Notes/Study Materials

Chapter: 1

ENVIRONMENT & ECOLOGY

1.1 ENVIRONMENT

1.1.1 Definition

- The word environment means surroundings. Environment is the sum of all external factors (biotic and abiotic) that influence the life of an organism.
- Biotic factors include all living beings e.g., men, animals, plants and micro-organisms. Abiotic factors include all physico-chemical entities like air, water, soil, rocks, minerals, mountains etc.

1.1.2 Environment: Types

- The word environment means surrounding. It can be natural or human engineered or even abstract (non-material).
- Due to such vagueness, the term 'environment' has been used in various ways or in various perspectives. Examples are: natural environment, extra-terrestrial environment, man engineered environment, socio-political-cultural environment, business environment, family environment, work place environment etc. These all terms are used in general conversation.
- There is nothing wrong to use the word 'environment' in all these contexts. But due to variety of meanings of the same word, people often get confused about the basic concept of the subject 'Environmental Sciences'. They often raise some questions like: What is the definition of Environment in the domain of environmental sciences? What exactly do we study under the subject 'Environmental sciences?
- If environment means surrounding, then environmental science should mean scientific study of everything that surrounds us; and that mean studying not only air & water but also of every insect, every chemical,... and every human made article like computer, building, furniture,... similarly every relations at home, at office ...etc. It means environmental science is sum of all sciences, all engineering, all social sciences, etc. This cannot be true, as a single subject cannot replace all; it means the concept of environment need to be understood more precisely.
- For purpose of conceptual clarification, different uses of the word environment have been classified into two broad groups:
- Non-essential life supporting environment
- Essential life supporting bio-physical environment
- ***Non-essential life assisting environment:*** Here environment is perceived as any kind of surrounding that is non-essential for life to exist physically. It is another fact that these are often accessory for life, or add some additional or relevant dimension to life. Examples are socio-economic environment, cultural environment, business environment, work place environment, family

environment, extra-terrestrial environment etc. Without this kind of surrounding life can exist in physical sense.

- ***Essential life supporting bio-physical environment:*** It includes bio-physical entities as well as the processes that contribute in providing us (human as well as other living beings) the basic material needs of life e.g., oxygen, water, food, habitat etc, so that life can exist. It can be natural (e.g., forest) or human engineered (e.g., urban town) or a mixture of both (e.g., village and agricultural landscape). In fact the concepts of environmental sciences are based on this meaning.

- 'The essential life supporting bio-physical environment' is commonly termed as 'environment' or 'natural environment' or 'bio-physical environment' or 'biosphere' or 'ecological system'. These words are used almost synonymously. The differences in the usage of these words are described as below:

  - As has already been discussed, the term 'environment' is used in much wider or vague sense. Hence there are all possibilities of confusion if we just use the term 'environment' to denote the essential life supporting bio-physical environment'.

  - The term 'natural environment' is used to denote two distinct levels of nature: (a) the whole earth and the universe (b) the 'bio-physical environment' or 'ecological system' or 'biosphere'. It is remarkable that life is possible only within the boundaries of bio-physical environment or ecological system or biosphere; while majority of the whole earth and the universe do not support life. Hence only latter is the better notion of the essential life supporting environment.

  - Further, the terms 'bio-physical environment' or 'biosphere' or 'ecological system' can be used almost synonymously to denote the essential life supporting bio-physical environment. There are, still, slight differences among these.

  - The term bio-physical indicates a surrounding that is made up of biological (life) as well as physical (abitioc) components.

  - The term biosphere indicates the part of the earth which can sustain life or where life exists naturally. The boundaries of biosphere extend up to 10kms in atmosphere, about 10kms in hydrosphere and only few meters in lithosphere. The entire biosphere is considered a big life supporting system. For the purpose of study, biosphere is further divided into biomes and ecosystems.

  - The term ecological system indicates a complex web of ecological interrelations among abiotic and abitic components of nature. It is assumed that life is sustained on the earth due to presence of these interrelations which, in fact, facilitate continual recycling of material and flow of energy across different life forms.

- Despite so much scientific advancement, life cannot be supported exclusively with artificial means on sustainable basis (for long term). Even the much sophisticated life supporting system of space crafts and projects like 'Biosphere-2' cannot run independently or without the support of nature for infinite time. Human engineered systems, no doubt, have added several accessory dimensions in our existence (e.g., means of comfort, better lifestyle). However, when it comes to providing basic needs to support life on sustainable basis, we are still dependent

on nature or ecological system. Hence, human engineered environment, the term often used in parallel to natural environment, cannot be said as fully life supporting. Moreover, it is better to use the phrase 'human dominated' instead of 'human made' or 'human engineered' for such an environment.

- Since human activities have spread almost in every part of the earth surface, it is hard to find out a pure natural environment on this planet. For practical purpose, however, a geographical area is regarded as natural environment, if the human impact on it is kept under a certain limited level. On the other hand, human dominated environment means the areas that are strongly influenced by human activities. In both the cases, the basic life supporting needs (e.g., air, water, food), are ultimately derived from the natural environment.

1.1.3 Bio-physical or Natural Environment: Segments

- Bio-physical or natural environment consists of three basic segments: Atmosphere, hydrosphere and lithosphere. Biosphere is often considered the fourth segment. Characteristics of each segment are described in detail in the following sections.

1.1.4 Atmosphere

- Definition: Atmosphere is the gaseous envelope of the earth.
- Composition: It is composed of major gases viz. N_2 (78%), O_2 (21%), Ar (0.9%) and CO_2 (385 ppm); minor gases viz. H_2, Ne, CH_4, SO_2, O_3, NO_x, NH_3 etc. (in varying concentration); water vapour and solid particles.
- Vertical structure: Atmosphere extends up to 500km vertically and consists of following 5 layers: Troposphere, Stratosphere, Mesosphere, Thermosphere and Ionosphere.
- Major Functions of the atmosphere are as following:
  - Feeding functions: Atmosphere contains O_2 and CO_2 which are essential for respiration and photosynthesis.
  - Protection Functions: It protects the earth from temperature extremes and maintains moderate temperature (17°C). It also protects from harmful UV-rays and cosmic rays and falling meteors.
  - Circulation Functions: It helps in circulation or transport of matter and energy across different regions of the earth. It include climatic events, hydrology etc.

