



## UNIT-2

**UNIT2: Natural Resources:** Introduction, Classification. **Water Resources;** Availability, sources and Quality Aspects, Water Borne and Water Induced Diseases, Fluoride and Arsenic Problems in Drinking Water. **Mineral Resources;** Material Cycles; Carbon, Nitrogen and Sulfur cycles. **Energy Resources;** Conventional and Non conventional Sources of Energy. **Forest Resources;** Availability, Depletion of Forests, Environment impact of forest depletion on society.

Unit outcomes:

### Natural Resources

- Natural resources are the materials and substances that exist in the environment and are utilized by humans for various purposes. They are essential for the survival, development, and well-being of societies and play a vital role in supporting economic activities.
- Word resource means a source of supply, so the natural resources are the material which living organism can take from nature for their welfare.
- Natural resources can be a substance, an energy unit or a natural process or phenomena eg- water, air etc.
- Natural resources can be broadly categorized into two main types:
  - i) **Renewable Resources:**
    - Renewable resources are replenished naturally over time and have the ability to regenerate or be replaced through natural processes.
    - Examples of renewable resources include sunlight, wind, water (such as rivers and lakes), forests, agricultural crops, and fisheries.
    - These resources have the potential for sustainable use as long as they are managed responsibly and their rates of exploitation do not exceed their natural regeneration capacities.
  - ii) **Non-Renewable Resources:**
    - Non-renewable resources are finite in nature and cannot be replenished within a human lifespan or at a rate that matches their consumption.
    - They are formed over geological time scales and exist in limited quantities.
    - Non-renewable resources include fossil fuels (such as coal, oil, and natural gas), minerals (such as copper, iron, and gold), and precious metals.
    - Once these resources are depleted, they cannot be replaced, making their conservation and efficient use critical.
- Major Natural resources :
  1. Water resource
  2. Mineral resource
  3. Energy resource
  4. Forest resource
  5. Land resource
  6. Food resource



### Water Resources

- Water is indispensable (essential) natural resource on which all life depends.
- About 71% of earth surface is covered with water.
- 97% of the earth water is salt water and only 3% is fresh water.
- Slightly over 2/3<sup>rd</sup> of this fresh water is frozen in glaciers and polar ice caps
- Water is a renewable resource; scarcity of quality water is still a big issue in many parts of the world.
- Water resources are essential for sustaining life, supporting ecosystems, and enabling human activities. Here are some key points about water resources:
- Importance of Water: Water is a fundamental resource for all living organisms. It is crucial for drinking, sanitation, agriculture, industry, energy production, and maintaining healthy ecosystems.
- Freshwater vs. Saltwater: Most of Earth's water is in the form of saltwater in the oceans, which is not directly usable for most human needs. Freshwater, found in rivers, lakes, groundwater, and glaciers, constitutes only about 2.5% of the total water on the planet.
- Renewable, Yet Limited: Water is a renewable resource as it is replenished through the hydrological cycle (evaporation, condensation, and precipitation). However, its availability can vary regionally and seasonally, and its quantity is finite.
- Water Stress and Scarcity: Many regions around the world face water stress or scarcity, where the demand for water exceeds the available supply. Factors such as population growth, climate change, pollution, inefficient water management, and overconsumption contribute to water scarcity.
- Water for Agriculture: Agriculture is the largest consumer of water globally, accounting for around 70% of freshwater withdrawals. Efficient irrigation practices and technologies are crucial to optimize water use in agriculture.
- Industrial and Energy Water Use: Industries require water for various processes, such as manufacturing, cooling, and cleaning. Similarly, energy production, including thermal power plants and hydropower, relies on water for cooling and generation.
- Water Pollution: Pollution from human activities, including industrial discharges, agricultural runoff, and improper waste management, can contaminate water bodies, making them unfit for consumption and harmful to ecosystems.
- Water Management: Effective water management involves conservation, allocation, and sustainable use of water resources. It includes measures like water conservation practices, water recycling and reuse, watershed management, and the development of infrastructure for storage and distribution.
- International Water Management: Transboundary rivers and shared water resources often require international cooperation and agreements to ensure equitable use, resolve conflicts, and protect ecosystems.
- Adaptation and Conservation: With growing water challenges, adaptation strategies like water-efficient technologies, rainwater harvesting, water pricing mechanisms, and awareness campaigns are crucial. Conservation efforts, such as protecting watersheds, preserving wetlands, and minimizing water waste, are also essential for sustainable water resource management.
- Safeguarding water resources and promoting sustainable water management practices are crucial to ensure water availability for present and future generations, maintain ecosystem health, and support social and economic development.



### **Classification of water:**

Classification of water into surface water and groundwater is based on its location and storage within the Earth's hydrological system. Here's an explanation of these two categories:

#### **Surface Water:**

- Surface water refers to water sources that are visible and located on the Earth's surface, such as rivers, lakes, streams, reservoirs, and wetlands.
- It is typically supplied by precipitation (rain, snow, etc.) that collects in depressions or flows in river channels.
- Surface water is directly exposed to the atmosphere and can interact with the surrounding environment.
- It plays a crucial role in supporting ecosystems, providing habitats for aquatic organisms, and serving as a source of freshwater for various human activities like drinking water, irrigation, industrial use, and recreational purposes.
- Surface water is dynamic and subject to seasonal variations in flow, influenced by rainfall patterns, snowmelt, and other factors.
- It can be readily affected by changes in land use, pollution, and climate conditions.
- Management and protection of surface water resources involve strategies like water quality monitoring, flow regulation, watershed management, and the preservation of riparian zones.

