PRATHYUSHA ENGINEERING COLLEGE

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1	Environmental science notes	Chemistry	Mrs. Uma & Piragadheeswaran
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5	Unit I & V notes	Engineering Physics	Dr.R. Surekha
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PRATHYUSHA ENGINEERING COLLEGE
LECTURE NOTES
GE8291/ENVIRONMENTAL SCIENCEAND ENGINEERING
UNIT I- ENVIRONMENT ECOSYSTEM AND BIODIVERSITY

Introduction:

Environmental Science is a multi-disciplinary subject. **Environment** is derived from the French word **Environ** means surroundings.

The sum of all physical, chemical and biological factors around the man is called as environment.

Definitions:

Environmental Science: It is the study of interrelationship between biotic and abiotic components present in the environment.

Environmental Engineering: It is the study of technical processes which are used to minimize the pollution and to improve the quality of environment.

Environmental Education: It is the process of imparting knowledge to the people for maintaining healthy environment.

SCOPE OF ENVIRONMENTAL STUDIES:

- Studying the inter relationship between the components of environment.
- Carrying out impact analysis and environmental Audit.
- Preventing pollution from existing and new industries.
- Stopping the use of biological and nuclear weapons.
- Managing unpredictable disasters etc.

NEED FOR PUBLIC AWARENESS

- Due to many discoveries and inventions from16th century onwards, man overexploited the natural resource which leads to many environmental problems.
- Lack of awareness and less number of people participation leads to poor pollution management.
- To create awareness to the public about environmental problems and to protect the environment through implementing proper regulations.
- To protect the environment from the pollution, Supreme Court has initiated the environmental awareness to the public through government and non-government agencies.
- Environmental pollution cannot be removed by laws alone.
- The proper implementation and especially public participation are important aspects.
- Public participation is possible only when the public is aware about the ecological and environmental issues.

Types of public participation:

Environmental pollution can be reduced by creating the four ty

ECOSYSTEM:

First law of Ecology: "Everything is related to everything else" Basic Unit of Ecology.
It is derived form Greek word. Ecology means "study of home"

Definition: A group of organisms interacting among themselves and with the environment."
Biome: A Biome is a large area with similar flora, fauna and micro organisms and is generally designated by the dominant vegetation. The following are the major biomes of the world.
1. Mountain 2. Grassland 3.Desert 4.Forest 5.Marine
Ecology - Study of the distribution and abundance of organisms, the flows of energy and materials between abiotic and biotic components of ecosystems.

Structure or components of an ecosystem

The structure of an ecosystem explains the relationship between the abiotic (nonliving) and the biotic (living) components.

Biotic Components (Living Component)
The living organisms of ecosystem are known as biotic component. They are plants, animals and micro organisms. The biotic components can be classified into three main groups.
1.Producers 2.Consumers 3.Decomposers.

1.Producers (Or) Autotrophic components: (auto-self, trophs-food)
They produce their own food using photosynthesis. It is the process of converting CO2 and H2O in to carbohydrates by chlorophyll of the plants in the presence of sunlight.
Examples- Green plants, algae, bacteria, etc.

2.Consumers (Or) Heterotrophic components:

Consumers: These organisms which cannot prepare their own food and depends directly or indirectly on producers. The consumers are classified into three types:

1. Primary consumer (or) Herbivores: They depend directly on plants for food. They are called plant eaters. Eg. Insects, goat,cow,deer
2.Secondary consumer (or) Primary Carnivores: They feed on primary consumers and depend on the herbivores for food. Eg. Fox, snakes,cat.
3.Tertiary consumer (or) Secondary Carnivores: They feed on secondary consumers and depend on the primary carnivores for food . Eg. Lion Tiger

Decomposer: They are micro organism like fungi and bacteria, They attack the dead bodies(Producers and consumers) and decompose them into simple compounds. The decomposers are also called as Saprotrophs. Eg. Fungi, Bacteria.

Abiotic Component (Non-living component): The non-living components of an ecosystem is called abiotic components. It includes both physical and chemical components.
Physical component: It include energy, climate and space and are used for the growth and maintenance of the components. Eg. air, water, soil, sunlight

Chemical component: Source of essential nutrients.
Organic nutrient: Carbohydrates, Proteins, Lipids
Inorganic nutrient: Al, Co, Zn, C,H,O,N,P.

Functional Attributes
Every ecosystem performs under natural conditions in a systematic way. It receives energy from the sun and passes it on through various biotic components and in facts, all life depends upon this flow of energy.

The major functional attributes of an ecosystem are as follows:

1. Primary Function : Manufacture of Starch. The rate at which solar energy captured by the producers for the synthesis of organic compound through photosynthesis.

2.Secondary Function : Distribute the energy in the form of food to all consumers.

3.Tertiary Function: Cycling of nutrients due to all living systems die at particular stage.

FOOD CHAIN AND FOOD WEB:

Food chain: The sequence of eating and being eaten in an eco system
Food web: The interlocking pattern of food chain is known as food web.
ENERGY FLOW IN THE ECOSYSTEM

- Energy is the most essential requirement for all living organisms.
- **Solar energy** is the only source to our planet earth.

- Of the solar radiations reached the earth's surface, some of which is absorbed by **producers** (plants) to produce organic matter through **photosynthesis.**
- The plants are used by the **herbivores** and the herbivores are used by the **carnivores** as their food.
- Thus the energy enters the ecosystem through photosynthesis and passes through the different tropic levels (feeding levels).
- The conversion of solar energy is governed by the **law of thermodynamics**

LAW OF THERMODYNAMICS:

FIRST LAW OF THERMODYNAMICS

Energy can neither be created nor destroyed, but it can be converted from one form to another.

Solar energy is converted into **chemical energy** through photosynthesis by plants.

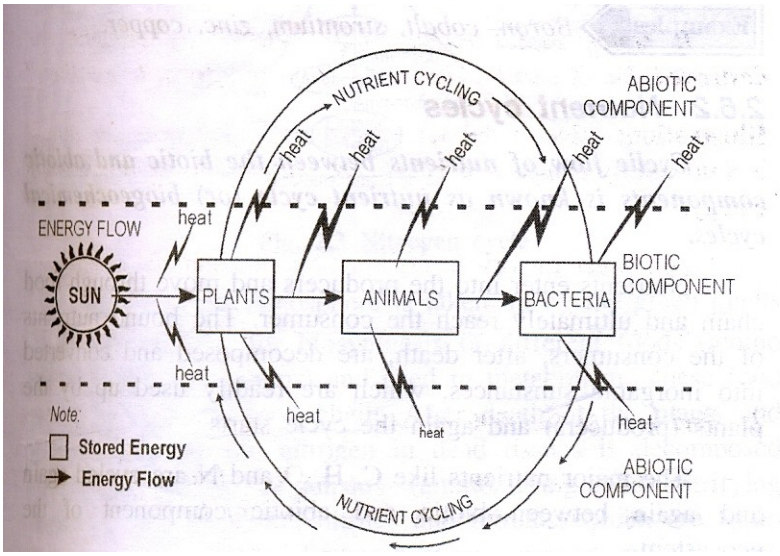
SECOND LAW OF THERMODYNAMICS

Whenever energy is transformed, there is a loss of energy through the release of heat.

This occurs when energy is transferred between tropic levels.

The loss of energy takes place through respiration, running, hunting, etc

RELATION BETWEEN STRUCTURE AND FUNCTION OF AN ECOSYSTEM:



ECOLOGICAL SUCCESSION

The progressive replacement of one community by another till the development of stable community in a particular area.

Types of succession:

There are two different types of succession. They are Primary Succession and Secondary Succession.

Primary Succession: It involves in the gradual establishment of biotic community on nearly lifeless ground. It begins in a lifeless area where there is no soil in a terrestrial ecosystem or no bottom sediment in an aquatic ecosystem**.**

Secondary Succession: It involves in the establishment of biotic communities in an area where some type of biotic community is already present**.**

(i) Hydrarch or Hydrosere: Starting in watery area like pond, swamp, bog

(ii) Mesarch: Starting in an area of adequate moisture.

(iii) Xerarch or Xerosere: Starting in a dry area with little moisture.

Process of Succession

The process of succession takes place in a systematic order of sequential steps as follows:

1. Nudation: It is the development of a bare area, without any life form. The bare area may be caused due to several anthropogenic activities.
2. Invasion: It is the successful establishment of one or more species on a bare area through dispersal or migration, followed by establishment.
3. Competition : As the number of individuals grows there is competition, for space, water and nutrition
4. Reaction : The living organisms have a strong influence on the environment which is modified to a large extent and this is known as reaction.
5. Stabilization : The succession ultimately culminates in a more or less stable community called climax which is in equilibrium with the environment.

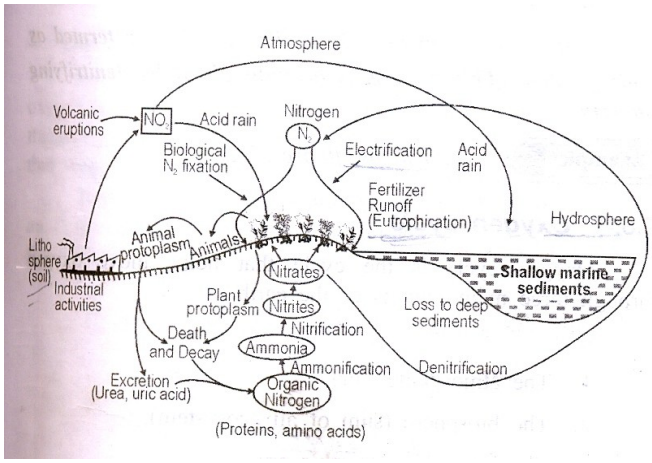
MATERIAL CYCLING (Or) NUTRIENT CYCLING (Or) BIOGEOCHEMICAL CYCLING:

An element required for thee survival of both plants and animals are called nutrients. The producers of an ecosystem take up the macronutrient and micronutrients from their environment and transfer them into biomass.

These are utilized by the consumer and react the environment through decomposers. The cyclic flow of nutrients between the biotic and abiotic components is known as

nutrient cycle or biogeochemical cycle.

NITROGEN CYCLE:

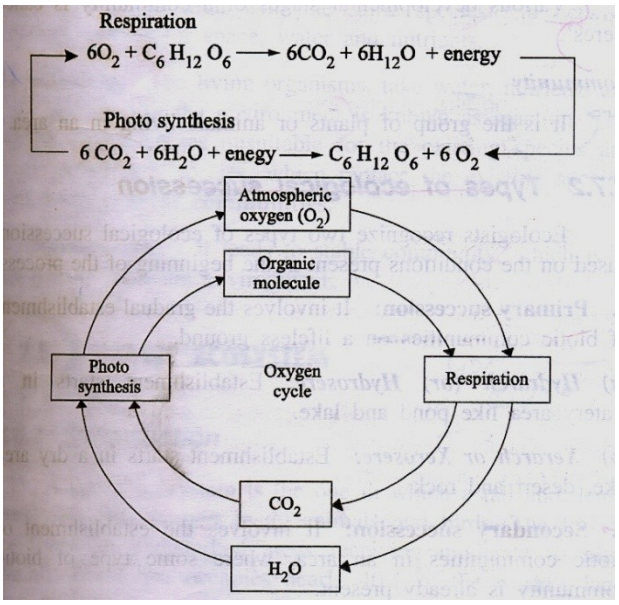


- Nitrogen is one of the primary nutrients critical for the survival of all living organisms.
- Nitrogen is present in the atmosphere in large amount (78%) and in the forms of food.
- Nitrogen from the atmosphere is taken up by the green plants as a raw material for biosynthesis of different foods and used in metabolic activity.
- This food move through the food chain.
- After death of the plants and animals the organic nitrogen in dead tissues is decomposed by several microorganisms into ammonia, nitrites and nitrates which are again used by the plants.
- Some bacteria convert nitrates into molecular nitrogen which is again released back into atmosphere and the cycle goes on.
  Nitrification: Conversion of ammonia into nitrates by Nitrobacter, Nitrosomonas bacteria.
  Denitrification: Conversion of nitrates into nitrogen by Pseudomonas bacteria.

OXYGEN CYCLE:

- The **oxygen cycle** is the biogeochemical cycle that describes the movement of oxygen within its three main reservoirs:
- **The atmosphere** (air): Largest reservoir of free oxygen on earth. Oxygen is released by plants during the process of photosynthesis.
- **Biosphere**: The main cycle of respiration and photosynthesis is carried out. During respiration oxygen is used and during photosynthesis oxygen is given out.
- **The lithosphere** (Earth's crust). Reservoir of oxygen in the form of silicates and oxides on the earth. During extraction of elements, chemical reaction occurs and produces oxygen.

- The main driving factor of the oxygen cycle is photosynthesis which is responsible for the modern Earth's atmosphere and life on earth. The main source of atmospheric free oxygen is photosynthesis, which produces sugars and free oxygen from carbon dioxide and water:



FOREST ECOSYSTEM (TERRESTRIAL ECOSYSTEM)

Introduction

A forest is an area with a high density of trees.

Of which total forests account for about 31% of the world's land area.

In India, the forest cover is roughly 19% of the total land area.

The forest ecosystems are of great concern from the environmental point of view

Depending upon the climate conditions, forest may be classified as:

Tropical Rain Forests: They are evergreen broad leaf forests found near the equator. They are characterized by high temperature, high humidity and high rainfall, all of which favour the growth of trees.

Tropical deciduous forests: They are found a little away from the equator and are characterized by a warm climate the year round. Rain occurs only during monsoon.

Tropical scrub forests: They are found in areas where the day season is even longer.

Temperate rain forests: They are found in temperate areas with adequate rainfall. These are dominated by trees like pines, redwoods etc.

Temperate deciduous forests: They are found in areas with moderate temperatures.

CHARACTERISTICS OF FOREST

- Tall trees will support many wild animal within ecosystem.
- Penetration of light is poor.
- The soil is rich in organic matter and nutrients which support the growth of trees.
- They occupies more space in earth than any other ecosystem.
- It moderate climate and rainfall.

- It provides the wood materials to human beings.
- It provides biodiversity.

Structure and Function of Forest Ecosystem

Abiotic Component	Biotic Component		
	Producers	**Consumers**	**Decomposers**
Physical factor: Temperature, light, Rainfall **Chemical factor:** Organic and Inorganic Substances present in the soil**.**	Trees, Shrubs and Vegetation in ground	**Primary consumers:** Ants, Flies, Leaf hoppers, snails **Secondary consumers:** Snakes, Birds, Fox **Tertiary Consumers** Lion, Tiger, Eagles	Micro organisms like fungi and bacteria**.**
Food chain of forest Ecosystem	**Plants → Rabbit → Snakes → Eagles** **Plants → Deer → Tiger**		

GRASSLAND ECOSYSTEM (TERRESTRIAL ECOSYSTEM)

Introduction

Grasslands are areas where the vegetation is dominated by grasses and other (non-woody) plants. Grasslands occupy about 24% of the earth's surface.

The annual rainfall ranges between 25- 75 cm, usually seasonal.

Three types of grasslands are found to occur in different climatic regions:

Tropical grasslands: They occur near the borders of tropical rain forests in regions of high average temperature and low to moderate rainfall.

Temperate grasslands: They are usually found on flat, gentle sloped hills, winters are very cold but summers are hot and dry.

Polar grass lands: they are found in arctic polar region where severe cold and strong, frigid winds along with ice and snow create too harsh a climate for trees to grow.

CHARACTERISTICS OF GRASS LAND ECOSYSTEM

- The soil is rich in nutrients and organic matter.
- Moderate tall grass support for grazing animals.
- Grasses traps solar energy and the biomass is consumed by herbivores.
- Grasses prevent soil erosion.

Structure and functions of Grassland Ecosystems:

Abiotic	Biotic Component

Component	Producers	Consumers	Decomposers
Physical factor: Temperature, light, Rainfall **Chemical factor:** Nutrients in the soil which includes C,H,N,P,S,H2O,CO2,/nitrate	Grasses, Shrubs and few trees.	**Primary consumers:** Cow, Rabbit ,Sheep and Deer. **Secondary consumers:** Snakes, Birds, Fox,Frog **Tertiary Consumers** Eagles and Hawks.	Micro organisms like fungi and bacteria**.**
Food chain of Grass land Ecosystem	**Grass → Grasshopper → Lizard → Eagle** **Grass → Rabbit → Hawk**		

DESERT ECOSYSTEM

Introduction

A desert is a landscape or region that receives almost no rain

Deserts are defined as areas with an average annual precipitation of less than 25cm per year.

It occupies about 17% of the earth's surface.

Deserts are characterized by hot days & cold nights.

Soils of deserts often have abundant nutrients but little or no organic matter.

Deserts are of three major types, based on climatic conditions:

Tropical deserts - Sahara in Africa and Thar Desert, Rajasthan

Temperature deserts - Mojave in Southern California

Cold deserts - Gobi desert in China

CHARACTERISTICS OF DESERT ECOSYSTEM

- The desert air is dry and the climate is hot
- Very large variations in daily temperature.
- The Soil is very poor in organic matter
- Very less vegetation.
- It is a place for evolution of adoptive animal like camel.

Structure and Functions of Desert Ecosystems

Abiotic Component	Biotic Component		
	Producers	**Consumers**	**Decomposers**
Dry soil with low rain fall and high temperature.	Some Grasses, Shrubs, bushes	**Primary consumers:** Insects and reptile **Secondary consumers:**	Micro organisms like

	and few trees.	Lizards and Darkling beetle. **Tertiary Consumers** Eagles and Hawks.	fungi and bacteria**.**
Food chain of desert Ecosystem	**Shrub or grass ⟶ Insects ⟶ Lizards⟶Eagles**		

AQUATIC ECOSYSTEM :

Aquatic ecosystems dealing with water bodies and the biotic communities present in them are either freshwater or marine. Let us consider some important aquatic ecosystems.

Pond ecosystems:

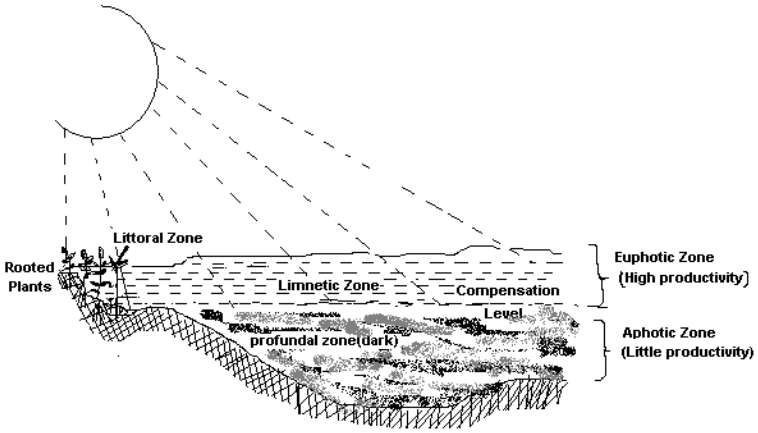
- It is a small freshwater aquatic ecosystem where water is stagnant.
- Ponds may be seasonal in nature i.e. receiving enough water during rainy season.
- Ponds are usually shallow water bodies
- They contain several types of algae, aquatic plants, insects, fishes, and birds.
- The ponds are exposed to tremendous anthropogenic pressures.
- They are used for washing clothes, bathing, swimming, cattle bathing and drinking etc. and therefore get polluted.
- **Structure and Functions of Desert Ecosystems**

Abiotic Component	**Biotic Component**		
	Producers	**Consumers**	**Decomposers**
Temperature, light,water,Organic and Inorganic compounds**.**	Rooted plants, Floating plants, Phytoplanktons, Microphyes.	**Primary consumers:** Zooplanktons **Secondary consumers:** Insects like water beetles and small fish. **Tertiary Consumers** Large fish	Micro organisms like fungi and bacteria**.**
Food chain of lake Ecosystem	Phytoplanktons ⟶ Zooplanktons ⟶ Small fish ⟶ Large fish		

Lake ecosystems:

- Lakes are usually big freshwater bodies with standing water.
- It is a permanent water body.
- They have shallow water zone called Littoral zone, an open-water zone called Limnetic zone and deep bottom area where light penetration is negligible, known as profundal zone
- It is a reservoir for large fresh water.

- It is also used for transport.
- It stores water during rainy season and later used for irrigation and community development.



Types of lakes:

(a) Oligotrophic lakes which have low nutrient concentrations.
(b) Eutrophic lakes which are over nourished by nutrients like nitrogen and phosphorus. They are covered with "algal blooms"
(c) Dystrophic lakes that have low pH, high acid content and brown waters
(d) Endemic lakes that are very ancient, deep and have endemic fauna which are restricted only to that lake
(e) Artificial lakes that are created due to construction of dams

STREAM OR RIVER ECOSYSTEM

- These are freshwater aquatic ecosystems where oxygen and nutrient in the water is more uniform
- It is used for irrigation.
- Due to mixing of water, dissolved oxygen is more.
- River deposits large amount of nutrients
- The river waters are very rich in bio diversity

Structure and Functions of Desert Ecosystems

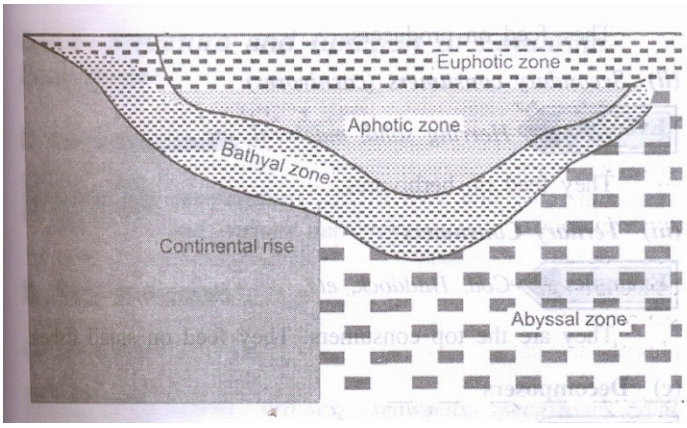
Abiotic Component	Biotic Component		
	Producers	Consumers	Decomposers

Temperature, light,water,Organic and Inorganic compounds**.**	Rooted plants, Floating plants, Phytoplanktons, Microphyes.	**Primary consumers:** Zooplanktons **Secondary consumers:** Insects like water beetles and small fish. **Tertiary Consumers** Large fish	Micro organisms like fungi and bacteria**.**
Food chain of River Ecosystem	Phytoplanktons ⟶ Zooplanktons ⟶ Small fish ⟶ Large fish		

OCEAN ECOSYSTEM:

- It is a saline water ecosystem
- It occupies a large surface area.
- Low dissolved oxygen content.
- It is rich in biodiversity.
- It provides huge quantity of marine products.
- It is a reservoir for NaCl and many other minerals.

ZONES OF OCEANS:



Coastal zone: It is relatively warm, nutrient rich shallow water. Due to high nutrients and sunlight this is the zone of high primary productivity.

Open sea: It is the deeper part of the ocean. It is vertically divided into three regions:

Euphotic zone which receives abundant light and shows high photosynthetic activity.
Bathyal zone receives dim light and is usually geologically active.
Abyssal zone is the dark zone, 2000 to 5000 meters deep. The abyssal zone has no primary source of energy i.e. solar energy. It is the world's largest ecological unit but it is an incomplete ecosystem.

Structure and Function of ocean ecosystem.

Abiotic Component	Biotic Component		
	Producers	**Consumers**	**Decomposers**
Temperature, light,water,Organic and Inorganic compounds**.**	Rooted plants, Floating plants, Phytoplanktons, Microphyes.	**Primary consumers:** Zooplanktons **Secondary consumers:** Insects like water beetles and small fish. **Tertiary Consumers** Large fish	Micro organisms like fungi and bacteria**.**
Food chain of River Ecosystem	Phytoplanktons ⟶ Zooplanktons ⟶ Small fish ⟶ Large fish		

ESTUARINE ECOSYSTEM:

- Estuary is a partially enclosed coastal area at the mouth of a river where fresh water and salty seawater meet.
- Estuary has a rich biodiversity and many of the species are endemic.
- There are many migratory species of fishes like eels and salmons in which half of the life is spent in fresh water and half in salty water.
- Estuaries are highly productive ecosystems.
- Estuaries are of much use to human beings due to their high food potential.

Structure and Functions of an Estuarine ecosystem.

Abiotic Component	Biotic Component		
	Producers	**Consumers**	**Decomposers**
Temperature, light,water,Organic and Inorganic compounds**.**	Rooted plants, Floating plants, Phytoplanktons, Microphyes.	**Primary consumers:** Zooplanktons **Secondary consumers:** Insects like water beetles and small fish. **Tertiary Consumers** Large fish	Micro organisms like fungi and bacteria**.**
Food chain of River Ecosystem	Phytoplanktons ⟶ Zooplanktons ⟶ Small fish ⟶ Large fish		

BIODIVERSITY

DEFINITION:

Biodiversity refers to the variety and variability among all groups of living organisms and the ecosystem in which they occur.

SIGNIFICANCE OF BIODIVERSITY:

- Biodiversity is very important for human life.
- Biodiversity protects the fresh air, clean water and productive land.
- Biodiversity is also important for forestry, fisheries and agriculture.
- We depend biodiversity for food, medicines and industrial products.
- Loss of biodiversity cause serious economic loss of our country

Types of Biodiversity:

1. Genetic biodiversity
2. Species biodiversity
3. Ecosystem biodiversity.

Genetic diversity

Genetic Diversity is the basic source of biodiversity. Genetic diversity means "variation of genes within the species"
Genes are the basic units of all life on earth.
They are responsible for both the similarities and the differences between organisms.
Each species made up of their own particular genetic composition.
Example, all rice varieties belong to the species oryza sativa, but there are thousands of wild and cultivated verities of rice which show variations at the genetic level and differ in their color, size, shape, aroma and nutrient content of the grain. This is the genetic diversity of rice

Species diversity

Species Diversity is the "Variation exists between different species". The sum of varieties of all the living organism at the species level is known as species diversity.
Species: A discrete group of organisms of the same kind is known as species.
Example
Plant species: Apple, Mango, Grapes, Wheat, Rice
Animal species: Lion, Tiger, Elephant, Deer.

Ecosystem (or) Community diversity

Ecosystem diversity is the variation exists at the habitat level.
Ecosystem diversity explains the interaction between living organisms and physical component in an ecosystem.
Example : River Ecosystem.
The river contains fish, aquatic insects and variety of plants.

BIOGEO GRAPHICAL CLASSIFICATION OF INDIA:

India is a mega diversity country. India has different types of climate and topography in different parts of the country.

It is important to study the distribution, environmental relationship of plants and animals in time and space.

India occupies 10^{th} position in the plant rich country in the world.

Biogeographers classified the India into10 biogeographic zones.

1. Trans Himalayan region
2. Himalayan ranges.
3. Terai
4, Gangetic and Brahmaputra plains.
5.Thar Desert
6.Semi-arid Grassland region
7.North East states of India
8.Western Ghats
9.Andaman-Nicobar Island
10.Western & Eastern Ghats of coastal region.

VALUES OF BIODIVERSITY:

- Biodiversity is a life supporting medium to human beings
- Biodiversity is important for healthy biosphere.
- More benefits can be derived from biodiversity.
- A rich biodiversity is the wealth of any nation.

- The multiple uses of biodiversity value have been classified by McNeely et al in 1990 as follows:

CLASSIFICATION AND IMPORTANCE OF BIODIVERSITY:

1. Consumptive use value:

These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fibre etc.

Food:

- A large number of wild plants are consumed by human beings as food. About 80,000 edible plant species have been reported from wild.
- About 90% of present day food crops have been domesticated from wild tropical plants.
- A large number of wild animals are also our sources of food.

Drugs and medicines:

- About 75% of the world's population depends upon plants or plant extracts for medicines.
- The wonder drug penicillin used as an antibiotic is derived from a fungus called penicillium.
- Likewise, we get Tetracyclin from a bacterium. Quinine, the cure for malaria is obtained from the bark of Cinchona tree.
- Recently vinblastin and vincristine, two anticancer drugs, have been obtained from periwinkle plant, which possesses anticancer alkaloids.

Fuel:

- The fossil fuels like coal, petroleum and natural gas are used as fuel. Fire wood is directly consumed by tribal and local villagers.

2. Productive use values:

- These are the commercially usable values where the product is marketed and sold.
- These may include the animal products like tusks of elephants, musk from musk deer, silk from silk-worm, wool from sheep, etc, all of which are traded in the market.
- Many industries are dependent upon the productive use values of biodiversity e.g. –the paper and pulp industry, plywood industry, railway industry, silk industry, ivory-works, leather industry, pearl industry etc.

3. Social value:

- These are the values associated with the social life, customs, and religion of the people.
- Many of the plants are considered holy and sacred in our country like Tulsi, peepal, Mango, and Lotus etc.(Holy plants)
- The leaves, fruits or flowers of these plants are used in worship or the plant itself is worshipped.

- Many animals like Cow, Snake, and Peacock also have significant place in our country. (Holy animals)

4.Ethical value:

- It is also sometimes known as existence value. It involves ethical issues like "all life must be preserved".
- The ethical value means that we may or may not use a species, but knowing the very fact that this species exists in nature gives us pleasure.
- We are not deriving anything direct from Kangaroo, Zebra or Giraffe, but we all strongly feel that these species should exist in nature.

5. Aesthetic value:

- No one of us would like to visit vast barren lands with no signs of visible life.
- People from far and wide spend a lot of time and money to visit wilderness areas where they can enjoy the aesthetic value of biodiversity and this type of tourism is now known as eco-tourism.
- Ecotourism is estimated to generate about 12 billion dollars of revenue annually.

6. Option values:

- These values include the potentials of biodiversity that are presently unknown and need to be explored.
- There is a possibility that we may have some potential cure for AIDS or cancer existing within the depths of a marine ecosystem or a tropical rain forest.

BIODIVERSITY AT GLOBAL, NATIONAL AND LOCAL LEVELS:

Global Biodiversity

- Globally around 7.5 million species have been
- Following the 1992 “Earth summit” at Rio de Janeiro, it become evident that there is a growing need to know scientifically name of the huge number of species which are still unknown on this earth.
- Roughly total number of living species in the world is about 20 million. Only 1.5 million species are given by scientific names.
- Tropical deforestation alone is reducing the biodiversity by half a percentage every year.
- Terrestrial biodiversity of the earth is best described as biomes, which are the largest ecological units present in different geographic areas and are named after the dominant vegetation e.g. the tropical rainforests, tall grass prairies, savannas, desert, tundra etc.
- Out of the 3000 plants identified by National Cancer Research Institute as sources of cancer fighting chemicals, 70% come from tropical rain forests.
- There is an estimated 1,25,000 flowering plant species in tropical forests.

- However, till now we know only 1-3% of these species.
- Temperature forests have much less biodiversity, but there is much better documentation of the species. Globally, we have roughly 1,70,000 flowering plants, 30,000 vertebrates and about 2,50,000 other groups of species that have been described.

Biological diversity at National Level

- Every country is characterized by its own biodiversity depending mainly on its climate.
- India has a rich biological diversity of flora and fauna. Overall six percent of the global species are found in India.
- It is estimated that India ranks 10^{th} among the plant rich countries of the world, 11^{th} in terms of number of endemic species of higher vertebrates and 6^{th} among the centers of diversity and origin of agricultural crops.
- The total number of living species identified in our country is 1,50,000.
- Out of a total 25 biodiversity hot-spots in the world, India possesses two namely Eastern Himalayas and Western Ghats.
- India is also one of the 12 mega-biodiversity countries in the world.

Regional or local biodiversity

Biodiversity at regional level is better understood by categorizing species richness into four types, based upon their spatial distribution as discussed below:

(i) **Point richness** refers to the number of species that can be found at a single point in a given space.

(ii) **Alpha (α) richness** refers to the number of species found in a small homogenous area.

(iii) **Beta (β) richness** refers to the rate of change in species composition across different habitats.

(iv) **Gamma (γ) richness** refers to the rate of change across large landscape gradients..

India as mega diversity nation

- India is one of the 12 mega diversity countries in the world.
- The twelve mega diversity nations are Australia, Brazil, China, Colombia, Ecuador, United States, India, Indonesia, Madagascar, Mexico, Peru and Democratic Republic of Congo Region.
- The Ministry of Environment and Forests, Govt. of India (2000) records 47,000 species of plants and 81,000 species of animals which is about 7% and 6.5% respectively of global flora and fauna.

- India has 5 heritage sites, 7 biosphere reserves, 6 wet lands, 83 National Parks and 490 Sanctuaries
- Species, which are restricted only to a particular area, are known as endemic. India shows a good number of endemic species.
- A large number of species are known to have originated in India. Nearly 5000 species of flowering plants had their origin in India.
- Along 7500 km long coastline of our country in the mangroves, estuaries, coral reefs, etc. there exists a rich biodiversity. More than 340 species of corals of the world are found here.

Hot spots of biodiversity

- Areas, which exhibit high endemic species are termed as hot spots of biodiversity.
- The term was introduced by Myers (1988).
- There are 25 such hot spots of biodiversity on a global level out of which two are present in India, namely the Eastern Himalayas and Western Ghats.
- These hot spots covering less than 2% of the world's land are found to have about 50% of the terrestrial biodiversity.
- About 40% of terrestrial plants and 25% of vertebrate species are endemic and found in these hotspots.

(a) Eastern Himalayas:

a. These areas comprise Nepal, Bhutan and neighboring states of Northern India.
b. Out of the world's recorded flora 30% are endemic to India of which 35,000 are in the Himalayas.
c. In Nepal, there are 7000 plant species of which 8% are endemic.
d. In Bhutan, there are 5000 plants of which 15% are endemic.
e. In Sikkim, there are 2550 plants of which 60% are endemic.

(b) Western Ghats:

a. It extends along a 17,000 Km^2 strip of forests in Maharashtra, Karnataka, Tamil Nadu and Kerala and has 40% of the total endemic plant species.
b. 62% amphibians and 50% lizards are endemic to Western Ghats.
c. It is reported that only 6.8% of the original forests are existing today while the rest has been deforested or degraded.
d. The Agasthimalai Hills and Silent Valley are two important places of biodiversity in Western Ghats region.

Reason for rich biodiversity in Tropics:

1. Tropical regions have more stable climate.

2.These areas have warm temperature and High humidity.
3.No single species can dominate, hence there is an opportunity for many species to co-exist.

RED DATA BOOK: This book is a catalogue of taxa facing risk of extinction. It contain the list of endangered species of plants and animals. It gives Warning Signal for those species which are endangered and if not protect they become extinct in future.

Threats to Biodiversity :

Any disturbances in a natural ecosystem tend to reduce its biodiversity. The waste generated due to increase in human population and industrialization, spoils the environment and biodiversity.

CAUSES FOR LOSS OF BIODIVERSITY (OR) THREATS TO BIODIVERSITY.

1.Habitat loss 2. Poaching 3. Man-Wild life conflicts.

1. Habitat loss : Loss of population is caused by Habitat loss. It threatened a wide range of animals and plants. Important factors are

i)DEFORESTATION: Destruction and loss of natural habitat is the single largest cause of biodiversity loss. Billions of hectares of forests and grasslands have been cleared over the past 10,000 years for conversion into agriculture lands, pastures, settlement areas or development projects.

ii)DESTRUCTION OF WET LANDS: Wetlands are destroyed due to draining, filling and pollution which cause loss of biodiversity.

iii)HABITAT FRAGMENTATION: The living areas are divided into small and scattered patches. This phenomenon is known as habitat fragmentation. Due to this many wild animals and song birds are vanished.

iv)RAW MATERIAL: Many wild plants are used for the production of hybrid seeds and medicines. As a result many plant species are extinct.

v)ILLEGAL TRADE: The illegal trade activities reduce the biodiversity life and leads to habitat loss.

2.POACHING: The Process of killing animals or commercial hunting is known as poaching which leads to loss of animal biodiversity .

TYPES: 1. Subsistence poaching 2. Commercial poaching..

Types : Commercial poaching – Killing for trade . Subsistence poaching - Killing for food

Factors influencing poaching –

Human population – Due to development on human population leads to pressure on forest resources

Commercial activities: Smuggling and Trading of wild life products such as furs, horns, live specimen and herbal products..

Remedial measures:

1. Illegal hunting and trading of animals and animal products should be stopped immediately.
2. We should not purchase fur coat, purse or bag made up of animal skin
3. Biodiversity laws should be strengthened.

MAN-WILD LIFE CONFLICTS:

- Instances of man animal conflicts keep on coming from several states in our country.
- In Sambalpur, Orissa 195 humans were killed in the last 5 years by elephants.
- In retaliation the villagers killed 98 elephants and badly injured 30 elephants.
- Several instances of killing of elephants in the border regions of Kote-Chamarajanagar belt in Mysore have been reported recently.
- The man-elephant conflict in this region has arisen because of the massive damage done by the elephants to the farmer's cotton and sugarcane crops.
- The agonized villagers electrocute the elephants and sometimes hide explosives in the sugarcane fields, which explode as the elephants intrude into their fields.
- In the early 2004, a man-eating tiger was reported to kill 16 Nepalese people and one 4-year old child inside the Royal Chitwan National Park of Kathmandu.
- In June, 2004 two men were killed by the leopards in Powai, Mumbai.

Cause of Man-animal conflicts:

(i) Dwindling habitats of tigers, elephants and bears due to shrinking forest cover compels them to move outside the forest and attack the field or sometimes even humans.

(ii) Usually the ill, weak and injured animals have tendency to attack man. Also, the female tigress attacks the human if she feels that her newborn cubs are in danger. But the biggest problem is that if human-flesh is tasted once then the tiger does not eat any other animal.

(iii) Earlier, forest departments used to cultivate paddy, sugarcane etc. within the sanctuaries when the favourite staple food of elephants i.e. bamboo leaves were not available. Now due to lack of such practices the animals move out of the forest in search of food.

(iv) Very often the villagers put electric wiring around their ripe crop fields. The elephants get injured, suffer in pain and turn violent.

(v) The cash compensation paid by the government in lieu of the damage caused to the farmers crop is not enough. The agonized farmer therefore gets revengeful and kills the wild animals.

Remedial Measures to Curb the Conflict:

(i) Tiger Conservation Project (TCP) has made provisions for making available vehicles, tranquillizer guns, and binoculars to tactfully deal with any imminent danger.
(ii) Adequate crop compensation and cattle compensation scheme must be started.
(iii) Solar powered fencing should be provided along with electric current proof trenches to prevent the animals from straying fields.
(iv) Cropping pattern should be changed near forest borders and adequate fruits and water should be made available for the elephants within forest zones.
(v) Wild life corridors should be provided for mass migration of big animals during unfavorable periods.

Endangered species of India

- The International Union for Conservation of Nature and Natural Resources (IUCN) publishes the Red Data Book which includes the list of endangered species of plants and animals.
- The red data symbolizes the warning signal for those species which are endangered and if not protected are likely to become extinct in near future.
- In India, nearly 450 plant species have been identified in the categories of endangered, threatened or rare.
- Existence of about 150 mammals and 150 species of birds is estimated to be threatened while an unknown number of species of insects are endangered.
- A few species of endangered reptiles, birds, mammals and plants are given below:
    - **Reptiles:** Green sea turtle, tortoise, python
    - **Birds:** Great Indian bustard, Peacock, Pelican, Great Indian Hornbill, Siberian
    - **Carnivorous Mammals:** Indian wolf, red fox, red panda, tiger, leopard, Indian, lion, golden cat, desert cat
    - **Plants:** A large number of species of orchids, Rododendrons, medicinal plants like Rauvolfia serpentina, the sandal, wood tree santalum, cycas beddonei etc
- The Zoological Survey of India reported that Cheetah, Pink headed duck and mountain quail have already become extinct from India.

- A species is said to e extinct when it is not seen in the wild for 50 years at a stretch eg. Dodo, Passenger pigeon.
- A species is said to be endangered when its number has been reduced to a critical level. If such a species is not protected and conserved, it is in immediate danger of extinction.
- A species is said to be in vulnerable category if its population is facing continuous decline due to overexploitation or habitat destruction.

- Species which are not endangered or vulnerable at present, but are at a risk are categorized as rare species.

Endemic species:

- The species are only found among a particular people or in a particular region are knows as endemic species.
- Out of about 47, 00 species of plants in our country 7000 are endemic.
- Some of the important endemic flora includes orchids and species like sapria himalayana, Uvaria lureda, Nepenthes khasiana etc.
- A large number out of total of 81,000 species of animals in our country is endemic.
- The western ghats are particularly rich in amphibians and reptiles.
- About 62%amphiians and 50% lizards are endemic to Western Ghats.
- Different species of monitor lizard, reticulated python are some important endemic species of our country.

VARIOUS TYPES OF SPECIES:

1.ENDEMIC SPECIES - species which are found only in a particular region.

2**.ENDANGERED SPECIES**: A species is said to be endangered when its number has been reduced to a critical level.

3.EXTINCT SPECIES : A species which is no longer found in the world.

4. VULNERABLE SPECIES : When the species population is facing continuous decline.

CONSERVATION OF BIODIVERSITY

The enormous value of biodiversity due to their genetic, commercial, medical, esthetic, ecological and optional importance emphasizes the need to conserve biodiversity.

CONSERVATION: The management of biosphere so that it will yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs of future generation.

Factors affecting biodiversity:

1. Developmental activities
2.Poaching
3.Pecticides and insecticides.
4.Pollution
5.Climatic factors.

TYPES:

There are two approaches of biodiversity conservation:

(a) In situ conservation (within habitat): This is achieved by protection of wild flora and fauna in nature itself. E.g. Biosphere Reserves, National Parks, Sanctuaries, Reserve Forests etc.

(b) Ex situ conservation (outside habitats): This is done by establishment of gene banks, seed banks, zoos, botanical gardens, culture collections etc.

<u>In Situ conservation:</u>

At present in our country we have:

- ★ 7 major Biosphere reserves,
- ★ 80 National Parks,
- ★ 420 wild-life sanctuaries and
- ★ 120 Botanical gardens
- ★ They totally cover 4% of the geographic area

The Biosphere Reserves :

The biosphere reserves large areas more than 5000 sq.km.
It is used to protect the species for long time.
It protects endangered species and maximum number of species and communities.
It helps for tourism, education and Research
Explosive activities are not permitted.
we have:

- ✓ Nanda Devi (U.P.),
- ✓ Manas (Assam),
- ✓ Sunderbans (West Bengal),
- ✓ Gulf of Mannar (Tamil Nadu),
- ✓ Nilgiri (Karnataka, Kerala, Tamil Nadu),

A National Park:

It is an area dedicated for the conservation of wildlife along with its environment
It covers an areas about 100-500 sq.kms
It is also meant for enjoyment through tourism but without affecting the environment.
Grazing of domestic animals, all private rights and forestry activities are prohibited within a National Park.
Each National Park usually aims at conservation specifically of some particular species of wildlife along with others.

Some major National Parks of our country are

Name of the National Park	**State**	**Important Wild life**
Kaziranga	Assam	One horned Rhino
Gir National Park	Gujarat	Indian Lion
Bandipur	Karnataka	Elephant
Periyar	Kerala	Elephant, Tiger
Sariska	Rajasthan	Tiger

Wildlife sanctuaries: These are also protected areas where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of highest authority.

Some major wildlife sanctuaries of our country are :

Name of the Sanctuary	**State**	**Major wild life**
Ghana Bird Sanctuary	Rajasthan	300 species of birds
Sultanpur Bird Sanctuary	Haryana	Migratory birds
Mudamalai Wildlife Sanctuary	Tamil Nadu	Tiger, elephant, Leopard
Vedanthangal Bird Sanctuary	Tamil Nadu	Birds

Gene Sanctuary: A gene sanctuary is an area where the plants are conserved.

For plants, there is one gene sanctuary for Citrus (Lemon family) and one for pitcher plant (an insect eating plant) in Northeast India.

OTHER PROJECTS: For the protection and conservation of certain animals, some special projects are framed in our country.

1.Project Tiger, Gir Lion Project, Project Elephant.

MERITS of In-Situ:

1. Very cheap and convenient method.
2.The species gets adjusted with the natural disasters like flood, drought,etc.

DEMERITS of In-Situ:

1.A large surface area of the earth is required.
2. Maintenence is not proper due to shortage of staff and pollution.

Ex Situ Conservation:

This type of conservation is mainly done for conservation of crop varieties and wild species in India; we have the following important gene bank/seed bank facilities:

National Bureau of Plant Genetic Resources (NBPGR) is located in New Delhi. Here agricultural and horticultural crops and their wild relatives are preserved by cryo-preservation of seeds, pollen etc. by using liquid nitrogen at a temperature as low as – 196 ^{o}C. Varieties of rice, turnip, radish, tomato, onion, carrot, chilli, tobacco etc. have been preserved successfully in liquid nitrogen for several years without losing seed viability.

National Bureau of Animal Genetic Resources (NBAGR) located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.

National Facility for Plant Tissue Culture Repository (NFPTCR) for the development of a facility of conservation of varieties of crop plants/trees by tissue culture. This facility has been created within the NBPGR.

MERITS of Ex-Situ:

1.Survivial period of species in increases.
2.Animals get assured food, water, shelter, security.

DEMERITS of Ex-Situ:

1.It is expensive method.
2.Freedom of wildlife is lost.
3.Animals cannot survive in natural environment.

PART – A (QUESTIONS AND ANSWERS)
UNIT 1: ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY

1. Define Environment.
Environment is sum total of water, air, and land, inter-relationships among themselves and also with the human beings, other living organisms and property.
2. Define Hazard and its types .
A hazard is a situation that poses a level of threat to life, health, property, or environment, e.g., exposure to benzene may cause cancer.
Types of Hazards:

1. Physical hazards, e.g., earthquakes, floods
2. Chemical hazards, e.g., mutagens, teratogens, carcinogens
3. Biological hazards, e.g., pathogens – viruses, bacteria, toxins and allergens

3. Define Risk.

Risk is the probability of suffering harm from a hazard that can cause injury, disease, economic loss, or environmental damage. Risk is expressed in terms of probability of the likelihood of harm

4. Define Ecosystem & Ecology & Estuarine.

Ecosystem : Ecosystem has been defined as a system of interaction of organisms with their surroundings.

Ecology : Study of the distribution and abundance of organisms, the flows of energy and materials between abiotic and biotic components of ecosystems.

Estuarine: The delta formed at the junction where river water joints with the sea water.

5.Enumerate some characteristics of an Ecosystem.

Ecosystem is the major ecological unit.

It contains both biotic and abiotic components.

Through the biotic and abiotic components nutrient cycle and energy flow occur.

6. What are the functional components of ecosystem?

Biotic and Abiotic are the components of eco system

Biotic: Producers, consumers, decomposers

Abiotic: Light, Temperature,Humidity

7. Define Food chain and Food web.

Food chain : The sequence of eating and being eaten in an eco system

Food web: The interlocking pattern of food chain is known as food web,

8. Define biogeochemical cycle.

Cyclic flow of nutrients between biotic and abiotic components.

9.What are the various types of functions in the ecosystem.

1.Primary function – Manufacture of starch

2.Secondary function – Distribution of energy in the form of food.

3.Tertiary function: Dead organism decomposed to initiate third function namely cycling.

10. Define Biome.

Biome is defined as a major ecological community of organisms occupying in a larger area.

11. Define Primary and secondary succession.

(i) Primary ecological succession comprises of Hydrarch(Hydrosere – establishment starting in a watery area like pond and lake) and Xerarch (Xerosere – establishment starting in a dry area like, desert and rock)

(ii) Secondary succession involving establishment of biotic communities in an area, where some types of biotic community is already present

12.Why is Biodiversity rich in tropics?

Biodiversity is rich in tropics.- more stable climate, warm temperatures and high humidity, opportunity for many species to coexist, rate of out crossing appear to be higher in tropics.

13. What is the significance of Biodiversity?

Significance of biodiversity. – very important for human life, as we depend on plants, microorganisms, animals for food, medicine and industrial products., protects fresh air, clean water and productive land., important for forestry, fisheries and agriculture.

14.What do you understand by α, β & γ diversity?

Alpha, beta and gamma diversity – alpha – refers to number of species found in a small homogeneous area, beta – refers to rate of change of species composition across different habitats, gamma – refers to rate of change across large landscape.

15. Define biodiversity. Mention its classification

Biodiversity is defined as 'the variety and variability all groups of living organisms and the eco system in which they occur.

TYPES:

1.Species diversity : Diversity between different species

2.Genetic diversity : Variation of genes within the species

3.Ecosystem diversity: Diversity between different ecosystem.

16. What is poaching? Mention its types. What are the factors influencing poaching?

Poaching – killing of animals or commercial hunting – leads to loss of animal biodiversity.

Types : Commercial poaching – Killing for trade . Subsistence poaching - Killing for food

Factors influencing poaching – human population and commercial activities

17. Write a note on man – wild life conflict. . What are the factors influencing man – animal conflicts?

Man–wildlife conflict–arise when wild life starts causing immense damage and danger to man. Factors influencing man–wild life conflict–shrinking of forest cover, human encroachment into forest, injured animals attacking man, of electric wiring around crop fields, etc.

18.What are the threats to the Indian biodiversity?

Threats to Indian biodiversity- deforestation, destruction of wetlands, habitat fragmentation, raw material, production of drugs, illegal trade and developmental activities.

19. Define Ecological succession. What are the different steps in the process of ecological succession?

The replacement of community by other community till the stable community formed in a particular areas.

1. Nudation 2. Invasion 3. Competition 4. Reaction 5. Stabilizations

20.Define First Law and Second Law of Thermodynamics.

I law: Energy can neither be created nor destroyed, but it can be converted from one form to another.

II Law: Whenever energy is transformed there is a loss of energy through the release of heat.

21.Define Hotspot. Mention the two hot spots in India.

The geographical areas which possess high endemic species. The two Hotspots in India are

1. Eastern Himalayas 2. Western Ghats.

22. What is meant by Red Data Book?

Red data book contains the list of endangered species of plants and animals. It gives warning signal for those species which are endangered and if not protected they become extinct in future.

23.Define conservation of biodiversity. Mention the methods and its advantages and disadvantages.

Management of biosphere that it will yield the greatest sustainable benefit to present generation while maintaining its potential meet the benefits of future generation.

Methods : Insitu(within habitat) and Exsitu. (outside habitats)

Insitu 1.Advantages: Cheap, Convenient, Species adjusted with natural disaster.

2.Disadvantages: Required Large area, Poor maintenance.

Exsitu 1. Advantages: Special care and attention, Longer life span.

2.Disadvantages: Expensive, Cannot survive with natural environment

24. Define endemic species endangered species, Extinct species, vulnerable species.

Endemic - species which are found only in a particular region

Endangered species : A species is said to be endangered when its number has been reduced to a critical level. Extinct species: A species which is no longer found in the world.

Vulnerable species: When the species population is facing continuous decline.

25.Mention the characteristics, biotic and abiotic components of forest, grassland, desert and aquatic ecosystem.

Ecosystem	**Characteristics**	**Biotic components**	**Abiotic components**
Forest Ecosystem	1.Maintain climate and rainfall. 2.Support wild animals 3.Protect Biodiversity	Producer: Trees Consumers: Insects, birds, snake, Lion, Tiger Decomposers: Fungi	Light, Temperature, Rainfall
Grass land Ecosystem	1.Soil is rich in nutrients 2.ideal place for grazing	Producer: Grass Consumers: Insects, birds, snake, Eagle Decomposers: Fungi	Light, Temperature, Rainfall
Desert Ecosystem	1.Climate is Hot 2.Annual rainfall is less	Producer: Shrubs Consumers: Mice, fox Decomposers: Fungi	Light, Temperature
Aquatic Ecosystem	Fresh water : Pond, lake, River Marine water : Ocean, Estuarine	Producer: Phytoplanktons Consumers:Zooplanktons, fishes Decomposers: Fungi	Light, Temperature, Rainfall,water

PART B

1. Distinguish between hazard and risk. What are the different types of hazards? Explain the different types of hazards with examples.

2.Define ecosystem. Give an account of the structure and functions of grassland ecosystems.

3.Describe the types, characteristic features, structure and functions of aquatic ecosystems(Fresh and Marine)

4. Describe the types, characteristic features, structure and functions of forest ecosystems.

5.Describe the types, characteristic features, structure and functions of desert ecosystems.

6. With a neat sketch discuss the nitrogen cycle. & Oxygen cycle

7. What do you mean by conservation of biodiversity? Explain its methods.

8.Discuss the values of Biodiversity in India.

9. Explain the major factors that are responsible for the loss of biodiversity or threats to biodiversity.

10. Define Hot Spot. Explain the hot spots of biodiversity that extend in India?

11. What are the major causes of man-wildlife conflicts? Discuss the remedial steps that can curb the conflict.

12.Discuss the biodiversity at Global, National and Local levels.

13.India is a mega diversity- Justify .

14.Discuss Bio geographical classification of India.

15.Discuss about Ecological succession.

PRATHYUSHA ENGINEERING COLLEGE
LECTURE NOTES
GE8291/ENVIRONMENTAL SCIENCEAND ENGINEERING
UNIT II - ENVIRONMENTAL POLLUTION

Introduction : Environmental pollution may be defined as, **" the unfavorable alteration of our surroundings"**. It changes the quality of air, water & land which interferes with the health of humans and other life on earth.

Pollutants are of 2 types

Biodegradable pollutants – decompose rapidly by natural processes.

Non-degradable pollutants – do not decomposeor decompose slowly in the environment. The slowly decomposed materials are more dangerous because it is more difficult to remove them.

CLASSIFICATION OF POLLUTION: The different kinds of pollution that affects the environment are,

1) Air Pollution 2) Water Pollution 3) Soil Pollution 4) Marine Pollution 5) Noise Pollution 6) Thermal Pollution 7) Nuclear hazard

AIR POLLUTION: Air pollution may be defined as, **" the presence of one or more contaminants like dust, smoke, mist and odour in the atmosphere which are injurious to human beings, plants and animals"**.

Some causes of pollution in general are Rapid industrialization, Fast urbanization, Rapid growth in population, Drastic increase in vehicles on the roads and other activities of human being.

Sources of Air Pollution:

Sources are of 2 types:

Natural sources: Volcanic eruptions,Forest fires,Radioactive materials etc.,

Man –made (anthropogenic) activities: Thermal power plants,Vehicular emissions.Fossil fuel burning, Agricultural activities etc.

Classification of Air Pollutants:

Depending upon the (origin) of pollutants present in the environment, they are classified as **Primary air pollutants -** emitted directly in the atmosphere in harmful form **– CO, NO, SO_2.**

Indoor air pollutants are primary air pollutants. The most important is **radon gas**.

Sources (causes) of indoor air pollutants

Radon gas is emitted from the building materials like bricks, concrete, tiles, etc., which are arrived from soil containing radium.

It is also present in natural gas & ground water and is emitted indoors while using them.

Burning of fuels in the kitchen, cigarette smoke, liberates the pollutions like CO, SO_2, formaldehyde, BAP (benzo-a-pyrene)

Secondary air pollutants:

Some of the primary air pollutants may react with one another or with the basic components of air to form new pollutants. They are called as **secondary air pollutants**.

$NO/NO_2 \xrightarrow{moist} (HNO_3/NO_3)$ etc.

COMMON AIR POLLUTANTS:

Pollutant	Description	Sources	Health Effects	Environmental Effects

Carbon monoxide (CO)	colourless, odourless , poisonous gas	Cigarette smoking, Incomplete burning of fuel, Motor vehicle	Head ache, Anemia, coma, Irreversible brain damage and death.	Increase Global temperature.
Nitrogen Dioxide	reddish brown irritating gas	Fossil fuel burning motor vehicles, Industrial Power Plants	Lung Irritation and Damage	Acid deposition damage trees, soils, aquatic life, corrode metals, stones, buildings, statues and monuments.
Sulphur Dioxide:	Colourless Irritating gas. Formed by combustion of coal and oil.	Power plants, Industries, Burning of coal	Breathing problem	Reduce visibility, acid deposition on trees, soils, aquatic life.
SPM (Suspended Particulate Matter)	Includes varieties of particles and droplets in atmosphere	Burning coal in industries, diesel in vehicles.	Nose & Throat irritation, lung damage, bronchitis, asthma, cancer.	Reduce visibility, acid deposition damage trees, soils and aquatic life.
Ozone	Highly reactive irritating unpleasant odour gas.	Chemical reaction of volatile compounds	If ozone layer depleted, UV rays enter into the atmosphere, ffects human life.	Moderates the climate.
Photochemical Smog	Brownish smoke formed during automobile traffic	Formed due to chemical reaction among nitrogen oxides and hydrocarbon	Breathing problem, cough, eye and nose , throat irritation, heart diseases	Damage plants and trees. Smog reduce visibility.
Hydrocarbon	Colourless	Burning of wet logs, Decay of plants.	Carcinogenic	Damage to plants even at low concentration.

Lead	Solid toxic metal	Paint, Leaded Petrol, smelters	Brain and nervous system damage, mental retardation in children,digestive and other health problems.	Harm wild life.
Chromium	Solid toxic metal	Paint, smelters, chromium manufacturer, chrome plating	Perforation of nasal septum, chrome holes, ulcer, central nervous system disease, cancer	Harm wild life.

CONTROL MEASURES OF AIR POLLUTION

SOURCE CONTROL:

- Use only unleaded petrol.
- Use petroleum products & other fuels that have low sulphur & ash content.
- Reduce the number of private vehicles on the road & encourage people to walk or use cycles.
- Ensure that houses, schools, restaurants & places where children play are not located on busy streets.
- Plant trees along busy streets because they remove particulates & CO, and absorb noise.

Control measures in industrial centers

- The emission rates should be restricted to permissible levels by each & every industry
- Incorporation of air pollution control equipments in the design of the plant layout must be made compulsory
- Continuous monitoring of the atmosphere for the pollutants should be carried out to know the emission levels.

Equipments used to control air pollution

The mechanical devices such as wet scrubbers, cyclone separator, bag house filter and electrostatic precipitators are used to reduce particulate pollutants ,SO_2 emissions in industries.

All these methods retain hazardous materials that must be disposed off safely.

WATER POLLUTION:

Definition: Alteration in physical, chemical and biological characteristics of water which may cause harmful effect on human and aquatic life.

TYPES, SOURCES AND EFFECTS OF WATER POLLUTION:

Name of the pollutant	Example	Sources	Effects
Infectious Agents	Bacteria, Virus, Protozoa	Human and Animal waste.	Variety of diseases
Oxygen Demanding waste.(Dissolved oxygen- Amount of O_2dissolved in given water at a particular pressure and temperature.)	Organic waste, Animal manure,plant debris	Sewage, Animal waste, Food processing facilities	Bacteria decompose these waste can degrade water quality by depleting water of dissolved oxygen. This causes oxygen consuming aquatic life to die.
Inorganic Chemicals	Acids, Lead, Salts	Industrial effluents, House hold cleansers.	Skin cancer, lung damage, Reduce crop yield, affects liver, kidney.
Organic Chemicals	Oil, Plastics, Pesticides	Industries, Household cleansers	Nervous system damage, cancer, harmful to fish
Plant Nutrients	Water soluble substance contain Nitrate, Phosphate	Sewage, agricultural fertilizers.	Due to death of excess of algae reduce DO which affects aquatic life.
Radio active materials	Uranium, Thorium	Nuclear Power plants, Mining	Genetic mutation, birth defect, cancer

Point sources (or) identified sources: Are specific sites near water bodies which directly discharge effluents in to them. Egs: Industries, power plants, underground coal mines etc.,

Non-point sources (or) unidentified sources: The discharge is not at any particular place but these sources are scattered which individually or collectively pollute water. Egs: Surface run-off from agricultural fields, rain water sweeping roads and fields, overflowing small drains.

Control measures of water pollution

- The administration of water pollution control should be in the hands of State or Central Government.
- Scientific techniques need to be adopted for the environmental control of catchment areas of rivers, ponds or streams.
- The industrial plants should be based on recycling operations.
- Plants, trees & forests control pollution and theyacts as natural air conditioners.

- The national goal should be "Conservation of Forests" and campaign should be "Plant more trees".
- It is not advisable to discharge any type of waste into streams, rivers, lakes, ponds & reservoirs.
- Highly qualified & experienced persons should be consulted for effective control of water pollution
- Public awareness regarding adverse effects of water pollution is a must.
- Suitable laws, standards & practices should be framed to regulate the discharge of undesirable flow of water in water bodies.
- Basic & applied research in public health engineering should be encouraged

Waste water (or) Sewage treatment

The main **objectives** are:

- To convert harmful compounds into harmless compounds.
- To eliminate the offensive smell.
- To remove the solid content of the sewage.
- To destroy the disease producing microorganisms.

The sewage (or) waste water **treatment process** involves the following steps,

Preliminary Treatment

I) **Primary Treatment (or) Settling process**

II) Secondary (or) Biological treatment

a) Trickling filter process

b) Activated sludge process

III)Tertiary treatment

Disposal of sludge

I) **Preliminary treatment**

Coarse solids & suspended impurities are removed by passing the waste water through bar and mesh screens.

Primary treatment (or) Settling process

Greater proportion of the suspended inorganic & organic solids are removed from the liquid sewage by settling.

To promote quick settling coagulants like alum, ferrous sulphate are added.

These produce large gelatinous precipitates, which entrap finely divided organic matter & settle rapidly.

$$Al_2(SO_4)_3 + 6H_2O \longrightarrow 2Al(OH)_3 + 3H_2SO_4$$

II) Secondary (or) Biological treatment

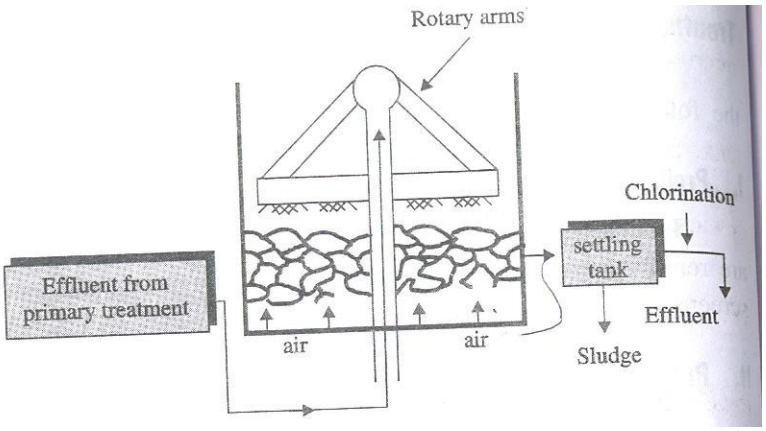
Biodegradable organic impurities are removed by aerobic bacteria. It removes upto 90% of the oxygendemanding wastes.

This is done by trickling filter or activated sludge process.

(i) Trickling filter process

- It is a circular tank filled with either coarse or crushed rock.

- Sewage is sprayed over this bed by means of slowlyrotating arms.
- sewage starts percolating downwards, microorganisms present in the sewage will grow on the surface of the filtering media, using organic material of the sewage as food.
- After completion of aerobic oxidation, the treated sewage is taken to the settling tank & the sludge is removed.This process removes about 80-85% of BOD.

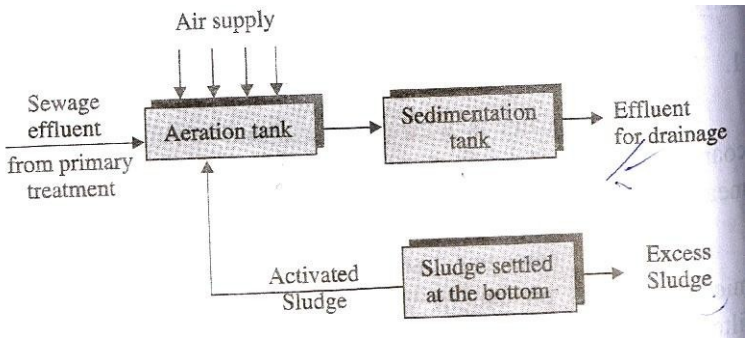


(ii) Activated sludge process

- Activated sludge is biologically active sewage a
- It has a large number of aerobic bacterias, which can easily oxidise the organic impurities.

Process:

- The sewage eff luent from primary treatment is mixed with the required amount of activated sludge and the mixture is aerated in the aeration tank.
- Under this condition, organic impurities of the sewage get oxidised rapidly by the microorganisms.
- After aeration, the sewage is taken to the sedimentation tank. Sludges settle down in this tank, called activated sludge.
- A portion of it was used for seeding fresh batch of the sewage. This process removes about 90-95% of BOD.



IIII) Tertiary treatment:

- The eff luent is introduced into a f locculation tank, where lime is added to remove phosphates.From this tank, the effluent is led to ammonia stripping tower, where pH is maintained to 11 & the NH_4 ions is converted to gaseous NH_3.

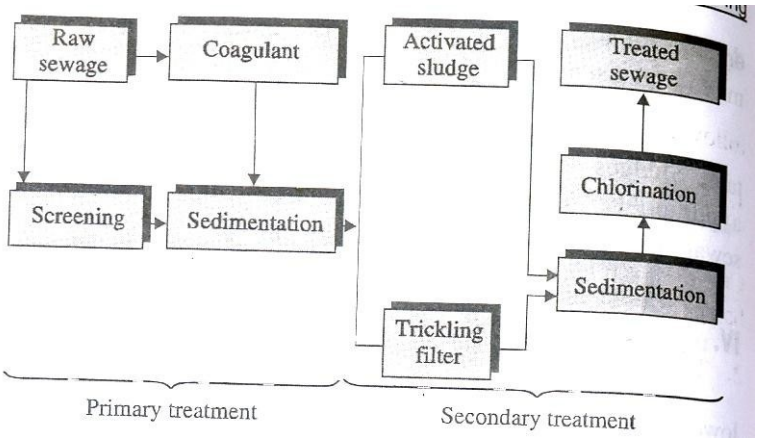
- Then the effluent is allowed to pass through activated charcoal column, where minute organic wastes are adsorbed by charcoal.
- Finally the effluent water is treated with disinfectant (chlorine).

Disposal of sludge

This is the last stage in the sewage treatment. Sludge formed from different steps can be disposed by,

- Dumping into low-lying areas
- Burning of sludge (incineration)
- Dumping into the sea
- Using it as low grade fertilizers.

The flow sheet diagram of sewage treatment.



Testing or River water:

Dissolved Oxygen : Dissolved Oxygen (DO) is the amount of O_2 dissolved in a given quantity of water at a particular temperature & atmospheric pressure. **Significance**: Support for aquatic animals, Minimum level: 4mg/lit.

Biological Oxygen Demand : Biological Oxygen Demand (BOD) is defined as the amount of DO required to aerobically decompose biodegradable organic matter over a period of 5 days at $20^{\circ}C$. . **Significance:** Indicate the amount of organic matter in the river.

Chemical Oxygen Demand : Chemical Oxygen Demand (COD) is defined as the amount of Oxygen required for chemical oxidation of organic matter using some oxidizing agent like $K_2Cr_2O_7$ and $KMnO_4$ **Significance**: Determine the pollution strength.

Adsorption of Heavy metals:

Heavy metals are chemical elements with a specific gravity is atleast 5 times the specific gravity of water.

Sources:

Mining Industry, Chemical and leather industries, Thermal power plants contribute heavy metals in the atmosphere.

Health Effect:

Small amount of heavy metals like antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, lead, copper, gold are necessary for good health. But large amount of any one of them cause acute and chronic toxicity.

Removal of heavy metals by adsorption:

1.Using coconut shell carbons: Coconut based carbon was found to remove 94% of

Cr(IV) solution after a 4 hrs contact time during equillibirium batch tests.

2.Using Rice-Husk Carbon(RHC) : Rice Husk is a better and low cost adsorbent used in water treatment process. It is used in the adsorption of Cr and Zn metal.

3.Using Fly ash: Fly ashes like pulverized-fuel (fly) ash, combustion od powdered coal are used as very good adsorbent in water purification. It is used to remove copper and chromium ions from water.

4.Using Clay and Coal based adsorbents:

(a) Fuller‟s earth and calcinated kaoline have been investigated for the removal of Pb and

Cd from the water.

(b) China clay can be used for the removal of As(III) and Zn(II) from distilled water.

SPECIFICATIONS OF DRINKING WATER:

- Water should be clear and odourless.
- It should be pleasant to taste.
- Turbidity of the water should not exceed 10ppm.
- pH of the water should be in the range of 7.0-8.5
- Chloride, Sulphate contents should be less than 250 ppm
- Total Hardness should be less than 500 ppm.
- Total Dissolved salts (TDS) should be less than 500 ppm.
- Fluoride should be less than 1.5 ppm.
- The water must be free from disease producing bacteria.
- Water should be free from H_2S, lead, chromium. Manganese and arsenic salts.

SOIL POLLUTION: It may be defined as “the contamination of soil by human and natural activities which may cause harmful effects on living beings”.

SOURCES, EFFECTS AND CONTROL MEASURES OF SOIL POLLUTION:

S.No	Sources	Examples	Effects

1	Industrial wastes	pulp and paper mills, chemical industries, oil refineries , sugar factories, steel industries,	alter the chemical and biological properties of soil ,hazardous chemicals can enter into human food leads to serious effects
2	Urban wastes	Plastics, Glasses, metallic cans, fibers, papers , rubber, street sweepings, sewage, garbage	Dangerous to health.

3	Agricultural practices	fertilizers, pesticides, herbicides , weedicides	Remove the soil quality
4	Radioactive pollutants	explosions of nuclear dust and radio active wastes	creating land pollution and dangerous effects to human beings
5	Biological agents	Human, animal and birds excreta	Remove the soil quality

Control measures:

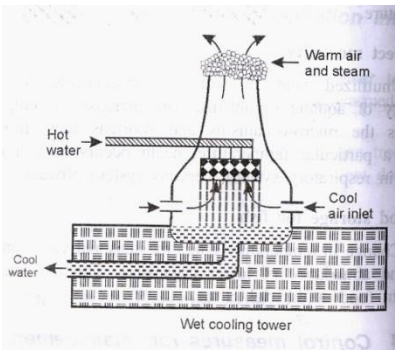
- Effluents must be treated before discharging to the soil
- Solid wastes must be collected properly and disposed off using proper methods
- Production of natural fertilizers
- Proper Hygienic condition
- Public awareness
- Recycling and Reuse of wastes
- Ban on Toxic chemicals
- Nature manures must be used eg: cow dung, compost manure

THERMAL POLLUTION: **Definition:** The addition of excess, unwanted and undesirable heat to water that makes it harmful to man, animal or aquatic life or otherwise causes significant departures from the normal activities of aquatic communities in water..

S.No	Sources	Examples	Effects	Control measures
1	Nuclear power plants	Drainage from hospitals, research institutes, nuclear experiments & explosions	**(i)Reduction in dissolved oxygen** – When temperature increases dissolved oxygen decreases	a) **Cooling towers**: - This is used as a coolant to reduce the temperature of water before discharge into water.
2	Coal fired power plants	Discharge the hot water back to the stream increasing the temperature to about 15^oC	**(ii)Increase in Toxicity** - When temperature increases the toxicity of chemical increases	1) wet cooling tower
3	Industrial effluents	The discharge water from steam electric power rise the temperature from 6^oC to 9^oC	**(iii)Interference with biological activities** – Affect Digestion, Respiration	2) Dry cooling tower
4	Domestic sewage	The Municipal sewage water have high temperature then dissolved oxygen decreases.	**(iv)Interference with reproduction** – Affect Breeding activity of aquatic animals	**b) Cooling ponds**
5	Hydro – electric power	Generation of electric power from water increase the temperature.	Fish migration is affected due to the formation of thermal zones	**c) Spray ponds**
			Direct mortality – Death increase in temp reduces the taste of water	**d) Artificial lakes**
			Increase in temperature reduces the taste of water	

TYPES OF COOLING TOWERS:

(1)



(2)

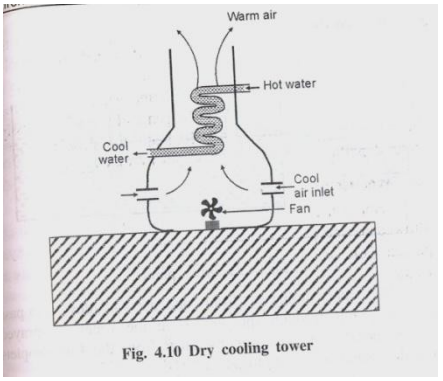


Fig. 4.10 Dry cooling tower

(3)

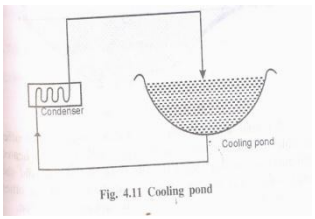


Fig. 4.11 Cooling pond

(4)

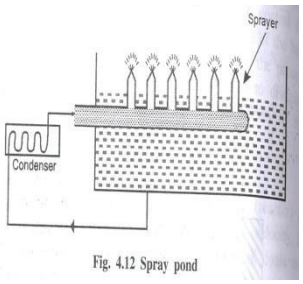


Fig. 4.12 Spray pond

(1) Wet cooling tower:

- The hot water has direct contact with continuously flowing air
- The hot water is flowing downwards and cooled air takes the heat from the hot water
- The cooled water can be recycled or discharged

Disadvantages:

- Large amount of water is lost through evaporation
- Extensive fog is formed not good for environment and causes damage to vegetation

(2) Dry cooling tower:

- The cooling air flows around the pipes and takes the heat from the hot water flowing inside the pipe
- There is no direct contact between cooling air and hot water

Advantages

- There is no water loss in this method

Disadvantages

- The installation and operation cost is many times

(3) Cooling ponds:

- The heat is reduced by natural evaporation process
- The hot water is discharged in the shallow ponds allowing it into few hours
- Then the cooled water is discharged into the water body

(4) Spray ponds:

- The hot water is sprayed from the condenser through the number of nozzles

- The nozzles are used to convert the water in to fine droplets which provide large surface area
- Thus heat is transferred to atmosphere

NOISE POLLUTION: It may be defined as " the unwanted, unpleasant or disagreeable sound that causes discomfort for all living beings.

Units of Noise (Decibel): The sound intensity is measured in decibel. One dB is equal to the faintest sound, a human ear can hear. Normal conversation sound ranges from 34dB to 60dB. Impairment of hearing takes place when exposure to 80dB or more. Noise above 140dB becomes very painful.

S.No	Sources	Examples	Effects	Control measures

1	Industrial noise	Steel industry, metal industry, Factories, etc	1.Affects human health, 2.It causes muscles to contract leading to tension 3. Loss of hearing 4.Brain is adversely affected by loud and sudden noise.. 5.Excessive secretion of adrenalin harmone which is responsible for high blood pressure. 6.prolonged exposure to noise leads to damage of hair cells in the inner ear. 7.Impairment of hearing. 8.Blood is thickened due to excessive noise.	1. **Source control –** acoustic treatment to machine surface , design changes , limiting the operational timings 2. **Transmission path intervention**- Construction of a noise barrier or provision of sound absorbing materials 3. **Oiling** : Proper oiling will reduce the noise. **4.Receptor control:** Protection of the receiver by altering the work schedule and personal protection by using ear plugs for operating noisy machinery.
2	Transport noise	Road, Rail, Air traffic etc		
3	Neighbour hood noise	Loud speaker, TV, VCR,musical instruments, Telephones Radio, etc		

Ambient Noise level dB

Zone	**Day time**	**Night time**
Silent Zone	50	40
Residential Zone	55	45
Commercial Zone	65	55
Industrial Zone	70	70

MARINE POLLUTION: The discharge of waste substances into the sea affect the water quality and harmful to fish, marine birds , aquatic life.

Coral reefs:

- These are underground structures made from calcium carbonate laid by corals
- Corals are colonies of tiny living animals found in marine water containing few nutrients

Benefits of coral reefs:

- Supports more than one million species
- Provides feeding, breeding and nursery areas to fish and shell fish
- Offers medicines
- It acts as buffer as ocean waves and protect coastal lines from storms
- The coral reefs have been valued at 47000 US dollars per square meter of shore line
- The coastal wetlands and sea grass beds provide habitats for over 2000 species of fish and plants

SOURCES , EFFECTS AND CONTROL MEASURES:

S.No	Sources	Examples	Effects	Control measures	Removal of oil

1	Dumping ofwaste	Untreated wastes are dumped in to sea by industries, towns and cities.	1. Thinning of egg shells and damage the eggs of birds. 2.Low body temperature in birds.(hypothermia) 3.Reduce photosynthetic activity due to oil film on the surface of water.	1. Conserve marine biodiversity. 2.Protect coastal areas. 3.Awareness to the people. 4.Oil films can be removed by using suction pump, by using absorbing material like poly urethane. 5.Treated waste must be allow to mix with marine water.	1**.Physical method**s: a.Skimming the oil surface by using suction pump bFloating oil can be adsorbed by using poly urethane foams. , chopped straw and saw dust
2	Oil pollution	Due to cracks in oil tankers, accidents, cleaning of fuel tanks.	4.Affects marine birds, sea fish, etc		2**.Chemical Methods** a. Dispersion method. 2.Emulsification. 3.Using chemical additives.

NUCLEAR HAZARDS (pollution) or (Radioactive pollution)

Introduction: The radiation hazard in the environment comes from ultraviolet, visible, cosmic rays & microwave radiation which produce genetic mutations in man. The biggest hazard comes from X-rays which account for 95% of out radiation exposure other than cosmic rays. Nuclear energy is used to produce clean electric power.

The energy released in the splitting of nuclei in the atoms is used to generate electricity. There were about 600 nuclear power plants in developed countries up to 1985.

US alone have 100 licensed nuclear plants.

About 53 power plants were cancelled between 1980 & 1984due to enormous radiation danger.

The fuel used in nuclear plants, being radioactive, is critically dangerous & the waste materials are hazardous.

The nuclear wastes released by the nuclear reactor also emit radiations, if not properly stored.

Sources of Nuclear Hazards

Various sources of nuclear hazards are grouped into 2 types,

1) Natural sources
2) Man-made sources (or) Anthropogenic activities

Natural sources

a)The very important natural source is space, which emit cosmic rays.

b)Soil, rocks, air, water, food, radioactive radon-222 etc., also contain one or more radioactive substances

Man-made sources

Nuclear power plants, X-rays, Nuclear accidents, Nuclear bombs, Diagnostic kits etc., where radioactive substances are used.

Effects of Nuclear Hazards

- Radiation pollution of the environment is one of the most horrible ecological crisis to which we are subjected severely.
- Radioactive radiation affects the cells in the body and the functions of glands and organs.
- People suffer from blood cancer & bone cancer if exposed to doses around 100 to 1000 roentgens.
- Unlike the other pollution, radioactive pollution can cause genetic disorders even in the subsequent generation.
- Exposure of the brain and central nervous system to high doses of radiation causes delirium, convulsions and death within hours or days.
- The use of eye is vulnerable to radiation. As its cell die, they become opaque forming cataracts that impair sight.
- Acute radiation sickness is marked by vomiting, bleeding of the gums & in severe cases, mouth ulcers.
- Internal bleeding & blood vessel damage may show up as red spots on the skin.
- Nausea & vomiting often begin a few hours after the gastrointestinal tract is exposed. Infection of the intestinal wall can kill weeks afterwards.
- Unborn children are vulnerable to brain damage or mental retardation, especially if irradiation occurs during formation of the central nervous system in early pregnancy

Control measures from Nuclear Hazards

- Nuclear devices should never be exploded in air. If necessary they can be exploded underground.
- In nuclear reactors, closed-cycle coolant systemwith gaseous coolants may be used to prevent extraneous activation products.
- Containments may also be employed to decrease the radioactive emissions. It can be achieved by using tightly sealed boxes & closed cycle system.
- Production of radioisotopes should be minimized, as once produced they cannot be rendered harmless byany means except the passage of time.
- Minimum number of nuclear installations should be commissioned.
- Fission reactions should be minimized
- Extreme care should be exercised in the disposal of industrial wastes contaminated with radio nuclides.
- Nuclear medicines and radiation therapy should be applied when absolutely necessary with minimum doses.
- Use of high chimneys and ventilations at the working place where radioactive contamination is high.
- Disposal methods are the possible ways to distribute the radio-pollutants.

Disposal of Radioactive wastes (Nuclear Hazards)

Since nuclear wastes are extremely dangerous the way in which they are disposed is strictly controlled by international agreement.

Classification of radioactive wastes:

1) High level wastes (HLW)
2) Medium level wastes (MLW)
3) Low level wastes (LLW)

1. High level wastes :Eg: Spent nuclear fuel

HLW have a very high radioactivity per unit volume. They have to be cooled and stored for several decades by its producer before disposal. Since they are too dangerous, they must be contained either by converting them into inert solids and then buried deep into earth or stored in deep salt mines.

2. Medium level wastes: Examples : filters, reactor components, etc.,

MLW are solidified and are mixed with concrete in steel drums before being buried in deep mines or below the sea bed in concrete chambers.

3. Low level wastes: Examples : solids or liquids contaminated with traces of radioactivity.

LLW are disposed off in steel drums in concrete-lined trenches.

SOLID WASTE MANAGEMENT: Rapid population growth and urbanization in developing countries leads to large quantity of solid waste and environmental

degradation.About 7.6million tonnes of municipal solid waste is produced per day in developing countries.

Types of Solid wastes:

1.Urban waste: The waste generated from Domestic, Commercial place, Constructional waste and biomedical waste.

2.Industrial Waste. The waste generated from Nuclear power plant, Chemical Industries, Thermal power plant and Other industries like plastic, paper, glass, paint.etc.,

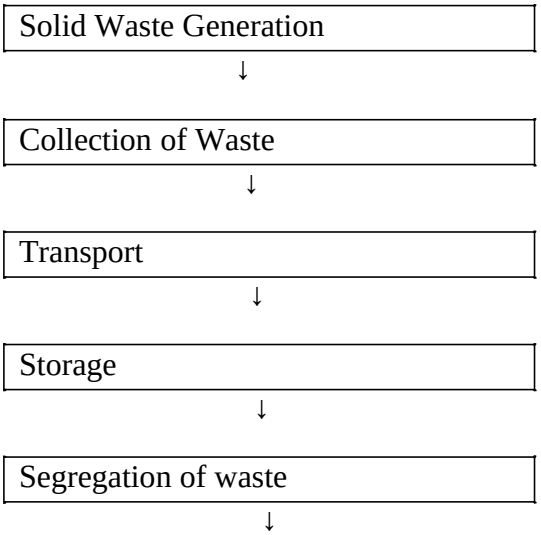
3.Hazardous Waste: The waste generated from Petroleum industries, Paper mills, Smelters, Radioactive substances, Biological waste.

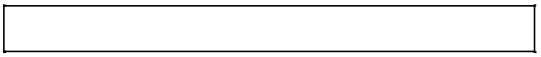
EFFECT OF SOLID WASTES:

- Due to improper disposal of municipal solid wastes on the road side and their immediate surroundings biodegradable materials undergo decomposition.This produces foul smell and breeds various types of insects which spoil the land value
- Industrial and hazardous waste affect the soil character and productivity
- Toxic substances contaminate the ground water
- Burning of the wastes produce furans, dioxins, polychlorinated biphenyls are harmful to human beings

Process of Solid Waste Management:

FLOW CHART :





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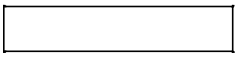

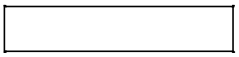

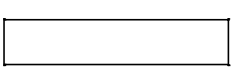

Steps involved in solid waste management :

1.Reduce , Reuse and Recycle of materials

Reduce the usage of raw materials: If the usage of raw materials are reduced, the generationof waste materials also get reduced.

2. Reuse of waste materials: Refillable containers

Rubber rings can be made from discarded cycle tubes, which reduces the waste generation during rubber bands manufacturing.

4. Recycling of materials

Old aluminium cans and glass bottles are melted and recast into new cans and bottles. Preparation of automobiles and construction materials from steel cans.

These process saves money, energy, raw materials and reduces pollution.

2. Disposal Methods:

(a) Land fill : Solid wastes are placed in sanitary landfill system in alternate layers of 80 cm thick refuse, covered with selected earth fill of 20cm thickness. After 2-3 years, solid waste volume shrinks 25-30% and the land is used for parks, roads and small buildings.The most common and cheapest method

Advantages

- It is simple and economical.
- Segregationnot required.
- Land filled areas can be reclaimed and used for other purposes.
- Converts low-lying, marshywaste-land into useful areas.
- Natural resources are returned to soil and recycled.