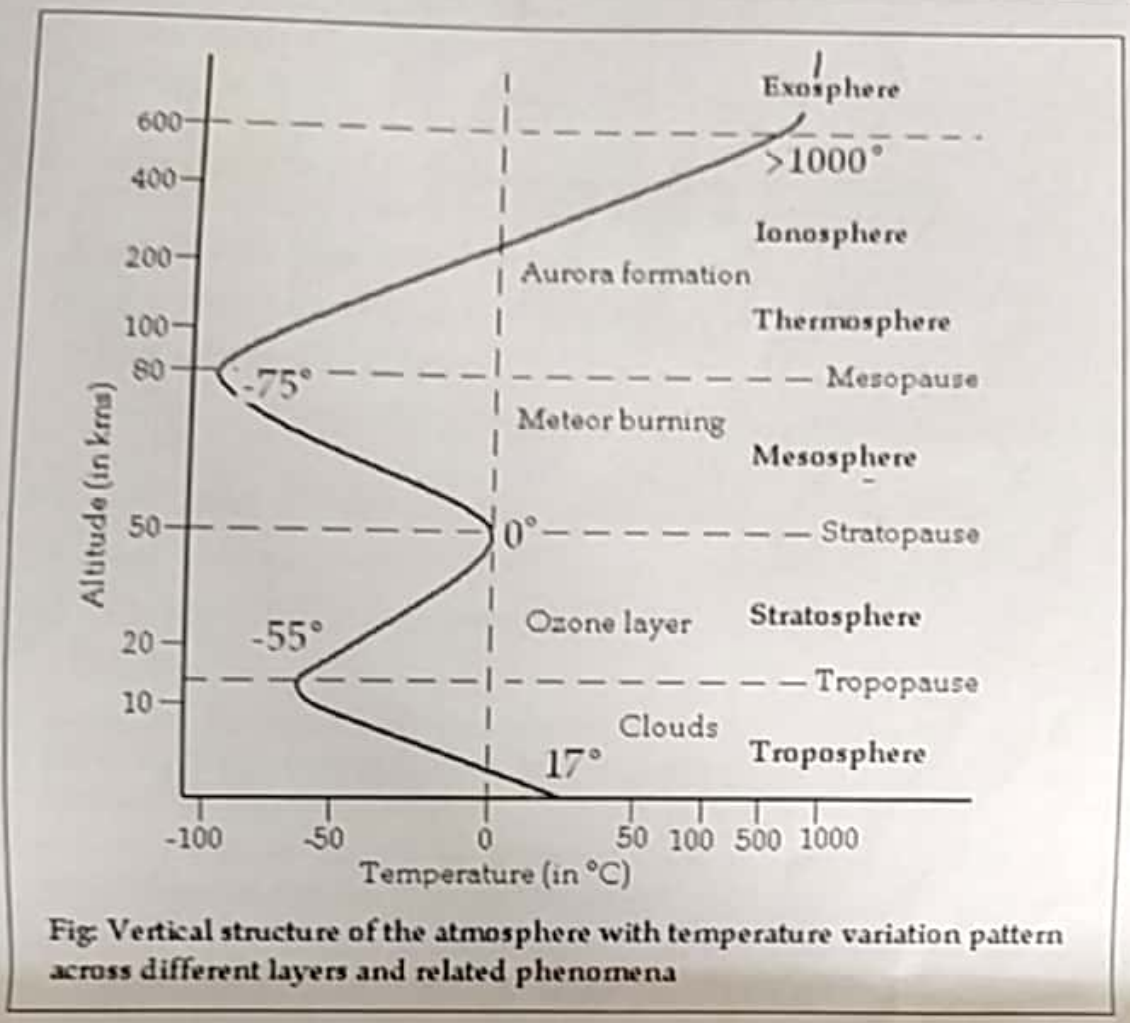

Fig: Vertical structure of the atmosphere with temperature variation pattern across different layers and related phenomena

1.1.5 Hydrosphere

- Definition: The part of the earth covered with water is called hydrosphere.
- Distribution: 70% of the earth surface is covered with water or hydrosphere. Out of total water resources 97% is in seas and oceans (salty water), 2% in glaciers and polar ice, and only 1% in form of fresh water.
- Specific properties of water: Water, due to polar nature of its molecule, has exceptional properties like high boiling point (helps in availability in liquid form), high specific heat (helps in thermal regulation), high surface tension (helps aquatic life in floating), excellent solvent nature (helps in making it a basic fluid of life) etc.
- Major functions of the hydrosphere are as following:
  - It provides habitat to aquatic life.
  - It forms basic fluid of plants and animals.
  - It regulates temperature of the earth (as heat buffer).
  - It provides circulation functions e.g., hydrological cycle, climate.
  - It provides numerous social and industrial uses as coolent, solvent, cleaning agent etc.

1.1.6 Lithosphere

- Definition: Solid part of earth surface is called lithosphere. Lithosphere includes earth crust and solid upper part of mantle.
- It is made up of three types of rocks viz. igneous rocks, sedimentary rocks and metamorphic rocks.
- The upper thick layer of lithosphere (few metres) is called soil which is mixture of minerals and organic matter. Soil is generally fertile and sustains plants growth.
- Major functions of the lithosphere are as following:
  - It provides solid surface/ground to terrestrial life.
  - Soil sustains plant growth.
  - Soil provides surface for decomposition process and different bio-geochemical cycles.
  - Lithosphere provides minerals for various purposes.
  - Land topography helps in hydrological cycle and other circulation functions.
  - It provides land for civilization, infrastructure, agriculture etc.

1.1.7 Biosphere

- Definition: The part of earth that sustains life is called Biosphere. It includes all the living beings (plants, animals, micro-organisms) and their immediate abiotic surroundings (air, water, soil etc).
- Extent: Biosphere extends up to about 2 km in atmosphere, 9-10 km in hydrosphere and only few metres in lithosphere.
- Different views: Certain scientists suggest that biosphere contains only biotic component while others define it as the part of the earth which sustain life and include both biotic and abiotic components.
- Earth is the unique planet that sustains life so far we know. Life is possible on the earth due to numerous factors. The major two reasons are:

  (i) Presence of optimum temperature (average 17^0C) for life

  (ii) Availability of Oxygen and water which are the basic needs of life.

1.2 ENVIRONMENT & ECOLOGY: THE SUBJECT

- The subject Environment & Ecology consist of two components: (i) Environmental Science and (ii) Ecology. These are two distinct subjects; but many times they are used almost synonymously. Brief introduction of each is as below:

1.2.1 Environmental Science

- Environmental Science is the methodological study of the environment and includes study of all bio-physical as well as anthropogenic conditions or circumstances under which an organism lives.
- Globally for the last three to four decades, several environmental issues remained in the major focus. Problems of pollution, global warming, ozone layer depletion, acid rain, deforestation, desertification etc. are the major examples. In fact, Environmental Science evolved as an attempt to understand these problems so as to find out appropriate solutions.

- Today Environmental Science is a well recognized and well elaborated subject. It is highly interdisciplinary in nature and utilizes information from Biology, Ecology, Chemistry, Physics, Geology, Geography, Sociology, Economics, management etc. Besides these, there are a number of parallel disciplines which have evolved from Environmental Science viz. Environmental Studies, Environmental Engineering, Environmental management, Environmental Economics etc.
- Since 1980s, this subject has been promoted world wide and gradually included in the formal education systems of different countries. For the purpose of widespread reach and adoptability by common man, the subject is often catered by the name Environmental Education (EE), which has relatively simplified content and higher applicability for an individual. (EE has been explained in more detail in Chapter-8).
- In India, Environmental Education has been made compulsory at graduate level (all branches or streams of higher education) in all the universities and colleges in 2003 as per the directives of the Hon'ble Supreme Court of India.

1.2.2 Ecology

- The term ecology is derived of two words: *Oikos* (means house or living place) and *logos* (means study). It was coined by Ernst Haeckel in 1869.
- To define; Ecology is the study of relationships between the organisms and their environment.
- In simple words ecology is the study of relationships between (i) Biotic and Abiotic components and (ii) Biotic and Biotic components of the ecosystem.
- In simple words, ecology is the study of basic principle of nature (bio-physical environment). This subject provides the basic framework on which Environmental Science has been developed.

1.2.3 Difference between Ecology and Environmental Science:

- There is much similarity between the two subjects, but the two are slightly different. Some insights differentiating the two are as:
  - While ecology is the scientific study of relationships of different components of ecosystem; environmental science includes study of these relationships (to some extent) as well detailing of all components of nature (surrounding) with particular focus on different environmental problems. Moreover, these problems are often perceived while keeping human society in the centre.
  - In fact, Environmental Science imbibes Ecological principles to understand nature and utilize this information for understanding and solving different environmental problems. Additionally, Environmental Science also utilizes principles of other sciences like biology, chemistry, physics, and economics etc. as accessory tools for the same purpose.
  - Examples: Ecology can be used to interpret relationship (e.g., population dynamics, resource disappearance rate) between deer (biotic component) and water (abiotic component). But Environmental Science studies the same relationship with more detail of each component (e.g., biology of deer, chemistry of water if relevant to explain the relationship) and often focuses some problem, e.g., effect of water pollution on deer and its implication on human health and his well being; remedial measure for water pollution etc.

1.3 SCOPE OF THE SUBJECT (ENVIRONMENT & ECOLOGY)

1.3.1 Scope: Major areas of concern

- This subject has very wide scope. The major areas in which it is applicable are:-
  - **Natural resources:** their conservation & management: Environmental Science is useful in the conservation and management of different types of natural resources viz. forest, water, minerals, land (soil), energy, plants, animals, food etc.
  - **Ecosystem and Bio-diversity:** Environmental Science is the major tool for the conservation of these two different types of ecosystems (i.e. terrestrial, aquatic and man-made ecosystems) and different levels of bio-diversity (i.e. genetic, species, ecosystem and landscape) are conserved using principles of environment and ecology.
  - **Pollution - its prevention and control:** Environmental Science helps in prevention and control of different types of pollutions i.e. air, water, soil, noise, thermal, radioactive pollutions etc.
  - **Issues related to environment and development:** Environmental Science helps to find solution against complex issues of environment and development like climate change, ozone-layer depletion, energy crisis, big-dams, urbanization, population explosion etc. It is also applicable in implementing different policies, programs and laws related to environment.