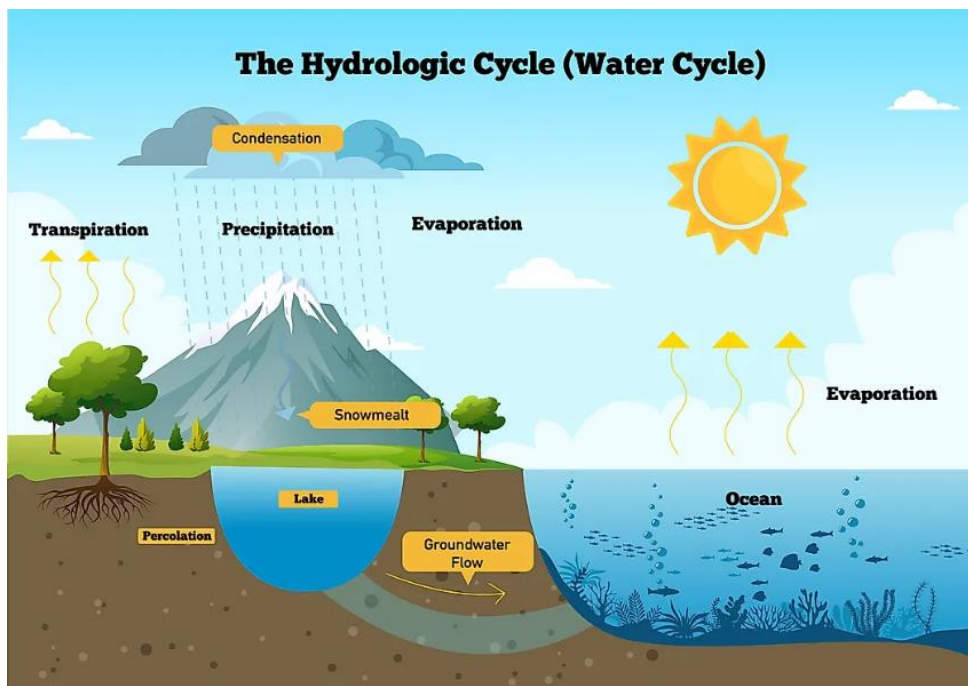
#### **Groundwater:**

- Groundwater refers to the water stored beneath the Earth's surface in underground aquifers, which are porous or permeable rock or sediment layers capable of holding and transmitting water.
- It exists in the pore spaces within soil, sediment, and rock formations, often located at varying depths.
- Groundwater is replenished through a process known as recharge, where precipitation infiltrates the soil and percolates downward to reach the water table, which is the upper surface of the saturated zone.
- It moves slowly through the subsurface, following the topography and the geological properties of the aquifer.
- Groundwater is an important source of freshwater, providing drinking water for millions of people worldwide and supporting agricultural irrigation.
- It also plays a vital role in sustaining wetlands, springs, and baseflow to rivers and streams, especially during dry periods.
- Managing and protecting groundwater resources involve measures like monitoring water levels, controlling pumping rates, implementing wellhead protection zones, and preventing contamination from human activities or industrial practices.

Both surface water and groundwater are interconnected components of the hydrological cycle, and they interact with each other in various ways. For example, surface water can recharge groundwater through infiltration, while groundwater can discharge into surface water bodies, sustaining their flow during dry periods. Integrated management of both surface water and groundwater resources is essential for maintaining water availability, ecological balance, and sustainable water use.

## Hydrological Cycle

- The hydrological cycle, also known as the water cycle, is the continuous movement and exchange of water between the Earth's surface, the atmosphere, and back again.
- It is a fundamental process that redistributes water resources around the planet.
- It is a biogeochemical cycle.
- It describes the continuous movement of water within the environment.
- It is a continuous process with help in exchange of water between atmosphere, earth surface, ocean, plants and other living beings.
- On third of solar flux absorbed by earth is use to continue the hydrological cycle
- It regulate the temperature of the surrounding, it change weather and creates rain. It circulate important minerals
- Here's an overview of the hydrological cycle:



1. **Evaporation:** The cycle begins with the process of evaporation, where solar energy heats up water bodies, such as oceans, lakes, and rivers, causing the water to change from a liquid to a vapour or gas state. This vapour rises into the atmosphere.
2. **Transpiration:** Transpiration is the process by which water vapour is released into the atmosphere by plants through tiny openings called stomata on their leaves. This occurs as part of the plant's natural respiration and photosynthesis processes.
3. **Condensation:** As the water vapour rises in the atmosphere, it cools down, leading to condensation. Condensation occurs when water vapour converts back into liquid form, forming tiny water droplets or ice crystals. These droplets or crystals gather to form clouds.
4. **Precipitation:** Precipitation refers to the process where condensed water droplets or ice crystals in the clouds combine and become heavy enough to fall from the atmosphere to the Earth's surface. Precipitation can take various forms, including rain, snow, sleet, or hail.



5. **Runoff:** After precipitation reaches the Earth's surface, it can either infiltrate into the soil, replenishing groundwater, or flow over the land as surface runoff. Surface runoff collects in rivers, lakes, and other water bodies, eventually returning to the oceans.
6. **Infiltration:** Infiltration occurs when precipitation seeps into the soil and enters underground storage, replenishing groundwater reserves. The rate of infiltration depends on factors such as

The hydrological cycle is driven by solar energy, gravity, and temperature differences. It is a dynamic and interconnected process that distributes water resources globally, ensuring the availability of freshwater for various ecosystems and human activities. Understanding the hydrological cycle is essential for managing water resources, predicting weather patterns, studying climate change impacts, and implementing sustainable water management practices.

### Conservation of water

Conservation of water refers to the efficient and responsible use, management, and protection of water resources to ensure their sustainable availability for present and future generations. Water conservation is crucial to address water scarcity, promote environmental sustainability, and minimize the impact of human activities on water ecosystems. Here are some key approaches and strategies for water conservation:

- **Reduce Water Consumption:** Encouraging individuals, households, and businesses to use water more efficiently is fundamental to water conservation. This can be achieved through:
  - **Fixing leaks promptly:** Regularly checking and repairing leaks in faucets, pipes, and irrigation systems to prevent water wastage.
  - **Installing water-efficient fixtures:** Using low-flow showerheads, faucets, and toilets, and efficient appliances (dishwashers, washing machines) that consume less water.
  - **Practicing responsible indoor water use:** Taking shorter showers, turning off taps while brushing teeth or washing dishes, and using full loads for laundry.
  - **Adopting water-wise landscaping:** Choosing drought-tolerant plants, mulching to retain soil moisture, and using efficient irrigation systems (drip irrigation, smart controllers).
  - **Rainwater Harvesting:** Collecting and storing rainwater for later use can significantly reduce reliance on potable water sources for outdoor irrigation, gardening, and other non-potable uses. Rainwater can be collected from rooftops and directed to storage tanks or permeable surfaces for groundwater recharge.
  - **Greywater Recycling:** Treating and reusing greywater from sources like sinks, showers, and laundry for purposes such as landscape irrigation or toilet flushing reduces the demand for freshwater. Greywater recycling systems filter and disinfect greywater for safe reuse.
  - **Sustainable Agriculture Practices:** Implementing water-efficient agricultural techniques can help conserve water in farming practices, such as:
    - **Precision irrigation methods:** Using technologies like drip irrigation or sprinkler systems to deliver water directly to plant roots, minimizing water loss through evaporation.
    - **Crop selection and rotation:** Opting for drought-tolerant crop varieties and employing crop rotation practices that promote efficient water use.
    - **Soil moisture management:** Employing techniques like mulching, conservation tillage, and cover cropping to reduce evaporation and retain soil moisture.
  - **Industrial and Commercial Water Management:** Industries and businesses can implement water-saving practices to reduce water consumption and improve efficiency. This can include:
    - **Auditing and optimizing water use:** Conducting water audits to identify areas of high water consumption and implementing measures to reduce wastage.



- Recycling and reusing water: Implementing water treatment and recycling systems to reuse water in industrial processes and cooling systems.
- Process optimization: Using advanced technologies and practices to minimize water use in manufacturing processes and operations.
- Public Awareness and Education: Raising awareness about the importance of water conservation through educational campaigns, community outreach, and public engagement can encourage individuals and communities to adopt water-saving behaviors and practices.
- Policy and Regulation: Governments and water management authorities play a crucial role in implementing policies, regulations, and incentives to promote water conservation practices and ensure sustainable water resource management.
- Water conservation is a collective effort that involves the participation of individuals, communities, businesses, and governments. By implementing these strategies, we can make a significant impact in conserving water resources, protecting ecosystems, and securing water availability for future generations.

