UG CBCS Semester-IV (MJC-7: Ecology)

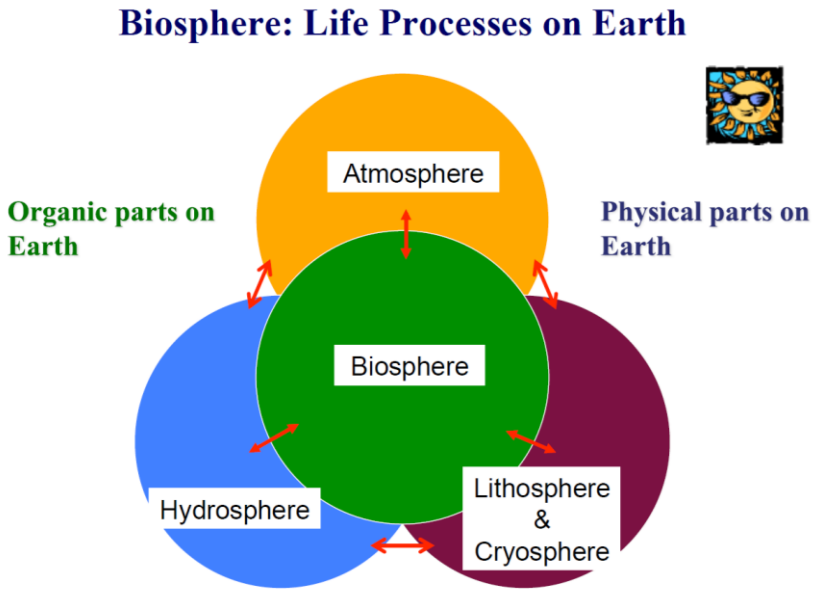
Concept of Biosphere (Lithosphere, Hydrosphere and Atmosphere)

The biosphere, *(from Greek bios = life, sphaira, sphere)* is the layer of the planet Earth where life exists. This layer ranges from heights of up to 10 kms above sea level, used by some birds in flight, to depths of the ocean such as the Puerto Rico trench, at more than 8 kms deep. These are the extremes; however, in general the layer of the Earth containing life is thin: the upper atmosphere has little oxygen and very low temperatures, while ocean depths greater than 1000 m are dark and cold. In fact, it has been said that the biosphere is like the peel in relation to the size of an apple.

The development of the term is attributed to the English geologist Eduard Suess (1831-1914) and the Russian physicist Vladimir I. Vernadsky (1863-1945). The biosphere is one of the four layers that surround the Earth along with the lithosphere (rock), hydrosphere (water) and atmosphere (air) and it is the sum of all the ecosystems.

The biosphere is unique. So far there has been no existence of life elsewhere in the universe. Life on Earth depends on the sun. Energy, provided as sun light, is captured by plants, some bacteria and protists, in the marvelous phenomenon of photosynthesis. The captured energy transforms carbon dioxide into organic compounds such as sugars and produces oxygen. The vast majority of species of animals, fungi, parasitic plants and many bacteria depend directly or indirectly on photosynthesis.

In the late 70's ecosystems were discovered which were relatively independent of the sun. From fissures in the deepest ocean, water of extremely high temperature (400° C) vents out, heated by the magma beneath the Earth's crust. On contact with the cold water dissolved minerals precipitate, forming chimneys that can reach great heights. In the vicinity of hydrothermal vents exists a dense animal community that is dependent on chemosynthetic bacteria. The bacteria use and convert sulphur compounds driven out by the hot water and are preyed upon by a variety of animals including small crustaceans (amphipods and copepods), which in turn are prey for snails, crabs, shrimp, worms, giant tube worms, fish and octopus.



Components

1. Hydrosphere:

It includes water in the oceans, lakes, ponds, etc., and covers about 73% area of the earth's surface. Water is the major inorganic nutrient needed by all living organisms, hence, water is essential to all life. First life originated in water.

The means of obtaining and conserving water have shaped the nature of terrestrial life; means of living within the water have the overwhelming influence on aquatic life. Water is one of the main agents in pedogenesis and is also the medium for several different ecosystems.

Water continuously circulates between atmosphere and the earth's surface; this cycle is referred to as the water cycle. The energy for driving the cycle and, thus, ensuring a constant supply of fresh water on land comes from the sun. Solar heat evaporates water from the ocean which is the great reservoir of water.