1.3.2 Scope: Major career opportunities

- Apart from above mentioned sectors, scope of the environmental science can also be described in terms of various career opportunities. The major ones can be described as below:-
  - **Industries:** Environment experts are needed in industries for adopting clean technologies, controlling pollution and disposing the wastes.
  - **Consultancy:** Environment consultancies are hired by Govt. NGOs and industries for different types of environmental problems and compliance processes.
  - **Research & Development:** R & D opportunities in this area include studying different types of pollution, their causes andeffects. It alsoinclude development of clean and efficient technologies for future. Scientists, Researchers and Analysts are some of the common career options.
  - **Academics:** Environmental Science is taught at almost every level of education i.e. from schools to university. Large number of teachers are required to fulfil this need.
  - **Green Marketing:** Skilled manpower is required to promote ecofriendly products in market. Quality certification like ISO-14000, Ecomark etc. also need to be incorporated in marketing strategy for international standard.
  - **Green Media:** Inorder to generate environment awareness there is immense need for skilled manpower in the field of print media and electronic media.
  - **Green Advocacy:** Environmental lawyers are emerging as major player in ensuring proper implementation of environmental norms, laws and programs.

- **NGO (Non-Governmental Organizations):** These days most of the environmental programs are being implemented through NGOs with the help of funds from national and international agencies.
- **Government Jobs:** Besides above there are conventional jobs in govt. bodies like pollution control boards, national part, ministry etc.

1.4 IMPORTANCE OF THE SUBJECT (ENVIRONMENT & ECOLOGY)

- Today the world is facing numerous environment problems ranging from local problems to global problems like climate change. In order to handle these challenges, environmental sciences/studies is promoted/taught at different levels of education.
- The objectives as well as importance of this subject can be described under following points:
  - To know environmental and health impacts of our development activities (i.e., to develop understanding)
  - To create pollution free environment i.e. clear air, clean water and clean land by means of preventing and controlling pollution from different activities.
  - To utilize different natural resources efficiently i.e. with minimum or no wastage eg. energy conservation, water conservation, recycling and reuse of resources.
  - To guide industrial development towards ecofriendly mode i.e. by adopting clean technologies, clean fuel etc.
  - To create public awareness for an ecofriendly lifestyle and to promote environmental ethics.
  - To contribute to solve complex global environmental problems like climate change, energy crisis etc.
  - To ensure inter-generation equity in resource availability (in terms of quality and quantity of the resources).
  - To guide the entire development process towards sustainable development (development while caring the environment).

1.5 NEED FOR PUBLIC AWARENESS FOR ENVIRONMENT

- Stockholm Conference (1972), Earth Summit in Rio-de-Janeiro (1992) and World Summit on Sustainable Development at Johannesberg (2002), all focussed on increasing need of environmental awareness among the public. In fact the goal of sustainable development cannot be achieved without the participation of the public/people.
- The perspective of need for public awareness can be analysed in the following sections:

1.5.1 Why there is need of public awareness:

- Public need to be made aware about the environment because of following three basic logics.

- Everyone interacts with environment i.e. influence his/her environment and in turn is affected by the environment. Hence the knowledge of immediate surrounding is desirable.
- The public is the cause of the most of the environmental problems eg. contaminating air, water, soil and wasting resources. Certain tendencies of public are responsible for this viz. lack of awareness, laziness, carelessness, consumerism, profit making etc.
- The public is also the part of solution to these problem. Public can be part of solution in two ways (i) by not harming the environment (ii) taking initiative or additional steps for betterment eg. planting trees etc.
- For all the three (above) reasons, it is desirable to make public aware about the environment.

1.5.2 On what issues to create awareness:

- The public need to be made aware at least about the following categories of issues:
  - How different day to day activities effect the environment.
  - How to prevent and control pollution related to day to day activities.
  - How to utilize resources efficiently so as to ensure maximum use and minimum wastage of the resources.
  - Besides these, there is need to emphasize the importance of obeying environmental laws/rules, following environmental ethics, and co-operating in programs related to environmental protection and conservation.

1.5.3 Means to create public awareness

- A number of means are used for creating awareness :
  - Educational bodies of schools, colleges, universities.
  - Print media e.g., newspaper, magazine, poster etc.
  - Electronic media e.g., TV, Radio, Internet etc.
  - Creative media e.g., street play, theatre, exhibition etc.
  - Campaign e.g., sanitation campaign, anti-polythene campaign.
  - Celebrations of special days concerned to environment.

NATURAL RESOURCES

NATURAL RESOURCES

Introduction

- All the materials or entities which are useful for human are called resources.
- Most of the things in the nature are useful/relevant for human; hence they can be called resources. There are, however, certain materials (e.g., toxic wastes) that are almost useless for us: these can not be called resources (until we discover any beneficial use of these).
- Resources include material, energy, information, services and other intangible entities that have any beneficial use for human or living beings.
- Resources that are derived from nature or bio-physical environment are called natural resources.
- Natural resources are naturally occurring substances that are considered valuable in their relatively unmodified (natural) form.
- Examples of natural resources: Soil, Water, Forest, Minerals, Fossil fuels, Solar energy, Wind energy etc.

Kinds of Natural Resources

- Depending on how human activities affect them, natural resources can be classified into three types viz. "Perpetual, Renewable and Non-Renewable". "Intangible resources" is also sometimes considered as the fourth type.

  1. **Perpetual (Inexhaustible) Resources:** They are eternal and inexhaustible in their supply. They have a particular rate of inflow but they are not affected by human use and can not be depleted by excessive use. Examples are: Solar energy, Wind energy, Rainfall, Ocean waves, Tides, Water (all forms together).
  2. **Renewable Resources:** They have inherent ability to reappear/ replenish by natural processes. They have a particular rate of replenishment, and they remain intact if they are exploited within this rate. But if they are exploited at a higher rate, they get depleted. Hence conservation or careful utilization is essential for these resources. Examples are: Forest, Wood, Food products, Biomass Energy, Fresh water, Geothermal energy etc.
  3. **Non-Renewable (Exhaustible) Resources:** These are the resources that are not regenerated or remade (as compared to their consumption). They exist in fixed amount and they are gradually being depleted by human consumption. They can however be reused by human for maximum utilization. Examples are: Fossil fuels (coal, petroleum and natural gas), Minerals, Uranium etc.
  4. **Intangible (Abstract) Resources:** These are the non-material kinds of resources which also give very important value to human life. They are often perpetual but they can also be destroyed by human

activities. Examples are: Beauty, Aesthetics, Silence, Open space, Diversity, Information etc.

WATER RESOURCES: AVAILABILITY AND QUALITY ASPECTS

Introduction

- Water constitutes hydrosphere that occupies 70.8% of earth surface. Water is the basic requirement of life on earth. Water constitutes almost 60% of human body and other living beings.
- Water has immense importance for human civilization. Most of the ancient cities were developed along the river banks. Water is also the major requirements of industrial development.

Water: Properties and Uses

- Water molecule has polar nature. Due to this, it has certain exceptional properties like high boiling point, high specific heat, high surface tension, universal solvent nature etc.
- These properties enabled water to serve many purposes in nature, domestic work and industrial processes.
- Important uses of water are:
  - It forms body fluid of living beings
  - It provide habitat and oxygen for aquatic life
  - It acts as heat regulator or heat buffer
  - It acts as coolant as well as medium of heat conductance
  - It acts as excellent solvent for polar solute
  - It acts as cleaning and diluting fluid
  - Its flow along gravity is used in electricity generation
  - It also acts as medium of smooth navigation

Distribution

- There is total 1360 million cubic km of water on earth. Out of total water stock, about 97% is in seas and oceans (as salty water), 2% is locked in polar ice and glaciers, and 1% is available as fresh water.
- Fresh water includes ground water (0.61 %) and surface water (<0.03%). Surface water includes lakes, rivers, springs etc.
- Water circulates between lithosphere and atmosphere through continuous cycling: known as hydrological cycle or water cycle. (later described along with material cycles).