### Waterborne diseases

Waterborne diseases are illnesses caused by pathogenic microorganisms that are transmitted through contaminated water. These microorganisms can include bacteria, viruses, protozoa, and parasites. Here are some common waterborne diseases:

1. Cholera: Cholera is caused by the bacterium *Vibrio cholerae*. It spreads through water contaminated with faecal matter containing the bacteria. Cholera leads to severe diarrhoea, vomiting, and dehydration, and can be life-threatening if not treated promptly.
2. Typhoid Fever: Typhoid fever is caused by the bacterium *Salmonella typhi*. It is transmitted through the ingestion of food or water contaminated with the bacteria. Symptoms include high fever, headache, stomach pain, and diarrhoea.
3. Hepatitis A: Hepatitis A is a viral infection that affects the liver. It is transmitted through water contaminated with fecal matter containing the hepatitis A virus. Symptoms include fatigue, jaundice, abdominal pain, and loss of appetite.
4. Giardiasis: Giardiasis is caused by the parasite *Giardia lamblia*. It is transmitted through water contaminated with the parasite's cysts. Symptoms include diarrhoea, abdominal cramps, bloating, and weight loss.
5. Cryptosporidiosis: Cryptosporidiosis is caused by the parasite *Cryptosporidium*. It is spread through water contaminated with the parasite's oocysts. Symptoms include watery diarrhoea, stomach cramps, nausea, and fever.
6. Amoebic Dysentery: Amoebic dysentery is caused by the protozoan parasite *Entamoeba histolytica*. It spreads through water or food contaminated with the parasite's cysts. Symptoms include severe diarrhoea with blood or mucus, abdominal pain, and fever.
7. Rotavirus Infection: Rotavirus is a viral infection that primarily affects infants and young children. It is transmitted through water or food contaminated with the virus. Symptoms include severe diarrhoea, vomiting, fever, and dehydration.

Preventing waterborne diseases requires access to clean and safe drinking water, proper sanitation and hygiene practices, and effective water treatment and disinfection systems. Boiling water, using water filters or purifiers, and practicing good personal hygiene, such as hand washing, are important measures to reduce the risk of waterborne diseases. Additionally, ensuring proper sewage disposal, maintaining clean water storage and distribution systems, and implementing public health measures are vital for preventing water contamination and protecting public health.



### Fluoride and Arsenic Problems in Drinking Water:

Fluoride and arsenic are two significant contaminants that can be found in drinking water sources. Let's explore each of them in more detail:

#### Fluoride:

Fluoride is a naturally occurring mineral found in various rocks and soil. It is often added to drinking water supplies in controlled amounts to promote dental health by preventing tooth decay. However, excessive fluoride levels can lead to dental fluorosis (a condition that affects tooth enamel) and, in severe cases, skeletal fluorosis (affecting bones and joints).

In some regions, particularly where naturally occurring fluoride levels are high, excessive fluoride in drinking water can be a concern. Long-term consumption of water with high fluoride concentrations may result in adverse health effects, such as weakened bones, mottled teeth, and skeletal abnormalities. It's important to note that the World Health Organization (WHO) provides guidelines on the permissible levels of fluoride in drinking water to ensure public safety.

WHO note that long term exposure to drinking water that contains 1.5ppm fluoride can lead to health problem. Fluoride content fluoride can lead to health problem. Fluoride content of 0.7ppm is now consider best for dental health

Fluoride in drinking water can have both positive and negative effects on health, depending on the concentration consumed. Here are some key points regarding the effects of fluoride:

- **Dental Health Benefits:** Fluoride has been recognized for its role in promoting dental health. When present at optimal levels in drinking water, fluoride helps prevent tooth decay (dental caries) by strengthening tooth enamel and making it more resistant to acid attacks from bacteria and sugars. This benefit is particularly important for children during the development of their permanent teeth.
- **Dental Fluorosis:** Excessive fluoride intake, especially during tooth development, can lead to dental fluorosis. Dental fluorosis is a cosmetic condition that affects the appearance of tooth enamel, causing white streaks or spots on the teeth. In severe cases, it may result in brown discoloration and pitting of the enamel. The risk of dental fluorosis is higher in areas with high natural fluoride levels in water or with excessive use of fluoride containing dental products.
- **Skeletal Fluorosis:** Prolonged exposure to high levels of fluoride, typically through drinking water, can lead to skeletal fluorosis. Skeletal fluorosis is a bone disorder that can cause joint pain, stiffness, and bone abnormalities. However, skeletal fluorosis is primarily associated with regions where fluoride levels in drinking water greatly exceed recommended limits.
- **Other Health Effects:** There have been some concerns and studies regarding potential health effects associated with long-term exposure to high levels of fluoride. Some research suggests possible links between high fluoride exposure and adverse effects on neurodevelopment and cognitive function, but the evidence is still limited and requires further investigation.

#### Ways to remove fluoride from water:

There are several methods commonly used to remove fluoride from water. Here are some of the most effective techniques:

- **Activated alumina** is a highly porous material with a high affinity for fluoride ions. It effectively adsorbs fluoride from water. The water is passed through a column or filter containing activated alumina, which traps the fluoride ions and reduces their concentration.



- **Reverse Osmosis (RO):** Reverse osmosis is a widely used water treatment process that can effectively remove various contaminants, including fluoride. In RO, water is forced through a semipermeable membrane that selectively allows water molecules to pass while rejecting dissolved minerals and contaminants, including fluoride.
- **Distillation:** Distillation involves heating water to create steam and then condensing the steam back into liquid form. This process effectively removes most impurities, including fluoride. However, it should be noted that distillation can be energy-intensive and may not be suitable for large-scale applications.
- **Ion Exchange:** Ion exchange is a process where ions in water are exchanged with ions of a similar charge in a resin. In the case of fluoride removal, a specific resin called anion exchange resin is used to capture fluoride ions and release other ions in exchange. Over time, the resin becomes saturated with fluoride and needs to be regenerated or replaced.
- **Bone Char Carbon Filters:** Bone char carbon filters are made from charred animal bones and have a high affinity for fluoride. These filters can effectively remove fluoride from water. However, it's important to ensure the quality and source of the bone char, as well as proper maintenance of the filters.

## Arsenic

Arsenic is a naturally occurring element found in rocks, minerals, and soils. It can leach into groundwater, making it a potential contaminant in drinking water sources. Prolonged exposure to high levels of arsenic in drinking water can lead to various health issues, including skin problems, cancer (such as skin, lung, bladder, and kidney cancer), cardiovascular disease, and developmental effects in children.

The permissible limits for arsenic in drinking water vary across countries. The WHO has set a guideline value of 10 micrograms per liter ( $\mu\text{g/L}$ ) for arsenic in drinking water, while in some countries; the regulatory limits might be lower.

To address these issues, water treatment processes can be implemented to remove or reduce fluoride and arsenic levels in drinking water. Common treatment methods include activated alumina, reverse osmosis, distillation, and ion exchange. These methods help to remove or minimize the concentration of fluoride and arsenic to levels that comply with health guidelines.

It's important for regulatory bodies, water suppliers, and individuals to monitor and ensure that drinking water sources meet the necessary quality standards to safeguard public health and mitigate the risks associated with fluoride and arsenic contamination.

### Methods for removing arsenic from drinking water:

- **Coagulation and Filtration:** Chemicals are added to water to form larger particles that can be removed by filtration.
- **Activated Alumina:** Water is passed through activated alumina, which adsorbs arsenic ions.
- **Reverse Osmosis (RO):** Water is forced through a membrane that selectively allows water molecules to pass, removing dissolved contaminants like arsenic.
- **Ion Exchange:** Anion exchange resin captures arsenic ions and releases other ions in exchange.
- **Activated Carbon:** Carbon adsorbs arsenic ions from the water.

