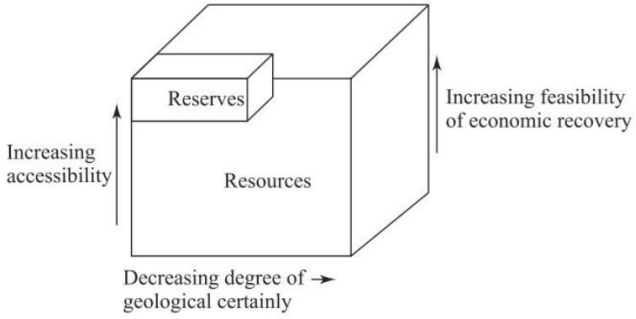
Resources are objects, materials, creatures, or any form of energy found in nature that can be used to perform any useful function. They are or may become of potential economic interest due to their inherent properties.

Reserves are that part of a resource which has been fully evaluated and is found commercially viable to work on the consideration of mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors.



Reserves and resources

Natural resources are naturally occurring materials that are useful to man or could be useful under conceivable technological, economic or social circumstances or supplies drawn from the earth, supplies such as food, building and clothing materials, fertilizers, metals, water and geothermal power. For a long time, natural resources were the domain of the natural sciences.

TYPES OF NATURAL RESOURCES

Based on their use, availability, origin and economic status, natural resources can be classified into the following types:

1) Perpetual, Renewable and Non-renewable Natural Resources

Based on their avail ability or how human activities affect them, natural resources are of the following three types:

(A) Perpetual Resources: Perpetual resources are those natural resources that naturally perpetuate themselves and are not affected by human use.

Examples- Sunlight, wind, rainfall water and tides.

(B) Renewable Resources: Renewable resources are those natural resources that have the inherent ability to renew or replenish themselves if given a reasonable amount of time.

Examples- Soil, fresh water, forest, etc.

(C) Non-renewable (or Exhaustible) Resources: Non-renewable resources are those natural resources that cannot be regenerated or renewed or replaced within a time framework.

Examples- Fossil fuels (such as coal, petroleum, natural gas, etc.), nuclear power.

(D) Intangible Resources: Intangible resources are those natural resources that are available in huge quantities, but at the same time can be destroyed easily.

Example-The tourism industry

2) Biotic and Abiotic Natural Resources

Based on their origin, natural resources are of the following two types:

(A) Biotic Resources: Biotic resources have originated from some living organism or have life.

Examples

- Renewable: Livestock, fisheries, flora, fauna, and humans.
- Non-renewable: Coal, petroleum, etc.

(B) Abiotic Resources: Abiotic resources are of non-living origin.

Examples- Minerals, rocks, water, etc.

The major natural resources are:

1. **Water resource**
2. **Mineral resource**
3. **Forest resource**
4. **Energy resource**
5. **Food resource**
6. **Land resource**

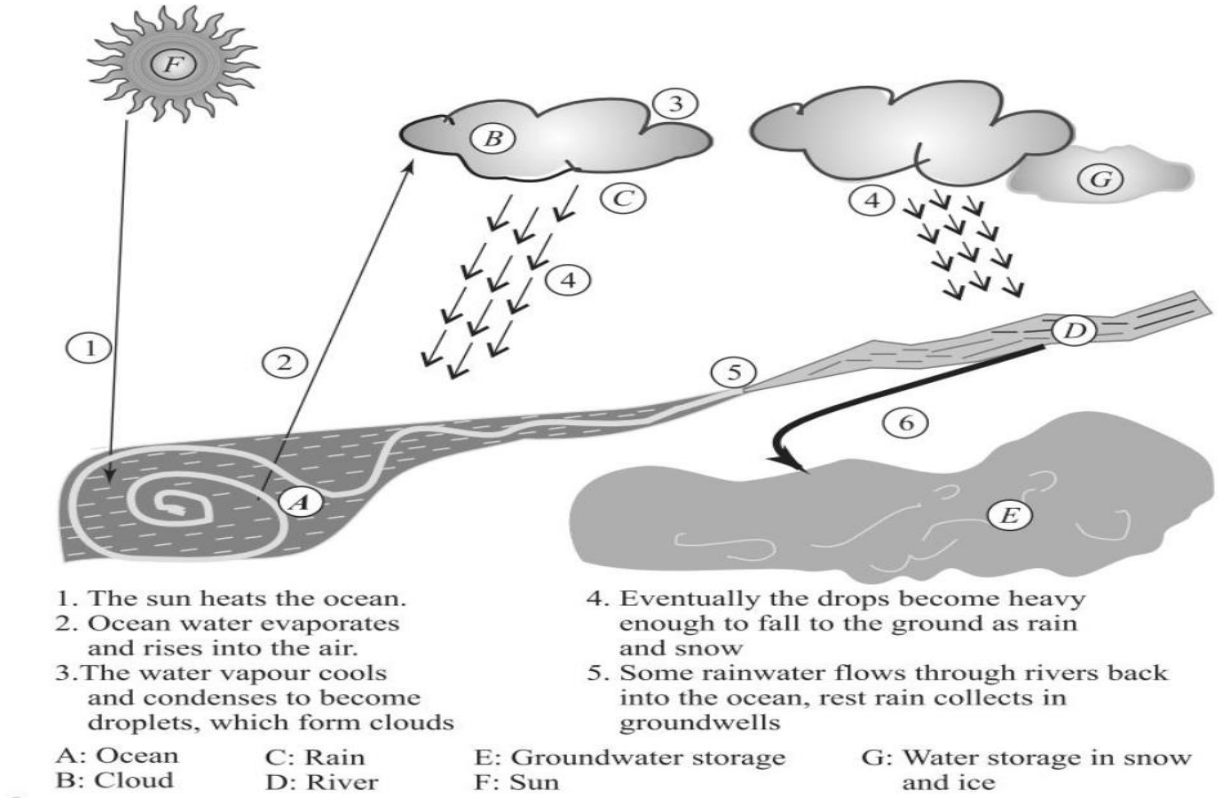
WATER RESOURCES

Water resources are sources of water that are useful or potentially useful to humans. Water is a prerequisite for the existence of life. Plants, animals, and human beings cannot survive without water. Water is used in agricultural, household, industrial, recreational, and environmental activities.

(A) The Water Cycle: It describes the continuous movement of water above and below the surface of the earth. It is driven by the sun.

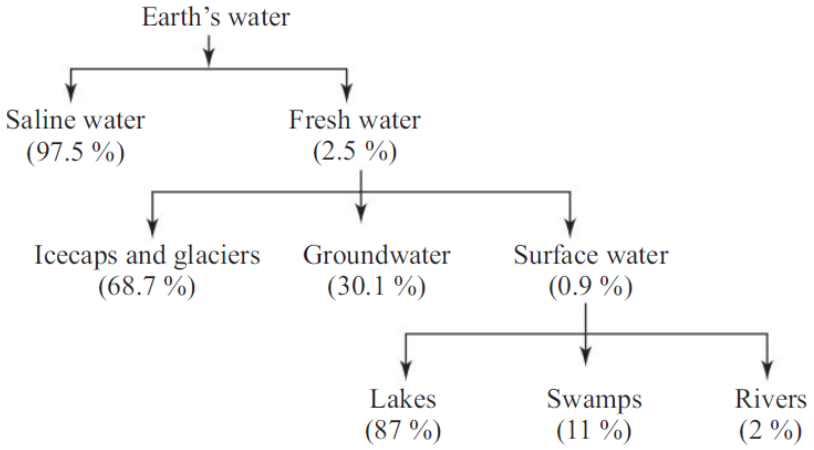
The sun heats water in seas and oceans. Water evaporates into the air as water vapour. Snow and ice can sublime directly into water vapour. Rising air currents take the water vapours into the atmosphere where cooler temperatures help them to condense into clouds. Air currents move clouds; they collide, grow, and fall out of the sky as precipitation. Most water falls back into the oceans or onto land as rain where the water flows over the ground as surface run-off.

1. **Evaporation:** The transformation of water from liquid to gaseous phase.
2. **Sublimation:** The state change directly from snow or ice to water vapour.
3. **Condensation:** The transformation of water vapours to liquid water droplets creating fog and clouds.
4. **Precipitation:** Condensed water vapour that falls to the earth's surface as rain.
5. **Surface run-off:** The way by which water moves across the land.
6. **Percolation:** Infiltration of surface water for groundwater storage.



The water cycle

(B) Sources of Water



Distribution of the earth's water

(C) Availability of Water The total water in the world is estimated to be 1400 x $10^6 km^3$Unfortunately, 97.5% of this water is found in the oceans and is too salty to drink. Of the remaining 2.5% fresh water, 2% is locked up in relatively inaccessible ice caps and glaciers, and 0.5% is groundwater and most of it lies too far underground.
About 2 x $10^5 km^3$ of freshwater is found in lakes and rivers and 14 $10^3 km^3$ of freshwater is found in the atmosphere.
With 16% of the world's population, India has only 4% of global water resources.

(D) Causes of Water Crisis in the World

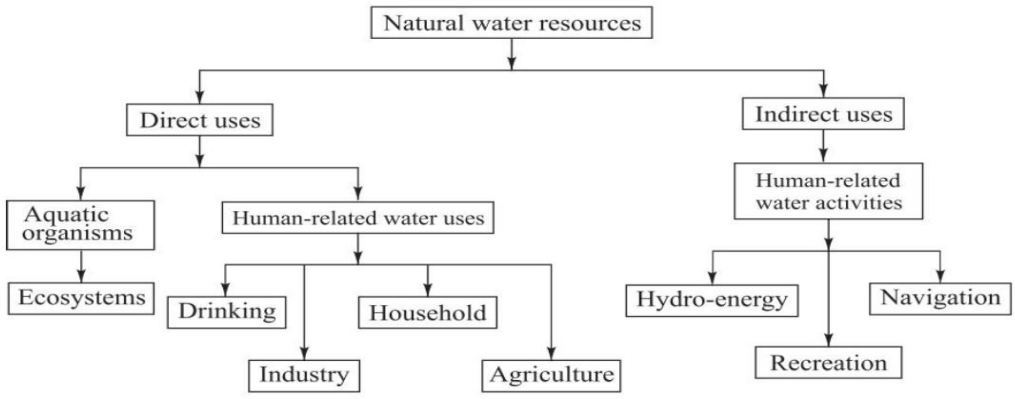
The causes for shortage of water leading to water crisis are the following:
(i) ***Growing population and with better lifestyles***, per capita use of fresh water is increasing, causing shortage of water.
(ii) ***Spatial and temporal variations*** in available water is also responsible for water crisis.
(iii) ***Freshwater resources are reduced by pollution***.
(iv) Increase in extreme weather conditions like ***floods, droughts, typhoons, cyclones***, etc., are also responsible for worsening of water quality and availability.

