Unit - I

Environment and Biodiversity

1.1 INTRODUCTION

The word environment is derived from the French word "Environ" meaning "Surroundings". Each and everything around us is called as environment.

Every organisms is surrounded by materials and forces which constitute its environment, from which it must derive its needs. Environment creates favourable conditions for the existence and development of living organisms.

Example

Cow eats plants for its survival. The plant requires nourishment from the soil. Nourishment is provided by nitrogenous mater excreted by animal (or) by the dead bodies of other plants and animals.

Thus for the survival of an animal (or) a plant, (or) a microbe, it requires a supply of materials and removal of waste products from its environment.

The degradation of the environment has become a serious problem. The pollution of soil, water and air leads to loss of valuable natural resources.

1.2 DEFINITIONS

1. Environment

Environment is defined as, "***the sum of total of all the living and non - living things around us influencing one another.***"

2. Environmental Science

Environmental science is the ***study of the environment, its biotic (ie., biological) and abiotic (ie., non biological) components and their interrelationship.***

3. Environmental Engineering

Environmental engineering is ***the application of engineering principles to the protection and enhancement of the quality of the environment and to the enhancement and protection of public health and welfare.***

4. Environmental Studies (or) Environmental Education

Environmental studies are ***the process of educating the people for preserving quality environment.***

1.3 TYPES OF ENVIRONMENT

Environment can be divided into two categories

1. Natural environment
2. Man - made environment

1. Natural environment

Natural environment is characterized by natural components. All biotic (living) and abiotic components (non-living) are created through a natural process. Creation of these biotic and abiotic components do not require any human support.

Examples *Soil, water, air, trees, radiations, noise, etc.,*

2. Man - made environment

Man is the most powerful environmental agent. He modifies the environment using modern technologies, according to his needs to a great extent. Thus the man-made environment is created by man.

Examples *House, road, schools, railway lines, parks, etc.,*

1.4 COMPONENTS OF THE ENVIRONMENT

The environment consists of the following three important components.

1. Abiotic (or) Non-living components.
2. Biotic (or) Living components.
3. Energy components.

1.4.1 Abiotic (or) Non - Living Components (or) Physical Components

The non - living components of the environment are called abiotic components.

Example *Air, water, soil and minerals.*

These abiotic components enter the body of living organisms directly (or) indirectly, take part in metabolic activities and then return to the environment.

Abiotic components are sub divided into three categories

1. Atmosphere
2. Lithosphere
3. Hydrosphere

1. Atmosphere

The cover of air, that envelopes the earth is known as the atmosphere. The atmosphere extends upto 500 kms from the earth surface.

The atmosphere is essential for all living organisms. It comprises 78% of nitrogen, 21% of oxygen and 1% of other gases.

Structure of atmosphere

Atmosphere consists of following five concentric layers

(a) Troposphere (0 - 18 kms): It is the lower portion of the atmosphere and extends from 0 - 18 kms. It contains 75% of the atmospheric air mass. The temperature of troposphere changes from 15°C to 56°C and the chemical constituents are O_2, CO_2, N_2 and water (clouds).

(b) Stratosphere (18 - 50 kms): It lies above the troposphere and extends from 18 - 50 kms. The temperature of which changes from -2°C to -56°C and the main chemical constituent is ozone.

(c) Mesosphere (50 - 85 kms): It lies above the stratosphere and extends from 50 - 85 kms. The temperature of which drops to about -95°C. The main chemical constituents are N_2, O_2, O_2^+ and NO^+.

(d) Thermosphere (or) Ionosphere (85 - 500 kms): It lies above the mesosphere and extends upto 500 kms above the earth surface. The temperature of which raises upto 1200°C. It contains the charged particles like O_2^+, O^+, NO^+ etc.,

(e) Exosphere: It is the upper most layer of the atmosphere and extends upto 1600 km. The temperature of which is very high due to direct solar radiation. The chemical constituents are only H_2 and He.

Table 1.1 Regions with temperature change and chemical species of atmosphere

Region	Altitude in km	Temperature change in °C	Chemical species
1. Troposphere	0-18	15 to –56	N_2, H_2O, CO_2, O_2
2. Stratosphere	18-50	–56 to –2	Ozone
3. Mesosphere	50-85	–2 to –92	NO^+, O_2^+
4. Thermosphere	85-500	–92 to 1200	NO^+,O^+, O_2^+

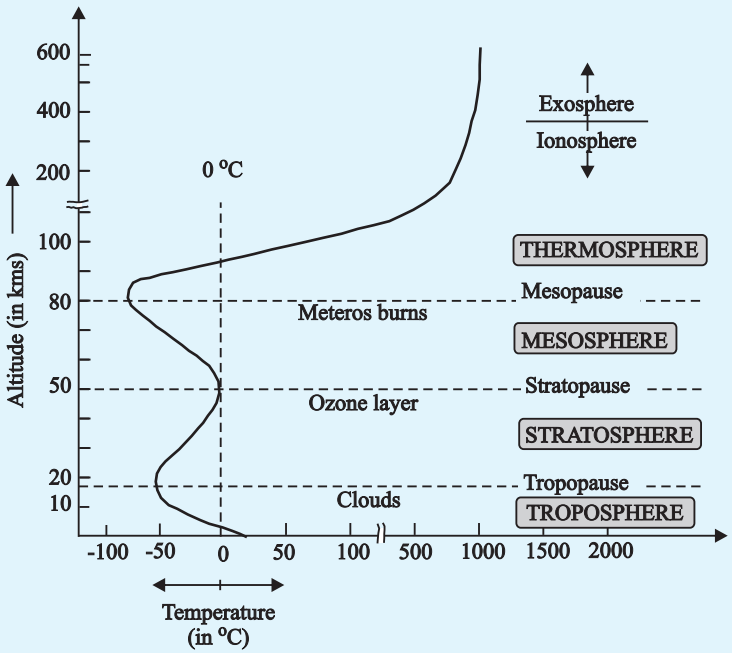


Fig. 1.1 Structure of atmosphere with temperature

Functions of atmosphere

1. It maintains the heat balance on the earth by absorbing the IR radiations.
2. The gaseous constituents play an important role in sustaining life on earth.

