Nutrients and minerals are always in circulation in the ecosystem from living to non-living and vice-versa in a more or less circular pattern. Biogeochemical cycles present a pathway through which various substances involved in these nutrients and minerals, pass through biotic and abiotic components of the earth.

Biogeochemical cycles

Importance of biogeochemical cycle:

1. It allows the transfer of molecules from one locality to another.
2. It enables the transformation of matter from one form to another.
3. It facilitates the storage of elements. Elements are stored in their natural reservoir and released to organisms in small consumable amounts.
4. In case of any imbalance, it helps the ecosystem to restore it. It may take a few days or a few years.
5. It links biotic and abiotic elements of ecosystems.

Biogeochemical cycles are sometimes called **nutrient cycles** because they involve the transfer of compounds that provide support to living organisms. Two important components of the cycle are:

1. **Reservoir pool**- atmosphere or rocks storing a large number of nutrients.
2. **Cycling pool**- short storage of carbon in the form of plants and animals.

Elements transported by biogeochemical cycle have been categorised as:

1. **Microelements**- The elements which are required in smaller quantities are referred to as microelements. For example, boron (used mainly by green plants), copper (used by some enzymes) and molybdenum (used by nitrogen-fixing bacteria).
2. **Macroelements**- The elements which are required in larger amounts are referred to as macronutrients. For example, carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur.

Types of Biogeochemical Cycles:

1. **Gaseous cycles**: Gaseous cycles include the transportation of matter through the atmosphere. Gaseous cycles are: Carbon cycle, Nitrogen cycle and Water Cycle
2. **Sedimentary cycles**: Sedimentary cycles include transportation of matter through the ground to water means the lithosphere to the

hydrosphere. Sedimentary cycles are the Phosphorus cycle and the sulphur cycle.

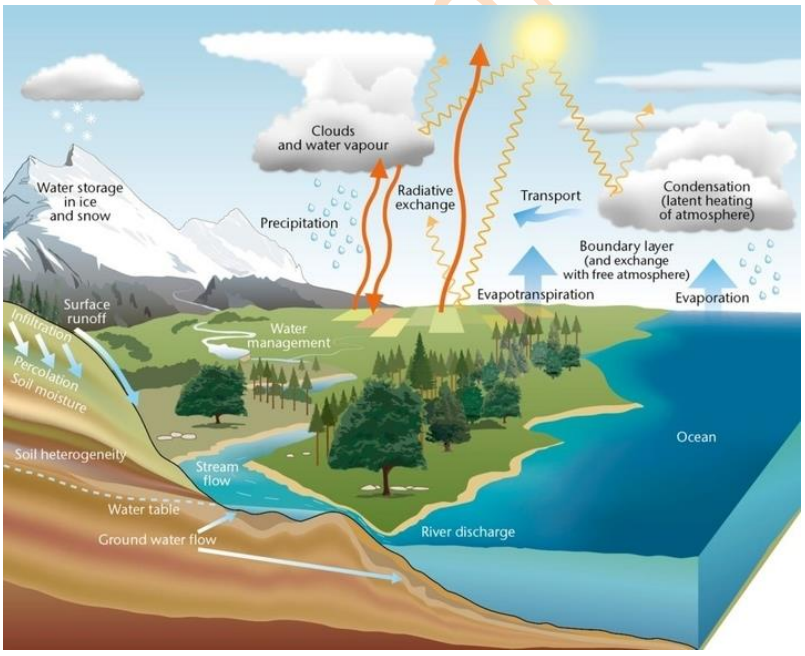
Complete detail of all biogeochemical cycles are as follows:

70% of the earth's surface is covered with water but still, the world is facing an acute water crisis. This is because, out of total water available on earth, 97.5% is saltwater. Of the remaining water, 99% is locked in glaciers and underground sources. So, technically, less than 1% of fresh water is available for human use in the form of rivers, lakes, streams, etc. please note that this less than 1% water availability is sufficient to fulfil the needs of even the last man on this planet.