(E) Impacts of Over-utilisation of Underground and Surface Water

Some of the major impacts are summarised below:
(i) Loss of Integrity of Freshwater Ecosystems
(ii) Risk to Ecosystem Functions
(iii) Depletion of Living Resources and Biodiversity
(iv) Pollution of Water Bodies

Uses and Overuses of Water Resources

(A) Uses of Good-Quality Water



Direct and indirect uses of water resources by humans and ecosystems

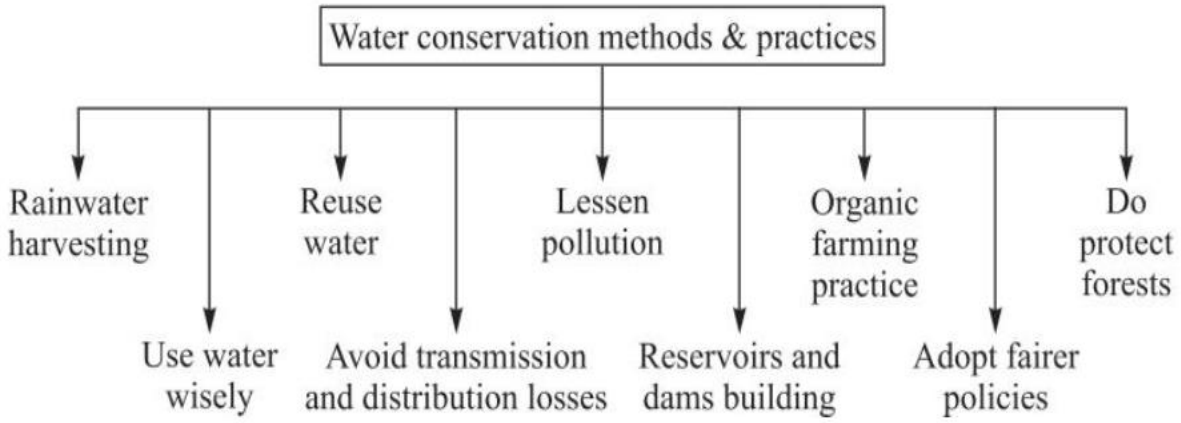
(B) Sectoral Demand of Water

Sector	*Water demand in Billion Cubic Metres*	
	Year 2010	*Year 2025*
Irrigation	688	910
Drinking water	56	73
Industry	12	23
Energy	5	15
Others	52	72
Total	813	1093

Water requirement for various sectors

(C) Water Conservation

"Water conservation is the most cost-effective and eco-friendly way to reduce our demand for water."



Water conservation

Measures to Conserve Water

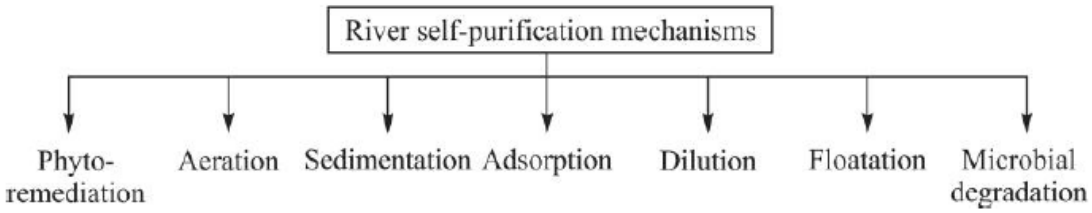
(a) Recharge groundwater by harvesting rainwater.
(b) Use water wisely for household, agricultural and domestic purposes.
(c) Reuse water whenever possible. For example, waste water after bath can be used for the toilet.
(d) Avoid transmission and distribution losses by checking leaks in pipes, hoses, etc.
(e) Prevent flow of untreated sewage to lakes and rivers. This will reduce the likelihood of water pollution and help in water conservation.
(f) Collect water by building dams and reservoirs, and digging wells.
(g) Use drip irrigation, precision sprinklers for agriculture. Practice organic farming.
(h) Adopt fairer policies for treatment, access, and pricing of water.
(i) Prevent flow of industrial effluents to natural water resources to avoid water pollution.
(j) Do protect forests to protect rivers, lakes, wells, and other sources of water.

(D)Characteristics of a Good-Quality Water

(a) It is transparent, colourless, and odourless.
(b) It has sufficient oxygen concentration for marine life to survive.
(c) It is free from bacteriological contamination.
(d) It is free from any water pollution.
(e) It is free from excessive nutrients like N, P, etc., which are responsible for eutrophication.
(f) It is fi t for the intended use.

(E) Self-Purification of Rivers

Various river-self-purification mechanisms are described below:



River self-purification mechanisms

(i) Phyto-remediation Aquatic plants and vegetation on the river banks absorb (nitrate, phosphate and other nutrients) and remove pesticides and heavy metals from water.

(ii) Aeration When a river runs through hills, turbulence mixes air into water increasing the dissolved oxygen (DO). The increased DO concentration facilitates many chemical and microbiological processes in water to reduce the pollutant concentration.

(iii) Sedimentation In this mechanism, sand in the river bed acts as a sink for the pollutants. From the hills, when river reaches flat lands, it spreads, its velocity reduces and suspended pollutants settle on the sand bed.

(iv) Adsorption Pollutants are adsorbed onto sand particles, plant surfaces, rocks, etc., and thereby their concentrations get reduced in the river water.

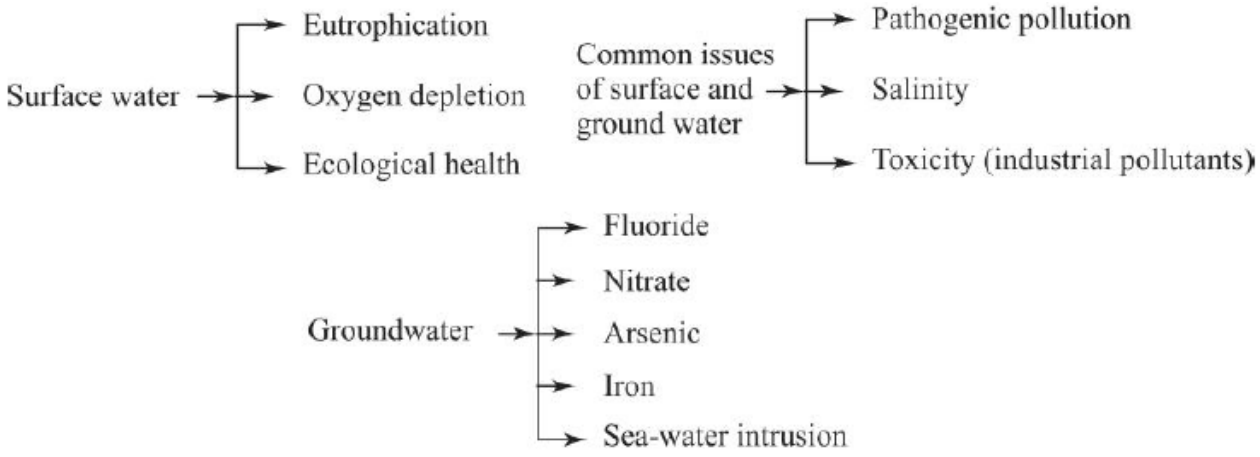
(v) Dilution When a polluted river is joined by less polluted tributaries or during the rainy seasons, the volume of water in the river is increased. It reduces the concentrations of pollutants by dilution process.

(vi) Floatation After rapid mixing of water in falls, air bubbles act as vehicles to lift many pollutants to the water surface in the form of froth (or a layer of foam). This froth is exposed to the atmosphere, and it facilitates oxidation of pollutants to less harmful forms. The top layer is also directly exposed to sunlight; so either by increased temperature or due to various photochemical reactions, volatile organic compounds are removed from the top layer. At different sections of the river, various artificial traps help in the removal of this froth and thus rivers get self-purified.

(vii) Microbial Degradation The shallow and turbulent water results in high aeration of water. It helps in growth of bacteria and other microorganisms. They help in river purification by microbial degradation of pollutants.

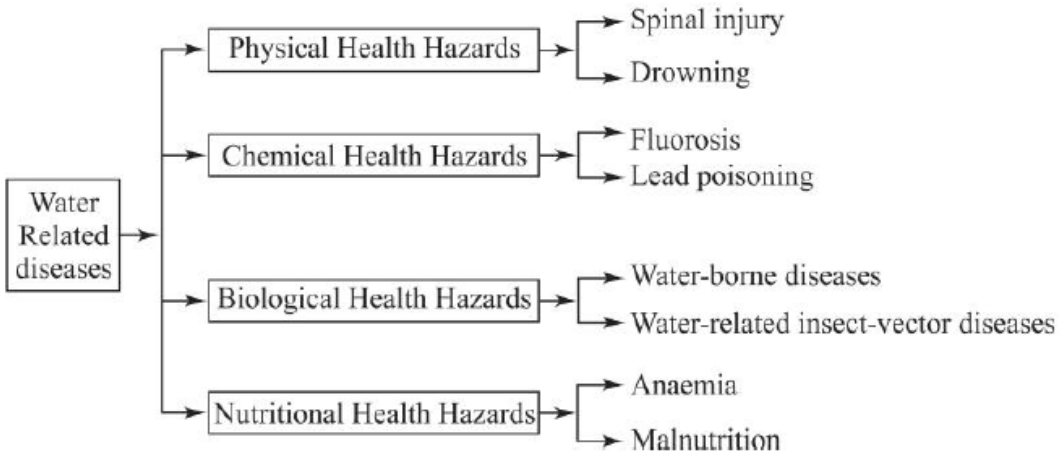
(F) Major Factors Responsible for Water-Quality Degradation

(i) Insufficient and incomplete treatment of domestic and industrial wastewater
(ii) Eutrophication
(iii) Pathogens, and pesticide contamination
(iv) Stagnation of domestic sewage and contamination of groundwater



Important quality issues of water

(G) Water-Borne Diseases Water-borne diseases are illnesses caused by consuming water contaminated by pathogenic microorganisms.



Illnesses caused by consuming contaminated water

Water-borne diseases

S.No.	*Water-borne disease*	*Caused by*	*Symptoms*
1.	Giardiasis (Type of diarrhoea)	*Giardia intestinalis*	Severe abdominal cramps, diarrhea, nausea, greasy stool, gas, etc.
2.	Amoebiasis (Type of diarrhoea)	*Entamoeba histolytica* (Protozoa)	Extreme abdominal discomfort, loose stools, bloating, weight loss, abdominal pain, etc.
3.	Cryptosporidiosis (Type of diarrhoea)	*Cryptosporidium parvum* (tiny parasites)	Mild fever, weight loss, diarrhoea, vomiting, nausea
4.	Cholera	*Vibro cholerae* (bacteria)	Sudden onset of acute diarrhoea, which may lead to excessive dehydration, kidney failure and finally, even death
5.	Gastroenteritis or stomach flu	Noroviruses	Low grade fever, diarrhoea, frequent vomiting, dehydration, stomach or abdominal cramping

The best ways to prevent water-borne diseases are
(i) avoid drinking untreated water,
(ii) avoid consuming undercooked food,
(iii) maintain good personal hygiene (e.g., wash hands before eating)
(iv) educate for clean sanitation.

(H) Fluoride Problem in Drinking Water
At low concentrations in drinking water, fluoride has beneficial effects on teeth. But excessive exposure to fluoride in drinking water can give rise to number of adverse effects.