Disadvantages

- Largearea is required.
- Since land is availableaway fromthe town, transportation cost is heavy.
- Bad odors, if landfillsare not properly managed.

(b) Incineration: It is a hygienic way of disposing the solid waste. It is a thermal process and is very effective .It is an expensive technology compared to land-fill and composting. Before the waste undergoes this process, combustible and non combustible substances can be separated.. The non combustible materials are undergoes for recycling and Reuse process.The combustible materials are fed into the incinerator and the left out ashes about 10-20% which can be disposed sanitary land fill. The heat produced in the incinerator is used in thee form of steam power for generation of electricity throughout turbines.The temperature normally maintained in a combustion chamber is about $700^{o}C$ and may be increased to about $1000^{o}C$ when electricity is to be generated.

Advantage:

- Requires little space.
- Safest method.
- Cost of transportation is not high.

Disadvantage:

- Capital Cost is high.
- Need skilled person.

(c) Composting: In this method , bulk organic waste is converted into a fertilizing manure by biological action by using actinomycetes.The waste is dumped into the underground in layers of 1.5m and finally covered 20cm with earth materials and introduced some microorganisms and left for active decomposition. Within 2 to 3 days biological action starts, the organic matters are being destroyed by actinomycetes and lot of heat is liberated increasing the temperature of the compost by about 75oC and finally the refuse is converted into powdery brown coloured odourless mass known as humus which can be used in agricultural field.

Advantage:

- Used as manure.
- Low cost.
- When the manure added to the soil, it increase the water retention capacity of soil.

Disadvantage:

- Non-combustible waste should be disposed separately.

Role of individual in prevention of pollution:

Environmental pollution cannot be prevented and removed. The proper implementation and individual participation are the important aspects to prevent pollution. A small effort made by each individual at his own place will have pronounced effect at the global level. It is aptly said " Think globally act locally".

Some suggestions:

- Plant more trees
- Help more in pollution prevention than pollution control.
- Use water, energy and other resources efficiently.
- Purchase recyclable, recycled and environmentally safe products.
- Use CFC Free refrigerators.
- Reduce deforestation.
- Increase use of renewable resources.
- Use of eco-friendly products.
- Use Organic manure.
- Use Rechargeable batteries.
- Reduce garbage by recycling and reuse.
- Use natural gas than coal.

ROLE OF WOMEN IN ENVIRONMENTAL PROTECTION

- In rural areas ,women plant trees ,grass,vegetables with drip irrigation method to save water
- Women use cloth bags instead of plastic carry bags in urban areas
- Refuse to use the disposal product to save energy and resources

- Choose green products instead of poor quality whivh harm to the environment
- Buy non-phosphate detergents to reduce water pollution
- They value paper and protect trees

DISASTER MANAGEMENT

Hazard: Hazard is a perceived natural event which threatens both life and property.

Disaster: A disaster is the realization of this hazard. Disaster is an event , concentrated in time and space in which a society undergoes severe danger and causes loss of its members and physical property.

Types of disaster:

- Natural disaster: Generated by natural process.Eg. Cyclone, Flood, Earthquake.
- Man made disaster: Disaster resulting from man made hazards.Eg. Pollution, Accidents.

Important disaster (Calamities)

1.Flood 2.Cyclone 3.Landslides 4.Earthquakes.

FLOOD: A flood is an overflow of water, whenever the magnitude of flow of water exceeds the carrying capacity of the channel within its banks.

Causes of flood:

- Heavy rainfall, melting of snow, sudden release of water from dams
- Prolonged downpour can also cause over-flowing of lakes and rivers.
- Reduction in the carrying capacity of the channel, due to accumulation of sediments or obstructions built on flood ways.
- Deforestation, overgrazing, mining
- Removal of dense and uniform forest cover over the hilly zones leads to occurrence of floods.

Effect of floods:

- Due to flood, water spreads in the surrounding areas and submerge them.
- The plain surface have become eroded and silted with mud and sand thus the cultivable land areas get affected.
- Extinction of civilization in some coastal areas also occur.
- It damages the standing crops and livestock
- It causes a great damage to economy and health

Flood management

- Deepening of river channels
- Build check dams on small streams
- By constructing dams or reservoirs.
- Channel management and embankments also control the floods.
- Encroachment of flood ways should be banned.
- Flood hazard may also be reduced by forecasting or flood warning.
- Flood may also be reduced by afforestation in the catchment area.

CYCLONE: It is a meterological phenomena, intense depressions forming over open oceans and moving towards the land. Cyclones are most powerful, destructive, dangerous atmospheric storms on the earth. Their speed varies between 180-500 km/hr.

Occurrence of cyclone: The main requirement of formation of tropical cyclone is that the sea surface temperature (SST) must be below 25^{o}C.The tropical cyclones move like a spinning top at the speed of 10-30 km/h. In India cyclone originates from bay of Bengal. It occurs during October to December and April to May.

Different names of cyclones:

Name of the cyclone	**Place**
Hurricanes	Atlantic, Caribbean and Eastern Pacific , USA
Typhoons	Western Pacific and southern Coast of china, Japan
Cyclones	Bangladesh, Eastern coastal areas of India
Willy Willies	Australia

Effect of cyclone:

- Damage depends upon the intensity of cyclone.
- The damage to human life, crops, road, transport, communications could be heavy.
- It slow down the developmental activities of the area.

Cyclone management:

- Satellite images are used by meteorological departments for forecasting the weather conditions.
- RADAR system is used to detect the cyclone and is being used for cyclone warning.
- For observing exact location or cyclone,every half an hour satellite pictures are analysed.
- Effect of cyclone can be minimized by planting more trees on the coastal belt, construction of dams, embankments.

LANDSLIDES:

The movement of earth materials form higher region to lower region due to gravitational forces of attraction is called landslides.

Causes:

- Movement of heavy vehicles on the unstable sloppy regions
- Earthquake, shocks, vibrations and cyclone also cause landslides
- Underground mining activities
- Soil erosion during rain

Effects:

- Landslides block the roads and diverts the passage
- Erosion of soil increases
- Damage houses, crop yield, live stock
- Leads to fall of trees

Landslides management: It is very difficult to control landslides be minimized by

- Unloading the upper parts of the slope.
- Steepness of the slope can be reduced.
- Concrete support can be made at the base of the slope.
- Draining the surface water form the weak sloppy regions.
- Improvement of cultivation in the sloppy region.

EARTHQUAKE: An earthquake is a sudden vibrations caused on the earth surface due to the sudden release of tremendous amount of energy stored in the rocks under the earth surface.

Causes:

- Disequilibirium is caused by volcanic eruptions, hydrostatic pressure of manmade water bodies like reservoir, dams, lakes which inturn causes movements of paltes.
- Underground nuclear testing.
- Decrease of groundwater level.
- Deep well disposal of liquid waste

SEVERITY OF EARTHQUAKE: The severity of earthquake is measured by its magnitude of Richter Scale.

Richter Scale.	Severity of earthquake
Less than 4	Insignificant
4-4.9	Minor
5-5.9	Damaging
6-6.9	Destructive
7-7.9	Major
More than 8	Great

Effects:

- Responsible for landslides, which damage the settlements and transport systems.
- It collapses houses and other structures due to poor construction and also loss the life of people.
- Deformation of ground surface.
- Seismic waves caused by earthquakes travel through sea water and generates high sea waves called TSUNAMI.

Earthquake management:

- By constructing earthquake – resistant buildings in the earthquake prone areas.
- Wooden houses are preferred in earthquake prone areas as in Japan.

- Seismologist should analyze the pattern of micro seismicity and indicate the possibility of occurrence of earthquake in a potential area**.**

POLLUTION CASE STUDIES:

1.The Taj Trapezium Case:

The Taj Mahal in Agra is one of the most beautiful monuments on the earth. It is built entirely of white marble and was declared as a UNESCO World Heritage Site in 1983. It attracts scores of tourists from all over the world. But now the monument has developed a yellowish tinge and in some areas ugly brown and black spots owing to the increased levels of pollution around the area. **The main pollutant was sulphur dioxide released by the industries which later on reacted with rain water to give acid rain. Suspended Particulate Matter (SPM) was also one of the culprits.** Thus, **M.C Mehta**, an attorney in the Supreme Court of India and an active environmentalist, filed a **Writ Petition** in

1984 mentioning the adverse effects of the industries and vehicles in the area on the Taj Mahal. He sought appropriate directions to be given to the concerned authorities to take immediate steps to stop air pollution in the area and save The Taj. This petition falls under **Public Interest Litigation** (PIL). This case is commonly referred to as **„Taj Trapezium Case'.**The report pointed out the sources of pollution in the area - all coal users consisting of two Power Plants, a number of small industries mainly foundries (approximately 250) and a Railway Shunting Yard. The committee had also made some suggestions in the report. It had asked to ensure that no new large industries come up in the area without conducting appropriate detailed studies to access the environmental effect of such industries on the monument, the existing industries are shifted away from the area. It categorized the various industries and reported that there were total of 511 industries in the area. **Notices were issued to all these industries regarding pollution control as per the orders of the court.Out of the 511 industries, 212 did respond to the notice.** The court ordered these industries to be shut down on 27th of August till necessary pollution control devices were installed.The court on 11thn of **April, 1994** after hearing learned counsel for the parties, passed the order indicating that as a first phase, the **industries situated in Agra be relocated out of TTZ**. As a result of the order the U.P. Government set up a Taj Trapezium Zone Pollution (Prevention and Control) Authority to work for the control of pollution in the area. It has its headquarters in Agra. The green belt started getting damaged later. There was an application seeking various directions pertaining to taking action against the authorities responsible for damaging and destroying the green belt within 500 metres of Taj Mahal, use of vehicles, generators or sound equipments within

500 metres etc. As a result of this order, presently there is no access into the green belt for the visitors. It was found that despite the presence of monitoring stations, the air quality had still not improved.In this case the Supreme Court oversteps its jurisdiction; all the directions/orders given are functions of the executive. According to me the judgment was apt, but the different stake holders have not been able to implement the same in its entirety.

2. Chernobyl Nuclear Disaster: **The Chernobyl nuclear power plant is located in**

Ukraine, 20km south of the border with Belarus. At the time of the accident, the plant had

four working reactors.**On April 26, 1986**, when operators of the power plant ran a test on an electric control system of one of the reactors. The accident happened because of a **combination of basic engineering deficiencies in the reactor and faulty actions of the operators:** the safety systems had been switched off, and the reactor was being operated under improper, unstable conditions, a situation which allowed an uncontrollable power surge to occur.This led to a cascade of events resulting in **a series of explosions and consequent fires that severely damaged the reactor building, completely destroyed the reactor, and caused the release of massive amounts of radioactive materials** over a ten-day period.If the test had gone as planned, the risk to the plant was very small. When things did go wrong, though, the potential for disaster was miscalculated and the test was continued even as serious problems arose. **Meltdown occurred at 1:23 AM, starting a fire that dispersed large quantities of radioactive materials into the atmosphere**. The amount of **radioactive material released was 400 times more than the amount the atomic bombing of Hiroshima** released. The fallout would be detected in almost all parts of Europe. The accident destroyed the Chernobyl 4 reactor, killing 30 operators and firemen within three months and several further deaths later. One person was killed immediately and a second died in hospital soon after as a result of injuries received.
Another person is reported to have died at the time from a coronary thrombosis[c]. **Acute radiation syndrome** (ARS) was originally diagnosed in **237 people** on-site and involved with the clean-up and it was later confirmed in 134 cases. Of these, 28 people died as a result of ARS within a few weeks of the accident. Nineteen more **subsequently died between 1987 and 2004** but their deaths cannot necessarily be attributed to radiation exposure. Nobody off-site suffered from acute radiation effects although a large proportion of childhood thyroid cancers diagnosed since the accident is likely to be due to intake of radioactive iodine. **At present, 100 000 people living in contaminated areas** still receive a higher dose of radiation than the limit recommended for the general public. Chernobyl has increased the number of cases of **leukaemia or solid cancers**, except for childhood thyroid cancer. Regarding agriculture, the contamination of crops, meat, and milk with short-lived radioactive iodine was a major concern in the early months after the accident. Now and for decades to come, **contamination with longer-lived radioactive caesium** is the main concern in some rural areas. The authorities of the **Soviet Union** and, later, of the **Commonwealth of Independent States (CIS**) spent huge resources to deal with the consequences of the accident. Efforts were made to clean up contaminated areas and to reduce the amount of radioactivity in food and drink with varying degrees of success.

3. BHOPAL GAS TRAGEDY: In the **early morning hours of December 3, 1984**, a poisonous grey cloud (forty tons of toxic gases) from **Union Carbide India Limited** (UCIL's)[1] **pesticide plant at Bhopal** spread throughout the city. Water carrying catalytic material had entered **Methyl Isocyanate (MIC)** storage tank No. 610. What followed was a nightmare.The killer gas spread through the city, sending residents scurrying through the dark streets. **No alarm ever sounded a warning and no evacuation plan was prepared.** When victims arrived at hospitals breathless and blind, doctors did not know how to treat them, as **UCIL had not provided emergency information.It was only when the sun**

rose the next morning that the magnitude of the devastation was clear. Dead bodies of humans and animals blocked the streets, leaves turned black, the smell of burning chilli peppers lingered in the air. Estimates suggested that as many as **10,000 may have died immediately** and 30,000 to 50,000 were too ill to ever return to their jobs. The pesticide factory was built in the midst of densely populated settlements. UCIL chose to store and produce MIC, one of the most deadly chemicals in an area where nearly 120,000 people lived. The MIC plant was not designed to handle a runaway reaction. When the uncontrolled reaction started, MIC was flowing through the scrubber (meant to neutralize MIC emissions) at more than 200 times its designed capacity.**MIC in the tank was filled to 87% of its capacity while the maximum permissible was 50%. MIC was not stored at zero degree centigrade** as prescribed and the refrigeration and cooling systems had been shut down five months before the disaster, as part of UCC's global economy drive. Vital gauges and indicators in the MIC tank were defective. The flare tower meant to burn off MIC emissions was under repair at the time of the disaster and the scrubber contained no caustic soda.As part of UCC's drive to cut costs, the work force in the Bhopal factory was brought down by half from 1980 to 1984. This had serious consequences on safety and maintenance. The size of the work crew for the MIC plant was cut in half from twelve to six workers. The maintenance supervisor position had been eliminated and there was no maintenance supervisor. **The period of safety-training to workers in the MIC plant was brought down from 6 months to 15 days. Human rights groups** say that thousands of tons of hazardous waste remain buried underground, and the government has conceded the area is contaminated. There has, however, been no long-term epidemiological research which conclusively **proves that birth defects are directly related to the drinking of the contaminated water.**

4. Marine pollution: (a) Gulf war (b) The miniamatta Epidemic

(a). Gulf war : The Gulf war in Kuwait from January 16 to February 26, 1991 between Iraq and USA. During the war American fighters dropped a lakh of boms and forces Iraqi army to withdraw from Kuwait. During the retreat of Iraqi, they have set fire on nearly 700 oil wells of Kuwait.

Since most of the oil wells are on shore of sea, oil form the oil well spills out into the sea. The floating oil over sea water covered nearly 80Km long and 25Km wide area.

The burning oil wells continued nearly for 10 months. The burning of oil wells released huge amounts of pollutants like CO_2 and SO_2 into the atmosphere.

Effects: 1. Nearly one million birds have been killed doe to the oil slick.. 2. The oil slick in the sea made the desalination plants ineffective.

(b) The miniamatta Epidemic : Miniamatta is a small coastal village in Japan. The Chisso chemical company which produces vinyl polymer plastics used organomercurial compopund. The industry released its effluent into Miniamatta sea. The effluent containing mercury ions is converted into methyl mercury, which is highly toxic.

The marine organisms like phytoplankton and zoo plankton easily absorb the toxic methyl mercury compound. These organisms are consumed by small fishes and these are inturn consumed by large fishes. Finally the large fishes are consumed by human beings. Thus

the poisonous chemical methyl mercury enter into the body of human beings through food chain.

Effects: 1. Loss of vision and hearing 2. Loss of muscular co-ordination and severe headache. 3. Nervous disorders.

5.Pesticides in Coca-Cola and Pepsi

Coca-Cola and Pepsi in India contain dangerously high levels of pesticides, according to a new study released by the **Centre for Science and Environment (CSE),** a leading public interest research and advocacy group in India.**CSE tested 57 samples of Coca- Cola and PepsiCo carbonated products from 25 different bottling plants** across 12 states and found pesticide residues in all samples.The study found that the pesticide residues were **24 times higher than European Union (EU) standards** and those proposed by the Bureau of India Standards (BIS), the government body responsible for standardization and quality control.The study found high levels of:

Lindane - a confirmed carcinogen - sometimes as high as 140 times those allowed by EU and BIS standards

Chlorpyrifos - a neurotoxin - sometimes as high as 200 times those allowed by EU and BIS standards

Heptachlor - which is banned in India and also has not been used in the US since 1988 - was found in 71 per cent of the samples, at levels 4 times higher than the proposed BIS standards.

Malathion - a pesticide :The **Joint Parliamentary Committee (JPC),** was convened to look into the issue of dangerous levels of pesticides in soft drinks. In February 2004, the **JPC confirmed the unsafe levels of pesticides in soft drinks,** and recommended that the government set standards for these residues in the products. Since then, a committee from the **Bureau of Indian Standards (BIS)** has convened over 20 meetings to deliberate on the standards, and Coca-Cola, Pepsico, consumer and environmental organizations have all been consulted.

In October 2005, the standards were finalized by the committee, and in March 2006, the committee met again to reconfirm the standards. **The BIS has adopted the same standards as the European Union - which stipulates a single residue limit of 0.0001 parts per million and multiple residue limit of 0.0005 parts per million**. The proposed standards, however, have been delayed from being implemented, ostensibly to do more research.The Centre for Science and Environment is demanding that the government implement the standards immediately and make the standards mandatory for the soft drink companies.Coca-Cola and Pepsi & Co together control about 90% of the carbonated beverage market in India. A number of studies, including those by the government of India, have confirmed the growing water shortages and pollution of groundwater and soil by the Coca-Cola company. **One of Coca-Cola's largest bottling plants in India, in Plachimada in Kerala, has remained shut down** since March 2004 because of community opposition and government action.More than ten colleges and universities in the **US and UK have taken action against the Coca-Cola company.** "It is Coca-Cola and Pepsico's responsibility to deliver a safe product in India, and they have failed to do so even after being informed that their products were toxic three years ago."

PART – A (QUESTIONS AND ANSWERS)

1. Define Environmental Pollution. Mention the types of pollutants.

Environmental Pollution is defined as any undesirable change in the physical, chemical, or biological characteristics of any component of the environment (air,water,soil)which can cause harmful effects on various forms of property. **TYPES:** Biodegradable pollutants: Decompose rapidly by natural process Non-degradable pollutants : Do not decompose or decompose slowly in the environment.

2. What do you mean by indoor air pollution?

Houses in the under-developed and developing countries use fuels like wood kerosene in their kitchens and incomplete combustion produces toxic gas like CO. The most important indoor radioactive material is radon gas that can be emitted from building materials like bricks, concrete etc. which are derived from soil containing radium. This is called indoor air pollution. It is also a type of primary pollutants**..**

3. Define air pollution. Mention causes and effects:

The presence of one or more contaminants like dust, smoke, mist and odour in the atmosphere which are injurious to human beings, plants and animals. **Causes** : CO, NO_2, SO_2,SPM **Effects:** Lungs damage, bronchitis, cancer

4. Define water pollution . Mention the causes and effects.

Water pollution can be defined as alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state. Causes: Infectious agents, Organic and Inorganic chemicals.

5. Define point and non point sources?

Point sources – specific sites near water which directly discharge effluents into them
Non point sources – location of the sources of polluting water is not identified.

6. Explain thermal pollution. Mention the causes and effects.

Thermal pollution can be defined as the presence of waste heat in the water which can cause undesirable changes in the environment. **Causes**:Thermal power plants, Industrial effluents, Domestic sewage
Effects: 1. The solubility of O_2 is decreased at high temperature.2.. Toxicity of pesticides increases with increase in temperature

7. Explain Marine pollution. Mention the causes and effects.

The discharge of waste into the sea which cause harmful effects to human health and aquatic organism
Causes: Dumping of waste in marine. Oil pollution of marine water
Effects: Prevent Photosynthetic activity, Affects marine birds..

8. Define nuclear pollution. Mention the causes and effects.

Radioactive substances undergo natural radioactive decay in which unstable isotopes spontaneously give out harmful radiation. **Causes:** Nuclear accidents, Nuclear bombs **Effects.** Genetic , eye cataract, bone cancer .

9. Mention the activities involved in solid waste management.

1.Waste generation 2. onsite handling ,storage and processing 3. Collection 4. transfer and transport 5.processing and recovery and disposal

10. What is meant by hazardous waste? How to manage hazardous waste?

The useless, unwanted, discarded material that may threat to human health and environment.

- Dispose the waste as early as possible
- Prevent illegal, international traffic in hazardous waste

11. Explain soil pollution. Mention the causes and effects.

The contamination of soil by human and natural activites which may cause harmful effects on living beings, Causes: Domestic waste, Industrial wastes, Effects:1. Alter the physical and chemical properties of soil, 2.Affects food chain.

13. Define the term Noise Pollution.Mention its unit.Mention its types.

Unpleasant, disagreeable and Unwanted sound that cause discomfort to all living being. The Unit of sound is Decibel. Normal conversation ranges from 35dB to 60 dB. Types: 1.Transport Noise 2. Industrial Noise 3. Neighbourhood Noise.

14. Define 3R.

Reduce, Reuse, Recycle, (if 5R add Remove, Refuse)

15. What are the classification of Radio active waste.

1.HLW – High Level Waste 2.MLW – Medium Level Waste 3.LLW- Low Level Waste

16. What are the role of individual in prevention of pollution.

1.Plant more trees.
2.Purchase environmentally safe products.
3.Reduce deforestation.
4.Reduce population growth.
5.Use renewable resources.

17. Mention the standard specification of drinking water.

1.pH should be in the range of 7.0-8.5
2.Chloride and Sulphate should be less than 250 ppm.
3.Total hardness should be less than 500 ppm.
4.TDS (Total Dissolved Salts) should be less than 500 ppm.

18. Define Disaster. Mention its types

A disaster is the realization of this hazard. Disaster is an event , concentrated in time and space in which a society undergoes severe danger and causes loss of its members and physical property.Types of disaster:Natural disaster: Generated by natural process.Eg. Cyclone, Flood, Earthquake,Man made disaster: Disaster resulting from man made hazards.Eg. Pollution, Accidents.

19. Define flood. Mention the causes and effects.

A flood is an overflow of water, whenever the magnitude of flow of water exceeds the carrying capacity of the channel within its banks.

Causes: Heavy rainfall, Sudden melt of snow, Reducing the capacity of dams.

Effects: Affects crops and Livestock. Economic loss.

20. Define Cyclone. What are the major Effects ?Mention various names of cyclone.

It is a meterological phenomena, intense depressions forming over open oceans and moving towards the land.**Effects**:It slow down the developmental activities of the area and damages the roads,buildings and houses.

Various names: Hurricanes in USA, Typhoons in China and Japan, Willy Willies in Australia. Cyclone in India.

21. Define Earthquake. What are the major causes and Effects of Earth quakes?

An earthquake is a sudden vibrations caused on the earth surface due to the sudden release of tremendous amount of energy stored in the rocks under the earth surface. **Causes:** Due to dis equillibirium in any part of the earth crust caused by volcanic eruptions, hydrostatic pressure.2.Underground Nuclear Testing 3. Decrease ground water level.

Effects: Deformation of ground surface, Loss of life and property

PART B

1.Explain about the causes, effects and control measures of air pollution.
2.Explain about the causes, effects and control measures of water pollution.
3.Explain about the causes, effects and control measures of soil pollution.
4.Explain about the causes, effects and control measures of Noise pollution
5.Explain about the causes, effects and control measures of Marine pollution.
6. .Explain about the causes, effects and control measures of thermal pollution.
7.Explain about the causes, effects and control measures of radioactive pollution.
9. Elaborately discuss the steps involved in solid waste management.
10.With a flow diagram explain the waste water treatment process.
12.Discuss the significant parameters of drinking water quality standards.
13. Discuss the ways and means for an individual to prevent environmental pollution
15.Discuss the properties (physical and Chemical)of terrestrial and marine water.
16.Pollution related case studies.
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PRATHYUSHA ENGINEERING COLLEGE

LECTURE NOTES

GE8291/ENVIRONMENTAL SCIENCEAND ENGINEERING

UNIT III - NATURAL RESOURCES

Natural resources are the sources which are useful to man. There are two types of natural resources: 1. Renewable resources: Resources which are capable of being regenerated by ecological process within a reasonable period of time. Eg. Soil, Water, Natural vegetation, etc

2.Non-Renewable resources:Resources whichcannotberegeneratedwithinaperiodoftime. Eg.Coal,Petroleum,etc

FOREST RESOURCES:

Forests are one of the most important renewablenatural resources on this earth.About one-third of the world's land surface is coveredwith forest**.**

TYPES OF FORESTS

1) Evergreen forests2)Deciduous forests 3) Coniferousforest

Evergreen forests

- Foundintheequatorialregions,wheretheTemperature&rainfallisveryhigh.
- Duetoheavyrainfallthroughouttheyeartheseforestsareevergreen.Example:Thesilent valleyinKerala. Importanttrees:Teak,rosewood.

Deciduous forest: These forests are of 2 types,

1) Tropical deciduous forests 2) Temperate deciduousforests

Tropical deciduous forests:

- Foundinthe tropicalmonsoon.
- They receive only seasonal rainfall and hence they shed their leaves during the summer season. Important Trees: Teak,sandalwood

Temperate deciduous forests:

- Duetosevere winter with heavy snowfall the trees shed their leavesjustbefore the winterseason.
- Important trees : Oak,Maple

Coniferous forests

- The snow slides downthesidesofthetrees.
- The needle typed leaves preserve the moisture. Importanttrees:Pinetree, sprucetree.

FUNCTIONS OF FORESTS

- Forestsarehabitatstomillionsofplants,animalsandwildlife.
- Theyrecyclerainwaterandremovepollutantsfromair.
- They control water quality andquantity.
- They moderate temperature and weather and help to maintainhumidity.
- Theypreventsoilerosionandperformwatershedfunctions.
- Theypromotetourismandcontributeaestheticbeauty.

Uses of Forest:

I.Commercialuses:

S.No	Name of the products	Uses
1.	Forests supply wood	Used as fuel
2.	Forests supply wood for various industries	Raw materials as pulp,paper, timberetc.,
3.	Forests supply minor forest products	Like gums, resins, dyes, etc
4.	Many plants	Utilized in preparing medicines andrugs.
5.	Forest produces variety of animal products	Honey, ivory, etc.,
6.	Forest lands·	Mining, grazing, recreation& for dams

II. Ecologicaluses

Production of oxygen: During photosynthesis trees produce oxygen which is essential for for life.

Reducing global warming: Green house gas carbon di oxide is absorbed by the trees.

Soil conservation: Roots of the trees bind the soil tightly and prevent soil erosion.**Regulation of hydrological cycle**: Watershed in forest act like sponges which absorb rainfall and slowly release water for recharge of springs.

Pollution moderators: Forest can absorb many toxic gases.

Wildlife habitat: Homes for the millions of wild animals and plants.

III. Aesthetic value : Forestalsohave aesthetic value and serve as gene reserve of important species.

Tribals utilize bamboo and wild grass for erecting the huts to reside and for making other product like mats, basket, cots, etc.,

Some of the forest plants are used as food by the tribal people.

IV.Touristicvalue

Ecotourism provides a growing income for those who have facilitated it.

Several countries are now attracting the tourists.

OVER EXPLOITATION OF FORESTS:

Due to over population the materials supplied by the forest arenot sufficient to meet thepeople‘s demand.

Hence exploitation of forest materials is going on increasing day by day.
It has been estimated that in India the minimum area of forests required to maintain good ecological balance is about 33% of total area.
But at present, it is only about 22%. So over exploitation of forest materials occur.

Causes of over exploitation

- Increasing agriculturalproduction
- Increasing industrialactivities
- Increaseindemand of woodresource

Effects (or) consequences of over exploitation

- Migration of thefarmers.
- Environmentaldamage
- The tropical forests are destroyed at veryfastrate.
- Countless plant species & animals areendangered.
- Marine populations will go intoextinction.
- The dumping of waters intoland,water &airhas become a seriesproblem.

DEFORESTATION:

Deforestationistheprocessofremovalof(or)eliminationofforestresourcesduetomanynaturalorman-madeactivities.

Causes of deforestation

- **Developmental projects**: Developmental project works submergeofforest area or destruction of forest area. Eg:Bigdams, hydro electricprojects
- **Mining operations**: Due to extraction of mica, coal, limestone , etc reduce forest area.
- **Raw materials for industries**: Woodisan important raw material for making match boxes, furnitures,etc.,
- **Fuel requirements**: Mainly woodisused as afuel.
- **Shifting cultivation**: Replacement of natural forest ecosystem for monospecific tree plantation leadstodisappearance of number ofplants.
- **Forest fires**: Duetorise inambient temperature and human activities forestfireis happened.

Consequences (or) ill effects (or) impact of deforestation on the environment.

- **Global warming :**Cutting and burningofforest trees increases the CO_2content in the atmosphere which raises the sea level and depletion of ozonelayer.
- **Loss of genetic diversity**: Destructionofforest destroys the greatest storehouseofgenetic diversity onearth.
- **Soil erosion**: Deforestation responsible for soil erosion, landslides. Duetohigh speed of wind velocity soiliserodedingreatextent.
- **Loss of biodiversity**: Most of the species areverysensitivetoany changes. When the plantsnolongerexist, animals depend on plantsalsobecomeexist.

- **Unemployment problems**: The people living around forest areaslosetheir livelihood.

Preventive measures (or) avoid of deforestation (or) methods of conservation of forest

- New plants shouldbeplanted to replace the trees cut down fortimber.
- Use of wood for fuel shouldbediscouraged.
- Forestpestscanbecontrolledbysprayingpesticidesbyusingaeroplanes.
- Forestfiremustbecontrolled by modernt e c h n i q u e s .
- Over grazing by cattle mustbecontrolled.
- Education and awareness programmes mustbeconducted.
- Strictimplementationoflaw ofForestConservationAct.

TIMBER EXTRACTION:

Due to population growth and lack of alternative fuels, people living near by forest area are mostly using wood as fuel.

Uses of timber

- Rawmaterialsforvariouswoodbased industrieslikepaper,furniture,etc.,
- Forvariousdevelopmentalactivitieslikerailways,boats,roadconstructionetc.,

Consequences (or) effects of timber extraction

- Large scale timber extraction causesdeforestation.
- Soil erosion,lossof fertility, landslides and loss ofbiodiversity.
- Loss of tribal culture and extinction of tribalpeople.
- Reducesthethicknessoftheforest.

MINING:

Mining is the process of extracting mineral resources & fossil fuels like coal from the earth.These deposits are found in the forest region & any operation of mining will naturally affect the forest.

Mining operation requires removal of vegetation along with underlying soil mantle.

Types of mining

a) Surface miningb)Undergroundm i n i n g

Steps involved in mining

- Exploration (investigation and searchingofminerals)
- Development
- Exploitation (extraction ofminerals)
- Ore processing (separation ofore)
- Extraction and purification ofminerals

Effects of mining

- Mining activity not only destroys trees,italsopollutessoil,water ana i r .
- Destruction of natural habitatatthemineand waste disposalsites
- Duetocontinuous removalofminerals, forest covers, the trenches are formed on the ground, leading to water logged area, whichinturn contaminates the groundwater.
- Duringminingoperations,thevibrationsaredeveloped,which leadstoearthquake.

- Noisepollutionisanothermajorproblemfromminingoperations.
- Mining reduces the shape and size of the forestareas.
- Landslides may also occur as aresultof continuous mininginforestarea.
- Pollutionofsurface and ground water resources duetothe discharge of waste material.
- Migrationoftribal people from mining areastoother areas for searching land and food

DAMS AND THEIR EFFECTS ON THE FOREST AND TRIBAL PEOPLE:

Dams are the massive artificial structures built across the river to create a reservoir in order to store rain water for many beneficial purpose.

However, these dams are also responsible for the destruction of vast areas of forest & displacement of local people.

India has more than 1600 large dams,Maharastra has 600 large dams.

Tehri dam is the highest built across the river Bhagirathi in the state of Uttarakhand. It is the 10thtallest dam in the world.

Effects of dam on forest

- Thousandsofhectaresofforesthavebeenclearedforexecutingrivervalleyprojects.
- Hydroelectric projectsalsohaveledtolossofforest.
- Constructionofdamsundertheseprojectsledtokillingofwild animals&destroying aquaticlife.
- Hydroelectric projects provide opportunities for the spread waterbornediseases.
- The big river valley projects also cause waterloggingwhich leads tosalinity

Examples

Narmada sagar project : submerged 3.5 lakh hectares of forest comprising teak and bamboo trees.

Tehri dam : submerged 1000 hectares of forest affecting about 430 species of plants.

Effects of dam on tribal people

- Widespread displacement of tribal people, such a biodiversity cannotbetolerated.
- The displacement & cultural change affects the tribal people both mentally & physically.
- They do not accommodate the modern food habits &lifestyles.
- Tribal people are ill-treated by the modernsociety.
  Many of the displaced people were not recognized & resettled and compensated.
- Tribal people & their culture cannotbequestioned &destroyed.
- Generally, the body conditions of the tribal people will notsuitwith the newareas

They affectedby manydiseases.

II. WATER RESOURCES:

Waterisan important constituent of all the living beings. Nearly 80% of the earth‘s surfaceiscovered with water. Water existinthree phases, soild, liquid and gas. Itiscirculated in accordance with hydrologicalcycle.

Hydrological cycle

Hydrological cycle involves the following steps,

1) Evaporation 2) Condensation and precipitation 3) Transpiration and respiration

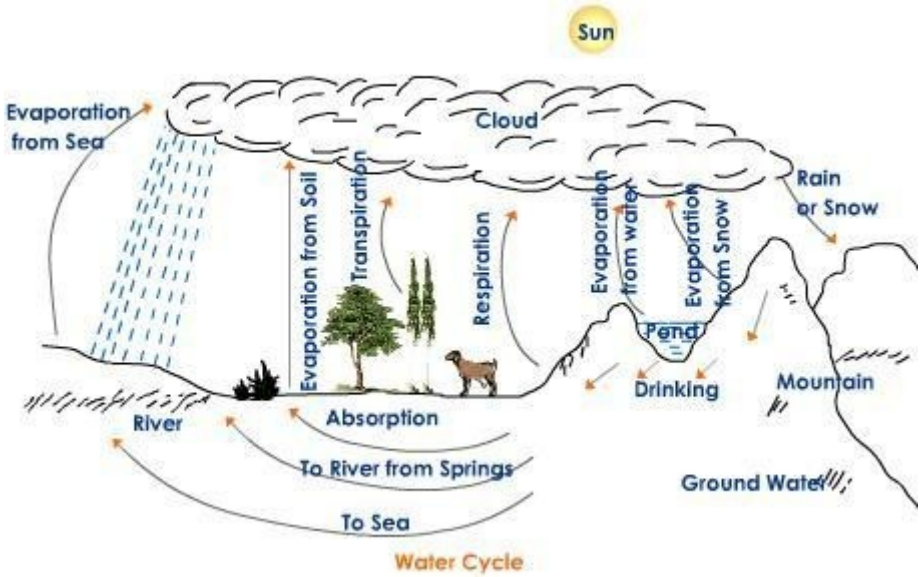
1) Evaporation : Heat energy from the sun constantly causes evaporation from all the water surfaces. Oceans, rivers, streams, lakes, ponds and the surfaces of terrestrial organisms lose water due to evaporation. The evaporated water in the form of water vapour forms clouds.

2) Condensation and precipitation: The water in the gaseous form (water vapour) now gets condensed by means of condensation. Once water condenses, it is pulled into the ground by gravity. The process by which the condensed water falls to the earth is known as precipitation (rainfall).

3) Transpiration and R e s p i r a t i o n

Organisms play an important role in the water cycle. Plants absorbs water through their roots and some of the water get lost through their leaves by the process known as transpiration. Respiration is the process by which both the plants & animals break down sugars in their body to produce energy. Thus the process of evaporation, condensation and transpiration is called hydrological cycle.

Distribution of water Resources: About 97.4% by volume of water is found in oceans and is too salty and cannot be fit for drinking and any other industrial purposes. 2.6% by volume is found to be in fresh water.



Types of fresh water resources:

1.Surface water:

a.Standing water bodies: Lakes, Reservoirs, estuaries.

b.Flowing water bodies: Streams, Rivers

2.Under ground water. Eg:Wells,springs,Aquifers

Aquifers: A layer of highly permeable rock containing water.

Types of aquifers: i)Unconfined aquifer ii) Confined aquifer

Unconfined aquifer: This is formed when water collects over a less permeable rock.

Confined aquifer: This is formed when water collects over a non permeable rock.

Uses of water:

1. Consumptive use: Wateriscompletely used butitisnot reused. Eg. Domestic and Irrigationactivities

2. Non-consumptive use: Waterisnot completely utilized andit isreused.Eg. Hydro power plant.

3. Otheruses:

- Commercial purposelikehotels, offices, educationalinstitutions.
- Irrigation.
- Industrialoperationslikerefineries,paperandpulpindustries.
- Very essential for alllivingorganisms and moderateclimate.

OVER UTILIZATION OF SURFACE AND GROUND WATER:

The rapid increase in population & industrial growth have increased the demand for water resources.

Effects on over-utilization of water (or) Consequences of overdrawing of ground water

1) **Decrease of ground water-**Duetoincreased usageofground water, inadequate rain fall, due to sealing permeable soil zone reduce the percolation of rain waterintotheground.

2) **Ground subsidence –**When the ground water with drawlismore than its recharge rate, the sedimentsinthe aquifer get compacted resultsinsinking of land surface leads to ground subsidence.

3) **Lowering of water table**– Duetoover utilizationofground waterinarid and semi arid regions for agriculture disturbs the ground waterlevel.

4) **Intrusion of salt water**:Incoastal areas, over exploitationofground water leadstointrusion ofsaltwater from thesea.

5) **Earthquake & landslides**: Duetodecreaseinwater table leadstoearth quake and landslides.

6) **Drying up of wells**: The levelofground water getting depleted faster rate than the regeneratingcapacity.

7) **Pollution of water**: Ground waterinagricultural areas contain nitrate, when its concentration exceeds 45mgs/lit notfitfor domesticpurpose.

DAMS BENEFITS AND PROBLEMS:

Dams are built across the river in order to store water for Irrigation, Hydroelectric power generation and flood control.

Most of the dams are built to serve for more than one purpose called —multi purpose dams‖. These dams are called Temples of Modern India by the country‘s first Prime Minister Jawaharlal Nehru.

Benefits of constructing dams

- Control flood & store floodwater
- Fordivertingpartorallofthewaterfromriverintoa channel
- Drinking & agriculturaluses
- Generateelectricity
- For recreationalpurposes
- Problems of constructingdams
- Navigation and

Fishery.**Problems on constructing dams:**

Upstreamproblems

- Displacement of tribalpeople
- Loss of non-forestland
- Loss of forests, flora andfauna
- Landslips, sedimentation & siltationoccurs
- Stagnation and waterloggingaround reservoirs retardsplantgrowth
- Breeding of vectors and spread of vector-bornediseases.
- Reservoir induced seismicity (RIS) causesearthquakes.

Downstream problems

- Water logging & salinity due to overirrigation
- Reduced waterflow&siltdepositioninrivers
- Salt water intrusion at rivermouth
- Since the sediments carrying nutrients get depositedinthe reservoir, the fertilityofthelandalong the river getsreduced.
- Sometimes duetostructural defects the dam may collapse suddenly & destroy many livingorganisms.
- Salt water intrusion at rivermouth

MINERAL RESOURCES:

Minerals: They are naturally occurring substances having definite composition and physical properties.

Ores: Combination of minerals from which useful substances can be extracted profitably.

Formation of mineral deposits:

- Due to biological decomposition of dead animals and organicmatters.
- During cooling of molten rock(lava from volcano)
- Due to evaporation of seawater.
- Due to oxidation and reduction reactionofinside the earthsurface.

CLASSIFICATION OF MINERAL RESOURCES:

1. Identified resources: The location, existence, quality and quantity are known by geographical evidence andmeasurements.
2. Undiscovered resources: Assumed tobeexist of geographical knowledge and theory but their specific locations, quality, quantity areunknown.

3.Reserves: These are identified resources from which a usable minerals canbeextracted profitably.

USES AND EXPLOITATION OF MINERAL RESOURCES:

Minerals are usedina large numberofwaysineverydayindomestic, agricultural, industrial and commercial sectors. Economic and political power of the countryisdetermined from the number of reserves of mineralsinthecountry.

USES:

- Iron, Aluminium, Copper are usedinthe development of industrial plants and machinery.
- Iron, aluminium, Nickel are usedinconstruction andhousing.
- Coal, Lignite, Uranium are usedinGeneration ofenergy.

- Zineb-containing zinc and maneb-containing manganese are used for Agriculture purpose as fertilizer, fungicides,etc.
- Gold, silver, Platinum, Diamond are usedinJewellery.
- Copper, Zinc,Tin , etc are used formakingalloys.
- Many minerals are used generally for communication purposes, medicinal purposes, defence equipments,automobiles.

CLASSIFICATION OF MINERALS:

Minerals are classified into two ways based on their composition and usage.

Based on Composition:

1. Metallic Minerals: Minerals from which various metals canbeextracted. Eg. Iron, Aluminium,copper.etc.
2. Non-metallic minerals: Minerals from which various non metals canbeextracted. Eg. Quartz,dolomite,etc.

Based on Usage:

1. Critical Minerals: Minerals whichisessential for economic power of a country. Eg. Iron, Aluminium, Copper andGold.
2. Strategic Minerals: Minerals whichisessential for the Defence of a country. Eg. Manganese, Cobalt,Chromiun.

MINING: Extraction of minerals or metals from the earth surface:

Types of Mining:

Surface mining: The process of extraction of minerals from the near surface deposits.

Underground Mining: The process of extraction of minerals from the below the earth‘s surface. It involves,

1. Open pit mining: Machine dig holes and remove theores.
2. Dredging: Chained buckets and draglines are used to scrap up the minerals from the under-water mineraldeposit.
3. Strip Mining: The oreisstripped off by using bulldozers, stripping wheels.

ENVIRONMENTAL DAMAGE CAUSED BY MINING: The environmental damage caused by mining activities are as follows,

1. Devegetation and defacing of landscape: Thetopsoil as well as the vegetation are removed from the mining area. Large scale deforestation or devegetation leadstoseveral ecological losses and also landscape getsbadlyaffected.

2.Groundwater contamination: Mining pollutes the ground water. Many ores has sulphur as an impurity which gets converted into H_2SO_4due to microbial action. This makes the wateracidic.Some heavy metals also get leached intogroundwater.

3. Surface water pollution: The drainage of acidmineoften contaminates the nearby streams and lakes. The acidic waterisharmfultomany aquatic life. Radioactive substanceslikeuranium also contaminate the surfacewater.

4. Air pollution: Smelting & roasting are donetopurify the metals, which emits enormous amounts of air pollutants damaging the nearby vegetation. The suspended particulate matter (SPM), SO, arsenic particles, cadmium, lead, etc., contaminate the atmosphere & leads to several health relatedproblems.

5. **Subsidence of land**: Itismainly associated with underground mining. Subsidenceofmining area resultsincracksinhouses, tilting of buildings, bending of railtracks.

Effects of over exploitation of mineral resources

- Rapid depletion of mineraldeposits.
- Wastage & dissemination of mineraldeposits.
- Causes environmentalpollution.
- Needs heavy energy requirement.

Management of mineral resources

- Re-use & Re-cycling of themetals
- Eco-friendly miningtechnology
- Modernization of the miningindustries
- Efficient use and protection of mineralresources.
- Search of new mineraldeposit.

FOOD RESOURCES: Food is an essential requirement for the human survival. The main components of food are carbohydrates, fats, proteins, minerals & vitamins. Historically humans have dependent on 3 systems for their food supply,

1. Croplands – grains – 76%ofworld‘s food –rice,wheat, maize, barley, sugarcane, etc.,
2. Rangelands – food from the grazing livestock – 17% of world‘s food – meat, milk, fruits,etc.,
3. Oceans – 7% of world‘s food –fish,prawn, crab,etc.,

WORLD FOOD PROBLEMS:

1. In earth 79%ofthe total areaiscovered by water, only 21% areaisland,ofwhichmostof the areas are forest, desert, mountains, only less percentage areaisused for cultivation. TheWorldpopulation increases and cultivable land decreases. Therefore world Food problemarises.
2. Soil Erosion, Water logging, Salinity, Water pollution affect agriculturallands.
3. Urbanisation deteriorates the agriculturallands.
4. Food grains like rice, wheat, corn and the vegetable like potato are the major food for the people all over the world, the food problemarises.

UNDER NUTRITION AND MAL NUTRITION:

1. **Nutrition:**To maintain good health and resist disease, we need large amount of Macronutrients such as carbohydrates, proteins and fats and small amountofMicronutrients such as Vitamin A,C and E and minerals such as iodine, calcium, iron.

As per FAO (Food and Agriculture Organisation) of United Nations estimated that on an average, the minimum calorie intake on a global scale is 2,500 calories/day.

2. **Under Nutrition**: People who cannot get enough food tomeettheir basic energy needs (carbohydrates) suffer from Under nutrition. They receivelessthan 90% of these minimumcalories.
3. **Malnutrition:**Besides the minimum calories, we also need proteins, minerals, vitamins, iron and iodine.Deficiency ofNutrition leads to Malnutrition.

Effects :

Deficiency of nutrient	Effects
Proteins	Growth
Iron	Anemia
Iodine	Goitre
Vitamin A	Night Blindness

CHANGES CAUSED BY OVERGRAZING AND AGRICULTURE:

1. **Overgrazing:**Processofeating away the vegetation along with its roots without giving a chance toregenerate

Impacts:

a. **Land degradation:**Overgrazing leadstoorganically poor,dry,compacted soil cannotbeused for further cultivation Soil erosion- Overgrazing leads to remove the vegetation fromsoil.

b. **Loss of useful species:**The grasslandconsist of good quality grasses and herbs with high nutritive value, when grazedloseeven the root stocks which carry the reserve food for regeneration get destroyed which gives raisetosecondary species like parthenium, Lantane, Xanthium etc

2. **Agriculture**: Agricultureisan art, science and industry of managing the growth of plants and animals for humanuse.

Types:

a. Traditional Agriculture b. Modern or Industrilalized Agriculture.

a. Traditional Agriculture: It involves small plots,simpletools, surface water, organic fertilizer to produce enough food for their families and tosellitfor theirincome.

b. Modern Agriculture: It involves the use of hybrid seeds, high tech equipments, lotoffertilizers, pesticides and water to produce large amount of singlecrops.

IMPACTS OF MODERN AGRICULTURE:

I.Fertilizer relatedproblems:

Micronutrient imbalance: Chemical fertilizers have nitrogen, phosphorus and potassium (N,P,K)which are essential macronutrients. Excessive use of fertilizers cause micronutrient imbalance.(Eg. Deficiency of micronutrient zinc in the soil affects the productivity of the soil.

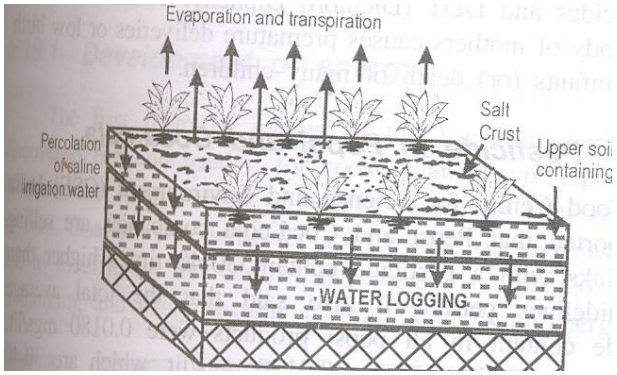
Blue Baby Syndrome (Nitrate Pollution):. When nitrogenous fertilizer are applied in the fields, the nitrates get concentrated in the water and when their concentration exceeds 25 mg/L, they become the cause of a serious health hazard called "Blue Baby Syndrome" This disease affects the infants causing even death.

Eutrophication: (Blooming of algae) A large proportion of nitrogen and phosphorus used in crop fields is washed off and reach the water bodies causing over nourishment of the lakes, a process known as Eutrophication. (Eu=more, tropic=nutrition). Due the eutrophication, the algal species grows very rapidly but the life time is less, they die quickly and pollute the water which affects aquatic life.

II. Pesticide related problems: Thousands of types of pesticides are usedinagriculture.
1. Thefirstgeneration pesticides_ sulphur, arsenic,leador mercurytokill thepests.
2. Second generation Pesticides: DDT (Dichloro Diphenyl Trichlotomethane)isusedtokill the pests but they produce sideeffects.
1.Death of non-target organisms: Many insecticides kill non target organism like earthworm (Friend of Farmer)which are usefultous.
2. Producing new pests.Somepests are immune to all typesofpests arecalledsuper pests.**3.Biological magnification**: Manyofthe pesticides are non-biodegradable and keeponpresentinthe foodchain,a process called biologicalmagnification.
4. Risk of Cancer: Pesticides directly acts as carcinogens(Cancer Producing Agents) and indirectly suppress the immune system.

III . Water Logging: Water stagnantina particular place formostof the years duetoheavy rainfall, Excessive Water supply, Poor drainage facility. Duetothis water logged conditions, the airinthe soil gets depleted and the roots of the plants do not get enough air to respiration which reduce theproductivity.

IV. **Salinity**: The accumulationofsoluble saltslikesodium chloride, sodium sulphate, calcium chloride, magnesium chloride etc.inthe soil .The pH exceeds to 8.0(alkaline), the cropyielddecreases.



ENERGY RESOURCES: Energy may be defined as—the capacity to do work‖.

RENEWABLE AND NONRENEWABLE ENERGY RESOURCES:
Based on the continual utility ,natural resources can be classified into twotypes.
1.Renewable energy resources 2.Non renewable energy resources.
Renewable energy resources: Resources which can be regenerated continuously and inexhaustible. They can be used again and again in an endless manner. Eg. Wind, Solar, Ocean energy.

MERITS:

- Unlimitedsupply
- Provides energysecurity.
- Fits into sustainabledevelopment.
- Decentralized Energyproduction.

Non renewable resources: Resources cannot be regenerated continuously. Once they get exhausted, cannot be used again. Eg. Coal, petroleum.

Wood is renewable but not coal- Why?

Wood is renewable because we can get new wood by growing a sapling into a tree within 15-20 years. But formation of coal from trees takes millions of years and cannot be regenerated in our life time.

RENEWABLE ENERGY RESOURCES:

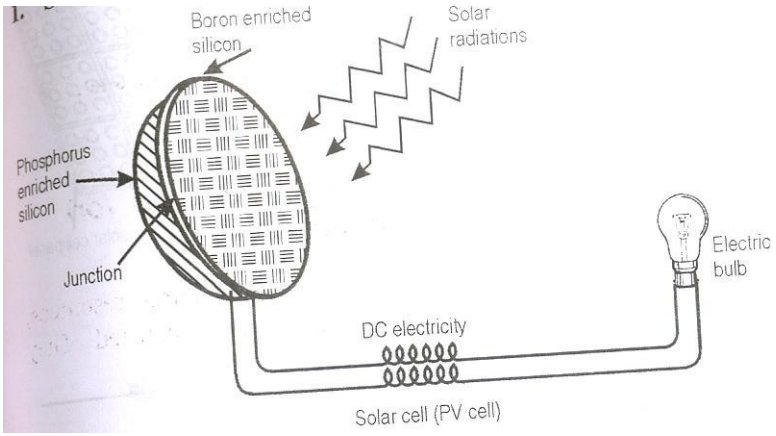
1. Solar energy 2. Wind energy 3. Ocean Energy 4.Biomass energy.

SOLAR ENERGY:

Itisthe process of conversion of light energyinto electrical energy. Solar energy can be used to generate electrical power, thereby providing an alternativetothermal and nuclear power. Photo conversion canbedone by photogalvanic cell/photovoltaic cell/solar cell. Solar cell/ photogalvanic cellisa device by which solar energyisconverted directlytoelectricalenergy.

Principle:

The basic principle involved in the solar cell is photovoltaic effect. When a beam of sunlight falls on a solar cell consisting of two layers of semiconductors, an electrical potential is developed between two layers. This potential difference causes flow of electrons from one layer to another through the circuit and produces electricity.



Construction:

Solar cell is made up of two very thin layers of semiconductor material.

Upper layer: p-type semiconductor - Si doped with B. Lower layer: n-type semiconductor - Si doped with P.

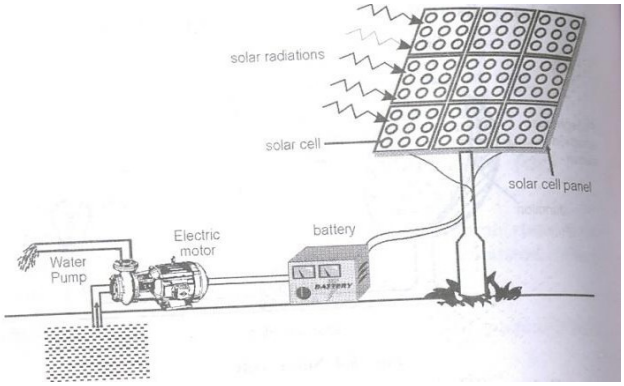
Working:

When a beam of light from sun fall on the top layer of solar cell containing p-type semiconductors, the electrons in the valence band in this layer absorb some of this incident light energy and get promoted to the conduction band and cross the p-n junction in to n-type semiconductor as result of potential difference between the two layers of semi conductors. The potential difference and current are increased when more light falls on the solar cell.

Uses: Used in calculators, watches, street lights, water pumps .

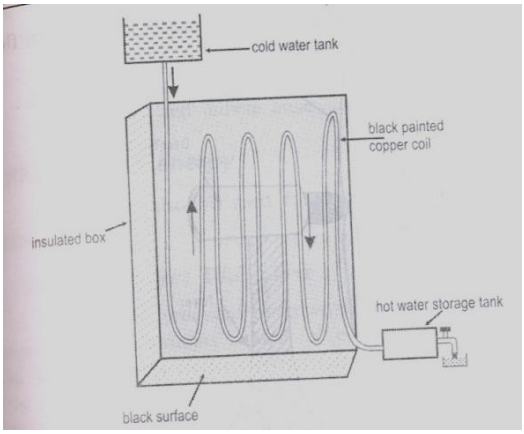
Solar battery:

When a large number of solar cells are connected in series it form a solar battery. Solar battery produce more electricity which is enough to rum water pump, to run street light, etc., They are used in remote areas where conventional electricity supply is problem.



Solar water heater:

It consists of an insulated box inside which is painted with black. It is also provided with a glass lid to receive and store solar heat. Inside the box it has black painted copper coil through which cold water is allowed to flow in, which gets heated up and flows out into a storage tank. From the storage tank water is then supplied through pipes.



Merits:

- Pollutionfree
- Usedinremote and isolatedareas.
- Fuelisnot required for solar water heater,solarcooker,

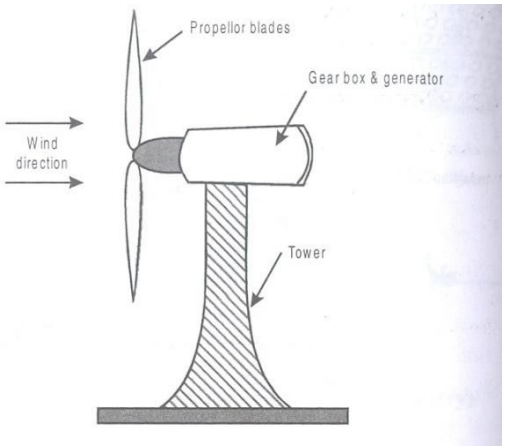
WIND ENERGY:

The energy harnessed from moving air (wind) is called wind energy.

Wind mills: Itisa simple machine which consists of large blades mounted on ashaftonvertical pole. The shaftisconnected with a waterpumpor generator accordingtothe application. When the wind blows, the blades starts rotating which runs the machine attached toit.

Wind farms: Large number of wind mills is installed over a large area of land.

The minimum wind speed required for satisfactory working of a wind generator is 15 km/hr.



Merits:

- Does not produce any airpollution.
- Renewable and inexhaustible source ofenergy.

Demerits:

- Speed of wind changes with time of day andseason.
- Requires large landarea.
- Very high initial capitalinvestment
- Need for backup systems to store energy during the windlessperiod.
- Produces noise pollution.
- Interfere with electromagnetic radiation (TV and radio signals).

OCEAN ENERGY:

Ocean can also be used for generating energy in the following ways.

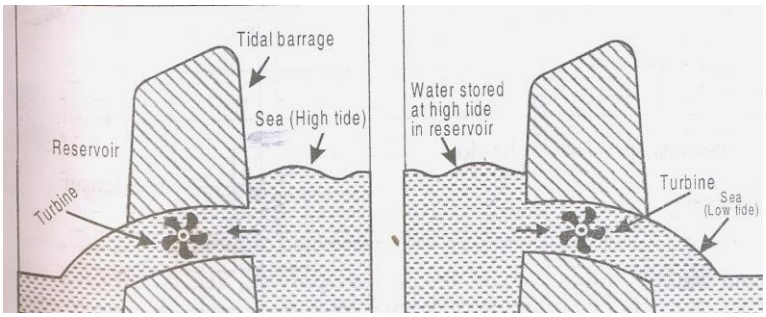
1.Tidalenergy 2. OceanThermalEnergy 3.Geothermalenergy

1. TidalEnergy:

Tides are produced by gravitational forces of sun and moon.

The tidal energy can be harnessed by constructing a tidal barrage.

During high tide, the sea waterisallowedtoflow into the reservoir of the barrage and during low tide the sea water storedinthe barrage reservoirisallowedtoflowinto thesea.In both cases the turbine rotates and produceelectricity.



HIGHTIDE LOWTIDE

MERITS:

- Do not requires largeareas.
- Pollutionfree
- Does not require anyfuel
- Does not produce anywaste.
- Sea waterisinexhaustible, so completely independent onrainfall.

2.OCEAN THERMAL ENERGY:(OTE)

The energy harnessed due to the difference in temperature of water is called ocean thermal energy.

The energy difference should be of 20^{o}C or more is required between surface water and deeper water.

The warm surface water of ocean is used to boil a low boiling liquid like ammonia. The high vapour of the liquid formed by boiling is used to turn the turbine of the generator and generates electricity.

MERITS:

- Continuous source ofenergy
- Pollutionfree
- OTE canbeused to producehydrogen.

3.GEO THERMAL ENERGY(GTE)

When we move down the earth surface, temperature increases at the rate of 20-75^{o}C. High temperature and pressure steam fields exist below the earth‘s surface in many places.

The energy harnessed from the high temperature present inside the earthiscalled geothermalenergy.

Natural geysers: Hot water comes out of the ground through cracks naturally.

Artificial geysers: Artificially drill a hole up to the hot region and rush out hot water through the pipe with very high pressure.

MERITS:

- Power generationishigh.
- Very Quickprocess
- Canbeused effectively andefficiently.

4.BIOMASSENERGY:

Biomass is the organic matter, produced by plants or animals. Most of the biomass is burned directly for heating, cooling or industrial purposes.

Eg. Wood, Cattle dung, Sewage, Agricultural waste.

1. Biofuels:(Ethanol, Methanol) Itisobtained by fermentation ofbiomass.

a. Ethanol : Itisobtained by fermentation of sugarcane. Its calorific valuesis lessthan petrol

b. Methanol: Itisobtained from ethanol or sugar containing plants. Its calorific valueistoo low.

c. Gasohol: Itisa mixture of ethanol+gasoline and tried to used as fuelincars andbuses.

2.Hydrogenfuels:

It is prepared by thermal dissociation or photolysis or electrolysis of water, It has high calorific value. No pollution.

$$2H_2 + O_2 \rightarrow 2H_2O + 150KJ$$

Disadvantages:

- Hydrogenishighlyinflammable
- Explosiveinnature.
- Safe handlingisrequired.
- Difficulttostore andtransport.

Significance of bio-mass energy:

- Low cost
- Biomass consumed more carbon di oxide butitreleased during combustionofbiomass.

NON-RENEWABLE ENERGY SOURCES:

Sources which cannot be regenerated within reasonable period of time is called Non-renewable sources.

Eg. 1.Coal 2. Petroleum 3.LPG 4.Natural Gas.

1. Coal: It is a solid fossil fuel formed in several stages.

Various stages are wood→ Peat Lignite→ Bituminuous coal → Anthracite coal.

The carbon content oc Anthracite coal is 90% with calorific value 8,700 k.cal.

Disadvantages:

1.CO_2emission whichisresponsible for Globalwarming.

2.Due to presence of Sulphur and Nitrogen impurities,itproduce toxic gases during combustion.

2. **PETROLEUM**: Itisa crude oil contain more than hundreds of hydrocarbons with small amount of N,S,O as impurities. The fossil fuel if formed by decompositionofdead plants and animals that were buries under thelake,ocean at high temperature and pressure for million of years.From the crude oil various hydrocarbon are obtained from fractional distillationmethod.

3. LPG(Liquified Petroleum Gas)

It is colour less and odour less hydrocarbon gas. But during bottling, some mercaptans is added which produces more bad odour, there by any leakage of LPG from the cylinder can be detected immediately.

4.**NATURAL GAS:** Itisfound above the oilinthe oil well. Itisa mixture of50-90%methane and small amount of other hydrocarbon. Calorific values : 12,000 -14,000 k.cal/m^3Lower hydrocarbon methane and ethane are called dry gas and higher hydrocarbon like propane and butane along with methane are called wetgas.

USE OF ALTERNATE (RENEWABLE) ENERGY SOURCES:

(Role of alternate sources or Energy sources in environmental impact)

- The importance of solar energy canbeemphasized.
- Energy sources which have least pollution, safety and security and enhance of large scale utilizationinfuture.
- Hydroelectric power generationisexpected to upset the ecological balance existing onearth.
- Hydel power plants critically affectsaquaticand terrestrialcommunities.
- Radioactive pollutantsreleasedfrom nuclear power plants arechronicallyhazardous.
- The radioactive waste cannotbe buried in landwithout theriskof polluting soil and under groundwater.
- The burning ofcoal,wood , dung cakes produce environmentalproblems.

Bio Gas OR Gobar gas:

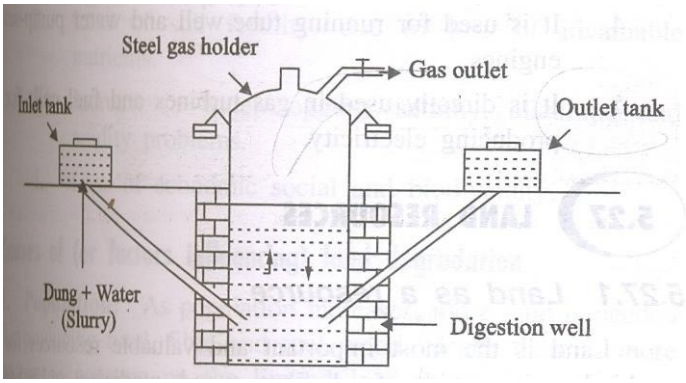
It is a mixture of various gases formed by the anaerobic degradation of biological matter (Cowdung) in the absence of oxygen.

Composition: CH_4= 50-75% , CO_2=25-50% , N_2= 0-10% , H_2=0-1%, H_2S =0-3% , O_2=0%

Production : It is produced by using Biogas plant:

Construction:

Itisconsists of a underground tank (Digester) with dome shaped roof with a outlet gaspipe.Onleft sideof the digester tank, thereisainlet pipetofedcow dungalongwith water(Slurry) On rightsideof the digester tank, thereisa outletpipeto collect the spentslurry.



Working:

- The slurryisfed into the digester tank andleftiffor two months for the fermentation processbyusing anaerobicmicroorganisms.
- After anaerobic fermentation, the sufficient amount of biogasiscollectedinthedome whichexertspressureontheslurry.

- The spent slurryiscollected through the outletpipe.

Uses:

- Cooking food andheatingwater
- To runengines
- Used asilluminant invillages
- To run gas turbine and fuel cells forproducingelectricity.

LAND RESOURCES:

Land isthemost important valuableresourceswhichprovidefuel,wood,fibre, medicines,etc.
Soil is a mixture of inorganic materials (Rock and minerals) and organic materials (Dead plants and animals).
Top soilisrenewable becauseit iscontinuously regeneratedbynatural processat slowrate.Landdegradation: Itisthe process of deterioration of soil orlossof fertility of thesoil.

Harmful effects:

- The soil texture and structure aredestroyed.
- Loss of soil fertility and loss of economic social andbiodiversity.
- Increase waterlogging,salinity,alkalinity and acidityproblems.

REASONS:

1.Population: Due tomorepressure on the limitedlandresources responsible for degradation.
2.Urbanization: The increased urbanization duetopopulation growth reduces the extent of agriculturalland.Urbanization alsoleadstodeforestation which affectsmillionsof plant and animalspecies.
3.Fertilizers and Pesticides: By applying excess use of fertilizers and pesticides leadstolandpollution.
4. Damage of top soil: Increase the food production,damagethe top soil nutrient depletion.
5.Water logging, Salinity, contamination of the soil with industrial wastealsoreason forlanddegradation.

SOIL EROSION:

Removal of superficial layer of topsoil from one place to another.

TYPES:

1.Normalerosion: Removal of topsoil by natural process. Rate of erosionisslow.
2.Aceleratederosion:Removal of topsoil by manmade activites. Rate of erosionisfast.**REASONS:**

- Water: Due to rain and rapidflowof water affects soilerosion.
- Wind:Itcarriedaway thefineparticles of soil which creates soilerosion.
- Bioticagents: Overgrazing,Mining, Deforestation activitesleadsto soilerosion.
- Landslides: Downwarddisplacementof materials leads to soilerosion.
- Constructional activites: Due to construction of building, dams, roads removes the protective vegetative coverleadsto soilerosion.

EFFECTS:

- Loss of fertility ofsoil.
- Los of its ability of soil toholdwater.

CONTROL OF SOIL EROSION (OR) SOIL CONSERVATION PRACTICES:

In order to prevent soil erosion and conserve the soil the following methods are practiced:

1. **Conventional tillfarming:**

In traditional method the soil is broken up and smoothed to make a planting surface.
This disturbs the soil and makes it susceptible to erosion.
Conservational till farming, popularly known as no-till-farming causes minimum disturbance to the top soil.
The tilting machines make slitsinthe soil and inject seeds, fertilizers, and little waterinthe slit, so that crop growssuccessfully.

2. **Contourfarming:**

On gentle slopes, crops are grown in rows across, rather up and down.
This practice is knows as contour farming.
It helps to hold soil and slow down loss of soil through run-off water.

3. **Terracing:**

It is used on still steeper slopes
Terracing retains water for crops at all levels and cuts down soil erosion.

4. **Strip cropping**:

Here strops of crops are alternated with strips of soil saving crops like grasses
What ever run-off comes from the cropped soil is retained by the strip of cover- crop and this reduces soil erosion.

5. **Alley cropping:**

It is a form of inter – cropping in which crops are planted between rows of trees or shrubs.
This is also called**Agro forestry**.
Even when the cropisharvested, the soilisnot fallow because trees and shrubs still remain on the soil holding the soil particles and prevent soilerosion.

6. **Wind breaks orshelterbelts**:

The trees are planted in long rows along the cultivated land boundary so that wind is blocked.
The wind speed is substantially reduced which helps in preventing wind erosion of soil.

DESERTIFICATION: The progressive destruction or degradation of arid and semi arid lands to desert. It also responsible for land degradation.

CAUSES:

- Deforestation: Duetodeforestation activities, thereisno vegetationtoholdback the rain water and the ground water level do notincreases.
- Over grazing: Increased cattle populationisresponsible for overgrazing.Asa result the land becomes dry, loose and promote soil erosion leadstodesert.
- Water Management: Over utilizationofground waterincoastal regions, leadstointrusion ofsaltwater whichisunfit forirrigation.
- Mining and quarrying: Duetothese activities, loss of vegetative cover leads to desertification.
- Climate Change: Duetofailure of monsoon season and climate change leadstodesertification.
- Pollution: Excessive use of fertilizers and pesticides leads todesertification.

EFFECTS:

- Productive landsinthe arid and semi arids lands are converted todesert.
- Most of the people are threatened bydesertification.

MAN INDUCED LANDSLIDES:

Land slides are downward and outward movement of earth materials such as rock, soil, etc.**Man induced landslides**: During construction of roads and mining activities weaken the landmasses and leads to landslides are called man induced landslides.

CAUSES:

- Removal of vegetation: Deforestationinthe sloppy areas creates soil erosion leadstolandslides.
- Underground mining: These activitiesisresponsible for groundsubsidence.
- Transport: Due to movement of buses and trains in the unstable sloppy areas causes landslides.
- Ground waterlevel:Over exploitation of ground water leadstolandslides.

ROLE OF INDIVIDUAL IN CONSERVATION OF NATURAL RESOURCES:

Since resources are being exhaustible,it isthe duty of every individual on this earth to conserve the natural resources. Due to advancementintechnology and population growth, the present worldisfacing lot of problem on degradation of naturalresources.

Measures to conserve natural resources:

1.Conseration ofenergy:

- Switch offlights
- Use solarheater
- Dry the clothesinsunlight
- Use pressurecooker
- Ride bicycle orwalk

2.Conservation ofwater:

- Check the leaksinpipes.
- Build rainwater harvestsystem
- Waste water from kitchen used for watering theplants.
- Use dripirrigation.
- Watering the plantsinearly morning and lateevening.

3.Conservation ofsoil:

- Prevent soilerosion.
- Use greenmanure
- Don‘t uproot theplants
- Usemixedcropping
- Grow moretrees.

4.Conservation offood:

- Eat minimum amount offood
- Don‘t waste thefood
- Don‘t cook morefood.
- Don‘t store large foodgrains.

- Protect grains frominsects.

5.Conservation offorest:

- Use non timberproducts
- Plant moretrees
- Avoiddeforestation
- Reduce the use ofpaper
- Grazingmust becontrolled.

EQUITABLE USE OF RESOURCES FOR SUSTAINABLE LIFE STYLE:

Sustainable development: The development of healthy environment without damaging natural resources and the resourcesmust beusedinsuch a way thatitmustbeavailable for the future generation also.

Unsustainable development: Degradation of environment due to over utilization of natural resources.

LIFE STYLE IN DIFFERENT COUNTRIES:

1.Life stylein mostdeveloped countries (MDC‘s) : They have only 22%ofworld‘s population but they are using 88% of its natural resources.Theirincomeis85% of total global income.They contribute more proportion of pollution leads tounsustainability.

2. LifestyleinLess developed countries (LDC‘s) : They have only 78% of world‘s population but they are using 12 % of its natural resources.Theirincomeis15% of total global income.They are struggling with large population and poverty problems also leads tounsustainability.

REASON: Due to difference in MDC‘s and LDC‘s.

- Over populationinpoor countries, consume too low resources with lowincome.
- Less populationinrich countries consume more resources with more income.

CONDITIONS FOR SUSTAINABLE LIFE STYLE:

- Equal distribution oflandresources and income to meet eneryone‘s basicneeds.
- Rich countries lower down the consumption level and support for the growth of poorcountries.

CASE STUDIES:

1. Deforestation in hilly region of theHimalayas:

DeforestationinHimalayas, involving clearance of natural forest and plantationofmonocultureslikePinux roxburghi, Eucalyptus camadulensis etc, haveupsetthe ecosystem by changing various soil and biological properties. Nutrient cycling has become poor, original rich germplasmis lostand the areaisinvaded by exotic weeds. These areas are notabletorecover and are losing their fertility.The original vegetation of Himalaya has been greatly destroyed which has resultedingradual lossofthe natural resources. Due to overpopulation, industrialization, urbanization, road construction, mining and other developmental activities the natural habitats of the flora and fauna are disturbed and have caused tremendous pressure on the living resources. Many plant and animal species are on the vergeofextinction or endangered. Forest destruction may alsobecaused by several adverse factors aslandslides, drought, flood,storm,earthquakes, diseases, water andairpollution and human interference. Other adverse factors such aslackofstable soil,aridity,

swampiness, biotic agencies, commercial exploitation etc. may also be responsible for depletion of forest vegetation. Natural diversity of india is one of the richest in the world which is disappearing gradually due to aforesaid factors.The destruction of forest cover in the ecologically sensitive Himalaya region has already started showing adverse impact in the form of increasing shortage of water, recurrent landslides, increasing flood, high sedimentation ii the rivers, shortage of fuel and fodder and decrease in grassing land. Due to deforestation the life supporting systems are disturbed. Underground water table is progressively going deeper and deeper. Large are of the land becomes affected by drought and well tube, wells, lakes, pounds etc. dry up sooner than expected during summer months.

2. Cauvery Conflicts overwater:

The Cauvery water dispute: The sharing of waters of theKaveri riverhas been the source of a serious conflict between the Indian states ofKarnatakaandTamil Nadu.The genesis of this conflict rests in two agreements in 1892 and 1924 between the erstwhileMadrasPresidencyandPrincely State of Mysore. The 802 kilometres (498 mi)Kaveririver[1]has 44,000 km^{2}basin area inTamil Naduand 32,000 km^{2}basin area in Karnataka.

The Cauvery water dispute, which has been a bone of contention between Karnataka and Tamil Nadu for decades now, has again ledtoviolenceinthe region after Supreme Court pronounced its order . The court has directed Karnataka state government to release 15,000 cusecs of Cauvery water to Tamil Nadu for the next 10 daysinan attempt to save the samba crops.Cauvery Horata Samiti, the organisation which has been at the forefront of issueinKarnataka, called for a statewide ‗bandh' leadingtoviolent protests byfarmers. The protestshaveaffected public transport facilities, schools, colleges and government officesinMandya.

The Cauvery water dispute has influenced the politicsofthe region forlongwith parties stirring emotions of people as the river has a deep cultural, economic and religious significance for them. This,inturn,ledtoa situation where the public opinion became more rigid with time makingiteven difficult for the political outfitstofinda common ground.As Kerala and Puducherry alsolaidclaim on shareofCauverywaterafter India attained Independence, a Fact Finding Committee was set-upin1970tofigureout the situation on ground. The committee submitted its reportin1972 and further studies were done by expert committee and the states reached at an agreementin1976. However, after a new government cametopowerinTamil Nadu,itrefusedtogivea consent to termsofagreement paving way for further dispute.Laterin1986, Tamil Nadu government appealed the Central government to constitute a tribunal for solving theissueunder Inter-State Water Disputes Act, 1956. However, the tribunal was not set-up until Supreme Court took cognizance of the matter and ordered the Central government todosoin1990. The Cauvery Waters Tribunal was constituted on June, 2,1990.

After 16 years of hearing and an interim order, the Tribunal announced its final order in 2007 allocating 419 tmc ft water to Tamil Nadu and 270 tmc ft to Karnataka. Kerala was given 30 tmc ft and Puducherry got 7 tmc ft. The Tribunal had come to a conclusion that total availability of water in Cauvery basin stood at 740 tmc ft. However, both Tamil Nadu and Karnataka filed a review petition before the Tribunal.

In 2012, Prime Minister Manmohan Singh, as chairmanofCauvery River Authority, directed the Karnataka government to release 9,000 cusecsofwater daily. The Supreme Court slammed state government asitfailedtocomply with the order. The government offered an unconditional apology and started the releaseofwater leadingtowidespread violent protests.However, the issue kept troubling the region as Karnataka stopped release of water again and Tamil Nadu government led by Chief Minister J Jayalalithaa decided to sue the Karnataka government for contempt of court. With the Karnataka government continuously failingtorelease the water to Tamil Nadu, Chief Minister Jayalithaa filed an interlocutory petitioninthe Supreme CourtinAugust, 2016 seeking releaseofwater as per guidelinesofCauvery Tribunal. Announcing its verdictinthe case, the SC hasnowdirected Karnataka government to release 15,000 cusecs of water to its neighboring state .so that the stateisabletosatisfy the demandsofits farmers for growing summer crops this year.

3. Aravalli range tigerreserve

However, as the community went about restoring their**johads with the help of TBS(Tarun Bharath Singh**) , they could not help observing that the hills were being gouged mercilessly by mining, thus affecting the natural system of water and drainage. They realised that even the hills needed protection.A protected forest with unclear boundaries, a tiger reserve chalked out in a limestone-rich area, mining leases whose legality is questionable — all these have created a mess in the**Sariska National Park (Tiger Reserve) in Rajasthan**. The TBS found that even after constructing johads, the water level did not go up in the wells and lakes around Sariska. But soon found what was wrong. TBS traced the missing water to the pits left unfilled by the miners after their operations. Water collected in them, depriving the wells and lakes of water.

The mining mafia was growing at an alarming rate as their strong adversary. Their mining activities were destroying not only the Aravalis (an oldest mountain range in the world), but the indiscriminate dumping was also causing damage to the Sariska National Park and endangering the lives of the wild animals. An ecological imbalance was setting in, with faster degradation of the area under mining operations.

So, with one voice TBS protested, gathering villagers as they went on their long marchers to demonstrate the injustice.**Nearly 45 organizations from other states supported the*yatra*as part of the*Save Aravalis Campaign*.**A public interest**petition was filed by TBS in the Supreme Court of India. In 1991, the court issued an order against continuing mining in the ecologically fragile Aravalis.**This was followed up by a notification by the Ministry of Environment and ForestsinMay 1992 banning mininginthe Aravalli hill system. It eventually ledtothe**closure of 470 mines**operating within the buffer area and peripheryofthe Sariska National Park.During this struggle, TBS activists hadtofacethe wrath of themineowners. They were threatened and attacked. The miners carried on a vilification campaign against them. Pro-mining elements disturbed village meetings, with outsiders hurling abuse and stones. But, TBS remained undaunted through all this. The important thingisthat they were able to arouse the potentialofthe communities to think, decide and act. During all this TBS learnedtobepatience in struggle againstinjustice.

PART A QUESTIONS AND ANSWERS

1. What are the benefits and Problems ofdams?

Benefits:1. Provides large scale employment of tribal people 2.Help in checking flood 3.Generate electricity 4. Reduce power and water shortage 5. Provide irrigation water 6. Promote navigation and fishery.

Problems: 1. Displacement of tribal people 2.Loss of flora and fauna 3. Breeding of disease vectors 4.Water logging and salinity

2. What is waterlogging?

Water logging is the land where water stand for most of the year.

3. What are the effects or consequences of timberextraction?

1. Deforestation. 2.Soil erosion 3. Loss of fertility of soil. 4.Reduce thickness of forest 5.Loss of tribal culture**..**

4.Define Deforestation. What are the causes and effects of deforestation?

Deforestation: Destruction of forestarea.

Causes: Developmental projects, Mining, Forest fire

Effects: Global warming, Soil erosion, Loss of biodiversity.

5. Why wood is renewable but coal is non-renewable?

Wood is renewable because we can get new wood by growing a sapling within 15-20 years. But the formation of coal is not able to regenerate in our life time.

6. Define Hydrologiccycle.

The cyclic process of evaporation, condensation and transpiration.

7.Define mining. Mention its causes andimpacts.

Extraction of minerals form the earth surface is known as mining.

Causes: Large usage of minerals in industries, Source of raw material

Impact: Air pollution, Surface & Ground water pollution. Subsidence of land.

8.Define biomagnification.

Most of the pesticides are non-biodegradable and keep on concentratinginthe foodchain.**9.Define overgrazing. What are the causes and adverse effects caused by overgrazing?**

Eating away the forest vegetation without giving a chance for regeneration.

Causes: Increase Livestock population (Cattle population)

Effects:Land degradation, soil erosion, loss of useful species.

10. Explain soil leaching?Mention itseffects.

The processinwhich materialsinor on the soil gradually dissolve and are carried by water seeping through the soil.**Effects**: Remove valuable nutrients form soil. 2. Ground watercontamination.

11. What are strategic and critical minerals? Giveexamples.

Strategic minerals – required for the defence of the country [Eg. – manganese, cobalt.] Critical minerals – essential for the economic power of a country. [Eg. – iron, aluminium.]**12.Define biogas (Gobar gas)? Mention its composition and its uses.**

Biogas is a mixture of various gases formed by the anaerobic degradation of cowdung in the absence of air.

Composition: Methane 50-75%, CO_2-25-50%,N_2-0-10%,H_2-0-1%.H_2S-0-3%,O_2-0%

Uses: Cooking food and heating water, To run engines 3. Illuminant in villages.

13. What do you understand by micronutrientimbalance?

Most of the chemical fertilizers used in modern agriculture contain N.P.K. which are macro-nutrients, when excess of nutrients is used in the fields it leads to micronutrient imbalance.

14. What is blue baby Syndrome?

When nitrogen fertilizers are applied in the fields they leach deep into the soil and contaminate the ground water, the nitrate in the water gets increased, when the nitrate concentration exceeds 25mg/lit they cause serious health problem called blue baby syndrome.

15. Define Eutrophication.

A large portion of N and P used in crop fields is washed off by the runoff water and reaches the water bodies causing over nourishment of lakes called Eutrophication.

16. Explain the methods practice for conservation ofsoil.

1. Conservational till farming 2. Contour farming 3.Terracing 4. Alley cropping 5. Wind breaks.

17. What is anaerobicdigestion?

Anaerobic digestion is a series of biological processes in which microorganisms breakdown biodegradable materials in the absence of oxygen.

18. What are renewable and non-renewable energysources?

Renewable energy resources are natural resources which canberegenerated continuously and are inexhaustible. They canbeused again and again. Eg:solarenergy, wind energy etc. Non-renewable energy resources are energy resource thatisnot replaced orisreplaced only very slowly by natural processes. Eg: fossil fuels--oil, natural gas, andcoal.

19. Write briefly about GTE andOTE:

GTE: Geo thermal Energy: Temperature of the earth increases at the rate of 20 – 75°C per Km, when we move down the earth‘s surface. High temperature and pressure fields exist below the earth‘s surface in many places. The energy harnessed from the high temperature present inside the earth is called geothermal energy.

OTE: Ocean Thermal Energy: Due to temperature difference between upper and lower level of the ocean , able to rotate turbine to generate electricity.

20. What are biofuels?ExplainGasohol.

Fuels obtained by fermentation of biomass is bio fuels. Gasohol: It is a mixture of Ethanol and Gasoline.

21. What isLPG?

Petroleum gas obtained during cracking and fractional distillation can be converted into liquid under pressure, colorless and odourless gas.

22. What is the role of an individual in conservation of naturalresources?

Role of individual in the conservation of natural resources. – duty of every individual to conserve natural resource in such a way that it is available for future generations also. Due to advancement I technology and population growth, the present world is facing lot of problems on degradation of natural resource..

23. What is land degradation? What are the causes of land degradation? Mention its harmfuleffects.

Land degradation. – Process of deterioration of soil or loss of fertility of soil.
Causes of land degradation. – Increase in population, increase in urbanization, increased applications of fertilizers and pesticides, damage of top soil.
Harmful effects of land degradation. – Soil structure and texture are deteriorated, loss of soil fertility due to loss of valuable nutrients, increase in water logging, salinity, alkalinity, acidity problems.

24. What do you understand by desertification? What are the causes and effects for desertification.

Desertification–Progressive destruction or degradation of arid orsemiarid landstodesert.
Causes: Deforestation, Overgrazing Mining and quarrying , Pollution
Effects: Productive land in arid and semi arid region converted to desert People are in threatened condition.

25. Define Landslides. Mention the causes and Effects of landslides.

Landslides: Downward and outward movement of a slope composed of earth materials such as rock, soil,etc.
Causes of landslides – removal of vegetation, underground mining, transport, addition of weight
Effects: Loss of life, Destruction of communication links, Loss of infrastructure.

26. Define soil erosion and mention itstypes.

Soil erosion. Damage or removal of top soil renders the soil infertile.
Natural erosion: Erosion takes by nature itself Accelerated erosion : Erosion takes place due to man made activities.