But owing to human encroachments at all levels, the existence of mankind will be at risk in the near future if proper precautionary measures for optimum use of water resources are not put in place. For instance, 12% of the Indian population is already at the brunt of the "day zero" scenario.

To tackle this global problem of the water crisis, let us understand the genesis of the water cycle through this article. This article consists of all relevant information required from exam point of view.

Hydrological cycle (Water cycle)



The water cycle is defined as continuous circulation of water from the earth to atmosphere and vice versa which is powered by the energy of the sun. It shows storage and movement of water between biosphere, lithosphere and hydrosphere.

Major Water Sinks

Water can be stored in any of the reservoirs like atmosphere, oceans, lakes, rivers, soils, glaciers, snowfields and groundwater.

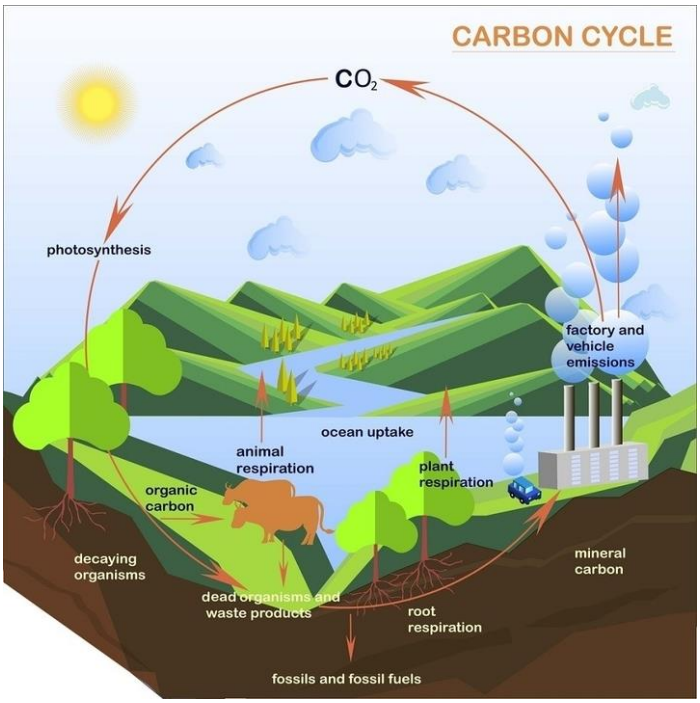
Processes involved

- The processes involved in the movement of water from one reservoir to another are-
    - **Evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, melting and groundwater flow.**
- The driving source of energy for the water cycle is **solar radiation or solar energy**.
- Evaporation and precipitation are the main processes involved in the water cycle.
- Some of the processes are discussed below:
    - **Evaporation**- Water from the ocean, lakes, ponds, rivers and streams evaporates by the sun's heat and energy. Water remains in vapor state in air and forms cloud.
    - **Transpiration**- Evaporation through the plant surface due to solar energy is known as transpiration. Plants also transfer a huge amount of water in the atmosphere through transpiration.
    - **Precipitation**- Cloud meets with the cold air in the mountains and above forest regions and condenses to form rain precipitates.
    - **Condensation**- It is the process by which water vapours in the atmosphere gets converted into liquid droplets.
    - **Runoff:** Water discharged from the surface is known as runoff. If it is discharged through rivers, it is known as river runoff.

The ocean supplies most of the evaporated water. On average 84% of water lost from the oceans through evaporations while 77% gained by precipitation. Water from runoff, streams and rivers covers the 7% to balance the evaporation deficit of oceans. On land, evaporation is 16% and precipitation is 23%.

Carbon cycle

The carbon cycle is a biogeochemical cycle where the carbon and its compounds are continuously exchanged between the three spheres of earth, i.e. hydrosphere, lithosphere and atmosphere (collectively called as biosphere).