Sources of Fluoride
(a) Fluoridated water supplies
(b) Food processed with fluoridated water
(c) Mouthwash enhanced with fluoride
(d) Toothpaste enhanced with fluoride
(e) Food supplements

Dangers of fluoride consumption
(a) Fluoride damages the teeth A permanent discoloration and mottling of the tooth enamel (dental fluorosis) is caused by a child's ingestion of fluoride (0.5–1.5 ppm) before its permanent teeth have erupted.
(b) Fluoride damages the bone In an area of high natural levels of fluoride (1.5–5.5 ppm), fluoride can weaken bone and increase the risk of fractures.

(c) Fluoride damages the brain Fluoride lowers the IQ of children, even when present at 1.8 ppm in water. It is apparent that fluorides can interfere with the functions of the brain.

Defluoridation of Water Defluoridation of water can be carried out by
(a) Reverse osmosis filtration
(b) Activated alumina defluoridation filter
(c) Nalgonda technique (The process comprises of addition of aluminium salt, lime and bleaching powder to the raw water followed by flocculation, sedimentation, and filtration.)

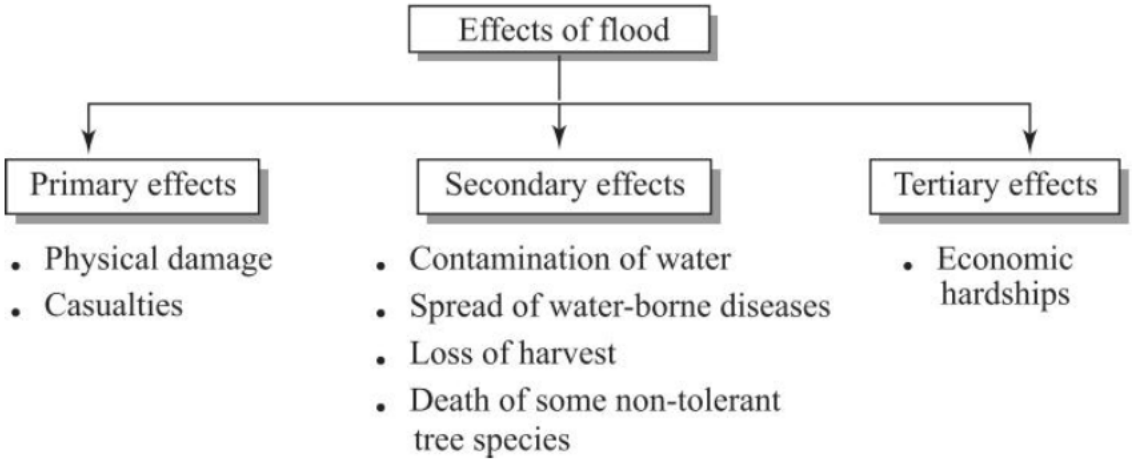
(I) Arsenic problem in drinking water
Arsenic is a naturally occurring, metalloid component of the Earth's crust. Minuscule quantities of arsenic occur in all rock, air, water, and soil. It can be found combined with other elements in different chemical compounds. The drinking water standard for arsenic is **10 ppb.**
Organic forms of arsenic also contain carbon, but inorganic forms do not. Inorganic arsenic compounds are more harmful than organic ones.
Exposure to arsenic in drinking water can cause significant skin changes, like thickening and pigmentation.
Ingestion of large amount of arsenic in a short time, can have severe, stomach-related symptoms such as vomiting and nervous system damage.
They are carcinogenic in nature and can affect skin, lungs, bladder, and kidney.

Prevention
The following measures can be taken to protect people from the arsenic in groundwater:
- Education and community engagement
- Arsenic removal systems in homes
- Testing nearby water sources for traces of arsenic
- Taking care when harvesting rainwater
- Considering the depth of wells

(J) Pesticide Removal Methods from Drinking Water
Water contaminated or suspected of being contaminated by pesticide and synthetic/volatile organic compounds can be purified using following methods shown in Fig

Pesticide removal methods from drinking water

Floods
Flood can be defi ned as a temporary rise of the water level, as in a river or lake or along a sea coast, resulting in its spilling over and out of its artificial or natural confines onto land that is normally dry or flood is a temporary covering by water of land not normally covered by water.



Effects of flood

Benefits of Floods

The more frequent and smaller floods can bring following benefits:

(i) Water Availability

(ii) Ecosystem Services

(iii) Increase in Soil fertility

(iv) Improved Fisheries

(v) Benefits to Birds

(vi) Higher Viability of Hydro-energy Projects

Flood Disaster Impact Minimisation

(i) If it has been raining hard for several hours, or steadily raining for several days, individuals must listen carefully to the radio or TV flood forecasts issued by the Central Water Commission.

(ii) They should listen to and follow the instructions of the emergency services.

(iii) They should extend all possible help to the administrative and engineering agencies of the states/union territories to take appropriate measures.

Drought

Drought may be defi ned as the deficiency of rainfall (relative to the statistical multi-year average for a region) over an extended period of months or years.

Types of Drought

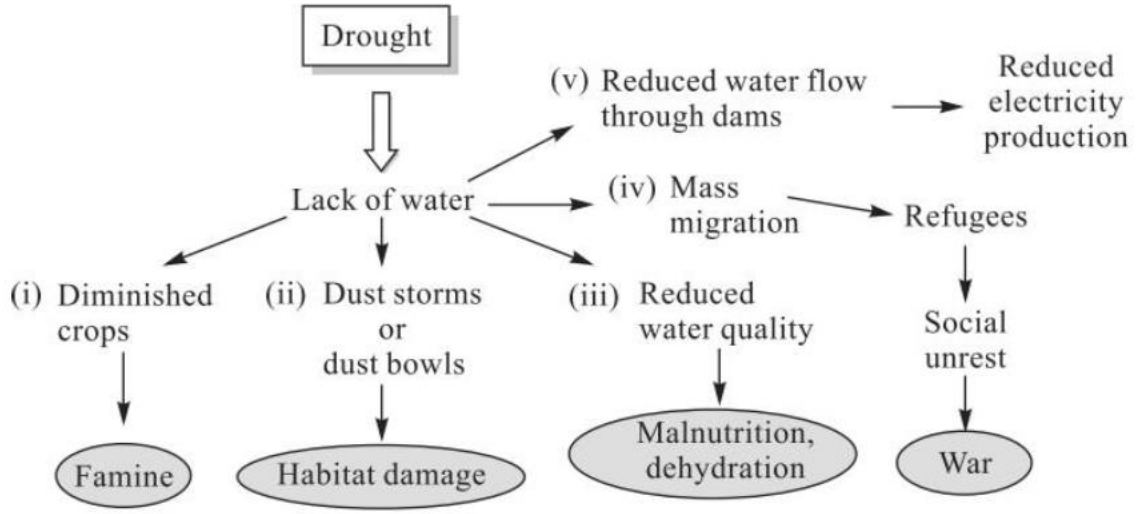
(i) Meteorological Drought

As per the India Meteorological Department (IMD), meteorological drought occurs when the seasonal rainfall received over an area is less than 75% of its long-term average. The drought can be classified as 'moderate' or 'severe' depending on the rainfall deficit between 26% to 50% or exceeds 50% respectively.

(ii) Agricultural Drought It is a drought that affects crop production or the ecology of the range. It is caused by extended period of below-average rainfall resulting in a shortfall in water for the crops.

(iii) Hydrological Drought It is brought about when the water reserves available in sources such as reservoirs, lakes or aquifers fall below the statistical average.

Effects of drought



Effects of drought

Consequences of Drought

The impacts of drought are briefly described below:

(i) Impact on Agriculture Droughts are responsible for diminished crop growth or diminished production yields due to lack of water for irrigation.

(ii) Impact on Environment When drought hits an area suffering from desertification and erosion, dust storms and/or dust bowls result which further erode the landscape.

(iii) Impact on Health Drought is responsible for malnutrition, dehydration, and related diseases. Drought can also reduce water quality.

(iv) Social Impacts Subsistence farmers are forced to migrate during drought because they do not have alternative food sources.

(v) Economic Impacts Droughts lead to reduced electricity production due to reduced water flow through hydroelectric dams and insufficient available coolant for power stations.

Strategies for Mitigation of Drought Impacts

Society's vulnerability to drought is minimised through the following actions:

(i) An artificial technique of cloud seeding helps in inducing rainfall.

(ii) For consumption or irrigation, desalination of sea water can be done in times of scarcity.

(iii) Carefully planned crop rotation can help to minimise soil erosion. This also allow farmers to plant less water-dependent crops in drier years.

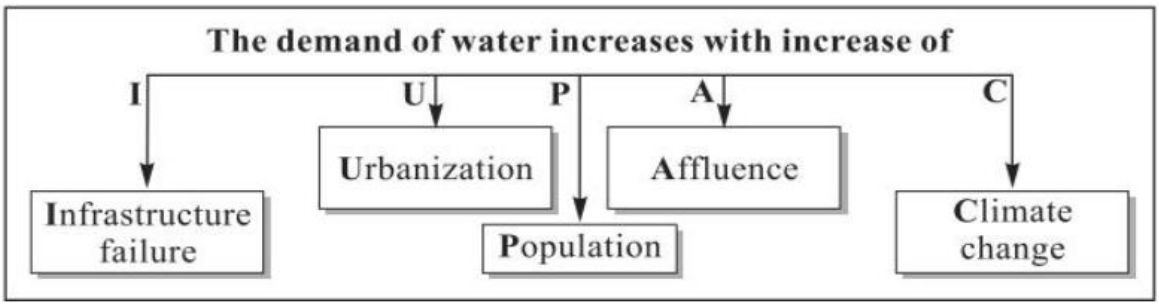
(iv) Collection and storage of rainwater through rainwater harvesting is very useful.

(v) Regulating the use of water-intensive home maintenance tasks and the use of sprinklers, hoses, etc., on outdoor plants.

(vi) Redirecting rivers for irrigation in drought-prone areas.

Conflicts Over Water

Water might be the source of the world's next big conflict. This is because fresh water availability is limited but its demand is rising day by day.



Demand for water

(i) Infrastructure Failure
(ii) Rapid Urbanisation
(iii) Population Growth
(iv) Increasing Affluence.
(v) Climate Change
Climate change poses a series of risks to water availability as a result of the following:
(a) Rising temperatures could increase the rate of evaporation from surface waters and reservoirs and lead to loss of freshwater held in glaciers.
(b) Increased rainfall might come in the form of storms that lead to floods.

Water conflicts in India can be classified as per the following themes:
Conflicts over (a) equity, access and allocations, (b) water quality, (c) dams and displacement, (d) privatisation, (e) contending water uses, (f) sand excavation and mining, (g) trans-boundary conflicts, and (h) micro-level conflicts are also present.