Hydrological Cycle (Water Cycle)

- Cyclic movement of water across hydrosphere, lithosphere and atmosphere is called hydrological cycle or water cycle. It maintains almost constant ratio of water in different locations.
- Hydrological cycle involves following major steps:
  - Water moves up to the sky from ocean and land (Evaporation and Transpiration)
  - Water vapour forms tiny droplets and clouds (Condensation)
  - Water falls back to earth (Precipitation or Rainfall)

- Water moves on land (Run-off, Infiltration and Percolation)

o Of the total evapo-transpiration, about 88% is from oceans & seas while only 12% is from land. Of the total rainfall, 77% is received by oceans & seas while 23% is received by land. Again, of the total rainfall on land, 60% of this returns back to sky by evapo-transpiration while 40% moves through run-off and infiltration.

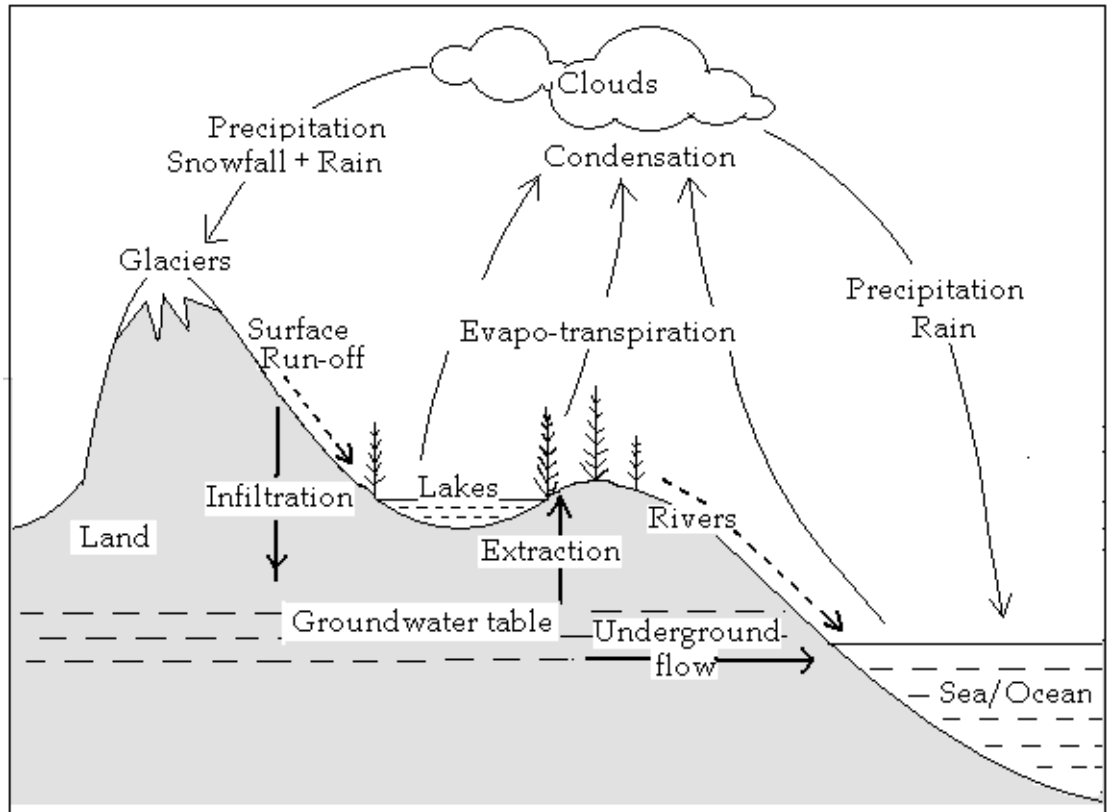

Fig: Hydrologic Cycle

Water Quality Aspects

o A number parameters are used to determine water quality and its usefulness for various purposes.

o Major physico-chemical parameters include:

Alkanity,	Ammonia,
Biological Oxygen Demand (BOD),	Carbon-di-oxide,
Chlorine,	Cyanide,
Dissolved Oxygen (DO),	Electrical Conductivity,
Nitrate & Nitrites,	pH,
Phosphate,	Sulphate,
Suspended solids,	Temperature,
Total dissolved solids,	Turbidity

o Biological parameters include:

Coliform Count	Total Bacterial Count

- Many elements are also detected for water quality, they include: Arsenic, Boron, Calcium, Chromium, Iron, Lead, Mercury, Sodium, Zinc etc.
- Out of these pH, DO, BOD and Coliform number are the major indicators of water pollution in Indian rivers. Briefly these can be described as:
  - pH is the measure of acidity-alkanity of water.
  - DO (Dissolved Oxygen, mg/l) is the amount of oxygen present in 1 litre water of a water body which sustain aquatic life. It decreases with pollution.
  - BOD (Bio-chemical Oxygen Demand, mg/l) is the amount of oxygen needed by bacteria to oxidize organic waste present in 1 litre water. It increases with pollution.
  - Coliform number (Fecal Coliform Organism Count) is the number of disease causing bacteria in 100 ml of water. The origin of these bacteria is faecal matters. It increases with pollution.
- For public safety, most of the countries have prescribed certain limits for these parameters as per the use of water for various purposes.
- In India, the Central Pollution Control Board (CPCB) has declared following criteria for five categories of water use:

Use Category	**pH**	**Coliform** (MPN/ 100mL)	**DO** (mg /l)	**BOD** (mg / l)	**Others** (Use Specific)
Drinking water source without conventional treatment but after disinfections (Class-A)	6.5 - 8.5	50 or less	6	2	NA
Outdoor bathing (organised) (Class-B)	6.5 - 8.5	500 or less	5	3	NA
Drinking water source with con-ventional treatment followed by disinfection (Class-C)	6.0 - 9.0	5000 or less	4	3	NA
Propagation of wild life, fisheries (Class-D)	6.5 - 8.5	NA	4	NA	Ammonia (<1.2 mg/l)
Irrigation, industrial cooling, con-trolled waste disposal (Class-E)	6.0 - 8.5	NA	NA	NA	EC (2250 mhos/cm); Na absorption ratio (<26); Boron (<2mg/l)

DRINKING WATER CRISIS

Introduction

- Fresh (non-saline) water is one of the basic requirements of human life. It is required for drinking, cooking, bathing and performing sanitation activities.
- Water need to be clean or non-polluted for human intake. Safe water require to fulfill certain water quality criteria e.g., pH between 6.5-8.5; Fecal Coliform less than 50 per 100 ml, DO more than 6; and BOD less than 2.
- As per WHO (World Health Organization) annual water requirement for a healthy life is 2000 cubic metre per person per year. About 40 do not fulfill this requirement due to shortage of fresh water.
- About 2 billion people worldwide (one third of world population) lack access to safe drinking water. About 6000 children die everyday from the diseases associated with unsafe drinking water and poor sanitation.

Reasons of water crisis

- Water is present in great abundance on earth. But the fresh water is available only less than 1% of total water. And easily accessible surface water is only about 0.1% of total water.
- The present availability (about 7000 cubic metre per person) is enough as per WHO criteria. But due to unequal distribution, a large population is facing water crisis.
- Unequal distribution is chiefly due to geographical or climatic reasons. A large region of the globe is dry in form of desert and semi desert. There rainfall is very low, and as a result of this ground and surface water resources are also very thin.
- Unequal distribution is also associated with disparity (unequal) economic development. Poor countries particularly suffer from crisis of safe water. Similarly within a country poor people particularly suffer from this crisis.
- Pollution is another problem which makes the water unfit for consumption. Increasing population and thereby increasing industrial development is associated with increasing level of pollution of water.