27. Explain overgrazing. What are the changes caused due to overgrazing?

Overgrazing-A process of eating awayofforests without givingita chancetoregenerate.
Overgrazing leadstolossof biodiversity, loss of minerals, Soil erosion, leadstodesertification..

PART B QUESTIONS

1. Describe the causes and effects and control measures ofdeforestation.
2.Discuss the impact of mining on environment and human health OR Consequencesofover-exploitation of mineralresources.
3.Give an account of non-conventional energy resources OR Renewable energysources
4.Discuss the effects of modern agriculture on the environment.
5.Discuss in detail the benefits and problems of constructing dams.
6.Discuss the role of an individual in the conservation of natural resources.
7.Explain briefly the soil conservation practices adopted in India.
8. With the help of a neat diagram explain the production of biogas and mention itsuses.
9. Discuss the causes and consequences ofdesertification.
10. Discuss the consequencesofoverdrawing surface and groundwater.
11.Discuss the various techniques for harnessing solar energy. 12.Describe the utilization of wind energy to produce electricity.
13.Explain the following: i) tidal power ii) OTE iii) GTE iv) biomass energy.
14.Discuss about Non-Renewable Energy Resources.
15.Compare Nuclear Power and CoalPower.
16. Whatisland degradation? Discuss the factors responsible forlanddegradation.

PRATHYUSHA ENGINEERING COLLEGE
LECTURE NOTES
GE8291/ENVIRONMENTAL SCIENCEAND ENGINEERING

UNIT IV - SOCIAL ISSUES AND THE ENVIRONMENT

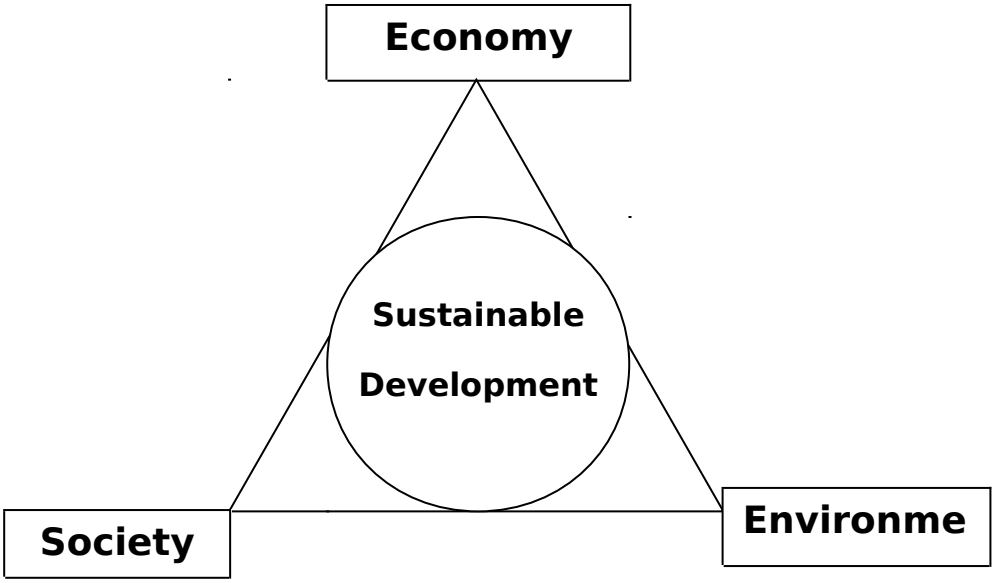
From unsustainable to sustainable development:

Sustainable development is defined as, **M e e t i n g the needs of present generation without compromising the ability of future generation to meet their own needs.**

Sustainable development aims at:

- Optimum use of natural resources with
- High degree of reusability
- Minimum wastage
- Least generation of toxic byproducts and pollutants
- Maximum productivity

Sustainable development is a multi dimensional concept aiming at benefits derived from the interactions between society, economy and environment.



Significance of sustainable development:

- A symbiotic relationship between human beings and natural resources
- Suitability between ecology and economics

Goals of sustainable development:

- Promoting equality
- Economic efficiency
- Ecological harmony
- Sustaining our natural resources
- Improving the quality of life

The key aspects to achieve the above goal are:

a) **Inter generational equity:**
It states that

To build up the sustainable development, the following approaches are proposed.

Developing appropriate technology

Reduce, Reuse, Recycle (3R) approach

Providing environmental education & awareness

Consumption of renewable resources

Conservation of non renewable resources

Population control

URBANISATION: Urbanization is the movement of human population from rural areas to urban areas for the want of better education, communication, health, employment, etc.,

Causes of urbanization: Since cities are the main centers of economic growth, trade, transportation, education, medical facilities & employment, rural people moves to cities

About 50% of the world population lives in urban area & people from rural area is moving to cities for employment. Thus the urban growth is so fast & it is difficult to accommodate all their facilities within a limited area. **As a result there is spreading of the cities into sub-urban or rural areas.** This phenomenon is known as **urban sprawl**.

Energy demanding activities

In developing countries, urban growth is very fast & pollution is uncontrollable.When compared to rural people, urban people consumes a lot of energy & materials & generates a lot of waste. This is because urban people have a higher standard of life & their lifestyle demands more energy inputs.

Examples for energy demanding activities

Residential & commercial lightings.

Transportation including motor cycle, car & public transport

Modern lifestyle using a large number of electrical gadgets in everyday life.

Solution for urban energy problem

Urban people may use public transport instead of using motor cycles & cars.
Energy consumption must be minimized in all aspect.

Use of energy efficient technology.

Use of solar energy & wind energy.

Imposing strict laws, penalties & energy audit.

WATER CONSERVATION: **The process of saving water for future utilization is known as water conservation.**

Need for water conservation:

The quality & reliability are not high due to changes in environmental factors.

Better lifestyle requires more fresh water.

Increase in population

Due to deforestation, the annual rainfall is also decreasing.

Over exploitation of ground water, leads to drought.

Agricultural & industrial activities require more fresh water.

Strategies of water conservation

Reducing evaporation losses :• By placing horizontal barriers of asphalt below the soil surface, which increases the water availability & crop yield.

Reducing irrigation losses :

1.Sprinkling irrigation & drip irrigation conserves water by 30-40%.

2. Growing hybrid crop varieties, which require less water.

3.Irrigation in early morning or later evening, reduces evaporation losses.

Re-use of water

Treated waste water can be again used

Grey water from washings, bathrooms, etc., may be used for washing cars, watering gardens.

Preventing wastage of water

Closing the taps when not in use.

Repairing any leakage from pipes.

Using small capacity of taps.

Decreasing run-off losses: By contour cultivation or terrace farming.

Avoid discharge of sewage : The discharge of sewage into natural water resources should be prevented .

Methods of water conservation

1) Rainwater harvesting
2) Watershed management

Rainwater harvesting :Rainwater harvesting is a technique of capturing and storing of rainwater for further utilization.

Need (or) Objectives of Rainwater Harvesting

To meet the increasing demands of water.
To raise the water table by recharging the ground water.
To reduce the groundwater contamination from the intrusion of saline water.
To reduce the surface run off loss.
To minimize water crisis & water conflicts.

Concept of rainwater harvesting : Rainwater harvesting involves collecting water that falls on the roof of house during rain storms & passing it through PVC or aluminium pipe to a near by covered storage unit.

Method (or) type of Rain water Harvesting : The most common method of rainwater harvesting is roof top rainwater harvesting

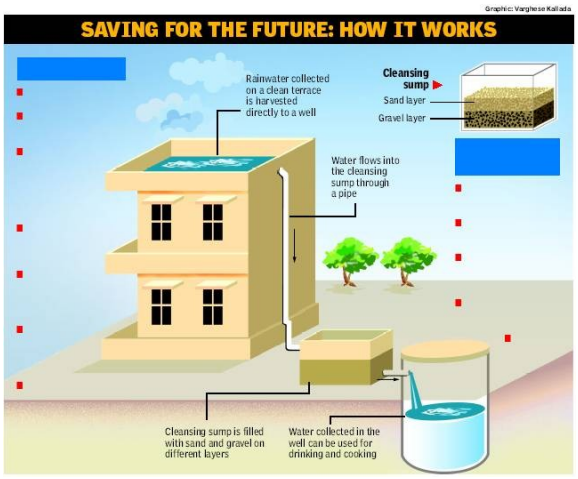
Roof top rainwater harvesting:

In this method rainwater is collected from the roof of the building & is stored in the ground for future use.
It is the low cost & effective technique.
The rainwater from the top of the roofs, road surfaces, play grounds, open lands is diverted into the surface tank or recharge pits through a delivery system.This can be used to recharge underground

Advantages of Rainwater Harvesting

Reduction in the use of current for pumping water..
Mitigating the effects of droughts .
Increasing the availability of water from well.
Rise in ground water level.

RAIN WATER HARVESTING METHOD



Watershed (or) Drainage basin

Watershed is defined as the land area from which water drains under the influence of gravity into a stream, lake, reservoir or other body of surface water.

Watershed management : The management of rainfall and resultant runoff is called watershed management.

Factors affecting watershed

Uncontrolled, unplanned & unscientific land use activities.

Overgrazing, deforestation, mining, construction activities also affect & degrade various watershed.

Droughtly climates also affects the watershed.

Need (or) Objectives of watershed management

1) To minimize the risks of floods, droughts &landslides.

2) For developmental activities like domestic water supply, irrigation, hydropower generation, etc.,

3)To generate huge employmental opportunities in the backward rain-fed areas to ensure livelihood security.

4) To promote social forestry & horticultural activity on all suitable areas of land.

5) To protect the soil from erosion by runoff.

6) To raise the groundwater level.

Concept of watershed management.

Watershed is not a technology but a concept which integrates construction management & budgeting of rainwater through simple but discrete hydrological units.

Watershed management techniques:

In watershed management, various civil structures were constructed to improve groundwater storage.

1) **Trenches (Pits)** : to improve groundwater storage.
2) **Earthern dam (or) Stone embankment** : to check the run-off water.
3) **Farm pond** : to improve water storage capacity of the catchment area.
4) **Underground barriers (Dykes)** : to raise the water table.

Maintenance of watershed (or) components of integrated watershed management

1) Water harvesting: Proper storage of water which can be used in dry season.
2) Afforestation & Agroforestry : To prevent soil erosion.
3) Reducing soil erosion : by following Terracing, contour cropping to minimize erosion.
4) Scientific mining & quarrying
5) Public participation
6) Minimizing livestock population

RESETTLEMENT AND REHABILITATION:

RESETTLEMENT : **Resettlement is simple relocation or displacement of human population.**

REHABILITATION: **Rehabilitation includes replacing the lost economic assets, safeguard employment, provide safe land for building, repair damaged infrastructures, etc.,**

Resettlement & rehabilitation is one of the most serious problems caused by the developmental activities. Though the developmental projects raises the quality & standard of living of the people, there is over exploitation of natural resources & degradation of the environment.

Causes of displacement of people

1) Due to developmental activities
2) Due to disaster – natural as well as man made disaster.
3) Due to conservation initiatives.

Rehabilitation issues

In India, most of the displacements have resulted due to land requirements by the government using Land Acquisition Act, 1897.

Tribals are usually the most affected among the displaced, who are already very poor.

Break up of families is an important social issue.

Even if the tribals get cash compensation, they are not familiar with the market policies & trends.

Loss of identity & loss of the intimate link between the people & the environment is one of the big loss.

Rehabilitation policy:

The rehabilitation & resettlement work should be a partof the project & all those affected should be rehabilitated before the commencement of the project.

The people should be rehabilitated on "minimum dislocation basis", by choosing adjacent areas.

The extent of rehabilitation should meet the ends of social justice & balanced development.

ENVIRONMENTAL ETHICS:

Environmental ethics refers to the issues, principles & guidelines relating to human interactions with their environment.

It also means that efforts must be taken to protect an environment &• to maintain its stability from the hazardous chemical pollutants.

Functions of environment

Life supporting medium for all organisms.

Provides food, air, water & other important natural resources to the human beings.

Disintegrates all the waste materials discharged by the modern society

Moderates the climatic condition of the soil.

A healthy economy depends on a healthy environment.

Environmental problems

1) Deforestation activities
2) Population growth & urbanization.

3) Pollution due to discharge of effluent & smoke discharge from the industries.

4) Water scarcity.

5) Land degradation & degradation of soil fertility.

Solutions to Environmental problems

1) Reduce the waste of matter & energy resources.

2) Recycle & reuse as many of our waste products & resources as possible.

3) Over-exploitation of natural resources must be reduced.

4) Soil degradation must be minimized.

5) Biodiversity of the earth must be protected.

6) Reduce population & increase the economic growth of our country.

Ethical guidelines:

1.You should love & honor the earth since it has blessed you with life & governs your survival.

2. You should keep each day sacred to earth & celebrate the turning of its seasons.

3. You should not hold yourself above other living things & have no right to drive them into extinction.

4. You should be grateful to the plants & animals which nourish you by giving you food.

5.You should not waste your resources on destructive weapons.

6.You should not steal from future generations their right to live in a clean & safe planet by polluting it.

GREEN CHEMISTRY: Green chemistry is the chemistry that involves developing and protection of chemicals without polluting the environment. Green chemistry is the pollution free chemistry.

GOAL (or) 12 PRINCIPLES OF GREEN CHEMISTRY:

1.Prevention of wastes: Better to prevent waste than to treat or clean up the waste.

2.Atom economy: Synthetic methods should be designed to incorporate all materials to get final product.

3Less hazardous chemical systhesis: Synthetic methods should be designed to produce hazardous free products.

4.Designing safer chemicals: Chemical substances should be designed to affect their desired functions during minimizing their toxicity.

5.Safer solvents and auxillaries: The use of toxic substances should be avoided.

6.Design for energy efficiency: Energy requirement during the chemical process should ne minimized.

7.Use of renewable feedstock: Raw material should be renewable.

8.Reduce derivatives: Unnecessary derivatives should be minimized or avoided.

9.Catalysis: Catalytic reagents are superior to stoichiometric reagents.

10.Design for degradation: At the end of the reaction, the chemical substances break into harmless products.

11.Real time analysis for pollution prevention: Analytical methodologies used to be developed.

12.Inherently safer chemistry for Accident prevention: Chemicals should be chosen to minimize the chemical accidents.

NUCLEAR ACCIDENTS AND NUCLEAR HOLOCAUST:

NUCLEAR ENERGY: Energy released during a nuclear reaction is called nuclear energy.

The most serious hazard to human & environmental health from the nuclear accident is the release of large amounts of nuclear energy & radioactive products into the atmosphere.

Type of nuclear accidents

Nuclear test :

Nuclear explosions carried out in underground cause settling down the radioactive materials on the earth's surface & radioactive particles, radioactive rays into the atmosphere.

Nuclear power plant accidents

Radiation get released during this accident.

The nuclear power plant located in the seismic vulnerable areas cause nuclear accidents.

Improper disposal of radioactive waste

Drums stored underground can rust & leak radioactive materials into water, land & air.

Accident during transport : Trucks carrying radioactive wastes or fuels are involved in frequent accidents.

Core melt down : The major accident at a nuclear power plant.

Effect of nuclear radiation

1.Radiation may break chemical bonds such as DNA in cells .

2.Exposure at low dose of radiation (100-250 rads), people do not die, suffer from fatigue, vomiting, lose of hair.

3)Exposure at higher dose of radiation(400-500 rads),affect bone marrow, blood cells, natural resistance blood fails to clot.

4) Exposure at very high dose of radiation (10,000 rads) kills the organism by damaging the tissues of heart, brain.

Nuclear Holocaust

It means destruction of biodiversity by nuclear equipments & nuclear bombs.

In a holocaust, a large number of living beings are totally destroyed as in case of nuclear war.

Effect of nuclear holocaust

Nuclear winter

Nuclear bombardment will cause combustion of wood, plastics, petroleum, forest, etc.,

Large quantity of black soot will be carried to the stratosphere.

Black soot will absorb all UV-radiations & will not allow the radiation to reach the earth cause ill result.

Thus, due to nuclear explosions, a process opposite to global warming will occur. This is called nuclear winter.

Effect of nuclear winter:

Crop productivity will be reduced causing famines & human sufferings.

Lowers the global temperature, even in summer the temperature will be at around freezing temperature.

Examples of Nuclear Holocausts

Nuclear war

Japan, Hiroshima & Nagasaki are the examples of nuclear holocaust, which had happened at 2nd world war.

At Chernobyl

When the operators lost the control of a water-cooled, graphite moderated reactor during a low power tests at Chernobyl in Ukraine, the nuclear reactor exploded.

Chernobyl victims include,

a. 31 deaths at the time.

b.An estimated 2000 extra cases of cancer in Europe over the next 50 years.

c.A much greater loss of life & damage to health can still be attributed to the coal industry.

Control measures

1) Suitable precautions are to be taken & training must be given to people for handling these materials to avoid accident.

2) Constant monitoring of the radiation level has to be carried out.
3) Regular checks & control measures are done by Atomic Energy
4) Regulatory Board under the Department of Atomic Energy.

Waste land Reclamation(Development)

The land which is not in use is called waste land.
The waste land is unproductive, unfit for cultivation, grazing & other economic uses.
About 20% of the geographical area of India is waste land.

Type of waste lands

Uncultivable waste lands

These lands cannot be brought under cultivation.

Examples- baren rocky areas, hilly slopes, sandy deserts, etc.,

Cultivable waste lands

These are cultivable but not cultivated for more than 5 years.

Cultivable waste lands are important for agricultural purposes.

Examples- degraded forest lands, saline lands, water logged & marsh land

Causes of waste land formation

1)Due to soil erosion, deforestation, overgrazing, water logging, salinity.
2)The increasing demand for fire-wood & excessive use of pesticides.
3)Developmental activities like construction of dams & power projects have caused considerable damage to land due to water logging.
4)Over exploitation of natural resources.
5)By the sewage & industrial wastes.
6)Mining activities destroy the forest & cultivable land.
7)Growing demands for fuel, fodder, wood & food cause degradation and loss of soil productivity.

Objectives (or) Need of waste land reclamation

1. To improve the physical structure and quality of the soil.
2.To prevent soil erosion, flooding &landslides
3. To prevent soil erosion, flooding & landslides.
4. To avoid over exploitation of natural resources
5. To improve the availability of good quality of water
6.To conserve the biological resouuces and ecosystem.

7. To provide the source of income to the rural poor.

Methods of waste land reclamation (or) Integrated waste land development programme

Drainage

Excess water is removed by artificial drainage.

This process is used for water-logged soil reclamation.

Leaching

It is the process of removal of salt from the salt affected soil by applying excess amount of water.

Leaching is done by dividing the field in small plots.

In continuous leaching 0.5 to 1.0 cm water is required to remove 90% of soluble salts.

Irrigation practices

High frequency irrigation with controlled amount of water helps to maintain better water availability in the land.

Green manures & biofertilizers

Application of green manure is found to improve the saline soils.

Application of Gypsum

Soil sodicity can be reduced with gypsum.

Calcium of gypsum replaces sodium from the exchangeable sites which converts clay soil to calcium rich soil.

Afforestation programmes

The National Commission on Agriculture (NCA) has launched several afforestation schemes.

The National Development Board has decided to bring 5 million hacres of waste land annually for firewood & fodder plantation.

Social Forestry Programmes

These programmes involve strip plantation on road, canal sides, degraded forest land, etc.

CONSUMERISM AND WASTE PRODUCTS:

Consumerism: Consumerism refers to the consumption of resources by the people.

It is an organized movement of citizens & government.

The special concentration is given to improve the rights & power of the buyers in relation to the sellers.

Consumerism is related to both increase in population size as well as increase in our demand due to change in life-style.

In the modern society our needs have increased & so consumerism of resources has also increased.

Traditionally favourable rights of sellers

1) The right to introduce any product.
2) The right to change any price.
3) The right to spend any amount to promote their product.
4) The right to use incentives to promote their products.

Traditional buyer rights

1) The right to buy or not to buy.

2) The right to expect a product to be safe.

3) The right to expect the product to perform as claimed.

Important informations to be known by buyers

1) Ingredients of a product.
2) Manufacturing date & expiry date.
3) Whether the product has been manufactured against an established law of nature or involved in rights violation.

Objectives of consumerism

It forces the manufacturer to reuse & recycle the product after usage.
The items which are very difficult to decompose like computers, televisions etc., can be returned to manufacturer for reclaiming useful parts & disposing the rest.
The reusable packing materials like bottles can be taken back to the manufacturer.
It makes the products cheaper & avoids littering & pollutions.
Active consumerism improves human health & happiness & also it saves resources.

Sources of wastes

The sources of the waste materials are agriculture, mining, industrial & municipal wastes.

Examples for waste products

Glass, papers, garbage, plastics, soft drink canes, metals, foodwastes, automobile wastes, construction & factory wastes.

E-waste (Electronic & electrical wastes)

Computers, printers, mobile phones, xerox machines,calculators, etc.,

Effects of wastes

1.The wastes released from chemical industries & from explosives are dangerous to human life.
2.The dumped wastes degrade soil & make unfit for irrigation.
3.E-waste contains more than 1000 chemicals, which are toxic & cause environmental pollution.
4.Plastics are difficult to recycle or incinerate safely because they are non biodegradable & their combustion produces several toxic gases.

Factors affecting consumerism & generation of wastes

People over-population

It occurs when there are more people than the available supply of food & water.

Over population causes degradation of resources, poverty & premature death.

This situation occurs in less developed countries (LDCs)

Thus in LDCs per capita consumption of resources & waste generation are less.

Consumption over-population

It occurs when there are less people than the available resources.

Due to luxurious life-style per capita consumption of resources is very high.

If the consumption is more, the generation of waste is also more & greater is the degradation of environment.

ENVIRONMENTAL LEGISLATION & LAWS:

Environmental management requires a strong legal framework inorder to protect our valuable environment from environmental pollution.

Important Protection Acts:

The Government of India and State governments have implemented a number of protection act.

1.Environment Protection Act, 1972

2.Air Act, 1981amended in 1987.

3.Water Act,1974, amended in 1978.

4.Wildlife protection Act, 1972.

5.Forest Act, 1980.

1.Environment Protection Act, 1972

This Act empowers the Central government to fix standards for quality of air, water, soil & noise and to formulate procedures and safeguards for handling of hazard substances.

Objectives of environmental act

a) To protect & improvement of the environment.

b) To prevent hazards to all living creatures & property.

c) To maintain harmonious relationship between humans & their environment.

Important features of Environment act

The Act further empowers the government to lay down procedures & safeguards for the prevention of accidents which cause pollution & remedial measures.

The government has the authority to close or prohibit or regulate any industry or its operation, if the violation of this act occur

The penal sections of the Act contain more stringent penalties such as imprisonment for a term extending to 5 years and fine upto Rupees 1 lakh or both.

If the violation continues, an additional fine of Rupees 5000 per day may be imposed.

The Act fixes the liability of the offence punishable under Act on the person who is directly in charge.

The Act empowers the officer of Central government to inspect the site or the plant or the machinery for preventing pollution & to collect samples of air, water, soil or other material from any factory or its premises for testing.

The Environment (Protection) Act is the most comprehensive legislation with powers for the central government to directly act, avoiding many regulatory authorities or agencies.

Air Act, 1981amended in 1987.

This act deals with the problems relating to air pollution.
It allows the establishment of Central & State Control Boards provided with absolute powers to monitor air quality & pollution control.

Objectives of the Air act

a) To prevent, control & abatement of air pollution.

b) To maintain the quality of air.

c) To establish a board for the prevention & control of air pollution.

Important features of Air act

The Central Board may lay down the standards for the quality of air.

The State Boards are empowered to lay down the standards for emissions of air pollutants from industrial units or automobiles or other sources.

The State Boards also function as inspectorates of air pollution.

The State Boards will examine the manufacturing processes & the control of equipment to verify, whether they meet the standards prescribed.

The State Board can advice the State Government to declare certain heavily polluted areas as pollution control areas & can advice to avoid the burning of waste products which cause air pollution in such areas.

The directions of the Central Board are mandatory on State Boards.

The operation of an industrial unit is prohibited in a heavily polluted areas without the consent of the Central Board.

Violation of law is punishable with imprisonment for a term which may extend to 3 months or fine upto Rs 10,000 or both.

Water Act,1974, amended in 1978.

This act provides for maintaining & restoring the sources of water.

It also provides for preventing & controlling water pollution.

Objectives of the water act

1.Prevention and control of water pollution

2.Maintaining or restoring the water.

3.Estabilishing central and state boards for the prevention of control of water pollution.

Important features of water act

This act aims at, to protect the water from all kinds of pollution & to preserve the quality of water in all aquifers.

Establishment of Central Board & State Boards for prevention of water pollution.

The States are empowered to restrain any person from discharging a pollutant or sewage or effluent into any water body without the consent of the Board.

Violation of this act leads to prison sentence ranging from 3 months to 6 years.

State Pollution Control Board

The approval of the State Pollution Control Board is needed to,

Establishing any industry or any treatment & disposal system or any extension or addition there to, discharge effluent into a stream or well or river or on land.

Use of any new or altered outlet for the discharge of a sew

In case of violation of this act, the State Board can

Send a notice to the concerned organization. Issue orders to closure or stoppage of supply of electricity, water or any other services to the polluting unit.

Non-compliance of the order leads to imprisonment for a term of one & a half years to 6 years & fine of Rs.5000 for everyday if the default continues.

4.Wildlife protection Act, 1972.

This Act is aimed to protect & preserve wildlife.

Wildlife refers to all animals & plants that are not domesticated.

India has rich wildlife heritage which includes 350 species of mammals, 1200 species of birds & about

20,000 known species of insects.

Some of them are listed as ‘endangered species’ in the Wildlife (Protection) Act.

The wildlife is declining due to human actions.

Wildlife populations are regularly monitored & management strategies formulated to protect them.

Objectives of the wildlife Act:

To maintain essential ecological processes and life supporting system
To ensure a continuous use of species
To Preserve biodiversity.

Important features:

The Act covers the rights & non-rights of forest dwellers.
It also prohibits the collection of non-timber forest.
The rights of forest dwellers recognized by the Forest Policy of 1988 are taken away by the Amended Wild life Act of 1991

5.Forest Act, 1980.

This act provides conservation of forests & related aspects.
This act also covers all type of forests including reserved forests, protected forests & any forested land.
This act is enacted in 1980 & aims at to arrest deforestation.

Objectives of forest act

1) To protect & conserve the forest.
2) To ensure judicious use of forest products.

Important features of forest act

The reserved forests shall not be diverted or dereserved without the prior permission of the central government.
The forest land may not be used for non-forest purposes. Any illegal non-forest activity within a forest area can
be immediately stopped under act.

Important features of Amendment Act of 1988

Forest departments are forbidden to assign any forest land 'by way of lease or otherwise to any private person' or non-government body for re-afforestation.
Clearance of any forest land of naturally grown trees for the purpose of re-afforestation is forbidden.
The diversion of forest land for non-forest uses is cognisable offence & any one who violates the law is punishable.

There are number of environmental laws in the form of Acts for safeguarding our environmental quality.
But we cannot implement it strictly as there are many drawbacks & problems in implementing environmental legislations.

Problems in enforcing the legislation

1)We have not achieved the target of bringing 33% of our land cover under forest.

2) We lose our wildlife continuously.

3)The rivers are now opened to sewer.

4) The air in town is badly polluted.

5) There are many drawbacks in our environmental laws & in their implementation.

Drawbacks of the Wildlife Protection Act, 1972

Since this Act has been enacted just as a fallout of Stockholm Conference held in 1972, it has not included any locally evolved conservation measures.

The ownership certificates for some animal articles (like leopard & tiger skins) often serves as a tool for illegal trading.

Since Jammu & Kashmir has its own Wildlife Act, hunting & trading of many endangered species, prohibited in other states, are allowed in J&K.

The offenders of the Act are not subjected to very harsh fines.

It is just a fine of Rs.25,000 or imprisonment for upto 3 years.

Drawbacks of the Forest (conservation) Act, 1980

This Act just transfers the powers from state to centre to decide the conversion of reserve forest lands to non-forest areas.

The power has been centralized at the top & the local communities have been completely neglected.

The tribals were totally dependent on forest resources. When they were stopped from taking those resources, they involve in criminal activities like smuggling, killing, etc.,

The tribal communities have rich knowledge about forest resources, their importance & conservation. But their role & contribution is not acknowledged.

Drawbacks of Pollution related Act

The power & authority has been given only to central government with little of power to state government.

The penalties is very small when compared to the damage caused by the big industries due to pollution.

Litigation, related to environment is expensive, since it involves technical knowledge.

For small unit it is very expensive to install Effluent Treatment Plant.

The position of chairman of the Board is occupied by political appointee. Hence it is difficult to implement the act without political interference.

Non government organization is a people's organization which is working for the protection of the environment.

The following are some environmental organizations in India.

Voluntary organizations help the government in local environmental issues & interact at grass root level.

The NGO, "mahila mandals", create awareness among the women in remote villages by educating & helping them to become healthy & economically self-dependent.

Kerala Sastra Sahitya Parishad, Centre for Science & Environment (CSE). The report as per CSE on permissible limits of pesticides in the cola drinks sensitized the public all over the country.

- Bombay Natural History Society (BNHS), Madras Naturalists Society (MNS), Chennai, World Wide Fund for Nature (WWF), India are some of the NGOs taking many steps for the environmental protection & health.
- Chipko movement works for the conservation of trees by Darholi Gram Swarajya Mandal in Gopeshwar.

Central & state pollution control boards takes many step to control pollution.

Functions of Central Board

It advises the central government regarding the prevention of pollution.

It plans for the prevention & control of pollution.

It establishes labs for the analysis of air & water samples.

It provides technical assistance & guidance to state boards & sponsor research regarding water, air pollution.

It identifies areas or industries causing air pollution.

It encourages industries to recycle & reuse the wastes.

It also advises the industries to treat waste water & gases with modern technology.

Functions of the State Board

It advises the state government on any matter concerning the prevention & control of pollution.

It has the right to inspect at all times any pollution control equipment, industrial plant & gives orders to take the necessary steps to control pollution.

It encourages research & investigations regarding pollution.

It organises educational programme in collaboration with central board.

The analyst of the board is expected to analyze the sample, sent to him & submit a report to the board & industry.

ENVIRONMENTAL AUDIT:

Environmental audits are intended to qualify the environmental performance and position. It aims to define what needs to be done to improve environmental performance and position.

Types:

Liability audit: It assess compliance with legal obligations

A Management audit: It vefifies that an environmental management strategy meets its states objectives.

A Functional audit: It investigates a specific area such as energy or water use.

BIO-MEDICAL WASTE:

Bio medical wastes are one type of biowaste generated from health care activities. It may be solid or liquid in nature also be hazardous or non hazardous. It must be properly managed and disposed off safely to protect the environment. If it is not properly treated, produces many infectious diseases.

Bio medical waste rules 1998 and amendments:

In order to regulate the disposal of biomedical wastes, MEF(Ministry of Environment and Forest) Govt, of India notified biomedical wastes Rules 1988 and amended in 2000. These rules apply to all hospitals, nursing homes, laboratories, etc.

Steps involved in management of biomedical wastes:

1. Generation and accumulation

2.Handling and Storage

3.Transport and Disposal.

1. Generation and accumulation

Bio medical waste generated by health care centres should be collected in the containers which are leak proof and strong to prevent breakage during handling. It should not be mixed with other waste.

Containers of biomedical wastes are marked with bio hazard symbol. The colour of marking is red .

Discarded sharp materials are collected in specified boxes called needle boxes.

Types of biomedical waste:

Category No.	Types of wastes	Example	Treatment of disposal
1	Human anatomical wastes	Body parts, organs, body tissues	Incineration or deep burial
2	Animal waste	Body parts. Bleeding parts. Body fluid	Incineration or deep burial
3	Microbiology and Biotechnology waste	Wastes from laboratory culture, specimen of microorganism	Microwaving or incineration
4	Waste sharps	Needle, Syringes, balde, glass	Disinfection or microwaving
5	Discarded medicines and cytotoxic drugs.	Outdated wastes, contaminated medicines	Incineration or microwaving
6	Solid waste	Contaminated blood parts, cotton	Incineration or microwaving or Autoclaving
7	Liquid waste	Laboratory washing, cleaning	Discharged into drains
8	Incineration ash	Ash of any bio medical waste	Disposal in municipal landfill
9	Chemical waste	Chemical used in hospitals, laboratories	Chemical treatment.

2.Handling & Storage:

Handling refers to the act of manually moving biomedical waste between the point of generation, accumulation areas, storage locations and onsite treatment facilities.

No untreated biomedical wastes should be kept and stored beyond a period of 48 hours.

3.Treatment of Disposal:

Treatment occurs in two places. 1.On-site treatment 2.Off-site treatment.

1.On-site treatment : It involves use of relatively expensive equipments and is used only by very large hospitals and major universities.

2.Off-site treatment : It involves hiring of a biomedical waste disposal service.

Type of treatment:

1.Incinerator: It will destroy pathogens and sharps.

2.Autocalve: It uses steam and pressure to sterilize the waste or reduce its microbiological contents.

3.For liquids 1-10% solution of bleach load can be used to disinfect biomedical wastes.

Disposal: Waste liquids may be disposed off to a sanitary sewer leads to a sewage treatment plant.

SCHEME OF LABELLING ENVIRONMENTALLY FRIENDLY PRODUCTS:

Environmentally friendly products are generally indicated by the symbol(logo) called Eco Mark. Eco-mark is a certification mark issued by the Bureau of Indian standard(BIS) to the environmental friendly products.

Logo for eco-mark in India:

Objectives of the Scheme:

The specific objectives of the scheme are as follows:-
(i) To provide an incentive for manufacturers and importers to reduce adverse environmental impact of products
(ii) To reward genuine initiatives by companies to reduce adverse environmental impact of their products.
(iii) To assist consumers to become environmentally responsible in their daily lives
(iv) To encourage citizens to purchase products which have less harmful environmental impacts.
(v) Ultimately to improve the quality of the environment and to encourage the sustainable management of resources.

Requirements for awarding ecomark:

1.Sources of rawmaterials
2.Production process
3.Use of natural resources.
4.Energy conservation in the production of products.
5Disposal of wastes.
6.Utilisation of wastes and recycled materials
7.Product to be accompanied by detailed instructions for proper use.
8.Bio-degradability.

Procedure for obtaining Ecomark:

1.The procedure for grant of licence is the same as applicable for grant of licence by BIS for its product certification mark scheme.
2.Licence will be granted initially for one year and is renewable.
During the licence period, officers will inspect and if they find deviation, action as provided under the BIS Act is taken.

PUBLIC AWARENESS:

Our environment is presently degrading due to many activities like pollution, deforestation, overgrazing, rapid industrialization & urbanization.

In order to conserve our environment, each & every one must be aware about our environment problems & objectives of various environmental policies at national & local levels.

Objectives of public awareness

To create awareness among people of rural & city about ecological imbalances, local environment & technological development.

To organise meetings, group discussion on development, tree plantation programmes, exhibitions.

To focus on current environment problems & situations.

To learn to live simple & eco-friendly manner.

Methods to create Environmental Awareness.

Environmental awareness must be created through formal & informal education to all sections of the society.

The various methods that is useful for raising environmental awareness are discussed here.

1) Environmental awareness in schools & colleges

2) Through mass media

3) Cinema

4) News papers

5) Voluntary organizations – NSS, NCC, Rotary club

6) Traditional techniques – folk plays, dramas for rural people

7) Competitions – story and essay writing & painting competitions on environmental issues.
8) Leaders appeal – political leaders, cine actors & popular social reformers

9)Non-government organizations (NGOs)

UNIT V - HUMAN POPULATION

POPULATION: It is defined as a group of individuals belonging to the same species, which live in a given area at a given time.

Population Density : It is expressed as the number of individuals of the population per unit area (or) per unit volume. This varies in response to changes in the environment and introduction with other living organisms.

Parameters affecting population size

Changes in population are governed by 4 main parameters. They are

1. **Birth rate (or) Natality:** It is the number of live birth per 1000 people in a population in a given year.
2. **Death rate (or) Mortality:** It is the number of deaths per 1000 people in a population in a given year.
3. **Immigration:** It denotes the arrival of individuals from neighbouring population.
4. **Emigration:** It denotes the dispersal of individuals from the original population to new areas.

POPULATION GROWTH

The rapid growth of the global's population for the past 100 years results from the differences between the rate of birth and death.

Causes of rapid population growth

The rapid population growth is due to decrease in death rate and increase in birth rate.
The availabllity of antibiotics, clean water and air decreses the famine-related deaths and infant mortality.
In agricultural based countires childrens are required to help parents in the fields that is why population increased in the developing countries.

Characteristics of Population Growth.

Exponential growth: Now population growth occurs exponentially like $10,10^2,10^3,10^4$ etc., which shows the dramatic increase in global population in the past 160 years.

Doubling Time: It is the time required for a population to double its size at a constant annual rate. It is calculated as follows.

T_d (Doubling time) = 70/r

Where r = annual growth rate
(OR) It is the number of years needed for a population to double its size

If the nation has 2% annual growth its population will double in next 35 years.

The doubling time for India is about 28 years.

Infant mortality rate: It is the percentage of infants died out of those born in one year. Eventhough this rate has decreased in the last 50 years, the pattern differs widely in developing and developed countries.

Total fertility rates(TFR): It is the average number of children delivered by a women in her life time. The TFR value varies from 2 in developed countries to 4.7 in developing countries.

Replacement level: Two parents bearing two children will be replaced by their off spring. Due to infant mortality this replacement level is changed. But, due to high infant mortality the replacemnt level is generally high in developing countries.

Male-Female ration: The ratio of girls and boys should be fairly balanced in a society to flourish. But the ratio has been upset in many countries including China and India. In China the ratio of girls and boys is 100:140.

Demographic transition: Population growth is generally related to economic development. The death rates and birth rates fall due to improved living conditions. This results in low population growth This phenomenon is referred to as demographic transition.

Problems (environmental isssues) of population growth

1. Increasing demands for food and natural resources.
2. Inadequate housing and health services.
3. Loss of agricultural lands.
4. Unemployment and socio-political unrest.
5. Environmental pollution

VARIATION OF POPULATION AMONG NATIONS.

At present the world's population has crossed 6 billions. This existing population is also not evenly distributed, less developed countries have 80% population while the developed countries have only 20%.

Less developed coutries (Africa, Asia, South America) have 80% of the total world population and occupy less than 20% of the total land area.

In the most developed countries like U.S.A., Canada, Australia, the population increases at the rate of less than 1% per year. But in less developed countries like South America, Africa and Asia, the population increases at the rate greater than 1% per year.

Variation of Population based on Age structure.

Age structure of population can be classified into three classes.

Pre-productive population (0-14 years).

Reporductive population (15-44 years)

Post reproductive population (above 45 years)

Variation of population is now explained based on the above three classes.

1.Pyramid shaped variation of population (Increase) :Example: India, Bangladesh, Ethiopia, Nigerria etc.,

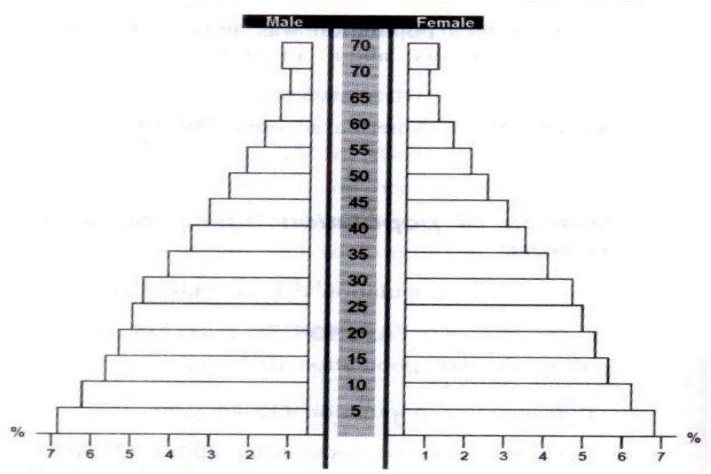


Fig. 7.2 Pyramid shaped variation of population

The fig7.2 shows that the pre-productive age group population (0-14 years) is more, indicated at the base of pyramid and post reproductive age group population (above 45 years) is less, indicated at the top of pyramid. The large number of young age people will soon enter in to reproductive age group population (15-44 years), which **increases the population growth.** But the less number of old age people indicates les loss of population due to death.

2.Bell shaped variation of population (Stable) Example: France, U.S.A., U.K. Cnada etc.,

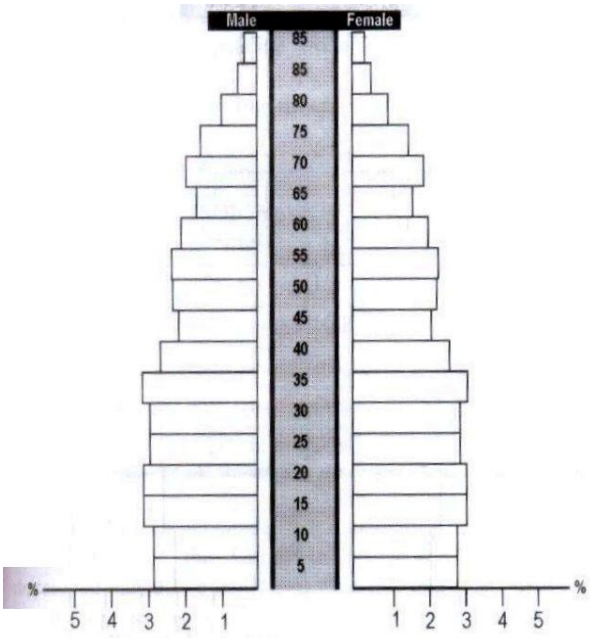


Fig. 7.3 Bell shaped variation of population

The fig 7.3 shows that the pre-productive age group population (0-14 years) and reproductive age group population (15-44 years) are more or less equal. So, the people entering into the reproductived age group will not change the population and thus the population growth is stable.

3.**Urn Shaped Variation of Populatio (decrease)- Examples**: Germany, Italy, Sweden, Japan etc.,

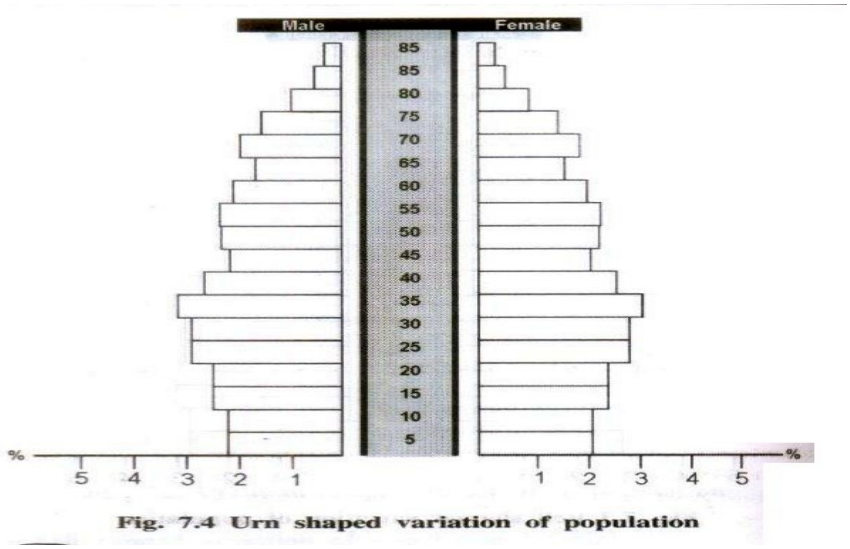


Fig. 7.4 Urn shaped variation of population

The fig 7.4 shows that the pre-productive age group population (0-14 years) is smaller than the reproductive age group population (15-44 years). In the next 10 years , the number of people in the reproductive age group is less than the before, resulting in a **decrease of population growth.**

POPULATION EXPLOSION

Definition: The enormous increase in population due to low death rate (mortality) and high birth rate (Natality), is termed as **population explosion**. The human population is not increasing at a uniform rate in all parts of the world.

Doubling Time : Population explosion can be better understood by considering the doubling time, i.e., the **number of years needed for a population to double in size.** The table below shows the doubling times of population growth.

Less developed Country		**Developed Country**	
Country	**Doubling Time**	**Country**	**Doubling Time**
India	28 yrs	United State	87 yrs
Turkey	28 yrs	U.K.	231 yrs
Nigeria	27 yrs	Italy	99 yrs
Saudi Arabia	25 yrs	France	117 yrs
Pakistan	21 yrs	Japan	58 yrs

The human population is not increasing at a uniform rate in all parts of the world. In many non-industrial, poor developed called **less developed countries** like Asia, Africa and South America shows higher growth rate. In contrast the population of industrialized **developed countries** like U.S. A. U.K., France, Italy, Soviet Union the growth rate is low.

Causes (or) reasons of population explosion

1. Invention of modern medical facilities reduces the death rate (mortality) and increases the birth rate (Natality), which leads to population explosion.
2. Increase of life expectancy is another important reason for the population explosion.

Example: In 1950, the average life expectancy of the human being was 40 years. But now it is 61 years.

3.Illiteracy is one of the reasons for the population explosion.

Effect of population Explosion

1. **Poverty:**
   Infant mortality is one of the most tragic indicators of poverty. There are still 34 developing countries where more than 1 in 10 children die before he (or) she reaches the age of five. In developing countries few mothers opt for smaller families in the face of such high infant mortality rates. Efforts to keep children alice and healthy are one of the keys to reduce population growth rate.
2. Population explosion leads to environmental degradation.
3. Population explosion causes over exploitation of natural resources. Therefore there will be a shortage of resources for the future generation
4. Many of the renewable resources like forsts, grasslands, are also under threat.
5. The increase in population will increase disease, economic inequity and communal war.
6. Over crowding of cities leads to development of slums.
7. Lack of basic amenities like water supply and sanitation, education, health etc.

8. Unemployment and low living standard of people

Remedy : We should immediately reduce the fertility rate through birth control programs.

Family Welfare Programme :

Family Welfare Programme was implemented by the Government of India as a voluntary programme. It is an integral part of overall national policy of growth covering human health, maternity, family welfare, child care and women's right.

Objectives of Family Welfare programme

1. Slowing down the population explosion by reducing the fertility
2. Pressure on the environment due to over exploitation of natural resources is reduced.

Population stabilization ratio

The ratio is derived by dividing crude birth rate by crude death rate.

Developed countries: The stabilization ratio of the developed countries is 1, which is more or less stabilized indicating zero population growth.

Developing Countries: The stabilization ratiio of the developing countries is nearing 3, which is expected to lower down by 2025.

Stabilisation in developing countries is possible only through various family welfare programmes.

FAMILY PLANNING PROGRAMME: Family planning provides educational and clinical services that help couples to choose how many children to have? And when to have them? Such program vary from culture to culture, but it provides information on birth spacing, birth control and health care for pregnant women and infants. It also has reduced the number of legal and illegal abortion per year and decreased the risk of death from pregnancy.

Objectives of Family Planning Programmes (OR)Factors influencing family size.

1. Reduce infant mortality rate to below 30 per 1000 infants.
2. Achieve 100% registration of birth, deaths, marriage and pregnancy.
3. Encourage late marriages and later child-bearing.
4. Encouraging breast feeding.
5. Enables to improve women's health, education, employment.
6. Making family planning available to all women, also wanted to choose the number of children and the spacing of births.
7. Constraint the spread of AID / HIV.
8. Prevent and control of communicable diseases.
9. Promote vigorously the small family norms.
10. Making school education upto age 14 free and compulsory.

Fertility control methods (or) Methods of family planning (Sterilization)

1. **Traditional method**

   It includes some traditions like taboos and folk medicine

2. **Modern Method**

   (i) **Permanent method:** Permanent method (or) sterilization is done by minor surgery.

   (a) **Tubectomy:** It is female sterilization done by tying the tubes that carry the ovum to the uterus.

   (b) **Vasectomy:** It is male sterilization done by tying the tubes that carry the sperm.

   Both are very simple procedures done under local anesthesia which are painless and patients have no post operative problems.

   (ii) Temporary method

   (a) **Condoms:** Condoms are used by males to prevent sperms.

   (b) **Copper Ts:** Copper Ts are small objects and can be placed by a doctor in the uterus so that the ovum cannot be implanted, even if fertilized. They do not disturb any functions in the woman's life.

   (c) **Oral contraceptive pills** and injectable drugs are available that prevent sperms from fertilizing the ovum.

Family planning Programme in India

1. In 1952, India started the family planning programme.
2. In 1970's Indian Government forced family planning programme.
3. In 1978, the government legally raised the minimum age of marriage for men from 18 to 21 years and for women 15 to 18 years.
4. In 1981, census report showed that there was no drop in population. Since then funding for family planning programmes has been increased further.

ENVIRONMENT AND HUMAN HEALTH

Human health and environment are two inseparable entities. If one get disturbed other will be automatically disturbed. A person is not suffering from any disease is called a healthy person. But the factors like nutritional, biological, chemical or psychological which causes harmful changes to the body conditions are called disease

Factors Influencing human health : Human health is influenced by

1. Nutritional factors
2. Biological factors
3. Chemical factors
4. Psychological factors

Environmental degradation due to population explosion

It is caused by dramatic increase in the world population and population densities in different parts of the world. 15% of the world's population controls 85% of the natural resources. This leads to more exploitation of natural resources. People living in urban areas

produce little food but consume more natural resources and generate more wastes, polluting the environment. Earth surface and the surrounding environment is very important to human health. The environment is polluted due to man made activities, millions of people die every year due to illness caused by environment pollution.

Important Hazards and their Health effects(OR) Deterioration of environment and Health effect.

Physical hazards and their health effects

S.No:	Physical hazards	Health effects
1	Radioactive radiations	i) Affects the cells in the body and the function of glands and organs ii) Suffer from cancer
2	UV radiation	Skin cancer
3	Global warming	Temperature increases cause famine, mortality
4	Noise	Painful and irreparable damage to human ear

Chemical hazards and health effects

S.No:	chemical hazards	Health effects
1	Combustion of fossil fuels: Liberates SO_2, NO_2, CO_2 and particulate matters	Asthma, bronchities and other lung disorders
2	Industrial effluents (toxic)	Kill cells and cause cancer and death
3	Pesticides like DDT and chlorinated pesticides	Affect the food chain
4	Heavy metals like Hg, Cd, Pb, fluoride, nitrate	Contaminate water, cause ill effects
5	Choloro fluorocarbons	Damage O_3 layer, allows more UV rays, cause skin cancer

Biological hazards

S.No:	Biological hazards	Health effects
1	Bacteria, viruses and parasites	Diarrohea, malaria, parasitic worms, anaemia, respiratory diseases , cholera

Preventive measures

1. Always wash your hands before eating
2. Cut short and clean your nails
3. Maintaining the skin, tooth, hair of our body
4. Drinking chemically treated and filtered water
5. Before cooking wash the raw vegetables and fruits with clean water
6. Try to avoid plastic containers and aluminium vessels
7. Do physical exercise to have proper blood circulation in the body.

NIMBY Syndrome

NIMBY means Not In My Back Yard, which describes the opposition of residents to the nearby location of something they consider undesirable even if it is clearly a benefit for many.

Example: An incinerator, an ethanol plant, a nuclear power plant, a prison.

An airport is a typical example of a NIMBY complex. It benefits a city economically, but no-one wants it near them because of the noise pollution and traffic it generates.

HUMAN RIGHTS

Human rights are the fundamental rights which are possessed by all human beings irrespective of their caste, nationality, sex and language.

These rights cannot be taken away by any legislation or any government act. As natural rights they are seen as belonging to men and women by their very nature.

India is a democratic country. The aim of our government is to ensure happiness to all the

Citizens with equal rights, opportunities ad comforts. Every citizen must enjoy certain rights and also has certain duties towards the country.

Universal Declaration of Human Rights: Universal Declaration of Human Rights (UNDHR) by the UN was established in 1948.

Some of the declarations of Human Rights which are globally accepted are as follows:

1. Human right to freedom
2. Human right to property
3. Human right to freedom of religion

4. Human right to culture and education
5. Human right to constitutional remedies
6. Human right to equality
7. Human right against exploitation
8. Human right to food and environment
9. Human right to good health

Human right to freedom

1. Every citizen has the freedom to express his views
2. They have freedom to form unions or association
3. They have freedom to build their houses
4. They have full right to start any profession

Human right to property: Every human beings has the right to earn property.

Human right to freedom of religion: Every citizen has the freedom to choose their religion according to his wishes. All religions are equal before the law.

Human right to culture and education: All the citizens have equal rights both in culture and education. The minority communities like Christians, Muslims have their own rights to conserve the culture, language and to establish educational institutions of their own choice.

Human right to constitutional remedies: If a citizen is denied any of these fundamental rights, he or she can go to the court for protection. The court has the power to protect the basic rights of the citizen.

Human right to equality: All citizens are equal before the law. There is no any discrimination on grounds of religion, caste, sex (or) place of birth. All are given equal opportunity for employment.

Human right against exploitation: Children should not be employed as labours. Every citizen has the right to fight against exploitation.

Human right to food and environment: All human beings have the right to get sufficient healthy food, safe drinking water and healthy environment

Human right to good health: All human beings have the right to have very good physical and mental health.

INDIAN CONSTITUTION

Indian constitution provides for civil, social, cultural, educational and political rights including the right to judicial enforceability.

1. **Article 14:** It provides for equality before law.
2. **Article 15:** It prohibits discrimination on the grounds of race, religion, caste,sex or place of birth.

3. **Article 16:** It provides for equal opportunity for all citizens in matters related to employment.
4. **Article 19:** It provides for freedom of speech and expression, forming associations and unions and so on.
5. **Article 20:** It provides for protection from conviction except in accordance with the law of the land.
6. **Article 22:** It lays down the rights of a person in custody
7. **Article 23:** It prohibits traffic in human beings and all other forms of forced labour.
8. **Article 24:** It prohibits the explosion of labour children.
9. **Article 25:** It guarantees freedom t profess, practice and propagate a religion of one's choice.
10. **Article 26:** It authorize the right to establish and maintain charitable and religious institutions.
11. **Article 27:** It prohibits compulsion for pay any tax meant for promotion of any religion etc.,
12. **Article 28:** It guarantees the secular character of instruction in educational institutions etc.,
13. **Article 29:** It guarantees to the minorities , the right to conserve their language etc.,
14. **Article 30:** It guarantees the right of linguistic minority and religions to establish and administer educational institution etc.
15. **Article 32:** It provides for right to constitutional remedies for the enforcement of fundamental rights by appropriate proceeding in the Supreme court of India.

Consistent with these provisions, the Central and State governments have framed a number of laws to preserve and safeguard basic human rights. Government of India has set up national institutions such as National commission for scheduled castes and scheduled tribes. National Commission for women, Minority Commissions etc., for the promotion and protection of the interests of most vulnerable section of society.

VALUE EDUCATION

Education: It is nothing but learning through which knowledge about the particular thing can be acquired. With the help of our knowledge and experience we can identify our values to understand ourselves and our relationship with others and their environment.

Types of Education:

1.Formal education: All learning process in formal education are self related. All people will read, write, will get good Formal education: All learning process in formal education are self related. All people will read, write, will get good jobs and tackle any problem only with the help of formal education.

2.Value education: It is an instrument used to analyze our behaviors and provide proper direction to our youths. It teaches them the distinction between right and wrong, to be compassionate, helpful, loving, generous and tolerant. So that a youth can move towards the sustainable future.

Example: If a person is highly qualified, well employed and rich living style, sometimes he does not know to behave properly with his environment. But, value education does this properly with this environment. But, value education does this.

3.**Value-based environmental education:** Environmental education provide knowledge about the principles of ecology, fundamentals of environment and biodiversity. It creates a sense of duty to care for the natural resources and to manage them in a sustainable way.

When environment gets degraded it affects our health, well-being and our future. So, it is important to know all about the environment and also have a right to safe and clean environment.

Objectives (or) Importance of Value education

1. To improve the integral growth of human being.
2. To create attitudes and improvement towards sustainable lifestyle
3. To increase awareness about our national history, our cultural heritage, constitutional rights, national integration, community development and environment.
4. To create and develop awareness about the values and their significance and role.
5. To understand about our natural environment in which how land, air and water are interlinked.
6. To know about various living and non-living organisms and their interaction with environment.

Concept of Value education

The following are the concepts of values in environmental education.

1. Why and how can we use less resources and energy?
2. Why do we need to keep our surroundings clean?
3. Why should we use less fertilizers and pesticides in farms.
4. Why it is important for us to save water and keep our water sources clean.
5. Separate our garbage into degradable and non-degradable types before disposal.

Methods (Elements) of imparting value education

1. **Telling:** It is a process of developing values to enable a pupil to have a clear picture of a value-laden situation by means of his own narration of the situation.
2. **Modeling**: It is a method in which a certain individual perceived as ideal values is presented to the learners as a model
3. **Role playing:** Acting out the true feelings of the actor/actors by taking the role of another person but without the risk of reprisals.
4. **Problem solving:** It is a method where a dilemmais presented to the learners asking them what decisions they are going to take.
5. **Studying biographies of great man:** This method makes use of the lives of the great man as the subject matter for trying to elicit their good deeds and thoughts worthy for emulation.

Types of Values

1. **Universal values (or) Social values:** Universal values tell us about the importance of the human condition. These values are reflected in life, joy, love, compassion, tolerance, service, truth etc..
2. **Cultural values:** It varies with respect to time and place. These values are concerned with right and wrong, good and bad, true and false and behaviour of human beings. It is reflected in language, aesthetics, education, law, economics, philosophy etc.
3. **Individual values:** Individual values are our personal principles and the result of individual personality and experiences. Parents and teaches are the main key to shape our individual values. It is reflected in individual goals, relationships, commitments etc.
4. **Global Values:** Global values stress the concept , that the human civilization is a part of the planet and similarly nature and natural phenomena over the earth are interconnected and inter-linked with special bonds of harmony
5. **Spiritual Values:** It promotes conservationism and transform our consumeristic approach. It is reflected in self-restraint, self-discipline, contentment, reduction of wants.etc.

HIV/AIDS

AIDS is the abbreviated form for **Acquired Immune Deficiency Syndrome** caused by a virus called **HIV (Human Immune deficiency Virus).** Many myths have been spread about AIDS and it is very important for every one to know the facts about

HIV and AIDS.

Origin of HIV / AIDS

AIDS was discovered in 1983. Through sufficient knowledge has been gained about the disease, yet a definite source of this virus could not be identified. But the following theories have been suggested.

1. **Through African Monkey:**
   Most of the evidence have been suggested that the AIDS has spread from Africa. It has been believed that the HIV has transferred to human from African monkey (or) Chimpanzees.
2. **Through Vaccine Programmes**
   - **(i)** HIV has spread in Africa through HIV contaminated polio vaccine prepared from monkey's kidney.
   - **(ii)** It had spread through hepatitis-B viral vaccine in Los Angels and New York.
   - **(iii)** It had also spread through small pox vaccine programme of Africa.

World Scenario

Nearly 90% of the people who are infected with AIDS live in developing countries. 13% of world's population live in Africa, almost all states of African countries were affected by HIV. About 3 million people so far died due to HIV/AIDS in 2003. AIDS is rapidly spreading in eastern Europe and Asia. India ranks 2nd in the world with 5.1 million

HIV/AIDS affected people. The percentage is lower than Thailand, Myanmar and South Africa.

Scenario in India:

The largest number of infected cases have been found in Maharashtra and TamilNadu, followed by Delhi, U.P., Karnataka and Goa. In TamilNadu alone, till September 2003 a total of 24,667 cases of AIDs have been found out.

Factors influencing modes of Transmission of HIV

HIV is spreading due to the following activities.

1. HIV from infected person can pass to a normal person through blood contact, generally during unprotected sex with infected person.
2. Using needles or syringes contaminated with small quantities of blood from HIV positive person also transmit HIV to others.
3. HIV can also pass from infected mothers to their babies during pregnancy delivery or breast feeding.
4. Blood transfusion from the infected person at the time of accidents or pregnancy also result in HIV/AIDS
5. HIV is 2 to 4 times more efficient than female to male transmission.
6. Women around 18-20 years are at more risk, since their cervical tissue is more vulnerable to invading HIV
7. Since, the majority of HIV infections occur in women of child-bearing age, transmission of HIV to their new born babies happen easily.

Factors Not influencing transmission of HIV

HIV is not spreading by the following activities

Tears, food and air, cough, handshake, mosquito, flies, insect bites, urine, saliva during normal kissing, sharing of utensils, clothes toilet, bathroom etc.,

Functions of HIV in Human Body

AIDS itself does not kill humans. The death occur due to the attack by diseases because of the weakening of immune system.

White Blood Cell (WBC) responsible in the formation of antibodies are called **T-helper cells,** T-helper cells are the key infection fighters in the immune system. The HIV enter into the human body and destroys the T-cells as a result of which various types of infection diseases occur. Even cancer can easily develop in the HIV infected persons.

Symptoms (or) Diagnosis of HIV/AIDS

Many people have no symptoms when they are first infected with HIV. But some people get fever, headache, fatigue. During this time, HIV is present in large amounts in semen and vaginal fluids and it is very easy to pass the infection to another person.

HIV is very active inside a person's body. The virus multiplies and kills more and more T-cells of the immune systems. Consumption of alcohol increases, the susceptibility to infection and progress of AIDS.

Minor Symptoms

1. Persistant cough for more than one month.
2. General skin disease
3. Viral Infection
4. Fungus infection in mouth and throat
5. Frequent fever, headache, fatigue.

Major Symptoms

1. Fever , Diarrhea for more than one month
2. Cough and TB for more than 6 months
3. Fall of hairs from the head
4. 10% body weight get reduced within a short period

Control and Preventive measures of AIDS

Once a person is infected with HIV the person remain infected for life. There is neither cure nor a vaccine but can be prevented. "Prevention is better than cure" is a slogan for all of us.

The basic approaches to control AIDS are

Education: Health education enables people to avoid indiscriminate sex and encourages the use of condoms. One should avoid the use of sharing razors, needles and syringes.

Prevention of Blood borne HIV Transmission: People in high risk groups should not donate blood. Blood should be screened for HIV before transmission and strict sterilization practices should be followed in hospitals.

Primary Health Care: AIDS awareness programmes should be encouraged. Voluntary health agencies should participate in large. Training programmes to doctors and paramedical workers should be conducted.

Counselling Services: Counselling services should be provided either in person or through telephone.

Drug Treatment: Testing HIV positive does not mean the end. They can still stay healthy leading productive lives for many years. Seeking early medical care and staying active are very vital in managing HIV. The immune system has to be kept boosted by taking nutritious diet and maintaining a stress-free mind.

Effects of HIV/AIDS

1. Large number of death occurs which affect environment and natural resources.

2. Due to large number of deaths, there is loss of labour and level of production decreases.
3. More water is required for maintaining hygiene in AIDS affected locality.
4. The people affected by HIV cannot perform work well due to lack of energy and frequent fever and sweating.

WOMEN WELFARE:

The main aim of women welfare is to improve the status of the women by providing Opportunities in education, employment and economic independence.

Need for women welfare

Generally women faces the following problems in the society.

1. Generally women suffer gender discrimination and devaluation at home, at workplace, in matrimony, in public life and power.
2. High number of cases of dowry deaths, rape, domestic violence, criminal offences and mental torture to women.
3. The human rights of women are violated in the male dominated society.
4. Generally in policy making and decision making process women are neglected.

Objectives of Women welfare (OR) Necessity of formation of women self help group

To overcome the above problems, a sound national strategy is needed with the following objectives.

1. To provide education
2. To impart vocational training
3. To generate awareness of the environment
4. To improve the employment opportunities
5. To know the problems of population
6. To restore the dignity, status, equality and respect for women.

Objectives of a National Commission for Women created by Government of India

A National commission for Women has been created by Government of India, its main objectives are:

1. To examine constitutional and legal rights for women
2. To review existing legislations
3. To sensitize the enforcement and administrative machinery to women's causes.

Environmental Degradation and Women welfare

The development work not only affects the natural environment but also affects the traditional, social, cultural and family life of women.

Example1: For various developmental activities like construction of dams , losing the forest cover, men generally migrate to towns for some job while the women are left h migrate to towns for some job while the women are left behind to look after their family with little resources.

Example 2: Mining projects play havoc with the life of rural women. Men can still work in the mines or migrate to towns for same job after getting compensation from the government. The displaced women are the worst affected as they do not get any compensation and depend on the men for wages.

Measures (or) Various schemes of various Organizations towards Women Welfare

1. **The National Network for women And Mining. (NNWM):** It is fighting for a "gender audit" of India's mining companies.
2. **United Nations Decade for Women:** It witnessed inclusion of several women welfare related issues on international agenda.
3. **International Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW):** It has created an international standard for the protection and promotion of women's human and socio-economic upliftment.
4. **Non-Government Organizations (NGO's) as Mahila Mandals:** It creates awareness among women of remote villages to empower them, train them, educate them and help them to become economically self-dependent.
5. **Ministry for Women And Child Development:** It aims to work for the up liftment of women by family planning, health care, education and awareness.

CHILD WELFARE

Children occupy nearly 40% of total population. They are considered to be the assets of a society. Of 21 million children born every year in India, 20 million children in our country are estimated to be working as child labours in various hazardous industries like match industry, fire work industry, pottery industry

Reason for Child Labour

1. Poverty: It is the main reason to force these children to work in unhealthy conditions.
2. Want of Money: Parents require money for their family so they are in a position to send their children for work.

Measures (or) Various schemes of various Organizations towards Child welfare

1. **UN convention on Rights of Child (or) International Law:** It formulated a set of international standards and measures to promote and protect the well being of children in our society.

   Rights of the Child: The international law defines right of the child to Survival, participation, development and protection.

   (a) **The right to survival:** It emphasizes on good standards of living, good nutrition and health.
   (b) **The right to participation:** It means freedom of thought and appropriate information to the child.
   (c) **The right to development:** It ensures access to education, childhood care and support, social security and recreation.

(d) **The right to protection:** It means freedom from exploitation, inhuman treatment and neglect.

1. **World summit on children:** It had focused agenda for the well being of the children targeted to be achieved in the beginning of the new millennium.
2. **Ministry of Human Resource Development (MHRD):** It concentrates on child's health, education, nutrition, clean and safe drinking water, sanitation and environment

Environmental degradation and child welfare: Children are most affected due to environmental pollution . Water borne diseases are the biggest threat to children. Around 6 million children are affected by these disease in India. Even the child growing in the mother's womb get affected by environmental toxins.

Centre for Science and Environment (CSE): Its scientific report says "children consume more water, food and air than adults and hence, more susceptible to any environmental contamination". So, it is essential to keep the cleaner environment to our children for the better and healthy life.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) : EIA is defined as a formal process of predicting the environmental consequences of any development projects. It is used to identify the environmental, social and economic impacts of the project prior to decision making.

Objectives of EIA

1. To identify the main issues and problems of the parties.
2. To identify who is the party.
3. To identify what are the problems of the parties.
4. To identify why are the problems arise.

Benefits of EIA

1. Cost and time of the project is reduced.
2. Performance of the project is improved.
3. Waste treatment and cleaning expenses are minimized.
4. Usages of resources are decreased.
5. Biodiversity is maintained.
6. Human health is improved.

The key elements used in the process of EIA are

1. Scoping
2. Screening
3. Identifying and evaluating alternatives
4. Mitigating measures dealing with uncertainity
5. Issuing environmental statements

1. **Scoping:** It is used to identify the key issues of the concern in the planning process at an early stage. It is also used to aid site selection and identify any possible alternatives.
2. **Screening:** It is used to decide whether an EIA is required or not based on the information collected.

3. **Identifying and evaluating alternatives:** It involves knowing alternative sites and alternative techniques and their impacts.

4. **Mitigating measures dealing with uncertainity:** It reviews the action taken to prevent (or) minimize the adverse effects of a project.
5. **Environmental statements:** This is the final stage of the EIA process. It reports the findings of the EIA.

ROLE OF INFORMATION TECHNOLOGY IN ENVIRONMENT

Information technology means collection, processing, storage and dissemination of information. A number of software have been developed to study about the environment. The internet facilities, information through satellites, world wide web and Geographical information systems provide us up-to-date information on various aspects of environment and weather.

Soft wares for environment education

Remote sensing: Remote Sensing is used to gather information about an object without actually coming in contact with it. Any force field like acoustic, gravity, magnetic, electromagnetic etc could be used for remote sensing from laboratory to astronomy. At present the term "remote sensing is used more commonly to denote identifications of earth feature by detecting the characteristics electromagnetic radiation that is reflected/emitted by the earth. Remote sensing data image have been used to derive thematic information on various natural resources and environment. The type and level of information extracted depends on the expertise of the analyst and what he is looking in the data.

Example:

The remote sensing image of land can be used to derive iformation of vegetation cover, water sources, land use , pattern, geological features, soil etc.,

Application of remote sensing

1. **In agriculture:** In India sector sustains the livelihood of around 70% of the population and contributes to about 35% of year net national product. We require judicious and optimal management of both land and water resources along with the use of high yielding variety seeds, optimal fertilizer input, post central etc. Remote sensing can provide valuable information for land and water management.
2. **In forestry:** Sustainable forest management requires reliable information on the type, density and extent of forest cover, wood volume and biomass, forest fire, pest and disease induced losses, encroachment etc., Remote sensing provide all such information clearly.
3. **In Land cover:** Spatial information on land use is required at different scales depending upon the use. Remote sensing data is converted to map, the spatial resolution plays a role in the scale of mapping.
4. **Water resources:** Remote sensing data has been used in many applications related to water resources such as surface water body mapping ground water targetting, wetland,

inventory, flood monitoring, reservoir sedimentation, water quality monitoring, runoff modeling. Snow cover monitoring, irrigation water management and many more.

Database

It is the collection of inter-related data on various subjects. In the computer the information of data base is arranged in a systematic manner that is easily manageable and can be very quickly retrieved.

Applications of database

(a) The Ministry of Environment and Forest

(i) They are compiling a database on various biotic communities.

(ii) Database is also available for diseases like HIV/AIDS, Malaria, Fluorosis etc.,

(b) National Management Information System (NMIS)

They compiled a database on R & D projects along with information about research scientists and personnel involved.

Environmental Information System (ENVIS)

It functions in 25 centres all over the country. They generate a network of database in areas like pollution control, clean technologies, remote sensing, biodiversity, environmental management, desertification etc.,

Geographical Information System (GIS)

"GIS is a technique of superimposing various thematic maps using digital data on a large number of inter-related aspects."

Application of GIS

1. Different thematic maps containing digital information on various aspects like water resources, soil type, forest land, cropland, grassland are superimposed on a layered form in computer using soft wares.
2. Interpretation of polluted zone, degraded lands can be made based on GIS.
3. GIS can be used to check unplanned growth and related environmental problems.

Satellite Data

1. Satellite data helps in providing correct and reliable information about forest-cover.
2. It also provide information of atmospheric phenomena like monsoon, ozone layer depletion, smog. etc.

3.From the satellite data many new reserves of oil, minerals can be discovered.

World wide web

More current ata is available on world wide web.

Important on-line learning Centre

1. www.mhhe.com/ environmental science.
2. Multimedia Digital Content Manager (DCM) in the form of CD-ROM.

Applications

1. These on-line learning centre provides the current and relevant information on principles, problems, queries, application of environmental science.
2. It has digital files of photos, power-point lecture presentation, animations, web-exercises and quiz. These are useful to both students and teachers of environmental studies.

ROLE OF INFORMATION TECHNOLOGY IN HUMAN HEALTH PROTECTION

Introduction

Information Technology plays a key role in human health. It has changed the human life style completely. Many health organizations are turning to package solution of IT for stream inning service oriented work in an effective manner.

The health service technology mainly involves three systems. They are:

1. Finance and accounting
2. Pathology
3. Patent administration: Clinical system

Applications of IT in health services.

1. With the help of IT packages, the data regarding birth and death rates, immunisation and sanitation programme are maintained more accurately.
2. It helps the doctor to monitor the health of the people effectively.
3. The information regarding the out break of epidemic diseases can be conveyed easily.
4. On-line help of expert doctors can be consulted to provide better treatment and services to the patient.
5. With a central control system the hospital can run effectively.
6. Drugs and its replacement can be administered efficiently.

CASE STUDIES:

1. Study on polluted backwaters of Kerala: A part of the back waters present in the Anchutengu-Kodianam Kulam, Kerala has been polluted due to the soaking of coconut-husk for the production of coir fibre. This polluted water has affected the fishery resources to a large event. The environment of the coastal areas covering the polluted and non polluted zones were studies in Indian Remote Satellite(IRS). The IRS data were compared with water quality paramaters such as turbidity, dissolved oxygen, production of H_2S and the primary productivity mechanism. Proper Analysis of these IRS have been carried out and the necessary steps were undertaken for the proper development of aquatic systems.

2.Ocean Colour Monitor (OCM) on Indian Remote Sensing Satellite IRS-P4

The Ocean Colour Monitor (OCM) instrument designed for the IRS-P4 Satellite programme is significantly different from similar instruments built and launched to date.. The OCM is the first instrument to take advantage of pushbroom technology for achieving higher radiometric performance and higher spatial resolution while maintaining a large swath to provide high revisit time for ocean observations. The instrument is mounted on a mechanism to provide tilt in the along track direction to avoid sun glint. The OCM instrument mounted on IRS-P4 will be launched by PSLV and placed in a polar sun synchronous 720 kilometer altitude orbit. Equatorial crossing is at 12 noon ±20 min, descending node. The satellite has provision for data recording onboard and will also transmit real time data to ground stations in X-band. The ground station at Hyderabad, India will acquire data over the Indian subcontinent and the adjacent Arabian Sea and the Bay of Bengal. IRS-P4 OCM data may also be acquired by other ground stations with suitable augmentation / modification. A comprehensive programme for IRS-P4 OCM data utilisation has been drawn up in India along with a host of users. The IRS-P4 OCM data would be extremely useful for estimation of phytoplankton in oceanic /coastal waters, detection and monitoring of phytoplankton blooms, coastal upwelling, suspended sediment dynamics, location of fronts, identification of water mass boundaries and oil pollution. With additional input from other sensors as well as conventional data, IRS-P4 OCM data will provide detailed information on the coastal region owing to its increased spatial resolution. The information on pigments, in conjuction with sea surface temperature, will greatly assist in identification of potential fishery zones in coastal and oceanic waters. The potential end users of the OCM data products include fisheries management, marine industries, environmental management and studies related to the estimation of primary productivity in the oceanic basins. IRS-P4 OCM, along with other ocean colour sensors such as IRS-P3 MOS, SeaWiFS , MERIS and MODIS will assist the ocean colour community in filling data gaps, and can also be used for the inter-calibration of different ocean colour sensors.

3.GIS for forest management: GIS technology helps us organize the data about problems and understand their spatial relationship associations and provides a powerful means for analyzing and synthesizing information about them. GIS is designed for the collection, storage, and analysis of objects, and phenomena where geographic location is an important characteristic or critical to the analysis. GIS is now accepted as a fundamental tool for the effective use of geographic information.

Forestry involves the management of a broad range of natural resources within a forested area. In addition to timber, forests provide such resources as grazing land for animals, wildlife habitat, water resources and recreation areas. The U.S. Forest Service is responsible for the management of forest harvesting, grazing leases, recreational areas, wildlife habitat, mining activities as well as protecting endangered species. To balance the competing resource conservation and resource use, activities must be accommodated. Accessing the feasibility of these multiple uses is greatly enhanced by the use of GIS techniques.

Over the past eight years, GIS technology has been widely accepted by public as well as private forestry agencies. In large part this has been a result of the benefit of using GIS technology over current forest maps. The primary management tool for timber production in America is the forest inventory. It is used to access the existing forest resource and develop harvest schedules and treatment programs to project future timber supplies and for other

operational planning activities. Forest inventory data is collected using remote sensing techniques.

The conventional forest inventory was done progressively with a small portion of the forest being inventoried each year. To update a forest cover map could take 20 years or more with expensive manual drafting. With GIS, the forest cover maps can be updated on a constant basis and it provides the forest managers more current data than what was previously available. With GIS technology, the average age of the information in the forest data base could be reduced from 20 years to only a few weeks. The time factor alone has led to a wide acceptance and large demand for GIS applications in forestry.

4. Case study on Role of IT in Human health:

The New South Wales Ministry of Health, a department of the New South Wales Government, is responsible for monitoring the performance of the public health system in New South Wales, particularly through public hospitals. The goals of the Ministry are to keep people healthy, provide the health care that people need, deliver high quality services, and manage health services well. The provision or delivery of health services are delegated to fifteen local health districts who provide services in a wide range of settings, from primary care posts in the remote outback to metropolitan tertiary health centres. In addition, two specialist networks are focused on children's and paediatric services, and forensic mental health, and a third network covers the delivery of public health services provided by three Sydney facilities operated by St Vincent's and Mater Health.A New IT package was introduced in these health centres to streamline the various operations of the hospitals and help in providing better services to the people. The IT packages purchased from U.S company was found successful in the finance and accounting and pathology systems. But there were difficulties in implementing Patient Administrative System(PAS) or clinical system which involves the registration, admission and transfer of patients as well as medical records, clinical order entry results operating the clinic scheduling systems.The implementations IT packages of the PAS went off successfully with rural hospitals as well as medium sizes hospitals without much complications, where as the PAS system was met constant difficulties in implementations in larger hospitals and with networks.

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PART – A (QUESTIONS AND ANSWERS)

UNIT 1: ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY

1. Define Environment.

Environment is sum total of water, air, and land, inter-relationships among themselves and also with the human beings, other living organisms and property.

2. Define Hazard and its types .

A hazard is a situation that poses a level of threat to life, health, property, or environment, e.g., exposure to benzene may cause cancer.

Types of Hazards:

1. Physical hazards, e.g., earthquakes, floods
2. Chemical hazards, e.g., mutagens, teratogens, carcinogens
3. Biological hazards, e.g., pathogens – viruses, bacteria, toxins and allergens

3. Define Risk.

Risk is the probability of suffering harm from a hazard that can cause injury, disease, economic loss, or environmental damage. Risk is expressed in terms of probability of the likelihood of harm

4. Define Ecosystem & Ecology & Estuarine.

Ecosystem : Ecosystem has been defined as a system of interaction of organisms with their surroundings.

Ecology : Study of the distribution and abundance of organisms, the flows of energy and materials between abiotic and biotic components of ecosystems.

Estuarine: The delta formed at the junction where river water joints with the sea water.

5.Enumerate some characteristics of an Ecosystem.

Ecosystem is the major ecological unit.

It contains both biotic and abiotic components.

Through the biotic and abiotic components nutrient cycle and energy flow occur.

6. What are the functional components of ecosystem?

Biotic and Abiotic are the components of eco system

Biotic: Producers, consumers, decomposers

Abiotic: Light, Temperature,Humidity

7. Define Food chain and Food web.

Food chain : The sequence of eating and being eaten in an eco system is known as food chain.

Food web: The interlocking pattern of food chain is known as food web,

8. Define biogeochemical cycle.

Cyclic flow of nutrients between biotic and abiotic components.

9.What are the various types of functions in the ecosystem.

1.Primary function – Manufacture of starch

2.Secondary function – Distribution of energy in the form of food.

3.Tertiary function: Dead organism decomposed to initiate third function namely cycling.

10. Define Biome.

Biome is defined as a major ecological community of organisms occupying in a larger area.

11. Define Primary and secondary succession.

(i) Primary ecological succession comprises of Hydrarch(Hydrosere – establishment starting in a watery area like pond and lake) and Xerarch (Xerosere – establishment starting in a dry area like, desert and rock)

(ii) Secondary succession involving establishment of biotic communities in an area, where some types of biotic community is already present

12.Why is Biodiversity rich in tropics?

Biodiversity is rich in tropics.- more stable climate, warm temperatures and high humidity, opportunity for many species to coexist, rate of out crossing appear to be higher in tropics.

13. What is the significance of Biodiversity?

Significance of biodiversity. – very important for human life, as we depend on plants, microorganisms, animals for food, medicine and industrial products., protects fresh air, clean water and productive land., important for forestry, fisheries and agriculture.

14.What do you understand by α, β & γ diversity?

Alpha, beta and gamma diversity – alpha – refers to number of species found in a small homogeneous area, beta – refers to rate of change of species composition across different habitats, gamma – refers to rate of change across large landscape.

15. Define biodiversity.Mention its classification

Biodiversity is defined as 'the variety and variability all groups of living organisms and the eco system in which they occur.

TYPES:

1.Species diversity : Diversity between different species

2.Genetic diversity : Variation of genes within the species

3.Ecosystem diversity: Diversity between different ecosystem.

16. What is poaching? Mention its types. What are the factors influencing poaching?

Poaching – killing of animals or commercial hunting – leads to loss of animal biodiversity.

Types : Commercial poaching – Killing for trade . Subsistence poaching - Killing for food

Factors influencing poaching – human population and commercial activities

17. Write a note on man – wild life conflict. . What are the factors influencing man – animal conflicts?

Man–wildlife conflict–arise when wild life starts causing immense damage and danger to man. Factors influencing man–wild life conflict–shrinking of forest cover, human encroachment into forest, injured animals attacking man, of electric wiring around crop fields, etc.

18.What are the threats to the Indian biodiversity?

Threats to Indian biodiversity- deforestation, destruction of wetlands, habitat fragmentation, raw material, production of drugs, illegal trade and developmental activities.

19. Define Ecological succession. What are the different steps in the process of ecological succession?

The replacement of community by other community till the stable community formed in a particular areas.

1. Nudation 2. Invasion 3. Competition 4. Reaction 5. Stabilizations

20.Define First Law and Second Law of Thermodynamics.

I law: Energy can neither be created nor destroyed, but it can be converted from one form to another.

II Law:Whenever energy is transformed there is a loss of energy through the release of heat.

21.Define Hotspot. Mention the two hot spots in india.

The geographical areas which possess high endemic species. The two Hotspots in India are

1. Eastern Himalayas 2. Western Ghats.

22. What is meant by Red Data Book?

Red data book contains the list of endangered species of plants and animals. It gives warning signal for those species which are endangered and if not protected they become extinct in future.

23.Define conservation of biodiversity. Mention the methods and its advantages and disadvantages.

Management of biosphere that it will yield the greatest sustainable benefit to present generation while maintaining its potential meet the benefits of future generation.

Methods : Insitu(within habitat) and Exsitu. (outside habitats)

Insitu 1.Advantages:Cheap, Convenient,Species adjusted with natural disaster.

2.Disadvantages: Required Large area, Poor maintenance.

Exsitu 1. Advantages: Special care and attention, Longer life span.

2.Disadvantages: Expensive, Cannot survive with natural environment

24. Define endemic species endangered species, Extinct species, vulnerable species.

Endemic - species which are found only in a particular region

Endangered species : A species is said to be endangered when its number has been reduced to a critical level. Extinct species: A species which is no longer found in the world.

Vulnerable species: When the species population is facing continuous decline.

25.Mention the characteristics, biotic and abiotic components of forest, grassland, desert and aquatic ecosystem.

Ecosystem	Characteristics	Biotic components	Abiotic components
Forest Ecosystem	1.Maintain climate and rainfall. 2.Support wild animals 3.Protect Biodiversity	Producer: Trees Consumers: Insects, birds, snake, Lion, Tiger Decomposers: Fungi	Light, Temperature, Rainfall
Grass land Ecosystem	1.Soil is rich in nutrients 2.ideal place for grazing	Producer: Grass Consumers: Insects, birds, snake, Eagle Decomposers: Fungi	Light, Temperature, Rainfall
Desert Ecosystem	1.Climate is Hot 2.Annual rainfall is less	Producer: Shrubs Consumers: Mice, fox Decomposers: Fungi	Light, Temperature
Aquatic Ecosystem	Fresh water : Pond, lake, River Marine water : Ocean, Estuarine	Producer: Phytoplanktons Consumers:Zooplanktons, fishes Decomposers: Fungi	Light, Temperature, Rainfall,water

UNIT- II: ENVIRONMENTAL POLLUTION

1. Define Environmental Pollution. Mention the types of pollutants.

Environmental Pollution is defined as any undesirable change in the physical, chemical, or biological characteristics of any component of the environment (air,water,soil)which can cause harmful effects on various forms of property. **TYPES:**

Biodegradable pollutants: Decompose rapidly by natural process

Non-degradable pollutants : Do not decompose or decompose slowly in the environment.