These methods vary in effectiveness based on factors like initial arsenic concentration and pH. Combination approaches can provide enhanced removal. Consulting professionals and adhering to regulatory guidelines is important when selecting a method for arsenic removal.





## Mineral Resources

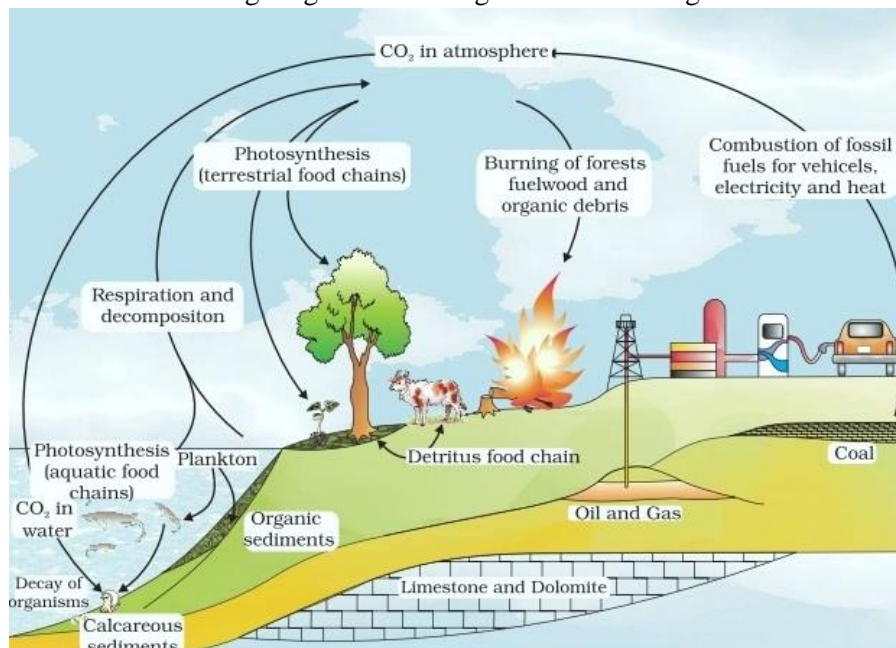
- Mineral resources are valuable substances found in the Earth's crust that have economic significance. They include metals (gold, copper, iron), industrial minerals (limestone, gypsum), energy minerals (coal, oil), and precious stones (diamonds, rubies).
- Mineral resources are valuable substances found in the Earth's crust.
- They include metals, industrial minerals, energy minerals, and precious stones.
- These resources are essential for various industries and economic development.
- They serve as raw materials for manufacturing goods and energy production.
- Mining and extraction are involved in obtaining mineral resources.
- Environmental and social impacts can arise from mining activities.
- Sustainable practices and responsible resource management are crucial.
- Mineral resources are distributed unevenly worldwide.
- Conservation efforts include recycling and efficient resource use.
- Balancing economic benefits with environmental and social considerations is important.

## Material Cycles:

- material cycles, also known as biogeochemical cycles
- Material cycles, or biogeochemical cycles, involve the movement and recycling of essential elements and compounds through Earth's systems.
- The major material cycles include the carbon cycle, nitrogen cycle, phosphorus cycle, and water cycle.
- The carbon cycle involves the exchange of carbon between the atmosphere, plants, animals, soil, and oceans through processes such as photosynthesis, respiration, decomposition, and combustion.
- The nitrogen cycle encompasses the conversion of atmospheric nitrogen into usable forms by nitrogen-fixing bacteria, its incorporation into living organisms, and its return to the atmosphere through processes like denitrification.
- The phosphorus cycle involves the movement of phosphorus through the lithosphere, hydrosphere, and biosphere. It primarily cycles through the soil, plants, and animals.
- The water cycle, also known as the hydrological cycle, describes the movement of water through the atmosphere, surface waters, groundwater, and organisms, driven by processes such as evaporation, condensation, precipitation, and runoff.
- Material cycles are driven by biological, geological, chemical, and physical processes.
- Human activities can influence material cycles through activities such as deforestation, fossil fuel combustion, and the use of fertilizers, which can disrupt natural cycles and lead to environmental issues like climate change and nutrient pollution.
- Understanding and managing material cycles is essential for maintaining ecological balance, sustainable resource management, and addressing environmental challenges.

## Carbon Cycle

- Carbon flows between each reservoir in an exchange called the carbon cycle, which has slow and fast components.
- Carbon is the basic building element of all living organisms.
- The carbon cycle is the process by which carbon moves between the atmosphere, land, oceans, and living organisms.
- Carbon exists in various forms, including atmospheric carbon dioxide ( $\text{CO}_2$ ), organic carbon in living organisms, and inorganic carbon in rocks and minerals.
- Carbon enters the atmosphere through natural processes like respiration and volcanic activity, as well as human activities such as burning fossil fuels and deforestation.
- Plants take in atmospheric  $\text{CO}_2$  through photosynthesis and convert it into organic carbon, which is stored in their tissues.
- Carbon is transferred from plants to animals through consumption. When animals respire or decompose, carbon is released back into the atmosphere as  $\text{CO}_2$ .
- Some carbon is stored for long periods in the form of fossil fuels like coal, oil, and natural gas, which are derived from ancient plant and animal remains.
- The exchange of carbon between the atmosphere and oceans occurs through processes like diffusion and ocean-atmosphere gas exchange.
- The oceans act as a significant carbon sink, absorbing atmospheric  $\text{CO}_2$  through surface waters and storing it in the form of dissolved inorganic carbon and as carbonate compounds.
- Carbon can be stored in terrestrial ecosystems through the formation of soil organic matter or in long-lived vegetation such as forests.
- The carbon cycle is influenced by human activities, particularly the burning of fossil fuels and deforestation, which have led to increased atmospheric  $\text{CO}_2$  concentrations and contribute to climate change.
- Efforts to reduce carbon emissions, promote reforestation, and enhance carbon sequestration are essential for mitigating climate change and maintaining a balanced carbon cycle.



The main processes in the carbon cycle include:

1. **Photosynthesis:** Green plants, algae, and some bacteria use sunlight, carbon dioxide (CO<sub>2</sub>), and water to produce glucose (a form of organic carbon) and oxygen through photosynthesis.
2. **Respiration:** All living organisms, including plants, animals, and microorganisms, release carbon dioxide into the atmosphere through respiration. During respiration, organic carbon is broken down to release energy, and CO<sub>2</sub> is produced as a byproduct.
3. **Decomposition:** When plants and animals die, their organic matter undergoes decomposition by bacteria, fungi, and other decomposers. During this process, carbon is released back into the atmosphere as CO<sub>2</sub> or converted into organic carbon compounds in the soil.
4. **Combustion:** The burning of fossil fuels, such as coal, oil, and natural gas, releases large amounts of carbon dioxide into the atmosphere. Combustion is a human-driven process that contributes significantly to the increase in atmospheric CO<sub>2</sub> concentrations.
5. **Fossilization:** Over millions of years, some organic carbon is buried and transformed into fossil fuels like coal, oil, and natural gas. These fuels store carbon for long periods until they are extracted and burned, releasing CO<sub>2</sub> back into the atmosphere.
6. **Carbon Sequestration:** Carbon can be stored for extended periods in long-lived vegetation, such as forests, as well as in the oceans and in soil organic matter. This process, known as carbon sequestration, helps reduce the amount of CO<sub>2</sub> in the atmosphere and mitigates climate change.
7. **Ocean-Atmosphere Exchange:** The exchange of carbon dioxide between the oceans and the atmosphere occurs through diffusion and ocean-atmosphere gas exchange. The oceans act as a carbon sink, absorbing CO<sub>2</sub> from the atmosphere, which can impact ocean acidity and marine ecosystems.