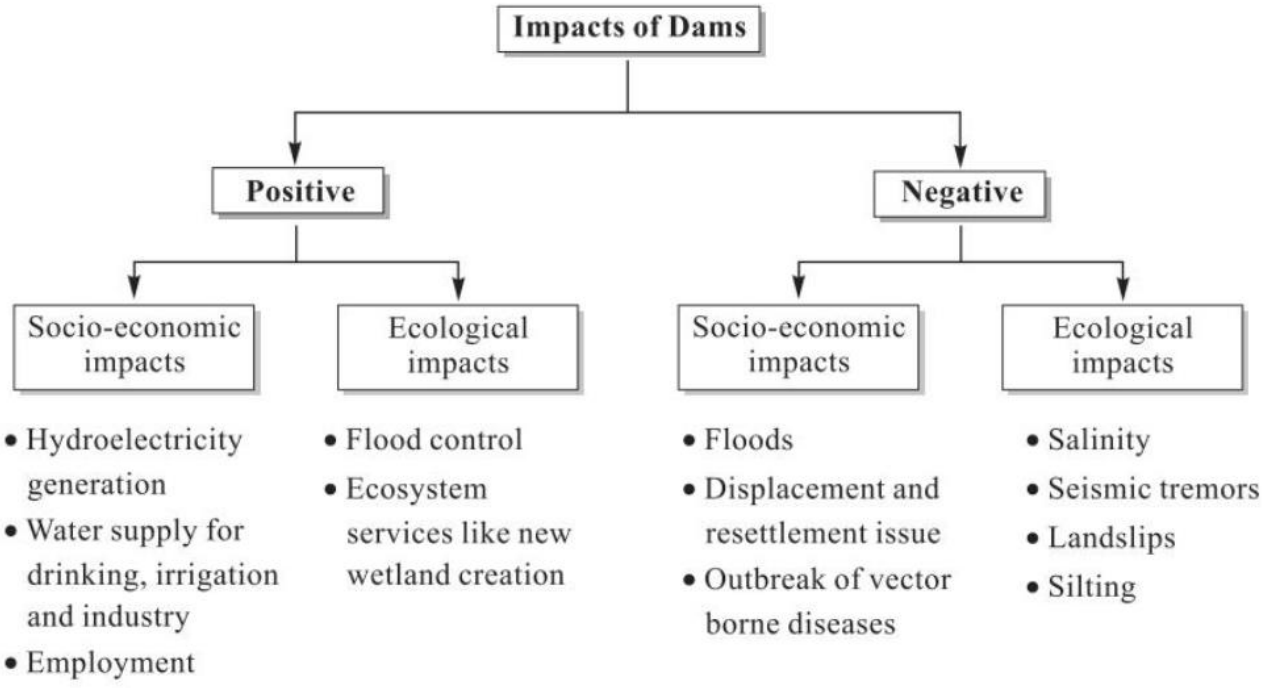
Dams—Benefits and Problems
(A) Positive Impacts of Dams

(i) Ecological Impacts
(a) Flood Control Dams help in controlling river flow and flooding.
(b) Ecosystem Services

(ii) Socio-economic Impacts
(a) Hydroelectricity Generation
(b) Help in Solving Problems of Hunger and Starvation
(c) Water Supply

(B) Negative Impacts of Dams

(i) Ecological Impacts
(a) Seismic Tremors
(b) Evaporation Losses
(c) Salinisation of the Soil
(d) Landslips



Socio-economic and ecological impacts of dams

MINERAL RESOURCES

"Natural resources in the form of minerals are known as mineral resources." They include the ores of base metals such as copper, iron and lead as well as strategic and critical metals such as chromium, titanium, platinum, cobalt, manganese, palladium, etc.

Minerals and Their Classification

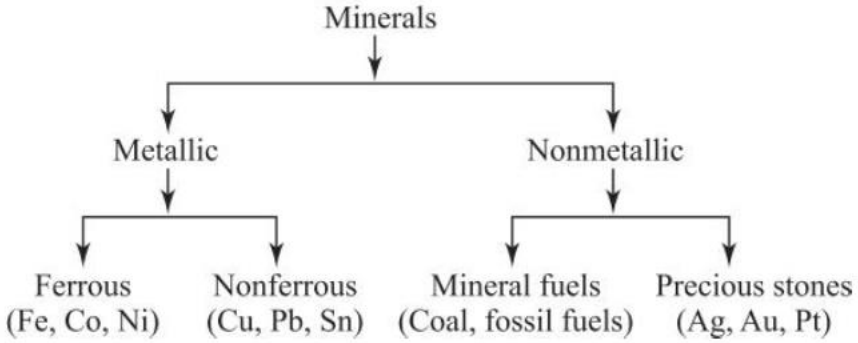
Minerals are naturally occurring, inorganic, solid, crystalline substances which contain a specific composition of elements.

A mineral which can be extracted and processed at a profit is known as an ore.

Types of Minerals

Minerals are broadly classified into two categories: **metallic and non-metallic.**

Metallic minerals are further sub-divided into ferrous and nonferrous materials. Non-metallic minerals comprise of mineral fuels, precious stones, etc.



Classification of minerals

Importance of Minerals

(i) Almost all rocks are made of minerals.

(ii) They have high aesthetic value, e.g., gemstones.

(iii) They have natural resource value:

- Minerals are sources of metals needed for electronic manufacture, airplanes, cars, etc.
- Minerals are raw materials for making window glass, plaster, etc.

Mineral Resource of India

India produces and works with roughly 100 minerals, which are an important source for earning foreign exchange as well as satisfying domestic needs.

We import graphite, mercury, cobalt, etc., and export iron ore, granite, bauxite, titanium, manganese, etc.

Coal, iron ore, manganese, mica, bauxite, copper, etc., are found in the North- Eastern peninsular belt located in Chhota Nagpur Plateau and the Orissa Plateau covering the states of Jharkhand, West Bengal, and Orissa. These regions are called the mineral heartland of India.

Gems, marble, coal, mica, graphite, manganese etc. exist in large quantities in Central Belt located in Chhattisgarh, Andhra Pradesh, Madhya Pradesh, and Maharashtra. The central Belt is the second largest belts of minerals in the country.

According to the 2008 Ministry of Mines estimates:

- India ranks 2nd in the production of chromite, barites
- India ranks 3rd in the production of coal and lignite,
- India ranks 4th in the production of iron ore,
- India ranks 5th in the production of bauxite and crude steel,
- India ranks 7th in the production of manganese, and
- India ranks 8th in the production of aluminium.

Environmental effects of extracting and using Mineral Resources

The impacts on forest, land, occupation, water, ecological functions, rehabilitation of population, or impact on flowers due to pollution created during extraction and use of mineral resources are:
(i) Deforestation including to loss of flora and fauna.
(ii) Degradation of land due to excavations.
(iii) Occupational health hazards.
(iv) Pollution of ground and surface water resources due to accidental or periodic discharge of pollutants.
(v) Damage to local ecological functions, nutrient cycling and biodiversity due to alterations in water availability or quality.
(vi) Problem in rehabilitation of affected population.
(vii) Pollution of air due to emission of dust and gases during mining and processing stages.
(viii) Problems in the safe disposal of tremendous amounts of solid waste generated during mining

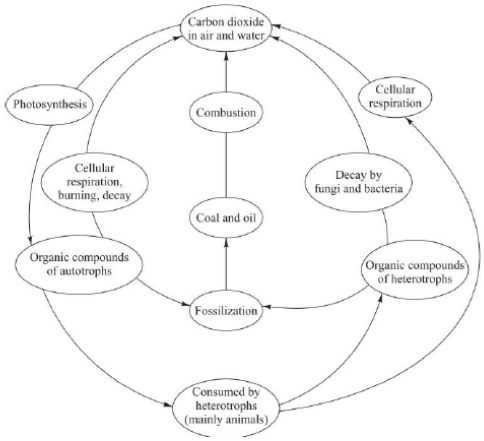
Conservation of Mineral Resources

The mineral resources are very essential for the growth and development of a country. The ever-increasing population in the world with improved lifestyles are responsible for the rapid consumption of mineral resources.
A sincere effort must be made in order to use the mineral resources in a planned and sustainable manner. The following four steps are very useful for the conservation of mineral resources:
(i) Encourage use of improved technologies to reduce waste generation.
(ii) Encourage ***recycling*** of metals.
(iii) ***Regulate*** the use of mineral resources.
(iv) ***Reduce*** the purchase of unwanted products made from mineral resources.
(v) Encourage ***research*** for providing suitable eco-friendly alternatives for fossil fuels, metals, etc.

These are known as **4R's** for the sustainable use of mineral resources.

The Carbon Cycle

The carbon cycle is a complex series of processes through which all the carbon atoms in existence rotate. In the carbon cycle, plants absorb carbon dioxide from the atmosphere and through photosynthesis convert this CO2 and water into oxygen and carbohydrates, which they need for growth. Animals breathe in this oxygen, eat the plants, and use the carbon of carbohydrates to build their own tissues. These animals return carbon dioxide into the air, when they breathe and when they die, as the carbon is returned to the soil during decomposition. The carbon atoms in the soil may then be used in a new plant or small microorganisms. When we burn fossil fuels like oil, the carbon in the fuel combines with atmospheric oxygen to form carbon dioxide (Fig. 2.60). Every ton of CO2 emitted from combustion of fossil fuels changes the carbon cycle for thousands of years as it upsets the carbon balance in the atmosphere. The current excessive levels of CO2 lead to global warming, climate change, floods, droughts, etc.