Remedial measures

- Conserving clean water, controlling water pollution, protecting water bodies, harvesting rain water and taking initiative for equal distribution of water are some of the remedial measures.

WATER BORNE DISEASES

Introduction

- Water-borne diseases are "dirty-water" diseases: these are spread by contamination of drinking water systems with the urine and faeces of infected people or animal.

- Water-borne diseases include cholera, typhoid, shigella, polio, meningitis, and hepatitis A and E. These are caused by pathogens like bacteria, viruses, protozoa, helminthes, algae etc.
- World wide these diseases cause over 12 million deaths a year. Children mostly suffer from these diseases.

Major diseases and their causing agents

- Example of major water borne diseases and names of their causing pathogens are as follow:

  Bacterial diseases:

  Cholera by *Vibrio cholerae*

  Typhoid fever by *Salmonella typhi*

  Viral diseases:

  Meningitis by *Coxsackie viruses*

  Hepatitis A by *Hepatitis A virus*

  Protozoal diseases:

  Amoebic dysentery by *Entamoeba histolytica*

  Dysentry by *Balantidium coli*

Causes of the diseases

- Lack of sanitary waste disposal and of clean water for drinking, cooking, and washing is the cause of water borne diseases.
- Worldwide, an estimated 3 billion people lack sanitary toilet and over 2 billion people lack access to safe freshwater.
- These diseases often occur where public and private drinking water systems get their water from surface waters (rain, creeks, rivers, lakes etc.), which can be contaminated by infected animals or people.
- Runoff from landfills, septic fields, sewer pipes, residential or industrial developments can also contaminate surface water.
- Using contaminated sewage for fertilizer can result in epidemics of such diseases as cholera. In the early 1990s, for example, raw sewage water that was used to fertilize vegetable fields caused outbreaks of cholera in Chile and Peru.

Prevention and solutions.

- Improving public sanitation and providing a clean water supply are the two steps needed to prevent most water-borne diseases and deaths.
- While the cost of building freshwater supply systems and sanitation facilities is high, the costs of *not* doing so is many times higher.
- In Karachi, Pakistan, for example, a study found that poor people living in areas without any sanitation or hygiene education spent six times more on medical care than people who lived in areas with access to sanitation and who had a basic knowledge of household hygiene.
- Disinfection is used to prevent the growth of pathogenic organisms in supply water. The two most common methods to kill microorganisms in

the water supply are: oxidation with chemicals such as chlorine, chlorine dioxide or ozone, and irradiation with Ultra-Violet (UV) radiation.

FLUORIDE PROBLEMS IN DRINKING WATER

Introduction

- Fluoride is one of the important mineral of earth crust and it is found in all drinking water sources, particularly in ground water.
- Fluoride is one of the essential mineral for human and animals. Fluoride in human body is chiefly (96%) found in bones and teeth. Due to high electro negative character of fluorine, it readily combines with calcium.
- For proper growth of teeth and bones, human body requires 1-3 mg of fluoride daily: this amount is normally supplied by drinking water having 1.0 ppm fluoride.
- In soft water there is almost nil fluoride while in hard water there may be 5 ppm or even10 ppm fluoride.
- As per Bureau of Indian Standards, 1.0 ppm is the acceptable limit and 1.5 ppm is tolerable limit in absence of alternatives and better sources.

Effects of excessive intake

- Consumption of water having fluoride more than 1.5 ppm is considered unsafe and toxic. It is reported to cause dental and skeletal fluorosis. These harmful effects are often termed as fluoride poisoning.
- In dental fluorosis, teeth lose their shine appearance and discoloration of enamel starts from chalky white, yellow, brown to black. The teeth lose their enamel and all these changes are permanent. At higher concentration of fluoride dental cavities are developed.
- In skeletal fluorosis, bones, ligaments and tendons are affected. The patients feel pain, stiffness or rigidity in neck, backbone, joints and waist. This results into difficulty in movements of knee and shoulder joints. This disease is generally detected in advanced stage.
- Not only teeth and bones, excessive intake of fluoride results into muscle fibre degradation, low haemoglobin level, deformity in RBCs and blood vessel, gastro-intestinal problems, nervousness, excessive thrust, damage of foetus, painful skin rashes etc.

Sources & extent of the problem

- Drinking water is the major cause of fluoride poisoning. Other sources are food, drugs, tooth pastes, mouth-rinses and industrial exposure.
- Worldwide, fluoride poisoning is reported from several countries including India, China, Argentina, East and South Africa where water supply contains over 10 ppm fluoride.
- In India, fluoride poisoning is reported from most of the states (almost 16 states). Ground water of these regions has 3 to 15 ppm fluoride. This is due to heavy concentration of fluoride containing minerals in earth crust.

Solution Measures

- In case of higher fluoride concentration, defluoridation of water is done through fluoride exchanger methods like tri-calcium phosphate, anion exchangers, activated carbon, magnesium salts or aluminium salts.
- In order to cater the needs of rural areas, such techniques need to be simple, cheap and applicable to small water supply.
- In India defluoridation is widely done by Nalgonda Technique developed by National Environmental Engineering Institute (NEERI), Nagpur.
- Prevention measures for fluorosis include: being careful to detect the symptom of disease in early stage, consuming defluoridated water, avoiding foods, drugs and toothpastes that have high fluoride content and taking enough calcium and vitamin-C so as to counter ill effects of fluoride.

FOREST RESOURCES

Introduction

- Forests are important renewable resources. They provide a range of economic commodities as well as ecological services.
- Forests are the biotic community of trees, shrubs and woody vegetation, usually with a closed canopy.
- As per Food and Agricultural Organization (FAO): Forests are the landuse with crown cover more than 10%, area more than 0.5 hectare, average tree height more than 5 m and mainly composed of indigenous trees.
- Forests exist where average temperature is more than 100C and annual rainfall is more than 200 mm.

Forests worldwide

- Globally forests constitute about 30% of the land. Africa (33%) and South America (25%) have largest forest areas.
- About 80% of total forest area is closed canopy forest (crown cover more than 20%) and 20% is open canopy forest (crown cover less than 20%) (as per FAO estimate in 1994).
- South America, former Russia, Canada and USA have largest area of closed canopy forest. Africa has largest area of open forest.
- Major forest types worldwide include: Taiga forests, Mixed temperate forests, Temperate forests, Sub-tropical forests, Tropical forests and Equatorial rainforests.

Forest of India

- As per State of the Forest Report, 1999, total forest cover of India was 19.4% of the total geographical area of the country. (However 2001 Report declared forest area as 20.55% of total area).
- Out of 19.4%, dense forests (crown cover more than 40%) account for about 11.5%, open forests for 7.8% (crown cover 10-40%), and Mangrove forests for 0.15%.
- There are 16 different types of forests in India which fall in following 6 broad groups:

I. Moist Tropical Forests

1. Tropical Wet Evergreen Forest
2. Tropical Semi-evergreen Forest
3. Tropical Moist Deciduous Forest
4. Littoral and Swamp Forest

II. Dry Tropical Forests

5. Tropical Dry Deciduous Forest
6. Tropical Thorn Forest
7. Tropical Dry Evergreen Forest

III. Montane Sub-tropical Forests

8. Sub-tropical Broad Forest
9. Sub-tropical Pine Forest
10. Sub-tropical Dry Evergreen

IV. Montane Temperate Forests

11. Montane Wet Temperate Forest
12. Himalayan Wet Temperate Forest
13. Himalayan Dry Temperate Forest

V. Sub-alpine Forests

14. Sub-alpine Forest

VI. Alpine Scrubs

15. Moist Alpine Scrub
16. Dry Alpine Scrub

- In India 96% forest area is owned by Government and remaining forest by corporate bodies and private ownership.
- Forest area varies across different states. Highest forest area is shown by Madhya Pradesh followed by Arunachal Pradesh and Chhatisgarh.