## Nitrogen Cycle

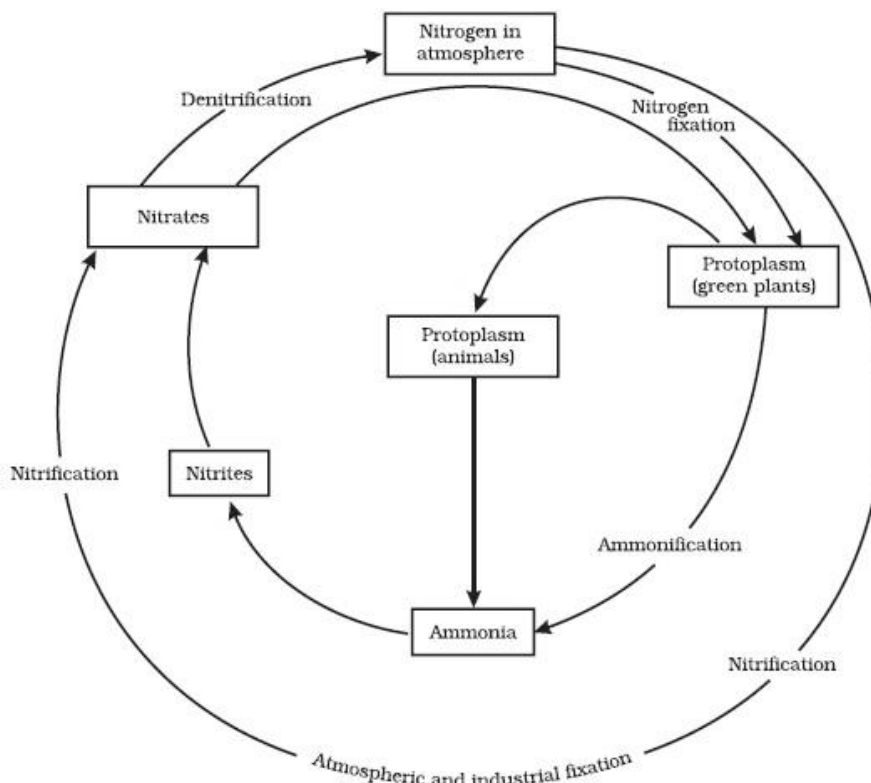
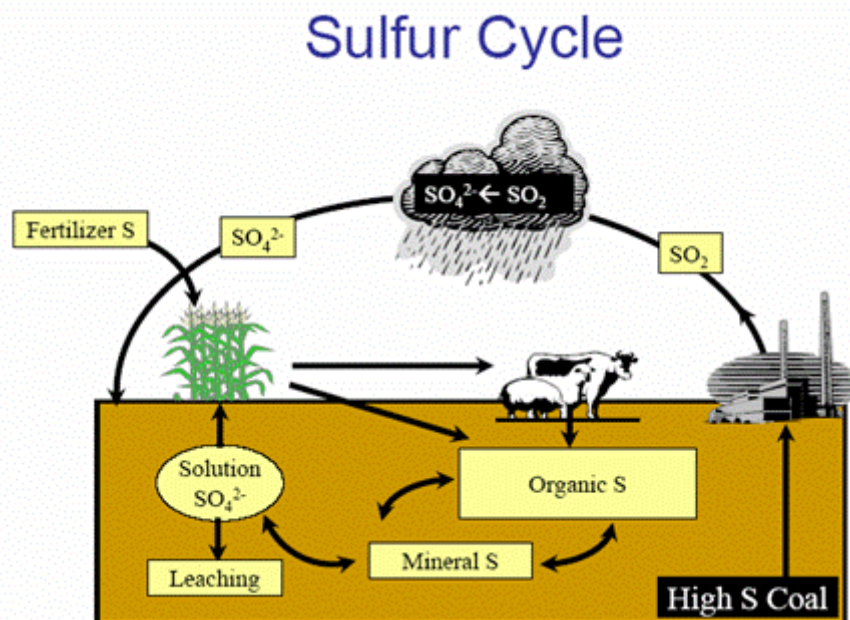


Fig.14.6: Nitrogen-cycle in nature

The nitrogen cycle is the biogeochemical process by which nitrogen is converted and cycled through various forms in the environment. It involves several key processes:

1. **Nitrogen Fixation:** Nitrogen gas ( $N_2$ ) from the atmosphere is converted into forms usable by plants through nitrogen fixation. This process can occur through two main mechanisms: biological nitrogen fixation, carried out by nitrogen-fixing bacteria that convert  $N_2$  into ammonia ( $NH_3$ ) or ammonium ( $NH_4^+$ ), and industrial nitrogen fixation, which is human-driven and involves the production of nitrogen-based fertilizers.
2. **Nitrification:** Ammonia or ammonium is converted into nitrite ( $NO_2^-$ ) and then into nitrate ( $NO_3^-$ ) through nitrification. This process is carried out by nitrifying bacteria.
3. **Assimilation:** Plants take up nitrate or ammonium from the soil and incorporate nitrogen into organic compounds, such as proteins and nucleic acids. Animals obtain nitrogen by consuming plants or other animals.
4. **Ammonification:** Decomposers break down organic matter, such as dead plants and animals, and convert the organic nitrogen compounds into ammonium through ammonification. This process releases ammonium back into the soil.
5. **Denitrification:** Denitrifying bacteria convert nitrate back into gaseous nitrogen ( $N_2$ ), completing the nitrogen cycle. Denitrification occurs in oxygen-poor environments like waterlogged soil or sediments, and it releases nitrogen gas back into the atmosphere.
6. **Human Impact:** Human activities, particularly the use of synthetic nitrogen fertilizers in agriculture and industrial processes, have greatly influenced the nitrogen cycle. Excessive application of fertilizers can lead to nitrogen runoff, which can cause water pollution and contribute to issues such as eutrophication in aquatic ecosystems.

The nitrogen cycle is vital for sustaining life and plays a crucial role in the productivity of ecosystems. It ensures a continuous supply of nitrogen, an essential nutrient, for plants and other organisms. However, human activities have disrupted the natural balance of the nitrogen cycle, emphasizing the importance of sustainable nitrogen management to minimize environmental impacts.



The sulfur cycle is a biogeochemical process that involves the cycling of sulfur through various forms in the environment. It includes both organic and inorganic components and consists of several key processes:



**Weathering:** Sulfur compounds in rocks and minerals are gradually released through weathering processes, which break down these materials over time. This leads to the release of inorganic sulfur into the environment.

**Sulfur Deposition:** Sulfur compounds can be deposited in the atmosphere through natural processes like volcanic emissions and ocean spray. Human activities, such as burning fossil fuels and industrial processes, also contribute to sulfur deposition through the release of sulfur dioxide ( $\text{SO}_2$ ) and other sulfur compounds.