Gaseous Constituent	Functions
Oxygen	supports life of living organisms.
Carbon-dioxide	essential for photosynthetic activity of plants.
Nitrogen	essential nutrient for plant growth.

2. Lithosphere

The soil and rock components of the earth is called lithosphere.

Functions of lithosphere

1. It is a home for human beings and wildlife.
2. It is a storehouse of minerals and organic matters.

3. Hydrosphere

The aqueous envelope of the earth (ie., 75% of the earth surface) is called hydrosphere. Oceans, lakes, streams, rivers and water vapour constitute hydrosphere. About 97% of earth's water is in oceans, which is too salty and not fit for drinking. Only 3% is available as fresh water.

Functions of hydrosphere

1. It is used for drinking purpose and also supports the aquatic life.
2. It is also used for irrigation, power production, industries and transport.

1.4.2 Biotic (or) Living Components

The living components of the environment are called biotic components.

Examples *Animals, plants and micro organisms.*

Biosphere: The biological environment, where the living organisms live and interact with physical environment (soil, water and air) is called biosphere.

Functions of biosphere: Plants through photosynthesis produce oxygen in the atmosphere. Animals inhale oxygen during respiration and give out carbondioxide, which is again utilised by plants during photosynthesis.

1.4.3 Energy Components

The components of energy flows across biotic and abiotic components, which play an important role to maintain the life of living organisms.

Examples *Solar energy, nuclear energy, geochemical energy, thermo electrical energy.*

1.5 SCOPE OF ENVIRONMENTAL STUDIES

Environmental study is an important tool to educate the people for preserving quality environment. The main scope of environmental studies include

1. To get an awareness and sensitivity to the total environment and its related problems.
2. To motivate the active participation in environmental protection and improvement.
3. To develop skills for identifying and solving environmental problems.

4. To know the necessity of conservation of natural resources.
5. To evaluate environmental programmes interms of social, economic, ecological, and aesthetic factors.

1.6 IMPORTANCE (or) SIGNIFICANCE OF ENVIRONMENTAL STUDIES

The air we breathe, the water we drink, the food we consume and the land we live on are all contaminated by the industrial activities. There is no zero pollution industry. Because of the lack of self discipline and not worrying about our future generation, the valuable resources are polluted.

To solve the above problems, the knowledge of environmental studies is very important.

1. By environmental studies, people will understand the concept of "need of development without destruction of environment".
2. Through environmental studies, people can gain the knowledge of different types of environment and the effects of different environmental hazards.
3. Environmental studies inform the people about their effective role in protecting the environment by demanding changes in laws and enforcement systems.
4. Environmental studies have a direct relation to the quality of life we live.
5. Environmental studies develop a concern and respect for the environment.

1.7 NEED FOR PUBLIC AWARENESS

Increasing population, urbanisation and poverty have generated pressure on the natural resources and lead to a degradation of the environment. To protect (or) prevent the environment from the pollution, Supreme Court has ordered and initiated the environmental awareness to the public through Government and Non - government agencies to take part to protect our environment.

1.7.1 Importance of Public (or) Community participation

Environmental pollution cannot be removed by the laws alone. The proper implementation and especially public participation are the important aspects, which should be given importance and stress. The public participation is useful in law making process and controlling the pollution activities. Thus the public participation plays a major role in the effective environmental management.

1.7.2 Types of Public Participation

Public participation in the decision making process can be at any stage and of various forms.

1. Pressure Group: The public "Pressure group" may be formed to influence the government on one hand and the industries on the other hand.

2. Watch dog: The public can act as "watch dog" to protect the interests of public against environmental hazardous activities.

3. Advisory council: The public can also act as advisory council and agencies, which is constituted to keep the environment suitable for living.

4. Enforcing the environmental laws: The services of public can be utilized to enforce the environmental laws. If necessary the member of public should conduct public interest litigations.

Thus many countries have accepted the concept of public participation in environmental management.

1.8 ECOLOGY

All living organisms, whether plant (or) animal (or) human being is surrounded by the environment, from which it derive its needs for its survival. Each living component interacts with non-living components for their basic requirements form different ecosystem.

Definition

Ecology is the study of interactions among organisms (or) group of organisms with their environment. The environment consists of both biotic components (living organisms) and abiotic components (non-living organisms).

(or)

Ecology is the study of ecosystems.

1.9 ECOSYSTEM

Ecosystem is the basic functional unit of ecology. The term ecosystem is coined from a Greek word meaning study of home.

Definition

A group of organisms interacting among themselves and with environment is known as ecosystem. Thus, an ecosystem is a community of different species interacting

with one another and with their non-living environment exchanging energy and matter.

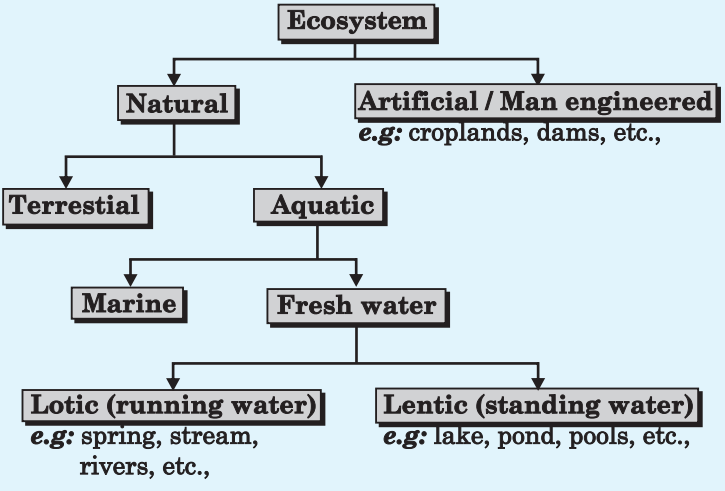
Examples *Animals cannot synthesis their food directly but depend on the plants either directly (or) indirectly.*

1.9.1 Biome (Small Ecosystem)

The kind of organisms which can live in a particular ecosystem depends on their physical and metabolic adoptions to the environment of that place. On earth ***there are many sets of ecosystems which are exposed to same climatic conditions and having dominant species with similar life cycle, climatic adoptions and physical structure. This set of ecosystem is called a biome***.