Importance of forests

- Forests have great economical, ecological and socio-cultural values. Major importance/uses of forests are as below:
- Economic value
  - Fuel-wood: Forests provide fuel-wood for cooking and heating. In Africa and South-East Asia fuel-wood accounts for 58% and 42% of total energy consumption.
  - Timber: Timber wood obtained from forests is used to make houses, doors, furniture, plywood, boards, tools, sport goods etc. Timber account for almost half of the global wood consumption, 80% of that is consumed in developed countries.
  - Minor Forest Products (Non-Timber Forest Products or NTFP): Forests provide fibres, sticks, bamboos, thatch, fruits, nuts, medicinal plants,

oil, honey, lacs, wax, flower, spices, tendu-leaves, resin, dyes, gums etc.

- Ecological value
  - Maintain biodiversity and provide habitat to wildlife
  - Produce oxygen and act as sink of carbon-di-oxide
  - Reduce atmospheric pollution particularly SPM
  - Regulate climate and hydrology of the area
  - Contribute to soil fertility of downstream areas
  - Check soil erosion, landslide, floods and desertification
- Value for Tribal life
  - Forests provide food, medicine, shelter and commercial products to tribal people. Forests are integral part of tribal life.
- Cultural and Aesthetic value
  - Worldwide forests are valued for their beauty and greenery. They have close relations with recreation, culture, religion, literature, art, music and spiritual pursuit.

Deforestation

- Deforestation means cutting or felling of trees by human for various purposes. Economic gain is often the goal of most of these purposes.
- Deforestation is widespread across the globe as well as India. In India almost 1.3 million hectare forests are destroyed each year.
- Following are the major reasons of deforestation:
  - Removal of forests for getting fertile land for agriculture particularly slash & burn agriculture
  - Removal of forests for expansion of cities and villages
  - Removal of forests for the construction of big projects and infrastructure, e.g., dams, mines, factories, refinery, roads, highways, railways, airports, power-lines etc.
  - Removal of forests for resettlement of displaced people and landless people
  - Massive extraction of timber wood
  - Over-grazing by animal and uncontrolled fuel-wood collection
- Deforestation results into several environmental problems e.g., biodiversity loss, wildlife habitat loss, desertification, increased soil erosion, disturbance in climate, hydrology and soil fertility etc.

Forest Conservation

- Worldwide efforts are being made to conserve or save existing forests and to increase forest area. Forest plantation programs (afforestation and reforestation) are often encouraged by government.

- Forest Policy of government of India (1952) has a goal of achieving forests on 33% of total area (against the present situation of 20% area under forest). For this a number of conservation measures are adopted.
- Government has designed four types of conservation strategies: Reserve Forests, Limited Production Forests, Production Forests and Social/Commercial Forests.
- Joint Forest Management (JFM) is another program in which both govt and public participate in forest management.

  Besides these, many International Organizations and Non- Government Organizations (NGOs) are also working for forest conservation and spreading awareness about forests.

MINERAL RESOURCES

Introduction

- Minerals are required for two major purposes:
  - Proper functioning and growth of body of living beings
  - Economic-development of human society
- Minerals are non-renewable resources. They are formed by very slow geological processes. Hence rate of their formation is negligible as compared to their consumption.
- Minerals are extracted from earth crust by the process of mining and then converted into useful commodities.

Types and distribution

- Minerals are of two types: metallic and non-metallic
  - Metallic minerals include Aluminium, Copper, Gold, Iron, Platinum, Silver, Tin, Uranium etc.
  - Non-metallic minerals include Asbestos, Mica, Nitrate, Phosphate, potassium, Salt, Sulphur etc.
- India has rich deposits of minerals. Based on availability following classes of minerals are identified for India:
  - High availability (export): Bauxite, Chromite, Iron, Manganese, Mica, Titanium etc.
  - Medium availability (self sufficient): Coal, dolomite, feldspar, fluoride, gold, gypsum, limestone etc.
  - Low availability (import): Copper, Graphite, Lead, Mercury, Tin, Tungsten, Zinc, Sulphur, Phosphorus, Potassium etc.
- Geographical distribution of minerals is very unequal. Geological Survey of India has identified 50 important minerals and 400 major sites of their occurrence in India.

Uses, exploitation and conservation of minerals

- Minerals have numerous uses for human. Broad groups of their uses are as follow:

- Development of metal based technology (e.g., different metals)
- Building material production (e.g., Silica, Gypsum, Limestone)
- Chemical industries (e.g., different non-metals and metals)
- Fertilizers for agriculture (e.g., Nitrate, Phosphate, Potassium)
- Energy generation and making of explosives (e.g., Coal, Uranium, Gun-powder)

o Both metals and non-metals are utilized with almost similar importance.

o Rate of their consumption is extremely high, e.g., Globally Iron is used @ 1 billion tonne per year; similarly fertilizer making minerals are used @ 10-100 million tonne per year.

o Due to extremely high consumption, most of the mineral deposits are now depleted. Certain crucial elements have become scarce e.g., Copper, Gold, Mercury, Phosphorus, Platinum, Silver, Tin, etc.

o Following measures are recommended for the conservation or best utilization of minerals:

- Careful or judicious use of minerals
- Collection of mineral wastes and Recycling
- Developing more efficient technologies (less wastage)
- Designing smaller equipments
- Developing substitute to rare minerals demanding old technologies
- Exploring untapped deposits (e.g., deep sea mining) so as to lessen pressure on conventional sources.

ENERGY RESOURCES

ENERGY: FORMS AND USES

Energy: Introduction

o The word energy is derived from Greek word '*energia'* which mean 'activity or operation'.

o Energy is simply defined as ability to do work and often it is equivalent to amount of work done. It is a scalar physical quantity. SI unit of energy is Joule (J).

o Energy exists in numerous forms (manifestations). One form of energy can be converted into other form.

o During each conversion the more useful energy get converted into less useful energy. In other words, with each conversion, entropy of energy increases and entropy of whole universe expand in same amount.

o Energy conversions are of two basic types:

- Mass loss based e.g., nuclear energy (fusion and fission)
- Non-mass-loss based e.g., most of the day to day used energy, like fossil fuel energy

- Practically, energy is obtained from energy resources e.g., fossil fuel, hydroelectricity, nuclear energy, solar energy, biomass energy etc.

Energy: Forms

- There are multiple ways to classify forms of energy. As per one classification, there are two basic forms:
  - Kinetic energy (energy of motion)
  - Potential energy (energy in stored form)
- Other classification supports following forms of energy:

Mechanical energy	Thermal (heat) energy
Chemical energy	Sound energy
Electrical energy	Sound energy
Electrical energy	Electromagnetic energy
Magnetic energy	Nuclear energy
Solar energy	Gravitational energy
Elastic energy	Rest mass energy

Energy: Uses

- In the universe, energy is consumed in all the activities or movements. It includes energy consumed by living being for their body functions as well as energy consumed in economic developmental activities.
- Broad categories of energy consumption are:
  - For body function and growth (in form of food)
  - For household uses (cooking, heating, lighting etc.)
  - For transporting people and goods
  - For manufacturing different items
- Development process depends on energy input. The two are often proportional.
- Ratio of energy demand and GDP (Gross Domestic Production) is a good indicator of energy efficiency of the development process. Higher the ratio, lower the energy use efficiency. Developed countries have higher efficiency as compared to developing countries.
- With increasing energy demand world wide, there is great need to conserve energy resources and to utilize them with efficiency.

DIFFERENT TYPES OF ENERGY RESOURCES

- Energy is obtained from energy resources e.g., fossil fuel, hydroelectricity, nuclear energy, solar energy, biomass energy etc.
- There are multiple ways to classify energy resources. Some of these classifications are as follow:
- Based on replenish or recycling ability, they are of two types:
  - **Renewable energy resources:** They include inexhaustible resources which can be replenished (reproduced) by natural process. e.g., solar energy, wind, oceanic waves, geothermal energy, biomass energy etc.

- **Non-renewable energy resources:** They are exhaustible and have a fixed stock. They are depleting day by day due to consumption. e.g., coal, petroleum, natural gas, nuclear fuel etc.