**Biological Sulfur Assimilation:** Plants and microorganisms take up inorganic sulfur from the soil and water and convert it into organic sulfur compounds through assimilation. These organic compounds, such as sulfur-containing amino acids, are essential for the synthesis of proteins and other organic molecules in living organisms.

**Decomposition:** When organisms die and organic matter decays, sulfur compounds are released back into the environment through the process of decomposition. Decomposers, such as bacteria and fungi, break down organic materials and convert them into simpler compounds, including sulfur compounds.

**Sulfur Cycling in Aquatic Systems:** In aquatic environments, sulfur can undergo various transformations. Sulfur-reducing bacteria can convert sulfate ( $\text{SO}_4^{2-}$ ) into sulfide ( $\text{S}^{2-}$ ), a process known as sulfate reduction. Sulfide can then be oxidized back to sulfate through microbial processes.

**Volatile Sulfur Compounds:** Certain microorganisms produce volatile sulfur compounds, such as dimethyl sulfide (DMS), which can be released into the atmosphere. DMS plays a role in the global sulfur cycle and can influence cloud formation and climate processes.

**Human Impact:** Human activities, particularly the burning of fossil fuels, contribute significantly to sulfur emissions and the alteration of the sulfur cycle. Sulfur dioxide released from industrial processes and fossil fuel combustion can lead to acid rain, air pollution, and environmental damage.

The sulfur cycle plays a vital role in ecosystem functioning and is closely linked to other biogeochemical cycles, such as the carbon and nitrogen cycles. Understanding and managing sulfur cycling are essential for minimizing environmental impacts and maintaining ecological balance.



## Energy resources

- **Energy resources** can be defined as materials or elements that can be used to produce energy. Energy is a quantitative property, which produces an output or a force that can be analysed.
- This energy can be in the form of **electricity, heat, or mechanical energy**
- Three primary types of energy include fossil fuels, nuclear energy and renewable energy, each type of energy resource with its own advantages and disadvantages.
- Energy can be defined as the capacity produce an effect to do some work.
- Energy is one of the most important building blocks for human life on earth and economic development of the country.
- The demand for energy resources are increasing day by day in the development of industries, transportation and agricultural activities.

### TYPES OF ENERGY RESOURCES

On the basis of sources energy are classified into categories, renewable energy resources and non renewable energy resources.

- i) **Renewable energy resources:** These energy resources are also known as non conventional energy resource, which can be regenerated continuously. It can be used again and again in an endless manner because these resources are available in large amount. For example, solar energy, wind energy, bio-fuels, hydro energy, geothermal energy, wave & tidal energy.
- iii) **Non renewable resources:** These energy resources are also known as conventional (traditional) energy resources. It cannot be replenished when these sources are exhausted because these resources are present in limited amount and take a long period of time to resynthesize. For example, nuclear energy, coal, petroleum, natural gas etc.

## Non conventional Sources of Energy

### ➤ BIOMASS :

- Biomass is a renewable energy resource, also known as 'carbon neutral' (because biomass formed by sunlight, water, carbon dioxide, so biomass does not increase carbon dioxide on the earth) or 'phytomass'.
- It is formed by the excreta or waste materials of living organism (like sewage, cow dung etc.) and dead plants & trees (firewood, wood shavings, fruit stone etc.).
- In biomass, the energy from the sunlight is stored in the form of cellulose, sugar, starch, lignin etc.
- The chemical energy released from these molecule when they undergoes digestion or combustion because chemical bonds between carbon, hydrogen and oxygen are broken.
- Energy generation from biomass
  - a) Combustion or burning is most common method to obtain energy directly from biomass.
  - b) **Fermentation:** in this process, biomass (carbohydrate) is converted into alcohol in presence of bacteria or yeast.



- c) **Biomass gasification:** In this process, biomass is converted into combustible fuel like producer gas ( $\text{CO} + \text{H}_2$ ) and small amount of methane through incomplete combustion.

#### Advantage of biomass energy

1. It is also a renewable source of energy.
2. Burning of alcohol or producer gas produce less amount of pollutant gases.
3. Biomass present in large amount.
4. Help to reduce waste.

#### Disadvantage of biomass energy

1. Direct combustion of biomass generates pollutant gases like fossil fuel.
2. Cause deforestation.
3. Not efficient like fossil fuel.

### BIOGAS

It is formed by the bacterial degradation of biomass under anaerobic condition (airtight digesters). Biogas mainly contains methane (50-70%), carbon dioxide and trace amount of water, sulfur and hydrogen sulphide. Biogas generation The biogas generated by anaerobic digestion of organic waste (animal waste, plant residue, crops) in biogas plant, mainly involve three steps: hydrolysis, acid formation and gas production.

- a. **Hydrolysis:** In this step, macromolecule like fats, proteins, carbohydrates are broken down through hydrolysis into fatty acids, amino acids and sugars respectively.
- b. **Acid formation:** in this step, fatty acids, amino acids and sugars are fermented by acid producing bacteria under anaerobic condition into acetic acid, carbon dioxide and hydrogen.
- c. **Gas production:** In this step, methanogenic bacteria produce methane either by fermenting acetic acid to form methane and carbon dioxide or by reduction of carbon dioxide into methane.

#### Advantage of biogas

- Produce organic waste
- Burn without smoke
- Renewable
- Help to reduce waste.

#### Disadvantage of biogas

- i) Methane is health hazardous.
- ii) Not efficient like fossil fuel



## Solar Energy:

Solar energy refers to the energy derived from the Sun's radiation. It is a renewable and sustainable source of power that has gained significant attention in recent years due to its numerous environmental and economic benefits. Solar energy can be harnessed using various technologies, such as photovoltaic (PV) systems and solar thermal systems.

**Photovoltaic (PV) Systems:** PV systems convert sunlight directly into electricity using solar cells. These cells are typically made of semiconductor materials, such as silicon. When sunlight strikes the cells, it excites electrons, creating an electric current. PV systems can range from small-scale installations on rooftops to large utility-scale solar farms.

**Solar Thermal Systems:** Solar thermal systems use the Sun's energy to generate heat. These systems typically consist of solar collectors that capture sunlight and transfer it to a fluid, such as water or thermal oil. The heated fluid can be used directly for various applications, including heating buildings, generating hot water, or even powering steam turbines for electricity generation.

**Solar collectors:** A solar collector is a device that collects and/or concentrates solar radiation from the Sun. These devices are primarily used for active solar heating and allow for the heating of water for personal use. These collectors are generally mounted on the roof and must be very sturdy as they are exposed to a variety of different weather conditions.

There are many different types of solar collectors. There is some material that is used to collect and focus energy from the Sun and use it to heat water. The simplest of these devices uses a black material surrounding pipes that water flows through. The black material absorbs the solar radiation very well, and as the material heats up the water it surrounds.

- 1. Flat Plate Collectors:** These collectors are simply metal boxes that have some sort of transparent glazing as a cover on top of a dark-coloured absorber plate. The sides and bottom of the collector are usually covered with insulation to minimize heat losses to other parts of the collector. Solar radiation passes through the transparent glazing material and hits the absorber plate. This plate heats up, transferring the heat to either water or air that is held between the glazing and absorber plate. Sometimes these absorber plates are painted with special coatings designed to absorb and retain heat better than traditional black paint. These plates are usually made out of metal that is a good conductor - usually copper or aluminium.