Major carbon sinks of our Earth

- In the form of organic molecules in living and dead organisms in the biosphere.
- As the gaseous carbon dioxide in the atmosphere.
- As organic matter in soils.
- As fossil fuels and sedimentary deposits like limestone, dolomite and chalk etc.
- As dissolved atmospheric carbon dioxide in the oceans and as calcium carbonate shells in marine organisms.

Processes involved in the Carbon Cycle

- **Photosynthesis**: Ecosystem gains most of their carbon dioxide from the atmosphere. Most of the autotrophs have a mechanism that allows for the absorption of this gas into their cells. With the help of water and energy from solar radiation, these organisms use **photosynthesis** to chemically convert carbon dioxide to sugar molecules.
- **Respiration:** Carbon released from the ecosystem as carbon dioxide gas by the process of respiration. It involves the breakdown of the carbon-based organic molecule into carbon dioxide and some other by-products in both plants and animals.
- Detritus food chain contains a number of organisms whose primary role is to decompose organic matter. Partially decomposed organic matter becomes part of the soil carbon storage pool.
- Ultimately organic material in the soil becomes part of soil constituents, water and carbon dioxide which return to the atmosphere. This flow accounts for most of the carbon from the atmosphere but not all.
- **Diffusion:** Carbon dioxide enters the water by this method. Once it is dissolved in water it can remain as it is or can convert into carbonate or bicarbonate. When carbon dioxide enters the ocean, carbonic acid is formed.
- Certain organisms fix bicarbonate with calcium to form calcium carbonate. This is used to make hardbodies such as shells and corals.

When such organisms die their remains accumulate as carbonate-rich deposits to the ocean floor.

Note- ocean deposits are the biggest sink of carbon on the planet.

- In the lithosphere, carbon is stored in both organic and inorganic forms. Inorganic forms include fossil fuels, coal, natural gas, oil shale and sedimentary deposits like limestone. Organic deposits are organic matter, humus etc. some carbon dioxide released from volcanoes.

Nitrogen is important for living organisms to produce a number of complex organic compounds like amino acids, building blocks of proteins and nucleic acids (DNA and RNA). Though nitrogen is abundantly available in atmosphere as dinitrogen (N_2), it can not be directly used by living organisms. It needs to be fixed before being utilised by the primary producers, i.e. plants. In the same way, before being released in the atmosphere in the end, it should again be converted in the form it originally was. This complete transfer of nitrogen from the atmosphere to living beings and then back to the atmosphere represents the nitrogen cycle.

Here in the article, all relevant details regarding nitrogen cycle are discussed below which are important for exams like UPSC, State PCS and other government examinations.