- Based on history of their use by human, they are of two types:
  - **Conventional energy resources:** These resources are being used by man since long (i.e., more than 50 years since now) and are still in common use. e.g., fossil fuels (coal, petroleum, natural gas) and hydroelectricity.
  - **Non-conventional energy resources:** These are the recently explored energy resources which are in practice for 4-5 decades only. They are still in the phase of further R&D (research and development). e.g., solar energy, wind, oceanic wave, biomass, geothermal, nuclear energy and hydrogen.
- Based on commercial orientation, they are of two types:
  - **Commercial:** These distribute through well defined market system. e.g., coal, oil, natural gas, electricity etc.
  - **Non-commercial:** These chiefly distribute through non-market channels. e.g., fuel wood, cow-dung, agricultural wastes etc.

ELECTRO-MAGNETIC RADIATION

- Electromagnetic radiation (EMR) are self-propagating waves. EMR have electric and magnetic components, which oscillate in perpendicular to each other and to the direction of energy propagation.
- EMR require no medium for propagation (travel) and can travel in space or vacuum. They can also travel through material medium, depending on intensity of component waves as well as nature of matter.
- EMR are classified into different waves as per their frequency. These are: (in order of increasing frequency or decreasing wavelength): Radio-waves, Microwaves, Infrared-radiation, Visible-light, Ultraviolet-radiation, X-rays and Gamma rays.
- ERM carry energy, which is realized when they interact with matter. Waves with higher frequency have higher energy or intensity.
- Exposure to high frequency EMR, particularly UV, X-ray and Gamma-rays have harmful effects on living beings.
- A small part of EMR is called visible spectrum or light (400-700nm). It has 7 colours (VIBGYOR) and can be sensed by the eye of various animals.
- Visible light along with Infra-Red radiation are the major components of sunlight falling on the earth. This is also called solar energy which is the basic source of energy on earth. Wind energy, oceanic waves, biomass energy, hydroelectricity all are derived from solar energy.

HYDRO-ELECTRICITY

Introduction

- Hydroelectricity is the most widely used form of renewable energy. It is a clean source of energy which does not create pollution. Besides it is cheap source of power generation.
- Most hydroelectric power comes from the potential energy of dammed water. Flowing or falling water (from dams) drives turbine, which generate electricity.
- The energy extracted from the water depends on the volume and on the difference in height between the source and the water's outflow. This height difference is called the head. The amount of potential energy in water is proportional to the head.
- One disadvantage of hydroelectricity is site dependency, i.e., it requires water and height gradient. Due to this limitation, lot of transmission loss and cost is involved for in the distribution of this electricity.
- Hydroelectricity world wide is chiefly generated through large scale hydroelectric projects. They are generally developed in the form of river valley projects with multiple objective including power generation, irrigation, drinking water, fishery etc.

Hydroelectricity generation across the World and India

- Presently, hydroelectricity supplies about nearly 20% of world electricity. Globally, it also accounts for over 63% of the total electricity from renewable sources in 2005.
- The hydro-electric potential of India is estimated to be about 1.5 lakh MW out of which a capacity of 20% has been developed and 9% of capacity is under construction. 5% of this is expected from small, mini and micro hydro schemes.
- In India, present total power generation capacity is 1.35 lakh megawatts, out of which thermal occupies 64%, hydro 25%, nuclear 3%, and renewable 8% (August 2007).

Small scale hydroelectricity projects

- Large scale hydro electricity projects are often associated with number of environmental issues: Major challenge is sinking of a large area in water which causes massive displacement of the people along with loss of human assets, forest, wildlife, fertile land etc. They are also linked with risks of earthquake. Disturbance in aquatic ecosystem is another problem.
- To certain extent, small hydro power projects can be considered as sustainable alternative to mega hydroelectricity projects. A series of small hydro power projects can be constructed in place of one mega project.
- Small and mini hydel projects are also useful in remote and hilly areas where extension of an electrical transmission grid system is uneconomical.
- Small hydro schemes are particularly popular in China, which has over 50% of world small hydro capacity.
- Indian government is also encouraging development of small hydro power (SHP) projects in the country. Since 1994, over 760 sites of about 2,000 MW capacity have already been allotted.

FOSSIL FUEL BASED ENERGY

Introduction

- Fossil fuels are the non-renewable and conventional energy resources. They include coal, petroleum oil and natural gas. They are the most consumed energy resources to drive power and transport sectors till date.
- Fossil fuels were formed over millions of years through the decay, burial and compaction of rotting vegetation on land (coal), and of marine organisms on the sea floor (oil and gas).
- Burning fossil fuels (particularly coal and oil) often releases large quantities of sulphur dioxide and nitrogen oxides which can cause acid rain.
- In India, present total power generation capacity is 1.35 lakh megawatts, out of which thermal occupies about 64%, hydro 25%, nuclear 3%, and renewable 8% (August 2007). Out of the total contribution of fossil fuels (64%), coal produces 53%, gas produces 10% and oil produces a mere 1%.

Coal

- Coal is a solid fuel formed over millions of years by the decay of land vegetation.
- Coal is widely used in the generation of electricity because it is a highly concentrated energy source. However, it is not a "clean" fuel, releasing more acidic pollution than either oil or gas.
- Coal was the first fossil fuel to be exploited on a large scale during the 19th century with the beginning of the Industrial Revolution. Before the commercial introduction of electricity, coal was primarily used in industrial boilers to create steam energy to power machinery.
- India has rich reserves of coal as it is the third largest producer of coal in the world. As per estimates, coal stock of India can last for 200 years with present level of utilization.

Petroleum Oil

- Petroleum oil is the most popular energy resource worlwide. Due to its high energy content and liquid nature, it is the most suitable fuel particularly for transport sector.
- Oil is formed from the remains of marine microorganisms deposited on the sea floor.
- The marine microorganisms accumulate over millions of years and gradually infiltrate into microscopic cavities of the sea floor sediment and rock where they decay. The oil thus formed through decay is extracted through large drilling platforms.
- Crude oil is refined in refineries to get petrol, diesel and other petroleum products.
- The use of oil increased significantly after the Second World War. In the early 1970s, approximately 40% of global fossil fuel use came from oil. This resulted into Oil-Crisis and price rise.
- After 1990s, improved energy efficiency has caused oil consumption to decline in many developed countries. There is increasing focus to shifts

to other fuels such as natural gas, nuclear energy and other renewable energy resources.

- India has limited oil reserves. As per one estimate oil reserves of India can provide energy for coming 20 years only.

Natural gas

- Natural gas is formed in the same way as oil, from the remains of marine microorganisms.
- Natural gas provides an alternative to oil or coal. It is a cleaner fuel and does not create acidic pollution. Commonly, it is used in form of LPG and CNG.
- Since1960s, up until the present day, there has been a dramatic increase in the amount of available reserves of natural gas. Consequently, natural gas has become the fastest-growing energy resource.
- The present global use of natural gas is approximately 20% of all fossil fuel use, and this figure is predicted to rise in the future. Some estimates indicate the reserves of natural gas may be available for up to 400 years.
- Reserves of natural gas in India are limited. As per one estimate natural gas reserves of India can provide energy only for coming 20 years.

NUCLEAR ENERGY

Introduction

- Energy released during nuclear reaction is called nuclear energy. Infact, it is the binding energy of sub-atomic particles (protons and neutrons) that is released during the process.
- Nuclear energy is produced in two ways:
  - Nuclear fission: It refers to breakdown of nucleus (of heavy element) into smaller fragments (lighter elements) by bombardment of neutrons.
  - Nuclear fusion: It refers to fusing (combining) of light atomic nuclei to form a single heavy nucleus. $_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + 24$ MeV
- The mass lost in the process converts into huge amount of energy following mass-energy conversion equation, given by Einstein in 1905: "$E=mc^2$", where E refers to amount of energy released, m refers to mass loss, and c refers to speed of light.

Nuclear power generation

- Of the two processes, nuclear fission is commonly applied to generate electricity in nuclear power plants or nuclear reactors. In nuclear power plants nuclear fission reaction is carried out in controlled environment and the energy thus released is harvested.
- Heat energy generated by burning uranium fuel is collected in ordinary water and is carried away from the reactor's core either as steam in boiling water reactors or as superheated water in pressurized-water reactors.
- There are 17 functional nuclear power plants in India. These account for about 3% of total electricity generation capacity of India.