Thus the biome is a small ecosystem with in an ecosystem.

1.10 TYPES OF ECOSYSTEM



1.10.1 Natural ecosystem

Natural ecosystems operate themselves under natural conditions. Based on habitat types, it can be further classified into three types.

1. Terrestrial ecosystem

This ecosystem is related to land and types of vegetation.

Examples *Grassland ecosystem, forest ecosystem, desert ecosystem, etc.,*

2. Aquatic ecosystem

This ecosystem is related to water, it is further sub classified into two types based on salt content.

(i) Fresh water ecosystem.

(a) Running water ecosystems.

Examples *Rivers, streams.*

(b) Standing water ecosystems.

Examples *Pond, lake.*

(ii) Marine ecosystem

Examples *Seas and sea shores.*

1.10.2 Man-made (or) Artificial ecosystems

Artificial ecosystem is operated (or) maintained by man himself.

Examples *Croplands, gardens.*

1.11 STRUCTURE (OR) COMPONENTS OF AN ECOSYSTEM

The term structure refers to the various components. So the structure of an ecosystem explains the relationship between the abiotic (non-living) and the biotic (living) components.

An ecosystem has two major components

1. Abiotic (non-living) components.
2. Biotic (living) components.

1.11.1 Abiotic (non-living) components

The non-living components (physical and chemical) of an ecosystem collectively form a community called abiotic components (or) abiotic community.

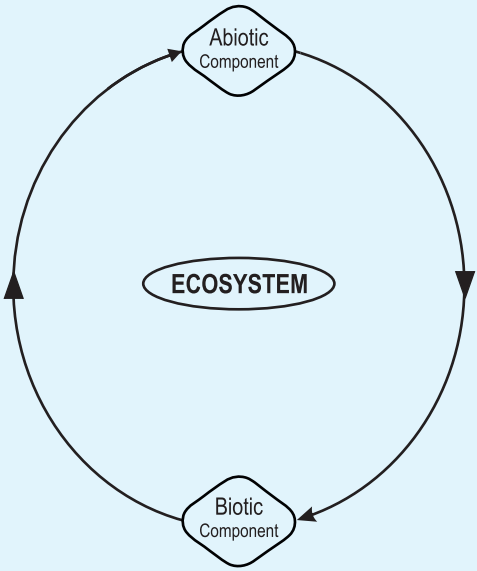


Fig. 1.2 Components of an ecosystems and their relationship

Examples *Climate, soil, water, air, energy, nutrients, etc.,*

1. Physical components: They include the energy, climate, raw materials and living space that the biological community needs. They are useful for the growth and maintenance of its member.

Examples Air, water, soil, sunlight, etc.,

2. Chemical Components: They are the sources of essential nutrients.

Examples

(i) Organic substances: *Protein, lipids, carbohydrates, etc.,*

(ii) Inorganic substances: *All micro (Al, Co, Zn, Cu) and macro elements (C, H, O, P, N, P, K) and few other elements.*

1.11.2 Biotic components

The living organisms (or) living members in an ecosystem collectively form its community called biotic components (or) biotic community.

The living components are made of many different species. These species are distinguished on the basis of their nutritional (feeding) relationship. It includes

1. Autotrophic components: ***The members of autotrophic components are producers***, which are autotrops (self-nourishing organisms). They derive energy from sunlight and make organic compounds from inorganic substances.

Examples Green plants, algae, bacteria, etc.,

2. Heterotrophic components: ***The members of heterotrophic components are consumers and decomposers,*** which are heterotrophs (dependent on others for food). They consume the autotrophs (producers). The heterotrophs are

(a) Macro consumers: They are herbivores, omnivores (or) carnivores.

(b) Saprotrophs (micro consumers): They are decomposers (bacteria, fungi, etc).

Members of biotic components of an ecosystem (or) Classification of biotic components

The members of biotic components of an ecosystem are grouped into three groups based on how do they get their food.

1. Producers (Plants).
2. Consumer (Animals).
3. Decomposers (Micro-organisms).

1. Producers (Autotrophs): Producers synthesize their food themselves through photosynthesis.

Examples *All green plants, trees.*

Photosynthesis

The green pigments called chlorophyll, present in the leaves of plants, converts CO_2 and H_2O in the presence of sunlight into carbohydrates.

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{h\nu} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

This process is called photosynthesis.

2. Consumers (heterotrophs): Consumers are organisms, which cannot prepare their own food and depend directly (or) indirectly on the producers.

They cannot make organic compounds, but can transform one form of organic compounds into other form of organic compounds.

Examples

(i) Plant eating species

Insects, rabbit, goat, deer, cow, etc.,

(ii) Animals eating species

Fish, lions, tiger, etc.,

Types of consumers

Consumers are of the following types.

(i) Primary consumers (Herbivores) (plant eaters)

Primary consumers are also called herbivores, they directly depend on the plants for their food. So they are called plant eaters.

Examples *Insects, rat, goat, deer, cow, horse, etc.,*

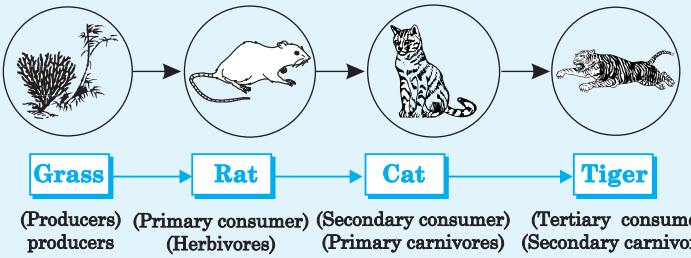
(ii) Secondary consumers (primary carnivores) (meat eaters)

Secondary consumers are primary carnivores, they feed on primary consumers. They directly depend on the herbivores for their food.