Nitrogen Cycle

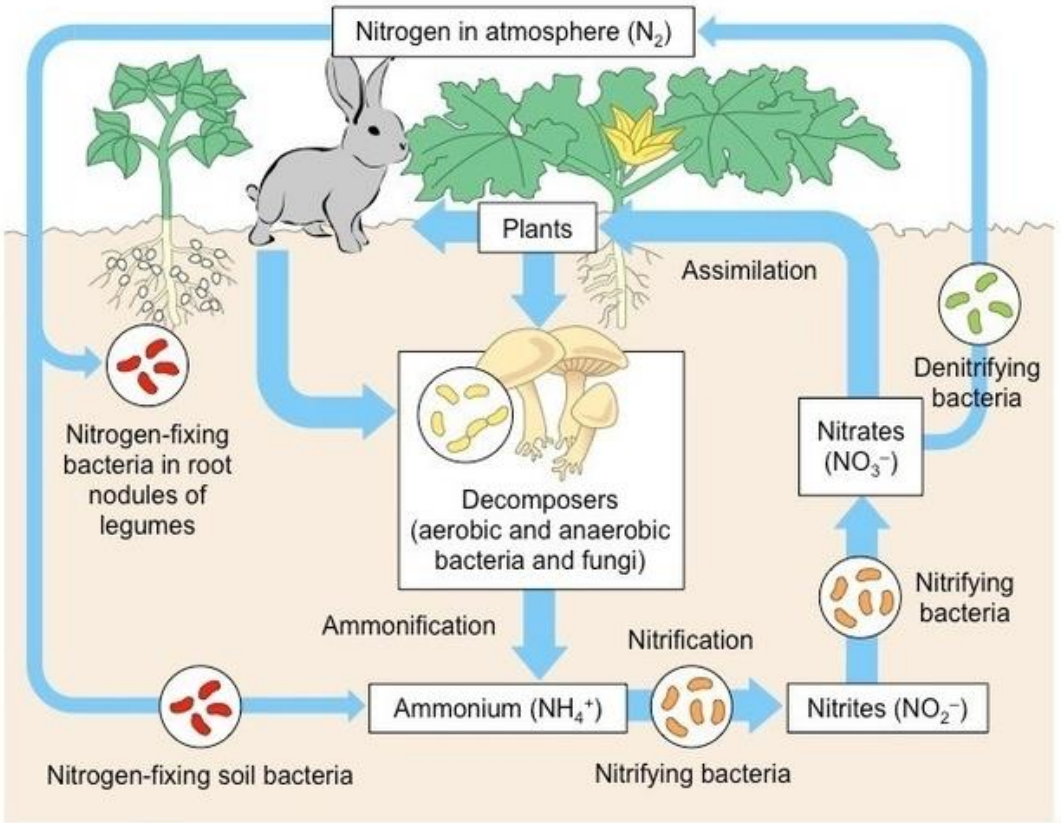
The main processes involved in the nitrogen cycle-

Nitrogen fixation

It involves the conversion of gaseous nitrogen into ammonia, which can be used by plants. It can be done by following methods-

- **Atmospheric fixation**- This is done by lightening, combustion and volcanic activity.
- **Industrial fixation**- This is done in industries at high temperature and high-pressure where nitrogen molecule is broken into atomic nitrogen and combines with hydrogen to form ammonia. This is also known as Haber's Process.
- **Bacterial fixation**- Symbiotic and free-living bacterias can combine atmospheric or dissolved nitrogen to form ammonia. Rhizobium in roots of the leguminous plant is a symbiotic bacterium and nostac, acetobacter is an example of free-living bacteria.

Note: Symbiotic relationships are those relationships where both the organisms are benefitted from each other. The classic example of symbiotic relationship can be seen as Lichen which shows mutualism between algae and fungi.



Nitrification

The process in which ammonia is converted into nitrates and nitrites by Nitrosomonas and Nitrococcus bacteria respectively. Nitrobacter can convert nitrate into nitrites.

Assimilation

Nitrogen fixed by plants is converted into organic molecules such as DNA, RNA etc. which forms plant and animal tissues.

Ammonification

- Nitrogenous waste products such as urea and uric acid produced by living organisms, waste products and dead remains of organisms are converted back into inorganic ammonia by the bacteria.

- Ammonifying bacterias like Clostridium, Pseudomonas, Streptomyces etc. help in this process.