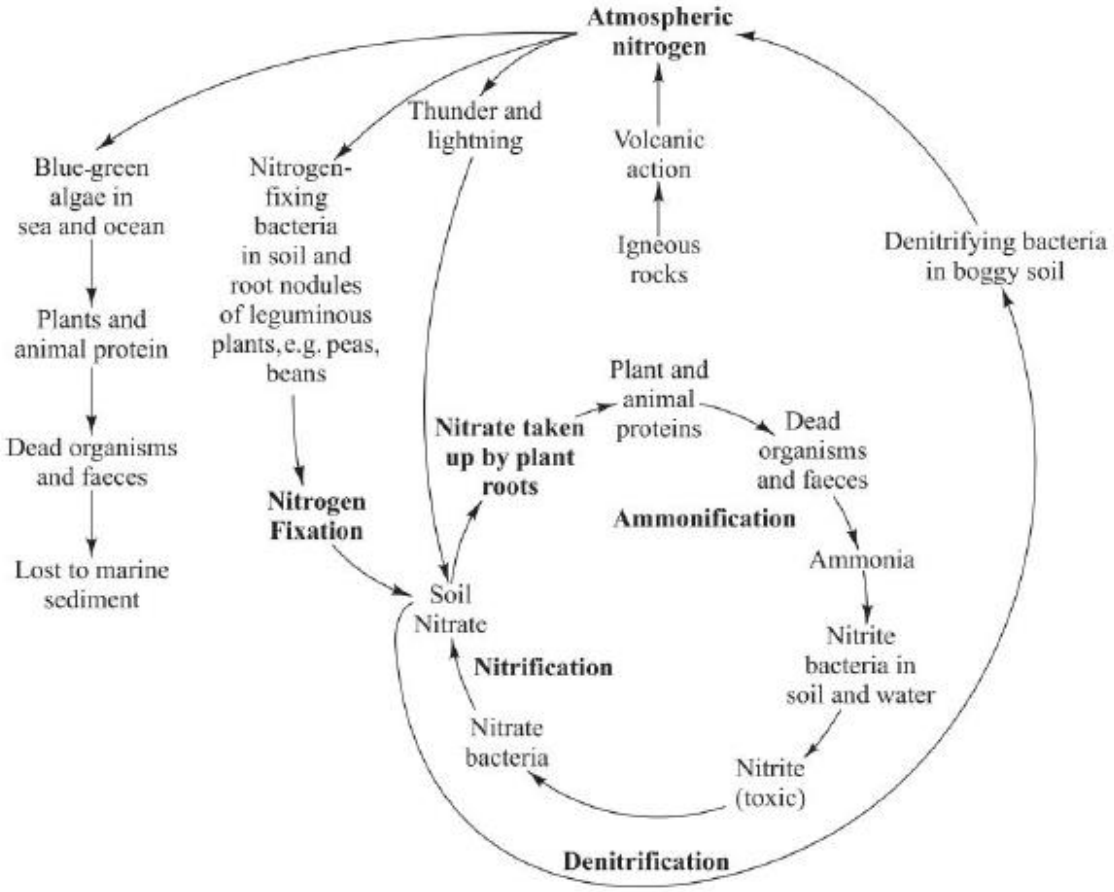


The carbon cycle

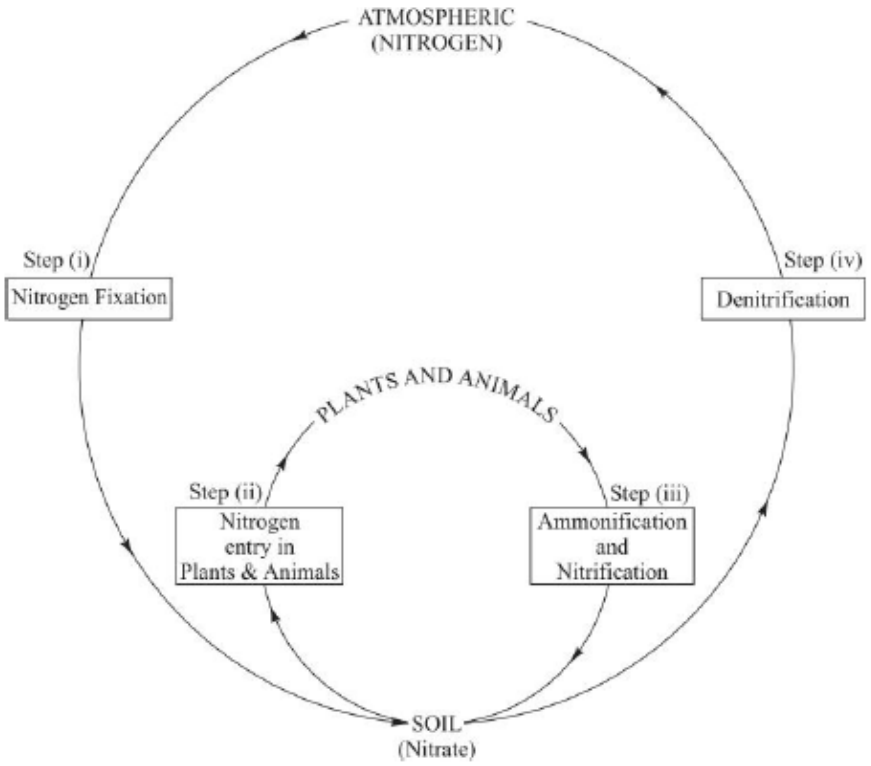
The Nitrogen Cycle

The process of converting atmospheric nitrogen to useful nitrogenous compounds by plants, passing it to animals and then the decomposition of these compounds to give back free nitrogen in the atmosphere is called the nitrogen cycle

The nitrogen cycle consists of following steps:
Fixation of Nitrogen: The process of conversion of free nitrogen of the air to useful nitrates is termed nitrogen fixation.
Entry of Nitrogen in Plants and Animals: The nitrates in the soil are absorbed by plants as mineral salts. The proteins from the plants enter the body of animals in the form of food.
Ammonification and Nitrification Processes:
Ammonification refers to any chemical reaction in which NH_2 groups are converted into ammonia or its ionic form, ammonium (NH_4^+), as a product.
Nitrification is a process that converts ammonia and nitrogen compounds into nitrite (NO2–) and then nitrate (NO3–).
Denitrification: Denitrifying bacteria found in the soil convert nitrates of the soil to free nitrogen which escapes to the atmosphere



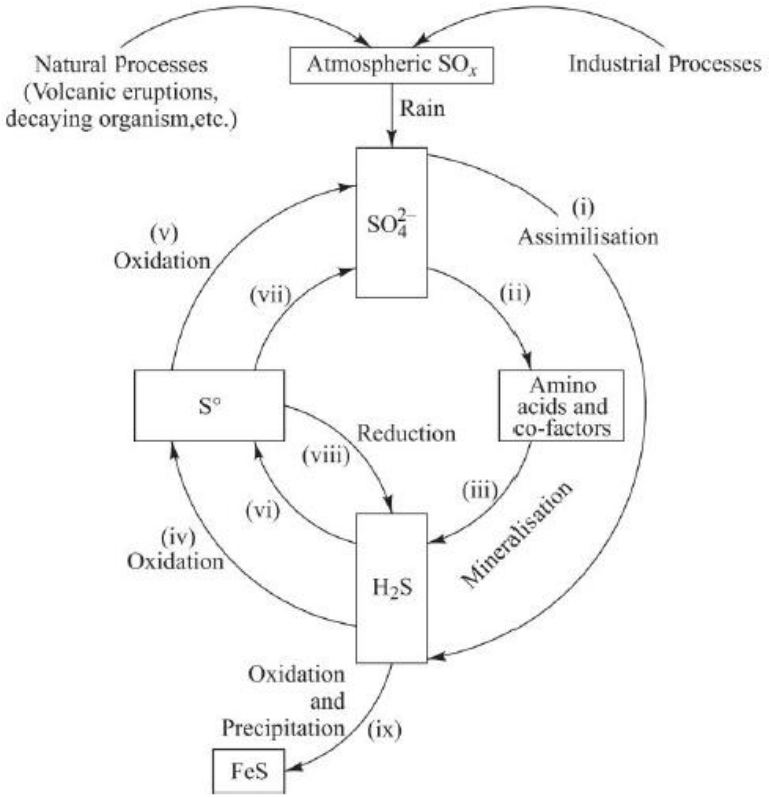
The Nitrogen Cycle



The simplified nitrogen cycle

The Sulphur Cycle

Sulphur enters the atmosphere through both natural and human sources in the form of oxides of sulphur (SOx). It reacts with rain and falls into earth as acidic sulphate ($SO4^{2-}$)deposition.



The sulphur cycle

(i) Sulphate ($SO4^{2-}$)is reduced to hydrogen sulphide (H2S) by Sulphate- Reducing Bacteria (SRB).
(ii) Some sulphate is assimilated by organisms to form cell components such as amino acids and co-factors.
(iii) Organic sulphur is converted to H_2S upon mineralisation.
(iv) H_2S is transformed to elemental sulphur (S°).

(v) Sulfide oxidising bacteria convert S° into $SO4^{2-}$
(vi & vii) Anoxygenic phototrophic bacteria also convert H_2S to $SO4^{2-}$via elemental sulphur.
(viii) Sulphur-reducing bacteria transform back the elemental sulphur to H_2S.
(ix) Some H2S complexes with iron to form black FeS precipitates, whose recycling is slow.

ENERGY RESOURCES

Energy Import India, though rich in coal and abundantly endowed with renewable energy in the form of hydro, wind, solar and bio-energy, has very small hydrocarbon reserves. India is a net importer of energy, more than 25% of primary energy needs being met through imports mainly in the form of natural gas and crude oil.

Energy Production Pattern Coal and oil account for 54% and 34% respectively, with natural gas, hydro, solar and nuclear contributing to the balance. Nearly 62% of power generation is from coal-fi red thermal power plants and 70% of the coal produced every year in India has been used for thermal power generation.

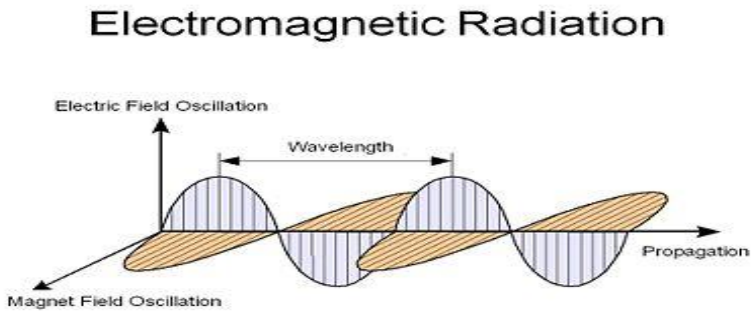
About 60 years back, at the time of independence, the installed power generation capacity was 1300 megawatt, (MW). In 2009, power demand in India touched 99,027 MW.

	The installed power generation capacity
Thermal	80,902.45 MW
Hydro	30935.63 MW
Wind	13065.37 MW (as on 31st Dec. 2010)
Nuclear	2770 MW

Energy is the key input to drive and improve lifestyles. Improvement in the living standards, industrialisation, education, health-care services, etc., all depend on availability of energy.

Electromagnetic Radiation

Electromagnetic radiation can be defined as a form of energy that is produced by the movement of electrically charged particles travelling through a matter or vacuum or by oscillating magnetic and electric disturbances. The magnetic and the electric fields come at 90° to each other, and the combined waves move perpendicular to both electric and magnetic oscillating fields occurring during the disturbance. The electromagnetic radiation travels at 3 x 10^8 m/s in vacuum.



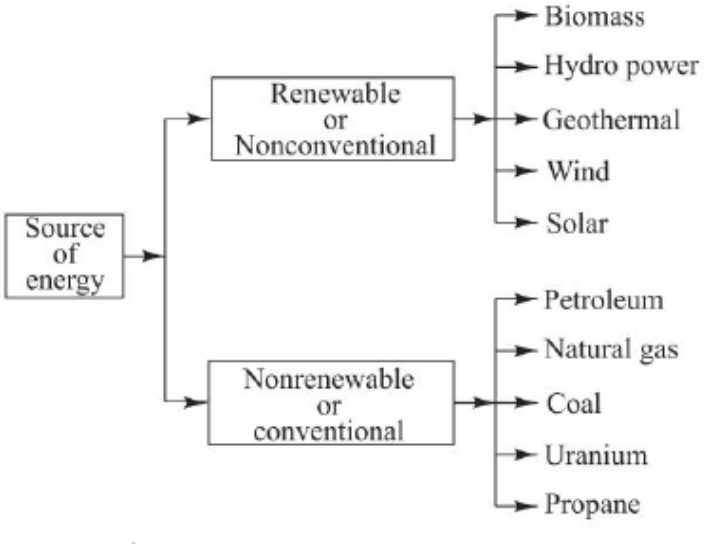
Examples of Electromagnetic Radiation AM and FM radio waves, TV signals, cell phone communication links, microwaves, infrared radiation, light, X-rays, gamma rays.