Examples *Frog, cat, snakes, foxes, etc..,*

(iii) Tertiary consumers (Secondary carnivores) (Meat eaters)

Tertiary consumers are secondary carnivores, they feed on secondary consumers. They directly depend on the primary carnivores for their food.



Examples *Tigers, lions, etc.,*

3. Decomposers: Decomposers are those organisms which feed on dead organisms plants and animals and decompose them into simpler compounds. During the decomposition inorganic nutrients are released. These inorganic nutrients together with other organic substances are then utilized by the producers for the synthesis of their own food.

Examples *Microorganisms like bacteria and fungi.*

Meanings

(i) Herbivores: Animals that eat only plants are called herbivores. (vegetarian)

(ii) Carnivores: Animals that eat other animals are called carnivores. (non-vegetarian)

(iii) Omnivores: Animals that eat both animals and plants. (Vegetarian and non-vegetarian)

1.12 FUNCTION OF AN ECOSYSTEM

To understand clearly the nature of ecosystem, its functioning should be thoroughly understood. The function of an ecosystem is to allow flow of energy and cycling of nutrients.

1.12.1 Types of Functions

Functions of an ecosystem are of three types.

1. Primary function (or) primary production

The primary function of all ecosystems is manufacture of starch (photosynthesis).

2. Secondary function (or) secondary production

The secondary function of all ecosystem is distributing energy in the form of food to all consumers (or) the energy stored by the consumer.

3. Tertiary Function

All living systems die at a particular stage. These dead systems are decomposed to initiate the third function of ecosystems namely "cycling".

The functioning of an ecosystem may be understood by studying the following terms.

(a) Energy and material flow.

(b) Food chains.

(c) Food webs.

(d) Food pyramids.

1.13 ENERGY FLOW IN THE ECOSYSTEMS

Energy is the most essential requirement for all living organisms. Solar energy is the only source to our planet earth. Solar energy is transformed to chemical energy in photosynthesis by the plants (called as primary producers). Though a lot of sunlight falls on the green plants, only 1% of it is utilized for photosynthesis. This is the most

essential step to provide energy for all other living organisms in the ecosystem.

Some amount of chemical energy is used by the plants for their growth and the remaining is transferred to consumers by the process of eating.

Thus the energy enters the ecosystem through photosynthesis and passes through the different tropic levels (feeding levels).

1.13.1 Energy flow through atmosphere to an ecosystem

Sun is the ultimate source of energy, its radiations travel through the space in the form of waves and reaches the earth's atmosphere. The atmosphere absorbs 50% of the radiations and allow the remainings to reach the earth surface. Of the solar radiations, reached the earth's surface, some of which is absorbed by organisms (primary producers) to produce organic matter through photosynthesis.

Photosynthetic equation

$$\underset{\text{carbon dioxide}}{CO_2} + \underset{\text{water}}{2H_2O} \xrightarrow{\text{sunlight}} \underset{\text{carbohydrate}}{CH_2O} + \underset{\text{oxygen}}{O_2} + \underset{\text{water}}{H_2O}$$

The plants (producers) are used by herbivores and herbivores are used by carnivores as their food. In this way energy is transfered from one organism to another and so on. The conversion of solar energy is governed by law of thermodynamics.

1. Ist law of thermodynamics

It states that, "energy can neither be created nor destroyed, but it can be converted from one form to another."

Illustration: Energy for an ecosystem comes from the sun. It is absorbed by plants, wherein it is converted into stored chemical energy.

i.e., Solar energy in converted into chemical energy.

Solar energy $\rightarrow$ Chemical energy (plants)

2. IInd law of thermodynamics

It states that, "whenever energy is transformed, there is a loss of energy through the release of heat."

Illustration: This occurs when energy is transferred between tropic levels. There will be a loss of energy (about 80-90%) in the form of heat as it moves from one tropic level to another tropic level. The loss of energy takes place through respiration, running, hunting etc.,

Respiration equation

$$\underset{\text{carbohydrate}}{CH_2O} + \underset{\text{oxygen}}{O_2} \longrightarrow \underset{\text{carbondioxide}}{CO_2} + \underset{\text{water}}{H_2O}$$

The net production of biomass is only about 0.5% of the total incident radiation (3000 k.cal/m^2/day) and 1.0% of energy absorbed and the remaining gets wasted.

1.13.2 Relationship between structure and function (flow model)

From the above it is clear that, the biotic components and abiotic components are linked together through energy flow and nutrient cycling as shown in the following figure 1.2

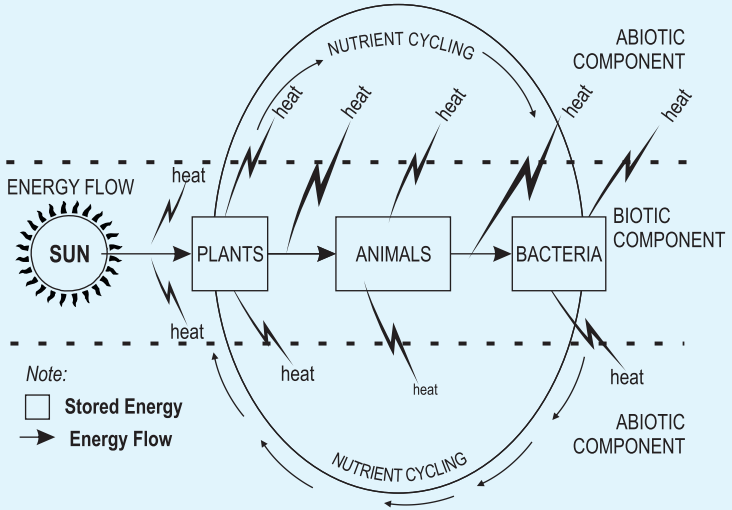


Fig.1.3 Flow of energy and nutrient cycling from abiotic to biotic and vice versa.

1.14 ECOLOGICAL SUCCESSION

In an area one community may be replaced by another community (or) by a series of communities. Thus ***the progressive replacement of one community by another till the development of stable community in a particular area is called*** **ecological succession.**

1.14.1 Stages of ecological succession

1. Pioneer community: The first group of organism, which establish their community in the area is called 'Pioneer' community.