2. What do you mean by indoor air pollution?

Houses in the under-developed & developing countries use fuels like wood kerosene in their kitchens & incomplete combustion produces toxic gas like CO. The most important indoor radioactive material is radon gas that can be emitted from building materials like bricks, concrete etc. which are derived from soil containing radium. This is called indoor air pollution. It is also a type of primary pollutants..

3.Define air pollution. Mention causes and effects:

The presence of one or more contaminants like dust, smoke, mist and odour in the atmosphere which are injurious to human beings, plants and animals. **Causes** : CO, NO_2, SO_2,SPM **Effects:** Lungs damage, bronchitis, cancer

4.Define smog. Mention its types and effects.

Smog is a mixture of smoke and fog in suspended droplet form. Types : 1. London smog 2.Los angles smog.

Health Effects: Breathing problems, cough, eye, nose and throat irritation, heart ailments, reduces resistance to colds and pneumonia.

5.What is SPM & PAN. Mention its effects.

SPM: Variety of particles and droplets suspended in atmosphere for short periods to long periods.

Effects:Nose and throat irritation and lungs damage

PAN : Peroxy Acetyl Nitrates is a secondary pollutants, lachrymatory substance, thermally unstable.

Effects: Eye irritants, toxic, damage to vegetation, skin cancer.

6.Define Acid rain.Mention its impacts

Acid rain occurs when these gases SO_2 , NO_2react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds.

Eg. $NO/NO_2 + H_2O$ ----------> (HNO_3/ NO_3) etc.

Effects 1. Dangerous to destroy life 2.Corrode metals, paints, buildings 3. Affects vegetation.

7. Mention the impacts of ozone layer depletion. How will you measure the ozone layer thickness?

Impacts: 1.Harmful UV rays reach the atmosphere and damage genetic material and cause skin cancer.

2.suppress the immune system in human and animals.3.Resposible for global warming.

Measurement: The amount of atmospheric ozone is measured by Dobson Spectrometer and is expressed in Dobson unit. 1 DU is equivalent to 0.01mm thickness .

8. Define water pollution . Mention the causes and effects.

Water pollution can be defined as alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state. Causes: Infectious agents, Organic and Inorganic chemicals.

9. Define point and non point sources?

Point sources – specific sites near water which directly discharge effluents into them

Non point sources – location of the sources of polluting water is not identified.

10. What do you mean by DO , BOD &COD and mention its significance.

Dissolved Oxygen (DO) is the amount of O2 dissolved in a given quantity of water at a particular temperature & atmospheric pressure. **Significance**: Support for aquatic animals, Minimum level: 4mg/lit.

Biological Oxygen Demand (BOD) is defined as the amount of DO required to aerobically decompose biodegradable organic matter over a period of 5 days at 20°C.It is represent by BOD_5 . **Significance**: Indicate the amount of organic matter in the river.

Chemical Oxygen Demand (COD) is defined as the amount of Oxygen required for chemical oxidation of organic matter using some oxidisisng agent like $K_2Cr_2O_7$ and $KMnO_4$. **Significance**: Determine the pollution strength.

11. Explain thermal pollution. Mention the causes and effects.

Thermal pollution can be defined as the presence of waste heat in the water which can cause undesirable changes in the environment.**Causes**:Thermal power plants, Industrial effluents, Domestic sewage

Effects: 1. The solubility of O_2 is decreased at high temperature.2.. Toxicity of pesticides increases with increase in temperature

12. Explain Marine pollution. Mention the causes and effects.

The discharge of waste into the sea which cause harmful effects to human health and aquatic organism

Causes: Dumping of waste in marine. Oil pollution of marine water

Effects: Prevent Photosynthetic activity, Affects marine birds..

13. Define nuclear pollution. Mention the causes and effects.

Radioactive substances undergo natural radioactive decay in which unstable isotopes spontaneously give out harmful radiation. **Causes:** Nuclear accidents, Nuclear bombs **Effects.** Genetic , eye cataract, bone cancer .

14.Mention the activities involved in solid waste management.

1.Waste generation 2. onsite handling ,storage and processing 3. Collection 4. transfer and transport

5.processing and recovery and disposal

15.What is meant by hazardous waste? How to manage hazardous waste?

The useless, unwanted, discarded material that may threat to human health and environment.

- Dispose the waste as early as possible
- Prevent illegal, international traffic in hazardous waste

16. Explain soil pollution. Mention the causes and effects.

The contamination of soil by human and natural activites which may cause harmful effects on living beings, Causes: Domestic waste, Industrial wastes, Effects:1. Alter the physical and chemical properties of soil, 2.Affects food chain.

17. Define green house effect. Name some green house gases present in the atmosphere

The greenhouse effect is a naturally occurring process that makes the earth warmer by trapping more energy in the atmosphere. The green house gases absorb and hold heat from the sun, preventing it from escaping back into the space; much like a green house absorbs and holds the sun's heat.

Carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_20); chlorofluorocarbons (CFC); water vapour (H_2O) and troposphere ozone (0_3)

18. Define the term Noise Pollution.Mention its unit.Mention its types.

Unpleasant, disagreeable and Unwanted sound that cause discomfort to all living being. The Unit of sound is Decibel. Normal conversation ranges from 35dB to 60 dB.

Types: 1.Transport Noise 2. Industrial Noise 3. Neighbourhood Noise.

19.What are heavy metals? Explain the methods for removal of heavy metals.

Heavy metals are chemical elements with a specific gravity that is atleast 5 times greater than specific gravity of water. The atomic number is grater than 20. **Methods:**

1.Using coconut Shell carbons. 2. Using Rice-Husk carbon 3. Using fly ash 4. Using caly and coal nased adsorbents,

20.Define 3R.

Reduce, Reuse, Recycle, (if 5R add Remove, Refuse)

21.What are the classification of Radio active waste.

1.HLW – High Level Waste 2.MLW – Medium Level Waste 3.LLW- Low Level Waste

22.What are the roles of individual in prevention of pollution.

1.Plant more trees.

2.Purchase environmentally safe products.

3.Reduce deforestation.

4.Reduce population growth.

5.Use renewable resources.

23. Explain the mechanism responsible for depleting ozone layer. List the ozone depleting chemicals.

Choloro Fluoro Carbon is green house gas , ozone depleting chemicals.CFC release chlorine which breaks ozone into oxygen.

$$CF_2Cl_2 + hv \rightarrow Cl + CF_2Cl$$
$$CF_2Cl + O2 \rightarrow CF_2O + ClO$$
$$Cl + O_3 \rightarrow ClO + O_2$$
$$ClO + O \rightarrow Cl$$

Ozone depleting substances: Chlorofluorocarbons (CFC), HCFC, HBFC.

24.Mention the advantages and disadvantages of Ion-Exchange process & Zeolite process in Water treatment.

Ion-Exchange process : Advantages: 1.Highly acidic and alkaline water can be treated by this process.

2. The treated water will have very low hardness. **Disadvantages**: 1.Fe and Mn impurities in water cannot be treated 3.Very Costly 3. More expensive chemical are used.

Zeolite process : Advantages: 1.Very cheap 2. Easy to operate **Disadvantages**: 1.Fe and Mn impurities in water cannot be treated 2.Acidic water cannot be treated.

25. Mention the standard specification of drinking water.

1.pH should be in the range of 7.0-8.5
2.Chloride and Sulphate should be less than 250 ppm.
3.Total hardness should be less than 500 ppm.
4.TDS (Total Dissolved Salts) should be less than 500 ppm.

UNIT- III : NATURAL RESOURCES

1. What are the benefits and Problems of dams?

Benefits:1. Provides large scale employment of tribal people 2.Help in checking flood 3.Generate electricity 4. Reduce power and water shortage 5. Provide irrigation water 6. Promote navigation and fishery.

Problems : 1. Displacement of tribal people 2.Loss of flora and fauna 3. Breeding of disease vectors 4.Water logging and salinity

2. What is water logging?

Water logging is the land where water stand for most of the year.

3. What are the effects or consequences of timber extraction?

1. Deforestation. 2.Soil erosion 3. Loss of fertility of soil. 4.Reduce thickness of forest 5.Loss of tribal culture**..**

4.Define Deforestation. What are the causes and effects of deforestation?

Deforestation : Destruction of forest area.

Causes: Developmental projects, Mining, Forest fire

Effects: Global warming, Soil erosion, Loss of biodiversity.

5. Why wood is renewable but coal is non- renewable?

Wood is renewable because we can get new wood by growing a sapling within 15-20 years. But the formation of coal is not able to regenerate in our life time.

6. Define Hydrologic cycle.

The cyclic process of evaporation, condensation and transpiration.

7.Define mining. Mention its causes and impacts.

Extraction of minerals form the earth surface is known as mining.

Causes: Large usage of minerals in industries, Source of raw material

Impact: Air pollution, Surface & Ground water pollution. Subsidence of land.

8.Define biomagnification.

Most of the pesticides are non-biodegradable and keep on concentrating in the food chain.

9.Define overgrazing. What are the causes and adverse effects caused by overgrazing?

Eating away the forest vegetation without giving a chance for regeneration.

Causes: Increase Livestock population (Cattle population)

Effects:Land degradation, soil erosion, loss of useful species.

10. Explain soil leaching?Mention its effects.

The process in which materials in or on the soil gradually dissolve and are carried by water seeping through the soil.**Effects**: Remove valuable nutrients form soil. 2. Ground water contamination.

11. What are strategic and critical minerals? Give examples.

Strategic minerals – required for the defence of the country [Eg. – manganese, cobalt.]
Critical minerals – essential for the economic power of a country. [Eg. – iron, aluminium.]

12.Define biogas (Gobar gas)? Mention its composition and its uses.

Biogas is a mixture of various gases formed by the anaerobic degradation of cowdung in the absence of air.

Composition: Methane 50-75%, CO_2-25-50%,N_2-0-10%,H_2-0-1%.H_2S-0-3%, O_2-0%

Uses: Cooking food and heating water, To run engines 3. Illuminant in villages.

13.What do you understand by micronutrient imbalance?

Most of the chemical fertilizers used in modern agriculture contain N.P.K. which are macro-nutrients, when excess of nutrients is used in the fields it leads to micronutrient imbalance.

14. What is blue baby Syndrome?

When nitrogen fertilizers are applied in the fields they leach deep into the soil and contaminate the ground water, the nitrate in the water gets increased, when the nitrate concentration exceeds 25mg/lit they cause serious health problem called blue baby syndrome.

15. Define Eutrophication.

A large portion of N and P used in crop fields is washed off by the runoff water and reaches the water bodies causing over nourishment of lakes called Eutrophication.

16.Explain the methods practice for conservation of soil.

1. Conservational till farming 2. Contour farming 3.Terracing 4. Alley cropping 5. Wind breaks.

17.What is anaerobic digestion?

Anaerobic digestion is a series of biological processes in which microorganisms breakdown biodegradable materials in the absence of oxygen.

18. What are renewable and non-renewable energy sources?

Renewable energy resources are natural resources which can be regenerated continuously and are inexhaustible. They can be used again and again. Eg: solar energy, wind energy etc. Non-renewable energy resources are energy resource that is not replaced or is replaced only very slowly by natural processes. Eg: fossil fuels--oil, natural gas, and coal.

19. Write briefly about GTE and OTE:

GTE: Geo thermal Energy: Temperature of the earth increases at the rate of 20 – 75^oC per Km, when we move down the earth's surface. High temperature and pressure fields exist below the earth's surface in many places. The energy harnessed from the high temperature present inside the earth is called geothermal energy.

OTE: Ocean Thermal Energy: Due to temperature difference between upper and lower level of the ocean , able to rotate turbine to generate electricity.

20. What are bio fuels? Explain Gasohol.

Fuels obtained by fermentation of biomass is bio fuels. Gasohol: It is a mixture of Ethanol and Gasoline.

21. What is LPG?

Petroleum gas obtained during cracking and fractional distillation can be converted into liquid under pressure, colorless and odourless gas.

22.What is the role of an individual in conservation of natural resources?

Role of individual in the conservation of natural resources. – duty of every individual to conserve natural resource in such a way that it is available for future generations also. Due to

advancement I technology and population growth, the present world is facing lot of problems on degradation of natural resource..

23. What is land degradation? What are the causes of land degradation? Mention its harmful effects.

Land degradation. – Process of deterioration of soil or loss of fertility of soil.

Causes of land degradation. – Increase in population, increase in urbanization, increased applications of fertilizers and pesticides, damage of top soil.

Harmful effects of land degradation. – Soil structure and texture are deteriorated, loss of soil fertility due to loss of valuable nutrients, increase in water logging, salinity, alkalinity, acidity problems.

24. What do you understand by desertification?What are the causes and effects for desertification.

Desertification–Progressive destruction or degradation of arid or semi arid lands to desert.

Causes: Deforestation, Overgrazing Mining and quarrying , Pollution

Effects: Productive land in arid and semi arid region converted to desert People are in threatened condition.

25. Define Landslides. Mention the causes and Effects of land slides.

Landslides: Downward and outward movement of a slope composed of earth materials such as rock, soil,etc.

Causes of landslides – removal of vegetation, underground mining, transport, addition of weight

Effects: Loss of life, Destruction of communication links, Loss of infrastructure.

26. Define soil erosion and mention its types.

Soil erosion. Damage or removal of top soil renders the soil infertile.

Natural erosion: Erosion takes by nature itself Accelerated erosion : Erosion takes place due to man made activities.

27. Explain overgrazing. What are the changes caused due to overgrazing?

Overgrazing-A process of eating away of forests without giving it a chance to regenerate.

Overgrazing leads to loss of biodiversity, loss of minerals, Soil erosion, leads to desertification..

28.Define Environmental biochemistry.

Environmental biochemistry involves approaches to treat polluted air, waste water and solid waste using metabolic activities of micro organisms.

29. What do you mean by bioconversion of pollutants . What are the types of Biodegradable pollutants?

The change of pollutants into a source of energy by the action of microorganism **TYPES**: 1.Very easily degradable 2. Easily degradable 3.Potentially degradable 4. Very slowly degradable.

30.What are the types of bioconversion methods?

1.Enzymatic hydrolysis 2. Synthesis gas fermentation 3. Composing

UNIT IV: SOCIAL ISSUES AND ENVIRONMENT

1. Define Sustainable Development.What are the aim of sustainable development?

Sustainable Development : Meeting the needs of present generation without compromising the ability of future generation to meet their needs.

Aims: High degree of reusability, Minimum wastage, Least generation of toxic by products ,Maximum productivity..

2.What are the approached are there to attain sustainable development?

Developing appropriate technology

Reduce, Reuse, Recycle (3R) approach

Providing environmental education & awareness

Consumption of renewable resources

Conservation of non renewable resources

Population control

3.Define Urbanisation. Mention its causes

Urbanization is the movement of human population from rural areas to urban areas for the want of better education, communication, health, employment, etc.,

Causes of urbanization : Economic growth, trade, transportation, education, medical facilities

4.Define Urban sprawl.

Due to rapid urbanization there is spreading of the cities into sub-urban or rural areas. This phenomenon is known as *urban sprawl*.

5. Define Water conservation. Mention its necessities. Mention the methods of water conservation.

The process of saving water for future utilization is known as water conservation.

Need for water conservation:

Better life style requires more fresh water.

Increase in population

Due to deforestation, the annual rainfall is also decreasing.

Over exploitation of ground water, leads to drought.

Agricultural & industrial activities require more fresh water.

Methods of water conservation

1) Rainwater harvesting 2) Watershed management

6.Define Rainwater harvesting . Mention its objectives

Rainwater harvesting is a technique of capturing and storing of rainwater for further utilization.

Need (or) Objectives of Rainwater Harvesting

To meet the increasing demands of water.

To raise the water table by recharging the ground water.

To reduce the groundwater contamination

To reduce the surface run off loss.

7.Define Watershed and WSM. **Mention Watershed management techniques**

Watershed is defined as the land area from which water drains under the influence of gravity into a stream, lake, reservoir or other body of surface water.

Watershed management : The management of rainfall and resultant runoff is called watershed management..

8. Define Resettlement and Rehabilitation.

RESETTLEMENT : Resettlement is simple relocation or displacement of human population.

REHABILITATION: Rehabilitation includes replacing the lost economic assets, safeguard employment, provide safe land for building, repair damaged infrastructures, etc.,

9.Define Environmental Ethics.

Environmental ethics refers to the issues, principles & guidelines relating to human interactions with their environment.

10.Define Green Chemistry.

Green chemistry is the chemistry that involves developing and protection of chemicals without polluting the environment. Green chemistry is the pollution free chemistry.

11.What are the major reason for Nuclear Accidents?

1.Nuclear test 2. Nuclear power plant accidents 3. Improper disposal of radioactive waste

4.Accident during transport 5.Core melt down :

12.Mention the effect of nuclear radiation

1.Radiation may break chemical bonds such as DNA in cells .

2.Exposure at low dose of radiation (100-250 rads), people do not die, suffer from fatigue, vomiting, lose of hair.

3)Exposure at higher dose of radiation(400-500 rads),affect bone marrow, blood cells, natural resistance blood fails to clot.

4) Exposure at very high dose of radiation (10,000 rads) kills the organism by damaging the tissues of heart, brain.

13.Define Nuclear Holocaust

It means destruction of biodiversity by nuclear equipments & nuclear bombs.

14.Define Nuclear winter

Nuclear bombardment will cause combustion of wood, plastics, petroleum, forest, etc.,

Large quantity of black soot will be carried to the stratosphere.

Black soot will absorb all UV-radiations & will not allow the radiation to reach the earth cause ill result.

Thus, due to nuclear explosions, a process opposite to global warming will occur. This is called nuclear winter.

15. What are the reasons for the formation of waste land? Mention the methods of waste land reclamation

Reason : Soil erosion, Deforestation, Overgrazing, Water logging, Salinity, Excessive use of pesticides, Mining. **Methods:** 1. Drainage - Excess water is removed by artificial drainage. 2.Leaching - The process of removal of salt from the salt affected soil by applying excess amount of water. 3.Irrigation practices - High frequency irrigation with controlled amount of water 4.Green manures & biofertilizers

16. Define Consumerism. Mention its objective.

Consumption of resources by the people.

Objectives of consumerism

It forces the manufacturer to reuse & recycle the product after usage.

The items which are very difficult to decompose like computers, televisions etc., can be returned to manufacturer for reclaiming useful parts & disposing the rest.
The reusable packing materials like bottles can be taken back to the manufacturer.

17.Define E-Waste. Give Example

Electric and Electronic Waste is known as E-Waste. Eg: Computers, printers, mobile phones, xerox machines,calculators, etc**.,EFFECTS**: Environmental pollution, Respiratory problems.

18.What do you mean by Environmental Legislation law. Mention some important Protection Acts.

It means Environmental management requires a strong legal framework in order to protect our valuable environment from environmental pollution.

Important Protection Acts:
1.Environment Protection Act, 1972
2.Air Act, 1981amended in 1987.
3.Water Act,1974, amended in 1978.
4.Wildlife protection Act, 1972.
5.Forest Act, 1980.

19. Explain the Function of Central & state pollution control boards :

Central Board:

It advises the central government regarding the prevention of pollution.
It plans for the prevention & control of pollution.
It provides technical assistance & guidance to state boards
It encourages industries to recycle & reuse the wastes.
It also advises the industries to treat waste water & gases with modern technology.

State Board:

It has the right to inspect at all times any pollution control equipment, industrial plant & gives orders to take the necessary steps to control pollution.
It organizes educational programmed in collaboration with central board.
The analyst of the board is expected to analyze the sample, sent to him & submit a report to the board & industry.

20.Define Environmental Audit. Mention its types

Environmental audits are intended to qualify the environmental performance and position. It aims to define what needs to be done to improve environmental performance and position.

Types:

Liability audit: It assess compliance with legal obligations
A Management audit: It verifies that an environmental management strategy meets its states objectives.
A Functional audit: It investigates a specific area such as energy or water use.

21.What do you mean by Bio-Medical Waste.

Bio medical wastes are one type of biowaste generated from health care activities. It may be solid or liquid in nature also be hazardous or non hazardous. It must be properly managed and

disposed off safely to protect the environment. If it is not properly treated, produces many infectious diseases.

22. What are the steps involved in management of biomedical wastes?

1. Generation and accumulation
2.Handling and Storage
3.Transport and Disposal.

23.What do you mean by On-site and Off-site treatment?

1.On-site treatment : It involves use of relatively expensive equipments and is used only by very large hospitals and major universities.
2.Off-site treatment : It involves hiring of a biomedical waste disposal service

24.What are the important aspects of sustainable development?

1.Inter-generational equity: It states that we should handover a safe, healthy and resourceful environment to our future generation.

2.Intra-generational equity: IT states that technological development of rich countries should support the economic growth of the poor countries and help in narrowing the wealth gap between and lead to sustainability.

25. What are the requirements needed for awarding ecomark?

1.Sources of raw materials.2.Production process.3.Use of natural resources.4.Energy conservation in the production of products.5Disposal of wastes.6.Utilisation of wastes and recycled materials7.Product to be accompanied by detailed instructions for proper use.8.Bio-degradability

26.What is ECOMARK. Draw (I) bio-hazard symbol and (II) logo of Ecomark

Eco mark is a certification issued BIS (Bureau of Indian Standard) for the environment friendly product.

(I)

(II)

27.Define Disaster. Mention its types

A disaster is the realization of this hazard. Disaster is an event , concentrated in time and space in which a society undergoes severe danger and causes loss of its members and physical property.

Types of disaster:

Natural disaster: Generated by natural process.Eg. Cyclone, Flood, Earthquake.

Man made disaster: Disaster resulting from man made hazards.Eg. Pollution, Accidents.

28. Define flood.Mention the causes and effects.

A flood is an overflow of water, whenever the magnitude of flow of water exceeds the carrying capacity of the channel within its banks.
Causes: Heavy rainfall, Sudden melt of snow, Reducing the capacity of dams.
Effects: Affects crops and Livestock. Economic loss.

29.Define Cyclone. What are the major Effects ?Mention various names of cyclone.

It is a meterological phenomena, intense depressions forming over open oceans and moving towards the land.Cyclones are most powerful, destructive, dangerous atmospheric storms on the easth. Their speed varies between 180-500 km/hr.The main requirement of formation of tropical cyclone is that the sea surface temperature (SST) must be below 25^{o}C.The tropical cyclones move like a spinning top at the speed of 10-30 km/hr.Hurricanes in USA, Typhoons in China and Japan, Willy Willies in Australia. Cyclone in India.

30. Define Earthquake. What are the major causes and Effects of Earth quakes?

An earthquake is a sudden vibrations caused on the earth surface due to the sudden release of tremendous amount of energy stored in the rocks under the earth surface.

Causes: Due to dis equillibirium in any part of the earth crust caused by volcanic eruptions, hydrostatic pressure.2.Underground Nuclear Testing 3. Decrease ground water level.
Effects: Deformation of ground surface, Loss of life and property

UNIT V : HUMAN POPULATION

1.Define Population & Population density.

Population: It is defined as a group of individuals belonging to the same species, which live in a given area at a given time.

Population Density: It is expressed as the number of individuals of the population per unit area (or) per unit volume.

2. Define TFR and IMR.

TFR: Total Fertility Rate: Average number of children delivered by a woman in her life time.

IMR: Infant Mortality Rate: The percentage of infants died out of those born in one year.

3.What are the parameters affecting population size?

Birth rate (or) Natality: It is the number of live birth per 1000 people in a population in a given year.
Death rate (or) Mortality: It is the number of deaths per 1000 people in a population in a given year.
Immigration: It denotes the arrival of individuals from neighbouring population.
Emigration: It denotes the dispersal of individuals from the original population to new areas.

4. Define exponential growth:

Population growth occurs exponentially like $10,10^2,10^3,10^4$ etc., which shows the dramatic increase in global population in the past 160 years.

5. Define Doubling Time.

t is the time required for a population to double its size at a constant annual rate. It is calculated as follows.

T_d (Doubling time) = 70/r

Where r = annual growth rate (OR) It is the number of years needed for a population to double its size

6.Define Demographic transition:

Population growth is generally related to economic development. The death rates and birth rates fall due to improved living conditions. This results in low population growth This phenomenon is referred to as demographic transition.

7. How can we classify the population based on Age structure?

Age structure of population can be classified into three classes.

Pre-productive population (0-14 years).

Reporductive population (15-44 years)

Post reproductive population (above 45 years)

8.Define Population Explosion. What are the causes for population explosion.

The enormous increase in population due to low death rate (mortality) and high birth rate (Natality), is termed as population explosion.

Causes (or) reasons of population explosion

Invention of modern medical facilities reduces the death rate (mortality) and increases the birth rate (Natality), which leads to population explosion.

Increase of life expectancy is another important reason for the population explosion.

lliteracy is one of the reasons for the population explosion.

9.Mention the objectives of Family Welfare programme

Slowing down the population explosion by reducing the fertility

Pressure on the environment due to over exploitation of natural resources is reduced.

10. Define population stabilization ratio. Based on that expain zero population growth.

The ratio is derived by dividing crude birth rate by crude death rate.

Developed countries: The stabilization ratio of the developed countries is 1, which is more or less stabilized indicating zero population growth.

Developing Countries: The stabilization ratiio of the developing countries is nearing 3, which is expected to lower down by 2025.

11. Mention the objectives of Family Planning Programmes (OR) Factors influencing family size.

Achieve 100% registration of birth, deaths, marriage and pregnancy.

Encourage late marriages and later child-bearing.

Enables to improve women's health, education, employment.

Prevent and control of communicable diseases.

Promote vigorously the small family norms.

Making school education upto age 14 free and compulsory.

12.What are the factors influencing human health ?

1.Nutritional factors 2.Biological factors 3.Chemical factors 4.Psychological factors

13. Explain NIMBY Syndrome

NIMBY means Not In My Back Yard, which describes the opposition of residents to the nearby location of something they consider undesirable even if it is clearly a benefit for many.

Example: An incinerator, an ethanol plant, a nuclear power plant, a prison.

An airport is a typical example of a NIMBY complex. It benefits a city economically, but no-one wants it near them because of the noise pollution and traffic it generates.

14. Define Human rights. Mention all the rights.

Human rights are the fundamental rights which are possessed by all human beings irrespective of their caste, nationality, sex and language.

1.Human right to freedom 2.Human right to property 3.Human right to freedom of religion 4.Human right to culture and education 5.Human right to constitutional remedies 6.Human right to equality 7.Human right against exploitation 8.Human right to food and environment 9.Human right to good health

15. Define Value education. Mention its types. What are the types of values?

It is nothing but learning through which knowledge about the particular thing can be acquired. With the help of our knowledge and experience we can identify our values to understand ourselves and our relationship with others and their environment.

Types of Education:1.Formal education 2.Value education: 3.Value-based environmental education:

Types of values**:** 1.Universal values (or) Social values 2.Cultural values: 3.Individual values: 4.Global Values:

5.Spiritual Values:

16. Differentiate between HIV and AIDS.

HIV	**AIDS.**
Human Immune deficiency Virus	Acquired Immune Deficiency Syndrome
It is a Virus	It is a disease

17. Explain EIA.Mention its objectives. What are the elements used in the process of EIA

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) : EIA is defined as a formal process of predicting the environmental consequences of any development projects. **Objective:** It is used to identify the environmental, social and economic impacts of the project prior to decision making.

Elements:

Scoping, Screening,Identifying and evaluating alternatives, Mitigating measures dealing with uncertainity

Issuing environmental statements

18.Define population equillibitium.

A state of balance between birth rate and death rate in a population.

19.How does HIV function in Human body? Mention the factors Influencing and Not influencing of HIV

Functions: AIDS itself does not kill humans. The death occur due to the attack by diseases because of the weakening of immune system.White Blood Cell (WBC) responsible in the formation of antibodies are called T-helper cells, T-helper cells are the key infection fighters in the immune system. The HIV enter into the human body and destroys the T-cells as a result of which various types of infection diseases occur. Even cancer can easily develop in the HIV infected persons.

Influencing: Syringes Infected mother to babies, Blood transfusion.

Not Influencing: Tears, food and air, cough, handshake, mosquito, flies, insect bites, urine

20.What are the importance of Value education.

To improve the integral growth of human being.

To create attitudes and improvement towards sustainable lifestyle

To create and develop awareness about the values and their significance and role.

To understand about our natural environment in which how land, air and water are interlinked.

21.Define Geographical Information System (GIS)

"GIS is a technique of superimposing various thematic maps using digital data on a large number of inter-related aspects."

22.What are the problems of population growth?

1. Increasing demand for food 2. Loss of agricultural lands 3. Unemployment 4.Pollution

23.Define Population Equation.

$$P_{t+1} = P_t + (B-D)+(I-E)$$

P_t and P_{t+1} = sizes of population in an area at two different point in time t and t+1

B = Birth rate D = Death rate

I = Immigration E – Emigration

24.What are the objective Women Welfare? Mention the various schemes.

1. To provide education
2. To impart vocational training and improve employment opportunities.
3. To generate awareness of the environment and problems of population.
4. To restore the dignity, status, equality and respect for women.

Various schemes:

1. The National Network for Women And Mining(NNWM)

2.International Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW)

25.Mention the necessity of Child Welfare. Mention the various Schemes.

Most of the Children are working as a Child Labours due to poverty and demand of money.

Schemes:

1.United Nation Convention on Rights of Child.

2.Ministry of Human Resources and Development.

PART B & C – QUESTIONS (UNIT I to UNIT V)

PART B

UNIT –I

1. Distinguish between hazard and risk. What are the different types of hazards? Explain the different types of hazards with examples.

2.Define ecosystem. Give an account of the structure and functions of grassland ecosystems.

3.Describe the types, characteristic features, structure and functions of aquatic ecosystems(Fresh and Marine)

4. Describe the types, characteristic features, structure and functions of forest ecosystems.

5.Describe the types, characteristic features, structure and functions of desert ecosystems.

6. With a neat sketch discuss the nitrogen cycle. & Oxygen cycle

7. What do you mean by conservation of biodiversity? Explain its methods.

8.Discuss the values of Biodiversity in India.

9. Explain the major factors that are responsible for the loss of biodiversity or threats to biodiversity.
10. Define Hot Spot. Explain the hot spots of biodiversity that extend in India?
11. What are the major causes of man-wildlife conflicts? Discuss the remedial steps that can curb the conflict.
12.Discuss the biodiversity at Global, National and Local levels.
13.India is a mega diversity- Justify .
14.Discuss Bio geographical classification of India.
15.Discuss about Ecological succession.

UNIT II

1.Explain about the causes, effects and control measures of air pollution.
2.Explain about the causes, effects and control measures of water pollution.
3.Explain about the causes, effects and control measures of soil pollution.
4.Explain about the causes, effects and control measures of Noise pollution
5.Explain about the causes, effects and control measures of Marine pollution.
6. .Explain about the causes, effects and control measures of thermal pollution.
7.Explain about the causes, effects and control measures of radioactive pollution.
8.Expalin chemical and photochemical reactions in atmosphere.(Smog, PAN, Acid rain, Ozone chemistry)
9. Elaborately discuss the steps involved in solid waste management.
10.With a flow diagram explain the waste water treatment process.
11. Describe Ion-exchange and Zeolite process for water treatment.
12.Discuss the significant parameters of drinking water quality standards.
13. Discuss the ways and means for an individual to prevent environmental pollution
14.Write a note on disposal of radioactive wastes.
15.Discuss the properties (physical and Chemical)of terrestrial and marine water.
16.Pollution related case studies.

UNIT :III

1. Describe the causes and effects and control measures of deforestation.
2.Discuss the impact of mining on environment and human health OR Consequences of over-exploitation of mineral resources.
3.Give an account of non-conventional energy resources OR Renewable energy sources
4.Discuss the effects of modern agriculture on the environment.
5.Discuss in detail the benefits and problems of constructing dams.
6.Discuss the role of an individual in the conservation of natural resources.
7.Explain briefly the soil conservation practices adopted in India.
8. With the help of a neat diagram explain the production of biogas and mention its uses.
9. Discuss the causes and consequences of desertification.
10. Discuss the consequences of overdrawing surface and ground water.
11.Discuss the various techniques for harnessing solar energy.
12.Describe the utilization of wind energy to produce electricity.
13.Explain the following: i) tidal power ii) Ocean thermal energy iii)geothermal energy iv) biomass energy.
14.Discuss about Non-Renewable Energy Resources.

15.Compare Nuclear Power and Coal Power.
16.Write notes on the following i) Degradation of proteins ii)Bioconversion of pollutants iii)Bio chemical degradation of pollutants
17. What is land degradation? Discuss the factors responsible for land degradation.
18. Discuss the causes and consequences of desertification.

UNIT IV:

1. What are the objectives of water conservation? How is it carried out? (RWH &WSM)
2. Briefly discuss the salient features of all Environmental Legislation Acts.
3. Write a brief note on environmental ethics.
4.Give an account on Green Chemistry.
5. Write short notes on nuclear accidents and holocaust.
6. Discuss the resettlement and rehabilitation of people, its problems and concerns.
7. Discuss various measures for wasteland reclamation.
8.Explain the role of NGOs in environmental protection and health.
9. Write briefly on Bhopal disaster and Chernobyl disaster.
10.Explain the Role of CPCB and SPCB in control of pollution.
11.Discuss the causes, Effects and Management of Disasters like Flood, Earthquake, Cyclone and Landslides.
12.Define Sustainable Development. What are the approaches made to attain sustainable development.
13.Discuss the issues involved in the enforcement of environmental legislation or Drawbacks of Environmental Legislation Acts.
14.Define Biomedical Waste. What are the steps involved in management of biomedical waste.
15.What do you mean by Eco Mark. Mention the Objective and Criteria for awarding Ecomark.
16.Mention the Objective and Methods to create Environmental awareness to public.

UNIT – V

1.Define Population Growth. Mention the Characteristics of Population Growth.
2. Discuss the population growth variation among nations.
3.Write the methods and strategies of imparting value education.
4.Define Population Explosion. Mention the Causes and Effects of Population Explosion.
5. Briefly describe the various schemes launched for women and child welfare in India.
6. Discuss the origin, modes of transmission, symptoms, and control measures of AIDS.
7. Discuss the influence of environmental parameters on human health.
8. Define Human Rights and discuss the salient features of the Universal Declaration of Human Rights by UN.
9. Briefly discuss the following: i) factors affecting family size ii) family planning Programme.
10. Discuss in detail about EIA.
11. Explain the Role of IT in Environmental Protection and Human Health.

PART-C

1. Disaster Management- (Flood, Cyclone, Tsunami, Landslides, Earthquake)
2.Renewable and Non-Renewable Energy Resources - Solar, wind, Hydro energy, Usage of petrol
3.Environmental Act and Role of NGO's
4.Mineral Resources – Mining and Impacts
5.Water Resources - Dams – Benefits, Problems, Impact on forest and tribal people
6.Modern Agriculture- Impacts
7.Role of IT in Environment and Human Health – Case studies
8.Karnataka-TamilNadu water problem issues
9.Recent flood issues in Chennai
10.Any Pollution related case studies.
11.Bio degradable pollutants.
12. Recent cyclone issues in Chennai.
13.What are the conservation technologies available for water?
14.Explain the consequences and causes of flood and landslides by taking a case study.
15.Explain the environmental problems caused by population explosion. What are the measures to be taken to check population explosion.
16.Discuss 1. Taj Trapezium case 2. Bhopal Gas Tragedy 3. Chrenobyl nuclear disaster.
17.Discuss the impact of deforestation activity by taking any case study.
18.Discuss about bio conversion of pollutants.
19.Compare Renewable and Non-Renewable .
20.Write about the need for public awareness about the environment.

QUESTION BANK
UNIT-I
PART-A

1. Give any two examples of physical hazard: (June 2016)
2. Mention two primary and secondary consumers in grassland system: (June 2016)
3. Define Biodiversity (Dec 2015/ May 2015/June 2007)
4. What are called decomposers? (Dec 2015)
5. What is hot spot? (Dec 2015)
6. Distinguish between biotic and abiotic components of an ecosystem: (Dec 2015)
7. What is the effect of habitat loss on biodiversity? (Dec 2015)
8. What is an abiotic environment? (Dec 2014)
9. What are called endangered species? (Dec 2014 & May 2011)
10. Define ecological succession: (Dec 2014 & Dec 2011)
11. Differentiate between 'endangered' and 'epidemic'species: (Dec 2014 & Dec 2011)
12. Write about ecological pyramids: (June 2012)
13. Define the term producers and consumers: (May 2008)
14. What is meant by genetic diversity? (May 2008)

15. How does biome differs from an ecosystem? (Dec 2007)
16. Define genetic diversity and species diversity: (Dec 2007)
17. Explain the concept of ecosystem : (June 2007)
18. What do you meant by environmental impact? (Dec 2006)
19. Name the few endangered wild life species of India : (June 2006)
20. Explain threatened and endangered species: (Dec 2005)

PART-B

1. Discuss the components of ecosystem: (Dec 2005/Dec 2006)
2. Briefly explain the energy flow through ecosystem: (Dec 2005/Dec 2006)
3. What are the different types of ecosystem and explain them with an example: (June 2006)
4. Describe in-situ and ex-situ conservation of biodiversity: (June 2006)
5. Discuss the four kinds of diversity: (Dec 2006)
6. What are the causes for loss of biodiversity? (Dec 2006)
7. Explain the role of biodiversity at global, national and local levels: (June 2007)
8. Describe the term hot spot in Biodiversity: (Dec 2007)
9. Describe the types, characterisitic features, structure and functions of
    1. Forest ecosystem 2. Aquatic ecosystem (DEC 2015)
10. Explain the following : (i) Ecological Succession (ii) Energy flow in the ecosystem. (DEC 2015)
11. What are the major causes of man wild conflicts? Discuss the remedial steps that can curb the conflict: (DEC 2015)

UNIT-II

PART-A

1. What is PAN? Give its detrimental effect: (JUNE 2016)
2. What are the causes of thermal pollution? (JUNE 2016)
3. Define noise pollution: (DEC 2016)
4. What do you mean by land degradation? (DEC 2016)
5. Mention the effects of noise pollution: (DEC 2015)
6. What is eutrophication? (DEC 2015)
7. What is acid rain? (JUNE 2015)
8. What are renewable and non renewable energy resources? (JUNE 2015)

9. Mention the effects of ozone on plants: (JUNE 2015)
10. List the sources of marine pollution: (JUNE 2015)
11. Explain the term photo-chemical smog: ((JUNE 2012)
12. Mention any two anthropogenic sources responsible for soil pollution: (DEC 2015)
13. What are the impacts of thermal pollutant on aquatic ecosystem? (DEC 2015)
14. Mention few non renewable energy sources: (JUNE 2007)
15. Define air pollution: (JUNE 2007)
16. Give examples for primary and secondary air pollutants: (DEC 2007)
17. Define decibel: Give the permissible noise levels in heavy machinery shop and hospital zone: (DEC 2007)
18. Define Blue Baby Syndrome.
19. What do you mean by DO , BOD &COD and mention its significance.
20. What are Heavy Metals ? Explain the methods for removal of heavy metals.

PART-B

1. Discuss the sources, effects and control measures of air pollution: (DEC 2015/May 2015 JUNE 2016)
2. Write notes on salinity and dissolved oxygen: (DEC 2015)
3. Explain the methods of disposal of solid wastes: (DEC 2015)
4. Explain the causes, effects and control measures of water pollution: (DEC 2015)
5. Write an elaborate notes on chemical and photochemical reactions in the atmosphere: (JUNE 2016)
6. What are the causes and effects of marine pollution: (JUNE 2016)
7. What are the methods adopted for control of air pollutants? Explain each briefly: (JUNE 2016)
8. How are water pollutants classified? Give example of each type: (JUNE 2016)
9. Write notes on Nuclear hazards, thermal pollution: (DEC 2015)
10. What is marine pollution? Explain the ill effects of marine pollution with the help of a case study?
11. Explain the control and prevention measures of municipal solid wastes: (MAY 2015)
12. Write briefly about the hazards caused by the nuclear wastes: (MAY 2015)
13. Explain in detail the role of an individual in pollution prevention: (MAY 2015)

14. How would you manage the floods and cyclones? What are the precautionary measures to be adopted in such occurrences? (DEC 2014)
15. Explain the process of waste water treatment.

UNIT-III

PART-A

1. What are the reasons for land degradation? (JUNE 2016/DEC 2015)
2. Explain the term sustainability briefly: (JUNE 2016)
3. How does overgrazing contribute to environmental degradation? (DEC 2015)
4. In what tectonic environments do mineral deposits form? (MAY 2015)
5. What is desertification? (MAY 2015)
6. Define the term land slide: (MAY 2015)
7. What are renewable resources? (MAY 2015)
8. Define sustainable development: (DEC 2014)
9. What is deforestation? (DEC 2014)
10. What are the consequences of overgrazing? (DEC 2014)
11. What are man induced land slides? (DEC 2014)
12. Define BOD_5 (JUNE 2012)
13. Mention any four natural resources: (JUNE 2012/DEC 2011)
14. Indicate any four major global food problems: (DEC 2011)
15. What are oxygen demanding wastes? (MAY 2011)
16. What is an aquifier? Give example: (MAY 2011)
17. What is sustainable forest management? (DEC 2006)
18. Differentiate between deforestation and forest degradation: (DEC 2007)

PART-B

1. How is biogas produced? What are its advantages? (JUNE 2016/ MAY 2015/DEC 2014)
2. What are the effects of modern agriculture? (JUNE 2016)
3. What are renewable and non renewable energy resources? Why are non renewable energy resources preferred for energy utilization now a days? What are the advantages and disadvantages of harnessing non renewable energy resources? (JUNE 2016)
4. Explain bioconversion of pollutants with examples: (JUNE 2016)

5. Discuss the impact of mining on environment and human health: (DEC 2015/MAY 2015)
6. What are the effects of deforestation? Is deforestation justified?
   Comment: (DEC 2015/MAY 2015)
7. What are the effects of over utilization of surface and ground waters? (DEC 2015)
8. Explain the role of an individual in the conservation of natural resources: (DEC 2015)
9. Write in detail the effects of timber extraction of forest and tribal people: (DEC 2015)
10. What is land degradation? Discuss the factors responsible for land degradation: (DEC 2014)
11. What are the changes caused by agriculture and overgrazing? (DEC 2014)
12. Briefly explain the forest resources its use and over exploitation : (DEC 2014)
13. What is the need for soil conservation? Write briefly about different soil conservation practices in India? (DEC 2014)
14. Discuss the major world's food problems and suggest possible ways to solve the problems: (DEC 2014)
15. Explain the role of alternate energy sources in pollution control with case studies: (JUNE 2012)

UNIT-IV

PART-A

1. Define the term sustainable development. (Dec 2009, Dec 2008)
2. What is meant by environmental audit.(Dec 2008)
3. State the drawbacks of pollution related acts.(Dec 2008)
4. List the objectives of watershed management.(Dec 2009)
5. What are objectives of public awareness?(Dec 2009)
6. What are the various sources of radioactive pollution?(Dec 2008)
7. What are landslides? What are the harmful effects of landslides? (May 2008)
8. Define Resettlement and Rehabilitation.
9. Define Consumerism.(Dec 2015, May 2015)
10. State any two biomedical waste handling rules. (June 2016)
11. Define the term sustainability briefly .(June 2016)
12. What is environmental protection act? (May 2016)
13. What are the causes of unsustainable development? (May 2016)
14. List out the advantages of rain water harvesting.(Dec 2015)
15. What do you mean by disaster management? (May 2015)
16. What is rain water harvesting?(Dec 2014)
17. What are the objectives of water act?(Dec 2014)
18. Define green house effect.(Dec 2014)
19. Give some reasons behind global warming. (June 2014)
20. List any four environmental potentials act. (June 2014)

21. What is environmental ethics?
22. What are the objectives of Forest (Conservation) Act?
23. What are the objectives of Wild Life (Protection) Act, 1972?
24. What is meant by NIMBY syndrome?(Dec 2008)
25.What is meant by e-waste

PART-B

1. Write about water prevention and control pollution act 1974.(Dec 2014)
2. Discuss Forest conservation act 1980(Dec 2014)
3. What is rain water harvesting? Explain their types with suitable sketches(Dec 2014)
4. What is an earthquake? Enumerate its effects. What measures should be taken to mitigate this disaster. (Dec 2014)
5. Discuss the resettlement and rehabilation of people, its problems and concerns. (Dec 2014)
6. Discuss the sailent features of wild life protection act. (Dec 2014)
7. Discuss various measures for wasteland reclamation. (Dec 2015)
8. Write note on earthquake and cyclone. (Dec 2015)
9. Explain in detail how biomedical wastes are managed and handled. (Dec 2015)
10. Discuss the various applications of green chemistry for achieving sustainable development. (June 2016)
11. Explain the sailent features of water act. (June 2016)
12. What is environmental ethics? Write about the issues and possible solution .(June 2016)
13. Discuss about watershed management. (June 2016)
14. Write short notes on nuclear accidents and ozone layer depletion. (Dec 2013)
15. Give brief account of global warming.(Dec 2009)
16. Explain waste land reclamation practices. (Dec 2009)
17. Discuss chrenobyl and nuclear disaster. (Dec 2009)

UNIT-V

PART-A

1. Define population explosion. (Dec 2009, May 2015)
2. What are the effects of population explosion. (Dec 2009)
3. Define immigration and emigration(Dec 2009)
4. What are the objectives of family welfare programmes.(Dec 2009)
5. Mention the ill effects of HIV/AIDS on the environment. (Dec 2008)
6. State the Role of Information Technology in Environment. (Jan 2006)
7. Define population equilibirium, (Jan 2006)
8. Differentiate between HIV andAIDS.(Dec 2007)

9. What are the reasons behind the increased population growth in the less developed nations compared with developed nations. (Dec 2007)
10. What are the major precautions to avoid AIDS? (May 2008)
11. Define doubling time. (Dec 2008)
12. What are the effects of population explosion. (Dec 2009,June 2016)
13. Name any two family welfare programmes adopted in India. (June 2016)
14. Write any two child welfare schemes in TamilNadu.(June 2016)
15. What is population growth.(June 2016)
16. List out the advantages of family welfare programmes.(May 2015)
17. What are the sources of HIV function. (Dec 2014)
18. What are the objectives of value education. (Dec 2014)
19. Define HIV and causes of AIDS.(June 2016)
20. Define EIA

PART-B

1. What is AIDS? What are the sources and mode of transmission of HIV function.(Dec 2015, Dec 2014,May 2015)
2. Write note Women and Child Welfare and Human rights. (Dec 2015, May 2015)
3. Describe the role of IT in environment and Human health with case studies.(May 2015,Dec 2014, June 2016)
4. What are the objectives of value education? (May 2015)
5. Discuss the various of population among nations.(Dec 2014)
6. Write the methods and strategies of imparting value education. (May 2015)
7. Briefly describe the various schemes launched for women and child welfare in India. (Dec2014)
8. Draw a typical population pyramid of developing country and discuss. (June2016)
9. Explain problem by population explosion(June 2016)
10. Explain the causes , effects and control of HIV/AIDS. (June 2016)
11. Write about the reasons for population explosion in India. What are the measures to be taken to check the population explosion.(June 2016)

EVS - NPTEL LINKS

1. https://sites.google.com/a/mitr.iitm.ac.in/iitmcivil/ce3040

2. www.**nptel**videos.in/2012/12/fundamentals-of-**environmental-pollution**.html

3. www.**nptel**videos.in/2012/11/**environmental-air-pollution**.html

4. nptel.ac.in/course/120108002/3/4/5

5. www.**nptel**videos.in/2012/11/**natural-**language-processing.html

6. https://www.btechguru.com/**courses--nptel**--aquatic-**biodiversity**-and-environmental-poll...

7. www.**nptel**videos.in/2012/12/**population**-and-society.html

ALL THE BEST

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PRATHYUSHA ENGINEERING COLLEGE
LECTURE NOTES
GE8291/ENVIRONMENTAL SCIENCEAND ENGINEERING

UNIT V - HUMAN POPULATION AND ENVIRONMENT

Population: It is defined as a group of individuals belonging to the same species, which live in a given area at a given time.

Population Density : It is expressed as the number of individuals of the population per unit area (or) per unit volume.

Parameters affecting population size: Changes in population are governed by 4 main parameters. They are:

1. **Birth rate (or) Natality:** It is the number of live birth per 1000 people in a population in a given year.
2. **Death rate (or) Mortality:** It is the number of deaths per 1000 people in a population in a given year.
3. **Immigration:** It denotes the arrival of individuals from neighbouring population.
4. **Emigration:** It denotes the dispersal of individuals from the original population to new areas.

POPULATION GROWTH

The rapid growth of the global's population for the past 100 years results from the differences between the rate of birth and death.

Causes of rapid population growth:

- Due to decrease in death rate and increase in birth rate
- Convention of early marriage that makes reproduction span longer
- Hesitation to adopt birth control methods
- Reduced death rate due to improved medical facilities and advances in medicine and surgery
- Children are required to help their parents in their occupation
- Decrease in famine related deaths and infant mortality
- Increase in food production, clean water and air

Characteristics of Population Growth:

1. **Exponential growth:** When a quantity increases by a fixed percentage it is known as exponential growth (eg.,$10,10^2,10^3,10^4$ etc., (or) 2,4,8,16,32) which shows the dramatic increase in global population in the past 160 years.

2. **Doubling Time:** It is the time required for a population to double its size at a constant annual rate is known as doubling time (Td). It is calculated as follows.

T_d (Doubling time) = 70/r, Where r = annual growth rate

(or) It is the number of years needed for a population to double its size

3. If the nation has 2% annual growth its population will double in next 35 years. The doubling time for India is about 28 years and china 67 years.

4. **Infant mortality rate:** It is the percentage of infants died out of those born in one year. Even though this rate has decreased in the last 50 years, the pattern differs widely in developing and developed countries.

5. **Total fertility rates (TFR):** It is defined as the average number of children born by a women in her life time. The TFR value varies from 2 in developed countries to 4.7 in developing countries.

6. **Replacement level:** Two parents bearing two children will be replaced by their off spring. Due to infant mortality this replacement level is changed. But, due to high infant mortality the replacement level is generally high in developing countries.

7. **Male-Female ration:** The ratio of girls and boys should be fairly balanced in a society to flourish. But the ratio has been upset in many countries including China and India. In China the ratio of girls and boys is 100:140.

8. **Demographic transition:** Population growth is generally related to economic development. The death rates and birth rates fall due to improved living conditions. This results in low population growth.This phenomenon is referred to as demographic transition.

9. **Zero population growth:** When the birth plus immigration in a population are just equal to death plus emigration it is called zero population growth.

Problems (environmental isssues) of population growth

1. Increasing demands for food and natural resources.
2. Inadequate housing and health services.
3. Loss of agricultural lands.
4. Unemployment and socio-political unrest.
5. Environmental pollution

VARIATION OF POPULATION AMONG NATIONS.

- As on 2017, the world's population is 7.6 billions. This existing population is also not evenly distributed, less developed countries have 80% population while the developed countries have only 20%.

- Less developed coutries (Africa, Asia, South America) have 80% of the total world population and occupy less than 20% of the total land area.

- In the most developed countries like U.S.A., Canada, Australia, the population increases at the rate of less than 1% per year. But in less developed countries like South America, Africa and Asia, the population increases at the rate greater than 1% per year.

Variation of Population based on age structure.

Age structure of population can be classified into three classes based upon people belonging to different age classes.

1. Pre-productive population (0-14 years).
2. Reproductive population (15-44 years)
3. Post reproductive population (above 45 years)

Variation of population is now explained based on the above three classes.

1.Pyramid shaped variation of population (Increase) :Example: India, Bangladesh, Ethiopia, Nigeria etc.,

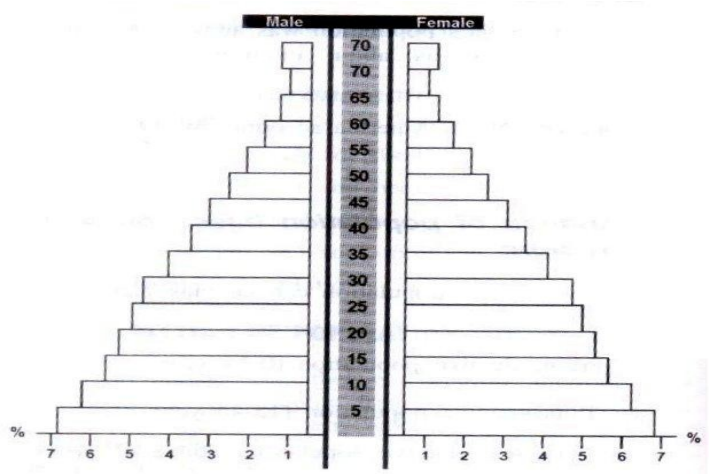

Fig. 7.2 Pyramid shaped variation of population

The fig7.2 shows that the pre-productive age group population (0-14 years) is more, indicated at the base of pyramid and post reproductive age group population (above 45 years) is less, indicated at the top of pyramid. The large number of young age people will soon enter in to reproductive age group population (15-44 years), which **increases the population growth.** But the less number of old age people indicates les loss of population due to death.

2.Bell shaped variation of population (Stable) Example: France, U.S.A., U.K. Cnada etc.,

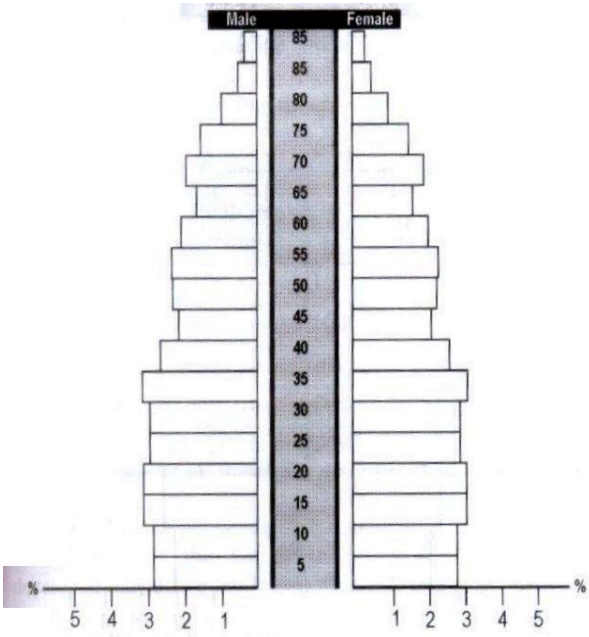

Fig. 7.3 Bell shaped variation of population

The fig 7.3 shows that the pre-productive age group population (0-14 years) and reproductive age group population (15-44 years) are more or less equal. So, the people entering into the reproductived age group will not change the population and thus the population growth is stable.

3.**Urn Shaped Variation of Populatio (decrease)- Examples**: Germany, Italy, Sweden, Japan etc.,

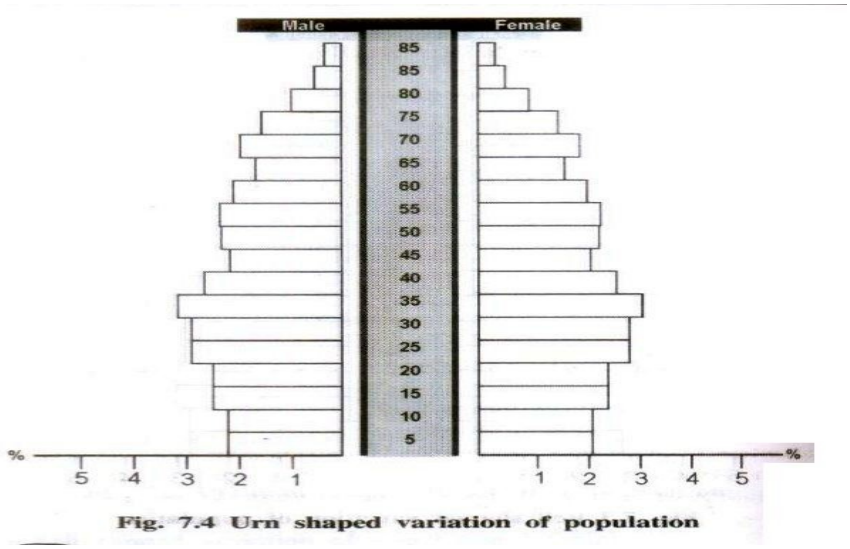

Fig. 7.4 Urn shaped variation of population

The fig 7.4 shows that the pre-productive age group population (0-14 years) is smaller than the reproductive age group population (15-44 years). In the next 10 years , the number of people in the reproductive age group is less than the before, resulting in a **decrease of population growth.**

POPULATION EXPLOSION

Definition: The enormous increase in population due to low death rate (mortality) and high birth rate (Natality), is called **population explosion**. The human population is not increasing at a uniform rate in all parts of the world.

Doubling Time : Population explosion can be better understood by considering the doubling time, i.e., the **number of years needed for a population to double in size.** The table below shows the doubling times of population growth.

Less developed Country		**Developed Country**	
Country	**Doubling Time**	**Country**	**Doubling Time**
India	28 yrs	United State	87 yrs
Turkey	28 yrs	U.K.	231 yrs
Nigeria	27 yrs	Italy	99 yrs
Saudi Arabia	25 yrs	France	117 yrs
Pakistan	21 yrs	Japan	58 yrs

From this table it is clear that:

- The human population is not increasing at a uniform rate in all parts of the world.
- The non-industrial, poor developed called **less developed countries** like Asia, Africa and South America shows higher growth rate.
- The population of industrialized **developed countries** like U.S. A. U.K., France, Italy, Soviet Union the growth rate is low.

Causes (or) reasons of population explosion

- Invention of modern medical facilities reduces the death rate (mortality) and increases the birth rate (Natality), which leads to population explosion.
- Increase of life expectancy is another important reason for the population explosion. **Eg:** In 1950, the average life expectancy of the human being was 40 years. But now it is 61 years.
- Illiteracy is one of the reasons for the population explosion.

Effect of population Explosion:

- It creates problem for food, clothing and shelter.
- It builds pressure on economic developments
- It is responsible for low standard of living
- Crime rate increases with increase in population
- It leads to environmental degradation
- It is responsible for unemployment and low living standard of people
- Over crowding of cities leads to development of slums.

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Measures to reduce population explosion:

- Checking the birth rate

- Enhancing the resources

Suggestions:
- Educating the people to reduce the birth rate
- Providing incentives like money
- Forcing the people to limit the size of the family
- Increasing the process of industrialization
- Expanding urbanisation

Family Welfare Programme:

Family Welfare Programme was implemented by the Government of India as a voluntary programme.
Definition: It is an integral part of overall national policy of growth covering human health, maternity, family welfare, child care and women's right.

Objectives of Family Welfare programme:

- To improve the life style
- To reduce the pollution
- To reduce the over exploitation of natural resources
- To decrease the population explosion by reducing the fertility

Population stabilization ratio (PSR):

The ratio is derived by dividing crude birth rate by crude death rate.

Developed countries: The stabilization ratio of the developed countries is 1, which is more or less stabilized indicating zero population growth.

Developing Countries: The stabilization ratiio of the developing countries is nearing 3, which is expected to lower down by 2025.

Stabilization in developing countries is possible only through various family welfare programmes.

FAMILY PLANNING PROGRAMME: It provides an educational and clinical service that helps the couples to choose their family size.

Objectives:
- Birth spacing
- Birth control
- Health care for pregnant women and infants

Factors influencing family size.

1. Reduce infant mortality rate to below 30 per 1000 infants.

2. Achieve 100% registration of birth, deaths, marriage and pregnancy.
3. Encourage late marriages and later child-bearing.
4. Encouraging breast feeding.
5. Enables to improve women's health, education, employment.
6. Making family planning available to all women, also wanted to choose the number of children and the spacing of births.
7. Constraint the spread of AID / HIV.
8. Prevent and control of communicable diseases.
9. Promote vigorously the small family norms.
10. Making school education upto age 14 free and compulsory.

Fertility control methods (or) Methods of family planning (Sterilization)

1. **Traditional method:**
   It includes some traditions like taboos and folk medicine.

2. **Modern Method:**
   (i)Permanent method: It is done by minor surgery.
   (a) **Tubectomy:** It is female sterilization done by tying the tubes that carry the ovum to the uterus.
   (b) **Vasectomy:** It is male sterilization done by tying the tubes that carry the sperm.
   Both are very simple procedures done under local anesthesia which are painless and patients have no post operative problems.

   (ii)Temporary method
   (a) **Condoms:** Condoms are used by males to prevent sperms.
   (b) **Copper Ts:** Copper Ts are small objects and can be placed by a doctor in the uterus so that the ovum cannot be implanted, even if fertilized. They do not disturb any functions in the woman's life.
   (c) **Oral contraceptive pills** and injectable drugs are available that prevent sperms from fertilizing the ovum.

Family planning Programme in India

1. In 1952, India started the family planning programme.
2. In 1970's Indian Government forced family planning programme.
3. In 1978, the government legally raised the minimum age of marriage for men from 18 to 21 years and for women 15 to 18 years.
4. In 1981,census report showed that there was no drop in population. Since then funding for family planning programmes has been increased further.

ENVIRONMENT AND HUMAN HEALTH

Human health and environment are two inseparable entities. If one get disturbed other will be automatically disturbed. A person is not suffering from any disease is called a healthy person.

Human health is influenced by the following factors

1. Nutritional factor 2.biological factor

3. Chemical factor 4.Psychological factor

Environmental degradation due to population explosion:

- Every year millions of people die due to the degradation in the environment.
- People suffer from different diseases
- The present environment is heavily polluted due to rapid industrialization and manmade activities
- Environmental pollution creates physical, chemical and biological hazards which have adverse health effect.

Important Hazards and their Health effects (Or) Deterioration of environment and Health effect.

Physical hazards and their health effects

S.no	Physical hazards	Health effects
1	Radioactive radiations	Affects the cells in the body and the function of glands and organs, Suffer from cancer
2	UV radiation	Skin cancer
3	Global warming	Temperature increases cause famine, mortality
4	Noise	Painful and irreparable damage to human ear

Chemical hazards and health effects

S.No	chemical hazards	Health effects
1	Combustion of fossil fuels: liberates SO_2, NO_2, CO_2 and particulate matters	Asthma, bronchities and other lung disorders
2	Industrial effluents (toxic)	Kill cells and cause cancer and death
3	Pesticides like DDT and chlorinated pesticides	Affect the food chain
4	Heavy metals like Hg, Cd, Pb, fluoride, nitrate	Contaminate water, cause ill effects
5	Choloro fluorocarbons	Damage O_3 layer, allows more UV rays, cause skin cancer

Biological hazards

S.No:	Biological hazards	Health effects
1	Bacteria, viruses and parasites	Diarrohea, malaria, parasitic worms,

		anaemia, respiratory diseases , cholera

Preventive measures

- Always wash your hands before eating
- Cut short and clean your nails
- Maintaining the skin, tooth, hair of our body
- Drinking chemically treated and filtered water
- Before cooking wash the raw vegetables and fruits with clean water
- Try to avoid plastic containers and aluminium vessels
- Do physical exercise to have proper blood circulation in the body.

NIMBY Syndrome:

NIMBY means **Not In My Back Yard.**

The developmental activities like airport, construction of railway tracks, roadways, nuclear power plants are essentially needed in the society. But it causes noise pollution and heavy traffic. So this kind of projects is opposed by the nearby residents. This is called nimby syndrome. These people are called nimbies.

HUMAN RIGHTS

Human rights are the fundamental rights which are possessed by all human beings irrespective of their caste, nationality, sex and language.

These rights cannot be taken away by any legislation or any government act. As natural rights they are seen as belonging to men and women by their very nature.

India is a democratic country. The aim of our government is to ensure happiness to all the

Citizens with equal rights, opportunities ad comforts. Every citizen must enjoy certain rights and also has certain duties towards the country.

Universal Declaration of Human Rights: Universal Declaration of Human Rights (UNDHR) by the UN was established in 1948.

Some of the declarations of Human Rights which are globally accepted are as follows:

1. Human right to freedom
2. Human right to property
3. Human right to freedom of religion
4. Human right to culture and education
5. Human right to constitutional remedies
6. Human right to equality
7. Human right against exploitation
8. Human right to food and environment

9. Human right to good health

Human right to freedom

1. Every citizen has the freedom to express his views
2. They have freedom to form unions or association
3. They have freedom to build their houses
4. They have full right to start any profession

Human right to property: Every human beings has the right to earn property.

Human right to freedom of religion: Every citizen has the freedom to choose their religion according to his wishes. All religions are equal before the law.

Human right to culture and education: All the citizens have equal rights both in culture and education. The minority communities like Christians, Muslims have their own rights to conserve the culture, language and to establish educational institutions of their own choice.

Human right to constitutional remedies: If a citizen is denied any of these fundamental rights, he or she can go to the court for protection. The court has the power to protect the basic rights of the citizen.

Human right to equality: All citizens are equal before the law. There is no any discrimination on grounds of religion, caste, sex (or) place of birth. All are given equal opportunity for employment.

Human right against exploitation: Children should not be employed as labours. Every citizen has the right to fight against exploitation.

Human right to food and environment: All human beings have the right to get sufficient healthy food, safe drinking water and healthy environment

Human right to good health: All human beings have the right to have very good physical and mental health.

INDIAN CONSTITUTION

Indian constitution provides for civil, social, cultural, educational and political rights including the right to judicial enforceability.

Article 14: Equality before law
Article 15: Freedom to practice and propagate any religion
Article 16: Equal opportunities for Employment.
Article 19: Freedom of speech, expression, forming associations and unions
Article 20: Protection from conviction
Article 22: Rights of a person in custody
Article 23: Prohibits forced labour.
Article 24: Prohibits exploitation of child labour
Article 25: Freedom of religion

Article 26: Establishment of charitable and religious institutions.
Article 27: Prohibits compulsion to pay any tax meant religious promotions
Article 28: Guarantees secular character
Article 29: Guarantees the right to conserve minority language
Article 30: Establishment of Minority Educational institution
Article 32: Provides for right to constitutional remedies

VALUE EDUCATION

Education: It is a systematic attempt towards human learning i.e., acquiring knowledge about a particular subject.

Types of Education:

1. **Formal education:** It is the systematic learning of subjects and is self related. Without formal education, all people cannot read and write, cannot get good jobs, cannot tackle any problems.
2. **Value education:** The education that develops the cultural, spiritual and moral sense and makes one able to take right judgement in one own's life is called value education
   Value education teaches us the following:
   - How to live a life with full satisfaction
   - How to deal with people in day to day life
   - How to be happy and make others also happy
   - How to communicate politely and sweetly with others
   - How to develop , grow and succeed in life
   - How to face old challenges

3. **Value-based environmental education:** Environmental education provides knowledge about the principles of ecology, fundamentals of environment and biodiversity. It creates a sense of duty to care for the natural resources and to manage them in a sustainable way.

When environment gets degraded it affects our health, well-being and our future. So, it is important to know all about the environment and also have a right to safe and clean environment.

Objectives (or) Importance of Value education

- To improve the integral growth of human being.
- To create attitudes and improvement towards sustainable lifestyle
- To increase awareness about our national history, our cultural heritage, constitutional rights, national integration, community development and environment.
- To create and develop awareness about the values and their significance.
- To understand about our natural environment in which how land, air and water are interlinked.
- To know about various living and non-living organisms and their interaction with environment.

Concept of Value education

The following are the concepts of values in environmental education.

1. Why and how can we use less resources and energy?
2. Why do we need to keep our surroundings clean?
3. Why should we use less fertilizers and pesticides in farms.
4. Why it is important for us to save water and keep our water sources clean.
5. Separate our garbage into degradable and non-degradable types before disposal.

Methods (Elements) of imparting value education

1. **Telling:** It is a process of developing values to enable a pupil to have a clear picture of a value-laden situation by means of his own narration of the situation.
2. **Modeling**: It is a method in which a certain individual perceived as ideal values is presented to the learners as a model
3. **Role playing:** Acting out the true feelings of the actor/actors by taking the role of another person but without the risk of reprisals.
4. **Problem solving:** It is a method where a dilemma is presented to the learners asking them what decisions they are going to take.
5. **Studying biographies of great man:** This method makes use of the lives of the great man as the subject matter for trying to elicit their good deeds and thoughts worthy for emulation.

Types of Values

1. **Universal values (or) Social values:** Universal values tell us about the importance of the human condition. These values are reflected in life, joy, love, compassion, tolerance, service, truth etc..
2. **Cultural values:** It varies with respect to time and place. These values are concerned with right and wrong, good and bad, true and false and behaviour of human beings. It is reflected in language, aesthetics, education, law, economics, philosophy etc.
3. **Individual values:** Individual values are our personal principles and the result of individual personality and experiences. Parents and teaches are the main key to shape our individual values. It is reflected in individual goals, relationships, commitments etc.
4. **Global Values:** Global values stress the concept , that the human civilization is a part of the planet and similarly nature and natural phenomena over the earth are interconnected and inter-linked with special bonds of harmony
5. **Spiritual Values:** It promotes conservationism and transform our consumeristic approach. It is reflected in self-restraint, self-discipline, contentment, reduction of wants.etc.

HIV/AIDS

AIDS is the abbreviated form for **Acquired Immune Deficiency Syndrome** caused by a virus called **HIV (Human Immune deficiency Virus).** Many myths have been spread about AIDS and it is very important for every one to know the facts about

HIV and AIDS.

Origin of HIV / AIDS

AIDS was discovered in 1983. Through sufficient knowledge has been gained about the disease, yet a definite source of this virus could not be identified. But the following theories have been suggested.

1. **Through African Monkey:**
   Most of the evidence have been suggested that the AIDS has spread from Africa. It has been believed that the HIV has transferred to human from African monkey (or) Chimpanzees.
2. **Through Vaccine Programmes**
   - **(i)** HIV has spread in Africa through HIV contaminated polio vaccine prepared from monkey's kidney.
   - **(ii)** It had spread through hepatitis-B viral vaccine in Los Angels and New York.
   - **(iii)** It had also spread through small pox vaccine programme of Africa.

World Scenario

Nearly 90% of the people who are infected with AIDS live in developing countries. 13% of world's population live in Africa, almost all states of African countries were affected by HIV. About 3 million people so far died due to HIV/AIDS in 2003. AIDS is rapidly spreading in eastern Europe and Asia.India ranks 2nd in the world with 5.1 million HIV/AIDS affected people. The percentage is lower than Thailand, Myanmar and South Africa.

Scenario in India:

The largest number of infected cases have been found in Maharashtra and TamilNadu, followed by Delhi, U.P., Karnataka and Goa. In Tamil Nadu alone, till September 2003 a total of 24,667 cases of AIDs have been found out.

Factors influencing modes of Transmission of HIV

HIV is spreading due to the following activities.

1. HIV from infected person can pass to a normal person through blood contact, generally during unprotected sex with infected person.
2. Using needles or syringes contaminated with small quantities of blood from HIV positive person also transmit HIV to others.
3. HIV can also pass from infected mothers to their babies during pregnancy delivery or breast feeding.
4. Blood transfusion from the infected person at the time of accidents or pregnancy also result in HIV/AIDS
5. HIV is 2 to 4 times more efficient than female to male transmission.
6. Women around 18-20 years are at more risk, since their cervical tissue is more vulnerable to invading HIV
7. Since, the majority of HIV infections occur in women of child-bearing age, transmission of HIV to their new born babies happen easily.

Factors not influencing transmission of HIV

HIV is not spreading by the following activities:

Tears, food and air, cough, handshake, mosquito, flies, insect bites, urine, saliva during normal kissing, sharing of utensils, clothes toilet, bathroom etc.,

Functions of HIV in Human Body

AIDS itself does not kill humans. The death occur due to the attack by diseases because of the weakening of immune system.

White Blood Cell (WBC) responsible in the formation of antibodies are called **T-helper cells,** T-helper cells are the key infection fighters in the immune system. The HIV enter into the human body and destroys the T-cells as a result of which various types of infection diseases occur. Even cancer can easily develop in the HIV infected persons.

Symptoms (or) Diagnosis of HIV/AIDS

Many people have no symptoms when they are first infected with HIV. But some people get fever, headache, fatigue. During this time, HIV is present in large amounts in semen and vaginal fluids and it is very easy to pass the infection to another person.

HIV is very active inside a person's body. The virus multiplies and kills more and more T-cells of the immune systems. Consumption of alcohol increases, the susceptibility to infection and progress of AIDS.

Minor Symptoms

1. Persistant cough for more than one month.
2. General skin disease
3. Viral Infection
4. Fungus infection in mouth and throat
5. Frequent fever, headache, fatigue.

Major Symptoms

1. Fever , Diarrhea for more than one month
2. Cough and TB for more than 6 months
3. Fall of hairs from the head
4. 10% body weight get reduced within a short period

Control and Preventive measures of AIDS

Once a person is infected with HIV the person remain infected for life. There is neither cure nor a vaccine but can be prevented. "Prevention is better than cure" is a slogan for all of us.

The basic approaches to control AIDS are

Education: Health education enables people to avoid indiscriminate sex and encourages the use of condoms. One should avoid the use of sharing razors, needles and syringes.

Prevention of Blood borne HIV Transmission: People in high risk groups should not donate blood. Blood should be screened for HIV before transmission and strict sterilization practices should be followed in hospitals.

Primary Health Care: AIDS awareness programmes should be encouraged. Voluntary health agencies should participate in large. Training programmes to doctors and paramedical workers should be conducted.

Counselling Services: Counselling services should be provided either in person or through telephone.

Drug Treatment: Testing HIV positive does not mean the end. They can still stay healthy leading productive lives for many years. Seeking early medical care and staying active are very vital in managing HIV. The immune system has to be kept boosted by taking nutritious diet and maintaining a stress-free mind.

Effects of HIV/AIDS

1. Large number of death occurs which affect environment and natural resources.
2. Due to large number of deaths, there is loss of labour and level of production decreases.
3. More water is required for maintaining hygiene in AIDS affected locality.
4. The people affected by HIV cannot perform work well due to lack of energy and frequent fever and sweating.

WOMEN WELFARE:

The main aim of women welfare is to improve the status of the women by providing Opportunities in education, employment and economic independence.

Need for women welfare

Generally women faces the following problems in the society.

1. Generally women suffer gender discrimination and devaluation at home, at workplace, in matrimony, in public life and power.
2. High number of cases of dowry deaths, rape, domestic violence, criminal offences and mental torture to women.
3. The human rights of women are violated in the male dominated society.
4. Generally in policy making and decision making process women are neglected.

Objectives of Women welfare (OR) Necessity of formation of women self help group

To overcome the above problems, a sound national strategy is needed with the following objectives.

1. To provide education
2. To impart vocational training
3. To generate awareness of the environment
4. To improve the employment opportunities
5. To know the problems of population
6. To restore the dignity, status, equality and respect for women.

Objectives of a National Commission for Women created by Government of India

A National commission for Women has been created by Government of India, its main objectives are:

1. To examine constitutional and legal rights for women
2. To review existing legislations
3. To sensitize the enforcement and administrative machinery to women's causes.

Environmental Degradation and Women welfare

The development work not only affects the natural environment but also affects the traditional, social, cultural and family life of women.

Example1: For various developmental activities like construction of dams , losing the forest cover, men generally migrate to towns for some job while the women are left h migrate to towns for some job while the women are left behind to look after their family with little resources.

Example 2: Mining projects play havoc with the life of rural women. Men can still work in the mines or migrate to towns for same job after getting compensation from the government. The displaced women are the worst affected as they do not get any compensation and depend on the men for wages.

Measures (or) Various schemes of various Organizations towards Women Welfare

1. **The National Network for women And Mining. (NNWM):** It is fighting for a "gender audit" of India's mining companies.
2. **United Nations Decade for Women:** It witnessed inclusion of several women welfare related issues on international agenda.
3. **International Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW):** It has created an international standard for the protection and promotion of women's human and socio-economic upliftment.
4. **Non-Government Organizations (NGO's) as Mahila Mandals:** It creates awareness among women of remote villages to empower them, train them, educate them and help them to become economically self-dependent.

5. **Ministry for Women And Child Development:** It aims to work for the up liftment of women by family planning, health care, education and awareness.

CHILD WELFARE

Children occupy nearly 40% of total population. They are considered to be the assets of a society. Of 21 million children born every year in India, 20 million children in our country are estimated to be working as child labours in various hazardous industries like match industry, fire work industry, pottery industry

Reason for Child Labour

1. Poverty: It is the main reason to force these children to work in unhealthy conditions.
2. Want of Money: Parents require money for their family so they are in a position to send their children for work.

Measures (or) Various schemes of various Organizations towards Child welfare

1. **UN convention on Rights of Child (or) International Law:** It formulated a set of international standards and measures to promote and protect the well being of children in our society.
   Rights of the Child: The international law defines right of the child to Survival, participation, development and protection.

   (a) **The right to survival:** It emphasizes on good standards of living, good nutrition and health.
   (b) **The right to participation:** It means freedom of thought and appropriate information to the child.
   (c) **The right to development:** It ensures access to education, childhood care and support, social security and recreation.
   (d) **The right to protection:** It means freedom from exploitation, inhuman treatment and neglect.
1. **World summit on children:** It had focused agenda for the well being of the children targeted to be achieved in the beginning of the new millennium.
2. **Ministry of Human Resource Development (MHRD):** It concentrates on child's health, education, nutrition, clean and safe drinking water, sanitation and environment

Environmental degradation and child welfare: Children are most affected due to environmental pollution . Water borne diseases are the biggest threat to children. Around 6 million children are affected by these disease in India. Even the child growing in the mother's womb get affected by environmental toxins.

Centre for Science and Environment (CSE): Its scientific report says "children consume

more water, food and air than adults and hence, more susceptible to any environmental contamination". So, it is essential to keep the cleaner environment to our children for the better and healthy life.

ROLE OF INFORMATION TECHNOLOGY IN ENVIRONMENT

Information technology means collection, processing, storage and dissemination of information. A number of software have been developed to study about the environment. The internet facilities, information through satellites, world wide web and Geographical information systems provide us up-to-date information on various aspects of environment and weather.

Soft wares for environment education

Remote sensing: This device is used to give information about the various natural resources and the environment. For this purpose, acoustic, gravity, magnetic, electromagnetic force fields are used.

The remote sensing image of land can be used to derive information of vegetation cover, water sources, land use , pattern, geological features, soil etc.,

Application of remote sensing

1. **In agriculture:** In India sector sustains the livelihood of around 70% of the population and contributes to about 35% of year net national product. We require judicious and optimal management of both land and water resources along with the use of high yielding variety seeds, optimal fertilizer input, post central etc. Remote sensing can provide valuable information for land and water management.
2. **In forestry:** Sustainable forest management requires reliable information on the type, density and extent of forest cover, wood volume and biomass, forest fire, pest and disease induced losses, encroachment etc., Remote sensing provide all such information clearly.
3. **In Land cover:** Spatial information on land use is required at different scales depending upon the use. Remote sensing data is converted to map, the spatial resolution plays a role in the scale of mapping.
4. **Water resources:** Remote sensing data has been used in many applications related to water resources such as surface water body mapping ground water targetting, wetland, inventory, flood monitoring, reservoir sedimentation, water quality monitoring, runoff modeling. Snow cover monitoring, irrigation water management and many more.

Database

It is the collection of inter-related data on various subjects. In the computer the information of data base is arranged in a systematic manner that is easily manageable and can be very quickly retrieved.

Applications of database

(a) The Ministry of Environment and Forest

(i) They are compiling a database on various biotic communities.

(ii) Database is also available for diseases like HIV/AIDS, Malaria, Fluorosis etc.,

(b) National Management Information System (NMIS)

They compiled a database on R & D projects along with information about research scientists and personnel involved.

Environmental Information System (ENVIS)

It functions in 25 centres all over the country. They generate a network of database in areas like pollution control, clean technologies, remote sensing, biodiversity, environmental management, desertification etc.,

Geographical Information System (GIS)

"GIS is a technique of superimposing various thematic maps using digital data on a large number of inter-related aspects."

Application of GIS

1. Different thematic maps containing digital information on various aspects like water resources, soil type, forest land, cropland, grassland are superimposed on a layered form in computer using soft wares.
2. Interpretation of polluted zone, degraded lands can be made based on GIS.
3. GIS can be used to check unplanned growth and related environmental problems.

Satellite Data

1. Satellite data helps in providing correct and reliable information about forest-cover.
2. It also provide information of atmospheric phenomena like monsoon, ozone layer depletion, smog. etc.

3.From the satellite data many new reserves of oil, minerals can be discovered.

World wide web

More current data is available on world wide web.

Important on-line learning Centre

1. www.mhhe.com/ environmental science.
2. Multimedia Digital Content Manager (DCM) in the form of CD-ROM.

Applications

1. These on-line learning centre provides the current and relevant information on principles, problems, queries, application of environmental science.

2. It has digital files of photos, power-point lecture presentation, animations, web-exercises and quiz. These are useful to both students and teachers of environmental studies.

ROLE OF INFORMATION TECHNOLOGY IN HUMAN HEALTH PROTECTION

Introduction

Information Technology plays a key role in human health. It has changed the human life style completely. Many health organizations are turning to package solution of IT for stream inning service oriented work in an effective manner.

The health service technology mainly involves three systems. They are:

1. Finance and accounting
2. Pathology
3. Patent administration: Clinical system

Applications of IT in health services.

1. With the help of IT packages, the data regarding birth and death rates, immunisation and sanitation programme are maintained more accurately.
2. It helps the doctor to monitor the health of the people effectively.
3. The information regarding the out break of epidemic diseases can be conveyed easily.
4. On-line help of expert doctors can be consulted to provide better treatment and services to the patient.
5. With a central control system the hospital can run effectively.
6. Drugs and its replacement can be administered efficiently.

CASE STUDIES:

1. Study on polluted backwaters of Kerala: A part of the back waters present in the Anchutengu-Kodianam Kulam, Kerala has been polluted due to the soaking of coconut-husk for the production of coir fibre. This polluted water has affected the fishery resources to a large event. The environment of the coastal areas covering the polluted and non polluted zones were studies in Indian Remote Satellite(IRS). The IRS data were compared with water quality paramaters such as turbidity, dissolved oxygen, production of H_2S and the primary productivity mechanism. Proper Analysis of these IRS have been carried out and the necessary steps were undertaken for the proper development of aquatic systems.

2.Ocean Colour Monitor (OCM) on Indian Remote Sensing Satellite IRS-P4

The Ocean Colour Monitor (OCM) instrument designed for the IRS-P4 Satellite programme is significantly different from similar instruments built and launched to date.. The OCM is the first instrument to take advantage of pushbroom technology for achieving higher radiometric performance and higher spatial resolution while maintaining a large swath to provide high revisit time for ocean observations. The instrument is mounted on a mechanism to provide tilt in the along track direction to avoid sun glint. The OCM instrument mounted on IRS-P4 will

be launched by PSLV and placed in a polar sun synchronous 720 kilometer altitude orbit. Equatorial crossing is at 12 noon ±20 min, descending node. The satellite has provision for data recording onboard and will also transmit real time data to ground stations in X-band. The ground station at Hyderabad, India will acquire data over the Indian subcontinent and the adjacent Arabian Sea and the Bay of Bengal. IRS-P4 OCM data may also be acquired by other ground stations with suitable augmentation / modification. A comprehensive programme for IRS-P4 OCM data utilisation has been drawn up in India along with a host of users. The IRS-P4 OCM data would be extremely useful for estimation of phytoplankton in oceanic /coastal waters, detection and monitoring of phytoplankton blooms, coastal upwelling, suspended sediment dynamics, location of fronts, identification of water mass boundaries and oil pollution. With additional input from other sensors as well as conventional data, IRS-P4 OCM data will provide detailed information on the coastal region owing to its increased spatial resolution. The information on pigments, in conjuction with sea surface temperature, will greatly assist in identification of potential fishery zones in coastal and oceanic waters. The potential end users of the OCM data products include fisheries management, marine industries, environmental management and studies related to the estimation of primary productivity in the oceanic basins. IRS-P4 OCM, along with other ocean colour sensors such as IRS-P3 MOS, SeaWiFS , MERIS and MODIS will assist the ocean colour community in filling data gaps, and can also be used for the inter-calibration of different ocean colour sensors.

3.GIS for forest management: GIS technology helps us organize the data about problems and understand their spatial relationship associations and provides a powerful means for analyzing and synthesizing information about them. GIS is designed for the collection, storage, and analysis of objects, and phenomena where geographic location is an important characteristic or critical to the analysis. GIS is now accepted as a fundamental tool for the effective use of geographic information.