Uses of Electromagnetic Waves

(a) One-way and two-way communication systems
(b) Radar
(c) Cooking (with microwaves)
(d) Medical imaging (X rays)
(e) Night vision (infrared)
(f) Astronomy (radio, gamma, UV, visible, IR, microwave)

Renewable and Non-renewable Energy Sources

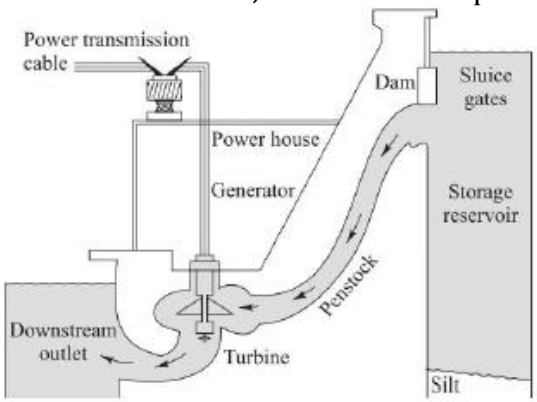
Conventional energy sources are energy sources which are non-renewable. However, nonconventional energy sources are energy sources which are renewable and ecologically safe.



Conventional Sources of Energy	Non-conventional Sources of Energy
(i) They are fully developed	(i) They are still undergoing development.
(ii) They use non-renewable resources.	(ii) They use renewable resources.
(iii) Inexpensive.	(iii) Expensive.
(iv) Require established technologies.	(iv) Require new technologies which are still under research and development.
(v) Ecologically not safe for usage.	(v) Ecologically safe to use.
(vi) Available in limited quantity.	(vi) Available in plenty.
(vii) Carbon and other greenhouse gas emissions from the combustion of coal, natural gas, etc., are known to have disastrous environmental and health consequences. These gases are also major culprit in climate change.	(vii) Free from such problems.
(viii) Examples: Petroleum, coal, etc.	(viii) Examples: Solar, wind and hydropower, etc.

Hydro-Power Energy or Hydroelectric Energy

Hydroelectricity or hydroelectric power is the electricity obtained by harnessing the power of water flowing down from a high level. It is a renewable, affordable and pollution-free source of energy.

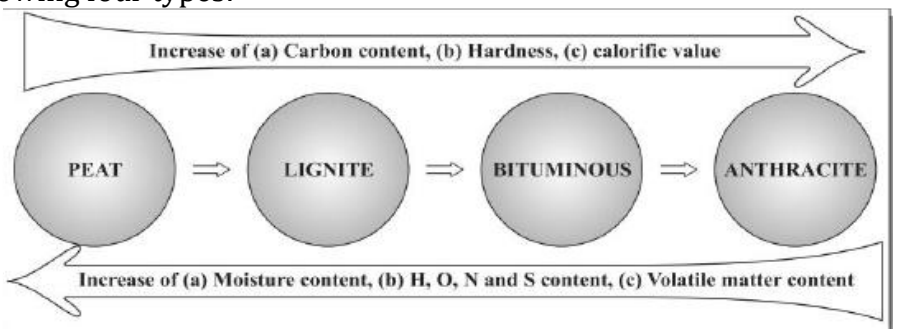


Generation of hydro-electric energy using a dam

Advantages
(a) **Economical** The cost of operating a hydroelectric plant is nearly immune to increases in the cost of fossil fuels. Operating labour cost is also low.
(b) **Safe** Hydroelectricity produces the least amount of greenhouse gases.

Disadvantages
(a) **Failure Hazard** In the case of failure of dams, millions of people become homeless, sick and even die.
(b) **Limited-Service** Life As rivers convey silt, higher the siltation, lower will be the service life of dam.
(c) **Environmental Damage** Dams are responsible for habitat fragmentation, aquatic ecosystem disruption, and greenhouse-gas emissions.
(d) **Population Relocation Problem** Millions of people need relocation and generally they do not get necessary compensation.
(e) **Energy Production is Affected by Amount of River Flow** Specially during drought period, hydroelectric power cannot be generated.

Fossil Fuels
Petroleum and coal are formed from the fossilised remains of animals and plants, hence they are known as fossil fuels.
Coal
Coal is defi ned as stratified rock, consisting of organic matter of fuel value derived from the partial decay and alteration of accumulated plant materials by the action of heat and pressure over millions of years.
Coal is of the following four types:



Advantages
The factors which are in favour of usage of coals in huge tonnage quantities are availability, low cost, least risk of fi re hazards and easy storage.
Disadvantages
(a) Combustion of coal is a slow process.
(b) Combustion control is not easy.
(c) After combustion, ash is always produced and so its disposal is a problem. Smoke is also invariably produced.
(d) Use of coal in internal combustion engines is not possible.
(e) Calorific value and thermal efficiency is least.

Petroleum
The word petroleum is derived from Latin petra which means rock and oleum which means oil.

Petroleum is a complex mixture of paraffinic, olefinic and aromatic hydrocarbons with small quantities of organic compounds containing oxygen, nitrogen and sulphur. It is also called mineral oil because it occurs beneath the earth.

Gaseous Fuels

(i) Natural Gas It is obtained from wells dug in the oil-bearing regions. It is mainly composed of methane, ethane and other hydrocarbons. It is also called marsh gas because it mainly consists of methane (about 88.5%). It is used as a domestic and industrial fuel, because of its high calorific value (8000–14000 kcal/m3).

(ii) Compressed Natural Gas (CNG) The natural gas compressed at very high pressure of about 1000 atmosphere is called CNG. The calorific value of CNG is 31400–37700 kJ/m3. The use of CNG as a fuel for automobiles has reduced pollution in urban cities. As it undergoes complete combustion in CNG engine so there is nil possibility of release of CO in the atmosphere. Further, CNG is much safer fuel with lower operating cost.

(iii) Liquified Petroleum Gas (LPG) The main constituents of LPG are n-butane, isobutane, butylene and propane. The calorific value of LPG is about 27,800 kcal/m3. It is mainly used as domestic fuel. To help in the detection of gas leakage, a strong-smelling substance, viz. ethyl mercaptan, is added to the LPG gas cylinders. LPG is also used as motor fuel because it easily mixes with air and burns cleanly without residue and without knocking.

Nuclear Energy

The study of nuclear fuel is important because energy changes involved are many million times greater than in chemical fuels. The source of energy in nuclear fuel is nuclear fission or nuclear fusion reaction. These are discussed below.

Nuclear Fission When an unstable nucleus of a heavy atom (like uranium– 235) is bombarded with neutrons, the former splits up into two medium weight nuclei with the liberation of an enormous amount of energy.

$$^{235}_{92}U + {}^{1}_{0}n \xrightarrow{\text{Fission}} {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3\,{}^{1}_{0}n + \text{Energy}$$

In all fission reactions, more neutrons are emitted than consumed. They, in turn, are capable of fission of more heavy atoms and a chain reaction is started. When this chain reaction is controlled, it can lead to power generation in a device called a nuclear reactor.

Nuclear Fusion When two lighter nuclei (like deuterium atoms) are heated to a very high temperature (~106°C), they fuse together to form a heavy, more stable nucleus and an enormous amount of energy is liberated.

$$^{2}_{1}H + {}^{2}_{1}H \xrightarrow{\text{Fusion}} {}^{4}_{2}He + \text{Energy}$$

High temperatures needed for fusion can be attained by using the heat evolved in a fission reaction. But, in this way, the fusion of hydrogen gets out of controlled and leads to explosion (hydrogen bomb).

Merits of Nuclear Energy

(a) **Availability** Nuclear power plants could still produce electricity after coal and oil become scarce.

(b) **Less Fuel Requirement** One ton of uranium produces more energy than is produce by several million tons of coal or several million barrels of oil.

(c) **Less Pollution** Well-operated nuclear power plants do not release contaminants into the environment.

(d) **Economical** Cost of fuel is a much smaller percentage of the total cost and operating cost is about the same as coal-based thermal power plant.

(e) **Employment** Energy generation from nuclear power plants creates high paying, skilled jobs.

(f) **Safe** Safety record of nuclear power plants in the world is fantastic.

(g) **Reliable** Nuclear power plants have very high-capacity factors. Presently, 12% to 18% of the world's electricity is generated through nuclear energy.

Demerits of Nuclear Energy

(a) **Large Initial Cost** To develop a single nuclear power plant about 15 years to 20 years are required along with expenditure of huge amount of money.

(b) **Dangerous Waste** The waste produced after fission reactions of uranium consist mainly of unstable, radioactive elements.

(c) **Less Life of Nuclear Reactors** They could only last for about 40 years to 50 years.

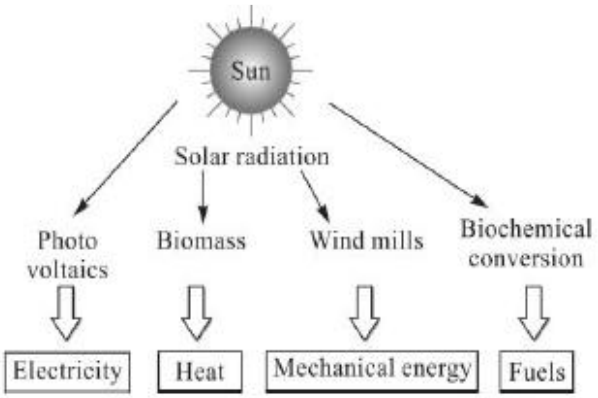
(d) **Chances of Worse Disasters** Meltdown is one possible type of reactor disaster in which the fission reaction goes out of control, leading to nuclear explosion.

(e) Domestic unavailability of safe storage and reprocessing facilities.

(f) Fear security concerns, terrorism and proliferation of nuclear weapons.

Solar Energy

Solar energy is the energy received by the earth from the sun that is converted into thermal or electrical energy. Solar energy influences the earth's climate and weather and sustains life. Although solar energy only provides 0.15% of the world's power, experts believe that sunlight has the potential to supply 5000 times as much energy
as the world currently consumes.



Applications of Solar Energy in Modern Days Some of the important applications of solar energy are summarised below:

(i) Space cooling and heating through solar architecture

(ii) Potable water via distillation and disinfection

(iii) Solar cooking

(iv) Solar hot water

(v) Day lighting

(vi) High-temperature process heat for industrial purposes

(vii) Solar air-conditioning

(viii) Solar desalination

(ix) Solar electricity–photovoltaic

(x) Solar electricity–thermal

(xi) Solar vehicles

(xii) Solar chimney

Advantages of Solar Energy

These are briefly discussed below:

(i) Cost-effectivity If you use a solar power system to reduce electric consumption from traditional power companies, the savings will be reflected in reduced electric bills.

(ii) Renewable Resource Solar power can be regenerated and replenished without fear of depletion because the sun is used as the energy source.

(iii) Easy Installation and Use of Solar Powered Products Solar panels, hotwater heaters, lighting, fountains, pumps, etc., are easy to install and/or use.