2. Seres (or) Seral stage: The various developmental stages of a community is called 'seres'.

Community

It is the group of plants (or) animals living in an area.

1.14.2 Types of ecological succession

Ecologists recognize two types of ecological succession, based on the conditions present at the beginning of the process.

1. Primary succession: It involves the gradual establishment of biotic communities on a lifeless ground.

(a) Hydrarch (or) Hydrosere: Establishment starts in a watery area like pond and lake.

(b) Xerarch (or) Xerosere: Establishment starts in a dry area like, desert and rock.

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

1.14.3 Process of Ecological Succession

The process of ecological succession can be explained in the following steps.

1. Nudation

It is the development of a bare area without any life form.

2. Invasion

It is the establishment of one (or) more species on a bare area through migration followed by establishment.

(a) Migration: Migration of seeds is brought about by wind, water (or) birds.

(b) Establishment: The seeds then germinate and grow on the land and establishes their **pioneer communities.**

3. Competition

As the number of individual species grows, there is a competition with the same species and between different species for space, water and nutrients.

4. Reaction

The living organisms, take water, nutrients and grow and modify the environment is known as reaction. This modification becomes unsuitable for the existing species and favour some new species, which replace the existing species. This leads to **seral communities**.

5. Stabilizations

It leads to stable community, which is in equilibrium with the environment.

1.15 BIODIVERSITY

Bio means 'life' and diversity means 'variety', hence, biodiversity refers wide variety of life on the earth.

Our planet-earth (biosphere) contains more than 20 million species of organisms. But, of which only 1.4 million species have been identified so far. These species differ widely from one another. This variation in living organisms is called biodiversity.

Diversification in the species is influenced by various physical and climatic factors, resulting in the production of new sub-species. The species which are unable to adjust with the new environment gradually become extinct.

Definition

Biodiversity is defined as, "the variety and variability among all groups of living organisms and the ecosystem in which they occur."

1.16 CLASSIFICATION (OR) LEVELS (OR) TYPES OF BIODIVERSITY

Biodiversity is generally classified into three types

1. Genetic diversity.
2. Species diversity.
3. Community (or) Ecosystem diversity.

1.16.1. Genetic diversity

Genera: A species with different genetic characteristics is known as sub-species (or) "genera".

Genetic diversity is the diversity within species ie., variation of genes within the species

Within individual species, there are number of varieties, which are slightly different from one another. These differences are due to differences in the combination of genes. Genes are the basic units of hereditary information transmitted from one generation to other.

Examples

1. Rice varieties: All rice varieties belong to the species **"oryzasativa"**. But there are thousands of rice varieties, which show variation at the genetic level differ in their size, shape, colour and nutrient content.

2. Teak wood varieties: There are number of teak wood varieties found available.

Examples *Indian teak, burma teak, malasian teak etc.*

1.16.2 Species diversity

Species: A discrete group of organisms of the same kind is known as species.

Species diversity is the diversity between different species. The sum of varieties of all the living organisms at the species level is known as species diversity.

The biotic component is composed of a large number of species of plants, animals and micro organisms, which interact with each other and with the abiotic component of the environment.

Example

1. Total number of living species in the earth are about more than 20 million. But, of which only about 1.5 million living organisms are found and given scientific names.

2. ***Plant species:*** Apple, mango, grapes, wheat, rice, etc.,

3. ***Animal species:*** Lion, tiger, elephant, deer, etc.,

1.16.3 Community (or) Ecosystem diversity

Community

It is a set of biotic components (plants, animals and micro organisms) interacting with one another and with abiotic components (soil, air, water, etc).

The diversity at the ecological (or) habitat level is known as ecosystem diversity. A large region with different ecosystems can be considered as ecosystem diversity.

Example *River ecosystem.*

The river which include the fish, aquatic insects, mussels and variety of plants that have adapted.

Thus, the ecosystem diversity is the aggregate of different environmental types in a region. It explains the interaction between living organisms and physical environment in an ecosystem.

1.17 VALUES OF BIODIVERSITY

Biosphere is a life supporting system to the human beings. It is the combination of different organisms. Each organisms in the biosphere has its own significance. Biodiversity is vital for healthy biosphere. Biodiversity is must for the stability and proper functioning of the biosphere.

We get benefits from other organisms in number of ways. Sometimes we realize the real value of the organism only after it is lost in this earth.

CLASSIFICATION AND IMPORTANCE OF VALUES OF BIODIVERSITY

Various uses of biodiversity are classified as follows

1.17.1 Consumptive use value

These are direct use values, where the biodiversity products are harvested and consumed directly.

Examples *Food, drug, fuel, etc.,*

1. Food

A large number of wild plants are consumed by human beings as food. Nearly 80 - 90% of our food crops have been domesticated only from the tropical wild plants. A large number of wild animals are also consumed as food.

Examples

(a) ***Ceropegia bulbosa:*** in central India and Western Ghats.

(b) ***Codonopisis:*** in Himalayan region.

(c) ***Cicer microphyllum:*** in Kashmir

(d) ***Insects:*** molluscs, spiders, and wild herbivores are consumed by many tribal and non-tribal communities in India.

2. Drugs

Around 70% of modern medicines are derived from plant and plant extracts. 20,000 plant species are believed to be used medicinally, particularly in the traditional system of Unani, Ayurveda and Sidha.

Examples

(i) Germany alone uses more than 2,500 Species of plants for medicinal purposes in Homeopathy and other systems of medicines.

(ii) India uses 3000 Species of plants in Ayurveda, Homeopathy and Unani system of medicines.

(iii) According to research about 85% of global community use plants for primary health care.

(iv) According to latest medical scienes, bee-sting venom is used for treating arthritis.

(v) Life saving drugs like quinine (Malaria), reserpine (hypertension), pencillin (antibiotic) and morphine (pain kill) are all of plant origin.

(vi) The peepal tree leaves, trunk and roots are used as effective medicines for curing disease like fever, cough, stomach and skin diseases.