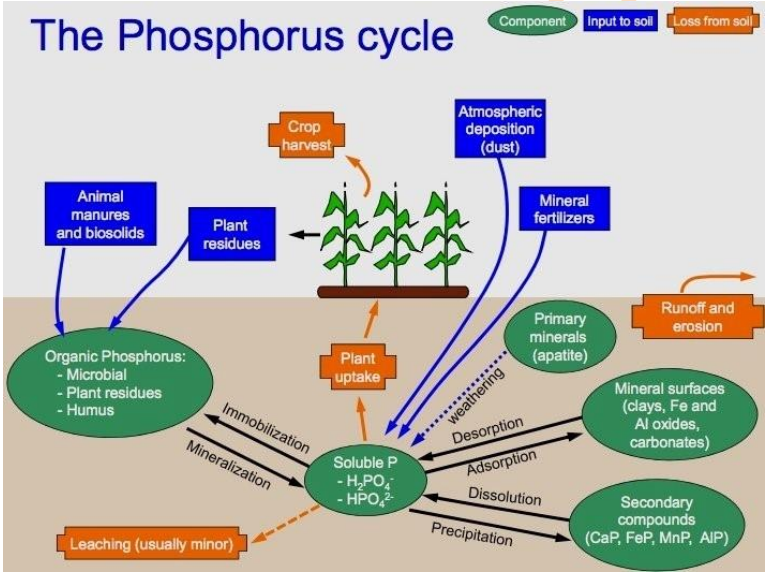
Denitrification

- The conversion of nitrates back into gaseous nitrogen is called denitrification. This process is the reverse of nitrogen fixation.
- This can even lower the fertility of soil because nitrogen, which is essential for the growth of plants, is removed from the soil and is lost to the atmosphere.

Phosphorous cycle

The transport and chemical transformation of phosphorus through the lithosphere, hydrosphere and biosphere are called phosphorus cycle.

The atmosphere does not play a significant role in the movement of phosphorus because phosphorus or phosphorus-based compounds are solids available in normal ranges of temperature and pressure of the earth. Most of the phosphorus remains within rocks, sediments, sand and the ocean floor with a fraction in living biomass. Phosphorus moves along trophic levels in an ecosystem by plant growth, herbivores and carnivores.



Note- Phosphates are effective fertilizers but they also cause pollution in lakes and streams. Over enrichment of it can lead to algae blooms. This excess of algae causes increased consumption by bacteria which lead to higher bacterial concentration. In this process, bacteria use much of dissolved oxygen in the water for cellular respiration and cause the death of fish due to oxygen deprivation.

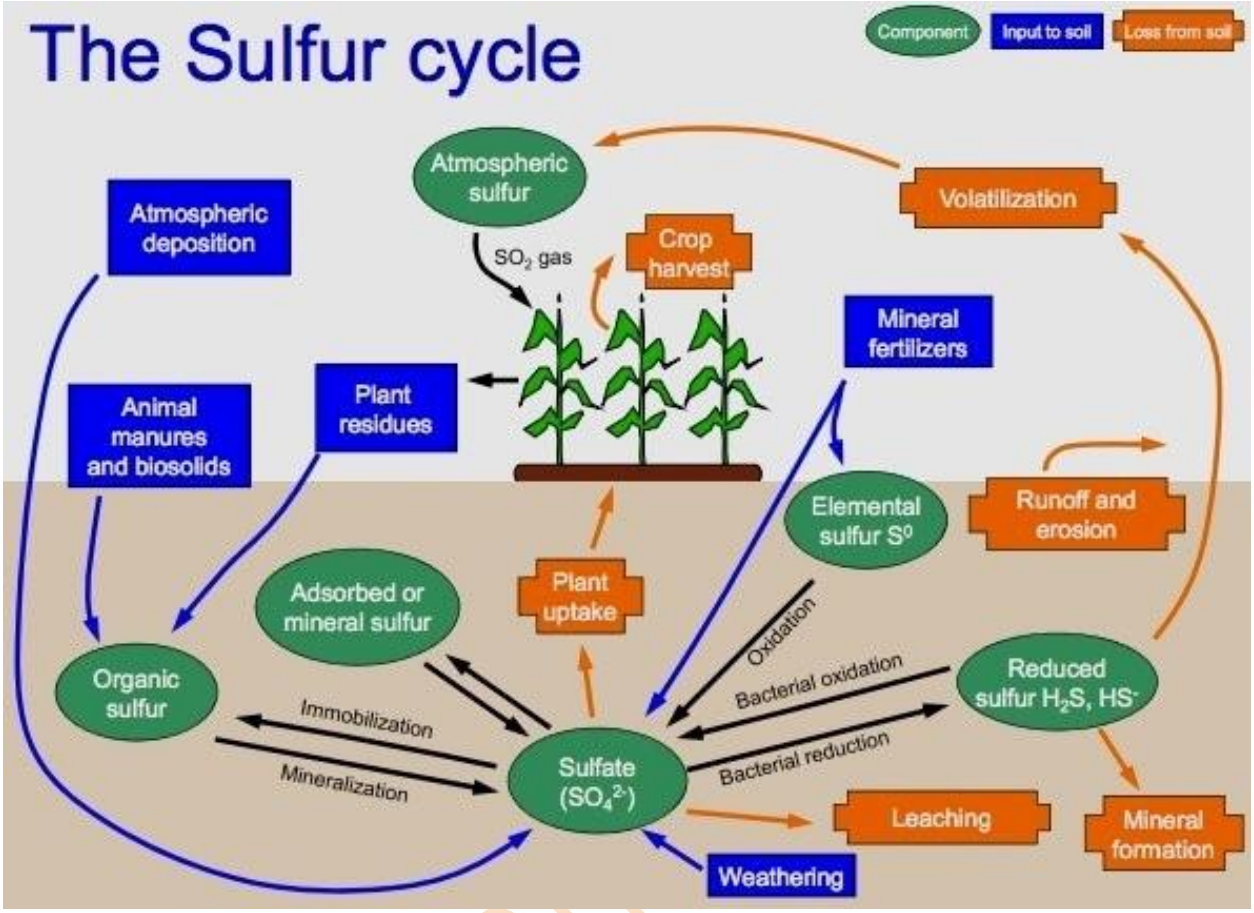
Sulphur Cycle is a type of sedimentary cycle which is sediments based. It does not involve circulation (in the form of gases) through the atmosphere as in case of gaseous cycles. It consists of all such processes through which sulphur is transferred from rocks to the living systems and vice versa.