## Benefits of Solar Energy:

- **Renewable and Sustainable:** Solar energy is abundant and will continue to be available as long as the Sun exists. It does not deplete natural resources like fossil fuels.
- **Environmentally Friendly:** Solar energy produces no greenhouse gas emissions or air pollutants during operation, helping to mitigate climate change and improve air quality.
- **Cost-effective:** While the initial installation cost of solar systems can be high, the operational costs are generally low. As technology advances and economies of scale improve, solar energy is becoming increasingly affordable.
- **Energy Independence:** Solar power allows individuals, communities, and countries to reduce dependence on fossil fuels and foreign energy sources, promoting energy security.





- Versatility: Solar energy can be used in various applications, including residential, commercial, and industrial sectors. It can power homes, buildings, streetlights, water pumps, and more.
- Job Creation: The solar industry has the potential to generate numerous jobs, from manufacturing and installation to maintenance and research.
- Challenges of Solar Energy:
- Intermittency: Solar power generation depends on sunlight availability, which varies with weather conditions and time of day. Energy storage systems or grid integration methods are needed to address this intermittency.
- Land and Space Requirements: Large-scale solar installations require considerable land or roof space, which can be a limitation in densely populated areas.
- Manufacturing Impacts: The production of solar panels involves some environmental impacts, such as the energy and resources required for manufacturing and the disposal of old or damaged panels.
- Upfront Costs: While the operational costs of solar energy are low, the initial investment for installing solar systems can be a barrier for some individuals or organizations.
- Geographic Limitations: The efficiency of solar panels can vary based on geographical location and climate. Areas with limited sunlight may not be suitable for large-scale solar energy generation.
- Despite these challenges, solar energy continues to grow in popularity and plays a vital role in the transition towards a more sustainable and clean energy future. Technological advancements, government incentives, and increased awareness of the benefits of solar power are helping to drive its adoption worldwide.

## Tidal Energy:

- Tidal energy is a renewable energy powered by the natural rise and fall of ocean tides and currents. Some of these technologies include turbines and paddles.
- Tidal energy production is still in its infancy. The amount of power produced so far has been small. There are very few commercial-sized tidal power plants operating in the world.
- The gravitational forces of the sun and the moon combined with the rotation of the earth result in an alternate rise and fall of the sea levels.
- The rise of the sea level is called the high tide, whereas the fall is called the low tide.
- There are currently three different ways to get tidal energy: tidal streams, barrages, and tidal lagoons.

### 1. Tidal streams:

- For most tidal energy generators, turbines are placed in tidal streams.
- A tidal stream is a fast-flowing body of water created by tides.
- A turbine is a machine that takes energy from a flow of fluid.
- That fluid can be air (wind) or liquid (water). Because water is much more dense than air, tidal energy is more powerful than wind energy.
- Unlike wind, tides are predictable and stable.
- Where tidal generators are used, they produce a steady, reliable stream of electricity
- Placing turbines in tidal streams is complex, because the machines are large and disrupt the tide they are trying to harness.
- The environmental impact could be severe, depending on the size of the turbine and the site of the tidal stream.



- Turbines are most effective in shallow water.
- This produces more energy and allows ships to navigate around the turbines.
- A tidal generator's turbine blades also turn slowly, which helps marine life avoid getting caught in the system.
- **The world's first tidal power station** was constructed **in 2007** at **Strangford Lough in Northern Ireland**.
- The turbines are placed in a narrow strait between the Strangford Lough inlet and the Irish Sea.
- The tide can move at 4 meters (13 feet) per second across the strait.

## 2. Barrage:

- Another type of tidal energy generator uses a large dam called a barrage.
- With a barrage, water can spill over the top or through turbines in the dam because the dam is low.
- Barrages can be constructed across tidal rivers, bays, and estuaries.
- Turbines inside the barrage harness the power of tides the same way a river dam harnesses the power of a river.
- The barrage gates are open as the tide rises.
- At high tide, the barrage gates close, creating a pool, or tidal lagoon.
- The water is then released through the barrage's turbines, creating energy at a rate that can be controlled by engineers.
- A barrage is a much more expensive tidal energy generator than a single turbine.
- Although there are no fuel costs, barrages involve more construction and more machines.
- Unlike single turbines, barrages also require constant supervision to adjust power output.
- The tidal power plant at the Rance River estuary in Brittany, France, uses a barrage. It was built in 1966 and is still functioning. The plant uses two sources of energy: tidal energy from the English Channel and river current energy from the Rance River.

## 3. Tidal Lagoon:

- A tidal lagoon is a body of ocean water that is partly enclosed by a natural or manmade barrier.
- Tidal lagoons might also be estuaries and have freshwater emptying into them.
- A tidal energy generator using tidal lagoons would function much like a barrage.
- Unlike barrages, however, tidal lagoons can be constructed along the natural coastline.
- A tidal lagoon power plant could also generate continuous power.
- The turbines work as the lagoon is filling and emptying.
- The environmental impact of tidal lagoons is minimal.
- The lagoons can be constructed with natural materials like rock.
- They would appear as a low breakwater (sea wall) at low tide, and be submerged at high tide.
- Animals could swim around the structure, and smaller organisms could swim inside it.
- Large predators like sharks would not be able to penetrate the lagoon, so smaller fish would probably thrive. Birds would likely flock to the area.
- But the energy output from generators using tidal lagoons is likely to be low.



- China is constructing a tidal lagoon power plant at the Yalu River, near its border with North Korea.
- A private company is also planning a small tidal lagoon power plant in Swansea Bay, Wales.

## Wind energy:

- Wind energy is a form of renewable energy that harnesses the power of the wind to generate electricity. It is a clean and sustainable source of power that does not emit greenhouse gases or other pollutants during operation.
- wind energy works:
  1. **Wind Turbines:** Wind turbines are the primary technology used to capture wind energy. They consist of large, tall structures with rotor blades mounted on top. The blades are designed to capture the kinetic energy of the wind.
  2. **Wind Capture:** When the wind blows, it causes the rotor blades to spin. The kinetic energy of the moving air is transferred to the rotor blades, causing them to rotate.
  3. **Power Generation:** The spinning rotor blades are connected to a generator through a shaft. As the blades rotate, they turn the generator, which converts the mechanical energy into electrical energy.
  4. **Power Distribution:** The electricity generated by the wind turbine is sent through a transformer to increase its voltage, making it suitable for transmission through power lines. It is then distributed to homes, businesses, and industries through the electrical grid.

## Advantages of Wind Energy:

1. **Renewable and Clean:** Wind is an abundant and inexhaustible resource. Harnessing wind energy reduces reliance on fossil fuels and helps combat climate change by reducing greenhouse gas emissions.
2. **Cost-effective:** The cost of wind energy has significantly decreased over the years, making it one of the most affordable sources of renewable energy. Once a wind turbine is installed, the operational costs are relatively low.
3. **Job Creation:** The wind energy sector creates jobs in manufacturing, installation, operation, and maintenance of wind turbines, supporting local economies.
4. **Land Use:** Wind turbines can be installed on agricultural land or offshore, making efficient use of space without interfering with other activities. Farming and grazing can often continue around wind turbines.