(vii) About 30 medicines have been prepared from neem tree which have been proved to be very effective for

stomach oilments, eye irritations, skin eruptions and diabetics.

(viii) Maxican yarn has been proved as a versatile boon to produce birth control in human beings.

Table 1.2: Medicinal products from Natural Resources

Product	Source	Use
Penicillin	Fungus	Antibiotic
Streptomycin	Actinimycete	Antibiotic
Tetracycline	Bacterium	Antibiotic
Digitalis	Foxglove	Heart stimulant
Quinine	Cinchona Bark	Malaria treatment
Diosgenin	Mexican your	Birth control drug
Cytarabuine	Sponge	Leukemia cure
Reserpine	Rauwolfa	Hypertension drug
Bee venom	Bee	Arthritis relief
Morphine	Poppy	Analgesic

3. Fuel

Firewoods are directly consumed by villagers, tribals. The fossil fuels like coal, petroleum and natural gas are also the products of fossilized biodiversity.

1.17.2 Productive use values

Biodiversity products have obtained a commercial value. These products are marketed and sold. These products may be derived from the animals and plants.

Table 1.3: Animal products

Animal product	Animal
Silk	Silk - worm.
Wool	Sheep.
Musk	Musk deer.
Tusk	Elephants.
Leather	All animals.
Food	Fish and animals.

Many industries are dependent upon the productive use values of biodiversity.

Table 1.4: Plant and animal products for various industries

Plant product	Industry
Wood	Paper and pulp industry, plywood industry railway sleeper industry.
Cotton	Textile industry.
Fruits, vegetables	Food industry.
Leather	Leather industry.
Ivory	Ivory - works.
Pearl	Pearls industry.

(a) Rice accounts for 22% of the cropped area and Cereals accounts for 39% of the cropped area.

(b) Oil seed production also helped in saving large amount of foreign exchange spent on importing edible oils.

1.17.3 Social Values

Social value of the biodiversity refers to the manner in which the bio-resources are used to the society. These values are associated with the social life, religion and spiritual aspects of the people.

Examples

1. Holy plants: Many plants are considered as the holy plants in our country.

Examples *Tulsi, peepal, lotus, bael, etc.,*

The leaves, fruits of these plants are used in worship.

2. Holy animals: Many animals are also considered as holy animals in our country.

Examples *Cow, snake, bull, peacock, rat, etc.,*

1.17.4 Ethical values (or) Existence value

It involves ethical issues like "all life must be preserved."

In India and in other countries biodiversity is considered to have great value on religious and cultural basis.

Our rich heritage teaches us to worship plants, animals, rivers and mountains. The ethical value means that a species may (or) may not be used, but its existence in nature gives us pleasure.

Examples

1. *The river Ganga is considered as holy river.*
2. *Vembu, Tulsi, Vengai are same of the trees, worshipped by the Tamilians.*
3. *We are not deriving anything directly from Kangaroo, Zebra (or) Giraffe, but we feel that these should exist in nature.*

Thus, there is an ethical value (or) existence value attached to each species.

1.17.5 Aesthetic value

The beautiful nature of plants and animals insist us to protect the biodiversity. The most important aesthetic value of biodiversity is eco-tourism.

Examples

1. ***Eco - tourism:*** People from far place spend a lot of time and money to visit the beautiful areas, where they can enjoy the aesthetic value of biodiversity. This type of tourism is known as eco - tourism.

2. The pleasant music of wild birds, colour of butterfly, colour of flowers, colour of peacocks are very important for their aesthetic value.

1.17.6 Option values

The option values are the potentials of biodiversity that are presently unknown and need to be known. The optional values of biodiversity suggests that any species may be proved to be a valuable species after someday.

Examples

1. *The growing biotechnology field is searching a species for causing the diseases of cancer and AIDS.*
2. *Medicinal plants and herbs play a very important role in our indian economic growth.*

1.18 INDIA AS A MEGA-DIVERSITY NATION

India is one among the 12 mega-diversity countries in the world. It has 89,450 animal species accounting for 7.31% of the global faunal species and 47,000 plant species which accounts for 10.8% of the world floral species. The loss of biodiversity (or) endemim is about 33%.

Table 1.5. Distribution of species in some groups of flora and fauna in India

Group-wise species Distribution			
Plants	**Number**	**Animals**	**Number**
Fungi	23,000	Mollusca	5042
Bacteria	850	Lower groups	9979
Algae	2500	Arthropoda	57,525
Bryophytes	2564	Amphibia	2546
Gymnosperms	64	Birds	1228
Pteridophytes	1022	Reptiles	428
Angiosperms	15,000	Mammals	372

1.18.1 Endemism (or) Endemic species

The species which are confined to a particular area are called endemic species. Our country has a rich endemic flora and fauna. About 33% of the flowring plants, 53%

of fresh water fishes, 60% amphibians, 36% reptiles and 10% mammalian are endemic species.

1. Plant diversity

Nearly 5000 flowering plants and 166 crop plant species have their origin in India.

2. Marine diversity

More than 340 coral species of the world are found here. Several species of mangrove plants and seagrasses are also found in our country.

3. Agro-biodiversity

There are 167 crop species and wild relatives. India is considered to be the centre of origin of 30,000 to 50,000 varieties of rice, mango, turmeric, ginger, sugarcane, etc.

4. Animal biodiversity

There are 75,000 animal species including 5,000 insects. India is a home to about nearly 2,00,000 living organisms.

1.18.2 'RED' Data book (or) Red list

Red book is a catalogue of taxa facing risk of extinction. The purpose of preparation of red list is to

(i) provide awareness to the degree of threat to biodiversity.

(ii) provide global index on already decline of biodiversity.

(iii) identification of species at high risk of extinction.

(iv) help in conservation action.

(v) information about international agreements.

India's biodiversity is threatened due to habitat destruction, degradation, fragmentation and over exploitation of resources.

According to 'RED' Data book 44 plant species are critically endangered, 54 endangered and 143 are vulnerable (exposed to damage).

India ranks 2nd interms of the number of threatened mammals and 6th among the countries with the most threatened birds.

