic substances. Earth contains $50\text{-}250 \times 10^{13}$ tonnes of C in organic form, 5% of it is fossil fuels. Inorganic carbon occurs as CO_2 ($\simeq 2.3 \times 10^{12}$ metric tonnes in the atmosphere), bicarbonate and carbonates. The C-content of the hydrosphere is about $1.3\text{-}5 \times 10^{13}$ metric tonnes. There is a regular exchange of CO_2 between the atmosphere and hydrosphere. Some exchange also occurs with the lithosphere which is the major but lesser available source of C ($\simeq 2.8 \times 10^{16}$ tonnes). About 60 billion (6×10^{10}) metric tonnes of C is annually assimilated or converted into 150 billion tonnes of organic matter through the process of photosynthesis. Some carbon is also assimilated through autotrophic bacteria but this amount is quite negligible. Another negligible amount is also fixed by other organisms in a non-photosynthetic processes. The organic carbon passes as food inside the biosphere through food chains. The major movement is from producers to consumers and from both to the decomposers.

Even though large quantity of inorganic carbon is withdrawn from the abiotic environment for photosynthesis, the atmosphere and hydrosphere do not get depleted of their carbon content because of its return through two major processes:

(i) Biological: Respiration of various organisms and decomposition of organic matters. Methane (CH_4) is a common gas produced during decomposition in marshes, rice fields and cattle. It escapes into the atmosphere where it is ultimately changed to CO_2.

(ii) Non-biological: Combustion of carbon containing fuel. Burning of fossil fuel adds about 6 billion tonnes of carbon to the atmosphere. Use of fossil fuel is increasing day to day. This has increased the CO_2 content of the atmosphere. Other sources of increasing CO_2 concentration of the atmosphere are volcanic eruptions and hot springs. They had add upto 100 million tonnes. It is believed that CO_2 of the atmosphere originally come through outgassing from early earth.

Small quantity of CO_2 is being regularly taken out of cycling pool and added to reservoir pool (Lithosphere) through: (i) formation of shells and carbonaceous skeleton of animals. (ii) precipitation by aquatic plants like Elodea and several algae. (iii) formation and sedimentation of carbonates at the bottom of sea and other aquatic bodies. (iv) Seepage of carbon rich water into interior of earth. (v) fossilisation of organic remains



[Carbon cycle]