## Challenges of Wind Energy:

- **Intermittency:** Wind energy is variable and depends on wind speed. Wind turbines require consistent wind flow to generate electricity, and energy production may fluctuate, requiring backup power sources or energy storage systems.
  - **Visual and Noise Impact:** Some people find wind turbines visually unappealing, particularly when installed near residential areas. Additionally, wind turbines can produce noise, although modern designs aim to minimize this impact.
  - **Location Limitations:** Wind energy is more viable in areas with consistent and strong wind resources. It may not be feasible or economically viable in regions with low wind speeds.
  - **Environmental Considerations:** While wind energy itself is environmentally friendly, there can be concerns about its impact on bird and bat populations, as well as potential disturbances to local ecosystems during construction and operation.
- Despite these challenges, wind energy has experienced significant growth worldwide and continues to contribute to the transition towards cleaner and more sustainable energy systems.



### Geothermal Energy:

- Geothermal energy utilizes heat from within the Earth to generate power or provide heating and cooling.
- It is a renewable and sustainable energy source that produces low greenhouse gas emissions.
- Geothermal reservoirs, consisting of hot water and steam, are found in regions with volcanic activity or hot rock formations.
- Wells are drilled into these reservoirs to extract steam or hot water.
- The steam or hot water is used to drive a turbine connected to a generator, producing electricity.
- Geothermal energy can also be used directly for heating and cooling applications.
- It is a reliable source of energy as it is not dependent on weather conditions like solar or wind energy.
- Geothermal power plants have minimal operational costs since no fuel needs to be purchased.
- It helps reduce air pollution and mitigate climate change by emitting minimal greenhouse gases.
- Geothermal energy has the potential to provide long-term energy stability and price predictability.
- However, its implementation is constrained by the availability of suitable geothermal resources and high initial investment costs.
- Proper management is necessary to address potential environmental impacts associated with geothermal fluid handling and wastewater reinjection.

**India has significant potential for geothermal energy** due to its geological characteristics. Here are some points highlighting the geothermal energy potential in India:

- **Geothermal Resources:** India has several geothermal areas with hot springs, geysers, and geologically active regions, indicating the presence of geothermal reservoirs. Prominent geothermal sites include Puga Valley in Jammu and Kashmir, Manikaran in Himachal Pradesh, Tattapani in Chhattisgarh, and several locations in the northeastern states.
- **Geothermal Gradient:** India has a relatively high geothermal gradient, which means that the temperature increases with depth at a faster rate compared to some other regions. This indicates the potential for accessing higher temperature geothermal reservoirs, which are ideal for power generation.
- **Direct Use Applications:** Geothermal energy can be utilized for direct heating and cooling applications in India. Hot water and steam from geothermal sources can be used for space heating, bathing, and agricultural processes, reducing the reliance on conventional energy sources.
- **Enhanced Geothermal Systems (EGS):** India also has potential for Enhanced Geothermal Systems, where hot rock formations are accessed and engineered to create artificial geothermal reservoirs. This can help tap into deeper and hotter geothermal resources that may not be naturally accessible.
- **Geothermal Policy Framework:** The Indian government has recognized the potential of geothermal energy and is taking steps to develop the sector. The Ministry of New and Renewable Energy (MNRE) has initiated projects for resource assessment, exploration, and



technology development. The National Geothermal Energy Programme is aimed at promoting geothermal energy utilization in the country.

- Challenges and Opportunities: Despite its potential, the development of geothermal energy in India faces challenges such as high upfront costs, uncertainty of resource availability, and the need for advanced drilling technology. However, advancements in technology, investment incentives, and research efforts can help overcome these challenges and unlock the full potential of geothermal energy in India.

## Forest Resource

- Forest resources refer to the various goods and services that are derived from forests and other wooded lands.
- These goods and services are used by people in various ways, including for subsistence, economic activities, and recreation.
- Forests provide a wide range of resources, including timber, food, fuel, and other materials.
- They are also important habitats for many species of plants and animals, and they help to protect water supplies and maintain soil health.
- Timber is one of the most important forest resources. It is used in a variety of ways, from construction to furniture and paper production.
- In addition, forests are important sources of food, such as berries, nuts, and wild game.
- Forests also provide fuel for cooking and heating, as well as materials for crafts and traditional medicines.
- Forests provide many other benefits, including recreational opportunities, such as hiking and camping, as well as educational opportunities, such as scientific research and nature study. They also help to regulate climate and weather patterns, filter pollutants and protect watersheds.

Finally, forests provide a number of aesthetic and spiritual benefits, such as providing a sense of connection to nature, beauty, and peace. They are also important cultural resources, providing a connection to past generations and a sense of identity for many people.

The challenges facing forest resources are numerous and varied. From climate change and unsustainable harvesting practices to deforestation and illegal logging, the effects of human activities on forests are far-reaching and concerning.

Climate change is one of the greatest challenges facing forests today. Rising temperatures, changing precipitation patterns, and intensifying storms can all have serious impacts on forest health.

Warmer temperatures may lead to more frequent and intense wildfires, while changing precipitation patterns can lead to drought, which can cause trees to die and make them more susceptible to pests and diseases. Unsustainable harvesting practices are another major challenge.

In many parts of the world, forests are harvested at rates that are too high and too quickly, leaving behind a landscape that is unable to regenerate itself. This means that the forests are not able to provide the same levels of biodiversity and other benefits that they once did. Deforestation is another major challenge. While some deforestation is a natural part of the forest cycle, much of it is caused by human activities such as logging, mining, and agricultural expansion. Deforestation destroys important habitats, reduces carbon storage capacity, and can lead to soil erosion and water pollution.



Illegal logging is another major challenge. In many parts of the world, logging is done without proper permits or regulations, resulting in the destruction of the forest and the loss of important habitats and resources. This can also lead to soil erosion and water pollution.

Finally, the effects of climate change are becoming increasingly evident in forests. Rising temperatures and changing precipitation patterns can lead to more frequent and intense wildfires, insect infestations, and droughts. These can have serious impacts on the health of forests and can lead to long-term damage.

### **The Conservation of Forest Resources:**

Forest resources are essential for life on Earth. They provide food, fuel, shelter, and other essential products. Forests also serve as important habitats for wildlife and play a key role in the global carbon cycle, regulating the climate and protecting watersheds.

Conservation of forest resources is essential for the sustainable use and management of forest resources. Conservation efforts are designed to protect these resources and ensure their continued availability for future generations.

The most important conservation measure is to reduce deforestation and encourage sustainable forest management. This includes reducing the use of wood for fuel, limiting the spread of invasive species, and implementing measures to protect vulnerable species.

Reforestation is also important for replacing trees lost due to deforestation or other activities. Protected areas are another important conservation measure. Protected areas are areas of land set aside for the conservation of natural resources and wildlife.

They are managed by governments and non-governmental organizations to ensure that forests are managed in a sustainable and responsible manner. Education and awareness are also important for the conservation of forest resources.

People need to understand the importance of forest resources and how they can help to conserve them. This includes learning about the impacts of deforestation and other unsustainable practices, such as logging and burning.

Finally, research is necessary to understand the effects of deforestation and other human activities on forest ecosystems. This knowledge can be used to develop strategies for the conservation and management of forests. Conservation of forest resources is essential for the sustainability of the world's forests and the ecosystems they support.

It requires the cooperation of governments, non-governmental organizations, and individuals to ensure that these resources are managed in a responsible and sustainable manner.