Examples

1. ***Pitcher plant*** *has become endemic in Eastern Himalayas.*
2. ***Taxus wallichina*** *has come under red dad category due to its over exploitation.*

1.19 HOT-SPOTS OF BIODIVERSITY

The most remarkable and threatened areas, many of them have been reduced to less than 10% of their original vegetation. These areas are called hotspots of biodiversity.

The hot spots are the geographic areas which possess high endemic species.

At the global level, these are the areas of high conservation priority, if these species lost, they can never be replaced (or) regenerated.

1.19.1 Criteria for recognising hot spots

1. The richness of the endemic species is the primary criterion for recognising hot spots.
2. The hot spots should have a significant percentage of specialised species.
3. The site is under threat.
4. It should contain important gene pools of plants of potentially useful plants.

1.19.2 Reason for rich biodiversity in the tropics

The followings are the reasons for the rich biodiversity in the tropics.

1. The tropics have a more stable climate.
2. Warm temperatures and high humidity in the tropical areas provide favorable conditions.
3. No single species can dominate and thus there is an opportunity for many species to coexist.
4. Among plants, rate of out-crossing appear to be higher in tropics.

1.19.3 Area of hot spot

These hot spots covering less than 2% of the world's land are found to contain 50,000 endemic species. According to myersetal (2000), an area is designated as a hot spot when it contains atleast 0.5% of the endemic plant species.

About 40% of terrestial plants and 25% of vertebrate species are endemic and are found in these hot spots. These

are the areas of high diversity, endemism and are also threatened by many human activities.

Table 1.6. Global hotspots of biodiversity

Hotspots	Plant species	Endemic Plants	% of Global Plants	Vertebrate Species	Endemic Vertebrates	% of Global Vertebrates
1. Tropical Andes	45000	20000	6.7	3389	1567	5.7
2. Mesoamerican forests	24000	5000	1.7	2859	1159	4.2
3. Caribbean	12000	7000	2.3	1518	779	2.9
4. Brazil's Atlantic Forest	20000	8000	2.7	1361	567	2.1
5. Panama Western Ecuador	9000	2250	0.8	1625	418	1.5
6. Brazil's Cerrado	10000	4400	1.5	1268	117	0.4
7. Central Chile	3429	1605	0.5	335	61	0.2
8. California Floristic	4426	2125	0.7	584	71	0.3
9. Madagascar	12000	9704	3.2	987	771	2.8
10. Eastern Arc and Coastal Forest of Kenya	4000	1500	0.5	1019	121	0.4
11. Western African Forests	9000	2250	0.8	1320	270	1.0
12. Cape Floristic Province	8200	5682	1.9	562	53	0.2
13. Succulent Karoo	4849	1940	0.6	472	45	0.2
14. Mediterranean Basin	25000	13000	4.3	770	235	0.9
15. Caucasus	6300	1600	0.5	632	59	0.2
16. Sundaland	25000	15000	5.0	1800	701	2.6
17. Wallacea	10000	1500	0.5	1142	529	1.9
18. Philippines	7620	5832	1.9	1093	518	1.9
19. Indo-Burma Eastern Himalayas	13500	7000	2.3	2185	528	1.9
20. South-Central China	12000	3500	1.2	1141	178	0.7
21. Western-Ghats Sri Lanka	4780	2180	0.7	1073	355	1.3
22. South-western Australia	5469	4331	1.4	456	100	0.4
23. New Caledonia	3332	2551	0.9	190	84	0.3
24. New Zealand	2300	1865	0.6	217	136	0.5
25. Polynesia/Micronesia	6557	3334	1.1	342	223	0.8
Total	–	133,149	44.4	–	9645	35.3

1.20 HOT SPOTS OF BIODEVERSITY IN INDIA

Fig 1.4 Hot spots of Biodiversity in India

Myers etal recognized 25 hot spots in the world as shown in table 1.7. Two of which are found in India.

Table 1.7 Biodiversity hot spots in India

1.	Eastern Himalayas	Indo - Burma region.
2.	Western Ghats	SriLanka region.

1.20.1 Eastern Himalayas

Geographically these area comprises Nepal, Bhutan and neighboring states of Northern India. There are 35,000

plant species found in the Himalayas, of which 30% are endemic.

The Eastern Himalayas are also rich in wild plants of economic value.

Examples *Rice, banana, citrus, ginger, chilli, jute and sugarcane.*

The taxol yielding plant is also sparsely distributed in the region.

(a) 63% mammals are from Eastern Himalayas, and

(b) 60% of the Indian Birds are from North East.

(c) Huge wealth of fungi, insects, mammals, birds have been found in this region.

1.20.2 Western ghats

The area comprises Maharastra, Karnataka, Tamilnadu and Kerela. Nearly 1500 endemic, dicotyledone plant species are found from Western ghats. 62% amphibians and 50% lizards are endemic in western Ghats.

It is reported that only 6.8% of the original forests are existing today while the rest has been deforested (or) degraded.

Some common plants: Ternstroemia Japonica, Rhododendron and Hypericum.

Some common animals: Blue bird, lizard, hawk.

1.21 THREATS TO BIODIVERSITY

Any disturbance in an natural ecosystem tend to reduce its biodiversity. The waste generated due to increase in human population and industrialisation, spoils the environment and leads to more diversity in biological

species. Any change in the system leads to a major imbalance and threatens the normal ecological cycle.

CAUSES FOR LOSS OF BIODIVERSITY (OR) VARIOUS THREATS TO INDIAN BIODIVERSITY

1.21.1 Habitat loss

The loss of populations of interbreeding organisms is caused by habitat loss. Habitat loss threatened a wide range of animals and plants.

Factors influencing Habitat loss

1. Deforestation: The loss of habitat is mainly caused by deforestation activities. Forests and grasslands have been cleared for conversion into agricultural lands, (or) settlement areas (or) developmental project. The forest and grasslands are the natural homes of thousands of species, which disintegrate due to loss of their natural habitat.

2. Destruction of wetlands: The wetlands, estuaries and mangroves are destroyed due to draining, filling and pollution, which causes huge biodiversity loss.