Forestry involves the management of a broad range of natural resources within a forested area. In addition to timber, forests provide such resources as grazing land for animals, wildlife habitat, water resources and recreation areas. The U.S. Forest Service is responsible for the management of forest harvesting, grazing leases, recreational areas, wildlife habitat, mining activities as well as protecting endangered species. To balance the competing resource conservation and resource use, activities must be accommodated. Accessing the feasibility of these multiple uses is greatly enhanced by the use of GIS techniques.

Over the past eight years, GIS technology has been widely accepted by public as well as private forestry agencies. In large part this has been a result of the benefit of using GIS technology over current forest maps. The primary management tool for timber production in America is the forest inventory. It is used to access the existing forest resource and develop harvest schedules and treatment programs to project future timber supplies and for other operational planning activities. Forest inventory data is collected using remote sensing techniques.

The conventional forest inventory was done progressively with a small portion of the forest being inventoried each year. To update a forest cover map could take 20 years or more with expensive manual drafting. With GIS, the forest cover maps can be updated on a constant basis and it provides the forest managers more current data than what was previously

available. With GIS technology, the average age of the information in the forest data base could be reduced from 20 years to only a few weeks. The time factor alone has led to a wide acceptance and large demand for GIS applications in forestry.

4. Case study on Role of IT in Human health:

The New South Wales Ministry of Health, a department of the New South Wales Government, is responsible for monitoring the performance of the public health system in New South Wales, particularly through public hospitals. The goals of the Ministry are to keep people healthy, provide the health care that people need, deliver high quality services, and manage health services well. The provision or delivery of health services are delegated to fifteen local health districts who provide services in a wide range of settings, from primary care posts in the remote outback to metropolitan tertiary health centres. In addition, two specialist networks are focused on children's and paediatric services, and forensic mental health, and a third network covers the delivery of public health services provided by three Sydney facilities operated by St Vincent's and Mater Health.A New IT package was introduced in these health centres to streamline the various operations of the hospitals and help in providing better services to the people. The IT packages purchased from U.S company was found successful in the finance and accounting and pathology systems. But there were difficulties in implementing Patient Administrative System(PAS) or clinical system which involves the registration, admission and transfer of patients as well as medical records, clinical order entry results operating the clinic scheduling systems.The implementations IT packages of the PAS went off successfully with rural hospitals as well as medium sizes hospitals without much complications, where as the PAS system was met constant difficulties in implementations in larger hospitals and with networks.

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PART A QUESTIONS AND ANSWERS

1.Define Population and Population density.

Population: It is defined as a group of individuals belonging to the same species, which live in a given area at a given time.

Population Density: It is expressed as the number of individuals of the population per unit area (or) per unit volume.

2. Define TFR and IMR.

TFR: Total Fertility Rate: Average number of children delivered by a woman in her life time.

IMR: Infant Mortality Rate: The percentage of infants died out of those born in one year.

3.What are the parameters affecting population size?

Birth rate (or) Natality: It is the number of live birth per 1000 people in a population in a given year.

Death rate (or) Mortality: It is the number of deaths per 1000 people in a population in a given year.

Immigration: It denotes the arrival of individuals from neighbouring population.

Emigration: It denotes the dispersal of individuals from the original population to new areas.

4. Define exponential growth:

Population growth occurs exponentially like $10,10^2,10^3,10^4$ etc., which shows the dramatic increase in global population in the past 160 years.

5. Define Doubling Time.

t is the time required for a population to double its size at a constant annual rate. It is calculated as follows.

T_d (Doubling time) = 70/r

Where r = annual growth rate (OR) It is the number of years needed for a population to double its size

6.Define Demographic transition:

Population growth is generally related to economic development. The death rates and birth rates fall due to improved living conditions. This results in low population growth This phenomenon is referred to as demographic transition.

7. How can we classify the population based on Age structure?

Age structure of population can be classified into three classes.

(i) Pre-productive population (0-14 years).
(ii) Reporductive population (15-44 years)
(iii) Post reproductive population (above 45 years)

8.Define Population Explosion. What are the causes for population explosion.

The enormous increase in population due to low death rate (mortality) and high birth rate (Natality), is termed as population explosion.

Causes (or) reasons of population explosion:

- Invention of modern medical facilities reduces the death rate (mortality) and increases the birth rate (Natality), which leads to population explosion.
- Increase of life expectancy is another important reason for the population explosion.
- lliteracy is one of the reasons for the population explosion.

9.Mention the objectives of Family Welfare programme

- Slowing down the population explosion by reducing the fertility
- Pressure on the environment due to over exploitation of natural resources is reduced.

10. Define population stabilization ratio. Based on that expain zero population growth.

The ratio is derived by dividing crude birth rate by crude death rate.

Developed countries: The stabilization ratio of the developed countries is 1, which is more or less stabilized indicating zero population growth.

Developing Countries: The stabilization ratiio of the developing countries is nearing 3, which is expected to lower down by 2025.

11. Mention the objectives of Family Planning Programmes (OR) Factors influencing family size.

- Achieve 100% registration of birth, deaths, marriage and pregnancy.
- Encourage late marriages and later child-bearing.
- Enables to improve women's health, education, employment.
- Prevent and control of communicable diseases.
- Promote vigorously the small family norms.
- Making school education upto age 14 free and compulsory.

12.What are the factors influencing human health ?

1.Nutritional factors 2.Biological factors 3.Chemical factors 4.Psychological factors

13. Explain NIMBY Syndrome

NIMBY means Not In My Back Yard, which describes the opposition of residents to the nearby location of something they consider undesirable even if it is clearly a benefit for many.

Example: An incinerator, an ethanol plant, a nuclear power plant, a prison.

An airport is a typical example of a NIMBY complex. It benefits a city economically, but no-one wants it near them because of the noise pollution and traffic it generates.

14. Define Human rights. Mention all the rights.

Human rights are the fundamental rights which are possessed by all human beings irrespective of their caste, nationality, sex and language.

1.Human right to freedom 2.Human right to property 3.Human right to freedom of religion 4.Human right to culture and education 5.Human right to constitutional remedies 6.Human right to equality 7.Human right against exploitation 8.Human right to food and environment 9.Human right to good health

15. Define Value education. Mention its types. What are the types of values?

It is nothing but learning through which knowledge about the particular thing can be acquired. With the help of our knowledge and experience we can identify our values to understand ourselves and our relationship with others and their environment.

Types of Education:1.Formal education 2.Value education: 3.Value-based environmental education:

Types of values**:** 1.Universal values (or) Social values 2.Cultural values: 3.Individual values: 4.Global Values, 5.Spiritual Values:

16. Differentiate between HIV and AIDS.

HIV	**AIDS.**
Human Immune deficiency Virus	Acquired Immune Deficiency Syndrome
It is a Virus	It is a disease

17.Define population equillibitium.

A state of balance between birth rate and death rate in a population.

18.How does HIV function in Human body? Mention the factors Influencing and Not influencing of HIV

Functions: AIDS itself does not kill humans. The death occur due to the attack by diseases because of the weakening of immune system.White Blood Cell (WBC) responsible in the formation of antibodies are called T-helper cells, T-helper cells are the key infection fighters in the immune system. The HIV enter into the human body and destroys the T-cells as a result of which various types of infection diseases occur. Even cancer can easily develop in the HIV infected persons.

Influencing: Syringes Infected mother to babies, Blood transfusion.

Not Influencing: Tears, food and air, cough, handshake, mosquito, flies, insect bites, urine

19.What are the importance of Value education.

- To improve the integral growth of human being.
- To create attitudes and improvement towards sustainable lifestyle
- To create and develop awareness about the values and their significance and role.
- To understand about our natural environment in which how land, air and water are interlinked.

20.Define Geographical Information System (GIS)

"GIS is a technique of superimposing various thematic maps using digital data on a large number of inter-related aspects."

21.What are the problems of population growth?

1. Increasing demand for food 2. Loss of agricultural lands 3. Unemployment 4.Pollution

22.Define Population Equation.

$P_{t+1} = P_t + (B-D)+(I-E)$

P_t and P_{t+1} = sizes of population in an area at two different point in time t and t+1

B = Birth rate, D = Death rate

I = Immigration E – Emigration

23.What are the objective Women Welfare? Mention the various schemes.

1. To provide education
2. To impart vocational training and improve employment opportunities.
3. To generate awareness of the environment and problems of population.
4. To restore the dignity, status, equality and respect for women.

Various schemes:

1. The National Network for Women And Mining(NNWM)

2.International Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW)

24.Mention the necessity of Child Welfare. Mention the various Schemes.

Most of the Children are working as a Child Labours due to poverty and demand of money.

Schemes:

1.United Nation Convention on Rights of Child.

2.Ministry of Human Resources and Development.

UNIVERSITY QUESTIONS

1. Define population explosion. (Dec 2009, May 2015)
2. What are the effects of population explosion. (Dec 2009)
3. Define immigration and emigration(Dec 2009)
4. What are the objectives of family welfare programmes.(Dec 2009)
5. Mention the ill effects of HIV/AIDS on the environment. (Dec 2008)
6. State the Role of Information Technology in Environment. (Jan 2006)
7. Define population equilibirium, (Jan 2006)
8. Differentiate between HIV andAIDS.(Dec 2007)
9. What are the reasons behind the increased population growth in the less developed nations compared with developed nations. (Dec 2007)
10. What are the major precautions to avoid AIDS? (May 2008)
11. Define doubling time. (Dec 2008)
12. What are the effects of population explosion. (Dec 2009,June 2016)
13. Name any two family welfare programmes adopted in India. (June 2016)
14. Write any two child welfare schemes in TamilNadu.(June 2016)
15. What is population growth.(June 2016)
16. List out the advantages of family welfare programmes.(May 2015)
17. What are the sources of HIV function. (Dec 2014)
18. What are the objectives of value education. (Dec 2014)
19. Define HIV and causes of AIDS.(June 2016)
20. Define EIA and its benefits.

PART-B

1. What is AIDS? What are the sources and mode of transmission of HIV function.(Dec 2015, Dec 2014,May 2015)
2. Write note Women and Child Welfare and Human rights. (Dec 2015, May 2015)
3. Describe the role of IT in environment and Human health with case studies.(May 2015,Dec 2014, June 2016)
4. What are the objectives of value education? (May 2015)

5. Discuss the various of population among nations.(Dec 2014)
6. Write the methods and strategies of imparting value education. (May 2015)
7. Briefly describe the various schemes launched for women and child welfare in India. (Dec2014)
8. Draw a typical population pyramid of developing country and discuss. (June2016)
9. Explain problem by population explosion(June 2016)
10. Explain the causes , effects and control of HIV/AIDS. (June 2016)
11. Write about the reasons for population explosion in India. What are the measures to be taken to check the population explosion.(June 2016)

UNIT 1: WATER AND ITS TREATMENT

LEARNING OBJECTIVE:

- Able to provide a basic description and understanding of the main technologies and processes for drinking water**.**
- **Know about the hardness of water, expression of hardness, estimation of hardness of water by EDTA.**
- **Understand about the boiler troubles, treatment of boiler feed water.**
- **To know about the Softening process of hard water.**
- **Able to understand the process of desalination of brackish water.**

1.1 INTRODUCTION

Water is a transparent, tasteless, odorless, and nearly colourless **chemical substance** that is the main constituent of Earth's streams, lakes, and oceans, and the **fluids** of most living **organisms**. Its **chemical formula** is H_2O, meaning that each of its **molecules** contains one **oxygen** and two **hydrogen atoms** that are connected by **covalent bonds**

Water is essential for the survival of all living beings. About 70% of the earth's surface is occupied by water. Although water is available in abundance, less than 2% of the world's water resources are available as fresh water. Hence, it is necessary to use the available water most carefully and economically.

Water plays an important role in the **world economy**. Approximately 70% of the freshwater used by humans goes to agriculture. Almost all human activities - domestic, agricultural, and industrial - demand use of water. Water is used in steam generation. Water is also used as coolant in power and chemical plants.

1.2 SOURCES OF WATER

The two major sources of water are surface water and underground water.

The water which is found on the surface is called surface water and includes rain water, river water, lake water, and sea water. Rain water is regarded as the primary source of water. Rivers, lakes, and ground water, are all secondary sources of water. The water which is available under the ground is known as underground water.

1.3 TYPES OF IMPURITIES IN WATER

The impurities present in the water may be broadly classified in to three types.

PHYSICAL IMPURITIES

Suspended Impurities: Suspended impurities like sand, oil droplets, vegetable and animal matter, gives turbidity to water.

Colloidal impurities: Colloidal impurities like finely divided silica, clay, and organic wastes, gives color, odour, and taste, to water.

CHEMICAL IMPURITIES

Dissolved Salts and gases: Water contains dissolved salts like bicarbonates, chlorides, and sulphates, of Mg, Ca, Na, and K, and dissolved gases like oxygen, carbon dioxide and hydrogen sulphide. Excess dissolved salts impart unpleasant taste to water. Oxygen in water accelerates the rate of corrosion, whereas carbon dioxide and hydrogen sulphide make the water acidic and corrosive.

BIOLOGICAL IMPURITIES

Pathogenic bacteria, fungi, and other microorganisms, cause diseases.

1.4 WATER TREATMENT

The process of removing all types of impurities from water and making it fit for domestic and Industrial purposes is called water treatment

1.4.1 Hard and soft water

HARD WATER	**SOFT WATER**
Water which does not give lather readily with soap is called hard water	Water which gives lather readily with soap is called soft water
Hardness is due to the presence of Ca^{2+} andMg^{2+}salts(Chlorides,sulphates,bicarbonates)	Due to the absence of Ca^{2+} and Mg^{2+} salts [Na^{+} and K^{+} salts are present]

1.4.2 Hardness of water

Hardness is the property or characteristics of water, which does not produce lather with soap, but forms a white scum or precipitate. This precipitate is formed, due to the formation of insoluble soaps of calcium and magnesium. Typical reactions of soap with calcium chloride and magnesium sulphate are shown below:

$$2C_{17}H_{35}COONa + CaCl_2 \rightarrow (C_{17}H_{35}COO)_2Ca\downarrow + 2NaCl$$

Sodium stearate (Soap) Hardness-causing salt calcium stearate (insoluble)

$$2C_{17}H_{35}COONa + MgSO_4 \rightarrow (C_{17}H_{35}COO)_2Mg\downarrow + 2Na_2SO_4$$

1.4.3 Types of Hardness

Depending upon the types of dissolved salts present in water; hardness of water can be classified into temporary hardness and permanent hardness.

(a) Temporary hardness (or) Carbonate hardness (CH) (or) Alkaline hardness

This is due to presence of dissolved bicarbonates of calcium and magnesium. Temporary hardness is removed by either boiling the water or adding lime to the water. The above processes convert bicarbonates of calcium and magnesium as their insoluble carbonates and hydroxides, which may be removed by settling the precipitate and filtration.

$$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3\downarrow + H_2O + CO_2$$

$$Mg(HCO_3)_2 + 2Ca(OH)_2 \xrightarrow{\Delta} Mg(OH)_2\downarrow + 2CaCO_3\downarrow + 2H_2O$$

(b) Permanent hardness (or) Non–carbonate hardness (NCH) (or) Non-Alkaline hardness

This is due to the presence of chlorides and sulphates of calcium and magnesium ions. Permanent hardness is removed by lime soda process, zeolite process, demineralization process etc

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3\downarrow + 2NaCl$$

$$CaSO_4 + Na_2Ze \rightarrow CaZe + Na_2SO_4$$

(sodium zeolite)

Total hardness is the sum of temporary hardness and permanent hardness, i.e.,

Total Hardness = Temporary hardness + Permanent hardness

1.4.4 Expression of hardness in terms equivalents of $CaCO_3$:-

The concentrations of hardness causing salts are usually expressed in terms of an equivalent amount of $CaCO_3$. The choice of $CaCO_3$ is because it is the most insoluble salt that can be precipitated in water treatment and the molecular weight and equivalent weight of calcium carbonate is a whole number 100 & 50.

$$\text{Equivalents of } CaCO_3 = \frac{\text{Concentration of hardness producing salt in mg/lit} \times \text{Equivalent weight of } CaCO_3}{\text{Equivalent weight of hardness producing substance}}$$

[OR]

$$\text{Equivalents of } CaCO_3 = \frac{\text{Concentration of hardness producing salt in mg/lit} \times \text{Molecular weight of } CaCO_3}{\text{Molecular weight of hardness producing substance}}$$

1.4.5 UNITS OF HARDNESS

Hardness is commonly expressed in terms of parts per million or milligrams per litre.

Parts per million (ppm) : It is defined as the number of parts of $CaCO_3$ equivalent hardness per 10^6 parts of water

Milligrams per litre (mg/l) : It is defined as the number of milligrams of CaCO equivalent in I litre of water

Clarke's degree (^oCl) : It is defined as the number of parts of $CaCO_3$ equivalent hardness per 70000 parts of water

Degree French (^oFr) : It is defined as the number of parts of $CaCO_3$ equivalent

hardness per 10^5 parts of water

Relationship between various units

1ppm = 1mg / lit = 0.1 ^oFr = 0.07 ^oCl

Table:1.1 Molecular weights of some hardness-producing substance

Hardness-producing salts	Molecular weight g/mole	Hardness-producing salts	Molecular weight g/ mole
$Ca(HCO_3)_2$	162	$CaCO_3$	100
$Mg(HCO_3)_2$	146	$MgCO_3$	84
$CaCl_2$	111	Ca^{2+}	40
$MgCl_2$	95	Mg^{2+}	24
$CaSO_4$	136	$Ca(NO_3)_2$	164
$MgSO_4$	120	$Mg(NO_3)_2$	148

1.4.6 PROBLEMS BASED ON HARDNESS

1. A water sample contains 73 mgs of $Mg(HCO_3)_2$ per litre. Calculate the hardness in terms of $CaCO_3$ equivalents.

Amount of $Mg(HCO_3)_2$ = 73 mgs/lit ; Mol.wt of $Mg(HCO_3)_2$ =146

$$CaCO3 \text{ equivalent} = \frac{\text{Amount of hardness producing salt}}{\text{Mol.wt. of hardness producing salt}} \times 100$$

$$= \frac{73}{146} \times 100 = 50 \text{ mg/lit}$$

2. A water sample contains 81 mgs of $Ca(HCO_3)_2$ and 111mgs of $CaCl_2$ per litre. Calculate the hardness in terms of $CaCO_3$ equivalents.

Amount of $Ca(HCO_3)_2$ = 81 mgs/lit ; Mol.wt of $Ca(HCO_3)_2$ =162 mgs/lit

$$CaCO_3 \text{ equivalent} = \frac{\text{Amount of hardness producing salt mg./lit}}{\text{Mol.wt. of hardness producing salt g./mole}} \times 100 \text{ g. /mole}$$

$= 81/162 \times 100 = 50$ mg/lit

Amount of $CaCl_2$ = 111mgs/lit ; Mol.wt of $CaCl_2$ =111

$$CaCO_3 \text{ equivalent} = \frac{\text{Amount of hardness producing salt mg./lit}}{\text{Mol.wt. of hardness producing salt g./mole}} \times 100 \text{ g./mole}$$

$= 111/111 \times 100 = 100$mg/lit

Total hardness = 50 mgs/lit + 100mgs/lit = 150mgs/lit

3. A water sample contains 16.8 mg/lit. $Mg(HCO_3)_2$, 12mg/lit. $MgCl_2$, 29.6 mg/lit $MgSO_4$ and 5.0 mg/lit. NaCl . Calculate total, permanent and temporary hardness of water and express it in ppm.

Name of the hardness producing salt	**Amount in gms/lit.**	**Molecular weights**	**Amounts equivalent to $CaCO_3$**
$Mg(HCO_3)_2$	16.8	146	(16.8x 100) / 146 = 11.50mgs/lit
$MgCl_2$	12	95	(12x 100) / 95 = 12.63mgs/lit
$MgSO_4$	29.6	120	(29.6x 100) / 120 = 24.66mgs/lit
NaCl	5.0	NaCl does not contribute to hardness to water , hence it is ignored	

Temporary hardness = $Mg(HCO_3)_2$ = 11.50mgs/lit

Permanent hardness = $MgCl_2 + MgSO_4$ = 12.63 + 24.66 = 37.29mgs/lit (or) ppm

Total hardness = 11.50 + 37.29 = 48.79 mgs / lit

4. A water sample contains $Mg(HCO_3)_2$ = 73 mg/lit, $CaCl_2$ = 111mg/lit. $CaCl_2$, $Ca(HCO_3)_2$ = 81mg/lit and $MgSO_4$ = 40mg/lit. Calculate the total, permanent and temporary hardness of water and express it in ppm.

Name of the hardness producing salt	**Amount in gms/lit.**	**Molecular weights**	**Amounts equivalent to $CaCO_3$**
$Mg(HCO_3)_2$	73	146	(73x 100) / 146 = 50mgs/lit
$CaCl_2$	111	111	(111x 100) / 111 = 100mgs/lit
$Ca(HCO_3)_2$	81	162	(81x 100) / 162 = 50mgs/lit

$MgSO_4$	40	120	(40x 100) / 120 = 33.33mgs/lit

Temporary hardness = $Mg(HCO_3)_2 + Ca(HCO_3)_2$ = 50 + 50 = 100mgs/lit

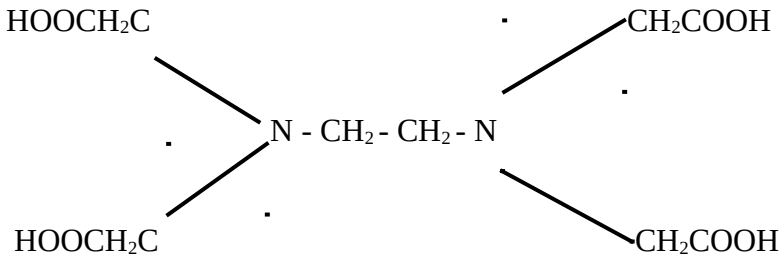
Permanent hardness = $CaCl_2 + MgSO_4$ = 100 + 33.33 = 133.33mgs/lit (or) ppm

Total hardness = 100 + 133.33 = 233.33 mgs / lit

1.4.6 ESTIMATION OF HARDNESS OF WATER BY EDTA METHOD

(Complexometric method)

The EDTA method is widely used for the estimation of hardness in water. The structure of EDTA (Ethylene Diamine Tetra Acetic acid) is given below



Principle:

The amount of hardness causing ions (**Ca^{2+}**and **Mg^{2+}**) can be estimated by titrating the water sample against EDTA after adding ammonium chloride – ammonium hydroxide buffer using Eriochrome Black–T (EBT) as an indicator.

EBT is a dye capable of forming unstable wine red colored complexes with Ca^{2+} ions and Mg^{2+} ions at a pH of 9-10. (**M^{2+} = Ca^{2+}/ Mg^{2+}**)

pH 8-10

M^{2+} + EBT^{2-} ⇌ [M– EBT]

Unstable - wine red coloured complex

When EDTA is added, the free (uncomplexed) $Ca^{2+}$and Mg^{2+} ions in water are complexed as metal ion–EDTA complex. This complex is more stable than the indicator-metal ion complex:

pH 9-10

M^{2+} + $EDTA^{2-}$ ⇌ [M – EDTA]

Colourless-stable complex

When all the free hardness-causing ions are complexed by EDTA, EDTA attacks the less stable metal-indicator complex, setting the indicator free. Thus, the end point is the colour change from wine red to steel blue.

pH=9-10

[M– EBT] + $EDTA^{2-}$ ⇌ [M^{2+} - EDTA) + EBT

Unstable (wine red) **Stable complex (Colourless)** **steel blue**

Preparation of Solutions:

EDTA Solution (0.01M): Dissolve 4 grams of salt of EDTA in 1000 ml distilled water.

Standard hard water (SHW): Dissolve 1 gram of pure dry $CaCO_3$ in minimum quantity of dilute HCl, evaporate it to dryness, and dissolve the residue in 1000 ml distilled water.

1ml of standard hard water = 1 mg of $CaCO_3$

EBT indicator: Dissolve 0.5. g of EBT in 100ml of alcohol.

Buffer solution: NH_4Cl (67.5 g) and NH_4OH (570ml) are made up to 1000 ml using distilled water.

Procedure

Standardization of EDTA solution

The burette is filled with the unknown EDTA solution and the initial reading noted. A 20-ml aliquot of the standard hard water is transferred into a clean conical flask by means of a pipette. This is followed by the addition of ammonia buffer (5 ml) and 2-3 drops of Eriochrome Black-T indicator, turning the solution wine red. The solution is titrated against unknown EDTA solution, the colour change from wine red to steel blue denoting the end point. The final burette reading is noted and the titration repeated for concordance. From the titre value, the strength of the given EDTA solution is calculated. Let the volume of EDTA consumed be V_1 ml

Estimation of total hardness

The burette is filled with the standard EDTA solution and the initial reading noted. A 20-ml aliquot of the given hard water sample is transferred into a clean conical flask by means of a pipette. This is followed by the addition of ammonia buffer (5 ml) and 2-3 drops of Eriochrome Black-T indicator, turning the solution wine red. The solution is titrated against standard EDTA solution, the colour change from wine red to steel blue denoting the end point. The final burette reading is noted and the titration repeated for concordance. From the titre value, the total hardness of the given water sample is calculated. Let the volume of EDTA consumed be V_2 ml

Estimation of permanent hardness

The burette is filled with the standard EDTA solution and the initial reading noted. A 20-ml aliquot of the soft water sample, obtained by boiling the hard water, is transferred into a clean conical flask by means of a pipette. The titration is carried out as done earlier. From the titre value, the permanent hardness of the given water sample is calculated. Let the volume of EDTA consumed be V_3 ml

Calculations:

(i) Standardisation of EDTA:

1 ml of Std hard water = 1 mg of $CaCO_3$

50 ml of Std hard water = 50 mgs of $CaCO_3$

50 ml of Std hard water consumes = V_1 ml of EDTA

V_1 ml of EDTA = 50 mgs of $CaCO_3$ equivalent hardness

(OR)

1 ml of EDTA = $50/V_1$ mgs of $CaCO_3$ equivalent hardness.

(ii) Estimation of total hardness of water sample:

50 ml of the given hard water contains = V_2 ml of EDTA

= V_2 X 50/ V_1 mgs of $CaCO_3$ equivalent hardness

[1 ml of EDTA = $50/V_1$ mgs of $CaCO_3$]

1000 ml of the given hard water sample = V_2 X 50/ V_1X1000/50

= 1000 X V_2/ V_1 mgs of $CaCO_3$ equivalent

hardness

Total hardness = 1000 X V_2/V_1 ppm

(iii) **Estimation of permanent hardness of water sample:**

50 ml of the same hard water sample after

boiling, filtering,etc, consumes = V_3 ml of EDTA

= V_3 X 50/ V_1 mgs of $CaCO_3$ equivalent hardness

1000 ml of the given hard water sample = V_3 X 50/ V_1X1000/50

= 1000 X V_3 / V_1 mgs of $CaCO_3$ equivalent hardness

Permanent hardness = 1000 X V_3/V_1 ppm

(iv) Temporary hardness:

Temporary hardness = Total hardness – Permanent hardness

= 1000 X V_2/V_1 – 1000 X V_3/V_1

Temporary hardness = 1000/ V_1 (V_2 – V_3) ppm

NOTE:

From the volume and strength of EDTA, it is equated to $CaCO_3$ equivalent as follows:

1000 ml of 1 M EDTA = 1000 ml of 1 M $CaCO_3$ solution

= 100 gms of $CaCO_3$

1000 ml of 0.01 M EDTA = 1 gm of $CaCO_3$ (or) 1000 mgs of $CaCO_3$

1 ml of 0.01 M EDTA = 1 mg of $CaCO_3$

OR

1 ml of 0.02 N EDTA = 1 mg of $CaCO_3$

1.4.7 PROBLEMS BASED ON EDTA METHOD

Problem 1

100 ml of a sample of water requires 18 ml of EDTA solution for the titration. 22 ml of the same EDTA solution was required for the titration of 100 ml of standard hard water containing 1 gm $CaCO_3$ per litre. Calculate hardness of water sample in ppm.

Solution:

Given

1 litre of std. hard water contains 1 gm of $CaCO_3$

i.e 1000 ml of std. hard water contains 1000 mgs of $CaCO_3$

$\therefore$ 1 ml of std. hard water = 1 mg of $CaCO_3$

22 ml of EDTA = 100 ml of std. hard water

= 100 X 1 mg of $CaCO_3$

$\therefore$ 1 ml of EDTA = 100 /22 mgs of $CaCO_3$

100 ml of sample of water = 18 ml of EDTA

= 18 X 100 /22 mgs of $CaCO_3$

$\therefore$ 1000 ml of sample of water = 18 X 100 /22 X1000/100

Hardness = 818.18 mgs/lit or ppm.

Problem 2.

100 ml of a water sample required 20 ml of EDTA solution for titration. 1 ml of EDTA solution is equivalent to 1.1 mgs of CaCO3.Calculate hardness in ppm.

Solution:

Given

1 ml of EDTA solution = 1.1 mgs of $CaCO_3$

$\therefore$ 20 ml of EDTA solution = 20 X 1.1 mgs of $CaCO_3$

= 22 mgs of $CaCO_3$

100 ml of water sample requires= 20 ml of EDTA

= 22 mgs of $CaCO_3$

∴ 1000 ml of water sample = 22 X 1000/100 mgs of $CaCO_3$

Hardness = 220 mgs/lit or ppm.

Problem 3.

0.28 gm of CaCO3 was dissolved in HCl and the solution made up to one litre with distilled water. 100 ml of the above solution requires 28 ml of EDTA solution for the titration. 100 ml of sample hard water required 33 ml of the same EDTA solution. 100 ml of this water (after boiling, cooling and filtering) required 10 ml of EDTA solution for titration. Calculate total, temporary and permanent hardness of water sample in ppm.

Solution:

Given

1000 ml of std. hard water contains = 0.28 mgs of $CaCO_3$

i.e

1000 ml of std. hard water contains = 0.28 X1000 mgs of $CaCO_3$

= 280 mgs of $CaCO_3$

∴ 1 ml of std. hard water contains = 0.28 mgs of $CaCO_3$

28 ml of EDTA = 100 ml of std. hard water

= 100 X 0.28 mgs of $CaCO_3$

= 100 X 0.28/28

1 ml of EDTA = 1 mgs of $CaCO_3$.

(i) **<u>Total hardness:</u>**

100 ml of hard water = 33 ml of EDTA

= 33 X 1 mgs of $CaCO_3$

= 33 mgs of $CaCO_3$

∴ 1000 ml of hard water = 33 X 1000/100

Total hardness = 330 mgs/lit or ppm.

(ii) **<u>Permanent hardness:</u>**

100 ml of the same water, after boiling, cooling and filtering required = 10 ml of EDTA

= 10 X 1 mgs of $CaCO_3$

= 10 mgs of $CaCO_3$

	∴ 1000 ml of the water	=	10 X 1000/100 mgs of $CaCO_3$
	Permanent hardness	=	100 mgs/lit or ppm
(iii)	**Temporary hardness:**		
	Temporary hardness	=	Total hardness – Permanent hardness
		=	330 – 100
	Temporary hardness	=	230 mgs/lit or ppm

Problem 4.

100 ml of a sample of water required 25.0 ml of 0.01 M EDTA for the titration using EriochromeBlack – T indicator. Calculate the total hardness.

Solution:

1 ml of 0.01 M EDTA	=	1 mg of $CaCO_3$
25 ml of 0..01 M EDTA	=	25 mgs of $CaCO_3$
100 ml of sample of water required	=	25 ml of 0.01 M EDTA
	=	25 mgs of $CaCO_3$ equivalent
∴ 1000 ml of the water is equal to	=	25 X 1000/100 mgs of $CaCO_3$ equivalent
Total hardness	=	250 mgs/lit or ppm.

Problem 5.

100 ml of a water sample required 20 ml of 0.01 EDTA for the titration with EBT indicator. 100 ml of the same water sample after boiling and filtering required 10 ml of 0.01 M EDTA. Calculate the total carbonate and non carbonate hardness of the sample.

Solution:

	1 ml of 1 M EDTA	**=**	100 mgs of $CaCO_3$
	1 ml of 0.01 M EDTA	=	1 mg of $CaCO_3$
(i)	**Total hardness:**		
	100 ml of hard water	=	20 ml of EDTA
		=	20 X 1 mgs of $CaCO_3$
		=	20 mgs of $CaCO_3$
	∴ 1000 ml of hard water	=	20 X 1000/100
	Total hardness	=	200 mgs/lit or ppm.

(ii) **Permanent hardness (NCH)**

100 ml of the same water, after boiling, cooling and filtering required	=	10 ml of EDTA
	=	10 X 1 mgs of $CaCO_3$
	=	10 mgs of $CaCO_3$
∴ 1000 ml of the water	=	10 X 1000/100 mgs of $CaCO_3$
Permanent hardness	=	100 mgs/lit or ppm

(iii) **Temporary hardness:**

Temporary hardness	=	Total hardness – Permanent hardness
	=	200 – 100
Temporary hardness	=	100 mgs/lit or ppm

1.5 BOILER FEED WATER

Boiler feed water is an essential part of boiler operations. The feed water is put into the steam drum from a feed pump. In the steam drum the feed water is then turned into steam from the heat. After the steam is used it is then dumped to the main condenser.

The main application of water in industry is for steam generation. The water used for steam generation should be free from dissolved salts of calcium, magnesium, iron, etc. The water suitable for steam generation in boilers is called boiler feed water. If we use untreated water in boiler the following things will happen.

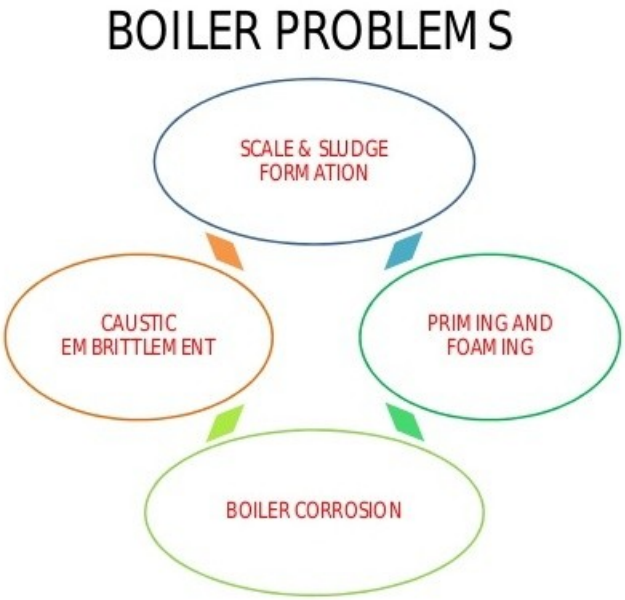
Boiler troubles (OR) Disadvantages of using hard water in boilers

(i) Scale and sludge formation

(ii) Priming and foaming

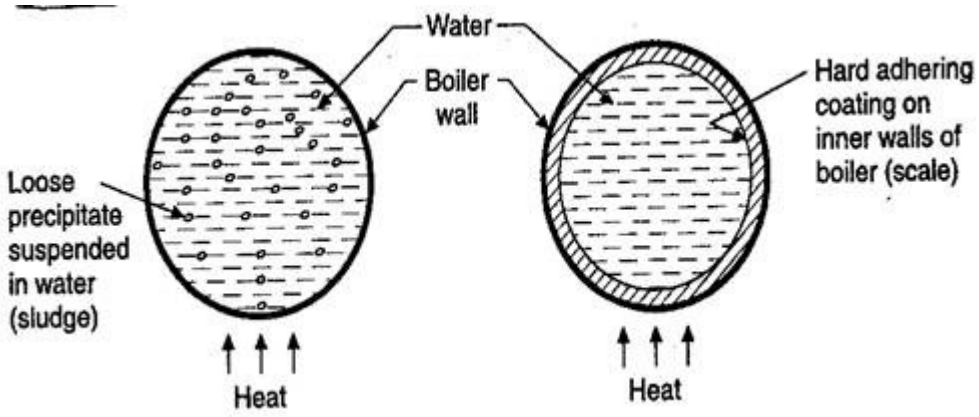
(iii) Boiler corrosion

(iv) Caustic embitterment



1.6.1 SCALE AND SLUDGE FORMATION

During boiler operation water evaporates continuously and the concentration of dissolved salts increases steadily. When it reaches a saturation point the salt starts precipitating. If the precipitate is soft and slimy, it is called **sludge.** On the other hand if the precipitate forms hard adherent coating on the inner walls of the boiler is called sludge.



Sludge: (Loose deposit)

Sludge is a soft, loose, and slimy precipitate. Sludge is usually formed by substances which have greater solubilities in hot water than in cold water, e.g., $MgCO_3$, $MgCl_2$, $CaCl_2$, $MgSO_4$, etc. It is formed at comparatively colder portions of the boiler.

Disadvantages of sludge formation

(i) Sludge is a poor conductor of heat, so a portion of heat generated is wasted.

(ii) Excess of sludge formation decreases the efficiency of boiler.

Prevention of sludge formation

Sludge formation in boilers can be prevented either using softened water or by frequent blow-down operation. Blow-down operation is the process in which concentrated water containing large amount of dissolved salts is removed at the end of the boiler operation and replaced with fresh water.

Scales: (Hard deposit)

Scales are hard, adherent coating formed on the inner walls of the boiler during steam generation. Scales are formed mainly by $Ca(HCO_3)_2$ and $MgCl_2$. In high pressure boiler, the scale-forming substances are mainly $CaSO_4$, silica, etc.

Disadvantages of scale formation

(i) Wastage of fuel: Scale is a poor conductor of heat. It acts as a thermal insulator. It reduces the evaporative capacity of the boiler. Thus scale formation decreases the efficiency of the boiler and causes the wastage of fuel

Thickness of the scale (mm)	0.325	0.625	1.25	2.5	12
Wastage of fuel (%)	10	15	50	80	150

(ii) Decreases the efficiency of the boiler: To get steady supply of steam from water over heating has to be done. Over- heating of the boiler walls makes the boiler materials soft and weak. So Scale formation decreases the efficiency of the boiler

(iii) Explosion of the boiler: When thick scales crack, due to uneven expansion the water comes suddenly, in contact with over- heated iron plates. This causes in formation of a large amount of steam suddenly, so sudden high pressure is developed, which may even cause explosion of the boiler

Prevention of scale formation:-

1. At the initial stage ,scales removed using scraper ,wire brush etc.,

2. If scales are brittle they can be removed by thermal shocks.
3. By using suitable chemicals like dil.acids and EDTA with which they form suitable complexes.
4. Loosely adhering sludge can be removed by frequent blow down operation.

Table 1:1 Comparison of Scale and Sludge

S.No	Sludge	Scale
1.	Sludge is a loose,slimy and non-adherent Precipitate	Scale is a hard and adherent precipitate
2.	The main Sludge forming substances are $MgCO_3$, $MgCl_2$, $CaCl_2$, $MgSO_4$	The main Scale forming substances are $Ca(HCO_3)_2$ $MgCl_2$ and $CaSO_4$,
3.	**Disadvantages:** 1.Sludge is a poor conductor of heat. 2.Excess of sludge formation decreases the efficiency of boiler.	**Disadvantages:** 1.Scales acts as thermal insulators. 2.It decreases the efficiency of the boiler.
4.	**Prevention:** 1. By using softened water 2. By blow down operation method.*	**Prevention:** 1.By using acids like HCl and H_2SO_4 2.By using Internal and External method

*Removing the portion of concentrated water frequently by fresh water from the boiler during production of steam.

Prevention of scale formation: The scale formation in boilers can be prevented by the following methods:

1.External treatment

2.Internal treatment

(i) **External treatment:** This method involves the removal of scale-forming impurities such as calcium and magnesium salts from the water before feeding to the boiler. Some of the external treatment methods are lime-soda process and demineralization process.

(ii) **Internal treatment:** This method involves the addition of chemicals directly to the water in boilers to remove the insoluble scale-forming substance in to soluble sodium salts which do not for scales

1.6.2. PRIMING AND FOAMING: (carry over)

Priming:

During rapid boiler operation, water droplets are carried along with steam. This process of wet steam forming is called priming.

Priming is caused by presence of large amounts of dissolved salts, high steam velocities, sudden / rapid boiling, very high boiler water level, improper boiler design etc.,

Priming can be minimized by

(i) Using treated water

(ii) Using mechanical steam purifiers

(iii) Maintaining medium water level

(iv) Proper design of boilers

(v) Uniform heating.

Foaming:

Bubbles formation on the surface of boiler water which do not break easily is called foaming. Foaming is due to the presence of impurities like oils (which reduce the surface tension of water) grease, clay, organic matters, dissolved salts, etc.

This can be minimized by

(i) Using antifoaming chemicals like castor oil, polyamides, sodium aluminate etc., during boiler operation

(ii) Using anti-foaming agents like synthetic polyamides.

1.6.3. CAUSTIC EMBITTERMENT:

It is defined as the intercrystalling cracking of boiler.

Caustic embitterment is a type of boiler corrosion caused by the use of highly alkaline water in the high pressure boiler

During softening by lime-soda process, it is likely that some residual Na_2CO_3 is still present in the softened water. In high pressure boilers Na_2CO_3 decomposes to give sodium hydroxide and CO_2 Sodium hydroxide thus produced makes the boiler water caustic

$$Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$$

$$NaOH + Fe \rightarrow Na_2FeO_2 + H_2$$

sodium ferrate

This caustic water flows into the minute hair cracks, present in the inner side of boiler, by capillary action. Here water evaporates and the dissolved caustic soda concentration increases progressively. This caustic soda attacks the surrounding area thereby dissolving iron of boiler as

sodium ferrate thus causes the embrittlement of boiler walls and particularly stressed parts like bends, joints, etc., even causing failure of the boiler

Prevention:

Caustic embitterment can be prevented by

(i) Using sodium phosphate as softening agent instead of sodium carbonate

(ii) Adding chemicals such as tannin, lignin, to boil water. They help in blocking the infiltration of NaOH through the hair cracks and crevices

(iii) Adjust the pH of the feed water carefully 8 to 9

1.6.4 BOILER CORROSION

The corrosion of boilers occurs due to dissolved oxygen, and due to carbon dioxide, alkali, and acids, produced by the hydrolysis of salt during boiler operations

1. DISSOLVED OXYGEN:

Dissolved oxygen present in water reacts with the boiler parts usually Iron, forming the corrosion products

$$2Fe + O_2 + 2H_2O \longrightarrow 2\,Fe(OH)_2$$

$$4Fe(OH)_2 + O_2 \longrightarrow 2(Fe_2O_3.2H_2O)$$

Ferrous hydroxide yellow rust

Removal of dissolved Oxygen:

1.By adding calculated quantity of sodium sulphite or sodium sulphide or hydrazine

$$N_2H_4 + O_2 \longrightarrow N_2 + 2H_2O$$

Hydrazine

$$2Na_2SO_3 + O_2 \longrightarrow 2\,Na_2SO_4$$

Sodium sulphite

$$Na_2S + 2O_2 \longrightarrow Na_2SO_4$$

Sodium sulphide

2.By mechanical de aeration:

Water is sprayed through perforate plates fitted tower and heated from sides and connected to vacuum pump. High temperature, low pressure and large exposed surface area provided by perforated plates reduces the dissolved oxygen in water

2. DISSOLVED CARBON DIOXIDE

When water containing bicarbonate is heated, CO_2 gas is evolved which makes the water acidic and leads to intense local corrosion called pitting corrosion

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2$$

$$CO_2 + H_2O \rightarrow H_2CO_3$$

Removal of Carbon dioxide

(i)By adding calculated quantity of NH_4OH

$$2NH_4OH + CO_2 \rightarrow (NH_4)_2 CO_3 + H_2O$$

(ii)By mechanical de aeration process along with oxygen

3. DISSOLVED SALTS

When water containing dissolved salt like $MgCl_2$ is used in the boiler, HCl is produced which attacks boiler in chain-like reactions producing HCl repeatedly:

$$MgCl_2 + 2H_2O \rightarrow Mg(OH)_2 + 2HCl \quad (1)$$

$$Fe + 2HCl \rightarrow FeCl_2 + H_2 \uparrow \quad (2)$$

$$FeCl_2 + 2H_2O \rightarrow Fe(OH)_2 + 2HCl \quad (3)$$

Prevention:

Corrosion by acidic can be prevented by adding alkaline solution from outside to neutralize them

1.7 TREATMENT OF BOILER FEED WATER (SOFTENING OR CONDITIONING METHODS)

The process of removing hardness producing salts and other impurities in water is known as softening. There are two types of treatment of water internal treatment and external treatment. In internal treatment the water is softened with in the boilers and in external treatment water is made soft before feeding into the boilers.

1.7.1 INTERNAL TREATMENT:

In this process (also called sequestration), an ion is prohibited to exhibit its original character by 'complexing' or converting it into other more soluble salt by adding appropriate reagent. An internal treatment is accomplished by adding a proper chemical to boiler water either : (a) to precipitate the scale forming impurities in the form of sludges, which can be removed by blow-down operation, or (b) to convert them into compounds, which will stay in dissolved form in water and thus do not cause any harm.

Internal treatments methods are, generally, followed by 'blow-down operation', so that an accumulated sludge is removed. Important internal conditioning/treatment methods are;

(i)Phosphate conditioning:

In high pressure boilers, scale formation can be avoided by adding sodium phosphate, which react with hardness producing substances like Calcium Chloride and Magnesium Chloride, forming soft sludge of calcium and magnesium phosphates , which can be removed by blow down operation:

$$3CaCl_2 + 2Na_3PO_4 \longrightarrow Ca_3(PO_4)_2\downarrow + 6NaCl$$

$$3Mg\,SO_4 + 2Na_3PO_4 \longrightarrow Mg_3(PO_4)_2\downarrow + 3Na_2SO_4$$

The main phosphates employed are sodium dihydrogen phosphate, NaH_2PO_4 (acidic), disodium hydrogen phosphate, Na_2HPO_4 (weakly alkaline), and trisodium phosphate, Na_3PO_4 (highly alkaline).

(ii) Colloidal conditioning:

In low pressure boilers, scale formation can be avoided by adding organic substances like kerosene, tannin, agar-agar, and gelatin. These chemicals convert scale forming substances into sludge that are non-adherent and loose precipitate which can be easily removed by blow down operation.

(iii) Sodium Aluminate conditioning:

When sodium aluminate is treated with boiler water, it gets hydrolysed to give sodium hydroxide and a gelatinous precipitate of aluminium hydroxide.

$$NaAlO_2 + 2\,H_2O \longrightarrow NaOH + Al(OH)_3$$

The formed NaOH reacts with magnesium salts.

$$MgCl_2 + 2\,NaOH \longrightarrow Mg(OH)_2 + 2\,NaCl$$

The flocculent precipitate of magnesium hydroxide and aluminium hydroxide entraps finely suspended and colloidal impurities like sand and oil drops which are difficult to remove ordinarily. The flocculent precipitates then settle to the bottom and can be removed easily.

(iv) Calgon conditioning

Calgon is sodium hexa meta phosphate, having the molecular formula $Na_2[Na_4(PO_3)_6]$. It prevents the scale and sludge formation by forming soluble complex compounds with scale-forming compounds like $CaSO_4$:

$$CaSO_4 + Na_2[Na_4P_6O_{18}]^{2-} \longrightarrow [Ca_2P_6O_{18}]^{2-} + 2Na_2SO_4$$

Scale-forming Salt	Complex ion Calgon	Soluble complex

1.7.2 EXTERNAL TREATMENT

External treatment includes efficient 'softening of water' (i.e. removing hardness producing constituents of water

ION EXCHANGE PROCESS (OR) DEMINERALIZATION

In this process, all ions present in the water are removed by ion- exchange resins. Ion exchange resins are insoluble, cross-linked, long chain organic polymers with a micro-porous structure. The active functional groups attached to the cross linked chains are responsible for the ion-exchanging properties. The ion exchange resins are of two types:

(i) cation-exchange resins and (ii) anion-exchange resins.

Cation-exchange Resin:

They are styrene divinylbenzene co-polymers which on sulphonation exchange their hydrogen ions with the cations in the water. These resins have acidic functional groups like $–SO_3H$, capable of exchanging their hydrogen ions for the cations present in salts in water, hence, they are termed as cation exchangers. Examples, sulphonated polystyrene, and phenol- formaldehyde resins.

Anion-exchange resin:

They are styrene–divinylbenzene co-polymer which contain basic functional groups such as quaternary ammonium hydroxide $(-N^+R_3)OH$, capable of exchanging their OH^- ions with anions in water; hence, they are termed as anion-exchangers.

Cation-exchange resins may be represented as RH^+, and anion-exchange resins may be represented as ROH^-.

Process

The hard water is first passed through the cation-exchange column which removes all the cation like Ca^{2+}, Mg^{2+}, Na^+, K^+ etc., from it, and an equivalent amount of H^+ ions are released from the column into the water:

$$2RH^+ + Ca^{2+} \rightarrow R_2Ca^{2+} + 2H^+$$

$$2RH^+ + Mg^{2+} \rightarrow R_2Mg^{2+} + 2H^+$$

$$RH^+ + Na^+ \rightarrow RNa^+ + H^+$$

he water coming out from the cation exchange column (acidic) is passed through an anion- exchange column. All the anions like SO_4^{2-},Cl^-, CO_3^{2-} , etc., present in the hard water are removed and an equivalent amount of OH^- ions are released into the water:

$$R'OH^- + Cl^- \longrightarrow R'Cl^- + OH^-$$

$$2R'OH^- + SO_4^{2-} \longrightarrow R_2SO_4^{2-} + 2OH^-$$

$$2R'OH^- + CO_3^{2-} \longrightarrow R_2'CO_3^{2-} + 2OH^-$$

H^+ and OH^- ions released from the cation- and anion-exchange column, respectively, combine to produce water molecules:

$$H^+ + OH^- \longrightarrow H_2O$$

Thus, the water coming out from the anion-exchange column is free from both cations and anions. This ion-free water is called as deionised water or demineralized water.

Regeneration:

After some time both the ion exchangers are exhausted. The exhausted cation- exchange column is regenerated by passing a solution of dilute hydrochloric acid.

$$R_2Ca^{2+} + 2H^+ \longrightarrow 2RH^+ + Ca^{2+}$$

$$R_2Mg^{2+} + 2H^+ \longrightarrow 2RH^+ + Mg^{2+}$$

$$RNa^+ + H^+ \longrightarrow RH^+ + Na^+$$

The exhausted anion-exchange column is regenerated by passing a solution of dilute NaOH:

$$R'Cl + OH^- \longrightarrow ROH + Cl^-$$

$$R'_2SO_4^{2-} + 2OH^- \longrightarrow 2ROH + SO_4^{2-}$$

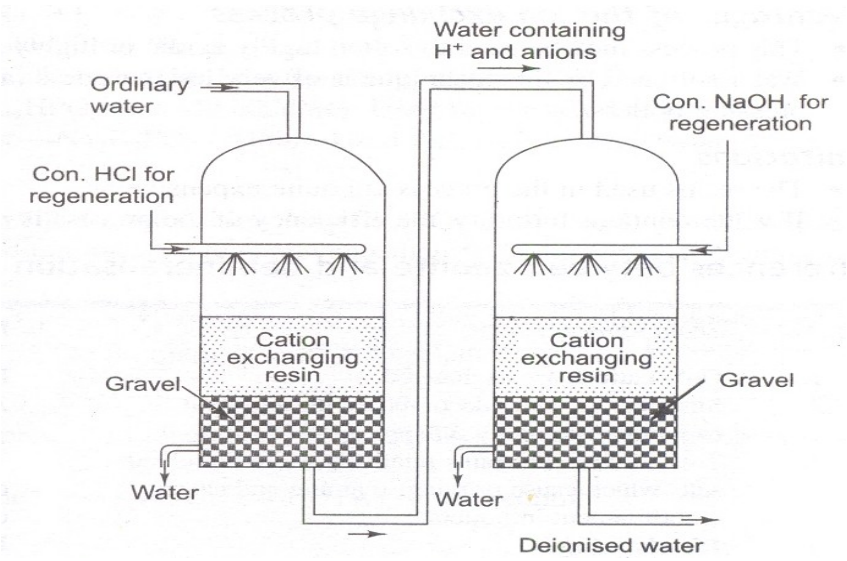


Figure 1.2 : Demineralization Process

Advantages:

(i) The process can be used to soften highly acidic or alkaline water.

(ii) The treated water has very low hardness less than 2ppm

Disadvantages:

(i) The process cannot be used to treat turbid water, as it block the pores present in zeolite.

(ii)The ion exchange resins are costly and more expensive chemicals are needed for regeneration.

(iii) Brackish water contains sodium ions can be treated by this method

1.7.3 ZEOLITE (or) PERMUTIT PROCESS :

Zeolites are naturally occurring hydrated sodium aluminosilicate. Its general formula is $Na_2O.Al_2O_3.xSiO_2.yH_2O$ (x = 2-10, y = 2-6).Natural zeolites are green and non-porous.The synthetic form of zeolite is known as permutit,which is porous and possess gel structure, hence it is generally used for water softening.Synthetic zeolite is represented by Na_2Ze.The sodium ions which are loosely held in Na_2Ze are replaced by calcium and magnesium ions present in the water.

Process :

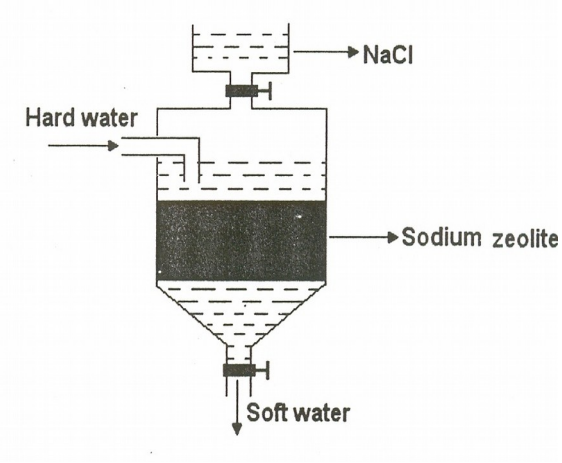


Fig 1.3 Zeolite Process

In this process the hard water is allowed to pass through a column packed with sodium Zeolite. The sodium ions are loosely held in this compound and replace the Ca^{2+} and Mg^{2+} ions from hard water.The following reactions involved in the softening process.

$$Na_2Ze + CaSO_4 \longrightarrow Ca\text{-}Ze + Na_2SO_4$$

$$Na_2Ze + MgSO_4 \longrightarrow Mg\text{-}Ze + Na_2SO_4$$

$$Na_2Ze + CaCl_2 \longrightarrow Ca\text{-}Ze + 2NaCl$$

$$Na_2Ze + MgCl_2 \longrightarrow Mg\text{-}Ze + 2NaCl$$

Regeneration

The converted Ca and Mg zeolite has to be regenerated to sodium zeolite again. This can be done by adding concentrated solution of sodium chloride.

$$Ca\text{-}Ze + 2NaCl \longrightarrow Na_2Ze + CaCl_2$$

$$Mg\text{-}Ze + 2NaCl \longrightarrow Na_2Ze + MgCl_2$$

Advantages of Zeolite process

(i) Water obtained by this process will have only hardness of 1-2 ppm.

(ii) This method is cheap , because the zeolite can be regenerated.

(iii) Equipment is compact and occupies less space

(iv) Its operation is easy

Disadvantages of Zeolite process

(i) The process cannot be used to treat turbid water, as it blocks the pores present in zeolite.

(ii)Acidic water cannot be treated by this method as it decomposes the structure of zeolite.

(iii)Water containing Fe,Mn , cannot be treated as it forms a stable complex with zeolite, which cannot be regenerated.

(iv)Brackish water cannot be treated by this method and the water obtained by this method contains Na_2CO_3, NaOH leads to boiler troubles like caustic embrittlement.

Differences between Zeolite and Demineralization process

S.No	Zeolite process	Demineralization process
1.	It exchanges only cations	It exchanges cations and anions
2.	Acidic water cannot be treated because acid decomposes the zeolite	Acidic water can be treated
3.	The treated water contains relatively large amount of dissolved salts which leads to priming, foaming and caustic embrittlement in boilers	The treated water does not contain any dissolved salts. Hence there is no priming and foaming
4.	Water containing turbidity. Fe,Ms cannot be treated.	Here also water containing turbidity, Fe, Mn cannot be treated

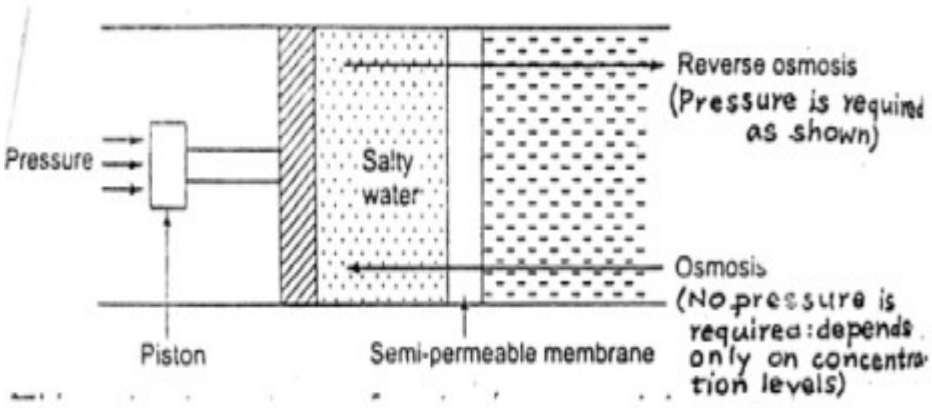
1.8. DESALINATION OF BRACKISH WATER

The process of removing common salt from the sea water is known as desalination. Water containing high amounts of dissolved salts (1,000 to 15,000 ppm) with peculiar taste is called brackish water**.**

The common methods for the desalination of brackish water are **reverse osmosis**, electrodialysis, distillation, and freezing.

Reverse Osmosis:

When two aqueous solutions of different concentrations are separated by a semi-permeable membrane, water molecules flow from dilute solution side to concentrated solution side. This phenomenon is known as osmosis. This flow depends upon the osmotic pressure existing on the membrane. If a pressure higher than the osmotic pressure is applied on the concentrated solution side, the solvent molecules flow from concentrated solution side to dilute solution side through the membrane. This phenomenon is called reverse osmosis. In this process, pressure of the order of 15 kg/cm^2 is applied to the impure water to be treated to force pure water to pass through semi-permeable membrane. Using this process, pure water is separated from the salt water. Polyamides, cellulose acetate, are used as semipermeable membranes.



Advantages

1. Low capital cost.
2. Maintenance cost is low.
3. Membrane replacement is easy.
4. Low energy consumption.
5. Removes ionic, non-ionic, and colloidal matter.

LEARN MORE

1. POTABLE WATER TREATMENT AND REQUIREMENTS

Water that is used for drinking purpose is known as potable water.

Requirements for potable water

(i) It should be clear and odourless (free from H_2S).

(ii) It should be free of turbidity.

(iii) It should be free of objectionable minerals like Pb and Mn salts.

(iv) It should have a pH in the range 7-8.

(v) It should be free from pathogenic bacteria or any other harmful micro-organisms.

(vi) The total dissolved solids content should be less than 500 ppm.

2. WATER QUALITY PARAMETER AS PER INDIAN STANDARD:

Colour :IS 10500-1991: Desirable : 5 Hz. , Permissible : 25 Hz.

pH : IS 10500-1991 Desirable :6.5 – 8.5, Permissible :No relaxation

TDS : IS 10500-1991 Desirable : 500 mg/l , Permissible : 2000 mg/l

Hardness : IS 10500-1991 Desirable :300 mg/l , Permissible : 600 mg/l

Alkalinity : IS 10500-1991 Desirable : 200 mg/l , Permissible : 600 mg/lit

Fe : IS 10500-1991 Desirable : 0.3 mg/l , Permissible : 1.0 mg/l

Mn	: IS 10500-1991 Desirable : 0.1 mg/l , Permissible : 0.3 mg/l
Sulphate	: IS 10500-1991 Desirable : 200 mg/l, Permissible : 400 mg/l
Nitrate	: IS 10500-1991 Desirable : 45 mg/l, Permissible : 100 mg/lit
Chloride	: IS 10500-1991 Desirable : 250 mg/l , Permissible : 1000 mg/l
Fluoride	: IS 10500-1991 Desirable : 1.0 mg/l, Permissible : 1.5 mg/l

3.ENVIRONMENTAL AND HEALTH RISKS ASSOCIATED WITH REUSE OF WASTEWATER FOR IRRIGATION

The positive effects are related to food security in poor areas.

Wastewater is possible (and commonly the only way) to produce food and increase income in poor areas.

Negative effects are due to the presence of pathogens and toxic chemical compounds in waste water . Irrigation with treated wastewater poses a number of potential risks to human health via consumption or exposure to pathogenic microorganisms, heavy metals, harmful organic chemicals. Four groups are at risk:

(1) agricultural workers and their families

(2) crop handlers

(3) consumers of crops, meat, and milk

(4) those living near the areas irrigated with wastewater, particularly children, and the elderly.

The diseases associated with such infections are also diverse and include typhoid, dysentery, diarrhea, vomiting. Any human contact with the treated wastewater might be hazardous

QUESTIONS

MULTIPLE CHOICE QUESTIONS:

1. Hardness of water is due to the presence of salts of

a) Potassium

b) Chlorine

c) Magnesium

d) Boron

2.Addition of washing soda removes

a) Softness of water

b) Temporary hardness of water

c) Permanent hardness of water

d) Hydrogen from water

3.Fluoride is also added to water, which helps in preventing

a) Infection

b) Sickness

c) Fever

d) Tooth decay

4.Temporary hardness can be removed by adding

a) Lime

b) Carbon

c) Oxygen

d) Slaked limewer

5. Select the incorrect statement from the following option.

a) Water which does not form lather with soap and forms white scum is called hard water

b) Hard water contains dissolved calcium and magnesium salts in it

c) In hard water, cleansing quality of soap is depressed

d) Due to the presence of dissolved hardness-producing salts, the boiling point of water is depressed

6.Water is mainly used in boilers for the generation of

a) Power

b) Electricity

c) Steam

d) Current

7 . Which of the following should not be a composition of boiler-feed water?

a) Hardness should be below 0.2ppm

b) Its caustic alkalinity should lie between 0.15 to 0.45 ppm

c) Its soda alkalinity should be 0.45-1 ppm

d) Its caustic alkalinity should be 1.5-2 ppm

8. If the precipitate formed is soft, loose and slimy, these are _____ and if the precipitate is hard and adhering on the inner wall, it is called _____.

a) Sludges, scale

b) Scale, sludges

c) Sludges, rodent

d) Scale, rodent

9. State true or false. The scales decrease the efficiency of boiler and chances of explosions are also there.

a) True

b) False

10.Ion-exchange resin is

a) Linear

b) Low molecular weight

c) Organic polymer with porous structure

d) Soluble

11.Select the incorrect statement from the following option.

a) Permanent hardness is due to dissolved chlorides and sulphates of calcium and magnesium

b) It can be removed by mere boiling of water

c) It is also known as non-alkaline hardness

d) The difference between the total hardness and the alkaline hardness gives the non-alkaline hardness

12. The propulsion of water into steam drum by extremely rapid, almost explosive boiling of water at the heating surface is called

a) Foaming

b) Priming

c) Corrosion

d) Caustic embrittlement

13. Foaming is caused by the formation of

a) Acids

b) Alcohols

c) Oils and alkalis

d) Ketones

14. An addition of small dose of chlorine gas to the filtered water is known as

a) Coagulation

b) Sedimentation

c) Filtration

d) Chlorination

15 . Hardness of water is conventionally expressed in terms of equivalent amount of

a) H_2CO_3

b) $MgCO_3$

c) $CaCO_3$

d) $Na_2 CO_3$

16.Semi-permeable membrane is selective membrane which does not permit the passage of dissolved _____ particles.

a) Solvent

b) Solute

c) Anhydrous

d) Saturated

17. The pH for the potable water should be in the range of

a) 5-6

b) 7-8.5

c) 9-10

d) 12-13

18. The basis of reverse osmosis is

a) Osmotic pressure is greater than hydrostatic pressure

b) Osmotic pressure is equal to hydrostatic pressure

c) Hydrostatic pressure is greater than osmotic pressure

d) Osmotic pressure does not exist

19. **The residual hardness in ion-exchange process is**

a) 0-2 ppm

b) 5-10 ppm

c) 10-15 ppm

d) 20-30 ppm

20.The chemical formula of Permutit is

a) $SiOAl_2O_3Na_2O$

b) $SiO_2Al_2O_3Na_2O$

c) $SiO_2Al_2O_3NaO$

d) $SiO_3Al_2O_3Na_2O$

21. **Which of the following is a disadvantage of zeolite process?**

a) No sludge is formed

b) The process is almost automatic

c) Suspended impurities get deposited around the zeolite particles

d) Zero hardness can be occurred

22. The color of the natural zeolite is

a) Green

b) Grey

c) Black

d) Blue

23. The maximum desirable limit Bureau of Indian Standards (BIS) of lead in the drinking water is

a) 0.05 mg/l

b) 0.09 mg/l

c) 0.1 mg/l

d) 1.0 mg/l

24.The maximum desirable limit (BIS) of total hardness (as $CaCo_3$) in drinking water is

a) 600 ppm

b) 300 ppm

c) 500 ppm

d) 1000 ppm

25. Permanent hard water may be softened by passing it through

a) sodium silicate

b**)** sodium bicarbonate

c). sodium hexametaphosphate

d) sodium phosphate

PART A

1.Classify the sources of water.

2.Classify the impurities present in the water

3.Define the hardness of water.[

4.Distinguish between hard water and soft water.

5.Mention the salts responsible for carbonate and non-carbonate hardness of water?

6.Why is water softened before using in boilers?

7.Differentiate between temporary hardness and permanent hardness of water.

8.How is hardness of water expressed? What are the units of hardness?

9.Estimatethe total hardness of water sample containing 60mg/l $MgSO_4$ and 162 mg/l $Ca(HCO_3)_2$.

10.Estimate the hardness of a water sample containing 2.4 mg $CaCl_2$ in 500 ml of water.

11.Estimate the hardness of water sample contains 73mgs of Mg(HCO3)2per litre in terms of CaCO3 equivalents.

12.Explain the need of an alkaline buffer in the EDTA method.

13.What is EDTA and write its structure.

14.Explain the function of EBT indicator in EDTA titration?

15.What are the problems caused by the use of untreated water in boilers?

16.What is priming? What is it due to?

17.Compare scales and sludges

18.Distinguish between priming and foaming.

19.Write about the causes of boiler corrosion.

20.What are the objective of internal conditioning?

21.What is desalination? Mention any two methods used.

22.Explain the concept of caustic embrittlement? How is it prevented?

23.What are the requisites of drinking and boiler feed water?

24.Distinguish between soft water and demineralised water.

25.What are ion exchange resins?

26.What is Calgon? What is its use in water technology?

27.Compare calgon conditioning with phosphate conditioning.

28.Distinguish between internal and external conditioning of water.

29.Explain about the reverse osmosis method?

30.Mention two advantages of the reverse osmosis process

PART – B

1.Estimate the total hardness of 100ml of water sample required 25ml of 0.01M EDTA for the titration using EBT indicator.

2.Explain in detail about the hardness of water by EDTA method.

3.What is meant by carbonate and non-carbonate hardness of the water with examples.

4.Mention the various problems caused by the use of untreated water in boilers.

5.Write about causticembrittlement in detail.

6.Explain the demineralization process in detail with a neat diagram and necessary equations

7.Explain the various methods of internal conditioning of boiler feed water.

8.Explain the purification of water by reverse osmosis.

9.How will you protect boiler from corrosion?

10.Differentiate between scales and sludges in boilers.

11. How is the softening of water carried out by the Zeolite process.

WEBSITE LINKS FOR REFERENCE

1) **Determination of hardness :**
https://youtu.be/Sa0WfA9UGG0

2) **Determination of hardness by EDTA method:**
https://youtu.be/rd22UDc28QQ

3) **Hard water & Soft water Differences (Animation video)**
https://youtu.be/F_lw6eSNtvA

4) **Working of sea water desalination (Animation video)**
https://youtu.be/mZ7bgkFgqJQ

5) **Manufacturing of water purifier at home**

https://youtu.be/pc0-TtkJScc

6) **Boiler feed water and its Treatment**
https://youtu.be/is5wdVgPOkI

7) **Desalination process (NPTEL link)**
http://nptel.ac.in/courses/116104045/lecture17.pdf

8) **Zeolite process**
https://youtu.be/UJkngC5933g

9) **Working of Reverse Osmosis**
1 .https://youtu.be/aVdWqbpbv_Y
2. https://youtu.be/4RDA_B_dRQ0

10) **Ion Exchange process**
https://youtu.be/BmpknJNDXfE

11) **Working of waste water treatment plant (Content Beyond Syllabus)**
https://youtu.be/FvPakzqM3h8

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CATALYSIS

3.1 INTRODUCTION:

Berzelius in 1836 realised that there are substances which are increases the rate of a reaction without themselves being consumed. He believed that the function of such substance was to loosen the bonds which hold the atoms in the reaction molecules together. Thus he coined the term **catalysis (Greek, kata** –wholly, lein – to loosen).

There is no doubt that usually a catalyst accelerate a reaction. But a number of cases are now known where the catalyst definitely slows down the rate of reaction.

Definition:

A catalyst is defined as a substance which alters the rate of a chemical reaction, itself remaining chemically unchanged at the end of the reaction. The process is called catalysis.

3.1.1 Types of catalysts

1. Positive catalyst

A catalyst which increases the rate of the chemical reaction is called a positive catalyst.

Example:

MnO_2 in the decomposition of $KClO_3$ into KCl and O_2.

$$KClO_3 \xrightarrow{MnO_2} KCl + O_2.$$

2. Negative catalyst

A catalyst which retards (decreases) the rate of the chemical reaction is called a negative catalyst (or) Inhibitors.

Example:

Alcohol retards the oxidation of chloroform to poisonous phosgene.

3.2 CATALYSIS

Definition

The process of altering (increasing or decreasing) the rate of a chemical reaction with the help of a catalyst is known as catalysis.

Types of catalysis

1.Positive catalysis

A catalyst which increases the rate of reaction is called positive catalyst and this phenomenon is called positive catalysis.

Example:

$$N_{2(g)} + 3H_{2(g)} \xrightarrow{Fe} 2NH_{3\,(g)}$$

2.Negative catalysis

A catalyst which decreases the rate of reaction is called negative catalyst and this phenomenon is called negative catalysis.

Example:

$$2CHCl_3 + O_2 \xrightarrow[\text{(oxidation)}]{C_2H_5OH} 2COCl_2 + 2HCl$$

3.2.1 Effect of a catalyst

A catalyst increases the rate of a reaction by lowering the energy barrier between the reactant and products. The catalyst provide another path for the reaction, that has lower energy of activation (Ea). Fig 3.1 shows the new path in the presence of the catalyst.

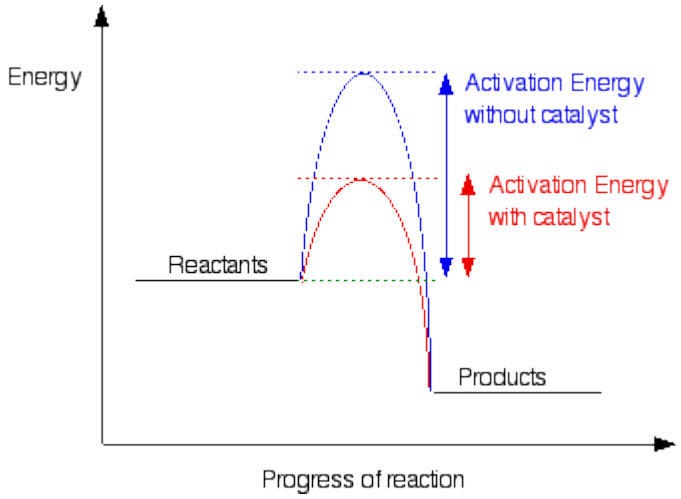


Fig.3.1 Energy level diagram of a catalyst

3.3 CLASSIFICATION (or) TYPES OF CATALYSIS

1. Homogeneous catalysis
2. Heterogeneous catalysis

3.3.1 Homogeneous catalysis:

In homogeneous catalysis, the catalyst is in the same phase as the reactants and is evenly distributed throughout. This type of catalysis can occur in gas phase or in liquid phase.

Examples:

1.Homogeneous catalysis in gas phase

(i) Oxidation of sulphur dioxide (SO_2) to sulphur trioxide (SO_3) with nitric oxide as catalyst.

$$2\,SO_{2\,(g)} + O_{2\,(g)} \xrightarrow{NO_{(g)}} SO_{3(g)}$$

(ii)Decomposition of CH_3CHO with iodine as catalyst.

$$CH_3CHO(v) \xrightarrow{I_{2(V)}} CH4(g) + CO(g)$$

2.Homogeneous catalysis in liquid phase.

(i) Hydrolysis of an ester in the presence of acid or alkali catalyst.

$$CH_3COOC_2H_{5(l)} + H_2O(l) \xrightarrow{[H^+/OH^-]} CH_3COOH(l) + C_2H_5OH(l)$$

3.3.2. Heterogeneous catalysis:

It is the reaction in which the catalyst and the reacting substances are present in the different phases.

Example: 1.Heterogeneous catalysis with gaseous reactants

(i) Oxidation of sulphur dioxide (SO_2) to sulphur trioxide (SO_3) in the presence of finely divided platinum or vanadium pentaoxide. This is called contact process of sulphuric acid manufacture.

$$2\,SO_{2\,(g)} + O_{2\,(g)} \xrightarrow{Pt_{(s)}} SO_{3(g)}$$

(ii) Combination of N_2 and H_2 to form NH_3 in presence of finely divided Fe.

$$N_{2(g)} + H_{2(g)} \xrightarrow{Fe(s)} 2NH_3\,(g)$$

2.Heterogeneous catalysis with liquid reactants

(i)Decomposition of aqueous H_2O_2 in presence of colloidal Pt.

$$2H_2O_2(l) + Pt(s) \longrightarrow 2H_2O(l) + O_2(g) + [Pt]\,(s)$$

3. Heterogeneous catalysis with solid reactants

(i)Decomposition of $KClO_3$ in presence of solid MnO_2

$$2KClO_{3(s)} + MnO_{2\,(s)} \longrightarrow 2KCl(s) + 3O_{2(g)} + MnO_{2\,(s)}$$

Table 3.1 Differences between homogeneous catalysis and heterogeneous catalysis

S.No	Homogeneous catalysis	Heterogeneous catalysis
1.	Reactants, Products and catalyst are present in only one phase	Reactants, Products and catalyst are present in different phase
2	Catalyst is not regenerated	Catalyst is regenerated
3	Thermal stability of the catalyst is low	Thermal stability of the catalyst is high.
4	Reactions are carried out at low temperature and pressure.	Reactions are carried out at high temperature and pressure.
5	Selectively of the catalyst does not depend on the physical nature.	Selectively of the catalyst depend on the physical nature.

3.4: Characteristics (or) Criteria for catalysis.

The following characteristics are common to most of the catalytic reactions.

1. A catalyst remains unchanged in mass and chemical composition.

Qualititative and quantitative analysis show that a catalyst undergo no change in mass or chemical nature. However, it may undergo some physical change.

2.Only a small quantity of the catalyst is generally needed.

In many reactions only a small amount of the catalyst is required. For instance, such a low concentration as one gram atom of colloidal platinum in 10^8 litres can catalyse the decomposition of H_2O_2.

As low a concentration of one gram ion of Cu (II) in 106 litres can catalyse the oxidation of sodium sulphite by atmospheric oxygen.

On the other hand there are catalysts which need to be present in relatively large mount to be effective.

$$RCOOR^1 + H_2O \xrightarrow{H^+/OH^-} RCOOH + R^1OH$$

The rate of above reaction is proportional to the concentration of the catalyst.

3.The catalyst does not alter the position of equilibrium in a reversible reaction.

Bodenstein was able to show that although the use of catalyst hastened the approach of equillibirium in the hydrogen iodide decomposition.

$$2HI \rightleftharpoons H_2 + I_2$$

It did not alter the concentration of the reactants and products. This has been found to be true in the case of several other reversible reactions as well.

4.The catalyst does not initiate the reaction.

The reaction is already occurring though extremely slow in the absence of the catalyst. The function of the catalyst seems to be only to speed up the reaction considerably. The reaction in the presence of a catalyst takes place through same alternative path which required much lower energy of activation. Hence it is speeded up.

5. The catalyst is generally specific in its action.

Manganese dioxide, for example, can catalyse the decomposition of potassium chlorate but not that of potassium per chlorate or potassium nitrate. Thus manganese dioxide specific in its action.

6. The catalyst cannot alter the nature of the products of the reaction.

The combination of nitrogen and hydrogen under suitable conditions forms ammonia whether a catalyst is added or not.

Potassium chlorate on decomposition gives potassium chloride and oxygen whether manganese dioxide is added or not.

There are however a few exceptions. CO and H_2 combine to form CH_4, CH_3OH or HCHO depending upon the nature of the catalyst used:

$$CO + 3H_2 \xrightarrow{Ni} CH_4 + H_2O$$

$$CO + 2H_2 \xrightarrow{ZnO + Cr_2O_3} CH_3OH$$

$$CO + H_2 \xrightarrow{Cu} HCHO$$

7. **A catalyst is more effective when finely divided**.

In heterogeneous catalysis, the solid catalyst is more effective when it is in a state of fine division that it is used in bulk.

Thus, a lump of platinum will have much less catalytic activity than colloidal or platinised asbestos. Finely divided nickel is a better catalyst than lumps of solid nickel.

8. **A catalyst is poisoned by certain substances or catalytic poison.**

It has been found that impurities of any type , even if it is present in small amounts, inhibit or retard the rate of catalysed reactions to a large extent. These impurities are, therefore, called catalytic poisons.

For example, the rate of combination of sulphur dioxide and oxygen (in contact process) is slowed down considerably if some arsenic compounds are present even in traces.

3.5 CATALYTIC PROMOTERS

Definition : A substance which promotes the activity of the catalyst to which it is added in small amounts is known as catalytic promoter. The process is called activation.

Examples:

1) In Haber's process of ammonia manufacture : Iron acts as a catalyst while molybdenum or a mixture of alumina and K_2O acts as a promoter.

2) In the manufacture of CH_3OH from CO and H_2, ZnO is the catalyst while chromium is the promoter.

Promoters improve one or more of the following properties of the catalyst:

(i) Activity enhancement
(ii) Selectivity enhancement
(iii) Increased catalyst life time

Function:

(i) Promoters increase the spaces between the catalyst particles. Hence , the adsorbed gas molecules like H2 are further weakened and finally broken. This enhances the rate of reaction.
(ii) Promoters increase the number of peaks and cracks on the catalytic surface.

3.5.1 CATALYTIC POISON

Definition:

A substance which reduces or destroys the catalytic activity of a catalyst is known as catalytic poison. The process is called catalytic poisoning. This is observed in solid catalysts

Examples:

1) In the contact process of H_2SO_4 manufacture: platinum is the catalyst, traces of arsenic compounds are catalytic poison.
2) Iron catalyst is poisoned by H_2S.
   Catalytic poisoning is of the following two types:
   (i) Temporary poisoning
   (ii) Permanent poisoning

Function

(i) By preferential adsorption of catalytic poisons on the surface of solid catalyst, the number of active centres or free valencies of the catalyst are reduced.
(ii) The catalyst may combine chemically with the catalytic poison.

Example: The poisoning of iron catalyst by H_2S.

$$Fe + H_2S \longrightarrow FeS + H_2$$

3.6 AUTO CATALYSIS

3.6.1 Definition:

When one of the products of a reaction itself acts as a catalyst for that reaction, the phenomenon is called autocatalysis.

During the occurrence of auto catalysis the initial rate of reaction increases as the catalytic product is formed but in a normal reaction where the rate of reaction decreases with time.

3.6.2 Examples:

1.Hydrolysis of an ester

The hydrolysis of ethyl acetate forms acetic acid and ethyl alcohol. Of these products, acetic acid acts as a catalyst for the reaction.

$$CH_3COOC_2H_5 + H_2O \xrightarrow{\text{catalyst}} CH_3COOH + C_2H_5OH$$

2.Decomposition of arsine

The free arsenic produced by the decomposition of arsine (AsH_3) auto catalyses the reaction.

$$2AsH_3 \longrightarrow \underset{\text{(Auto catalyst)}}{2As} + 3H_2$$

3.7 ACID – BASE CATALYSIS

Definition

Acid-base catalysis includes reactions in solution which are catalysed by acids or bases or both in aqueous solutions. It is a homogeneous catalytic reaction occurring in one liquid phase.

Types of acid-base catalysis

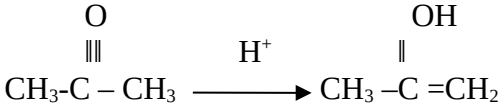
S.no	Types of Acid-Base Catalysis	Catalysed by
1.	Specific acid catalysis	Only H^+ or H_3O^+
2.	General acid catalysis	Bronsted acid
3.	Specific base catalysis	Only OH^-
4.	General base catalysis	Bronsted base
5.	Acid-base catalysis	Bronsted acid and base

3.7.1 Examples of acid –base catalysis

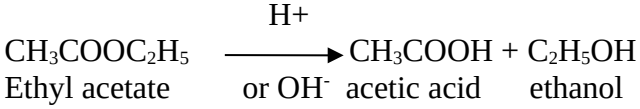
1. Inversion of cane-sugar in presence of an acid.

$$\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

2. Keto – enol tautomerism of acetone



3.Hydrolysis of an ester



3.7.2 Modern concept of acid-base catalysis

1.Acid catalysis

A reaction ,which is catalysed not only by H^+ (acid) ions, but also all Bronsted acids (Proton donors) cause acid catalysis.

Example:

H^+ , undissociated acids (CH_3COOH) , cations of weak bases (NH_4^+) and water (H_3O^+).

Classification of acid catalysis

(a) Specifically proton catalysed

If the reaction is catalysed only by H^+ or H_3O^+ ions, but not bronsted acids (Proton donors) the reaction is said to be specifically proton catalysed.

Example:

Inversion of cane sugar, keto-enol tautomerism.

(b) General acid catalysis

If the reaction is catalysed by bronsted acid, the reaction is said to be general acid catalysis.

2. Base catalysis

A reaction, which is catalysed not only by OH^- ions (base) , but also by bronsted bases (proton acceptors) cause base catalysis.

Example:

OH^-, undissociated bases (NH_4OH). anions of weak acids (CH_3COO^-) and water.

3.7.3 Classification of Base catalysis

(a) Specifically base – catalysed: If the reaction is catalysed only by OH^- ions ,the reaction is said to be specifically-base catalysed reactions.

(b) General base catalysis: If the reaction is catalysed by bronsted base, the reaction is said to be general base catalysis.
The solvent water may acts as a bronsted acid or base.

3.8 MECHANISM OF ACID-BASE CATALYSIS

Addition and removal of protons is the important part in the mechanism of acid-base catalysis.

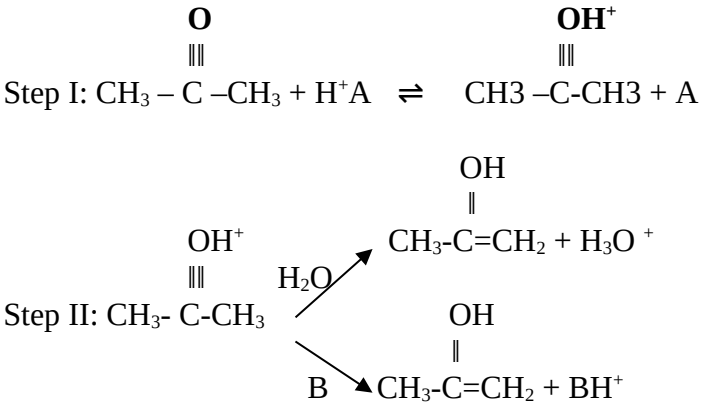
3.8.1 Acid catalysis

Step I: Involves addition of H^+ ions to the substrate forms intermediate complex.

Step II: Involves removal of proton from the intermediate complex using water or base.