(iv) Long Life and Low Maintenance The life of solar panels is long (≥25 years) and maintenance free. Maintenance only requires that solar panels are kept dirt-free and snow-free for maximum contact with sunlight.

(v) Pollution Free Solar power energy is eco-friendly as solar energy does not pollute the air or produce greenhouse gases like traditional energy sources.

Disadvantages of solar energy

These are briefly discussed below:

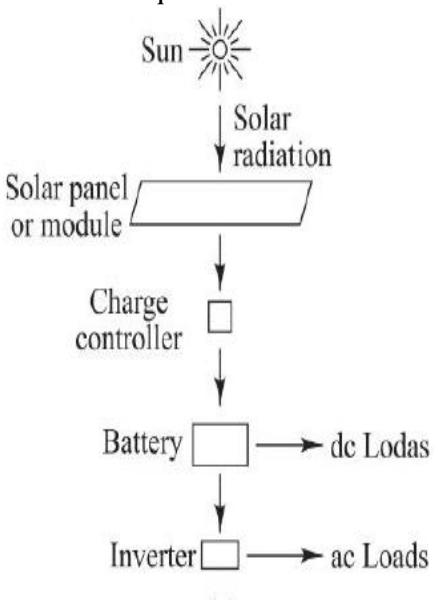
(i) As solar power uses the sun to produce electricity, generally, **solar power cannot be created at night**, during a cloudy day when sunlight is diminished or during a rainy seasons.

(ii) The initial cost of installation of solar panels is high.

(iii) Efficient collection of solar energy is a big challenge because solar radiations falls over a vast area in a scattered manner.

Use of Solar Energy for Generation of Electricity–Photovoltaics

Photovoltaics (PVs) are arrays of cells containing a solar photovoltaic material that converts solar radiation into direct current electricity. Solar cells produce direct current (dc) electricity from sunlight, which can be used to power bulb/equipment or to recharge a battery. However, for grid-connected power generation, an inverter is required to convert the dc to alternating current (ac)



Biomass

The term biomass is used for the dead plants and trees (e.g. wood, crop residue, etc.) and the waste material of living organisms (e.g. cattle dung, sewage, etc.). Biomass energy or bioconversion means the direct burning of waste paper, wood, cattle dung or converting them to a fuel.

The various ways of using biomass as a fuel:

(i) Biomass can be directly used as a fuel.

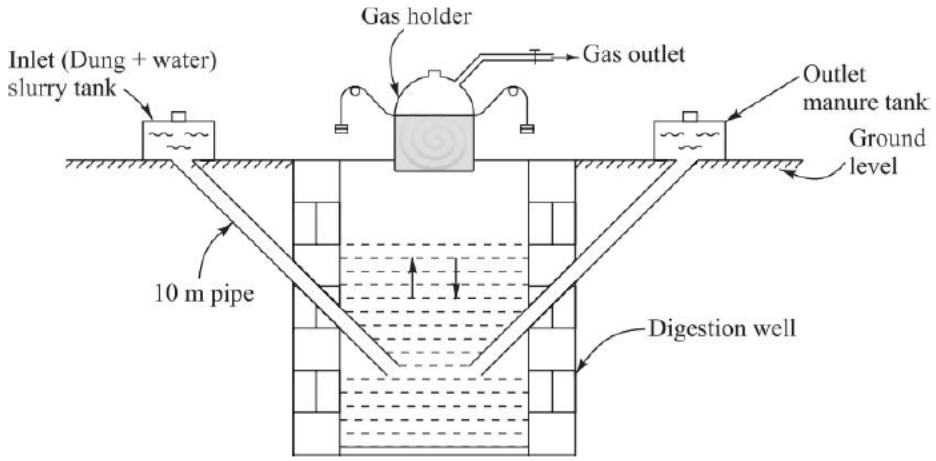
Example Burning of biomass like cattle dung in chulhas.

(ii) The biomass is first converted into a fuel and then these fuels are used for heating purposes, more effectively.

Example Conversion of cattle dung into biogas.

Biogas

Biogas consists mainly of methane. It burns with a blue flame and its average calorific value is about 5300 kcal/m3. Gobar gas is the cheapest and most easily available biogas. It is made in a gobar gas plant. Cattle dung is mixed with water (in equal parts) to form a slurry. It is then poured in a 'well' constructed of a masonry work (i.e., 'digester'). There anaerobic fermentation occurs at 34–48°C. The gas generated due to continuous decay is mostly methane (Fig. 2.41) and is collected in a gas holder. One kg of dung generates 160 litres of biogas and 164.6 kcal of extra heat is generated by this indirect burning.



Advantages

(a) More heat is generated by burning gobar gas instead of cattle dung.
(b) It is free from smoke, dust, dirt, etc.
(c) In addition to cattle dung, a gobar-gas plant can also digest human refuge, poultry, etc. Thus, production of gobar gas means optimum utilisation of waste.

Limitation

Gobar gas should be used within 10 metres of the gobar-gas plant.

Applications

(a) Biogas is used as domestic fuel in many villages.
(b) Biogas is also used for lighting purposes.
(c) A biogas plant also simultaneously gives good quantity of excellent manure.

Green Fuel

"Green fuel (or biofuel) is a type of fuel obtained from non-food sources like green algae which is more environmentally friendly than the widely used and quickly disappearing fossil fuels.''
In recent years, the processing of sugar and starch plants into ethanol has come under heavy criticism because
(i) This results in food shortages
(ii) The fermentation process causes air pollution
(iii) The obtained fuel on combustion may emit formaldehyde, ozone, and other carcinogenic substances
(iv) One acre of corn produces 200 times less oil as can be obtained from one acre of algae

Hydrogen as an Alternative Future Source of Energy

Hydrogen is a very light gas, and its density is eight times less than that of natural gas. There are no significant problems about storage, transportation, dispensation as well as end use of hydrogen.

Advantages of Hydrogen as an Important Energy Carrier in the Future

(i) Pollution free Hydrogen is a pollution free fuel.
(ii) Economical It is less costly to ship hydrogen by pipeline than sending electricity over long distances by wire in some instances.
(iii) Various Applications It can be used for transportation, heating, and power generation in places where it is difficult to use electricity.
(iv) Easy Storage A large volume of hydrogen can be easily stored in several different ways.
(v) High Efficiency Hydrogen is considered a highly efficient fuel.

Future Applications of Hydrogen

(i) Energy Carrier Hydrogen will join electricity as an important energy carrier in the future. This is because it can be made safely from renewable energy sources and is virtually non-polluting.
(ii) Electricity Production Hydrogen will be used to produce electricity in fuel cells.
(iii) As a Fuel Hydrogen will be used as a fuel for 'zero-emission' vehicles, and for aircraft.
(iv) In Heating Hydrogen will also be used to heat offices and homes.

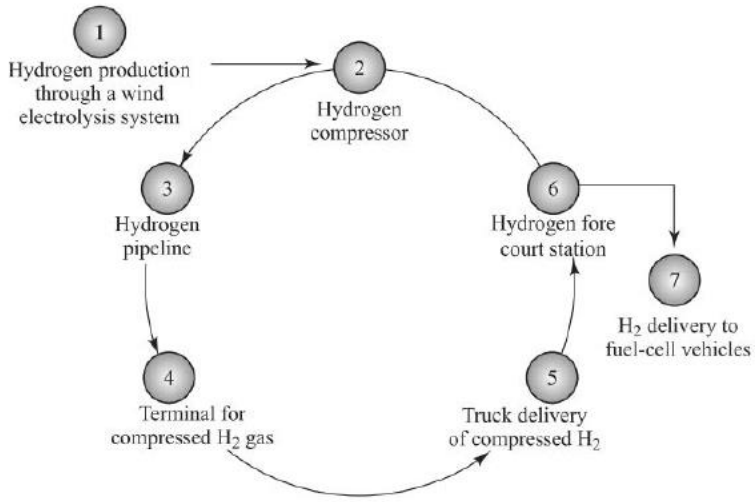
Limitations of Hydrogen Energy

The use of hydrogen as an alternative future source of energy is limited by

(i) Its low availability in pure H2 form in the environment

(ii) Difficulty in handling, storing and transportation of H2

(iii) Requirement of energy to produce H2



Infrastructure requirement for hydrogen as a source of energy for propelling vehicles

Wind Energy

Air in motion is known as wind. It is caused by the uneven heating of the surface of earth by the sun. During the daytime, the air above the land heats up more quickly than the air over water. The warm air over the land expands and rises, and the cooler, heavier air rushes in to take its place, creating wind. At night, the air cools more rapidly over land than over water; so, the winds are reversed.

The land near the earth's equator is heated more by the sun than the land near the North and South poles. This creates the atmospheric winds that circle the earth.

Wind is a renewable energy source because the wind will blow if the sun shines.

Advantages of Wind Energy (a Clean Source of Energy)

(i) Windmills do not release emissions that pollute the water or air.

(ii) They do not require water for cooling.

(iii) Windmills help in reducing the amount of electricity generation from fossil-fuel based thermal power plants.

(iv) Many windmills are located on farm, grazing and forest land. The extra income from windmills helps farmers live a better life.

(v) Wind power projects are best alternatives to mountain-top removal coal-mining projects for thermal power generation.

(vi) Wind is an important renewable and sustainable source of energy, available free of cost.

(vii) Power generation using windmills is very economical

Limitations of Wind Energy

(i) Wind energy is variable, irregular, erratic, intermittent, unsteady and sometimes dangerous.

(ii) Location sites for wind farms are generally away from cities.

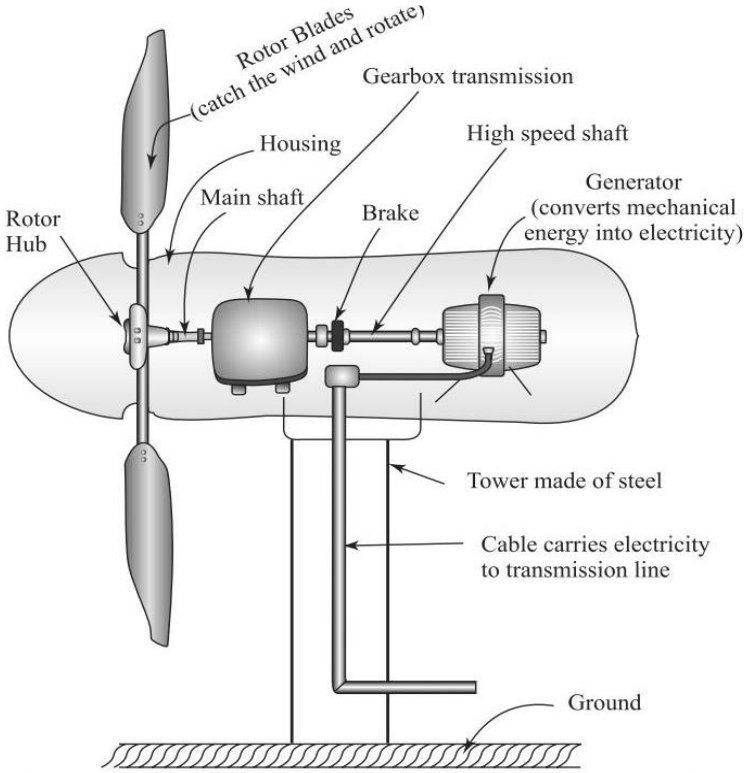
(iii) Design, manufacture, and installation of wind turbines is very complex.