A lesser amount of water is also evaporated from the surface of the land from plants, a process known as evapotranspiration. All this vaporized water forms clouds which moved by winds, may pass over land where they are cooled enough to precipitate the water as rain or snow. Some of the precipitated water soaks into ground, some runs off the surface into stream and goes directly back to the seas.

The ground water is returned to the surface by springs, by pumps and the transpiration—the movement of water in plants from roots to leaves. Water inevitably ends up back in the sea, but it may become incorporated into the bodies of several different organisms, one after another, en route.

2. Atmosphere:

It is a thick gaseous mantle which envelopes the hydrosphere and earth's surface, called the air. It supplies oxygen, nitrogen, carbon dioxide and other gases and is subjected to physical cycles by the sun and spin of earth. Cooled polar air sinks, while warm equatorial air rises, and the axial rotation of the earth causes to shift air masses laterally resulting into the formation of global air currents.

The composition of atmosphere is somewhat uniform up-to a height of about 80 kms. Higher levels have lighter gases. The atmosphere is denser near the earth and rarer away from the earth.

The atmospheric pressure is more near the earth than away from it. The atmosphere has a layer of ozone at a height of about 32-48 km; this layer acts as a barrier that checks ultraviolet rays of sun from reaching the earth which could be lethal for living organisms.

Table 12.1. Geographical area, mean plant biomass and net productivity in major world ecosystems

Major world ecosystems	*Geographical area* 10^6 *km*^{2}	*Mean plant biomass* ($t\ ha^{-1}$)	*Mean net primary productivity* ($t\ ha^{-1}\ year^{-1}$)
1. Tropical rain forest	17	440	20
2. Tropical deciduous forest	8	360	15
3. Temperate deciduous forest	7	300	12
4. Temperate coniferous forest	12	200	8
5. Savanna	15	40	9
6. Temperate grassland	9	20	5
7. Desert shrub	18	10	0.7
t = ton = 1000 kg ; ha = 10,000 m^2			

Out of the various constituents of atmospheric gases, oxygen, nitrogen and carbon dioxide serve as metabolites for living organisms and, hence, they are essentially needed by them for their normal functioning. However, all these undergo characteristic cycles in nature in which organisms play an important role and, hence, their normal percentage atmosphere.

3. Lithosphere:

The solid component of earth is called lithosphere. It is multilayered and includes following three main layers: crust, mantle and core (outer and inner). The core is the central fluid or vapourized sphere having diameter of about 2500 km from the centre and is possibly composed of nickel-iron. The mantle extends about 2900 km above the core. This is in a molten state.

The crust is the outermost solid zone of the earth and it is about 8 to 40 km above mantle. The crust is very complex and its surface is covered with the soil supporting rich and varied Cross section of earth showing different layers, biotic communities. The soil provides food, shelter, anchorage and concealment from predators to living organisms.

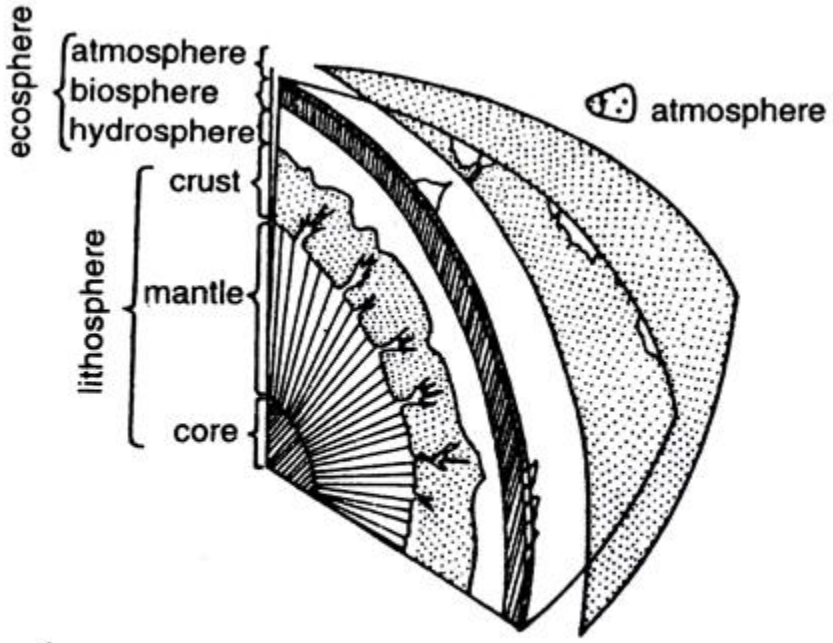


Fig. 12.2. Cross section of earth showing different layers.