Relevance

- Nuclear energy is one of most potential source of energy. It can decrease dependency on fossil fuels at least for electricity generation.
- Nuclear energy has also proven to be a protector of the environment because of the lack of CO_2, greenhouse gasses and other pollutants.
- There are, however, some major drawbacks to using nuclear energy, which include the actual safety of using nuclear energy, the waste it produces, and the atomic weapons that nuclear energy promotes.
- Overall, however, it can be said that the use of nuclear energy greatly outweighs any other source of energy.

SOLAR ENERGY

Introduction

- The sun is a source of enormous energy. It operates on the principle of fusion reactor and can supply energy for next 4 x 10^9 years. The earth receives only 0.1% of total solar energy and this energy is sufficient to fulfill our energy requirements.
- The term solar energy means utilization of the radiant energy from the sun. Solar energy technology comprises of two distinct categories:
  - **Thermal conversion**: It refers to utilizing thermal (heat) energy of solar radiation. In nature it is seen as direct heating of earth surface which lead to formation of ocean waves, winds, evaporation etc.
  - **Photovoltaic conversion:** It refers to utilizing solar power to get electricity (linear flow of energy through free electrons). This phenomenon is observed in different processes like photosynthesis, photochemistry and photo-electro-chemistry.
- Both effects of solar energy are utilized by man to harvest energy. For the purpose a number of application equipments have been devised. These equipments collect solar radiations and convert that energy into desirable form or application.

Applications

- Solar energy and shading are important considerations in building design. Day lighting techniques optimize the use of light in buildings.
- Photo voltaic cells or solar cells provide functions of electricity, like lighting bulbs and running electronic appliances.
- Solar water heaters heat swimming pools and provide domestic hot water. Simple applications include clotheslines and solar cookers which concentrate sunlight for cooking, drying and pasteurization.
- In agriculture, greenhouses expand growing seasons and pumps powered by solar cells provide water for grazing animals.
- Evaporation ponds are used to harvest salt and clean waste streams of contaminants.
- Solar distillation and disinfection techniques produce potable water for millions of people worldwide.

- More sophisticated concentrating technologies magnify the rays of the sun for high-temperature material testing, metal smelting and industrial chemical production.
- A range of prototype solar vehicles provide ground, air and sea transportation.

Indian Scenerio

- India due to its geo-physical location receives solar energy equivalent to nearly 5,000 trillion kWh/year, which is far more than the total energy consumption of the country today. But India produces a very negligible amount of solar energy - a mere 0.2 percent. Up till now, India's energy base has been more on conventional energy like coal and oil.
- However, India has now attained 7th place worldwide in Solar Photovoltaic (SPV) Cell production and 9th place in Solar Thermal Systems.
- Grid-interactive renewable power installed capacity was 9,013 MW in 2006, corresponding to around 7 percent of the total power installed capacity which equates to over 2 percent of total electricity.

Relevance and challenges

- Solar energy is the most desirable source of energy on the earth. It is renewable, clean, free of cost (except capital cost), inexhaustible and available almost everywhere (except polar regions).
- There are certain limitations which really pose challenges in its adoption:
  - Generation limited for day light period
  - Low efficiency of solar collectors
  - Manufacturing procedure that require expensive technology
  - Waste products due to manufacturing equipments that have any impact on the environment
  - Land requirements for erecting solar PVs.
- Much R&D is being done to improve efficiency of solar power devices and its application is increasing worldwide gradually.
- Solar power is considered one of the potential alternative sources of energy for future. However, there is need to focus the attention of government, corporate as well as public to adopt this resource as presently most of us are mainly depend on fossil fuels for energy.

BIOMASS ENERGY

Introduction

- Biomass energy or bio-fuels are the major renewable energy resources. They are often considered non-conventional energy resources, despite the fact that human society has been using biomass energy in different form (wood, straw, cow dung cake etc) since historical times.
- Infact, biomass energy refers to solid, liquid and gas fuel derived from recently dead biological material. This distinguishes it from fossil fuels, which are derived from long term breakdown of dead biological material.

- Biofuel can be theoretically produced from any (biological) carbon source. Many different plants and plant-derived materials are used for biofuel manufacture.

Bio-fuel production

- There are two common strategies of producing biofuels:
  - One is to grow crops high in either sugar (sugar cane, sugar beet, and sweet sorghum]) or starch (corn/maize), and then use yeast fermentation to produce ethyl alcohol (ethanol).
  - The second is to grow plants that contain high amounts of vegetable oil, such as oil palm, soybean, algae, or jatropha. When these oils are heated, their viscosity is reduced, and they can be burned directly in a diesel engine, or the oils can be chemically processed to produce

Uses and Relevance

- Biofuels are used globally, most commonly to power vehicles and cooking stoves. Biofuel industries are expanding in Europe, Asia and the Americas.The use of biofuels also reduces dependence on petroleum and enhances energy security.
- Biofuels offer the possibility of producing energy without a net increase of carbon into the atmosphere because the plants used in to produce the fuel have removed CO_2 from the atmosphere, unlike fossil fuels which return carbon which was stored beneath the surface for millions of years into the air. Biofuel is therefore more nearly carbon neutral and less likely increase atmospheric concentrations of greenhouse gases.
- Biofuels are discussed as having significant roles in a variety of international issues, including: mitigation of carbon emissions levels and oil prices, the "food vs fuel" debate, deforestation and soil erosion, impact on water resources, and energy balance and efficiency.

BIOGAS ENERGY

Introduction

- It is a type of bio-fuel. Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen.
- Generally biogas is produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure or sewage, municipal waste, and energy crops. This type of biogas comprises primarily methane and carbon dioxide.
- The other principal type of biogas is wood gas which is created by gasification of wood or other biomass. This type of biogas is comprised primarily of nitrogen, hydrogen, and carbon monoxide, with trace amounts of methane.
- The gases methane, hydrogen and carbon monoxide can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel.

Applications

- Biogas can be used as a low-cost fuel in any country for any heating purpose, such as cooking.
- It can also be utilized in modern waste management facilities where it can be used to run any type of heat engine, to generate either mechanical or electrical power.
- Biogas is a renewable fuel and electricity produced from it can be used to attract renewable energy subsidies in some parts of the world.

HYDROGEN AS AN ALTERNATIVE FUTURE SOURCE OF ENERGY

Introduction

- Hydrogen is an efficient, renewable and non-polluting fuel. When it is mixed with oxygen it provides 29 kcal/per gram energy which is higher than petrol (11.2 kcal/gram) and coal (7.8 kcal/gram).
- Hydrogen energy is believed to greatly reduce our reliance on fossil fuel and hence it is considered as major alternative source of energy in future.
- Hydrogen fuel cells are devised for the purpose of energy production. The fuel cell simply combines hydrogen and oxygen chemically to produce electricity, water and waste heat.
- There are several types of fuel cells, but the one most suited for cars is called the proton-exchange membrane (PEM) fuel cell.

Occurrence and manufacture

- Hydrogen (H) is the most abundant element in the universe, constituting about 93% of all matter. It is found in water (H_20), fossil fuels (basically, compounds of hydrogen and carbon), and all plants and animals. Its major reserve on the earth is water and that is inexhaustible.
- In atmosphere it is found in very low concentration (0.1 ppm) due to its high reactive nature and lowest density.
- There are three major ways to manufacture hydrogen:
  - Breaking down of hydrocarbon mainly methane
  - Electrolysis of water
  - Reacting water with metals
  - Bio-photolysis of water

Challenges

- Commercial level production of hydrogen is however very challenging. This is due to the fact that the process of splitting water molecule into hydrogen and oxygen is often energy consuming and energy input often exceeds energy output.
- Apart from manufacturing challenges, hydrogen is associated with limitation in its storage, transport and use in motor vehicles due to its low density. There are risk of leakage and catching fire also.
- Worldwide intensive R&D is being done for improving efficiency of processes of hydrogen manufacture and its applications in automobiles. Remarkable achievements have also been made.