(iv) Continuous whirling and whistling sound associated with rotation of blades

(v) The output of a single windmill is quite small and cannot be used for commercial applications.

(vi) Cost of maintenance is very high

(vii) The location of some windmills is on the routes of migratory birds. The working of windmills in these locations cause bird deaths.



[A windmill essentially consists of a structure similar to large electric fan that is erected at some height on a rigid support. Inflow of wind activates rotor hub and blades. These hub and blades then spin the main shaft and gearbox. Generator in turn is spinned by gearbox, resulting in electrical output]

Wind Turbine

Geothermal Energy

Geothermal energy is a clean, renewable, and environment-friendly energy source based on the heat inside the earth.

The word geothermal comes from the Greek words:

Geo = Earth ***Thermal = Heat***

Thus, the energy that can be extracted from the heat inside the earth is geothermal energy.

In the earth's core, about 4000 miles below the surface of the earth, geothermal energy is continuously produced by the slow decay of radioactive particles. The regions where the earth's tectonic plates collide and one slides beneath another create the conditions which are most favourable for the geothermal activity.

Merits of Geothermal Energy

(i) Flexible With growing demand for energy, additional units with modular designs can be installed easily, because there is no major land requirement.

(ii) Affordable The cost of electricity production is almost competitive with conventional energy sources.

(iii) Sustainable It is believed that enough heat will be radiated from the centre of the earth to fulfil human energy demand for all the times to come.

(iv) Clean Technology No emission and safe to use.

(v) Extraction Useful minerals (like zinc and silica) can be extracted from underground water.

Limitations of Geothermal Energy

(i) If the cooled water is not injected back into the reserve after the heat is extracted, the following harmful effects are observed:

(a) Brine can salinate soil.

(b) Land subsidence can occur leading to an increase in seismic activity.

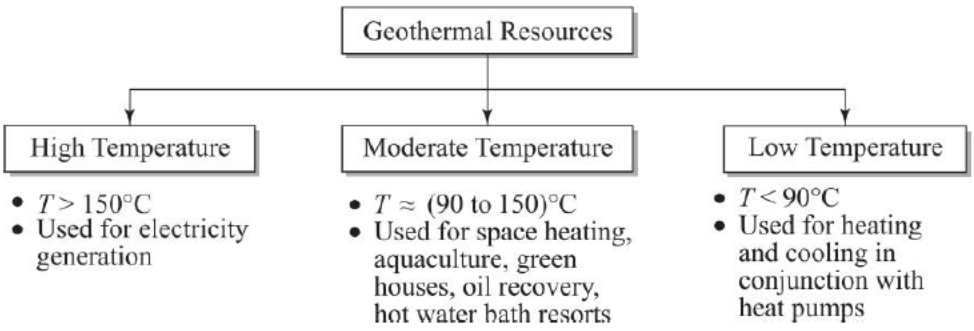
(c) Large quantities of H_2S "the rotten-eggs" gas can be released and inhaling it in too much quantities is fatal.

(ii) Geothermal hot spots are scattered and are at faraway regions than the areas that need energy.

(iii) The overall production efficiency is lower.

(iv) At geothermal sites, drilling operations cause noise pollution.

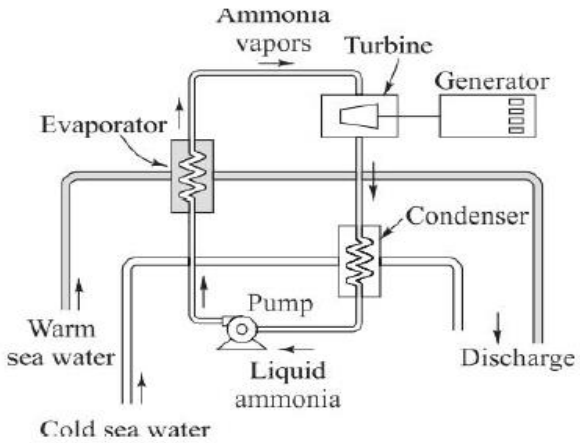
Uses of Geothermal Energy



Ocean Thermal Energy Conversion (OTEC)

The oceans absorb enough heat from the sun every day to equal the thermal energy contained in 250 billion barrels of oil. Thus, a great amount of heat is stored in the world's oceans.

This thermal energy is converted into electricity by using ocean thermal energy conversion systems. Closed-cycle plants are one type of OTEC systems. Its simple design is illustrated in Fig. They circulate a working fluid (which has a low boiling point, such as ammonia) in a closed system, heating it with warm surface sea water, flashing it to vapour, routing the vapour through a turbine, and then condensing it with cold sea water. The rotating turbine then activates a generator to produce electricity.



Tidal Energy

Periodic changes of water levels and the associated tidal currents, are due to the gravitational attraction of the sun and moon. At a particular location, the magnitude of tide is the result of

(i) the changing positions of the sun and the moon relative to the earth,

(ii) the effects of earth's rotation, and

(iii) the local geography of the sea floor and coastlines.

Tidal power, or tidal energy, is a form of hydropower that converts the energy of tides into electricity or other useful form of hydro power. Tidal power is a renewable energy resource because the earth's tides are practically inexhaustible.

Merits of Tidal and Wind Energy Resources

1. They are clean, renewable sources of energy.
2. Consumption of tidal and wind energy does not create pollution.
3. Use of tidal and wind energy reduces the dependence upon fossil fuels.
4. They are highly efficient resources.
5. Power generation using tides or waves does not create greenhouse gases.

Demerits of Tidal and Wind Energy Resources

1. The initial construction cost for making the plant for harnessing tidal and wind energy is very high.
2. The required technology is not fully developed for harnessing tidal energy.
3. Ecological impacts relating to alteration of tides and waves is not fully understood.
4. Waves are irregular in size, durability and direction; so they are a diffuse energy source.

Forest Resources

A forest can be defined as a biotic community predominant of trees, shrubs, or any other woody vegetation usually in a closed canopy. It is derived from latin word 'foris' means 'outside'. India's Forest Cover is 6,76,000 sq.km (20.55% of geographic area).

Functions of Forest

- It performs very important function both to human and to nature.
- They are habitats to millions of plants, animals, and wild life.
- They recycle rain water.
- They remove pollutant from air.
- They control water quality.
- They moderate temperature and weather.
- They influence soil condition and prevent soil erosion.

Types of Forests

Forests are classified broadly **into tropical, temperate, and boreal forests**.

Tropical Forests

Tropical rainforests have four characteristics which distinguish them from other forests.

1. Very high annual rainfall
2. High average temperatures
3. Nutrient-poor soil
4. High levels of biodiversity

Tropical rainforests are the habitat of two-third of the world's plant species. These forests are dominated by broad-leafed trees, which grow between 82 and 115 feet tall. Other vegetation includes vines, ferns, mosses, orchids, and palms.

Temperate Forests

Temperate forests are the second largest biome on this planet. They cover almost 25% of the world's forest area.

Characteristics are:

1. A long, warm growing season
2. Abundant moisture
3. Tree leaves are arranged in strata
4. Trees stop photosynthesis during winter and enter a dormant period.
5. Flat and broadleaf trees

Temperate forests typically have three levels of plants with a great variety of species. The forest floor is covered with lichen, moss, ferns, wildflowers, and other small plants. Shrubs fill up the middle level and hardwood trees like maple, beech, sycamore, oak, aspen, walnut, lime, chestnut, birch, elm, cypress, cedar, pine, Douglas fir, redwood, and spruce etc fill up the top level.

Boreal Forests

Boreal forests, also known as **Taiga forests**, are defined as forests growing in freezing temperatures in which trees can reach up to 5 meters minimum, with a canopy cover of 10%. The characteristics that separate boreal or taiga forests from other forests are:

1. Evergreen trees
2. Cold weather

3. Dry climate
4. Thin layer of soil
5. Short growing season

Examples of the trees include spruce, fir, pine, tamarack, trembling aspen, balsam poplar, and birch. The forest floor has limited vegetation, thanks to the dense canopy.

Deforestation

Deforestation involves the cutting down, burning, and damaging of forests. Deforestation can be defined as the change of forest with depletion of tree crown cover of more than 90%. However, depletion of forest-tree-crown cover less than 90% is considered as forest degradation.

Causes of Deforestation

The main causes of deforestation are summarised below:
(i) Population explosion
(ii) Agriculture: shifting cultivation, overgrazing, cash-crop economy, etc.
(iii) Commercial logging: cutting trees for sale as timber or pulp
(iv) Poverty
(v) Mining
(vi) Dams
(vii) Infrastructure creation for logging
(viii) Forest fi res
(ix) Acid rain
(x) Development projects and housing projects.

Ill Effects of Deforestation

The ill effects of deforestation are summarised below:
(i) Soil Erosion Soil is exposed to wind, sunlight, evaporation due to deforestation. Soil fertility goes down due to soil erosion and rapid leaching of essential mineral nutrients.
(ii) Harm to Fisheries As the soil is eroded, it accelerates siltation in dams, rivers, and the coastal zone. The increased sedimentation harms downstream fisheries.
(iii) More Floods and Droughts Because of deforestation, there is no regulation of the flow into rivers. As a result, floods and droughts alternate in the affected areas.
(iv) Habitat Loss of Wildlife Butterflies, migratory birds and wild animals suffer due to the loss of their habitat.
(v) Extinction of Some Species Many species are affected and some become extinct.
(vi) Local and Global Climate Changes The rainfall pattern is affected as the forest is cut down. Local and global climate changes may result from deforestation.
(vii) Global Warming If the trees are burned, the carbon is released immediately as carbon dioxide which lead to global warming.
(viii) Danger for the Survival of Local Communities Communities lose their source of food, fuel, construction materials and areas for livestock grazing by deforestation.

Causes of Deforestation in India

The deforestation in India is rooted in the commercially oriented forest use and ownership policies of the British government which continued even after India gained independence.
(i) State-sponsored agricultural expansion
(ii) Rapid industrialisation
(iii) Urbanisation
(iv) Growing consumerism
(v) Policies and programmes of unsustainable development like subsidies offered for making the paper and plywood industry a viable and prof table venture

The Measures Taken for Conserving Forest Wealth

(i) Sustainable Forest Management (SFM) SFM is the use of the world's forests in such a way that they continue to provide resources in the present, without depriving future generations of their use.

(ii) Forest Certification Be responsible consumers. Buy wood only from companies that follow sustainable practices.
(iii) Involve Local Communities in Joint Forest Management (JFM)
(iv) Improve Governance and Accountability
(v) Accelerate Education, Research and Training

Timber Extraction

Timber extraction is the removal of timber from forests. It requires various cutting, felling, and hauling practices.
Logging is the work or business of felling and trimming trees and transporting the logs to a mill.

Impacts of Timber Extraction
(i) Deforestation
(ii) Atmosphere
(iii) Harm to Nature
(iv) Climate Change
(v) Soil Erosion and Siltation