Example:

Keto-enol tautomerism of acetone



3.8.2 Base catalysis

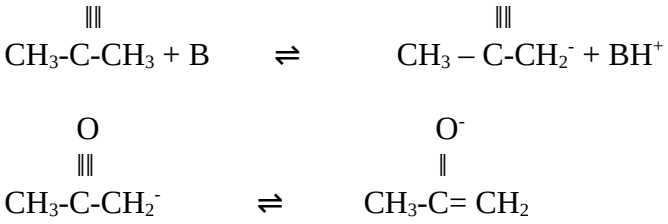
Step I: Involves removal of H^+ ions from the reactant to form an intermediate complex.

Step II: Involves addition of proton to the intermediate complex.

Example:

Step I:

O O



Step II:

3.9 KINETICS OF ACID –BASE CATALYSIS

The kinetics of acid-base catalysis can be illustrated by considering the two type of mechanisms.

1.Mechanism of specific acid catalysis

Assume that the step-I involves transfer of H^+ ions from an acid AH^+ to the substrate S.

The step II involves the reaction of the acid form of the substrate with water to form of the product P.

Step I:

$$S + AH^+ \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} SH^+ + A$$

Step II:

$$SH^+ + H_2O \xrightarrow{k_2} P + H_3O^+$$

Applying steady state approximation to the intermediate $[SH^+]$

$$\frac{d[SH^+]}{dt} = 0 = k_1[S]\,[AH^+] - k_{-1}\,[A]\,[SH^+] - k_2\,[SH^+] \text{ ---------(1)}$$

Since the reaction are conducted with very dilute solutions ,the concentration of H_2O remains almost constant. So the term $[H_2O]$ is not included in the above equation(1).

Solving for $[SH^+]$, the equation (1) becomes

$$k_1[S]\,[AH^+] = k_{-1}[A]\,[SH^+] + k_2\,[SH^+]$$

$$[SH^+] = \frac{k_1[S]\,[AH^+]}{k_{-1}[A]\,[SH^+] + k_2} \quad \text{----------(2)}$$

The rate of formation of product is given by

$$\frac{d[P]}{dt} = k_2\,[SH^+] \quad \text{----------(3)}$$

Substituting (2) in (3) we get

$$r = \frac{d[P]}{dt} = \frac{k_2\,k_1[S]\,[AH^+]}{k_{-1}[A] + k_2} \quad \text{----------(4)}$$

Two important cases

It follows two important cases

Case (i) When $k_2 >> k_{-1}[A]$, $k_{-1}[A]$ is negligible, so the above equation (4) becomes

$$r = \frac{k_2\,k_1[S]\,[AH^+]}{k_2}$$

$$r = k_1[S]\,[AH^+] \quad \text{----------(5)}$$

In this case the reaction is general acid catalysed.

Case (ii) When $k_{-1}[A] >> k_2$, k_2 is negligible, the equation (4) becomes,

$$r = \frac{k_2\,k_1[S]\,[AH^+]}{k_{-1}[A]} \quad \text{----------(6)}$$

The ionization constant of the acid $[AH^+]$ is

$$[AH^+] \rightleftharpoons [H^+] + [A]$$

$$\text{Therefore } K = \frac{[H^+]\,[A]}{[AH^+]}$$

$$[A] = \frac{K\,[AH^+]}{[H^+]} \text{ ----------(7)}$$

Equation (7) is substituted in (6)

$$r = \frac{k_2\, k_1[S]\,[AH^+]}{\frac{k_{-1}\, K\, [AH^+]}{[H^+]}}$$

$$r = \frac{k_2\, k_1[S]\,[H^+]}{k_{-1}\, K} \quad \text{…….(8)}$$

In this case the reaction is specifically hydrogen ion catalyzed, because the equation contains $[H^+]$.

2. Second mechanism

Assume that in the II step, the acid form of the substrate reacts with a base A instead of the water to form product P.

Step I:

$$S + AH^+ \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} SH^+ + A$$

Step II:

$$SH^+ + A \xrightarrow{k_2} P + AH^+$$

Applying steady state approximation for $[SH^+]$,as before we have

$$\frac{d[SH^+]}{dt} = 0 = k_1[S]\,[AH^+] - k_{-1}\,[A]\,[SH^+] - k_2\,[SH^+]\,[A] \text{---------(1)}$$

Solving for $[SH^+]$,the equation (1) becomes

$$[SH^+] = \frac{k_1[S]\,[AH^+]}{(k_{-1} + k_2)[A]} \quad \text{----------(2)}$$

The rate of formation of product is given by

$$\frac{d[P]}{dt} = k_2\,[SH^+][A] \quad \text{----------(3)}$$

$$r = \frac{k_1 k_2\,[S]\,[AH^+]}{k_{-1} + k_2} \quad \text{----------(2)}$$

The reaction is general acid catalyzed.

3.10 GENERAL APPLICATIONS OF CATALYSIS

1. Catalysis impacts the environment by increasing the efficiency of industrial processes.

2. Many fine chemicals are prepared by using catalysis.

3. Shape selective catalysis: The reaction that depends on the pore structure of the catalyst and the size of the reactant and product molecules is called shape selective catalysis.

4. Zeolites is used as catalysts in petrochemical industries for cracking of hydrocarbons and isomerisation.An important zeolite catalyst used in the petroleum industry is ZSM-5.It converts alcohols directly in to gasoline by dehydrating them to give a mixture of hydrocarbons.
5. Energy processing : Petroleum refining makes intensive use of catalysis for alkylation,catalytic cracking, naptha reforming and steam reforming. Fuel cells depend on catalyst.for both anodic and cathodic reactions.

6. Catalytic heaters generates flameless heat from a supply fuel.

7. Green chemistry in catalysis: Pollution control (air and waste streams) , avoiding toxic chemicals in industry and fuel cells generation.

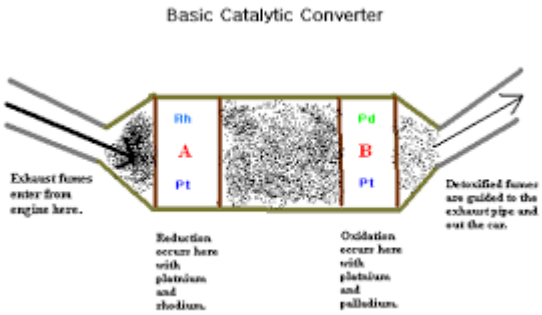
3.10.1 CATALYTIC CONVERTER

A catalytic converter is an emission control device that converts toxic gases and pollutants in exhaust gas to less toxic pollutants by catalyzing redox reaction. They use noble metals like platinum, Palladium and Rhodium as the heterogeneous catalysts.

Construction

A catalytic converter is a large metal box, bolted to the underside of a car, that has two pipes coming out of it.

1. One of them is connected to the engine and brings in hot, polluted fumes from the engine's cylinders.
2. The second pipe is connected to the tail pipe (exhaust).



Working

1. Molecules of polluting gases from the engine are pumped over the catalyst made of Platinum, Palladium or Rhodium.
2. The catalyst splits up the molecules in to their atoms.
3. The atoms then recombine into molecules of relatively harmless substances such as carbon di oxide, nitrogen and water, which blow out safely through the exhaust.

Functions

Catalytic converters change poisonous molecules like carbon monoxide and various nitrogen oxides in car exhausts into more harmless like carbon dioxide and nitrogen.

The three simultaneous functions of modern catalytic converter are as follows:

1.Reduction of Nitrogen oxides into elemental nitrogen and oxygen.

$$2NO_2 \longrightarrow N_2 + 2\,O_2$$

2.Oxidation of carbon monoxide to carbon dioxide.

$$2CO \longrightarrow O_2 + 2CO_2$$

3.Oxidation of hydrocarbons into carbon dioxide and water.

$$C_xH_y + O_2 \longrightarrow CO_2 + H_2O$$

3.11 ENZYME CATALYSIS (OR) CATALYSIS BY BIOLOGICAL CATALYST

Enzymes (or) biological catalyst are complex organic substances of high molecular weight proteins derived from living organisms. The catalysis brought about by enzymes are known as enzyme catalysis. Each enzyme can catalyse a specific reaction.

3.11.1 Examples for Enzyme Catalysis

1.Conversion of starch into Maltose

The enzyme **diastase** produced in the barely seeds converts starch in to maltose sugar.

$$2(C_6H_{10}O_5)_n + n\ H_2O \xrightarrow{\text{Diastase}} C_{12}H_{22}O_{11}$$

2. Inversion of cane sugar

The enzyme **invertase** present in yeast converts cane sugar into glucose and fructose.

3.Converesion of Glucose into Ethanol

The enzyme **Zymase** present in yeast converts glucose in to ethanol.

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} C_2H_5OH + 2\ CO_2$$

4.Hydrolysis of Urea

The enzyme **urease** present in soyabean converts urea into ammonia and carbon dioxide.

$$NH_2CONH_2 + H_2O \xrightarrow{\text{Urease}} 2NH_3 + CO_2$$

3.11.2 Characteristics of enzyme catalysis

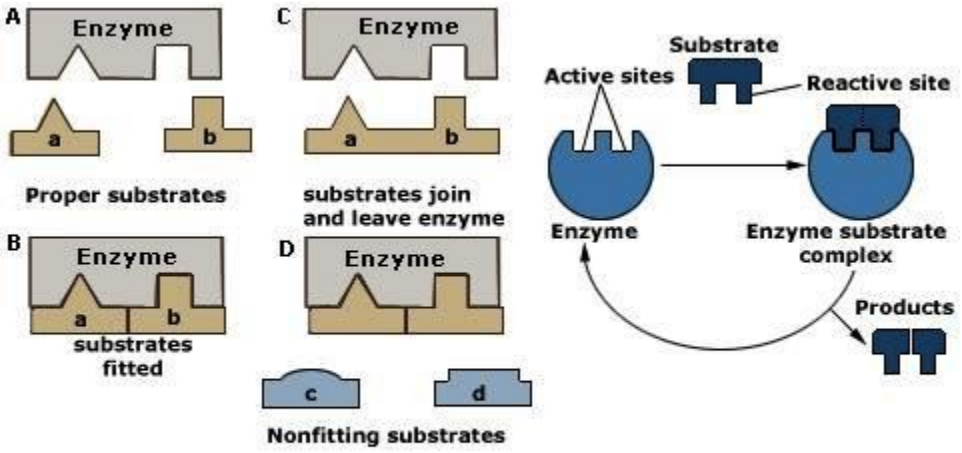
- A single molecule of this catalysis can transform a million molecules of the reactant per second. Hence it is highly efficient.
- These biochemical catalysts are unique in nature i.e. the same catalyst cannot be used in more than one reaction.
- The effectiveness of a catalyst is maximum at its optimum temperature. The activity of the biochemical catalysts declines at either side of the optimum temperature.

- Biochemical catalysis is dependent upon the pH of the solution. A catalyst works best at an optimum pH which ranges between 5-7 P^H values.
- The activity of the enzymes usually increases in the presence of a co–enzyme or an activator such as Na^+, Co^{2+} The rate of the reaction increases due to the presence of a weak bond which exists between the enzyme and a metal ion.

3.12 Mechanism of enzyme catalysis

The mechanism by which an enzyme binds with the substrate to forward the reaction of producing products can be explained by Lock and key hypothesis and Induced fit mechanism.

Lock and Key hypothesis: This hypothesis was put forth by Emil Fischer in 1894. Enzyme has a special site called as active site. the conformation of this active site corresponds to the shape of the substrate which fits into the active site. Enzyme is the lock and substrate is the key. A particular substrate can only fit into active site of the enzyme to form the enzyme substrate complex. (ES complex) This intermediate complex is later broken to form enzyme and the products. Enzyme undergoes no change but helps in forwarding the reaction. This is called as lock and key hypothesis.



Breakdown reaction catalysed by an enzyme according to lock-and-key hypothesis

Induced-Fit mechanism: In this mechanism, the substrate wraps over the enzyme bringing about the change in the enzyme molecule. Here substrate determines the final shape of the enzyme. ES complex is formed after bonding. ES complex breaks to give rise to enzyme and products. Enzyme undergoes no change. Exactly to say the active site is modified during Enzyme-Substrate complex formation.

3.12.1 KINETICS OF ENZYME CATALYSED REACTIONS (OR) MICHAELIS – MENTEN EQUATION

Biochemists L.Michaelis and M.Menten in1913 proposed a mechanism for the kinetics of enzyme catalysed reactions which involves the following steps.

Let the enzyme E react with the substrate (reactant) S. The first reaction, which is a fast reaction, is the formation of the intermediate complex, X.

$$E + S \xrightarrow{k_1} X \quad \text{----------(1)}$$

Enzyme substrate Intermediate complex

This intermediate complex may dissociate back into E and S.

$$X \xrightarrow{k_2} E + S \quad \text{----------(2)}$$

Or it may form the product ,P slowly

$$X \xrightarrow{k_3} P \quad \text{----------(3)}$$

Here k_1 ,k_2 and k_3 are the rate constants for the respective reactions.

The rate of formation of the intermediate complex, X is given by

$$\frac{d[X]}{dt} = k_1[E][S] - k_2[X] - k_3[X]$$

$$= k_1[E][S] - [X](k_2 + k_3) \quad \text{----------(4)}$$

Here ,[E] .[S] and [X] are the molar concentration of the enzyme ,substrate and intermediate complex respectively.

The rate of formation of the product ,P is given by,

$$\frac{d[P]}{dt} = k_3[X] \quad \text{----------(5)}$$

As,$[E_0] = [E] + [X]$ or $[E] = [E_0] - [X]$,the equation (4) can be written as,

$$d[X] = k_1\{[E_0] - [X]\}[S] - [X](k_2 + k_3) \quad \text{----------(6)}$$

$$\frac{}{dt}$$

Here , [E_0] = total concentration of the enzyme.

[E] = molar concentration of the unreacted enzyme.

[X] = concentration of the enzyme present in the complex.

The intermediate complex is unstable. It decomposes instantaneously.

$$\text{Hence }, \frac{d[X]}{dt} = 0 \quad \text{---------- (7)}$$

This state is called stationary state. At this state, we can write equation (6) as

$$k_1\{[E_0] - [X]\}[S] = (k_2 + k_3)[X] \quad \text{---------- (8)}$$

$$k_1[E_0][S] - k_1[X][S] = (k_2 + k_3)[X] \quad \text{----------(9)}$$

$$k_1[E_0][S] = k_1[X][S] + (k_2 + k_3)[X] \quad \text{----------(10)}$$

$$k_1[E_0][S] = \{k_1[S] + (k_2 + k_3)\}[X] \quad \text{----------(11)}$$

$$\text{or, } [X] = \frac{k_1[E_0][S]}{k_1[S] + (k_2 + k_3)} \quad \text{---------- (12)}$$

Dividing by $k_1[S]$, we have $[X] = \dfrac{[E_0]}{1 + \dfrac{(k_2 + k_3)}{k_1[S]}}$ ---------- (13)

Substituting this value of [X] in the equation (5) we get

$$\frac{d[P]}{dt} = \frac{k_3[E_0]}{1 + \dfrac{(k_2 + k_3)}{k_1[S]}} \quad \text{----------(14)}$$

$\dfrac{(k_2 + k_3)}{k_1} = K_m$ = Michaelis constant

Therefore $\frac{d[P]}{dt} = \frac{k_3 [E_0]}{1 + \frac{K_m}{[S]}}$ ----------(15)

Multiplying both numerator and denominator by [S]

$$\text{Rate} = \frac{k_3 [E_0] [S]}{[S] + K_m} \quad \text{----------(16)}$$

Equation (16) is known as **Michaelis – Menten equation.**

It has two important cases.

Case 1: At lower concentration

When the concentration of the substrate is less than K_m, [S] may be neglected in the denominator,i.e., $[S] << K_m$.

$$\frac{d[P]}{dt} = \frac{k_3 [E_0] [S]}{K_m} \quad \text{----------(17)}$$

This is a first order reaction.i.e., first order with respect to the substrate.

Case 1: At higher concentration

When the concentration of the substrate is higher than K_m ,ie., $[S] >>> K_m$, then

$$\frac{d[P]}{dt} = \frac{k_3 [E_0] [S]}{[S]} = k_3 [E_0] \quad \text{----------(18)}$$

This is a zero order reaction. i.e., it is zero order with respect to substrate.

Effect of substrate concentration on the rate

From the above two cases ,it is clear that the reaction rate of an enzyme catalysed reaction changes from first order to zero order on increasing the substrate concentration. This is due to the presence of one or more active sites in the enzyme molecules.

(i) When the substrate concentration is low, most of the these active sites remain unoccupied at any time. When we increase the substrate concentration ,the number of active sites which are occupied also increases. This increases the reaction rate.

(ii) When the substrate concentration is very high, almost all the active sites get occupied at any time. At this stage, further increase of concentration of the substrate will not increase in the formation of enzyme-substrate complex. Thus, the reaction becomes a zero order reaction.

Importance of Michaelis – Menten equation

1) When all the enzyme has reacted with the substrate at high concentrations, the reaction will be going at maximum rate. No free enzyme will remain. Hence $[E_0]$ = [X],
From equation (5),we have

$$\frac{d[P]}{dt} = V_{max} = k_3 [E_0] \quad \text{----------(19)}$$

Here, V_{max} = Maximum rate

The Michaelis – Menten equation (16) can now be written as

$$\text{Rate} = \frac{V_{max}[S]}{[S] + K_m} \quad \text{----------(20)}$$

Therefore ($V_{max} = k_3 [E_0]$) If K_m = [S],then

$$\text{Rate} = \frac{V_{max}[S]}{[S] + [S]} = \frac{V_{max}[S]}{2[S]} = \frac{V_{max}}{2} \quad \text{----------(21)}$$

Definition for K_m

Michaelis-Menten constant (K_m) is equal to that concentration of S at which the rate of formation of product is half the maximum rate obtained at high concentration of S.

Determination of K_m

Reciprocal of Michaelis-Menten equation (20) is known as Lineweaver-Burk equation and is written as,

$$\frac{1}{r} = \frac{1}{V_{max}} + \frac{K_m}{V_{max}[S]} \quad \text{----------(22)}$$

Equation (22) is an equation for a straight line of the form y = mx+ C.

A plot of $\frac{1}{r}$ Vs $\frac{1}{[S]}$ gives a straight line with intercept = $\frac{1}{V_{max}}$ and slope $\frac{K_m}{V_{max}}$ or,

K_m = Slope x V_{max} .

Thus, Michaelis-Menten constant is obtained.

Definition for Turn over number (k_3)

The constant k_3 is known as turnover number. It is the number of molecules converted in to products in unit time by one molecule of enzyme.

WEBSITE REFERENCES

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https://www.youtube.com/watch?v=wyH8HhENtko michaelis menten equation

REVISION QUESTIONS

UNIT-II -PART-1-SURFACE CHEMISTRY

SURFACE CHEMISTRY

LEARNING OBJECTIVES

After studying this chapter you will be able to:
Understand about surface chemistry
Know about adsorption and factors affecting adsorption
Explain about types of adsorption
Understand adsorption of gases on solids
Understand adsorption isotherms
Know about Freundlich adsorption isotherm
Know about Langmuir's theory of adsorption of a gas on the surface of solid
Understand kinetics of surface reactions

KEY WORDS

Adsorption, adsorbent, adsorbate, Adsorption isotherms, Freundlich isotherms, Langmuir theory of adsorption, Langmuir Hinshelwood mechanism, Michaelis –Menten equation

2.1 INTRODUCTION

Surface chemistry deals with the study of phenomena that occur at the surfaces or interfaces of substances, like adsorption, heterogeneous catalysis, formation of colloids, corrosion, crystallization, dissolution, electrode processes, chromatography etc. Surface chemistry finds its applications in industry as well as in daily life.

What is surface?

The physical boundary of any condensed phase like liquid or solid is considered as surface. It separates one phase from the other. It can be considered as series of points which make a plane or lssayer where one phase ends and the other begins. The surface may be uni-layered or multi-layered.

The interfaces that exist between two immiscible liquids like oil and water, between a metal and a gas like platinum and hydrogen; a liquid and a gas etc., are some examples.

The interfaces between two phases can be represented as: phase1/phase2 or phase1-phase2.

What is special about surface?

The atoms at the surface show unique properties that are different from those of atoms in the bulk due to unbalanced forces of attraction which are otherwise known as residual forces.

The atoms in the bulk are surrounded in all directions and hence the forces of attraction are balanced. However the forces of attraction at the surface are unbalanced since they are only attracted from inside. The forces of attraction acting outside are not balanced and hence are known as residual forces, which give unique properties to the surface.

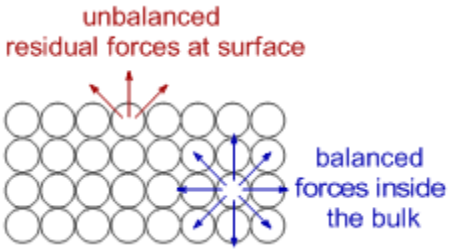


Figure 2.1

Energetics of surfaces:

Since the formation of a surface requires breaking of attractions between constituent particles, which is an endothermic process all the surfaces are relatively unstable and involves positive free energy of formation. Surfaces contribute positive free energy to the total system.

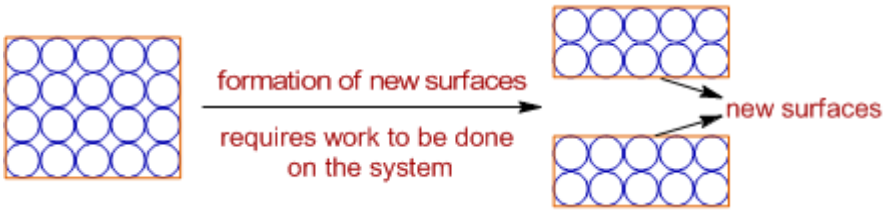


Figure 2.2

Hence systems try to minimize this unfavorable free energy at the surfaces, otherwise known as surface tension, in following ways.

i) By reducing the surface area.

ii) By altering the spatial arrangement of particles at the surface.

iii) By making attractions with particles of other systems.

2.1.1 DEFINITIONS

Adsorption is the accumulation or concentration of liquid or gas molecules (adsorbate) over the surface of a solid or a liquid (adsorbent). It is a surface phenomenon.

Adsorbate: The gas or liquid that is accumulated over the surface of a liquid or solid is known as adsorbate.

Adsorbent: The solid or liquid on whose surface, molecules of other substance are adsorbed. Solids, particularly in finely divided state, have large surface area and therefore act as good adsorbents.

E.g. activated charcoal, silica gel, alumina gel, clay, colloids, metals in finely divided state, etc.

Illustration: If a gas is taken in a closed vessel containing finely powdered charcoal, it is observed that the pressure of the gas in the enclosed vessel decreases. It is due to accumulation of gas molecules over the surface of charcoal.

Note: The charcoal is acting as adsorbent and gas as adsorbate.

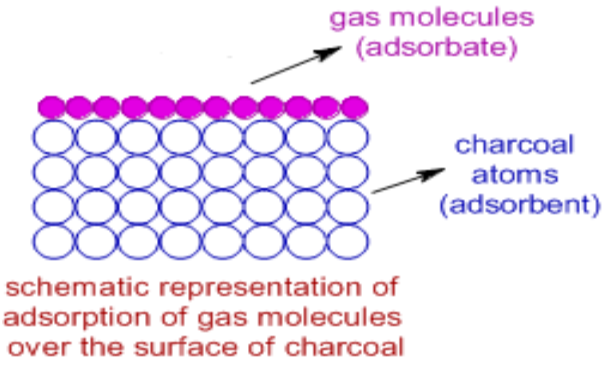


Figure 1.3

Desorption: The reverse of adsorption is called as desorption.

The surface atoms or molecules of adsorbent are relatively unstable due to positive surface free energy.Unlike in the bulk, there are unbalanced residual forces at the surface as the molecules at the surface are not symmetrically surrounded by other molecules. Hence they have tendency to attract adsorbate molecules and retain them to minimize the surface energy.

Adsorption is an exothermic process (i.e., ΔH = -ve) i.e., heat is liberated since new bonds are formed. However entropy of the system is also decreased (i.e., ΔS_{sys} = -ve) due to decrease in the number of microstates and decrease in the freedom of movement of molecules. Hence adsorption is thermodynamically more favourable at low temperatures.

Note: The value of ΔG becomes negative, only at low temperatures, when both ΔH and ΔS_{sys} are negative.

Therefore, in general, at higher temperatures, the bonds between adsorbate and adsorbent are weakened and the reverse of adsorption i.e. desorption is favoured.

A**d**sorption is different from a**b**sorption.

A**b**sorption involves the diffusion of molecules of a substance into the bulk of liquid or solid to form a solution.

E.g., Hydrogen gas is absorbed into the bulk of palladium metal, which is also known as occlusion.

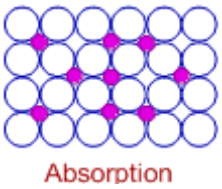


Figure 2.4

*A**b**sorption is a bulk phenomenon, whereas a**d**sorption is a surface phenomenon.*

Sorption: If both adsorption and absorption occurs simultaneously, the process is called as *sorption*. *Sorption = Adsorption + Absorption*

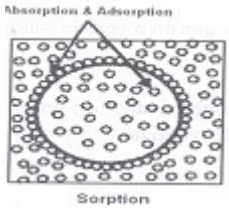


Figure 2.5

Table 2.1 Differences between adsorption and absorption

S.no	Adsorption	Absorption
1.	It is a surface phenomenon and occurs only at the adsorbent.	It is a bulk phenomenon and occurs throughout the body of material.
2.	It is a fast process	It is a slow process.
3.	Equilibrium is attained rapidly.	Equilibrium is attained slowly.
4.	The concentration of adsorbed molecules are more on the surface and less in the bulk	Distribution of absorbed species is uniform.
5.	e.g., Ammonia (adsorbate) is adsorbed on charcoal (adsorbent).	e.g., Ammonia gas absorbed in water. $NH_3 + H_2O \rightarrow NH_4OH$

2.2 TYPES OF ADSORPTION

Depending on the type of attractions between adsorbate and adsorbent, the adsorption can be divided into two types.

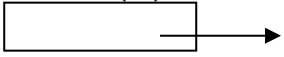
(1) Physical adsorption (or) Physisorption (or) van der Waals adsorption.

(2) Chemical adsorption (or) Chemisorption

1. Physical adsorption (or) Physisorption:

Physisorption occurs when the adsorbed molecules are held on the surface of the adsorbent by weak van der Waals forces of attraction.

Eg: Adsorption of H_2 (or) O_2 on charcoal.



2. Chemical adsorption or Chemisorption:

Chemisorption occurs when the adsorbed molecules are held on the surface of the adsorbent by chemical covalent bonds.

Eg: Adsorption of H_2 on Ni

H_2 molecule is first adsorbed by van der Waals forces, and then undergoes dissociation to hydrogen atoms. Then the H atoms are chemisorbed on Ni.

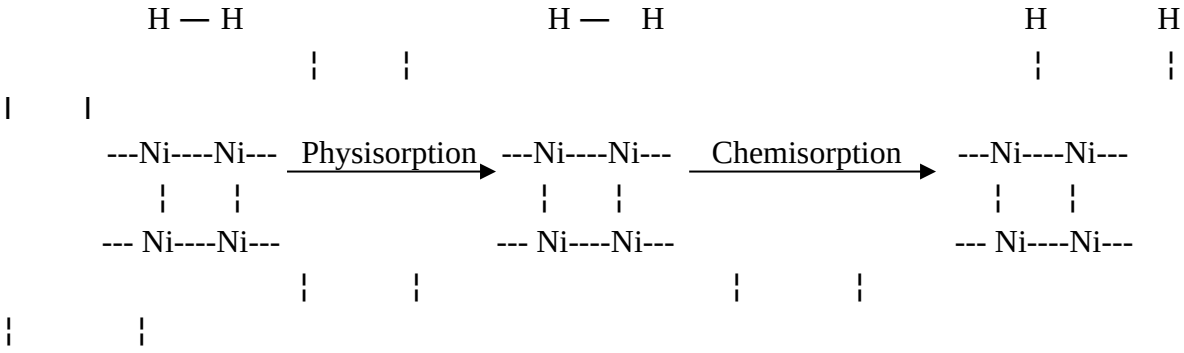


Table 2.2 Differences between Physisorption and Chemisorption

S.No.	Physisorption	Chemisorption
1.	Adsorption is due to weak Vander waals forces.	Adsorption is due to strong covalent bond formation.
2.	Heat of adsorption is low (20-40 kcal/ mol)	Heat of adsorption is high (40-400 kcal/mol).
3.	Adsorption is completely reversible.	Adsorption is irreversible.
4.	Adsorption decreases with increase in temperature	Adsorption increases with increase in temperature
5.	Multilayer adsorption occurs.	Only monolayer adsorption occurs.
6.	The rate of adsorption increases with increase of pressure and concentration.	The rate of adsorption decreases with increase of pressure and concentration.
7.	The equilibrium is established rapidly.	The equilibrium is established slowly.
8.	No surface compound formation takes place.	Surface compound formation takes place
9.	It involves very small activation energy.	It involves appreciable activation energy.
10.	It is not specific in nature.	Highly specific in nature.

2.3 Characteristics of Adsorption:

1. Adsorption is a selective process.
2. It depends on the nature of adsorbent and adsorbate.
3. It is always spontaneous and accompanied by evolution of heat, i.e., exothermic.

4. The rate of adsorption depends on temperature pressure or concentration of the adsorbate.
5. Surface area and activation of the adsorbent

1. Physical adsorption

- Physical adsorption is due to the weak Vanderwaals force of attraction.
- These forces are characterized by low heat of adsorption, less than 10 K cals/mole
- Physical adsorption proceeds at low temperature
- Physical adsorption decreases with increase in temperature
- The rise in temperature will increase the kinetic energy of gaseous molecules and hence gaseous molecules will leave the surface and thereby lowering the extent of adsorption.
- Physical adsorption is reversible. It can be reversed by lowering the pressure.
- Physical adsorption is not specific in nature
- Example: adsorption of nitrogen on mica

2. Chemical adsorption

- Chemical adsorption is due to the strong chemical bond.
- Chemical adsorption is associated with high heat of adsorption, lies between 50-100 K cals/mole
- Chemical adsorption proceeds at higher temperature
- Chemical adsorption increases with increase in temperature
- The rise in temperature will increase the kinetic energy of gaseous molecules and hence gaseous molecules collide with surface and thereby form chemical bond. hence adsorption is increased
- Chemical adsorption is irreversible. It cannot be reversed by changing the pressure.
- Chemical adsorption is specific in nature.
- Example; adsorption of oxygen on silver, adsorption of hydrogen on nickel

2.4 Adsorption of gases on solids

Since most of the surface reactions takes place by chemisorption .All solid absorb gases to some measurable extent .The magnitude of adsorption of gases by solids depends on the following factors.

1.Nature of gases.

2.Nature and surface area of adsorbents.

3.Heat or enthalpy of adsorption.

4.Reversible character of adsorbed gases.

5.Pressure of gas.

6.Temperature of gas.

7.Thickness of adsorbed layer of gas.

8.Activation of adsorbent.

2.4.1 Factors influencing adsorption of gases on solids

1.Nature of gases:

Gas molecules with high polarity, soluble and easily liquefied will be easily adsorbed . The amount of gas adsorbed by a solid depends on the nature of the gas. Easily liquefiable gases(HCl,NH_3,Cl_2,SO_2) are adsorbed easily than permanent gases(H_2,N_2,O_2 etc)

This is due to the following reason,

i) Critical temperature:

The effect of liquefaction depends upon its critical temperature (i.e minimum temperature above which a gas cannot be liquefied).

The higher the critical temperature(Tc) the more easily the gas is liquefied and consequently, more readily it is adsorbed.

Adsorption of various gases on 1 gm of activated charcoal.

Gases	**SO_2**	**NH_3**	**CO_2**	**CO**	**N_2**	**H_2**
Critical Temp(Tc) K	430	406	304	134	126	33
Amt.of gas adsorbed(ml)	380	180	48	9.3	8.0	4.5

Easily liquefiable gas ⟷ Permanent gas ⟷

ii)Vanderwaal's force:

Easily liquefiable gases posses greater Vanderwaal's forces than permanent gases ,so they are adsorbed more readily.

2.Nature of the surface area of adsorbent:

The extent of adsorption depends on the surface area.

i)When the surface area is more, the adsorption is also more.

ii) Highly pores on the adsorbent higher is the adsorption .This is because ,pores permit the diffusion of gases.

e.g : Charcoal and Silica gel are excellent adsorbents ,because their structure is highly porous and possess large surface area.

3. Heat or Enthalpy of adsorption:

Adsorption is always exothermic (evolution of heat) process.

Heat of adsorption : The energy liberated when one gram mole of a gas is adsorbed on the solid surface.

i)In Physisorption:

Heat of adsorption is about 5 K.Cal/mol due to weak vanderwaal's forces. Hence, such gases are adsorbed to a smaller extent on solid adsorbent.

ii)In Chemisorption:

Heat of adsorption is about 100 K.Cal/mol due to formation of chemical bond between the gas and the adsorbent .Hence, such a gases are adsorbed to a smaller extent on solid adsorbent.

4.Reversible character of adsorption:

i)In Physisorption:

It is a reversible process .So the adsorbed gases can be easily desorbed (removed) under reversible condition of temperature and pressure.

$$\text{Gas + Solid} \longrightarrow \text{Gas/solid + Heat}$$

ii)In Chemisorption:

It is a reversible process, because a surface compound is formed. So desorption is quite difficult.

5.Pressure of a gas:

The adsorption between solid and gas, when pressure is increased the adsorption also increased and decrease of pressure cause desorption.

Eg: 1.Adsorption of CO on tungsten.

2.Adsorption of H_2 on nickel.

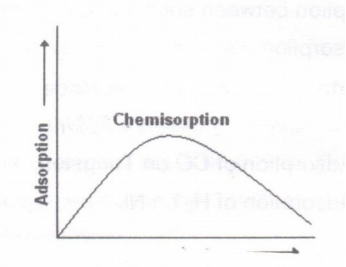
6. Temperature of gas:

i) In Physisorption:

It occurs rapidly at lower temperature and decreases with increase in temperature.

ii)In Chemisorption:

It increases with increase in temperature and then decreases.



7.Thickness of adsorbed layer of gas:

i) In Physisorption:

Adsorbed gas forms uni molecular thick layer of gas molecules .But above certain pressure, multi molecular thick layer is formed.

ii)In Chemisorption:

Only uni molecular thick layer is formed .Since adsorbed gas combines directly with the adsorbent surface only.

8. Activation of adsorbent:

Activation leads to increase in the surface area of the adsorbent i.e, increasing the adsorbing power of the adsorbent, which increase adsorption .This can be done by the following ways,

i) Increasing of rough surface:

a) by mechanical rubbing of the solid adsorbents

b) by subjecting to some chemical reactions on the solid adsorbent.

ii) Increasing the effective area of the surface:

a) by sub-dividing the solid adsorbent into finer particles.

b) by strong heating of solid adsorbent in superheated steam ,now its pores are opened and adsorption activity increases.

2.5 Adsorption of solutes from solutions

It follows two mechanisms,

1 Adsorbents adsorb dissolved substances from solutions.

Eg: a) Activated charcoal adsorbs Cl^- ions from NaCl solution or AgCl solid.

b)It adsorbs colouring matter present in sugar.

c) It also adsorbs acids like acetic and oxalic acid in water ,thereby acid concentration in water decreases.

d) It also adsorbs out ammonia from the solution of ammonium hydroxide and phenolphthalein.

2. Adsorption of certain substances from the solution preference to other substances.

Eg: a)Charcoal: It adsorbs non-electrolytes more readily than electrolytes from a solution.

b)Alumina : It adsorbs electrolytes more readily than non-electrolytes from the solution.

2.5.1 Factors influencing adsorption of solute from solution

1.Effect of temperature and concentration:

An increase in temperature decrease in extent of adsorption and vice-versa.

Freundlich adsorption equation is suitable to explain the effect of concentration .The equilibrium pressure in the expression of concentration 'C' i.e.

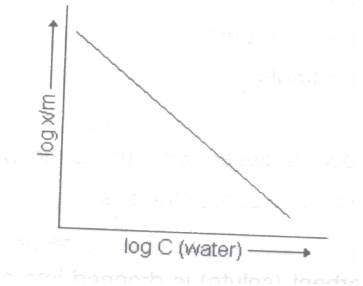
$x/m = KC^{1/n}$ x→mass of adsorbate

m→mass of adsorbent

$\log (x/m) = 1/n \log C + \log K$ K and n→constants

If graph is drawn between log x/m Vs log C,straight line is obtained for small ranges of concentrations.

When a adsorbent is dropped into a solution ,either the solute or solvent may be adsorbed.



i)Positive adsorption :

When the solute is adsorbed by a adsorbent it is called positive adsorption.

The adsorption increases with decrease of temperature and increase in concentration of solution.

Eg: From the concentrate solution of KCl , charcoal adsorbs KCl rather than H_2O and this leads to decrease in KCl Concentration.

ii) Negative adsorption:

If the solvent is taken up by a adsorbent it is called negative adsorption.

The adsorption of substance from the solution decreases with rise of temperature and decrease in concentration of solution.

Eg: Dilute solution of KCl ,charcoal adsorbs H_2O thereby the salt concentration gets increased.

2. Effect of surface area:

If the surface area of the adsorbent decreases, adsorption also increases.

3.The nature of the solute adsorbed:

The extent of adsorption is usually greater, when the molecular weight of the solute is high.

2.6 Adsorption Isotherms

It is plot of the variation amount of adsorption with pressure at constant temperature.

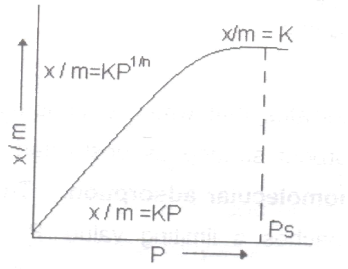
$x/m = kP^{1/n}$

x/m→extent of adsorption

x→mass of adsorbate

m→mass of adsorbent

k and n→constants



The extent of adsorption increases with increasing pressure (P) and becomes maximum at saturation pressure(Ps).

At (Ps) the rate of adsorption becomes equal to rate of desorption , thereby dynamic equilibrium is reached.

Free gases ↔ Gas adsorbed on solid.

Further increase in pressure does not any change in pressure.

2.6.1Freundlich Adsorption Isotherm

Freundlich have done a series of experiment and give the empirical formula(without any theoretical ideas) which explain the relationship between the amount of gas adsorbed on a particular amount of adsorbent at particular pressure at constant temperature called Freundlich ‘s adsorption isotherm given by

$x/m=kP^{1/n}$ →This equation only applicable for adsorption of gases on solids.

Variation of adsorption with pressure is explained by three cases,

i)At low pressure:

Adsorption increases with increasing pressure.

$x/m \alpha P^1$ $x/m= kP^1$ $1/n=1$→first order kinetics.

ii)At high pressure:

Adsorption is almost constant

$x/m \alpha P^0$ $x/m \alpha 1$ zero order reaction

x/m=constant x/m=k

iii)At intermediate (normal) pressure:

Adsorption depends on 0 to 1 power of fraction .Only a certain range of pressure , the adsorption $P^{1/n}$.

$0<1/n<1$

$x/m = kP^{1/n}$

$\log(x/m)=\log k + 1/n \log P$

(Y =C +mx) → eqn for straight line

Slope=1/n

logk intercept.

Limitation:

i)It fails, when the concentration of adsorbate is very high.

ii)The constant k and n are not temperature independents, it vary with temperature.

iii)The equation is valid only up to a certain pressure and invalid at higher pressure.

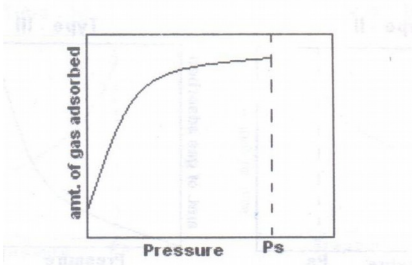
iv)It is purely empirical and has no theoretical basis.

2.6.2 Types of adsorption Isotherm

Different gases adsorbed on different solid studied completely. How adsorption varies with pressure at different temperature are noted and drawn the adsorption isotherm.

Totally five adsorption are we got and whose maximum adsorption occurs is indicated by Ps.

Type-I

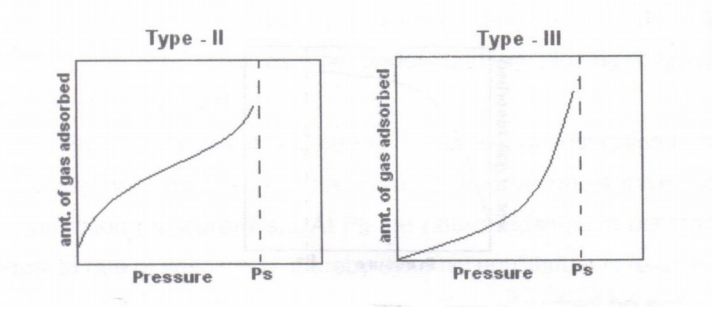


- It indicates the monomolecular layer is formed on the adsorbent surface postulated by Langmuir.
- Ps –just enough to complete monomolecular layer ,even when the gas pressure is low.

- If increase the pressure (x/m) will not increased.

  Eg: Adsorption of N_2 or H_2 on charcoal at 180^{o}c

Type-II and III

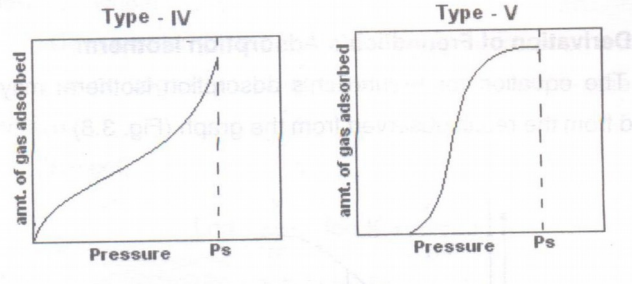


- x/m in each type is increases with increasing pressure.
- This shows large deviation from Langmuir model.
- This is due to the formation of multi molecular layer.

Eg : Physisorption of N_2 on silica gel (or) Pt catalyst at 195^{o}c.

Physisorption of Br or I on silica (or) alumina gel.

Type –IV and V



It indicates the possibility of condensation of gases in the pores of the adsorbed at the‘P’ ,even below the saturation pressure Ps-called capillary condensation of the gas.

Eg: Adsorption of benzene vapour on oxide gel at 50^{o}c .

Adsorption of H_2O vapour on charcoal at 100^{o}c

2.7 Langmuir’s Adsorption Isotherm

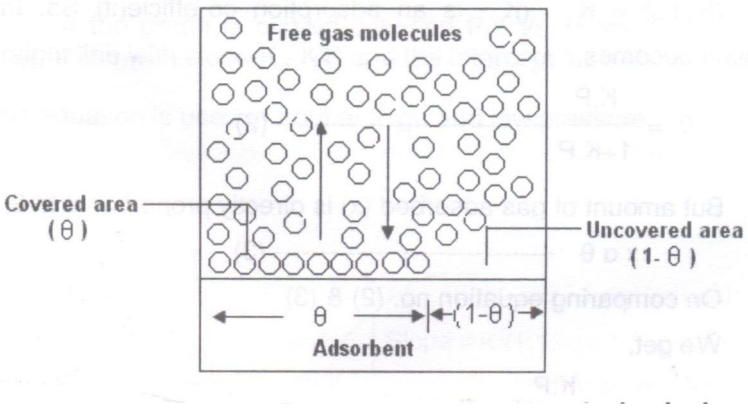
In 1916 Langmuir derived an equation based on some theoretical considerations.

Assumption (or) Postulates

- ❖ Valancies at the surface of adsorbent atoms are not fully satisfied.
- ❖ Dynamic equilibrium exists between adsorption and desorption process.

- The adsorbed gas forms a monomolecular thick layer on the solid surface.
- There is no interaction between adjacent adsorbent molecules.
- The adsorbed gas molecules do not move around on the surface.
- The surface of the solid is homogeneous, so the adsorbed layer is uniform all over the adsorbent.
- The adsorption consists of two opposing process, namely condensation of molecules on adsorbate and desorption of molecules.

2.7.1 Derivation of Langmuir adsorption isotherm:



When the gas molecule strike a solid surface , some of the molecules are adsorbed and some of these are desorbed. Thereby dynamic equilibrium is established between adsorption and desorption.

If A is gas molecule and M-is surface, then

$$A_g + M_{Surface} \underset{k_d}{\overset{k_a}{\rightleftharpoons}} AM$$

$$Gas + Solid \rightleftharpoons G\text{-}S$$

If adsorption starts, initially all sites of adsorbent is vacant. So rate of adsorption will be more, once particular portion of adsorbent is covered by the adsorbate , automatically desorption takes place.

If the total area is 1, then gas covered area θ and uncovered area = $1- \theta$

Total surface area covered by adsorbed molecule = θ

Rate of adsorption $R_a = k_a(1- \theta)P$

Rate of desorption $R_d = k_d \theta$

At equilibrium (saturation rate),

$R_a = R_d$

$k_a(1-\theta)P = k_d\,\theta$

$k_d\,\theta = k_aP - k_a\theta\,P$

$k_d\theta + k_a\theta.P = k_aP$

$\theta\,(k_d + k_aP) = k_aP$

$$\theta = \frac{k_aP}{k_d + k_a.P} \longrightarrow (1)$$

Dividing the eqn (1) by k_d

$$\theta = \frac{(k_a/k_d)P}{1 + k_a/k_d\,P}$$

$\frac{k_a}{k_d} = K \rightarrow$ adsorption coefficient

So the eqn becomes

$$\theta = \frac{K.P}{(1+K.P)} \longrightarrow (2)$$

But amount of the gas adsorbed (x) is directly proportional to θ

$x \alpha \theta \longrightarrow (3)$

Substrate (2) to (3)

$$x \alpha \frac{K.P}{1+K.P}$$

$$x = K^1.\frac{K.P}{1+K.P} \longrightarrow (4)$$

Equation 4 gives the relation between the amount of gas adsorbed to the presence of the gas at constant temperature is called Langmuir's Adsorption isotherm.

$$1+K.P = \frac{K'\,K.P}{x}$$

$$\frac{1+K.P}{} = \frac{P}{}$$

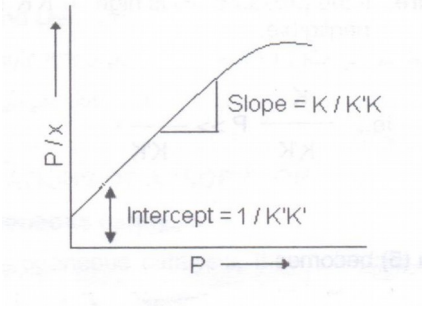
(K'K) x

$$\frac{P}{x} = \frac{P.K}{K.K'} + \frac{1}{K.K'} \longrightarrow (5)$$

(consider y= mx+c)

If the graph is plotted between P/x Vs P, we should get a straight line with slope K/K.K' and the intercept 1/K.K'.

The equation is used in normal, high and low pressure.



slope=1/K '

intercept: I/K'K

Case-1

At low pressure:

$\frac{1}{K.K'} >> \frac{P.K}{/K.K'}$

P is very low $\frac{K}{K.K'.P}$ term is negligible

Hence the equation (5) becomes

$\frac{1}{K.K'} = \frac{P}{x}$

x =P.K.K' ⟶ (6)

x α P The amount of adsorption per unit weight of adsorbent is directly proportional to the P at low pressure.

Case-2

At high pressure:

If P is high $\frac{1}{K.K'}$ term is negligible

$\frac{K}{K.K'} . P >> \frac{1}{K.K'}$

So Equation (5) becomes $\frac{K}{K.K'P} = \frac{P}{x}$

(or) $x = K'$

$x = K' P^0$ --------(7) i.e $x \alpha P^0$

The extent of adsorption is independent of P of the gas, because the surface becomes completely covered at high pressure.

Case-3

At normal pressure:

Equation (7) becomes

$x = K' P^n$ ----------(8)

where n lies between 0 and 1

At normal pressure ,the Langmuir adsorption isotherm takes the form of the Freundlich's adsorption isotherm.

Merits and Demerits

i)It holds good at low P but fails at high P

ii)The monolayer adsorption postulated by Langmuir is not strictly valid ,and multilayer adsorption has been shown to occur on several solids.

2.8 Role of adsorbents:

Contact Theory (or) Role of adsorbents in catalysis or adsorption:

Adsorption or Contact theory was postulated by Faraday (1883).

Postulates:

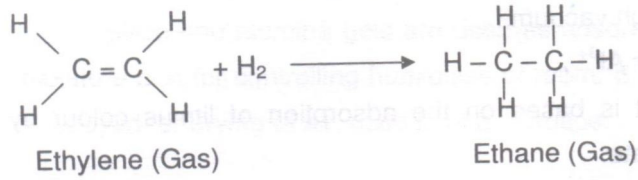
1.The surface of the solid catalyst possesses isolated active centres (or free valencies)

2.The reactant molecules get adsorbed forming a monolayer.

3.The adsorbed molecules react with each other due to their close proximity forming products which are then desorbed from the surface due to decreased affinity with the adsorbent surface. The adsorbent surface is free for further adsorption.

4. No intermediate compound is formed with the catalyst.

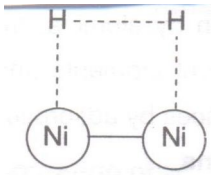
Example



2.8.1 Mechanism of contact theory:

In heterogeneous catalysis, the mechanism of adsorption undergoes stepwise manner.

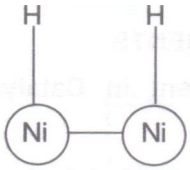
Step-1 Adsorption of reactant molecules



The surface of the solid catalyst has some active centres ,due to unsaturation of valencies. The gaseous reactant adsorbed at active centre of the solid surface either by physisorption (or) chemisorption .Heat of adsorption evolved during chemisorption provide activation energy for the adsorption reaction.

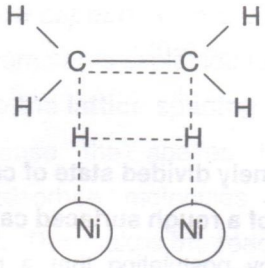
Step-2 Formation of Activated complex

The adsorbed molecules adjacent to one another combine to form an intermediate complex .This is named as unstable activated complex.



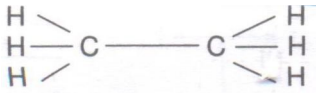
Step-3 Decomposition of activated complex:

The activated complex breaks to form the products .The separated particles of the products bound to the catalyst surface by partial chemical bond.



Step-4 Desorption of products

The products are desorbed (or) released from the surface .They are stable.



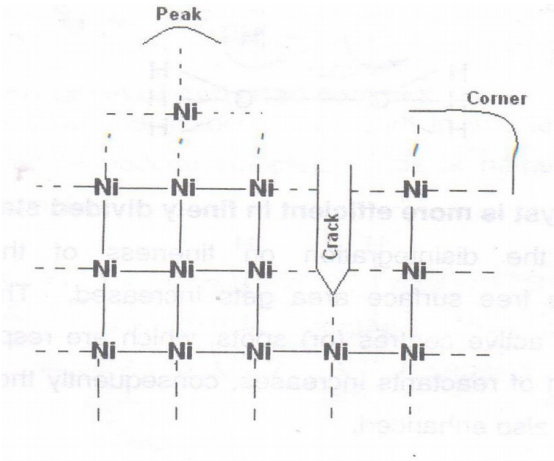
2.8.2 Factors influencing the contact theory

1.The catalyst is more efficient in finely divided states

When the disintegration on fineness of the catalyst increases ,the free surface area gets increases .Active centers (or) spots (or) free valencies increases adsorption of reactant increases ,the activity of the catalyst is also enhanced.

2.Enhanced activity of a rough surface catalyst

Rough surface of a catalyst possess cracks, peaks ,corners etc. and have large number of active centers or spots. These active centre increase the rate of adsorption.

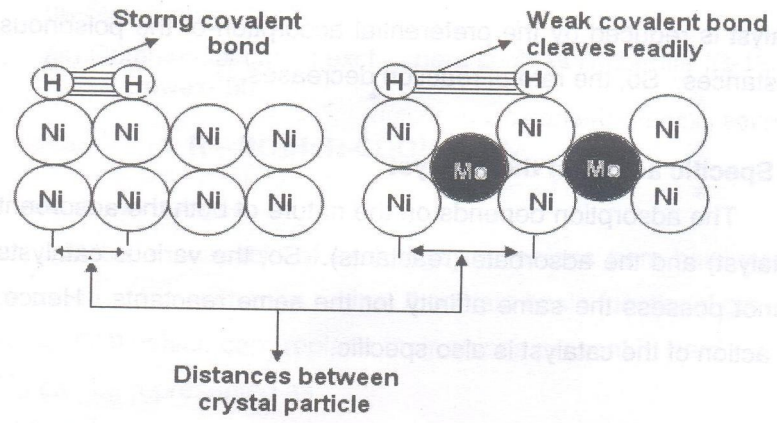


3.Action of promoters:

The action of promoter is explained

<u>i) Promoters change the lattice spacing</u>

Promoters increases the space between the catalyst particles. So the adsorbed molecules (H_2) are further weakened and cleaved. This makes the reaction to go fast.

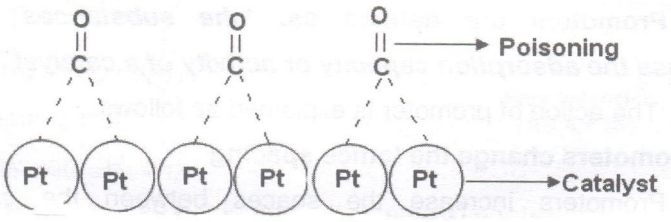


ii) Promoters increase the peaks and cracks on the catalyst surface

4.Action of catalyst poisons:

A substance which reduce the number of active sites in the catalyst to accelerate a reaction. This process is known as catalytic poisoning.

The number of free valencies (or) active centre of the catalyst is reduced by the preferential adsorption of the poisonous substance .So the rate of reaction decreases.



5. Specific action of the catalyst:

The adsorption depends on the nature of the adsorbent (catalyst) and the adsorbate (reactant),the various catalyst cannot possess the same affinity for the same reactant. Hence the action of the catalyst is also specific.

Kinetics of Surface Catalysed Reactions

A wide variety of rate laws and reaction mechanisms can apply to surface catalysed reactions. A few of these are considered below.

2.9 KINETICS OF SURFACE REACTIONS

2.9.1 UNIMOLECULAR DECOMPOSITION

Examples of unimolecular decomposition reactions include:

1. Decomposition of NH_3 to N_2 and H_2 on metal surfaces

2. Decomposition of phosphine on glass
3. Decomposition of formic acid on glass, Pt, Ag, Au, or TiO_2

Unimolecular surface reactions can often be described by the mechanism.

$$A(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} A(ads) \longrightarrow \text{Products}$$

The rate of product formation is $k_2\theta_A$ (where θ_A is the surface coverage of A), and provided $k_2 << k_{-1}$ (i.e. the rate of reaction of adsorbed A molecules is much greater than the rate of desorption of unreacted A), the Langmuir adsorption isotherm can be used to determine θ_A, giving

$$\theta_A = \frac{KP_A}{1 + KP_A} \quad \text{----------(1)}$$

Where , K= Adsorption coefficient

θ_A = Surface covered by the adsorbed molecule(A)

P_A = pressure of the reactant A.

The rate of surface decomposition is given by

$$\text{Rate} = k_2\,\theta_A \quad \text{----------(2)}$$

Substituting the value of θ_A from equation (1) in equation (2) it becomes

$$\text{Rate} = \frac{k_2 KP_A}{1 + KP_A} \quad \text{---------- (3)}$$

This type of reaction shows two limiting rate laws, corresponding to the two extreme behaviours of the Langmuir isotherm:

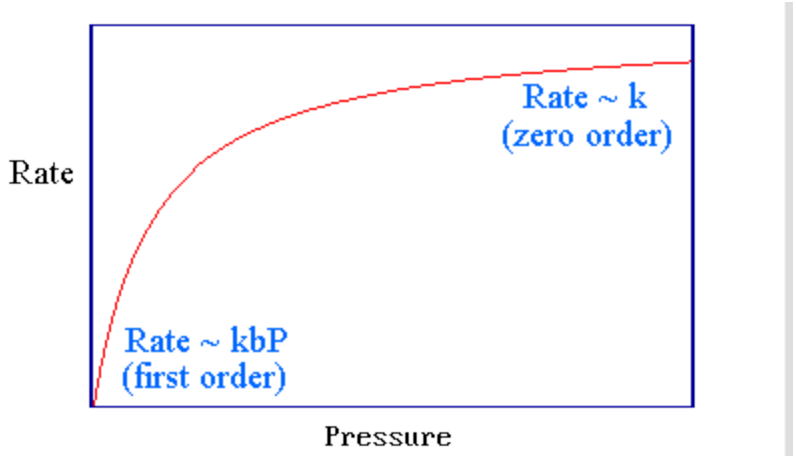
a) **At low pressure** ($P_A \rightarrow 0$), θ_A is very small and proportional to the pressure.

The rate becomes **first order** in A(g).

$$\text{rate (low P)} = k_2KP_A \quad \text{----------(4)}$$

b) At high pressures θ_A is approximately equal to unity, and the reaction is zeroth order.

$$\text{rate (high P)} = k_2 \quad \text{----------(5)}$$



2.9.2 Bimolecular Reactions

Bimolecular reactions involving surfaces fall into several different categories, depending on whether one or both molecules are adsorbed on the surface.

a) Reaction between two adsorbed molecules
(Langmuir-Hinshelwood mechanism)

This mechanism involves that both the reacting molecules A and B are adsorbed on the surface of the catalyst and the adsorbed molecules undergo a bimolecular reaction.

$$A_{(g)} + S \underset{k\_1}{\overset{k_1}{\rightleftharpoons}} AS_{(Ad)}$$

$$B_{(g)} + S \underset{k\_2}{\overset{k_2}{\rightleftharpoons}} BS_{(Ad)}$$

$$AS_{(Ad)} + BS_{(Ad)} \longrightarrow \text{Products}$$

Where,

A(g) and B(g) = Gaseous reactants
S = Adsorption site on surface
k_1, k_1, k_2, k_2 = Rate constant of the reaction

The surface reaction between the two adsorbed molecules is the rate determining step. The rate of the reaction is given by the following rate expression.

$$\text{Rate} = K_3 \theta_A \theta_B \text{ ----------(5)}$$

According to Langmuir isotherm for a singular molecular adsorbate the surface coverage is

$$\theta = KP / 1 + KP \text{ --------- (6)}$$

If two molecules (A & B) are competing for the same adsorption sites then the relevant expressions are

$$\theta_A = \frac{K_1P_A}{1+ K_1P_A+ K_2P_B} \quad \text{and}$$

$$\theta_A = \frac{K_2P_B}{1+ K_1P_A+ K_2P_B} \text{ ----------(7)}$$

Substituting equation (7) in equation (5) , it becomes

$$\text{Rate } (r) = K_3\, \theta_A\, \theta_B = \frac{K_3\, K_1P_A\, K_2P_B}{(1+ K_1P_A+ K_2P_B)^2}$$

Various expressions of the rate equation

Various expressions can be done depending upon the relative magnitudes of the two equilibrium constants.

(i) Both the molecules have low adsorption

If both the molecules have low adsorption , then it follows $1 >> K_1P_A$, K_2P_B

Therefore Rate (r) = $K_3\, K_1\, K_2\, P_A\, P_B$

The order is 1 with respect to both the reactants A & B.

(ii) One molecule has very low adsorption

If one of the reactant molecules has very low adsorption, then it follows $K_1P_A, 1 >> K_2P_B$

Therefore Rate (r) = $\frac{K_3\, K_1\, K_2\, P_A\, P_B}{(1 + K_1\, P_A)^2}$

The order is 1 with respect to B.

There are two extreme possibilities now.

(a) At low concentrations of A,

$$\text{Rate } (r) = K_3 K_1 K_2 P_A P_B$$

order is 1 with respect to A.

(b)At high concentrations of A

$$\text{Rate } (r) = \frac{K_3 K_1 K_2 P_A P_B}{(1 + K_1 P_A)^2}$$

$$\text{Rate } (r) = \frac{K_3 K_2 P_B}{K_1 P_A}$$

Order is – 1 with respect to A

(iii)One molecule has very high adsorption

If one of the reactant molecule has very high adsorption and the other one does not adsorb strongly, then it follows $K_1P_A >> 1$, K_2P_B

$$\text{Rate } (r) = \frac{K_3 K_1 K_2 P_A P_B}{(K_1 P_A)^2}$$

$$\text{Therefore Rate } (r) = \frac{K_3 K_2 P_B}{K_1 P_A}$$

The order of reaction is 1 with respect to B and -1 with respect to A. Thus the reactant A inhibits the reaction at all concentrations.

Example:

1.Oxidation of CO

On precious metal surfaces (e.g. Pt) the CO oxidation reaction occur through Langmuir-Hinshelwood mechansim of the following type :

$$\mathbf{CO}_{(g)} \leftrightarrow \mathbf{CO}_{(ads)}$$

$$\mathbf{O_2}(g) \leftrightarrow 2\mathbf{O}_{(ads)}$$

$$\mathbf{CO}_{(ads)} + \mathbf{O}_{(ads)} \xrightarrow{rds} \mathbf{CO_2}(ads) \xrightarrow{fast} \mathbf{CO_2}(g)$$

As CO_2 is comparatively weakly-bound to the surface, the desorption of this product molecule is relatively fast and in many circumstances it is the surface reaction between the two adsorbed species that is the rate determining step.

Other Examples

$$C_2H_{4(ad)} + H_{2(ad)} \longrightarrow C_2H_{6(g)}$$

$$N_2O_{(ad)} + H_{2\ (ad)} \longrightarrow N_2 + H_2O$$

$$C_2H_{4\ (ad)} + \tfrac{1}{2}\ O_{2\ (ad)} \longrightarrow CH_3CHO$$

2.10 APPLICATIONS OF ADSORPTION ON POLLUTION ABATEMENT

Among the various adsorbents, in pollution abatement of air and waste water, activated carbon is the most commonly used adsorbent because it has a large surface area per unit weight (or) unit volume of solid.

2.10.1 Treatment of Polluted Water and air

Polluted water and air can be treated by using the following two types of activated carbons.

1.Granular Activated Carbon (GAC)

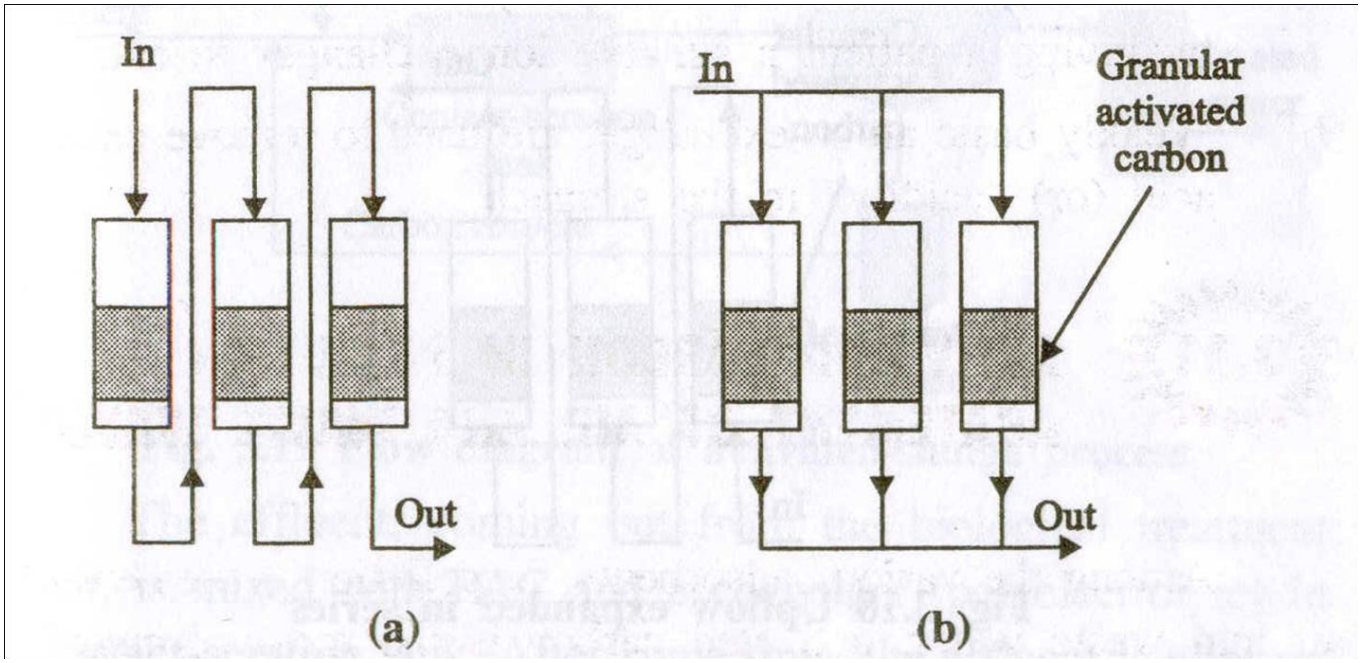
2. Powdered Activated Carbon (PAC)

1.Using Granular Activated Carbon (GAC)

A fixed – bed column is often used for contacting polluted water or air with GAC. It can be operated singly, in series or in parallel. Among the various type two are important.

1. Down flow carbon contactors.
2. Upflow carbon contactors.

(A) Down flow Carbon Contactors



It usually consist of two (or) three columns operated in series (or) in parallel.
The water or air is applied to the top of the column and withdrawn at the bottom. The AC is held in place with an under drain system at the bottom of the column. Provision for back washing and surface washing is usually necessary to limit the headless build up due to the removal of particle material with the carbon column.

Advantage

Adsorption of organic materials and filtration of suspended solids are accompanied in a single step.

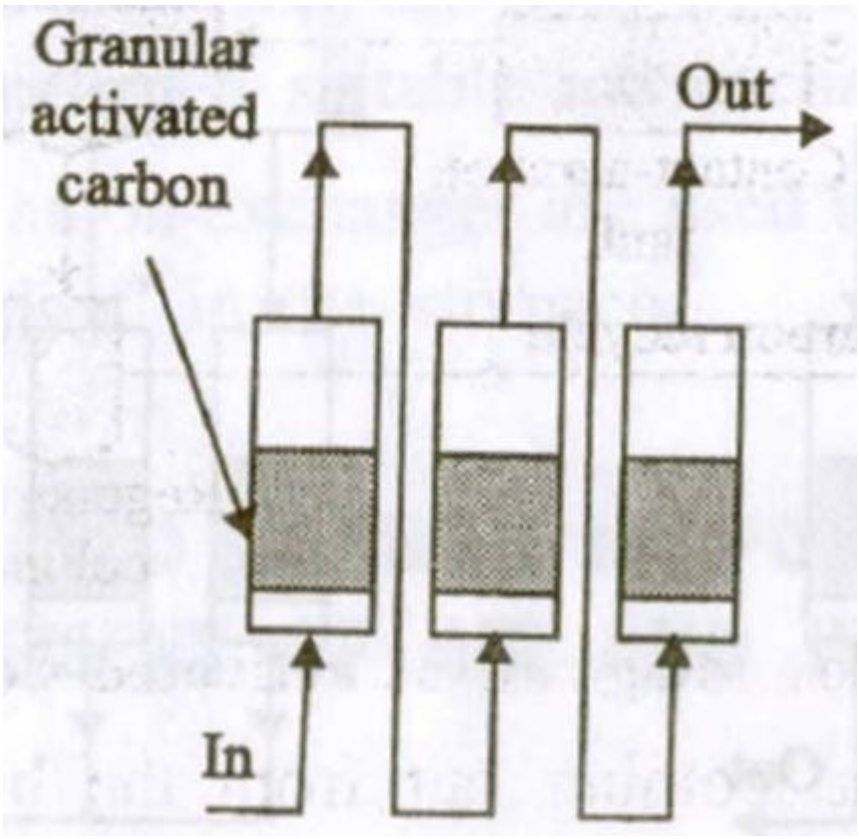
Disadvantages

Down flow filters may require more frequent back washing because of the accumulation of suspended materials on the surface of the contactor.

Plugging of carbon pores may require premature removal of the carbon for regeneration, thereby decreasing the useful life of the carbon.

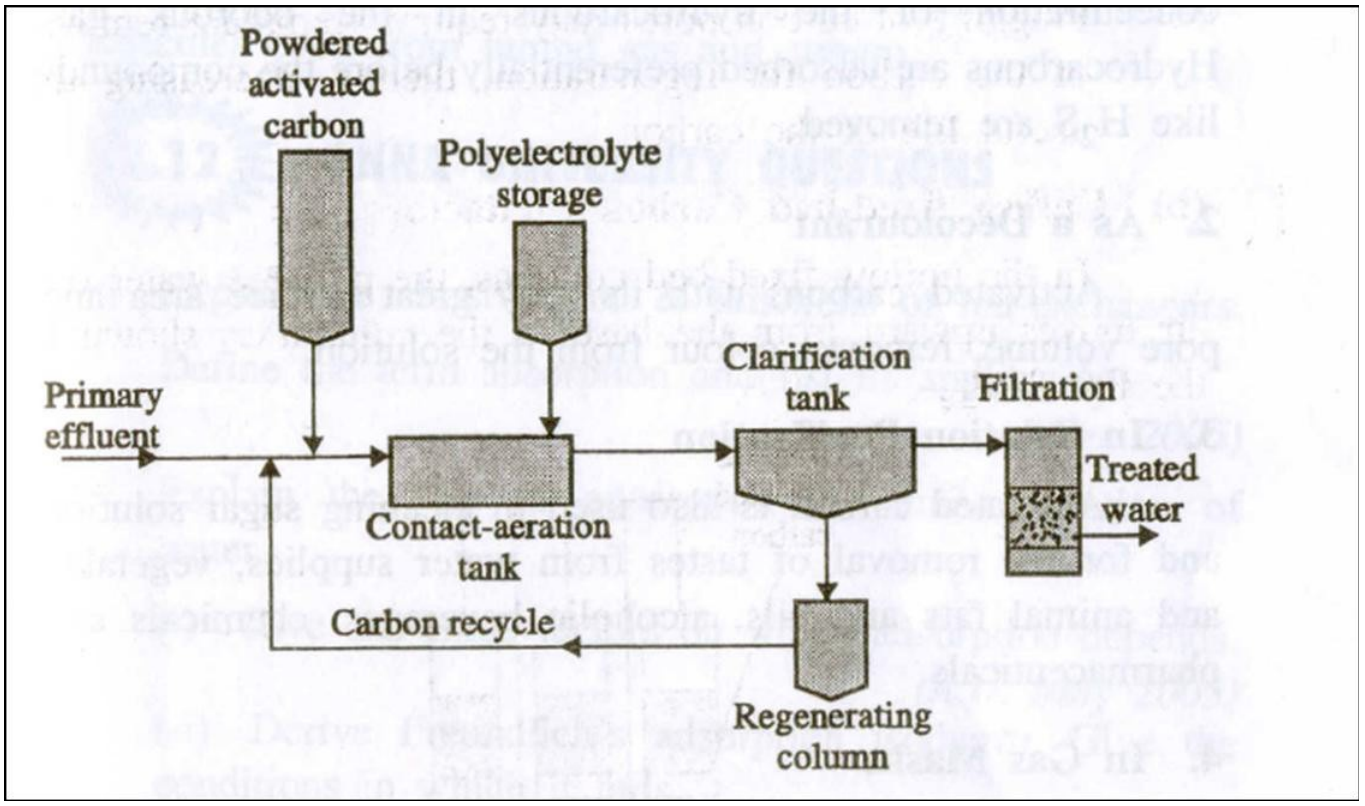
(b)Upflow Carbon Contactors

In the upflow columns, the polluted water or air moves upward from the base of the column .



Advantage:
As the carbon adsorbs organic materials, the apparent density of the carbon particles increases and encourages migration of the heavier or spent carbon downward.
Disadvantage
upflow columns may have more carbon fines in the effluent than downflow columns, because upflow tends to expand, not compress, the carbon.
Bed expansion allows the fines to escape through passage ways created by the expanded bed.

2.Using Powdered Activated Carbon (PAC)



In this method PAC is added directly to the effluent coming out from the various biological treatment processes. In the case of biological-treatment plant effluent, PAC is added to the effluent in a contacting basin. After some time, the carbon is allowed to settle at the bottom of the tank, and the treated water is then removed from the tank.
Since carbon is very fine, a coagulant such as polyelectrolyte may be added to aid the removal of the carbon particles or filtration through granular medium filters may be required.

2.11 GENERAL APPLICATIONS OF ADSORPTION

1.In heterogeneous catalysis , the molecules of reactants are adsorbed at the surface of catalyst which form "adsorption complex". Then it decomposes to form products.

Eg: i)Manufacture of SO_3 by contact process.

ii)Hydrogenation of oils.

iii)Haber's process.

2.**Silica and Alumina gels:**

They are used as adsorbent for removing moisture and for controlling humidities of room.

Silica gel has been used for drying of air, used in blast furnace.

3.Activated charcoal:

i)It absorbs all toxic gases immediately and reduces the concentration of toxic gases from 1000ppm to 1ppm.Therefore it is used in gas masks.

ii) It is used for removing colouring matter from the sugar solution and decolouration in vinegar.

4. Fuller's earth:

It is used in large amount for refining petroleum and vegetable oils, which absorb unwanted substance.

5. Minimization of evaporation of water :

During the summer, due to scarcity of water ,a layer of stearic acid is spread over water lakes and reservoirs. The stearic acid adsorbed on the water surface, and minimizes evaporation of water.

6.Charcoal adsorption filter :

It is used for removing organic matter from drinking water.

7. Production of High vaccum :

When the partially evacuated vessel is connected to a container of activated charcoal or silica gel cooled with liquid .air ,the charcoal adsorbs all the gas molecules in the vessel and produce very high vaccum.

8. Lake test for Al^{3+} :

Lake test is based on the adsorption of litmus colour by $Al(OH)_3$ precipitate.

9. Mordants:

Mordants like alum in dying cloths and adsorb the dye particle without attaching to the fabrics.

10. Arsenic poisoning :

During the arsenic poisoning ,colloidal ferric hydroxide is administered ,which absorbs arsenic poison and is removed from the body by vomiting.

11.Chromatographic analysis:

Selective adsorption by alumina,magnesia etc. has been used for separating different pigments and also mixture of small amount of organic substance by adsorption chromatography.

REVISION QUESTIONS

PART-A

1. What is adsorption?
2. Explain the terms adsorbent and adsorbate with examples.
3. Distinguish between adsorption and absorption.
4. How does chemisorption differ from physisorption?
5. Mention the factors which influence the adsorption of gases on solids.
6. What is the effect of increase in temperature and pressure on adsorption of gases on solids?
7. What is an adsorption isotherm?.
8. What are the limitations of the Freundlich adsorption isotherm?
9. How are the constants k and n determined for the Freundlich isotherm?
10. What are assumptions made in deriving the Langmuir adsorption isotherm?
11. How will you increase the activity of an adsorbent?
12. Explain the term promoter and catalytic poison.
13. Mention the factors which influence the adsorption of solutes from solution.
14. Explain how the finely divided state of catalyst is more efficient.
15. How does the contact theory explain the effect of catalytic poisons?
16. Mention four applications of activated charcoal.

PART-B

1. What are the factors which influence the adsorption of gases on solids?.
2. Differentiate between physisorption and chemisorption
3. Give the mathematical form of the Freundlich adsorption isotherm and states the terms involved .How are the constants k and n determined? State the limitation of the isotherm.
4. Derive the Langmuir adsorption isotherm and state the assumption made in deriving it. Discuss the form of the isotherm under low, high, and normal pressures.
5. Write a note on adsorption of solutes from solution.
6. Mention the application of adsorption in water softening
7. How is ion-exchange adsorption useful in demineralization of water?
8. Discuss the role of adsorbents in catalysis (**or**) contact theory in detail. (or) Explain the role of adsorption in catalysis using a suitable example.
9. What is the role of activated carbon in air and water pollution control?

UNIT 4: ALLOYS AND PHASE RULE

LEARNING OBJECTIVE:

- To understand alloys, significance of alloying
- To know about Nichrome, Stainless steel, heat treatment of steel.
- To understand phase rule, one component system-water system
- To know about reduced phase rule, thermal analysis and cooling curves
- To know about two component system-lead silver system
- To understand Pattinson process

4.1 INTRODUCTION

Alloys play a very important role in our daily life. Most of the vessels used in our kitchen, the vehicles, the mobile phones are all made of alloys and are being used by us in everyday life. Most of the engineering and medical equipments, machineries, tools are also made of alloys.

4.2. Definition

An alloy is defined as a homogeneous solid solution of two or more different elements, of which one is essentially a metal. Most of the metals can mix up in all proportions eg.tin and lead mix up in all proportions forming alloys. Alloys are formed not only by metals but also metal and non-metal. So the alloy contains atleast one metal. Alloys containing mercury as a constituent element are called amalgams.

4.3 Properties of alloys:

- Alloys are harder and less malleable
- They have low melting point
- They have low electrical conductivity
- They have high corrosion and acid resistivity

4.4 Need for making alloy (or) Significance of alloying:

Generally pure metals possess some physical properties such as high density, malleability, ductility, high melting point, excellent thermal and electrical conductivity. Alloying will improve the properties of materials like tensile strength, ductility, toughness, hardness, elasticity, heat resistance, corrosion resistance, abrasion resistance, etc.

Purpose of preparation of alloys - advantages over metals

(a) To increase the hardness of metal:
Pure metals which are generally soft can be made harder by alloying with other metal and non-metal. Eg:

i. Addition of copper to soft metals like Gold and Silver increases the hardness of these metals
ii. Addition of 0.5% arsenic to lead makes it so hard and it can be used for making bullets.
iii. Addition of 0.15 – 1.5% carbon to pure iron which is very soft will result in the formation of steel alloy, which is hard.

(b) To lower the melting point of the metal: The melting point of pure metal is lowered by alloying. Alloying makes the metals easily fusible.

i. Wood's metal (alloy of 50% Bi, 26.7% Pb,13.3% Sn and 10% Cd) melts at 70^{o}C which is very much lower than its constituent metal
ii. Rose metal(alloy of 50% Bi, 28% Pb,22% Sn) melts at 89^{o}C which is used for making fire alarms fuse wires

(c) To increase the tensile strength: Tensile strength of a metal can be increased by alloying, e.g., alloying iron with 1% carbon increases the tensile strength of iron by roughly ten times.

(d) To increase the corrosion resistance: Alloys are more resistant to corrosion than the metal(s) from which they are prepared, e.g., stainless steel is more corrosion resistant than iron.

(e) To modify the colour of the metal: Alloying can alter the colour and brightness, e.g., brass (yellow) is obtained from copper (red) and zinc (grey).

(f) To modify the chemical activity of the metal
Chemical activity of the metal can be increased or decreased by alloying. E.g., Al-Hg is more active than Al, Na-Hg is less active than Na.

(g) To obtain good casting of metal: Pure metals which are soft and brittle cannot be used for casting since they undergo contraction and expansion on solidification. But alloys are hard, fusible and have better castability. Eg: When 5% tin and 3% antimony are added to lead the alloy shows good casting properties.

4.5 FUNCTIONS AND EFFECT OF ALLOYING ELEMENTS:

The properties of alloys are greatly enhanced by the presence of small amount of certain elements such as Ni, Cr, V, Mn,Mo,W etc., such elements are called **alloying elements,** and the steel obtained by mixing these elements are called **alloying steel or special steels.**

Some important alloying elements and their functions are given in the following table.

Table 4.1 Effect of alloying elements

S. No.	Element	Effect on properties	Uses
1	Nickel	(i) Improves tensile strength, and elasticity (ii) Increases resistance to corrosion (iii) Co-efficient of expansion gets decreased (iv) Produces fine grains	For making balance wheels
2	Chromium	(i) Enhances tensile strength (ii) High corrosion resistant (iii)Improves hardness and toughness simultaneously	For making surgical instruments, utensils, connecting roads
3	Manganese	(i)Increases strength , toughness and brittleness (ii)High degree of hardness	For making grinding wheels, steering spindles and rails
4	Vanadium	(i)Increases Tensile strength and ductility	For making axles, crank pins, heavy locomotive forgings, piston rods.
5	Molybdenum	(i)High strength at high temperature (ii)Increases corrosion and abrasion resistance	For making high speed tools
6	Tungsten	(i)Increases abrasion and shock resistance (ii)Improves toughness and hardness at higher temperatures (iii)Enhances Magnetic retentivity	For making cutting tools, permanent magnets

4.6 FERROUS ALLOYS (or) ALLOY STEELS

Ferrous alloys are the type of steels in which the elements like Al, B, Cr, Co, Cu, Mn are present in sufficient quantity in addition to Iron and Carbon to improves the property of steel.

4.7. Properties of Ferrous alloys

(i) It possess high yield and high strength

(ii) It possess formability, ductility and weldability

(iii)They are sufficient corrosion and abrasion resistance

(iv) Distortion and cracking are less

(v) High temperature strength is greater

4.8. IMPORTANT FERROUS ALLOYS

4.8.1 Nichrome

Nichrome is an alloy of Nickel and Chromium. Its composition

Metal	Percentage
Nickel	60%
Chromium	12%
Iron	26%
Manganese	2%

Properties

1. Nichrome shows high resistance towards heat and oxidation.
2. Steel containing 16 to 20% chromium with low carbon content possess oxidation resistance upto 900^{o}C
3. It possess high melting point
4. It can withstand heat upto 1100^{o}C
5. It possess high electrical resistance

Uses

1. Used to make resistance coil, heating element in stoves
2. Used in electric irons and other household electrical appliances
3. Used in making parts of boilers, steam-lines stills, gas turbines, aero engine valves, retorts, annealing boxes
4. Used in making other machineries or equipments exposed to very high temperatures

4.8.2. Stainless steel

Stainless steels or corrosion resistance steels	Heat treatable stainless steels (Martensitic)		C < 1.2% Cr-12 – 16%	They are tough magnetic, corrosion resistant. They can be used at temperatures up to 800^{o}C	In making surgical instruments, scissor, blades, cutlery etc.
Stainless steels or corrosion resistance steels	Non–heat treatable stainless steels	Magnetic type (Ferritic)	Cr-12– 22%; C<0.35%	They can be forged, rolled, cold drawn and machined by the use of specially designed tools. Resist corrosion better than heat treatable ones.	In making chemical equipments and automobile parts
		Non – magnetic type (Austenitic)	Cr: 18 –26%, Ni - 8 – 21%, C – 0.15%	They exhibit maximum resistance to corrosion. They are usually referred as 18/8 stainless steel	In making household wares, sinks, decorative pieces, dental instruments, surgical instruments etc.

4.6 HEAT TREATMENT OF STEEL

Heat treatment is the process of heating and cooling of metals (or) alloys under controlled conditions to develop its physical properties without altering its chemical composition. On heating, internal structure of the steel changes. The temperature at which these structural changes occur is called critical temperature.

4.6.1 Objectives of heat treatment

- Refinement of grain structure
- Removal of imprisoned trapped gases
- Removal of internal stresses
- Improvement of corrosion resistance
- Improvement of magnetic and electrical properties

Heat treatment can be done by the following ways:

1. Annealing
2. Hardening (or quenching)
3. Tempering
4. Normalizing
5. Carburizing
6. Nitriding

1. **Annealing:** The process of heating steel and then cooling it to room temperature to make the steel soft.
   Purpose: It increases machinability, ductility, removes the internal stress and imprisoned gases. There are two type of annealing:
   a. Low temperature annealing or process annealing: The process involves heating the steel below the lower critical temperature followed by slow cooling.
   b. High temperature annealing or full annealing: The heating of steel to a temperature of about 30 – 50ºC above the higher critical temperature for sufficient time, and then cooling gradually to room temperature.
2. **Hardening or Quenching**: Steel is heated beyond the higher critical temperature point, then quenched (dropped) suddenly either in oil or brine solution. Steel of great hardness can be produced.
3. **Tempering**: The already hardened steel is heated to a temperature lower than the lower critical temperature and then slowly cooled. The process increases toughness and ductility and reduces brittleness. Tempering is used for objects such as hammers and chisels.
4. **Normalizing or Air quenching**: It involves heating of steel to a definite temperature above its higher critical temperature and allowing it to cool gradually in air. It results in increased toughness, removal of internal stresses, and refinement in grain structure.
5. **Carburizing**: The process in which very hard surface is produced on steel which has a soft core inside. Steel subjected to this process is usually of low carbon content, which cannot be hardened by quenching. The mild steel article is enclosed in a cast iron box

containing material rich in carbon such as wood charcoal. This is heated to 900 – 950ºC and the temperature is maintained for sufficient time to enable the carbon to be absorbed to the required depth. Thereafter the article in the box is subjected to slow cooling.