The topic **'Sulphur Cycle'** forms part of 'Biogeochemical cycle' which is important for various exams like UPSC, State PCS and other competitive exams.

Sulphur cycle

Sulphur is used in the process of proteins and vitamins production. Proteins consist of amino acids that contain sulphur atoms like thiophene. When sulphur is dissolved in water, plants absorb them. Animal consume these plants so that they take up enough sulphur to maintain their health.

- Most of the earth's sulphur tied up in the rocks and salts or buried deep in the ocean in oceanic sediments.
- Sulphur can also be found in the atmosphere. It enters the atmosphere by both natural and human sources.
- Natural sources can be volcanic eruptions, bacterial processes and evaporation from water or decaying organisms.
- Human activities mainly from industrial purposes where sulphur dioxide and hydrogen sulphide gases are emitted on a wide scale.
- When sulphur dioxide enters the atmosphere it reacts with oxygen to produce sulphur trioxide or with other chemicals to make sulphur salts. Sulphur dioxide also reacts with water to produce sulphuric acid. All these particles react with rain and fall back onto Earth as acid deposition.
- The particles then are absorbed by plants again and are released back into the atmosphere and then sulphur cycle will start over again.
- The entire Earth biosphere is a closed system so that nutrients are neither imported nor exported from the biosphere. The biogeochemical cycle also referred to as the cycle of nature because they link together all organisms and abiotic component.


The Sulfur cycle
Component
Input to soil
Loss from soil
Atmospheric sulfur
Atmospheric deposition
SO_2 gas
Crop harvest
Volatilization
Mineral fertilizers
Animal manures and biosolids
Plant residues
Elemental sulfur S^0
Runoff and erosion
Adsorbed or mineral sulfur
Plant uptake
Oxidation
Bacterial oxidation
Organic sulfur
Immobilization
Mineralization
Sulfate (SO_4^{2-})
Bacterial reduction
Reduced sulfur H_2S, HS^-
Leaching
Mineral formation
Weathering