The soil is the most characteristic feature of terrestrial environment. It is the top layer of earth's crust and is the mixture of weathered rock materials (i.e., minerals) and organic detritus, both of which are formed through the physical, chemical and biological processes occurring slowly and slowly for a long period at the earth's surface.

Besides being the source for the entry of nutrients and water in plants, the soil is the medium for the detritus food chain: nutrients released in detritus are decomposed by various soil microbes like bacteria, algae, fungi, protozoa, etc., bound in or on soil particles and taken back into plants through their roots.

Soil (mud) is also the main source of nutrients for all aquatic plants; rooted, submerged or free-floating. In addition, soil is the means to support for all terrestrial organisms: plants are anchored

to the soil by their root systems; animals walk upon it and are supported by it, as many animals like nematodes, polychaetes, arachnids, insects, rodents, etc., live under the soil.

Table 12.2. Composition of dry atmosphere.

S.No.	*Constituent*	*Percentage*
1.	Nitrogen (N_2)	78.084
2.	Oxygen (O_2)	20.947
3.	Argon (Ar)	0.934
4.	Carbon dioxide (CO_2)	0.0314*
5.	Other gases	0.003

* These constituents are highly variable.

Table 12.3. Chemical composition of earth's crust.

S.No.	*Constituent*	*Percentage*
1.	Oxygen (O)	46.6
2.	Silicon (Si)	27.7
3.	Aluminium (Al)	8.1
4.	Iron (Fe)	5.0
5.	Calcium (Ca)	3.6
6.	Sodium (Na)	2.8
7.	Potassium (K)	2.6
8.	Magnesium (Mg)	2.1
9.	Compounds of elements like B, Mn, Cu, Zn, Mo, Co, I, F, etc.	1.4

Thus, these three ecological components and the biotic component of the world constitute the biosphere. All these four components, thus, represent the four major global components of the world ecosystem.

These four spheres continuously exchange matter with one another in a cyclical manner. Thus, biosphere is that part of the earth in which life exists. More specifically, the sum of those portions of the hydrosphere, lithosphere and atmosphere into which life penetrates, is the biosphere.

However, together with the geological, chemical features of the totality of our habitats, these (air, water, earth and organisms) are sometimes grouped under the term ecosphere. Biosphere or ecosphere may be thought as a biochemical system capable of capturing, converting, storing and utilizing the energy of the sun.

Approximately three hundred thousand species of green plants and microorganisms are recognized as primary producers which utilize inorganic elements and compounds to synthesize the organic minerals of life.

Their productivity is consumed by more than a million other species of organisms which convert this organic store-house into animal form, adding to the beauty, and value of the biosphere as well as its complexity. Still other species, primarily bacteria and fungi, accomplish the recycling

process by returning plant and animal wastes and residues to inorganic form so the process may be renewed.

In this cyclic process of life, many elements are shared form a common global pool and are converted from inorganic to organic form and back again. Examples of such elements which commonly shuttle among the air, water, earth and organism are carbon, oxygen, hydrogen, nitrogen, phosphorus, sulphur, sodium, potassium, calcium, magnesium, iron, manganese, cobalt, copper, and zinc.

In physical terms, the biosphere is a relatively thin and incomplete envelope covering most of the world. It represents a mosaic of different biotic communities from simple to complex, aquatic to terrestrial, and tropical to polar. It does not exist in the extremities of the Polar Regions, the highest mountains, the deepest ocean troughs, the most extreme deserts, or the most highly polluted areas of land and water.

Its total thickness, including all portions of the earth where living organisms can exist, is less than 26 kilometres. Its zone of active biological production, in terms of photosynthesis, is much narrower, and varies from a few centimetres to over 100 metres.

This zone would, for instance, be only a few centimetres in muddy or turbid water, whereas in very clear ocean water, it could be more than 100 metres in thickness. On land, the zone of biological production might be only a few millimetres in a desert or rock environment, whereas it might again be more than 100 metres in a sequoia or tropical rain forest.

Living organisms can exist, of course, beyond the range of active biological production; some insects or birds may be airborne to altitudes above 20.000 feet, and viable spores, seeds of plants, and microorganisms may be found in the atmosphere and mountain tops above 25,000 feet.

In the ocean depths, many animals can exist well below a thousand feet—one hydra-like animal has been photographed at a depth of 15,900 feet in the south Atlantic.

However, in both extreme altitude and extreme depth, the organisms depend upon the much thinner zone of active biological production, that portion of the system which converts the energy of sunlight into the chemical and physical energy of living organisms.