6. **Nitriding**: Steel (containing Al, Cr, or V), are heated with NH_3 at 550ºC resulting in super hard surface with a soft core. Nitrogen from ammonia reacts with surface constituents to form extremely hard nitrides of Al, Cr, or V.

PHASE RULE

4.7 INTRODUCTION

The chemical reactions are broadly classified in to the following two types

1) Irreversible reactions

2) Reversible reactions

Irreversible reactions

In these type of reactions the reactants react to form the products and the products do not have the tendency to give back the reactants. Most of the precipitation reactions and gas evolution reactions are irreversible reactions.

Examples: (i) $NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl\downarrow$

(ii) $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$

Reversible reactions

In these type of reactions, the reactants react to form the products. When the product is formed in considerable amount, it has the tendency to give back the reactants. Thus the reaction occurs in both directions and tends to attain equilibrium. Hence these are called equilibrium reactions. These reactions are shown by two half arrows in opposite directions. These are further divided in to two types as:

a) Homogeneous reversible reactions

These reactions are explained using the law of mass action proposed by Guldberg and Waage in 1864. $N_{2\,(g)} + H_{2\,(g)} \rightleftharpoons 2\,NH_3\,(g)$

b) Heterogenous reversible reactions

The behaviour of these reactions can be studied using phase rule proposed by Willard Gibbs in 1874. $MgCO_3\,(s) \rightleftharpoons MgO(s) + CO_2\,(g)$

Gibbs predicted qualitatively this equilibrium is influenced by three variable pressure, temperature, concentration, and explained the equilibrium existing in heterogeneous systems. This equilibrium between any number of phases of a system at equilibrium (at a definite temperature and pressure), is not influenced by gravity, electrical, magnetic forces, and surface action, and only by temperature, pressure, and concentration, then the number of degrees of freedom (F) of the system, is related to the number of components (C), and of phases (P), by the phase rule equation: $F = C - P + 2$

4.8 DEFINITION OF THE TERMS PHASE, COMPONENT, AND DEGREE OF FREEDOM

4.8.1 Phase

It may be defined as "homogeneous, physically distinct, mechanically separable portion of a system, which can be separated from the portion of the system by a definite boundary". A system may consist of one or more phases.

Examples:

1. A gas or a mixture of gases, e.g., air (N_2, O_2, CO_2, etc.) P = 1
2. A system containing only liquid water P = 1
3. A system containing Miscible liquids(Alcohol and water) P = 1
4. A system containing Immiscible liquids (Oil and water) P = 2
5. Saturated solution of NaCl (NaCl solution and NaCl salt) P = 2
6. Unsaturated solution of NaCl (NaCl solution) P = 1
7. Every solid substance constitutes a separate phase:

$CaCO_3(s) \rightleftharpoons CaO_{(s)} + CO_{2(g)}$ (two solid and one gas phase) P = 3

4.8.2 Component

A component is the 'Minimum number of chemical constituent used to define each and every phase of the system in the form of chemical equation'. Zero and negative signs are permitted in writing such equations.

Examples:

(a) Ice $_{(s)}$ $\rightleftharpoons$ water $_{(1)}$ $\rightleftharpoons$ water vapour $_{(g)}$

The composition of each phase is H_2O, and only one chemical parameter or component is required to describe the composition of each phase. Hence, C = 1.

(b) A saturated solution of NaCl consists of the solid NaCl and NaCl solution, and water vapour. Only two chemical constituent is involved in this system and both need to define all the phases of system. Hence it is two component system, i.e., C = 2.

$$NaCl_{(S)} \rightleftharpoons NaCl_{(aq)} \rightleftharpoons H_2O\ (g)$$

(c) **Thermal decomposition of $CaCO_3$** (or other carbonates such as $ZnCO_3$, $MgCO_3$, etc.)

$$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$$

There are three chemical constituent, namely, $CaCO_3$, CaO, and CO_2, but any two constituent is enough to express the composition of all the phases of the system. Considering $CaCO_3$ and CO_2 as components to define the system as follows:

$CaCO_3 = CaCO_3 + 0CO_2$

$CaO = CaCO_3 - CO_2$

$CO_2 = 0CaCO_3 + CO_2$ C = 2

Similar equations could be written with CaO and CO_2, or $CaCO_3$ and CaO.

(d) $PCl_{3(l)} + Cl_{2(g)} \rightleftharpoons PCl_{5(s)}$ C = 2

(e) When NH_4Cl dissociates, the following equilibrium exists.

$$NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$$

If composition of $NH_{3(g)}$ and $HCl_{(g)}$ exist in the same ratio i.e. 1:1, then both will combine among themselves and exist as $NH_4Cl_{(g)}$. Then the equilibrium will be

$$NH_4Cl_{(s)} \rightleftharpoons NH_4Cl_{(g)}$$ C = 1

If composition of $NH_{3(g)}$ and $HCl_{(g)}$ exist in different ratio then it exists as two-component system (C = 2)

4.8.3 Degree of freedom or variance

It is 'the minimum number of independent variables such as concentration, pressure and temperature, must be fixed in order to define each and every part of the system completely'

(i) For the equilibrium, water $_{(l)} \rightleftharpoons$ water vapour $_{(g)}$

Applying the phase rule, F = C – P + 2; since C = 1, and P = 2, F = 1

Either the temperature or the pressure need to define the system completely. If one variable is known, other variable is automatically fixed. Hence, the degree of freedom is one or system is univariant (or) mono variant.

(ii) For a system consisting of water vapour only, F = C – P + 2; since C = 1, and P = 1, F = 2. Both temperature and pressure should be stated in order to define the system. Hence, the system is bivariant, i.e., F = 2.

4.8.4 Merits of phase rule

- Applicable to both physical and chemical equilibria
- Explains different systems with the same degree of freedom behave similarly.

4.8.5 Limitations of the phase rule

- Applicable only to systems at equilibrium
- Requires utmost care in deciding the number of phases existing in the equilibrium state
- External forces like electrical, magnetic and gravitational forces should be absent, and only pressure, temperature, and composition variables are to be considered.

4.9 ONE–COMPONENT SYSTEM – WATER SYSTEM

Water exist in three possible phases namely solid, liquid and vapour. If all the three phases exist in equilibrium i.e. $Ice_{(s)} \rightleftharpoons Water_{(l)} \rightleftharpoons Water\ vapour_{(g)}$

Then C=1, P=3, F=2, Maximum degree of freedom for this system is 2, (i.e) Minimum two variable is needed to define the system completely. Since only one chemical constituent is exist in equilibrium, neglecting composition variable and pressure and temperature used as a variable.

Number and type of phases exist at all possible temperature and pressure is noted and the graph is drawn by plotting pressure (x-axis), and temperature (y-axis).The graph obtained is called phase diagram. The phase diagram of the water system (Figure 1) contains:

a) The curves OA, OB, OC
b) The triple point O, Critical Point C.
c) The areas AOC, AOB, BOC.

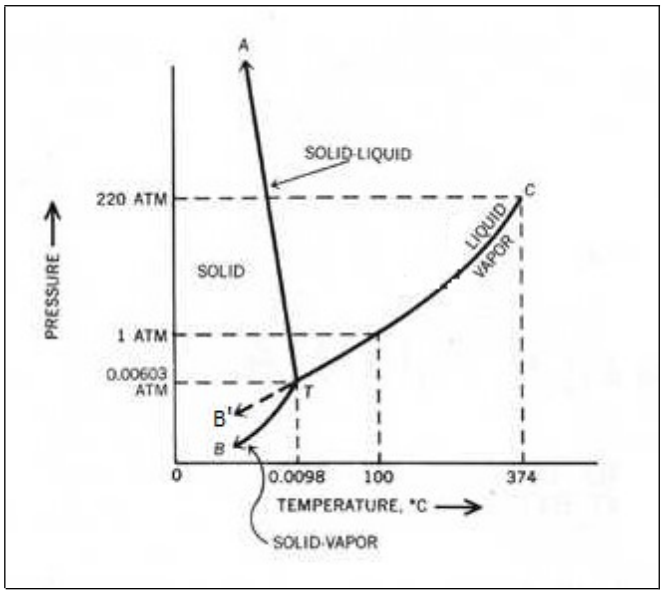


Figure 1: Phase diagram of water system

Curve OC: Vapourisation curve

$$H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$$

It represents the vapour pressure of water at different temperatures. The two phases, water and water vapour, coexist in equilibrium along this curve. The curve OC terminates at C, the critical point (218 atm, 374ºC), above which only water vapour will be existing.

Curve OB: Sublimation curve of ice.

$$H_2O_{(s)} \rightleftharpoons H_2O_{(g)}$$

It shows the vapour pressure of solid ice at different temperatures. The two phases, solid ice and vapour, coexist in equilibrium along this curve. At the lower limit, the curve OB terminates at absolute zero where no vapour exists.

Curve OA: fusion curve of ice

$$H_2O_{(s)} \rightleftharpoons H_2O_{(l)}$$

It depicts the effect of pressure on the melting point of ice. The fact that OA slopes to the left indicates that the melting point of ice decreases with increase of pressure. Since ice melts with decrease in volume, by Le Chatelier's principle, the melting point is lowered by an increase of pressure.

Along the curves OA, OB, and OC, since C = 1, and P = 2, applying the phase rule;

$F = C - P + 2 = 1 - 2 + 2 = 1$ **F = 1** (monovariant)

The curves are monovariant because, for a given value of pressure, the temperature is automatically fixed on a curve, and *vice versa*.

Triple point 'O'

$H_2O_{(s)} \rightleftharpoons H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$

The curves OA, OB, and OC, meet at the triple point 'O' where all the three phases, liquid water, ice, and vapour, are in equilibrium. This occurs at 0.0098ºC and 4.58mm Hg pressure (or 0.00603 atm.). Since C = 1 and P = 3,

$F = C - P + 2 = 1 - 3 + 2 = 0$ **F = 0** (invariant or zero-variant)

The triple point is invariant because, variation of any one of the variables, temperature or pressure, causes the disappearance of one of the three phases.

Areas AOC, AOB, BOC

Areas AOC, BOC, and AOB, represent the phases, liquid water, water vapour, and solid ice, respectively. In all the three areas, since C = 1, and P = 1,

$F = 1 - 1 + 2 = 2$ **F = 2** (Bivariant)

The system is bivariant because to locate any point in an area, both variables, pressure and temperature, need to be specified.

Metastable equilibrium, OC'

The curve, OC', is an extension of the vapour pressure curve of water, OC. Water can exist in the form of liquid below its freezing temperature i.e., up to -9 ºC. This water is called super cooled liquid. The super cooled water / vapour system is metastable (unstable), because as soon as small particle of ice or dust comes in contact with the supercooled liquid, the entire liquid solidifies.

4.10 TWO-COMPONENT SYSTEM

4.11 Condensed System and the Reduced (or Condensed) Phase Rule

In a two-component system, the number of degrees of freedom (F) has the highest value, when P = 1 (minimum), since C = 2, i.e., $F = C - P + 2 = 2 - 1 + 2 = 3$

The phase behaviour of a binary system may be represented by a three-dimensional diagram of pressure, temperature, and composition, requiring three axes, which cannot be conveniently shown on paper.

Since the solid $\rightleftharpoons$ liquid equilibrium of a two-component system is generally characterized by the absence of the vapour phase, and the process is conducted at constant pressure (1 atmosphere), i.e., keeping the pressure constant, the degrees of freedom get reduced by one. Systems in which the pressure is kept constant, or those in which the vapour phase is not considered, are known as **condensed or reduced systems**. For such systems, the phase rule becomes **$F' = C - P + 1$ Reduced phase rule**

The two variables to be considered are temperature and composition and the pressure is maintained at 1 atm. Solid – liquid equilibria are represented on phase diagrams.

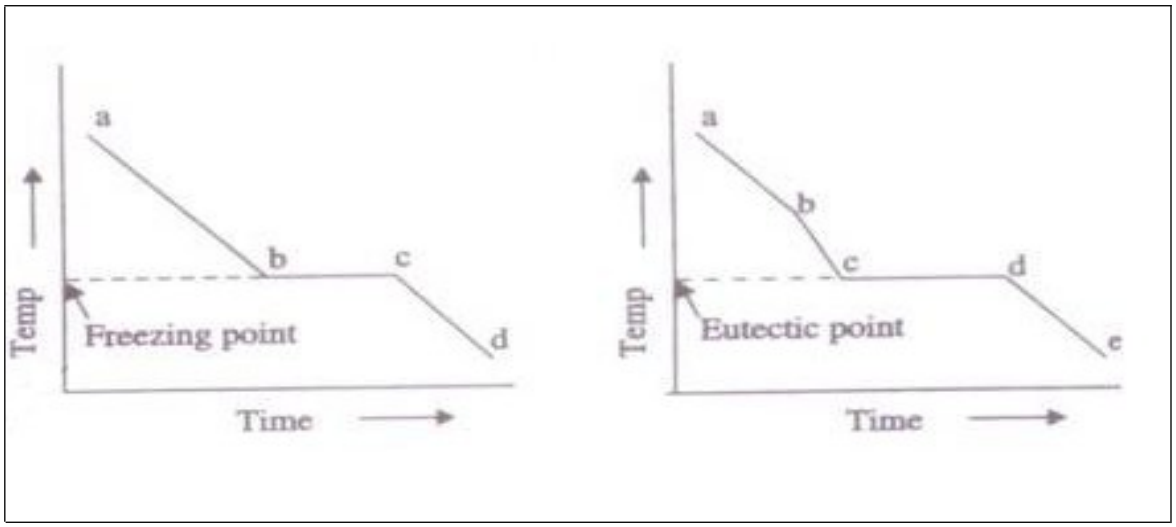
4.12 Cooling curves and Thermal Analysis

The shape of the freezing point curves for any system, especially those involving metals, can be determined by thermal analysis – a method involving a study of the cooling curves of various compositions of a system during solidification. Such diagrams are called temperature-time plots.

Thermal analysis

When a graph is plotted between temperature and time it is called ass cooling curve. The thermal analysis involves the study of cooling curve of various compositions of a two-component system during solidification with time.

1) Consider a pure solid substance which is in its fused state is cooled slowly. The fall in temperature is noted at periodic time intervals. Initially the rate of cooling is continuous. At the point ‘b’ freezing starts. The temperature remains constant until the liquid melt is completely solidified and this temperature is called freezing point of substance. This is because the liquid melt and solid crystals are of the same composition. At the horizontal section ‘bc’ the solid crystal and liquid melt are in equilibrium. After the point ‘c’ the temperature of solid again falls with time along the curve ‘cd’.



Cooling curve of pure solid **Cooling curve of a mixture A+B**

2) Consider a mixture of two solids, A and B, in the fused state. It is allowed to cool slowly. Initially the rate of cooling will be continuous (ab). When the crystals of either A or B separates from the liquid melt, it is indicated by a break in continuity of the cooling curve. Now the temperature again decreases with time but at a different rate, because the solid – crystal and liquid melt are not of the same composition. The slope 'bc' of the curve represents a continuous and progressive change in composition of liquid melt. Finally the liquid melt reaches the point 'c' at which it separates as solid A and solid B. now the temperature will remain constant until the liquid melt is completely solidified. Point 'c' called eutectic point, which is a minimum freezing point corresponding to eutectic mixture. Thereafter the temperature remain constant till solidification upto'd'. The eutectic cools at a different rate along 'de'.

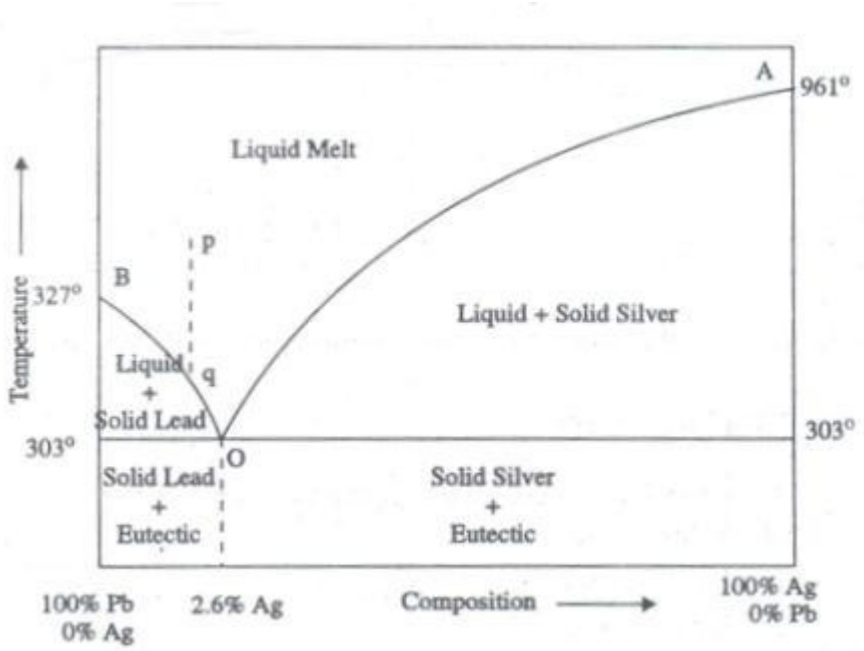
The experiment is repeated for different compositions of A and B and the various cooling curves are recorded. From the cooling curves of various compositions, the main phase diagram can be drawn by taking composition in the x-axis and the temperature in y– axis as shown in the figure.

Uses of cooling curves

1. From cooling curves, melting points and eutectic points are obtained, which is used in the construction of the phase diagram of a two-component system.
2. Percentage purity of compounds can be determined.
3. The composition corresponding to the freezing point gives the composition of an alloy.

4.14 SIMPLE EUTECTIC SYSTEM: LEAD – SILVER SYSTEM

Lead – silver system is a two-component system with the information of a simple eutectic. This system has two components and four phases. The phases are (a) solid Ag (b) solid Pb (c) solution of molten Ag and Pb and (d) vapour. Since, the boiling points of silver and lead are considerably high, the vapour phase is practically absent. .



The system is considered to be a condensed or reduced system. Hence, the reduced phase rule, i.e., F' = C – P + 1, is applied. The salient features of the diagram are: (a) Two curves, AO and BO (b) Eutectic point, O (c) area AOB

1. Curves

Curve AO: Freezing point curve of Ag

It shows the effect on freezing point of Ag on addition of lead in small quantities. The point A (961°C) is the melting point of pure Ag, where pure Ag co–exists as solid and liquid (C = 1).

This curve indicates that the melting point of Ag falls gradually as the addition of Pb increases, along AO, till the lowest point O (303°C) is reached. At point O, the solution gets saturated with respect to lead. Along the curve AO, solid Ag and liquid melt are in equilibrium

$$Ag_{(s)} \rightleftharpoons \text{Ag-Pb melt}_{(l)},$$

(P = 2, C = 2), and hence, according to reduced phase rule equation: F' = 2 – 2 + 1 = 1 (monovariant). Thus, either composition or temperature is needed to define the system along the curve AO.

Curve BO: freezing point curve of Pb represents the effect on freezing point of Pb on gradual addition of small amounts of Ag to it. Point B is the melting point of pure lead (327°C). Along BO, the melting point gradually falls on the addition of Ag, till lowest point O is reached. At C, the solution gets saturated with respect to Ag. As seen above, along BO, F' = 1.

2. Eutectic Point O: The curve AO and BO meet at O, which is called the eutectic point. Here three phases, solid Ag, solid Pb, and liquid melt, are in equilibrium. Applying the reduced phase rule, (P – 3; C = 2),

$$F' = C - P + 1 = 2 - 3 + 1 = 0 \text{ (invariant)}$$

Both variables temperature (303°C) and composition (97.4% Pb, 2.6% Ag: eutectic composition) are fixed. If the temperature is raised above the eutectic temperature, the solid phases Ag and Pb disappear. No mixture of lead and silver has a melting point lower than the eutectic temperature.

Area AOB: This region represents the single phase system, the solution of molten Ag and Pb (P = 1; C = 2). Applying the reduced phase rule;

$$F' = C - P + 1 = 2 - 1 + 1 = 2 \text{ (Bivariant)}$$

Thus, to define a system in this area, both temperature and composition are to be specified.

Pattinson's process for the Desilverisation of Argentiferrous lead

The argentiferrous lead contains small amount of silver (say, 0.1% of Ag). It is melted well above the melting temperature of pure lead (327°C). Let the point **p** represent molten lead on the diagram. It is then allowed to cool when the temperature of the melt falls along the dashed line **pq**. As the temperature corresponding to **q** on the curve BO is reached, solid pure lead begins to separate. On further cooling, more of pure lead separates along the curve **qO** until the eutectic point O is reached. Lead is continuously removed by means of ladles and the percentage of silver in the melt goes on increasing up to 2.6%. This process is called desilverisation of lead or Pattinson's process.

Uses of eutectic compounds:

1. Since eutectic mixtures are low-melting, they find use in safety devices, e.g., as plugs in fire sprinklers, and pressure cookers.
2. Preparation of solders, e.g., Pb-Sn solders, used in soldering electrical and electronic components.
3. As fuses, e.g., Wood's metal, fusion temperature 70°C.

MULTIPLE CHOICE QUESTIONS

1. What is Gibbs phase rule for general system?

a) P = C – 1 – F
b) P = C + 1 – F
c) P + F = C – 2
d) **P + F = C + 2**

2. In a single – component condensed system, if degree of freedom is zero, maximum number of phases that can co – exist is

a) 2
b) **3**
c) 0
d) 1

3. Which of the following is the property of high carbon steel?

a) High toughness
b) reduced ductility
c) high strength
d) reduced strength

4. High carbon steel is used in _____

a) **transmission lines and microwave towers**
b) structural buildings
c) fire resistant buildings
d) for waterproofing

5. What is the permissible percentage of micro-alloys in medium and high strength micro-alloyed steel?

a) 0.1%
b) 0.5%
c) **0.25%**
d) 1.0%

6. Fire resistant steels are also called as _____

a) Stainless steel
b) Weathering steel
c) High strength steel
d) **Thermo mechanically treated steel**

7. What is the minimum percentage of chromium and nickel added to stainless steel?
a) 0.5%, 10.5%
b) 2%, 20%
c) **10.5%, 0.5%**
d) 30%, 50%

8. What is weathering steel?
a) **low-alloy atmospheric corrosion-resistant steel**
b) low-carbon steel
c) high strength quenched and tempered steel
d) fire resistant steel

9. What is the name of the phase transition that occurs when a solid is converted directly into a gas (without going through the liquid phase)?

a) Melting

b) Boiling

c) Condensing

d)Sublimation

10. Which if the following statements are true about the Eutectic point on a two component (compounds A and B) phase diagram?

a) Both compounds are solid

b) The melting point of the mixture is lower than the melting points of either of the individual compounds

c) One compound is in the liquid phase whilst the other is in the solid phase

d) It always occurs when the ratio of compound A to compound B is 50:50

11. Which of the following statements is NOT true in relation to the triple point on a single component phase diagram?

a)The point at which the solid, liquid and gaseous phases for a substance co-exist

b) The triple point exists for a substance occurs at a specific temperature and pressure

c) The triple point exists at a single temperature and is independent of pressure

d) The system must be enclosed so that no vapour can escape

12) Following is wrong about a phase diagram.

(a) **It gives information on transformation rates.**

(b) Relative amount of different phases can be found under given equilibrium conditions.

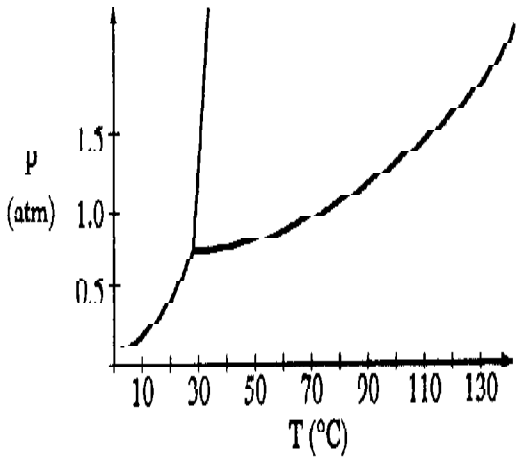
(c) It indicates the temperature at which different phases start to melt.

(d) Solid solubility limits are depicted by it.

13. wt. % of carbon in mild steels

(a) <0.008 **(b) 0.008-0.3** (c) 03-0.8 (d) 0.8-2.11

For questions **14 - 16**, refer to the phase diagram below of a pure substance.



(a) Sublimation

(b) Condensation

(c) Vaporization

(d) Melting

(e) Deposition

14) If the pressure decreases from 1.5 to 0.5 atmospheres at a constant temperature of 50˚C, which of the processes occurs?

Vaporization

15) If the temperature increases from 10°C to 50°C at a constant pressure of 0.5 atmospheres, which of the processes occurs?

Sublimation

16) If the temperature decreases from 110°C to 40°C at a constant pressure of 1.1 atmospheres, which of the processes occurs?

Condensation

17) Above what temperature is it impossible to liquefy this substance, no matter what the pressure?

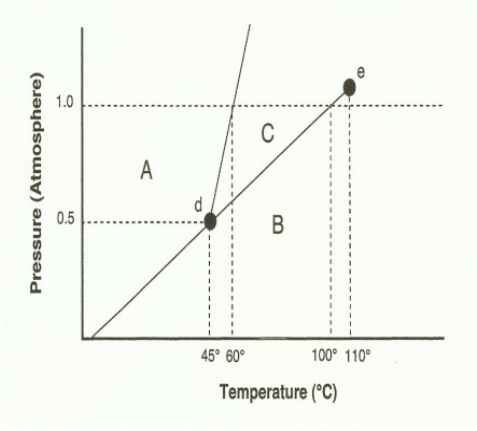
(a) Critical temperature

(b) Absolute temperature

(c) Eutectic temperature

(d) None of these

18) Answer the questions below in relation to the following phase diagram.



i) Which section represents the solid phase? **A**

ii) What section represents the liquid phase? **C**

iii) What section represents the gas phase? **B**

iv) What letter represents the triple point? **d**

19) Not an important heat treatment process parameter

(a) Heating rate (b) Temperature (c) Cooling rate (d) **Atmosphere**

20) Stainless steel is so called because of its----------

(a)High strength (b) **High corrosion resistance**(c) High ductility (d) Brittleness

21) Not a noble metal

(a)**Cu** (b) Pt c) Au (d) Ag

22) % C in medium carbon steels ranges from _____.

(a) 0.3- 0.4 (b) 0.3- 0.5 (c) **0.3- 0.6** (d) None

23) In white cast irons, carbon present as _____.

(a) Graphite flakes (b) Graphite nodules (c) **Cementite** (d) Carbon does not exist

24) Phase rule is used to study ----------reactions

(a)Homogeneous reversible **(b) Heterogeneous reversible** (c) Irreversible (d) None

25) Composition of 18/8 stainless steel

(a) Cr-18%,Ni-8% (b) Ni-18%,Cr-8% (c) Fe-18%,C-8% (d) C-18%,Fe-8%

REVISION QUESTIONS

Part A

1. Define the term component.
2. Illustrate the term phase with a suitable example.
3. What is meant by the number of degrees of freedom?
4. Identify the total number of phases involved in the decomposition of $CaCO_3$.
5. $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$. How many phases, components and degrees of freedom are available in this equilibrium?
6. $NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$. How many phases, components and degrees of freedom are available in this equilibrium?
7. Calculate the number of phases present in the following systems.
   a) $MgCO_{3(s)} \rightleftharpoons MgO_{(s)} + CO_{2(g)}$
   b) Rhombic $sulphur_{(s)} \rightleftharpoons$ Monoclinic $sulphur_{(s)}$
   c) $Ice_{(s)} \rightleftharpoons Water_{(l)} \rightleftharpoons Water\ vapour_{(g)}$
8. Write the phase rule for a system at constant temperature and pressure. (OR) What is the condensed (or reduced) phase rule?
9. What is condensed (or reduced) phase rule?
10. What is a eutectic mixture?
11. Mention three advantages of alloys over the metals from which they are prepared.
12. Give the composition and uses of: i) Nichrome ii) stainless steel
13. Give the composition and uses of brass.
14. What is meant by annealing?
15. What is meant by quenching?

Part B

1. State the phase rule and explain the terms involved in it with examples.
2. Discuss the application of phase rule to water system.
3. State the condensed phase rule and discuss its application to Ag-Pb system.
4. Discuss the application of phase rule for the extraction of silver from argentiferrous lead. (Pattinson's process)
5. What is meant by thermal analysis? How is it used to construct the phase diagram of a two-component system?
6. Write a note on heat treatment of steels.
7. Briefly indicate the purpose of making alloys.
8. Write a note on non-ferrous alloys.
9. What is meant by quenching, normalizing, carburizing, and flame hardening of metals? What is achieved by these treatments?

WEBSITE LINKS FOR REFERENCE

1. Alloys introduction

https://www.youtube.com/watch?v=eW9TCggFtB0

https://www.youtube.com/watch?v=NPqOIOznjas

2. Effects of alloying elements in steel

https://www.youtube.com/watch?v=4k8BI6SUnyA

3. Brass and bronze alloys

https://www.azom.com/article.aspx?ArticleID=2824

4. Stainless steel

https://www.azom.com/article.aspx?ArticleID=2867

5. Heat treatment of steel

https://www.youtube.com/watch?v=tnaNsMgSmP0

https://www.youtube.com/watch?v=Jt8pYX4nVSo

6. Phase rule Introduction

https://www.youtube.com/watch?v=lA1CZUnKDZc

https://www.youtube.com/watch?v=NETcZV6Sug0

7. One Component System

https://www.youtube.com/watch?v=si95eubFZdg

8. Cooling curves

https://www.youtube.com/watch?v=cFArOXIlqJ0

9. Two component system

https://www.youtube.com/watch?v=wyT_A6bBUWE

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UNIT 4: FUELS AND COMBUSTION

Learning Objectives

After studying this chapter you will be able to:

- **Understand fuels,classification of fuels.**
- **Know about coal,analysis of coal,carbonization manufacture of metallurgical of synthetic petrol(Bergius Process), Knocking,octane number.**
- **Understand diesel oil,Cetane number,natural gas, compressed natural gas(CNG),liquefied pewtroleum gases (LPG),power alcohol and biodiesel.**
- **Know about combustion of fuels,calorific value,higher and lower calorific values, theoretical calculation of calorific value.**
- **Understand ignition temperaqture,spontaneous ignition temperature,explosive range, flue gas analysis (ORSAT method).**

Introduction

A fuel is any combustible substance containing carbon as the main constituent which on burning gives large amount of heat, e.g., wood, coal, kerosene, petrol, producer gas, *etc.* During the process of combustion of a fuel, carbon and hydrogen combine with oxygen with the simultaneous liberation of heat at a rapid rate.

$$\underset{\text{Higher energy content}}{\text{Fuel}} + O_2 \longrightarrow \underset{\text{Lower energy content}}{\text{Combustion products}} + \text{Heat}$$

The primary or main sources of fuels are coals and petroleum oils. These are available in the earth's crust and are generally called fossil fuels.

Classification of fuels

The fossil fuels have been classified according to their:

1. **Occurrence:**
    a. Natural or primary fuels – which are found in nature (Coal,petroleum,natural gas)
    b. Artificial or secondary fuels – which are prepared from primary fuels.(Coke, diesel,kerosene)

2. **State of aggregation:**
    a. Solid Fuel (Coal, coke,lignite)
    b. Liquid Fuel (crude oil, diesel and petrol)
    c. Gaseous Fuel (natural gas, LPG and CNG)

Comparison of Solid, Liquid and gaseous Fuels

Property	Solid Fuels	Liquid Fuels	Gaseous Fuels
Availability	Available in plenty	Sources are limited	Sources are unlimited
Storage and handling	Easy to store and handle	Easy to handle	Should be careful in storage and handling
Transportation	No risk	Special care is needed	Special care is needed
Combustion	Slow	Quick	Rapid
Calorific value	Low	Higher	Highest
Moisture content	More	Less	Do not contain moisture
Ash content	Less	Lesser	Do not contain ash
Ignition temperature	Highest	Moderate	Low
Thermal efficiency	Least	Higher	Highest
Flammability	Not inflammable	Inflammable	Highly inflammable
Use in internal combustion	Not possible	Possible	Possible
Maintenance cost	More	Less	Do not contain moisture

COAL

Coal is a highly carbonaceous matter that has been formed as a result of alteration of vegetable matter (e.g., plants) under certain favourable conditions. It is mainly composed of C, H, N, and O, besides non–combustible inorganic matter.

Coalification or metamorphism

The process of conversion (or alteration) of vegetable matter to anthracite (coal) is called classification or metamorphism of coal:

Wood → Peat → Lignite → Bituminous → Anthracite

This progressive transformation of wood to anthracite results in:

i) Decrease in the moisture content
ii) Decrease in hydrogen, oxygen, nitrogen and sulphur contents, with a corresponding rise in carbon content

iii) Decrease in volatile matter content
iv) Increase in the calorific value
v) Increase in hardness

ANALYSIS OF COAL

Proximate analysis gives us an idea of the fixed carbon content, and hence, the rank of coal and its approximate calorific value. Ultimate analysis gives us the accurate elemental analysis data and is useful in calculating the HCV, LCV, and the minimum or theoretical air requirement during combustion.

1. **Proximate analysis or AVM analysis** (**A**sh, **V**olatile matter, and **M**oisture)

It involves the following determinations:

1. **Moisture content**

About 1g of finely divided air–dried coal sample is accurately weighed in a crucible and placed in an electric hot air oven, maintained at 105° – 110°C for 1 hour. After 1 hour the crucible is cooled in desiccators and weighed. Loss in weight of the sample is found and the % of moisture is calculated as

$$\%\ of\ moisture\ in\ coal = \frac{\text{Loss in weight}}{Weight\ of\ coal\ taken} \times 100$$

2. **Volatile matter**

After the analysis of the moisture content, the dried sample of coal left in the crucible is covered with a perforated lid and placed inside a muffle furnace, maintained at 925° ± 20°C. The crucible is taken out of the oven after 7 minutes of heating. The crucible is cooled first in air, and then in desiccator and weighed again. The loss in weight of the sample is taken and the % of volatile matter is calculated as

$$\%\ of\ volatile\ malter\ = \frac{\text{Loss in weight of coal}}{Weight\ of\ coal\ taken} \times 100$$

3. **Ash content**

After the analysis of volatile matter, the crucible is heated without lid in a muffle furnace at 700 ± 50°C for 30 minutes. The crucible is taken out cooled first in air, then in desiccator and then weighed. The process is repeated until a constant weight is obtained.

$$\%\ of\ ash\ content = \frac{\text{Weight of ash left}}{Weight\ of\ coal\ taken} \times 100$$

4. **Fixed carbon**

% of fixed carbon in coal = 100 - % (moisture content + volatile content + ash content)

Importance of proximate analysis

1. Moisture content
   High percentage of moisture is undesirable because, it reduces the effective calorific value of coal. It lengthens the time of heating hence, lesser the moisture content, better the quality of coal as a fuel.

2. Volatile matter
   Fuels with a high volatile matter content burn with a long flame, high smoke, and low calorific value, since a large proportion of the fuel escapes unburnt. Hence, lesser the volatile matter, better the rank of coal.

3. Ash content
   Formation of ash (non–combustible matter) which reduces the calorific value of coal, hinders the flow of air, and increases transport, handling, and storage cost.
   Hence, lower the ash content, better the quality of coal.

4. Fixed carbon
   Higher the percentage of fixed carbon, greater is its calorific value, and better is the quality of coal.

ULTIMATE ANALYSIS

It involves the determination of percentage of nitrogen, oxygen, carbon, ash, sulphur, and hydrogen content, in the coal sample. It is also known as NOCASH analysis.

Carbon and hydrogen content

A known amount of the coal sample is burnt in a current of O_2 in a combustion apparatus. The carbon and hydrogen present in the coal sample are converted into CO_2 and H_2O respectively according to the following equations:

$$C + O_2 \longrightarrow CO_2\uparrow$$
$$H_2 + \tfrac{1}{2}O_2 \longrightarrow H_2O\uparrow$$

The liberated CO_2 and H_2O vapours are absorbed respectively in KOH and anhydrous $CaCl_2$ tubes of known weights. The increase in weight of KOH tube is due to the formation of H_2O.

$$2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$
$$CaCl_2 + 7H_2O \longrightarrow CaCl_2.7H_2O$$

From the weights of CO_2 and H_2O formed, the % of carbon and hydrogen present in the coal can be calculated as follows:

Since 44 parts of CO_2 contains 12 parts by weight of carbon, and 18 parts of H_2O contains 2 parts by weight of hydrogen,

$$\%\,C = \frac{\text{Weight of } CO_2}{\text{Weight of coal sample}} \times \frac{12}{44} \times 100$$

$$\%\,H = \frac{\text{Weight of } H_2O}{\text{Weight of coal sample}} \times \frac{2}{18} \times 100$$

Nitrogen Content

The determination of nitrogen content is carried out by Kjeldahl's method. An accurately weighed powdered coal sample is heated with conc. H_2SO_4 in the presence of K_2SO_4 (catalyst) in a long-necked flask (Kjeldahl's flask). Nitrogen in the coal is converted in to ammonium sulphate and a clear solution is obtained. The clear solution is then heated with excess of NaOH and the liberated ammonia is distilled over and is absorbed in a known volume(excess) of standard acid (0.1 N HCl).

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow 2NH_3 + Na_2SO_4 + 2H_2O$$

$$NH_3 + HCl \longrightarrow NH_4Cl$$

The volume of unused acid (0.1N HCl) is determined by back-titrating it against standard base (0.1 NaOH). From the above, the amount of ammonia liberated ammonia from nitrogen in the coal can be calculated. From this the percentage of nitrogen is calculated as follows:

$$\%\,N = \frac{\text{Weight of } NH_3 \text{ liberated}}{\text{Weight of coal sample}} \times \frac{14}{17} \times 100$$

Sulphur content

A known amount of coal sample is oxidized with Eschka mixture (2:1 MgO/Na_2CO_3) followed by treatment with bromine water. During this process sulphur is converted into sulphate, which is treated with $BaCl_2$ solution, and $BaSO_4$ precipitated. The precipitate is filtered, dried, and weighed. From the weight of $BaSO_4$ obtained, the sulphur present in the coal is calculated as follows.

$$\%\,S = \frac{\text{Weight of } BaSO_4}{\text{Weight of coal sample}} \times \frac{32}{233} \times 100$$

Ash content

Determination of ash content is carried out in the same manner as in proximate analysis.

Oxygen content

The percentage of Oxygen in coal is calculated by difference.

% of oxygen in coal = 100 - % (C + H + N +S + ash)

Importance of ultimate analysis

1. Carbon and hydrogen: Greater the % of carbon and hydrogen better is the quality of coal and higher is the calorific value of coal. The amount of carbon depends on the type of coal and its % increases with rank from lignite to anthracite. Thus, % of carbon forms the basis of classification of coal.

2. Nitrogen: Nitrogen has no calorific value and hence its presence in coal is undesirable. A good quality coal should have little nitrogen content.

3. Sulphur: Sulphur, on combustion produces acidic oxides (SO_2 and SO_3), which cause corrosion of the equipment and also cause environmental pollution. Presence of sulphur is highly undesirable in coal to be used for making metallurgical coke for iron industry since it is transferred to the iron metal and badly affects the quality and properties of steel.

4. Oxygen: Oxygen content decreases the calorific value of coal. An increase of 1% oxygen content decreases the calorific value by about 1.7%, and hence, oxygen is undesirable.

Comparison between Proximate and Ultimate Analysis

Proximate Analysis of Coal	**Ultimate Analysis of coal**
Determines the percentage of fixed carbon,volatile matter,moisture and ash	Determines all element components of coal C,H,O,S and N.
Gives an idea for the rank of coal	Helps to calculate the quantity of air required for complete combustion of coal

COKE

Carbonisation of coal

When coal is heated strongly in the absence of air (called destructive distillation), it is converted into lustrous, dense, porous, and strong mass known as coke. This process of converting coal in to coke is known as carbonisation. Coke is largely used in metallurgical industries as a reducing agent, so it is called as **metallurgical coke.**

Comparison of Coal and Coke

Coal	**Coke**
It has lower strength and porosity	It has higher strength and porosity
It has very high moisture and volatile content	It has very low moisture and volatile content

It burns with a long flame	It burns with a short flame

Caking coals and coking coals

When coals are heated strongly, the mass becomes soft, plastic, and fuses to give a impervious (to air) mass. Such type of coals are called **caking coals**, and do not burn easily. On further heating, if the mass produced is hard, porous, and strong, then the original coal sample is called **coking coal**. Coking coals possesses lower volatile matter and are used for the manufacture of metallurgical coke.

Metallurgical coke

When bituminous coal is heated strongly in the absence of air, the volatile matter escapes (H_2S, tarry vapours, hydrocarbons), and the mass becomes hard, strong, and porous mass, which is called as metallurgical coke.

Characteristics of good metallurgical coke

1. Purity: Metallurgical coke should have low moisture, ash, phosphorus, and sulphur contents.
2. Porosity: Coke should be porous, so that oxygen can easily come in contact with the carbon of coke, thereby helping in complete combustion at a high rate.
3. Strength: The coke should have high mechanical strength in order to withstand high pressure of the overlying material in the furnace.
4. Calorific value: The calorific value of coke should be very high.
5. Combustibility: Coke should burn easily. The combustibility of coke depends upon the nature of the coal, carbonisation temperature, and reaction temperature.
6. Cost: Coke should be cheap and easily available near the site of the metallurgical plant, so that the transportation cost is low.

MANUFACTURE OF METALLURGICAL COKE:

Otto–Hoffmann By– product oven process:

The modern by-product oven process developed by Otto-Hoffmann is superior to the beehive oven process in the following respects:

i) Higher thermal efficiency of the carbonisation process

ii) Recovery of several valuable by-products, e.g., tar, ammonia, benzene derivatives

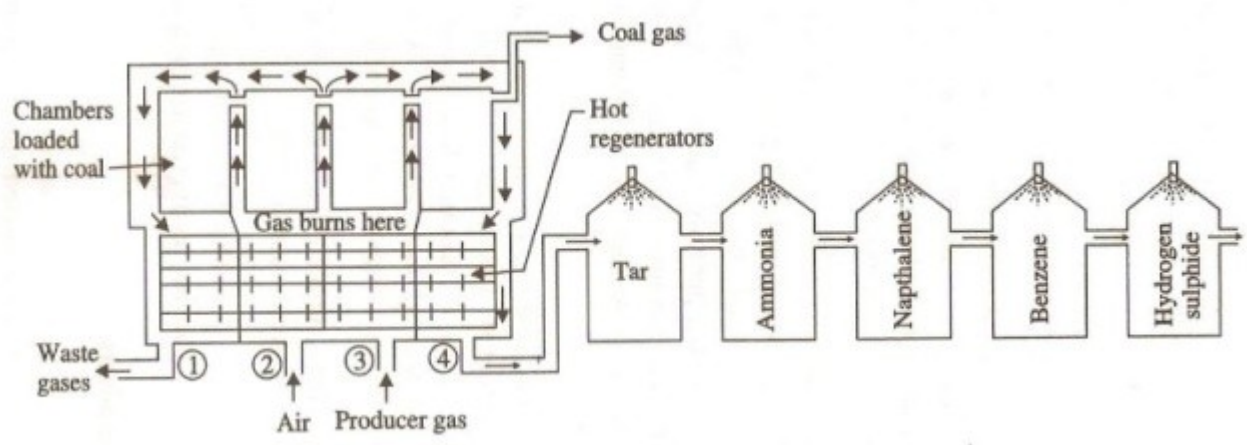
The main characteristics are external heating of the oven and the application of the regenerative system of heat economy.

Process: The by-product coke oven consists of number of narrow silica chambers (each about 10 to 12m long, 3 – 4m high and 0.5m wide) erected side by side. Each chamber is provided with a charging hole at the top, a gas off–take value, and a refractory-lined cast iron door at each ends for discharging coke.

Coal is introduced into the silica chambers which are then closed tightly at both ends so that no air is admitted. The chambers are heated to 1000-1200^{o}C by burning the preheated air and the producer gas mixture in the interspaces between the chambers.

The air and gas are preheated by sending them through 2nd and 3rd hot regenerators. Hot flue gas produced during carbonisation is allowed to pass through 1st and 4th regenerators until the temperature has been raised to 1000^{o}C. While 1st and 4th regenerators are heated by hot flue gases the 2nd and 3rd regenerators are used for heating the incoming air and gas mixture.

For economical heating, the direction of inlet gases and flue gases are changed frequently. The above system of recycling the flue gases to produce heat energy is known as the regenerative system of heat economy. When the process is complete, the coke is removed and quenched with water.



The time taken for complete carbonisation is about 12 – 20 hours and the yield of coke is about 70%. The valuable by products like coal gas, tar, ammonia, and benzene derivatives, etc., can be recovered from flue gas.

Recovery of by – products

i) Recovery of tar: The gas from the coke ovens is first passed through a tower in which liquor ammonia is sprayed. Tar and ammonia are recovered in a tank below, which is heated by steam coils to recover back the ammonia sprayed, which is recycled.
ii) Recovery of ammonia: The gases from the tower are passed through a chamber in which water is sprayed. Here ammonia goes into solution as NH_4OH.
iii) Recovery of naphthalene

The gases are then passed through another tower in which water at very low temperature is sprayed. Here naphthalene gets condensed.

iv) Recovery of benzene

The gases are then sprayed with petroleum spirit, when benzene and its homologues are recovered.

v) Removal of H_2S

The gases are then passed through a purifier, packed with moist Fe_2O_3, where H_2S is converted to Fe_2S_3. The exhausted Fe_2O_3 is regenerated by exposure to atmospheric air:

$$Fe_2O_3 \xrightarrow{H_2S} Fe_2S_3 \xrightarrow{air\ (O_2)} Fe_2O_3$$

vi) Fuel gases: The residual gas after recovery of the various by-products is collected in a gas holder. Depending on the temperature and rate of carbonization, the fuel gas may have a calorific value in the range of 5000-9500 kcal m^{-3}.

Advantages of Otto Hofmann's process

1. Valuable by-products like ammonia, coal gas, and naphthalene, are recovered.
2. The carbonisation time is less (12-20 hours) and the yield is higher (70%).

LIQUID FUELS

Petroleum: (Petra – rock; oleum – oil)

It is dark greenish-brown viscous oil found deep in earth's crust. It is composed of various hydrocarbons, (straight chain paraffins, cycloparaffins, olefins, and aromatics) together with small amounts of organic compounds containing oxygen, nitrogen and sulphur. The oil is usually found floating upon a brine solution and has a layer of gas on top of it. The average composition of crude petroleum is: C = 80 - 87%, H = 11 – 15%, S = 0.1 – 3.5%, and N+ O = 0.1 - .05%.

Classification of petroleum

Petroleum is classified into three types based on the chemical nature. They are

Paraffin base petroleum: It mainly consists of saturated hydrocarbons and little naphthenes and aromatics.

Naphthenic or Asphalt base petroleum: It contains mainly cycloparaffins or naphthenes with a smaller amount of paraffins and aromatics.

Mixed base petroleum: It contains both paraffinic and asphaltic hydrocarbons.

Refining of petroleum / crude oil:

Petroleum has resulted from the partial decomposition of marine animals and vegetable organisms of pre–historic forests. Mining of petroleum is done by drilling holes in the earth's crust and sinking pipes up to the oil-bearing porous rocks. The crude oil is separated in to various useful fractions by fractional distillation and finally converted into desired specific products. The process of removing impurities and separating the crude oil in to various fractions having different boiling points is called refining of petroleum.

Step1: Separation of water (Cottrell's process)

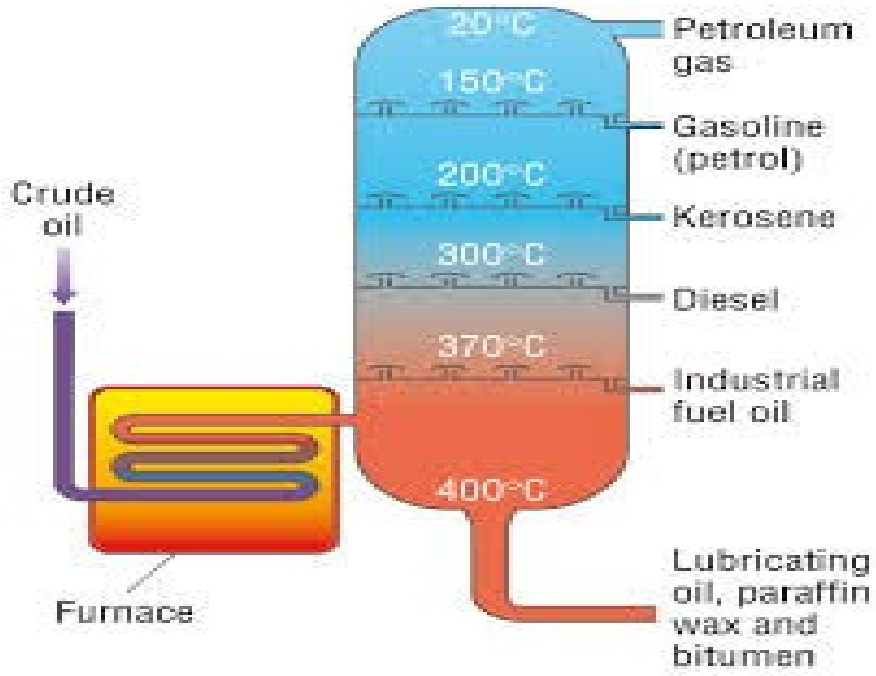
The crude oil obtained from the oil well is an extremely stable emulsion of oil and salt water. The oil is allowed to flow between two highly charged electrodes. The colloidal water droplets combine to form large drops which separate out from the oil.

Step2: Removal of harmful sulphur compounds:

Sulphur compounds are removed by treating the crude oil with copper oxide. The copper sulphide formed is separated out by filtration.

Step 3: Fractional distillation:

The purified crude oil is then heated to about 400°C in an iron retort where the oil gets vapourised. The hot vapours are then passed into the bottom of the fractionating column. The fractionating column is a tall cylindrical tower containing a number of horizontal stainless steel trays at short distances. Each tray is provided with small chimneys covered with a loose cap. When the vapours of the oil go up in the fractionating column, they become cooler and get condensed at trays at different heights. The fractions having higher boiling points condense at lower trays, whereas the fractions having lower boiling points condense at higher trays. The gasoline obtained by this fractional distillation is called **straight-run gasoline**.



S.No.	Fraction	Boiling range (°C)	Approximate composition	Uses
1.	Uncondensed gases	Below 30	$C_1 - C_4$	Domestic and industrial fuel (LPG)
2.	Petroleum ether	$30^o - 70^o$	$C_5 - C_7$	Solvent
3.	Gasoline / petrol	$40^o - 120^o$	$C_5 - C_9$	Fuel for IC
4.	Naphtha / solvent spirit	$120^o - 180^o$	$C_9 - C_{10}$	As a solvent in paints and in dry cleaning
5.	Kerosene Oil	$180^o - 250^o$	$C_{10} - C_{16}$	Fuel for stoves and jet engines
6.	Diesel Oil	$250^o - 320^o$	$C_{10} - C_{16}$	Diesel engine fuel
7.	Heavy Oil	$320^o - 400^o$	$C_{17} - C_{30}$	Fuel for ships; production of gasoline by cracking

Heavy oil on refractionation gives:

S.No.	Fraction	Uses
1.	Lubricating oil	Lubricants
2.	Petroleum jelly (Vaseline)	Pharmaceuticals, cosmetics
3.	Grease	Lubricant
4.	Paraffin wax	Candles, boot polishes
5.	Pitch (> 400^oC)	Making roads, Water-proofing of ceilings.

SYNTHETIC PETROL

The gasoline obtained from the fractional distillation of crude petroleum is called straight-run petrol. The amount of straight-run gasoline is not enough to meet the requirement of the present community. Hence, the need to manufacture synthetic petrol.

Hydrogenation of coal – manufacture of synthetic petrol

Coal contains about 4.5% hydrogen compared to about 18% in petroleum. If coal is heated to high temperature under high pressure, it is converted to gasoline. The preparation of liquid fuels from solid coal is called hydrogenation of coal or synthetic petrol.

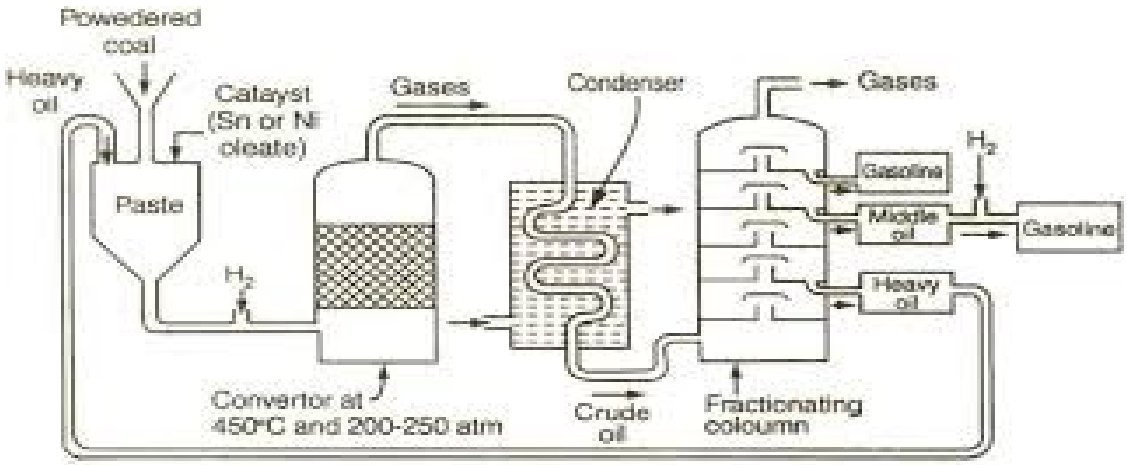
Two methods are available for the hydrogenation of coal:

1. Bergius process or direct method
2. Fischer–Tropsch process or indirect method

BERGIUS PROCESS (Direct process)

In this process, the finely powdered bituminous (low grade) coal is made into a paste with heavy oil and a catalyst powder (tin or nickel oleate) is mixed with it. The paste is heated with hydrogen at 450°C and under a pressure of 200 – 250 atm for about 1.5 hours to yield a mixture of saturated hydrocarbons. The saturated hydrocarbons undergo decomposition at higher temperature to yield a mixture of low-boiling hydrocarbons. The mixture is led into a condenser where a liquid resembling crude oil is obtained. The crude oil is then fractionated to yield: 1) **gasoline** (petrol), 2) middle oil, and 3) heavy oil.

The middle oil is hydrogenated in vapour phase in the presence of a solid catalyst to yield more gasoline. The yield of gasoline is about 60% of the coal used.



KNOCKING

Knocking is a sudden explosion of air – fuel mixture inside an internal combustion engines. In an **internal combustion engine**, a mixture of gasoline (petrol) vapour and air is used as a fuel. After the initiation of the combustion reaction by electric spark in the cylinder, the flame spreads rapidly and smoothly through the gaseous mixture, and the expanding gas drives the piston down the cylinder. Under certain circumstances, due to the presence of some

constituents in the gasoline used, the rate of oxidation becomes so great that the last portion of the fuel air mixture gets ignited instantaneously producing a detonating shock wave known as knocking.

Knocking results in lower efficiency of engines. The knocking tendency of fuel hydrocarbons mainly depends on their chemical structures. The knocking tendency decreases in the following order:

Straight chain alkanes > branched chain alkanes > cycloalkanes > alkenes > aromatics

Alkenes of the same carbon chain length posses better anti-knock properties that the corresponding alkanes.

Octane number or octane rating:

The knocking characteristics of an internal combustion engine fuel are expressed in terms of octane number. The hydrocarbon, *n*–heptane, $CH_3–(CH_2)_5–CH_3$ knocks very badly and it has been arbitrarily assigned an octane rating of zero. *Iso*-octane (2,2,4–trimethylpentane), which has very good combustion characteristics, *i.e.*, exhibits very little tendency to detonate, has been assigned a value of 100.

The **octane number** of a petrol fuel is defined as the percentage of *iso*-octane in a mixture of *iso*-octane and *n*-heptane that matches with the knocking characteristics of the test fuel under consideration, e.g., if a petrol sample gives as much knocking as a mixture of 75 parts of *iso*-octane and 25 parts of *n*-heptane, then its octane rating is 75.

Improvement of antiknock characteristics

The octane number of fuel can be improved by:

i) Blending petrol of high octane number with petrol of low octane number, so that the octane number of latter can be improved.
ii) The addition of anti-knocking agents like tetraethyl lead (TEL), tetra methyl lead (TML), diethyl telluride $(C_2H_5)_2Te$, etc.

Diesel oil:

It is a fraction obtained between 250 – 320 °C during fractional distillation of petroleum. It is a mixture of C15C32 and C18H38 hydrocarbons. Its calorific value is about 11,000 Kcal/Kg.It is used as a good diesel engine fuel.

Causes for knocking in diesel engine:

In diesel engine, air alone is first compressed in the cylinder. This compression raises the temperature of the cylinder to about 500°C. Then the diesel oil is sprayed into the hot air. Droplets of oil get vaporized and ignited. It raises the temperature and pressure. The expanding gases push the piston and power stroke begins inside the cylinder.

The combustion of fuel in a diesel engine is not instantaneous. The time interval between the fuel injection and its ignition is called ignition lag or ignition delay. This delay is due to time taken for the vaporization of oil droplets and raising the temperature of the vapour to its ignition temperature.

Long ignition delay leads to accumulation of more vapours in the cylinder, which undergo explosion during ignition. This is responsible for diesel knock. If the ignition lag is short, diesel knock will not occur.

Diesel Index:

The quality of diesel fuel is indicated by its diesel index number using the following formula.

$$\text{Diesel index number} = \frac{\text{specific gravity (API)} \times \text{Aniline point in °F}}{100}$$

The higher the diesel index number, the better is the quality of the fuel.

Cetane number or Cetane rating

The percentage of cetane (n-hexadecane) by volume in a mixture of cetane and 1-methylnaphthalene, which has the same ignition lag as the fuel under test is the **cetane number** of the test fuel. For example, a diesel of cetane number 40 will have the same ignition lag (or spontaneous ignition temperature) as that of a mixture containing 40% cetane and 60% 1-methylnaphthalene.

The cetane number of a diesel fuel can be increased by the addition of pre-ignition dopes, e.g., ethyl nitrate, *iso*-amyl nitrite.

The knocking tendency increases in the order:

Straight chain alkanes > cycloalkanes > alkenes > branched alkanes > aromatics.

An ideal gasoline should contain high amounts of n-alkanes and less amounts of unsaturated aliphatic and aromatic compounds.

GASEOUS FUELS

Gaseous fuels refer to various forms of gaseous substance that are used to produce energy through the process of combustion.

Example: Coal gas, biogas, natural gas, water gas,etc.

Compressed natural gas (CNG)

CNG is natural gas compressed to a high pressure of about 1000 atmosphere. A steel cylinder containing 15 kg of CNG contains about 2×10^4 litres or $20m^3$ of natural gas at 1

atmosphere pressure. It is derived from natural gas and the main constituent of CNG is methane.

Average composition: methane = 88.5%, ethane = 5.5%, propane = 3.7%, butane = 1.8%, pentane = 0.5%.

Properties

1. CNG causes comparatively much less pollution as it produces less CO, ozone, and hydrocarbons during combustion.
2. During its combustion, no sulphur and nitrogen gases are evolved.
3. It is less expensive than petrol and diesel.
4. The ignition temperature if CNG is 55^{o}C
5. The octane rate of CNG is high, and hence, thermal efficiency is more.
6. It mixes easily with air than the other gaseous fuel.
7. It is cheaper and cleaner than LPG.

Liquefied petroleum gas (LPG): Bottle gas or refinery gas

LPG is obtained as a by – product during the cracking of heavy oils or from natural gas. LPG consists of hydrocarbons of such volatility that they can exist as gas under atmospheric pressure, but can be readily liquefied under pressure. Traces of organic thiols, e.g., ethane thiol (C_2H_5SH), are added to make leak detection easier since LPG does not have any characteristic odour.

Average composition: Propane = 24.5%, *n* – butane = 38.5%, *iso*-butane = 37%,

Calorific value = 25,000 kcal/m^3 approx.

Uses:

1. The largest use of LPG is as domestic and industrial fuel.
2. It is also used as an automobile fuel.

Advantages of LPG over gaseous fuel

1. The calorific value of LPG is 3 times that of natural gas and 7 times that of coal gas.
2. It posses high thermal efficiency and heating rate.
3. Use of well-designed and durable burners ensures complete combustion with no smoke.
4. Portability in steel cylinders makes it use possible even in remote places.
5. Comparatively less health hazard even in the case of leakage.
6. Cleanliness in storage handling and use.

Liquefied Petroleum Gas (LPG)

LPG is obtained as a by – product during fractional distillation of crude oil or by cracking of heavy oil. It consists of propane and butane.It can be readily liquefied under pressure,so it can be stored and transported in cylinders.

Composition: The average composition of LPG as follows

n- Butane - 38.5

Iso Butane - 37

Propane - 24.5

Its calorific value is about 25,000Kcal/m3

Uses:

1. LPG is used as domestic and industrial fuel.
2. It is used as motor fuel.

Advantages of LPG over gaseous fuel:

1. The calorific value is three times higher than of natural gas and 7 times that of coal gas.
2. Need limited care for maintenance.
3. Easy to adapt.
4. Cleanliness in storage, handling and use.
5. It is free from CO, so it is less hazardous.
6. It has high thermal efficiency and heating rate.
7. Flexibility and easy control.

Disadvantages of LPG over other gaseous fuel:

1. Due to its faint odour, leakage cannot be easily detected.
2. Its cotan4e number is low
3. Its load sensitivity is high
4. It is suitable only for the engines working under high compression ratio

5. Handling must be done under high pressure.

Power Alcohol

When ethyl alcohol is blended with petrol at concentration of 5-10%, it is called power alcohol. Absolute ethyl alcohol is also called power alcohol.Ethyl alcohol is used in an internalcombustion engine. The addition of ethylalcohol to petrol increases its octane number.

Manufacture:

Manufacture of ethyl alcohol involves the following two steps

1. Manufacture of Ethyl alcohol:

Ethyl alcohol can be synthesized by fermentation of carbohydrates.Fermentation of molasses with yeast generates alcohol.This fermentation yields only about 20 % alcohol.

$$C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2\ C_2H_5OH + 2\ CO_2$$

Glucose ethyl alcohol

Concentration of alcohol can be increased up to 97.6% by fractional distillation yields rectified spirit.

2. Conversion of Ethyl alcohol to power alcohol

For the use in IC engines, 100% alcohol is prepared by removing last traces of water from rectified spirit.It can be done by the following methods**.**

1. Alcohol, containing traces of water is distilled with benzene. When benzene passes over, it leaves behind power alcohol.

2. Alcohol is distilled in the presence of dehydrating agent, which holds the water.

Finally absolute alcohol is mixed with petrol at concentration of 5 – 10% to get power alcohols.

Properties:

1. Power alcohol has a lower calorific value (700 cal/g).

2. It has high octane number (90)

3. It reduces CO emissions from the engine.

4. Its compression ratio is also higher.

Uses:

1. It is used as a motor fuel,

2. Used to power farm tractors, boats and airplanes.

Advantages and Disadvantages of power alcohol:

1. It is cheaper than petrol

2. Alcohol absorbs traces of water present in petrol.

3. Ethyl alcohol contains oxygen atoms, which help in complete combustion of power alcohol so emission of CO, hydrocarbon, particulates is reduced.

Disadvantages:

1. As the calorific value power alcohol (700 cal/gm) is lower than petrol (11,500 cal/gm), so output power is reduced up to 35%.

2. Due to its high surface tension, atomization of power alcohol is difficult, so it causes starting trouble.

3. It may under go oxidation to give acetic acid, which corrodes engine part.

4. As it contains oxygen atoms, the amount of air required for combustion of power alcohol is lesser and therefore carburetor and engine needs to be modified.

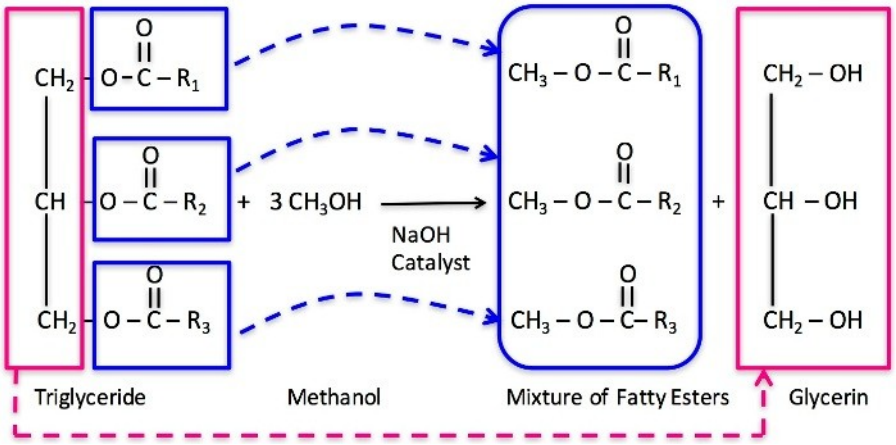
Biodiesel

It is a renewable fuel containing of a Mono alkyl esters of long chain fatty acids. They are produced by a Trans – esterification reaction between vegetable oil or animal fats with Methanol or Ethanol in the presence of an alkali. During this process bio - diesel and glycerol are formed.

Synthesis of Bio – diesel:

Trans-esterification or alcoholysis : Displacement of an alcohol from an ester by another alcohol is called trans-esterification.It involves treatment of vegetable oil with excess of methanol in presence of catalyst to give mono ethyl esters of long chain fatty acid (bio-diesel) and glycerine .It is allowed to stand for some time and glycerine is separated.

Transesterification is represented as



Advantages and Disadvantages of Bio-diesel

Advantages

1. Bio-diesel is bio-degradable.
2. It is prepared from renewable resources.
3. The gaseous pollutants are lesser as compared to the conventional diesel fuel.
4. Bio-diesel can be produced from different types of vegetable oils.
5. Best engine performance and less smoke emission are achieved.

Disadvantages

1. Bio diesel gels in cold weather.
2. As bio-materials are hygroscopic, bio-diesel can absorb the water from atmosphere.
3. Bio-diesel decreases the horse power of the engine.
4. Bio-diesel degrades and softens the rubber and plastics that are used in some old cars.
5. Bio-diesel has about 10% higher nitrogen-oxide (NO_x)emission than conventional pertroleum

COMBUSTION

It is process of rapid exothermic chemical reaction in which a fuel burns in the presence of oxygen with the evolution of heat and light.

Most of the combustible substances are enriched with carbon and hydrogen. During combustion they undergo thermal decomposition to give simpler products, which are oxidized to CO_2, H_2O etc.

$C + O_2 \rightarrow CO_2$ Exothermic

$H_2 + ½\ O \rightarrow H_2O$ Exothermic

The main aim of combustion to yield maximum amount of heat from the combustible substance in the shortest time.

Calorific value

It is defined as the amount of heat liberated by the complete combustion of a unit mass or volume of a fuel, and is usually expressed in kilocalories (kcal) or kilojoules (kJ).

Higher or gross calorific value (HCV or GCV)

It is defined as the total heat generated when a unit quantity of fuel is burnt completely and the products of combustion are cooled down to room temperature. When a fuel containing hydrogen is burnt, the hydrogen present undergoes combustion and will be converted in to steam. As the products of combustion are cooled to room temperature, the steam gets condensed in to water and the latent heat is evolved. Thus the latent heat of combustion of steam so liberated is included in the gross calorific value.

Theoretical calculation of calorific value:

When the ultimate analysis is available (i.e., % of C, H, N, O, and S), the calorific value of a fuel can be calculated. According to Dulong, the calorific value of a fuel is the sum of the calorific values of its constituent elements.

Dulong's formula for GCV

GCV or HCV = 1/100 (8,080C + 34,500 (H - O/8) + 2,240 S) kcal/kg,

Where the values 8080, 34,500, and 2,240 kcal/kg, correspond to the gross or higher calorific values of the C, H, and S, respectively. In the above formula, C, H, O, and S, represent the percentage of the respective elements. The quantity of hydrogen in combination with oxygen will not take part in the combustion reaction. So the 'free' hydrogen available for combustion is given by (H - O/8).

Lower or Net calorific value: (LCV or NCV)

It is defined as the net heat produced when a unit quantity of fuel is completely burnt and the products of combustion are allowed to escape.

NCV = GCV – Latent heat of condensation of water vapour produced

= GCV – (Mass of hydrogen × 9 × latent heat of condensation of water vapour)

NCV = GCV – 0.09H × 587, where

H = % of hydrogen in the fuel, and latent heat of steam = 587 cal/g

Problem based on calorific value

1. A sample of coal has the following percentage composition, C = 80%, H = 4%, S = 1%, O = 5 %,

N = 1% and ash = 9%. Calculate the approximate calorific values in cal/gm.

Formula for GCV = 1/100[8080 C + 34500(H-O/8) + 2240 S]

= 1/100[8080 x 80 + 34500 (4-5/8) + 2240 x 1]

= 1/100[646400 + 34500 (4 – 0.625 0 + 2240]

= 1/100(646400 + 116437.5 + 2240)

= 7650.77 cal/gm

LCV = GCV- 9H/100 x 587 (formula)

= 7650.77 – 9 x4/100 x587

= 7650.77 – 211.32

= 7439.45 cal/gm.

2. Calculate the gross and net calorific values of coal having the following compositions

C = 85%; H= 8%; S= 1%; N = 2%; ash = 4%, latent heat of steam = 587 cal/g.

Given: C = 85%; H =8%; S = 1%; N= 2%; ash= 4%

Laten heat of steam = 587 cal/g

Gross calorific value (GCV)

GCV = 1/100[8080x % C + 34500(% H-%O/8) + 2240 x % S] Kcal/Kg

= 1/100[8080 x 85 + 34500 (8 – O/8) + 2240 x 1] Kcal/Kg

= 1/100 [686800 + 276000 + 2240] Kcal/Kg

= 1 /100 [965040] Kcal/ kg

GCV = 9650.4 Kcal/Kg

(ii) NCV = GCV – 9/100 H x 587 Kcal /Kg

= 9650.4 – 9/100 x 8 x 587 Kcal/ Kg

= 9650.4 – 422.64 Kcal/Kg.

3. Calculate the gross and net calorific values of coal sample having the following

Compositions = 82%; H= 5%; O= 4%; S = 3%; N= 3.5% and ash = 2.5 %

Given: C = 82%; H =5 %; O = 4%; S = 3%; N= 3.5%; ash= 2.5%

GCV = 1/100[8080x % C + 34500(% H-%O/8) + 2240 x % S] Kcal/Kg

= 1/100[8080 x 82 + 34500 (5 – 4/8) + 2240 x 3] Kcal/Kg

= 1/100 [662560 + 155250 + 6720] Kcal/Kg

= 1/100 [8245.30] Kcal/Kg

GCV = 8245.3Kcal/ Kg

(ii) NCV = GCV – 9/100 H x 587 Kcal /Kg

= 8245.3 – 9/100 x 5 x 587 Kcal/ Kg

= 8245.3 – 26415/100 Kcal / Kg

= 8245.3 -264.15 Kcal/ Kg

NCV = 7981.15 Kcal/Kg

4. A sample of coal has the following composition by weight C = 90%; O = 3.0%; S = 0.5%; N = 0.5% and ash = 2.5 %. Net calorific value of the coal was found to be 8490.5Kcal/Kg.Calculate the percentage of Hydrogen and higher calorific value of the coal.

Given: C = 90%; O = 3.0%; S = 0.5%; N = 0.5% and ash = 2.5 %, NCV = 8490.5Kcal/Kg

GCV = (NCV + 0.09H × 587) Kcal/Kg

= (8490.5 + 0.09H x 587) Kcal/ Kg

= (8490.5 + 52.83 H) Kcal/ Kg ⟶ (1)

GCV = 1/100[8080x % C + 34500(% H-%O/8) + 2240 x % S] Kcal/Kg

= 1/100[8080 x 90+ 34500 (H – 3/8) + 2240 x 0.5] Kcal/Kg

= 1/100 [727200 + 34500 (H – 0.38) + 1120] Kcal/Kg

= 1/100[728320 + 34500H- 13110] Kcal/Kg

= 1/100[715210 + 34500H] Kcal/Kg

GCV = 7152.1 + 345H ⟶ (2)

Equation (2) is substituted in eq (1)

7152.1 + 345 H = 8490.5+ 52.83 H

345 H – 52.83 H = 8490.5 – 7152.1

292.17 H = 1338.4

H = 1338.4/ 292.17

H = 4.58 ⟶ (3)

Equation (3) is substituted in eqn. (1)

GCV = 8490.5 + 52.83 H Kcal/Kg

= 8490.5 + 52.83 x 4.58

= 8490.5 + 241.96

GCV = 8732.46 Kcal/ Kg

5. On analysis a coal sample has the following composition by weight; C = 85%; O = 3%

S = 0.5% and ash = 3%. Net calorific value was found to be 8400 Kcal/ Kg.Calculate the percentage of hydrogen and gross calorific value of coal.

GCV = (NCV + 0.09H × 587) Kcal/Kg

= (8490.5 + 0.09H x 587) Kcal/ Kg

= (8490.5 + 52.83 H) Kcal/ Kg ⟶ (1)

GCV = 1/100[8080x % C + 34500(% H-%O/8) + 2240 x % S] Kcal/Kg

= 1/100[8080 x 85+ 34500 (H – 3/8) + 2240 x 0.5] Kcal/Kg

= 1/100 [686800 + 34500H – 12937.5 + 1120] Kcal/Kg

= [6868 + 345 H – 129.4 + 11.2] Kcal/Kg

= 6749.8 + 345 H Kcal/ Kg ⟶ (2)

Equation (2) is substituted in eq (1)

6749.8 + 345 H = 8400 + 52.8 H

345 H – 52.8 H = 8400 – 6749.8

292.2 H = 1650.2

H = 1650.2/ 292.2

H = 5.647 ⟶ (3)

Equation (3) is substituted in equation (1)

GCV = (8400 + 52.8 x 5.647)

= 8698.16 Kcal/ Kg

Ignition temperature

It is the minimum temperature to which a fuel must be heated before it begins burning without the source of the heat.

Ignition temperature of coal is about 300C. In the case of liquid fuels, the ignition temperature is called the flash point, which ranges from 200 – 450 °C.For gaseous fuels; the ignition temperature is in the order of 800 °C.

Spontaneous Ignition Temperature

The minimum temperature at which the fuel catches fire spontaneously without external heating.

If the ignition temperature of a fuel is low it can catch fire very quickly. On the other hand if the ignition temperature is high it is difficult to ignite the fuel. If the heat evolved in a system is unable to escape, temperature of the system goes on increasing and when SIT is reached, the system burns on its own.

Explosive range or Flammable range

The Flammable range or explosive range is the range of a concentration of a gas that will burn if ignition source is introduced. The limits are commonly called the Lower Explosive or Flammable limit (LEL/LFL) and the upper explosive or flammable limit (UEL/UFL).

The minimum concentration of a particular combustible gas or vapour necessary to support its combustible in air is defined as the lower explosive limit for that gas. Below this level, the mixture is too lean to burn.

The maximum concentration of a gas or vapour that will burn in air is defined as the upper Explosive limit (UEL).Above this level, the mixture is too rich to burn. The range between the LEL and UEL is known as the explosive range for that gas or vapour. The explosive range decides the limit of the composition of the fuel – air mixture to be used for combustion purposes. The lower and upper explosive range limits for some common gases are indicated in the following table.

Fuel Gas	Lower Explosive Limit (LEL) (%)	Upper Explosive Limit (UEL) (%)
Hydrogen	4	75
Gasoline	1.4	7.6
Diesel fuel	1.80	7.5
Acetone	2.6	12.8
Ethane	1.0	12.4

FLUE GAS ANALYSIS – ORSAT'S APPARATUS:

The mixture of gases like CO_2, O_2, CO, N_2, etc., coming out from the combustion chamber is called flue gas. The flue gas analysis is carried out by using Orsat's apparatus. The analysis of flue gas generally deals with the determination of CO_2, O_2, and CO, by absorbing them in the solutions of KOH, alkaline pyrogallol, and ammoniacal cuprous chloride, respectively.

Flue gas analysis is carried out to determine the quality of the combustion process: the presence of CO indicates incomplete combustion and/or lack of air supply, while the presence of oxygen indicates complete combustion or excess air supply.

Procedure

Orsat's apparatus consists of a horizontal tube having a 3-way stopcock at one end and a water-jacketed measuring burette at the other end. The horizontal tube is connected to three different absorption bulbs for the absorption of CO_2, O_2, and CO, respectively. The lower end of the burette is connected to the leveling bottle by means of a rubber tube.

The level of water in the leveling bottle (water reservoir) can be raised or lowered by raising or lowering the water reservoir. By changing the level of water, the flue gas can be moved in to various parts of the apparatus during analysis.

It is essential to follow the order of absorbing the gases – CO_2, O_2, and finally CO. This is because the absorbent used for O_2 (alkaline pyrogallol) can also absorb some amount of CO_2 and the percentage of CO_2 left would be less.

BULB	REAGENT	FUNCTION
A	Potassium hydroxide	Absorbs **CO_2**
B	Alkaline pyrogallol	Absorbs **O_2** and CO_2
C	Ammoniacal cuprous chloride solution	Absorbs **CO**, CO_2, and O_2

a) **Absorption of CO_2**

Flue gas is passed in to the bulb A via its stopcock by raising the water reservoir. CO_2 present in the flue gas is absorbed by KOH (250g KOH in 500ml distilled water). This gas is again sent to the burette and then again sent to bulb A. This process is repeated several times by raising or lowering the water reservoir so as to ensure complete absorption of CO_2 in KOH. Now the stopcock of the bulb A is closed. The volume of residual gases in the burette

is taken by equalizing the water level both in the burette and in the water reservoir. The difference between original volume and the volume of gases after CO_2 absorption gives the volume of CO_2 absorbed.

b) **Absorption of O_2**

Stopcock of bulb A is closed, and bulb B is opened. Oxygen present in the flue gas is absorbed by alkaline pyrogallol (25g pyrogallol + 200g KOH in 500 ml distilled water). The decrease in volume of flue gas in the burette indicates the volume of O_2

c) **Absorption of CO**

Now the stopcock of bulb B is closed and the stopcock of bulb C is opened. CO present in the flue gas is absorbed by ammoniacal cuprous chloride (100g Cu_2Cl_2 + 125ml liquor NH_3 + 375ml water). The decrease in the volume of flue gas in the burette indicates the volume of CO.

Since the total volume of gas taken for analysis is 100ml, the volume of the constituents is their percentage. The residual gas after the above three determination is taken as **nitrogen**.

Importance of flue gas analysis

1. It helps to understand whether the combustion process is complete or not.
2. The presence of CO indicates incomplete combustion.
3. If there is considerable amount of oxygen, it shows that there is excess supply of O_2 or air, or completion of combustion.

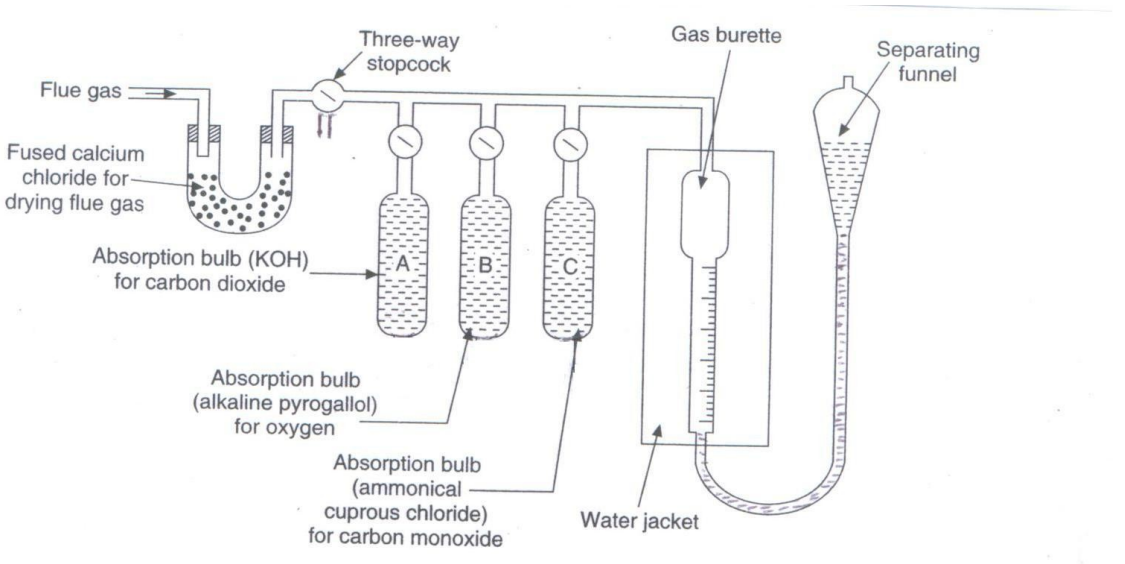


Figure: Orsat's apparatus for flue gas analysis

REVISION QUESTIONS

Part A

1. Define Fuel
2. How fuels are classified? Give one example for each.
3. Write the characteristics of a good fuel.
4. What is Coalification or metamorphism of coal?
5. Write briefly on the ranking of coal
6. Define Knocking
7. What is metallurgical coke?
8. Define cracking
9. What is LPG? Give its uses.
10. List out the advantages of solid fuels.
11. How are gaseous fuels superior to other types of fuels?
12. What is CNG?
13. Define octane number.
14. What is BIO- Diesel?
15. What is power alcohol? Mention the advantage
16. What is the average composition of LPG?
17. Define Cetane number.
18. Distinguish between Proximate and Ultimate analysis.
19. How coke is is superior to coal?
20. What is the difference between caking coals and coking coals?
21. What are the advantages of Otto- Hoffman's process?
22. What is meant by refining of petroleum?
23. What is Cottrell's process in crude oil refining
24. Define calorific value.
25. What is meant by gross and net calorific values?
26. The net calorific value of a fuel is less than that of the gross calorific value. Why?
27. What are the advantages of solid fuels over liquid fuels?
28. What are the characteristics of metallurgical coke?
29. What is meant by hydrogenation of coal?
30. What is the function of tetraethyl lead used in fuels?
31. Explain the term leaded petrol. What is its advantage?
32. What is spontaneous ignition temperature?
33. Select the compound which possesses highest octane number and highest cetane number out of n-heptane, n-hexadecane, n-octane and isooctane.

Part-B

1. What are the characteristics of good metallurgical coke?
2. How is metallurgical coke prepared? How is this different from coal?
3. How is proximate analysis of coal done? Explain the significance of proximate analysis of coal.
4. What is ultimate analysis of coal? Explain its importance.
5. What is meant by carbonization of coal?
6. Write notes on: i) water gas ii) producer gas
7. What is synthetic petrol? How is it manufactured by Bergius process?
8. How will you explain knocking in a diesel engine? How can it be controlled?
9. Write the relation between chemical structure and knocking.
10. What is cetane number? How can it be improved? What is its significance?
11. What is octane number? How can it be improved? What is its significance?
12. Write notes on synthetic petrol and petroleum cracking.
13. What is flue gas? Give its significance. Explain the analysis of flue gas by Orsat's apparatus. Indicate its significance. Draw the diagram of Orsat's apparatus.
14. What are LPG and CNG? Discuss the advantages of LPG over gaseous fuel, and CNG over LPG
15. Calculate the gross and net calorific value of coal having the following compositions. Carbon - 85% Hydrogen - 8% Sulphur – 1%, nitrogen – 2% and ash- 4%.
16. Write a detailed account on petroleum processing and fractions.
17. What is bio – diesel? Explain Trans – Esterification and advantages of bio – diesel.
18. What is Power alcohol? Explain its manufacture, properties of power alcohol.

WEB LINKS

1. https://www.youtube.com/watch?v=SiqTdF3dApw- Otto Hoffman By product oven

2. https://www.youtube.com/watch?v=9W3S5vAX4Fc - Fractional Distillation of Petroleum

3. https://www.youtube.com/watch?v=SiqTdF3dApw - Bergius process of Petroleum

4. https://www.youtube.com/watch?v=BlRIQ7_Z3PE - Analysis of Flue Gas by Orsat apparatus

5. https://www.youtube.com/watch?v=KtUWDzAsR-w - Biodiesel preparation

6. https://www.youtube.com/watch?v=xzAKWyEKvPs – Power Alcohol preparation

NPTEL LINKS

1. nptel.ac.in/courses/103103029/module5/lec32/2.html – Otto Hoffman by Product Oven

2. nptel.ac.in/courses/103105110/m2l13.pdf – Bergius Process

3. nptel.ac.in/courses/103102022/6 - Fractional Distillation of Petroleum

4. nptel.ac.in/courses/103106109/14 - Power Alcohol

MULTIPLE CHOICE QUESTIONS

1. In presence of which gas is the fuel burnt to generate energy in form of heat?

a) Oxygen
b) Hydrogen
c) Methane
d) Nitrogen
Answer: a

2. Which are the main constituents of fuel from given options?
a)Carbon and Nitrogen
b) Oxygen and Hydrogen
c) Carbon and Hydrogen
d) Helium and Oxygen

Answer: c

3. Which fuel is used widely in steam power plants?
a) Oil
b) Gas
c) Coal
d) Petroleum
Answer: c

4. What is phenomenon of formation of coal called?
a)Metamorphism
b) Diagenis'
c)Photosynthesis
d)Protolith
Answer: a

5. On what basis is the coal classified?
a)Period of formation
b)Depending on capacity to burn
c)Region/area where is it formed
d)Physical and chemical composition
Answer: d

6. What is the use of electrostatic precipitations in steam power plant?
a) To remove the steam
b) To draw the coal powder into boiler

c) To remove the feed water

d) To remove fly ash

Answer: d

7. Why is ‘make-up water’ added to drum continuously?

a) To remove the impurities in tube

b) To replace the water that has been converted into steam

c) To keep the system cool externally

d) To compensate for water loss trough blow down

Answer: d

8. What causes failure of boiler tube?

a) Heating the tubes, when desired water level is not maintained

b)Induced pressure in the water

c)Over use of boiler

d)Hardness of water

Answer : d

9. In flue gas analysis by Orsat's apparatus, carbon monoxide is absorbed by

a) Cuprous chloride
b) Potassium hydroxide
c) Alkaline pyrogallol solution
d) None of these

Answer: a

10. Presence of free moisture in coal during its high temperature carbonization

(a) Reduces the coking time
(b) Protects the volatile products from pyrolysis (cracking) in the presence of hot coke and hot oven walls
(c) Increases the loss of fine coal dust from the ovens when charging
(d) None of these

Answer: b

11. Presence of _____ in a dry gaseous fuel does not contribute to its calorific value.

a) Sulphur
b) Hydrogen

c) Oxygen
d) Carbon
Answer: d

12. The waste plastics are converted into liquid fuel by the …….process.

a. Pyrolysis

b. Cracking

c. Hydrolysis

d. Incineration

Answer: a

13. Gross calorific value will be equal to net calorific value for

a) H_2

b) C_2H_2

c) CO

d) C_2H_6

Answer: c

14. High amount of Sulphur and Phosphorous in coke causes

a) decreases its calorific value

b) increase itsstrength

c) brittleness of steelby made using it

d) none of these

Answer: c

15. What chemical reaction makes biodiesel?

a) sublimation

b) Trans esterfication ,

c) Fermentation,

d) polymerization

Answer: b

16. What is a byproduct of producing biodiesel?

a) methanol

b) glycerin,

c) Polymer

d) salt

Answer: a

17. Biodiesel is also called what?

a)glycerin

b) alcohol

c) Vegetable oil

d)methyl ester

Answer: c

18. Which of the following gas is chiefly present in LPG

a)Butane

b) Propane

c) Ethane

d)Methane

Answer: a

19. The following is the desirable property of good Internal Combustion engine fuel
a) High energy content per unit quantity of fuel
b) Free from fire hazards
c) Low toxicity
d) All of the above
Answer: d

20. The solid fuels can be used in Internal combustion engine only after their

a)Solidification
b)Liquefaction
c) Gasification
d) All of the above
Answer: c

21. The major constituent of natural gas is
a)Methane
b)Ethane
c) Propane
d)Butane
Answer: a

22. Which of the following gases is used as fuel in internal combustion engine?
a)Liquefied petroleum gas (LPG)
b) Blast furnace gas
c) Coke oven gas
d) All of the above
Answer: d

23. Decomposition of higher hydrocarbon **molecules into lower hydrocarbons having lower boiling temperatures is known as**
a)Polymerization
b)Hydrogenation
c) Isomerization
d) Cracking
Answer: d

24. The antiknock property of the fuel depends on its
a)Self-ignition temperature
b) Molecular structure
c) Chemical composition
d) All of the above
Answer: d

25. Iso-octane and n-heptane has assigned a rating of
a) 0, 100
b) 50, 50
c) 100, 0
d)20, 80
Answer: c

25. The following is used for rating for Compression ignition engines.
a)Octane number
b) Cetane number
c) Butane number
d) All of the above
Answer: b

UNIT 4: FUELS AND COMBUSTION – SEMESTER EXAM QUESTIONS

Part A (2 marks each)

1. What are the drawbacks of the presence of sulphur in coal?
2. Define cetane number.
3. Define the terms: a) cracking b) knocking.
4. How is water gas superior to producer gas?
5. With an example state what is cracking.
6. Write the expression for the amount of air required for combustion of 1kg of fuel.

Part B (16 marks each)

1. a) What is proximate analysis? Write its significance. (6)

b) What is synthetic petrol? How is it manufactured by Bergius process? (10)

2. a) Calculate the volume of air required for the completer combustion of 1 m^3 of gaseous fuel having the following composition by volume: H_2 = 50%; CH_4 = 36%; N_2 = 1.5%; CO = 6%; C_2H_4 = 4%; H_2O vapour = 2.5%. (6)

b) What is flue gas analysis? How is it carried out by Orsat's process? (10)

3. a) Describe the manufacture of metallurgical coke by Otto Hoffman's oven method. (10)

b) Explain the manufacture of gasoline by Fischer-Tropsch method. (6)

4. a) With a neat diagram explain the analysis of flue gas by Orsat apparatus and mention the precautions to be followed during the analysis. (8)

b) What are LPG and CNG? Discuss the advantages of LPG over gaseous fuel, and CNG over LPG. (8)

5. a) How is metallurgical coke manufactured by Otto Hoffman's method? What are the important by-products recovered from coke oven gas? (8)

b) Describe the significance of ultimate analysis of coal. (4)

c) List the fractions of hydrocarbons collected between boiling range of 30°C and 400°C by fractional distillation of crude oil. (4)

6. a) What is hydrogenation of coal? Write the Fischer-Tropsch process of manufacture of liquid fuels from solid fuels. (8)

b) Write in detail chemical reactions involved in manufacture of producer gas and mention its chemical composition. (8)

UNIT V

ENERGY SOURCES AND STORAGE DEVICES

Learning Objectives

After this lesson, students should be able to:

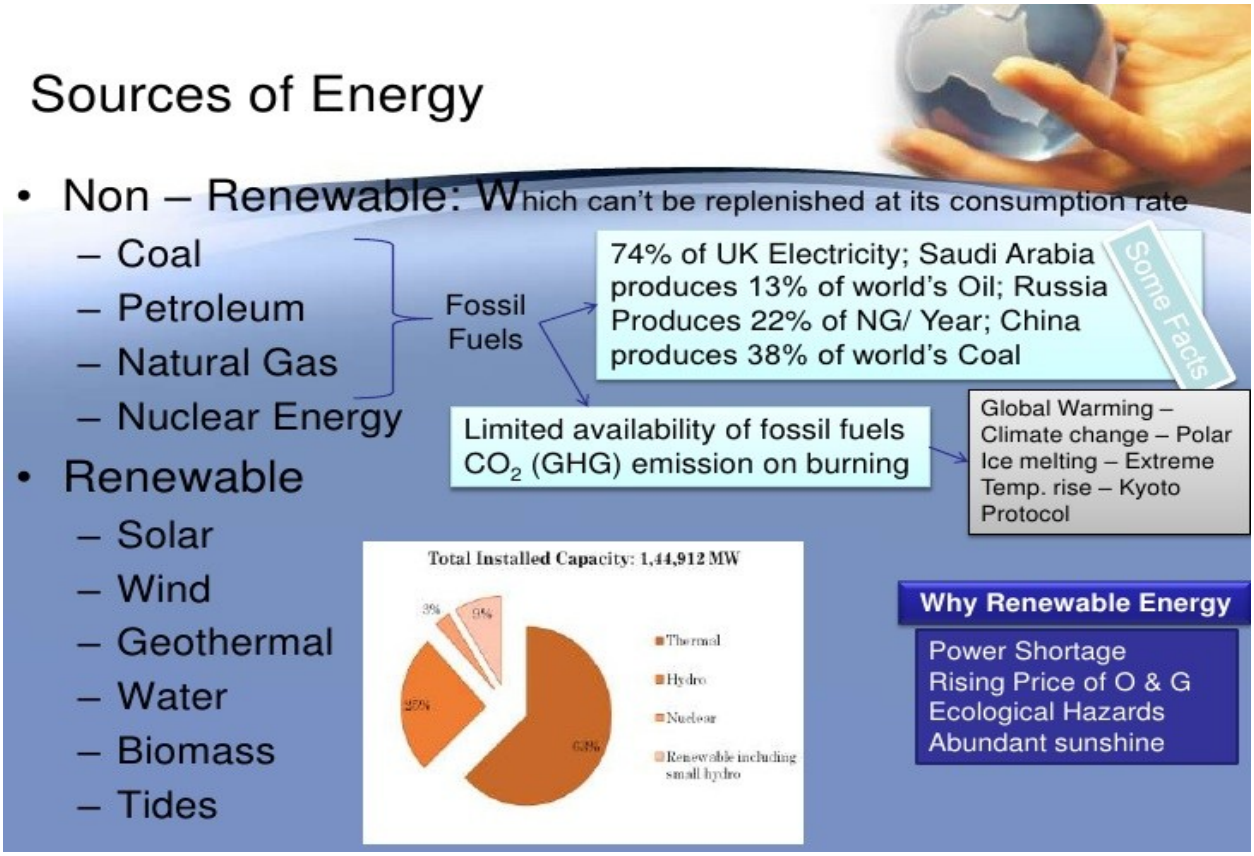
- Describe sources and uses of energy.
- Define renewable and non-renewable energy.
- Provide examples of common types of renewable and non-renewable resources.
- Understand and explain general ways to save energy at a personal, community and global level.
- Understand and explain, in general terms, how passive solar heating, wind power work and Nuclear power plant.
- Describe some general characteristics of solar power, Wind power and Nuclear energy.
- Understand the benefits and disadvantages to using renewable resources.
- Explain how engineers design more efficient ways to use generate electricity.
- Describe the role of engineers in energy conservation.

Introduction:

Energy is the capacity to do work and is required for life processes. An energy resource is something that can produce heat, power life, move objects, or produce electricity. Matter that stores energy is called a fuel. Human energy consumption has grown steadily .throughout human history. Early humans had modest energy requirements, mostly food and fuel for fires to cook and keep warm. In today's society, humans consume as much as 110 times as much energy per person as early humans. Most of the energy we use today comes from fossil fuels (stored solar energy). But fossils fuels have a disadvantage in that they are non-

renewable on a human time scale, and cause other potentially harmful effects on the environment. In any event, the exploitation of all energy sources (with the possible exception of direct solar energy used for heating), ultimately rely on materials on planet Earth.

Classification: Energy sources can be classified into two types: Non renewable and renewable. Nonrenewable resources, such as fossil fuels and nuclear material, are removed from the earth and can be depleted. These resources have been the most used type of energy in the modern era. Renewable resources, such as wind, water, solar, and geothermal, come from sources that regenerate as fast as they are consumed and are continuously available. Some, such as biofuel produced from food crops and other plants, are replenished every growing season. In the early part of the twenty first century, renewable resources have become more popular as non renewable sources have begun to be deleted.



NUCLEAR ENERGY:

Nuclear energy is the energy which is obtained from the nuclear reaction (nuclear fission or fusion).The enormous amount of energy released during the nuclear fission is due to the loss in some mass, when the reaction takes place. It has been observed that during nuclear fission, the sum of the masses of the products formed is slightly less than the sum of masses of target species and bombarding neutron The loss in mass gets converted into energy according to Einstein equation.

$$E = \Delta mc^{2;}\ \Delta m = (M\text{-}M')$$

Where, E is energy

Δm is loss in mass

C is velocity

M is mass of radioactive substance before emitting radiation

M' is mass of radioactive substance after emitting radiation

NUCLEAR FISSION:

Nuclear fission is a nuclear reaction in which the nucleus of an atom splits into smaller parts (lighter nuclei). The fission process often produces free neutrons and photons (in the form of gamma rays), and releases a **large amount of energy.**

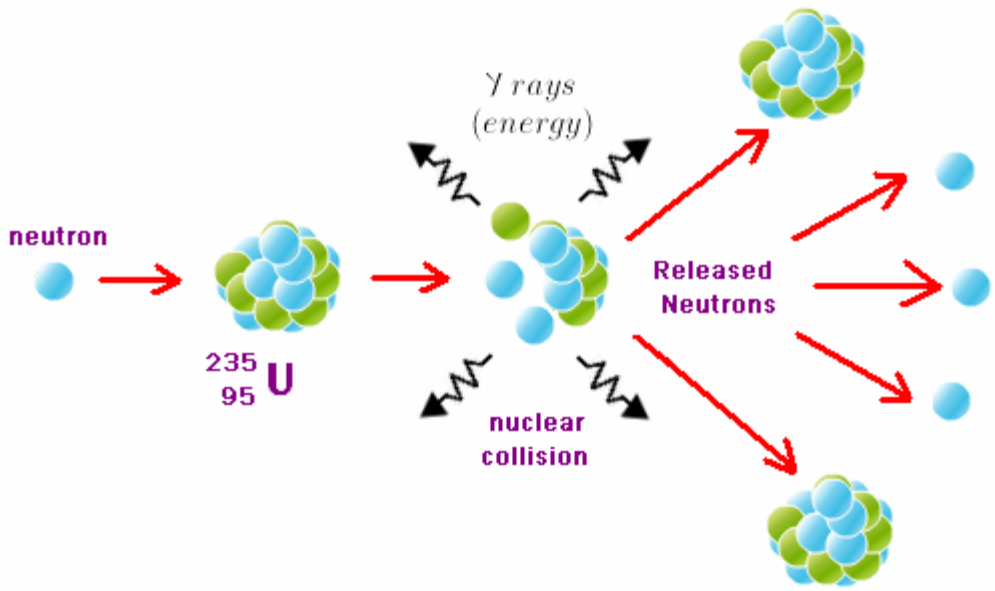
Example :

The fission of one atom of uranium-235 generates 202.5 MeV = 3.24×10^{-11} J, which translates to 19.54 TJ/mol, or 83.14 TJ/kg. This is around 2.5 million times more than the energy released

from burning coal. When $^{235}U_{92}$ nuclides are bombarded with neutrons, one of the many fission reactions that it can undergo is the following fission reaction

$$_{92}U^{235} + {}_{0}n^{1} \longrightarrow {}_{56}Ba^{140} + {}_{36}Kr^{93} + 3{}_{0}n^{1} + \text{energy}$$

Illustration:



Characteristics of nuclear fission:

- A heavy nucleus when bombarded by slow moving neutrons split into two or more nuclei.
- Two or more neutrons are produced by fission of each nucleus.

- Large quantities of energy are produced as a result of conversion of small mass nucleus into energy.
- 4. All the fission fragments are radioactive, giving off β and γ -radiations.
- The atomic weights of fission products range from about 70 to 160.
- All the fission reactions are self- propagating chain- reactions because fission products contain neutrons (secondary neutrons) which further cause fission in other nuclei.
- The nuclear chain reactions can be controlled and maintained steadily by absorbing a desired nu8mber of neutrons. This process is used in nuclear reactor.
- Every secondary neutron n, released in the fission process, does not strike a nucleus, some escape into air and hence a chain reaction cannot be maintained.
- Multiplication factor: the number of neutrons, resulting from a single fission, known as the multiplication factor.

When the multiplication factor is less than 1, a chain reaction does not take place.

Types of nuclear fission reaction:

1. Uncontrolled fission reactions – Atom Bomb

In this fission process, the heavy nucleus absorbs a neutron and forms an unstable compound nucleus. The compound nucleus then breaks up more of less in the middle to give fission product.

Further, the neutrons released (say three) from the fission of first uranium atoms can hit three other uranium atoms. In this way, a chain reaction is set up resulting in the liberation of the enormous amount of energy. In the case of nuclear fission, Uranium-236 formed breaks up in several ways.

This fission process is a self-multiplying process and hence a tremendous amount of energy is released in a very short interval of time. Therefore, the explosion takes place. Thus the fission is due to an uncontrolled chain reaction.

2. Controlled fission reactions – Nuclear reactor

The explosive effect of a nuclear chain reaction can be considerably reduced in a nuclear reactor.i.e. An apparatus in which nuclear fission is produced in the form of controlled self-sustaining chain reaction. This is achieved by using natural uranium in place of Uranium-235 since natural uranium contains a very large amount of Uranium-235 isotope which absorbs slow neutrons and thus reduces the explosive effect of the nuclear fission chain reaction seen in the case of Uranium-235 to a great extent.

The controlled nuclear fission reaction can be carried out in the presence of moderators which slow down the secondary neutrons which are fast neutrons. The secondary neutrons pass through the moderator controls the explosive effect of the nuclear fission chain reaction. The moderators used in the nuclear reactors are D2O, graphite, etc.

Nuclear Reactor:

An apparatus or structure in which fissile material can be made to undergo a controlled, self-sustaining nuclear reaction with the consequent release of energy.

LIGHT WATER NUCLEAR POWER PLANT

Most common nuclear reactors are **light water reactors (LWR)**, in which **light water** (ordinary water) is used as a moderator as well as the cooling medium. The use of ordinary water makes it necessary to use an enriched uranium fuel in order to **maintain** the **criticality** of the reactor along entire fuel cycle (e.g. for 18 month fuel cycle).

Light water reactors are thermal reactors which use thermal neutrons to sustain the chain reaction. In general, LWR's are divided into two categories:

- **Pressurized water reactors (PWR)** – are characterized by high pressure primary circuit (to keep the water in **liquid state**)

- **Boiling water reactors (BWR)** – are characterized by controlled boiling in the primary circuit.

Pressurized water reactors use a reactor pressure vessel (RPV) to contain the nuclear fuel, moderator, control rods and coolant. They are cooled and moderated by **high-pressure liquid water** (e.g. at pressure of 16MPa). At this pressure water boils at approximately 350°C (662°F). Inlet temperature of the water is about 290°C (554°F). The water (coolant) is heated in the reactor core to approximately 325°C (617°F) as the water flows through the core. As it can be seen, the reactor has approximately 25°C **subcooled coolant** (distance from the saturation).

Boiling water reactors are cooled and moderated by water like a PWR, but at a lower pressure (of about 7MPa), which allows the water to **boil inside** the pressure vessel producing the steam that runs turbines. A BWR is like a PWR but with many differents. The BWRs don't have any **steam generator**. Unlike a PWR, there is no primary and secondary loop. The thermal efficiency of these reactors can be higher, and they can be simpler, and even potentially more stable and safe. But the disadvantage of this concept is that any fuel leak can make the water radioactive and that radioactivity can reach the turbine and the rest of the loop.

Components:

Fuel. Uranium is the basic fuel. Usually pellets of uranium oxide (UO_2) are arranged in tubes to form fuel rods. The rods are arranged into fuel assemblies in the reactor core **Moderator.** Material in the core which slows down the neutrons released from fission so that they cause more fission. It is usually water, but may be heavy water or graphite.

Control rods. These are made with neutron-absorbing material such as cadmium, hafnium or boron, and are inserted or withdrawn from the core to control the rate of reaction, or to halt it.* In some PWR reactors, special control rods are used to enable the core to sustain a low level of power efficiently. (Secondary control systems involve other neutron absorbers, usually boron in

the coolant – its concentration can be adjusted over time as the fuel burns up.) PWR control rods are inserted from the top, BWR cruciform blades from the bottom of the core.

Coolant. A fluid circulating through the core so as to transfer the heat from it. In light water reactors the water moderator functions also as primary coolant. Except in BWRs, there is secondary coolant circuit where the water becomes steam. (See also later section on primary coolant characteristics.) A PWR has two to four primary coolant loops with pumps, driven either by steam or electricity – China's Hualong One design has three, each driven by a 6.6 MW electric motor, with each pump set weighing 110 tonnes.

Pressure vessel or pressure tubes. Usually a robust steel vessel containing the reactor core and moderator/coolant, but it may be a series of tubes holding the fuel and conveying the coolant through the surrounding moderator.

Steam generator. Part of the cooling system of pressurised water reactors (PWR & PHWR) where the high-pressure primary coolant bringing heat from the reactor is used to make steam for the turbine, in a secondary circuit. Essentially a heat exchanger like a motor car radiator.* Reactors have up to six 'loops', each with a steam generator. Since 1980 over 110 PWR reactors have had their steam generators replaced after 20-30 years service, 57 of these in USA.

Containment. The structure around the reactor and associated steam generators which is designed to protect it from outside intrusion and to protect those outside from the effects of radiation in case of any serious malfunction inside. It is typically a meter-thick concrete and steel structure.

Newer Russian and some other reactors install core melt localization devices or 'core catchers' under the pressure vessel to catch any melted core material in the event of a major accident.

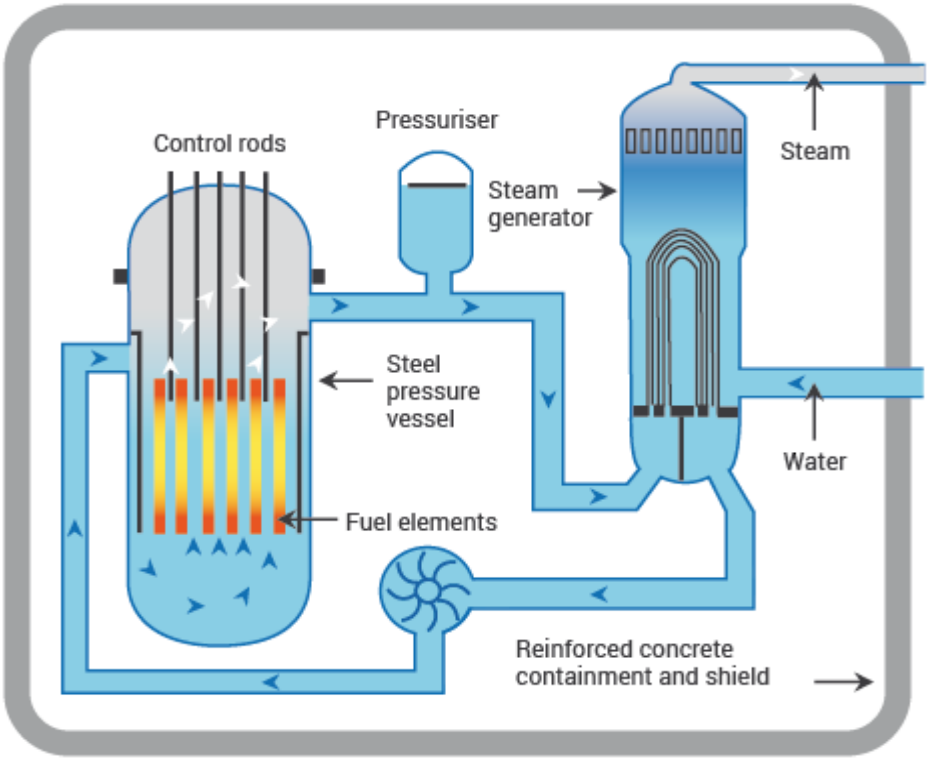
Working:

A PWR has fuel assemblies of 200-300 rods each, arranged vertically in the core, and a large reactor would have about 150-250 fuel assemblies with 80-100 tons of uranium.

Water in the reactor core reaches about 325°C, hence it must be kept under about 150 times atmospheric pressure to prevent it boiling. Pressure is maintained by steam in a pressuriser (see

diagram). In the primary cooling circuit the water is also the moderator, and if any of it turned to steam the fission reaction would slow down. This negative feedback effect is one of the safety features of the type. The secondary shutdown system involves adding boron to the primary circuit.

The secondary circuit is under less pressure and the water here boils in the heat exchangers which are thus steam generators. The steam drives the turbine to produce electricity, and is then condensed and returned to the heat exchangers in contact with the primary circuit.



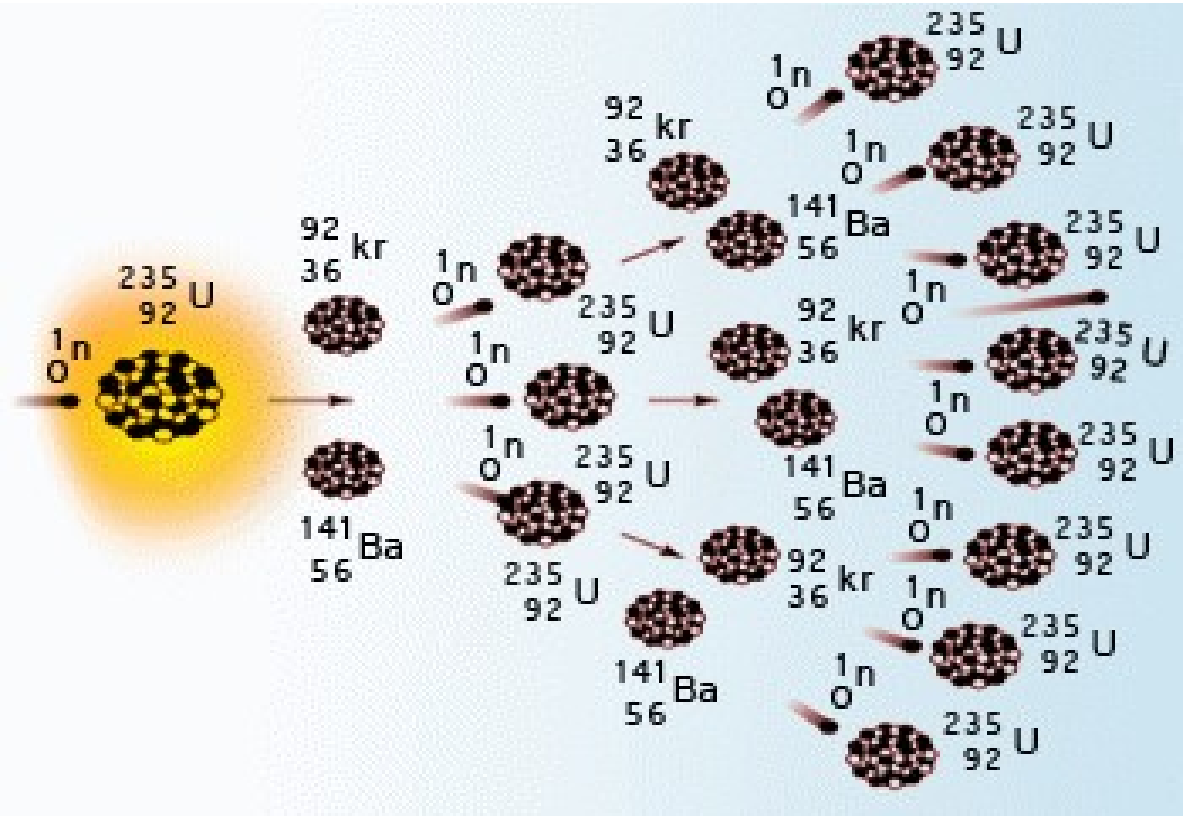
PWR

Nuclear Chain Reaction:

the fission process may produce **2, 3 or more <u>free neutrons</u>** that are capable of inducing **further fissions** and so on. This sequence of fission events is known as the **fission chain reaction**

Fission chain reactions occur because of interactions between neutrons and fissile isotopes (such as ^{235}U). The chain reaction requires both the release of neutrons from fissile isotopes undergoing nuclear fission and the subsequent absorption of some of these neutrons in fissile isotopes. When an atom undergoes nuclear fission, a few neutrons (the exact number depends on several factors) are ejected from the reaction. These free neutrons will then interact with the surrounding medium, and if more fissile fuel is present, some may be absorbed and cause more fissions. Thus, the cycle repeats to give a reaction that is self-sustaining.

Illustration:



A **critical mass** is the smallest amount of fissile material needed for a sustained nuclear chain reaction.

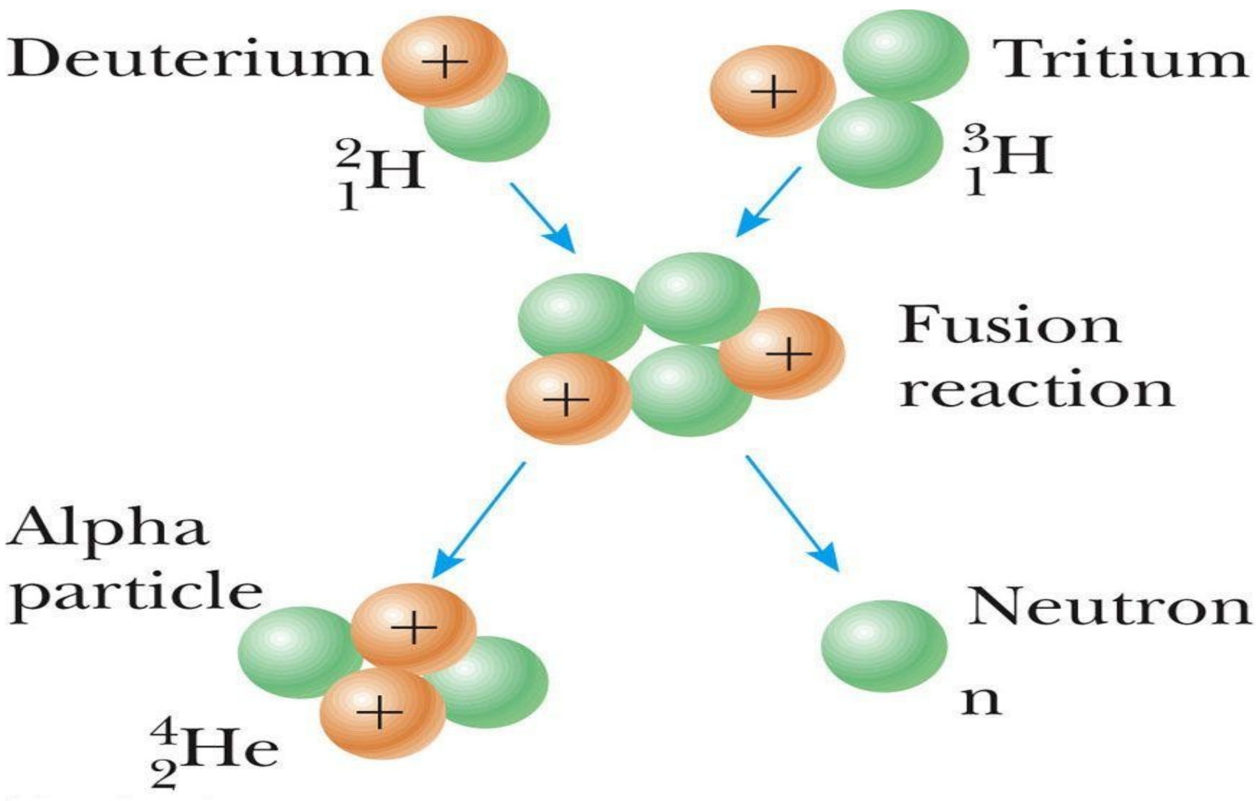
A *subcritical* mass is a mass of fissile material that does not have the ability to sustain a fission chain reaction

A *supercritical* mass is one in which, once fission has started, it will proceed at an increasing rate.

Nuclear fusion:

Nuclear fusion is a nuclear reaction in which two or more atomic nuclei collide at a very high energy and fuse together into a new nucleus, e.g. helium.

$$_{1}H^{2} + {}_{1}H^{2} \rightarrow {}_{2}He^{4} + \text{energy}$$



Breeder reactor:

Breeder reactor, nuclear reactor that produces more fissionable material than it consumes to generate energy. This special type of reactor is designed to extend the nuclear fuel supply for electric power generation. Whereas a conventional nuclear reactor (*q.v.*) can use only the readily fissionable but scarce isotope uranium-235 for fuel, a breeder reactor employs either uranium-238 or thorium,.

The first experimental breeder reactor, designated EBR-1, was developed in 1951 by U.S. scientists at the National Reactor Testing Station (now called Idaho National Engineering Laboratory), near Idaho Falls, Ida. France, Great Britain, Japan, and the Soviet Union subsequently built experimental breeders. As yet, however, no nation has developed a breeder suitable for high-capacity commercial use.

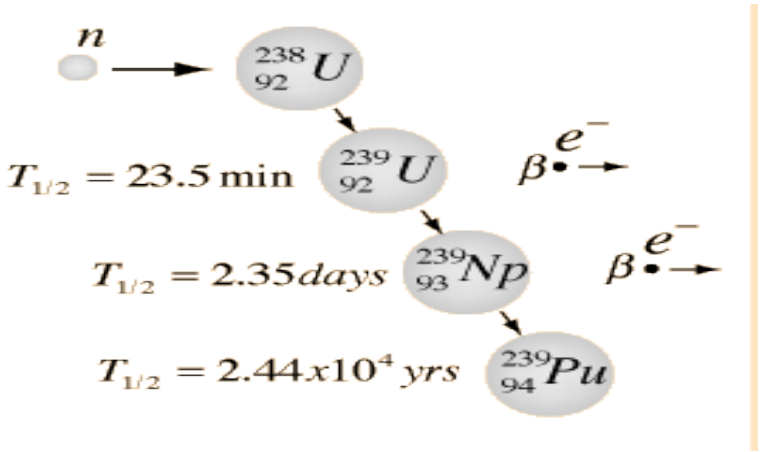
The most promising type of breeder, the liquid-metal fast breeder reactor, converts uranium-238 into the fissionable isotope plutonium-239 by means of artificial radioactive decay. The plutonium-239 is then bombarded with high-speed neutrons. When a plutonium nucleus absorbs one such free neutron, it splits into two fission fragments. This fissioning releases heat as well as neutrons, which in turn split other plutonium nuclei, freeing still more neutrons. As this process is repeated again and again, it becomes a self-sustaining chain reaction, yielding a steady source of energy, chiefly in the form of heat, which is transported from the reactor core by a liquid sodium coolant to a system of heat exchangers. This system utilizes the heat to produce steam for a turbine that drives an electric generator.

Another type of experimental breeder, the thermal breeder reactor, employs thorium-232 as its basic fuel, or fertile material. It converts this isotope into fissionable uranium-233, which is capable of creating a chain reaction. In the thermal breeder, whose technology is much simpler than that of the liquid-metal fast breeder, ordinary water is employed as a coolant to remove the heat produced by the continuous series of fission reactions.

$$_{92}U^{238} + {}_{0}n^{1} \longrightarrow {}_{94}Pu^{239} + 2e^{-}$$

$$_{94}Pu^{239} + {}_{0}n^{1} \longrightarrow \text{fission products}$$

Illustration:



Significance of Breeder Reactor:

- The fissional nuclides such as $U^{235\text{ and }}$ Pu ^{239} are called fissile nuclides.
- The non-fissionable nuclides, such as U ^{238} and Th ^{232}, are called fertile nuclides which are converted into fissile nuclides
- As regeneration of fissile nuclides take place, its efficiency becomes more.

Differences between Nuclear Fission and Nuclear Fusion

Nuclear Fission	Nuclear Fusion
Fission is the splitting of a large atom into two or more smaller ones.	Fusion is the fusing of two or more lighter atoms into a larger one.
Fission reaction does not normally occur in nature.	Fusion occurs in stars, such as the sun.
Fission produces many highly radioactive particles.	Few radioactive particles are produced by fusion reaction, but if a fission "trigger" is used, radioactive particles will result from that.
Critical mass of the substance and high-speed neutrons are required.	High density, high temperature environment is required.
Takes little energy to split two atoms in a fission reaction.	Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion.
The energy released by fission is a million times greater than that released in chemical reactions, but lower than the energy released by nuclear fusion.	The energy released by fusion is three to four times greater than the energy released by fission.
One class of nuclear weapon is a fission bomb,	One class of nuclear weapon is the hydrogen

also known as an atomic bomb or atom bomb.	bomb, which uses a fission reaction to "trigger" a fusion reaction.
Fission is used in nuclear power plants.	Fusion is an experimental technology for producing power.
Uranium is the primary fuel used in power plants.	Hydrogen isotopes (Deuterium and Tritium) are the primary fuel used in experimental fusion power plants.

SOLAR ENERGY:

Solar energy is that produced by the Sun's light – photovoltaic energy – and its warmth – **solar** thermal – for the generation of electricity or the production of heat. Inexhaustible and renewable since it comes from the Sun, solar energy is harnessed using panels and mirrors. Photovoltaic solar cells convert sunlight directly into electricity by the so-called photovoltaic effect, by which certain materials are able to absorb photons (light particles) and liberate electrons, generating an electric current. On the other hand, solar thermal collectors use panels or mirrors to absorb and concentrate the Sun's heat, transferring it to a fluid and conducting it through pipes to use it in buildings and installations, and also for electricity production (solar thermo electric).

THE BENEFITS OF SOLAR ENERGY

- Renewable
- Inexhaustible
- Non-polluting
- Avoids global warming
- Reduces use of fossil fuels

- Reduces energy imports
- Generates local wealth and jobs
- Contributes to sustainable development
- It is modular and very versatile, adaptable to different situations
- Can be applied alike for large-scale electricity generation and on a small scale in areas isolated from the network

Methods of Conversion:

1. It provides **heat** tapped by mirrors that focus sunlight on a receiver that contains a fluid which reaches temperatures up to 1,000 ° C. The heat transforms the fluid in steam which moves a turbine and finally produces electricity.
2. It provides **light** that is converted into electricity through photovoltaic solar panels. Photovoltaic panels are formed by groups of cells or solar cells that convert light (photons) into electrical energy (electrons).

Solar Water heater:

Solar water heating system is a device that uses solar energy to heat water for domestic, commercial, and industrial needs. Heating of water is the most common application of solar energy in the world. A typical solar water heating system can save up to 1500 units of electricity every year, for every 100 litres per day of solar water heating capacity.

Parts of the Solar Water Heating System

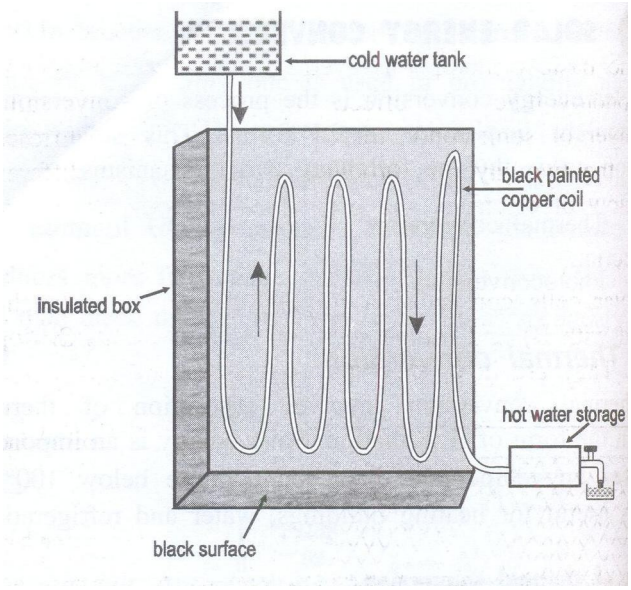
1. A solar water heating system consists of a flat plate solar collector, a storage tank kept at a height behind the collector, and connecting pipes.
2. The collector usually comprises copper tubes welded to copper sheets (both coated with a highly absorbing black coating) with a toughened glass sheet on top and insulating material at the back. The entire assembly is placed in a flat box.
3. In certain models, evacuated glass tubes are used instead of copper; a separate cover sheet and insulating box are not required in this case.

Working of a solar water heater

1. The system is generally installed on the roof or open ground, with the collector facing the sun and connected to a continuous water supply.
2. Water flows through the tubes, absorbs solar heat and becomes hot.
3. The heated water is stored in a tank for further use.
4. The water stored in the tank remains hot overnight as the storage tank is insulated and heat losses are small.

Uses of solar water heater

1.SWHs can be used at homes for producing hot water that can be used for bathing, cleaning, and washing. Solar water heaters (SWHs) of 100-300 litres capacity are suited for domestic application. Larger systems can also be used for a variety of industrial applications. Hot water at 60-80^{o}C could be obtained through use of solar water heaters.
2.Fuel Savings: A 100 litres capacity SWH can replace an electric geyser for residential use and saves 1500 units of electricity annually.
3. Saves cost on power generation - The use of 1000 SWHs of 100 litres capacity each can contribute to a peak load saving of 1 MW.
4. Environmental benefits - A SWH of 100 litres capacity can prevent emission of 1.5 tonnes of carbon-dioxide per year.
5. Pay back period - SWHs have a life span of 15-20 years. The pay back period is about 3-4 years when electricity is replaced, 4-5 years when furnace oil is replaced and 6-7 years when coal is replaced.



SOLAR CELL (or) PHOTOVOLTAIC CELL:

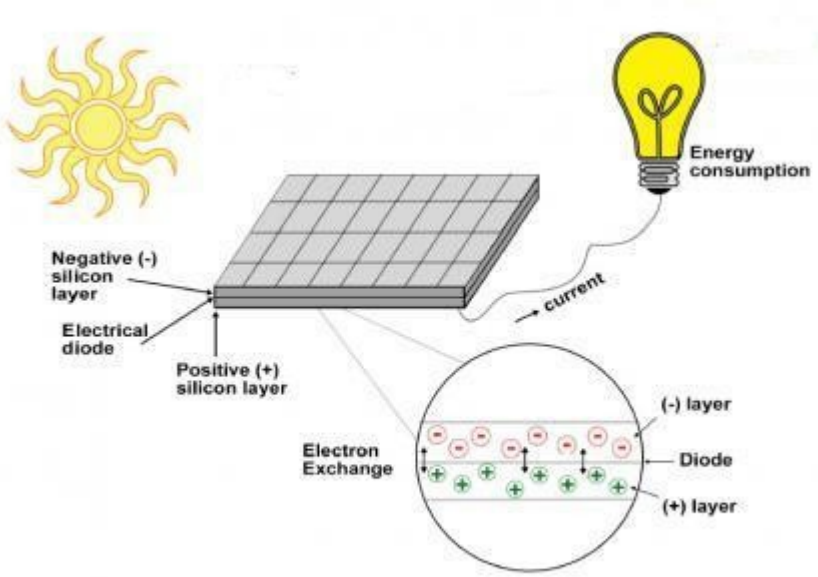
A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels.

The operation of a photovoltaic (PV) cell requires 3 basic attributes:

- The absorption of light, generating either electron-hole pairs or excitons.
- The separation of charge carriers of opposite types.
- The separate extraction of those carriers to an external circuit.

Construction-

It essentially consists of a silicon PN junction diode with a glass window on top surface layer of P material is made extremely thin so, that incident light photon’s may easily reach the PN junction.



Working of solar cell

1) Solar cell works under the principle of photovoltaic effect-when light is incident on 'P-N' junction a potential gets developed across the junction, this potential is capable of driving a current through the circuit.

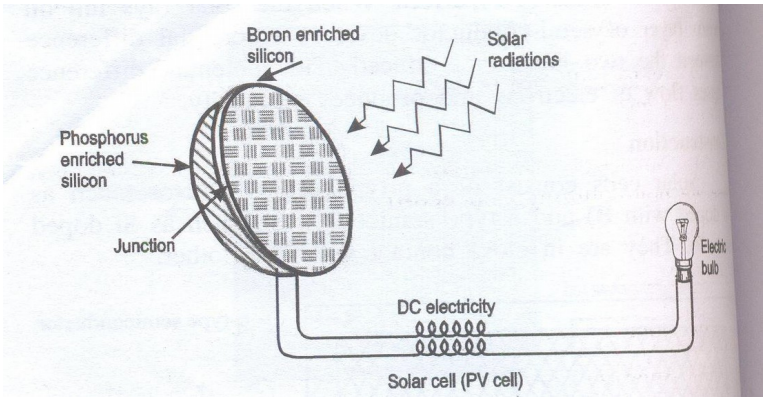
2) Hence light energy is getting converted to electrical energy.

3) Here electrons absorbs photons having energy greater than the band gap energy hence they can make transition from the valence band to the conduction band & hence contributes current.

4) The wavelength of light is given by the relation, $Eg=h=hc/\lambda=1.24Eg=h=hc/\lambda=1.24$

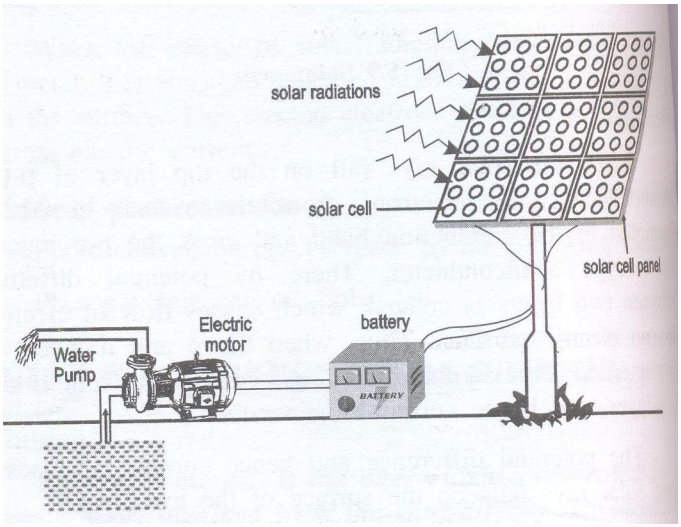
Application:

Lighting purpose



When the solar rays falls on the battery, direct current is produced, which is used to glow bulb.

Solar pump



WIND ENERGY:

Wind is a form of **solar energy**. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are

modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern **wind turbines**, can be used to generate **electricity**.

The terms "**wind energy**" or "**wind power**" describe the process by which the wind is used to generate **mechanical power or electricity**. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like.

Methods of conversion

Wind Turbines / Mill

Wind turbines, like aircraft propeller blades, turn in the moving air and power an **electric generator** that supplies an electric current. Simply stated, a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Wind Turbine Types

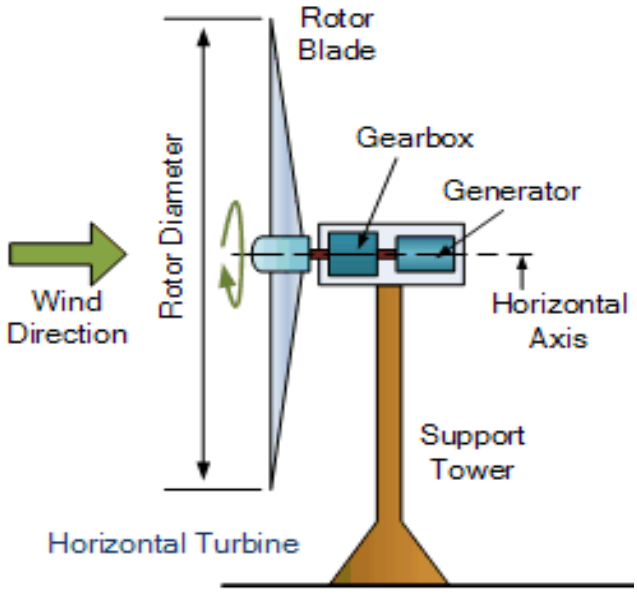
Modern wind turbines fall into two basic groups; the **horizontal-axis** variety, like the traditional farm windmills used for pumping water, and the **vertical-axis** design, like the eggbeater-style Darrieus model, named after its French inventor. Most large modern wind turbines are horizontal-axis turbines.

Turbine Components

Horizontal turbine components include:

- **blade** or **rotor**, which converts the energy in the wind to rotational shaft energy;
- a **drive train**, usually including a gearbox and a generator;
- a **tower** that supports the rotor and drive train; and

- other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment.



Advantages:

1. Wind energy is a clean and renewable technology that does not release pollutants, emissions or by-products into the atmosphere during operation since there are no chemical processes involved in its electrical generation.

2. Modern turbines produce very little mechanical noise when operating except for a low “whooshing” sound.

3. Wind energy, which is actually a secondary component of solar energy, is a “renewable energy” in the sense that there will always be wind as long as the sun continues to heat the earth unevenly, and the earth continues to rotate.

4.Although the strength of the wind varies from one day to another, the total output of energy over a set period of time, varies by only a small percentage as wind turbines are designed to operate within a wind speed window which is usually between 10mph and 60mph or 4m/s to 25m/s.

5. Although wind turbines and especially wind farms take up a lot of land space, the land on a wind farm can be used simultaneously for wind generation, crops growing, animal grazing or anything else below the vanes of the turbines.
6. Wind generation can be done in remote areas and on any scale from small personal and domestic use to large full size wind farms, which means that even remote mountainous places that might otherwise be regarded as “off grid” can generate power.

Disadvantages:

1.The environmental impact of wind energy as many people consider wind farms unsightly and as man-made structures, the turbines may have a negative visual impact or be viewed as a form of visual pollution.
2.Wind farms require large areas of land or have to be placed in environmentally sensitive areas such as deserts, on top of hills and mountain ridges or offshore in the sea were the winds force is stronger and constant.
3. The wind turbine is like a giant propeller and as such needs the kinetic power of the wind to rotate it meaning that at low wind speeds or prolonged levels of no wind (calm weather), the turbine does not generate any useful electricity.
4. Wind farms injure, kill and disturb the flight patterns of migratory birds and predatory birds. Some birds and even bats have been killed by flying into the wind turbine blades when rotating, but these numbers are very small.
5. Wind turbines cause noise pollution because they produce a low frequency “whooshing sound” as the blades rotate which itself is largely masked by the noise of the driving wind.
6. The initial investment in the turbines, transportation and ground works makes wind energy costs higher than for conventional fossil-fuel generators.
7. The best locations for converting wind into electricity are far away from populated urban areas, which often mean that the electricity must be stored and/or transported over long cable distances.
8. Although annual winds and power output from a wind turbine are relatively predictable, hourly and daily wind energy output levels are not as wind speed does not remain constant giving little power output in low winds.

Wind Farms

Multiple wind turbines that are arranged together in clusters to capture large amounts of wind energy at the same time and convert it into electrical power feeding this power into the electrical grid are known as **Wind Farms**. These wind farms can be located on flat land, mountain tops or offshore in the sea.

STORAGE DEVICE-BATTERY

Battery:

Batteries are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. All batteries are made up of three basic components: an anode (the '-' side), a cathode (the '+' side), and some kind of electrolyte (a substance that chemically reacts with the anode and cathode).

When the anode and cathode of a battery is connected to a circuit, a chemical reaction takes place between the anode and the electrolyte. This reaction causes electrons to flow through the circuit and back into the cathode where another chemical reaction takes place. When the material in the cathode or anode is consumed or no longer able to be used in the reaction, the battery is unable to produce electricity. At that point, your battery is "dead."

Batteries that must be thrown away after use are known as **primary batteries**. Batteries that can be recharged are called **secondary batteries**.

Working of Battery:

A battery is a device, which consists of a various voltaic cells. Each voltaic cell consists of two half cells connected in series by a conductive electrolyte holding anions and cat ions. One half-cell includes electrolyte and the electrode to which anions move, i.e. the anode or negative electrode; the other half-cell includes electrolyte and the electrode to which cat ions move, i.e. the cathode or positive electrode.

In the redox reaction that powers the battery, reduction occurs to cations at the cathode, while oxidation occurs to anions at the anode. The electrodes do not touch one another but are electrically connected by the electrolyte. Mostly the half cells have different electrolytes. All things considered every half-cell is enclosed in a container and a separator that is porous to ions but not the bulk of the electrolytes prevent mixing.

Each half cell has an electromotive force (Emf), determined by its capacity to drive electric current from the interior to the exterior of the cell. The net emf of the cell is the difference between the emf of its half-cells. In this way, if the electrodes have emf and in other words, the net emf is the difference between the reduction potentials of the half-reactions.

1) Primary Batteries:

As the name indicates these batteries are meant for single usage. Once these batteries are used they cannot be recharged as the devices are not easily reversible and active materials may not return to their original forms. Battery manufacturers recommend against recharge of primary cells.

Some of the examples for the disposable batteries are the normal AA, AAA batteries which we use in wall clocks, television remote etc. Other name for these batteries is disposable batteries.

2) Secondary Batteries:

Secondary batteries are also called as rechargeable batteries. These batteries can be used and recharges simultaneously. They are usually assembled with active materials with active in the discharged state. Rechargeable batteries are recharged by applying electric current, which reverses the chemical reactions that occur during discharge. Chargers are devices which supply the required current.

Some examples for these rechargeable batteries are the batteries used in mobile phones, MP3 players etc. Devices such as hearing aids and wristwatches use miniature cells and in places such as telephone exchanges or computer data centre’s, larger batteries are used.

Primary Batteries:

Dry Cell:

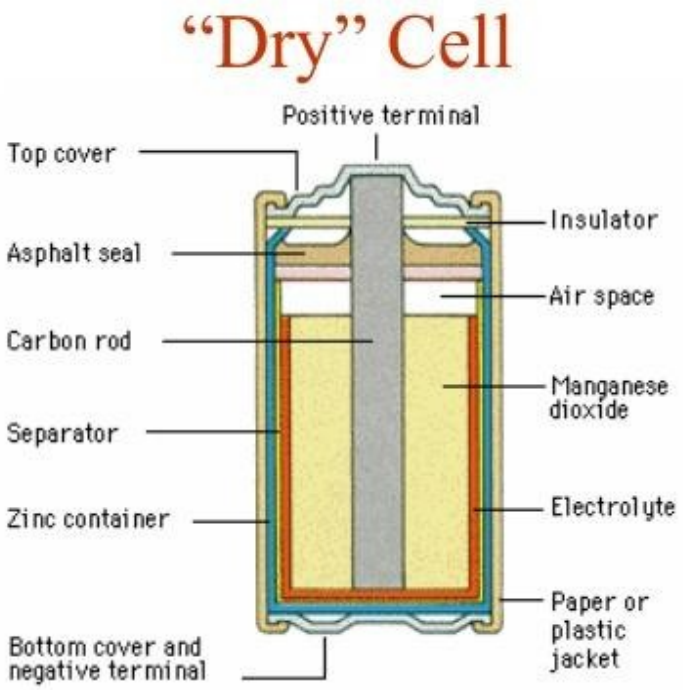
Dry Cell Battery

A dry-cell battery uses an immobilized electrolyte that minimizes moisture and allows for superior portability.

In electricity, a battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. The dry cell is one of many general types of electrochemical cells.

A dry cell has the electrolyte immobilized as a paste, with only enough moisture in it to allow current to flow. Unlike a wet cell, a dry cell can operate in any orientation without spilling, as it contains no free liquid. This versatility makes it suitable for portable equipment. By comparison, the first wet-cell batteries were typically fragile glass containers with lead rods hanging from an open top. They, therefore, needed careful handling to avoid spillage. The development of the dry-cell battery allowed for a major advance in battery safety and portability.

A common dry-cell battery is the zinc-carbon battery, which uses a cell that is sometimes called the Leclanché cell. The cell is made up of an outer zinc container, which acts as the anode. The cathode is a central carbon rod, surrounded by a mixture of carbon and manganese(IV) dioxide (MnO_2). The electrolyte is a paste of ammonium chloride (NH_4Cl). A fibrous fabric separates the two electrodes, and a brass pin in the center of the cell conducts electricity to the outside circuit.



Chemical reactions occur in every part of the battery to allow for energy storage; the reactions can be described using balanced chemical equations that delineate the electron flow. The paste of ammonium chloride reacts according to the following half-reaction:

$$2NH_4\,(aq) + 2e^- \rightarrow 2NH_3\,(g) + H_2\,(g)$$

The manganese (IV) oxide in the cell removes the hydrogen produced by the ammonium chloride, according to the following reaction:

$$2MnO_2(s) + H_2(g) \rightarrow Mn_2O_3(s) + H_2O(l)$$

The combined result of these two reactions takes place at the cathode. Adding these two reactions together, we get:

$$2NH_4(aq) + 2MnO_2(s) + 2e \rightarrow Mn_2O_3(s) + 2NH_3(g) + H_2O(l)$$

Finally, the anode half-reaction is as follows:

$$Zn(s) \rightarrow Zn^{2+} + 2e^-$$

Therefore, the overall equation for the cell is:

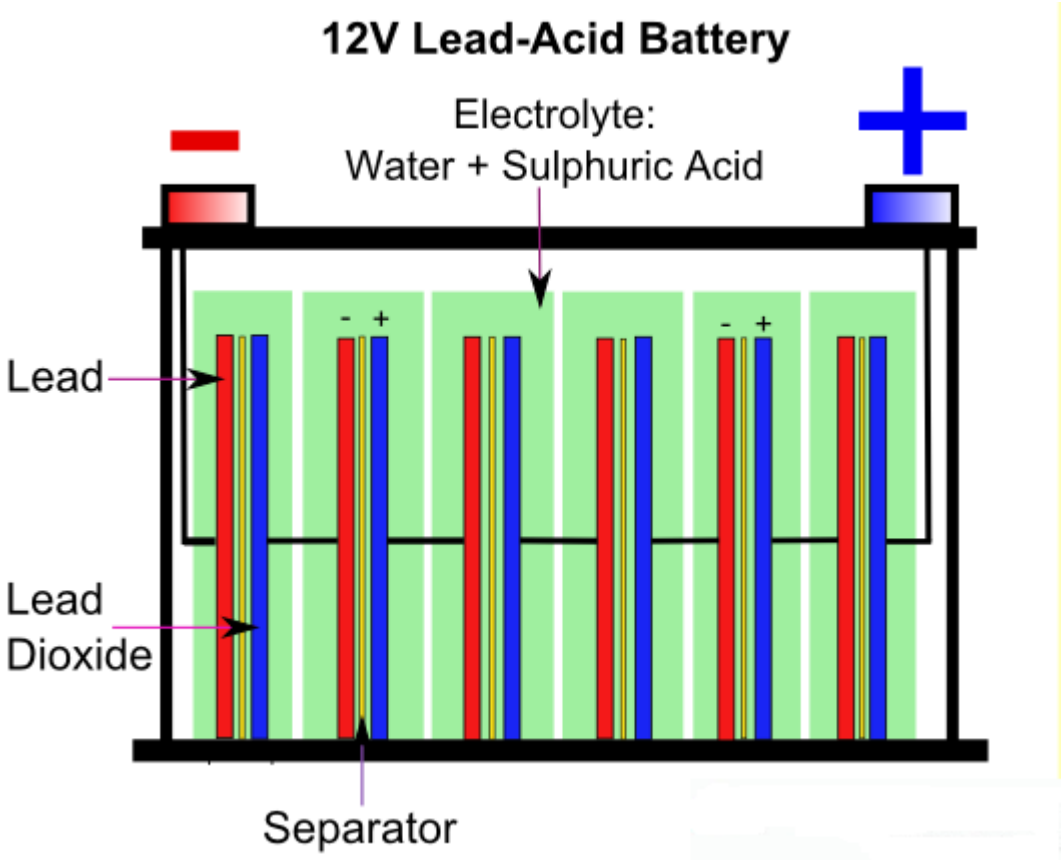
$$Zn(s) + 2MnO_2(s) + 2NH_4(aq) \rightarrow Mn_2O_3(s) + H_2O(l) + Zn^2 + 2NH_3(g)$$

The potential for the above reaction is 1.50 V.

Another example of a dry-cell battery is the alkaline battery. Alkaline batteries are almost the same as zinc-carbon batteries, except that the electrolyte used is potassium hydroxide (KOH) rather than ammonium chloride. In some more modern types of so-called “high-power” batteries that have a much lower capacity than standard alkaline batteries, the ammonium chloride is replaced by zinc chloride.

Lead Acid Battery:

Lead Acid batteries are widely used in automobiles, inverters, backup power systems etc. Unlike tubular and maintenance free batteries, Lead Acid batteries require proper care and maintenance to prolong its life. The Lead Acid battery consists of a series of plates kept immersed in sulphuric acid solution. The plates have grids on which the active material is attached. The plates are divided into positive and negative plates. The positive plates hold pure lead as the active material while lead oxide is attached on the negative plates.



A completely charged battery can discharge its current when connected to a load. During the process of discharge, the sulphuric acid combines with the active materials on the positive and negative plates resulting in the formation of Lead sulphate. Water is the single most important step in maintaining a Lead Acid battery. The frequency of water depends on usage, charge method and operating temperature. During process, the hydrogen atoms from the sulphuric acid react with oxygen to form water.

This results in the release of electrons from the positive plates which will be accepted by the negative plates. This leads to the formation of an electric potential across the battery. The electrolyte in the Lead Acid battery is a mixture of Sulphuric acid and water which has a specific gravity. Specific gravity is the weight of the acid-water mixture compared to equal volume of water. The specific gravity of pure ions free water is 1.

The lead-acid batteries provide the best value for power and energy per kilowatt-hour; have the longest life cycle and a large environmental advantage in that they are recycled at an extraordinarily high rate. No other chemistry can touch the infrastructure that exists for collecting, transporting and recycling lead-acid batteries.

CELL REACTION (discharging):

At anode (oxidation):

$$Pb + SO_4^{2-} \longleftrightarrow PbSO_4 + 2e^-$$

At cathode (reduction):

$$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \longleftrightarrow PbSO_4 + 2H_2O$$

OVERALL REACTION (DISCHARGING):

$$Pb + PbO_2 + 2H_2SO_4 \longleftrightarrow 2PbSO_4 + 2H_2O + ENERGY$$

OVERALL REACTION (CHARGING):

$$2PbSO_4 + 2H_2O \longleftrightarrow Pb + PbO_2 + 2H_2SO_4$$

Advantages:

1. It is available in all shapes and sizes.
2. It does not require any maintenance.
3. It is best in terms of reliability and working capabilities.

4. It withstands slow, fast and overcharging.
5. It is capable to withstand long term inactivity with or without solvent.
6. It offers best value for power and energy per KWH.
7. It offers longest life cycle.
8. About 97% of lead can be recycled and reused in new batteries.
9. It is inexpensive and simple to manufacture; low cost per watt-hour
10. It offers low self discharge, which is lowest among rechargeable batteries.
11. It offers good performance at low and high temperature.

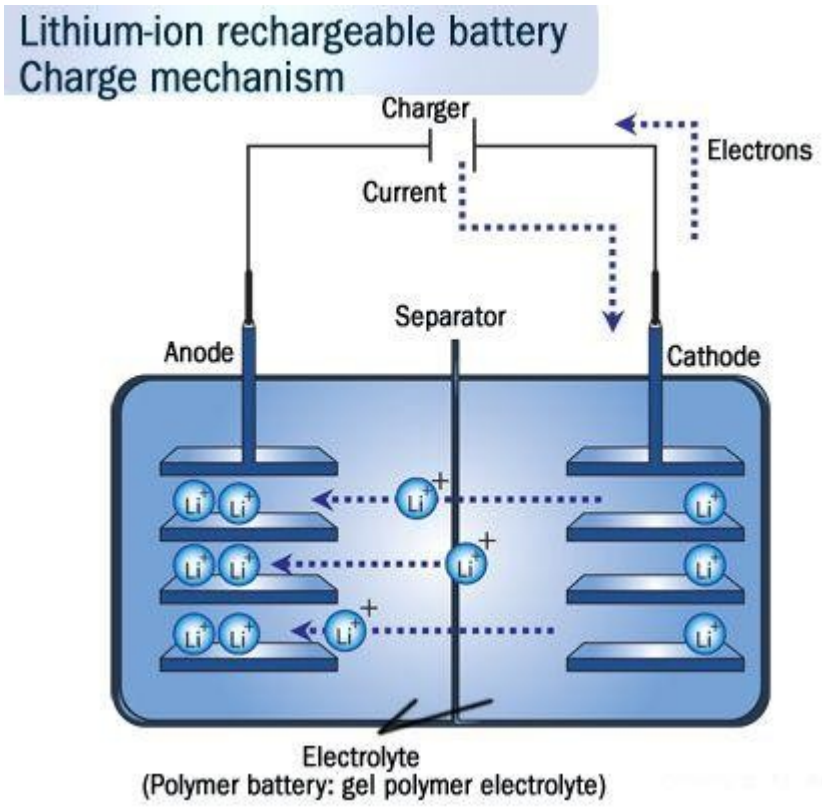
Disadvantages:

1. Lead is heavier compare to alternative elements.
2. It has low specific energy, poor weight to energy ratio.
3. It can be charged slowly i.e. fully saturated charge takes 14 to 16 hours.
4. It must be stored in charged condition in order to prevent sulfation.
5. It has limited cycle life. Moreover repeated deep cycling reduces battery life.
6. Flooded version of battery requires watering.
7. It is not environmentally friendly.
8. There are transportation restrictions on flooded type.

Lithium – Ion Battery:

Lithium –Ion batteries are now popular in majority of electronic portable devices like Mobile phone, Laptop, Digital Camera, etc due to their long lasting power efficiency. These are the most popular rechargeable batteries with advantages like best energy density, negligible charge loss and no memory effect. Li-Ion battery uses Lithium ions as the charge carriers which move from the negative electrode to the positive electrode during discharge and back when charging. During charging, the external current from the charger applies an over voltage than that in the battery. This forces the current to pass in the reverse direction from the positive to the negative electrode where the lithium ions get embedded in the porous electrode material through a process called Intercalation. The Li- Ions pass through the non aqueous electrolyte and a separator diaphragm. The electrode material is intercalated lithium compound.

The negative electrode of the Li-Ion battery is made up of carbon and the positive electrode is a metal oxide. The most commonly used material in the negative electrode is Graphite while that in the positive electrode may be Lithium cobalt oxide, Lithium ion phosphate or Lithium manganese oxide. Lithium salt in an organic solvent is used as the electrolyte. The electrolyte is typically a mixture of organic carbonates like Ethylene carbonate or Diethyl carbonate containing lithium ions. The electrolyte uses anion salts like Lithium hexa fluoro phosphate, Lithium hexa fluoro arsenate monohydrate, Lithium per chlorate, Lithium hexa fluoro borate etc. Depending upon the salt used, the voltage, capacity and life of the battery varies. Pure lithium reacts with water vigorously to form lithium hydroxide and hydrogen ions. So the electrolyte used is non aqueous organic solvent. The electrochemical role of the electrodes charge between anode and cathode depends on the direction of current flow.



In the Li-Ion battery, both the electrodes can accept and release lithium ions. During the Intercalation process, the lithium ions move into the electrode. During the reverse process called

de intercalation, the lithium ions move back. During discharging, the positive lithium ions will be extracted from the negative electrodes and inserted into the positive electrode. During the charging process, the reverse movement of lithium ions takes place.

Anode – lithium (Li)
Cathode – TiS_2
Electrolyte – Polymer
EMF of the cell – 3.0V

CELL REACTION (DISCHARGING):

At anode (oxidation):

$$Li \longleftrightarrow Li^+ + e^-$$

At cathode (reduction):

$$\mathbf{TiS_2 + e^- \longleftrightarrow TiS_2^-}$$

OVERALL REACTION (DISCHARGING):

$$\mathbf{Li + TiS_2 \rightarrow Li^+ + TiS_2^- \rightarrow LiTiS_2 + ENERGY}$$

OVERALL REACTION (CHARGING):

$$\mathbf{LiTiS_2 + ENERGY \longleftrightarrow Li + TiS_2^-}$$

Advantages:

1. Light weight compared to other batteries of similar size
2. Available in different shape including Flat shape
3. High open circuit voltage that increases the power transfer at low current
4. Lack of memory effect.

5. Very low self discharge rate of 5-10% per month. Self discharge is around 30% in NiCd and NiMh batteries.
6. Eco-friendly battery without any free lithium metal

Disadvantages:

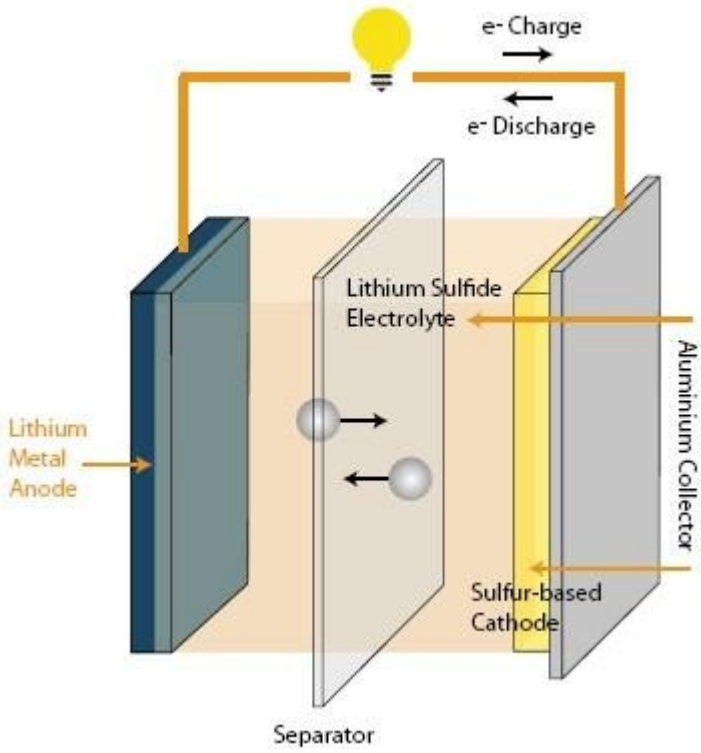
1. The deposits inside the electrolyte over time will inhibit the flow of charge. This increases the internal resistance of the battery and the cell's capacity to deliver current gradually decreases.
2. High charging and high temperature may leads to capacity loss
3. When overheated, Li-Ion battery may suffer thermal run away and cell rupture.
4. Deep discharge may short circuit the Li-Ion battery. So to prevent this, some makes have internal shut down circuitry that shut down the battery when its voltage is above the safe level of 3 to 4.2 volts. In this case, when the battery is not using for long time, the internal circuitry will consume power and drain the battery below its shut down voltage. So to charge such batteries normal chargers are not useful.

Li-Sulphur Battery:

At anode – Lithium

At cathode – Graphite

Electrolyte - β – alumina ($Na\ Al_{11}\ O_{17}$)



CELL REACTION (DISCHARGING):

At anode (oxidation):

$$2Li \longleftrightarrow 2Li^{+} + 2e^{-}$$

At cathode (reduction):

$$S + 2e^{-} \longleftrightarrow S^{2-}$$

OVERALL REACTION (DISCHARGING):

$$2Li + S \longleftrightarrow 2Li^{+} + S^{2-} \longrightarrow Li_2S + ENERGY$$

OVERALL REACTION (CHARGING):

$$Li_2S + ENERGY \longleftrightarrow 2Li^{+} + S^{2-}$$

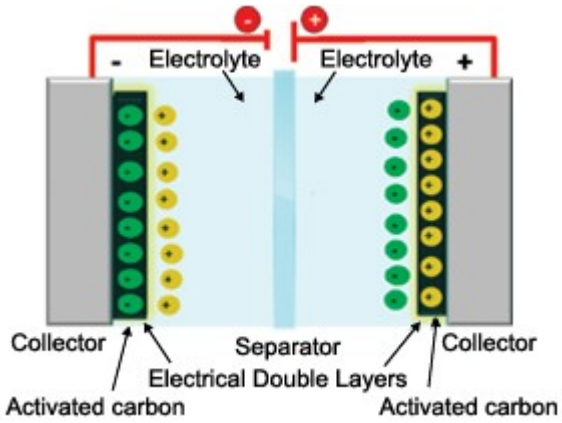
Super Capacitor:

Unlike a ceramic or electrolytic capacitor, a super capacitor (EDLC) does not have a dielectric. Instead, it uses the "electrical double layer" that is formed at the interface of the solid (electrode) and liquid (electrolyte).

Figure 1 is a representation of the structure of the super capacitor. A typical super capacitor is composed of electrodes and electrolytes (including electrolyte salt) and a separator (to prevent contact between the positive and negative electrodes). The electrodes are positioned on the electricity collectors and coated with activated carbon powder.

An electrical double layer is formed at each interface where the active carbon powder contacts the electrolyte. When you charge the super capacitor, the negative ions and vacancies on the positive electrode side and the positive ions and the electrons on the negative electrode side are arranged across the interface. This state of arrangement of ions and electrons (vacancies) is called an "electrical double layer."

Because this layer is formed by the physical movement of ions, there is no chemical reaction involved as there is with batteries. This gives the super capacitor a superior charge-discharge cycle life. The reason for using activated carbon on the electrode is to increase its surface area. Very fine pores on the activated carbon surface greatly increase the surface area of the electrode. Since the greater the surface area, the greater the charge that can be stored, the super capacitor is able to achieve very high capacitance.



Advantages:

1. Unlimited cycle life; as compared to the electrochemical battery, they are not subject to the wear or aging.

2. On-hand charge methods; no full-charge circuit required.

3. Quick charging times

4. Low impedance; by paralleling it with a battery, it enhances the pulse current.

5. Cost effective storage; a very high cycle count compensates the lower density.

Disadvantages:

1. Low energy density; usually holds 1/5-1/10 of a battery.

2. Cannot use the full energy spectrum for some applications.

3. Low voltage cells; to get higher voltages, serial connections are required.

4. Voltage balancing needed; when more than 3 supercapacitors are connected in series, the circuit needs a voltage balancing element.

5. High self-discharge as compared to electrochemical batteries

Flow battery or Fuel cell:

A fuel cell is a device that generates electrical power through a chemical reaction by converting a fuel (hydrogen) into electricity. Although fuel cells and batteries are both considered electrochemical cells and consist of similar structure, fuel cells require a continuous source of fuel and oxygen to run; similar to how an internal combustion engine needs a continuous flow of gasoline or diesel.

Ex. Hydrogen – oxygen fuel cell

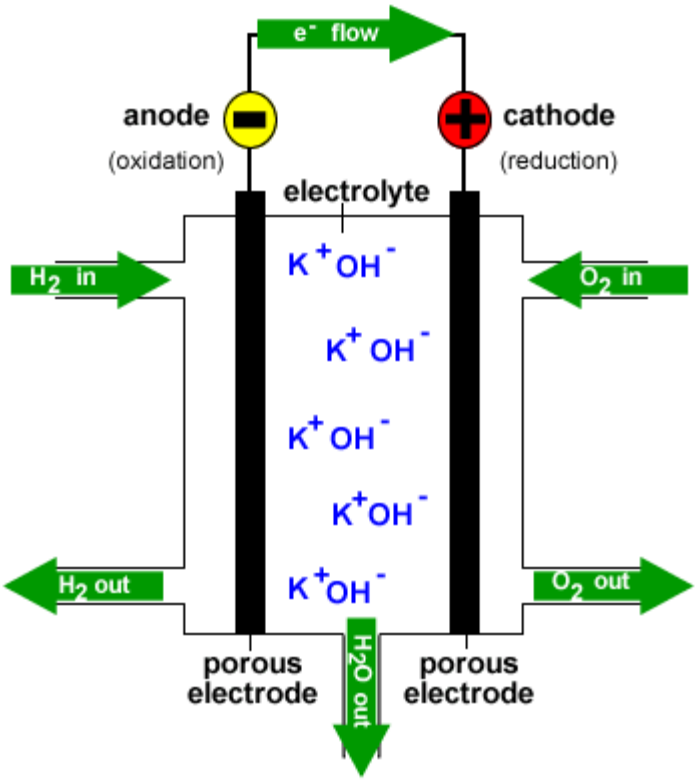
FUEL + OXIDISER ——— OXIDISED

Working

A fuel cell needs three main components to create the chemical reaction: an **anode**,**cathode** and an **electrolyte**. First, a hydrogen fuel is channeled to the anode via **flow fields**. Hydrogen atoms become ionized (stripped of its electrons), and now carry only a positive charge. Then, oxygen enters the fuel cell at the cathode, where it combines with electrons returning from the electrical circuit and the ionized hydrogen atoms. Next, after the oxygen atom picks up the electrons, it then travels through the electrolyte to combine with the hydrogen ion. The combination of oxygen and ionized hydrogen serve as the basis for the chemical reaction.

A polymer electrolyte membrane permits the appropriate ions to pass between the anode and the cathode. If the electrolyte gave free control for all electrons or ions to pass freely, it would disrupt the chemical reaction. At the end of the process the positively charged hydrogen atoms react with the oxygen to form both water and heat while creating electrical charge.

Within the fuel market there are many different applications with different power requirements. In order to provide adequate power, individual fuel cells can be assembled together forming a stack. A fuel cell stack can be sized for just the right amount of energy for the application.



CELL REACTION:

At anode (oxidation):

$$2H_2 + 4OH^- \longleftrightarrow 4H_2O + 4e^-$$

At cathode (reduction):

$$O_2 + 2H_2O + 4e^- \longleftrightarrow 4OH^-$$

OVERALL REACTION:

$$2H_2 + O_2 \longrightarrow 2H_2O + \text{ENERGY}$$

Uses:

1. Cars, trucks, buses, and recreational vehicles

2. Material handling equipment

3. Act as a primary power source for high-volume data centers or commercial, industrial, and residential buildings

4. Backup power source to critical computer and communications networks

5. Generating power on-site

Battery Type	Characteristics	Typical Uses	Advantages
Sealed Lead Acid (SLA) battery	Can hold a charge for up to 3 years	Backup emergency power source	Inexpensive
Nickel-	Fast, even energy discharge	Appliances, audio and video	Relatively

Cadmium (Ni-Cd) battery		equipment, toys; most popular batter	inexpensive; widely available
Nickel-Metal Hydride (Ni-MH) battery	Typical power capacity i1.2 V - 1200 to 1500 mAh; extended life 2300 mAh; 2.5 to 4 hours battery life	Portable computers; cellular phones; same as for Ni-Cd batteries	No memory effect; unused capacity remains usable
Lithium Ion (Li-Ion) battery	Stable and safe; highest energy capacity	Portable computers; cellular phones; same as for Ni-Cd batteries	Twice the charge capacity of Ni-Cd; slow self-discharge

1. Which of the following fuel material occurred naturally?

a. U^{235}

b. Pu^{239}

c. Pu^{241}

d. U^{-233}

(Ans: a)

2. The function of a moderator is to

a. Absorb the part of the Kinetic energy of the neutrons

b. Extract the heat

c. Reflect back some of the neutrons

d. Start the reactor

(Ans: a)

3. Which of the following is not used as moderator?

a. water

b. Heavy water

c. Graphite

d. Boron

(Ans: a)

4. The function of coolant is to

a. Extract heat from reactor

b. Slow down neutrons

c. Control the reaction

d. Reflect the neutrons

(Ans: a)

5. Which of the following has highest moderating ratio?

a. D_2O

b. H_2O

c. Carbon

d. Helium

(Ans: a)

6. The reactor performs the following function as that of _____ in a steam power plant.

a. Furnace

b. Turbine

c. Electric generator

d. Boiler

(Ans: a)

7. In pressurized water reactor

a. Light water is used as coolant

b. Light water is used as coolant and moderator

c. Heavy water is used as coolant

d. Heavy water is used as coolant and moderator

(Ans: b)

8.. The current density of a photo voltaic cell ranges from

a. 10 – 20 mA/cm^2

b. 40 – 50 mA/cm^2

c. 20 – 40 mA/cm^2

d. 60 – 100 mA/cm^2

(Ans: b)

9. A module in a solar panel refers to

a. Series arrangement of solar cells.

b. Parallel arrangement of solar cells.

c. Series and parallel arrangement of solar cells.

d. None of the above.

(Ans: c)

10. For satellites the source of energy is

a. Solar cell

b. Fuel cells

c. Edison cells

d. Cryogenic storage

(Ans: a)

11. Wind energy is harnessed as _____ energy with the help of windmill or turbine.

a. Mechanical

b. Solar

c. Electrical

d. Heat

(Ans: a)

12. Winds having following speed are suitable to operate wind turbines.

a.5 – 25m/s

b.10 – 35m/s

c.20 – 45m/s

d.30 – 55m/s

(Ans: a)

13. The following is (are) the classification of winds

a. Global wind

b. Local wind

c. Both (A) and (B)

d. None of the above

(Ans: c)

14. The wind intensity can be described by

a. Reynolds number

b. Mach number

c. Beaufort number

d. Froude number

(Ans: c)

15. When a lead acid battery is in fully charge condition, the color of its positive plate is

a. Brown.

b. Dark grey.

c. Dark brown.

d. None of it

(Ans: c)

16. The capacity of a battery is expressed in term of

a. Ampere.

b. Volt-hour.

c. Ampere-hour.

d. Volt-amp-hour.

(Ans: c)

17. Which of the following cell has the highest voltage?

a. Mercury.

b. Lithium.

c. Carbon-Zinc.

d. Manganese-Alkaline.

(Ans: b)

18. Lithium cells operates ranging from

a. -25 ° C to 25 ° C

b. -50 ° C to 25 ° C

c. -50 ° C to 75 ° C

d. -75 ° C to 75 ° C

(Ans: c)

19. The positive plates of nickel iron cell is made up of

a. Nickel hydroxide

b. Lead peroxide

c. Ferrous hydroxide

d. Potassium hydroxide

(Ans: a)

20. In lead acid accumulators, the container is filled with distilled water and concentrated sulphuric acid in the ratio of

a. 1 : 2

b. 2 : 1

c. 3 : 1

d. 1 : 3

(**Ans: c)**

21. The emf of the dry cell is about

a. 0 V

b. 0.5 V

c. 1 V

d. 1.5 V

(**Ans: d)**

22. In leclanche cell, anode is packed in a porous pot containing

a. Manganese dioxide

b. Charcoal powder

c. Sulphur dioxide

d. Only (a) and (b)

(**Ans: d)**

23. In Daniel cell,

a. Layer of hydrogen bubbles is formed

b. Polarization takes place

c. Negative pole is a copper vessel

d. None of these

(**Ans: d)**

24. In voltaic cell, anode and cathode of the cell is

a. Copper electrode, zinc

b. Zinc, copper

c. Aluminium, zinc

d. Nickel, cobalt

(**Ans: a)**

25. In cell, the current flows in outer circuit from

a. Positive terminal to negative terminal and electrons from negative terminal to positive terminal

b. Positive terminal to negative terminal and electrons from positive terminal to negative terminal

c. Negative terminal to positive terminal and electrons from negative terminal to positive terminal

d. Negative terminal to positive terminal and electrons from positive terminal to negative terminal

(**Ans: a)**

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Web links:

http://www.bring-knowledge-to-the-wor..
This animation explains nuclear power plants in detail and how they work

https://youtu.be/ZYO83TkM0To
very basic working principle of a solar cell

https://www.patreon.com/LearnEngineering
very basic working principle of a wind turbine

https://youtu.be/HhxtfULIO7c
Working Principle of Lead Acid Battery

https://youtu.be/vYlH3fJj_vQ
Working Principle of Dry cell Battery

https://youtu.be/WqOjyumEAsY
Working Principle of Li-ion Battery

https://youtu.be/FJZKm5khaAA
Working Principle of Super capacitor

https://youtu.be/bXHwnKMchkk
Working Principle of Super capacitor

NPTEL Links:

Nuclear Power Generation - nptel

nptel.ac.in/courses/108105058/12

Solar cells - nptel

nptel.ac.in/courses/113106065/26

Wind Energy - nptel

nptel.ac.in/courses/108105058/24

Power Supply - nptel

nptel.ac.in/courses/122104013/9

Batteries - nptel

nptel.ac.in/courses/108103009/32

Lithium Ion Battery (Contd.) - nptel

nptel.ac.in/courses/113105015/33

Capacitors - nptel

nptel.ac.in/courses/108106073/14

Fuel Cell - nptel

nptel.ac.in/courses/108103009/35