3. Habitat fragmentation: Sometimes the habitat is divided into small and scattered patches. This phenomenon is known as habitat fragmentation. Due to this many wild animals and songbirds are vanishing.

4. Raw material: For the production of hybrid seeds, the wild plants are used as raw materials. As a result, many plant species become extinct.

5. Production of drugs: Many pharmaceutical companies collect wild plant for the production of drugs. Therefore several medicinal plant species are on the verge of extinction.

6. Illegal trade: Illegal trade on wild life also reduces the bio-diversity and leads to habitat loss.

7. Developmental activities: Construction of massive dams in the forest areas, discharge industrial effluents which kill the birds and other aquatic organisms.

1.21.2 Poaching (over harvesting) of wildlife

Poaching means killing of animals (or) commercial hunting. It leads to loss of animal biodiversity.

1. Subsistence poaching: Killing animals to provide enough food for their survival is called subsistence poaching.

2. Commercial poaching: Hunting and killing animals to sell their products is called commercial poaching.

Factors Influencing Poaching

1. Human population: Increased human population in our country has led to pressure on forest resources, which ultimately causes degradation of wildlife habitats.

2. Commercial activities: Though international ban on trading the products of endangered species, smuggling of wildlife products continues. Since the trading of such wildlife products is highly profit, poaching makes the poachers to just hunt these prohibital wildlife and smuggle it to other countries.

Wild life products: Furs, horns, tasks, live specimens, herbal products.

Wealth of wildlife: The developing nations in Asia, Latin America and Africa have richest source of biodiversity.

Importers of wild life: The rich countries in Europe and North America, Japan, Taiwan, Hong Kong are the major importer of wildlife products (or) wildlife itself.

Examples

1. Male gorilla: In Rwanda and Zaire, it is hunted for its body parts, head and hands.

2. Blue morpho butterfly: In Brazil, it is poached for making attractive trays and other objects.

3. Snowy large egret: In U.S, it is poached for its white plumes, so as to keep it in ladies hats.

4. Blubber: It is used to prepare lamp oils and lubricating oils.

5. Baleen: It is used to prepare combs and other similar articles.

6. Elephant feet: It is used to make Ash trays.

7. Elephant: It is killed for ivory.

8. Bengal tigers: Its fur sell is more than $1,00,000 in the foreign market.

9. Bush meat: It is an important source of protein for many local people in west and central Africa.

10. Dynamite fishing: It is "high - tech fishing", which have exhausted the ocean marine life.

11. Seahorses, Star turtles: These valuable species are also illegally sold into the foreign market for want of money.

Remedy measures

1. Illegal hunting and trade of animals and animal products should be stopped immediately.

2. We should not purchase furcoat, purse (or) bag (or) items made of crocodile skin (or) python skin.
3. Bio-diversity laws should be strengthened.

1.21.3 Man - wildlife conflicts

Man - wildlife conflicts arise, when wildlife starts causing immense damage and danger to the man. Under such condition it is very difficult for the forest department to compromise the affected villagers and to gain the villagers support for wildlife conservation.

Examples for man - wildlife conflicts

1. In Sambalpur, Orissa, 195 humans were killed in the last 5 years by elephants. In retaliation, the villagers have killed 98 elephants and badly injured 30 elephants.
2. In the border of Kote - Chamarajanagar, Mysore, several elephants was killed because of the massive damage done by the elephants to the farmer's cotton and sugarcane crops.
3. The agonized villagers sometimes hide explosives in the sugarcane fields, which explode when the elephants enter into their fields.
4. It has been reported that a man - eating tiger killed 16 Nepalese people and one 4 - years old child inside the Royal Chitwan National Park, Kathmandu. Now the park has became a zone of terror for the locals.
5. Very recently, two men were killed by leopards in Powai, Mumbai.
6. A total of 14 persons were killed during 19 attacks by the leopards in Sanjay Gandhi National Park, Mumbai.

Factors influencing (or causes) man - animal conflicts

1. Shrinking of forest cover compels wildlife to move outside the forest and attack the fields and humans.
2. Human encroachment into the forest area induces a conflict between man and the wildlife.
3. Injured animals have a tendency to attack man. Usually the female wildlife attacks the human if she feels that her newborn cubs are in danger.
4. Earlier, forest departments used to cultivate sugarcane paddy, coconut trees, in the sanctuaries. When the favourite food of elephants (i.e., bamboo leaves) were not available, they feed them to the elephants. But, now due to lack of such practices the wild animals move out of the forest for searching food.
5. Often the villagers put electric wiring around their crop fields. The elephants get injured, suffer in pain and start violence.
6. The cash compensation paid by the government for the damage caused by the wild animals, is not enough. Therefore the agonized farmers gets revengeful and kill the wild animals.

Examples *A farmer, in Mysore, gets a compensation of Rs.400/- per quintal, but the market price is Rs.2400/- per quintal.*

7. Garbage near human settlements (or) food crops near forest areas attracts wild animals.

Remedial measures (or) Conservation of biodiversity

1. Adequate crop and cattle compensation schemes must be started.

2. Solar powered fencing must be provided along with electric current proof trenches to prevent the animals from entering into the fields.
3. Cropping pattern should be changed near the forest borders.
4. Adequate food, and water should be made available for the wild animals within forest zones.
5. The development and constructional work in and around forest region must be stopped.

1.22 ENDANGERED AND ENDEMIC SPECIES OF INDIA

According to International Union of Conservation of Nature and Natural Resources (IUCN) the species are classified into various types.

1. Extinct species: A species is said to be extinct, when it is no longer found in the world.

2. Endangered species: A species is said to be endangered, when its number has been reduced to a critical level. Unless it is protected and conserved, it is in immediate danger of extinction.

3. Vulnerable species: A species is said to be vulnerable when its population is facing continuous decline due to habitat destruction (or) over exploitation. Such a species is still abundant.

4. Rare species: A species is said to be rare, when it is localized within restricted area (or) they are thinly scattered over a more extensive area. Such species are not endangered (or) vulnerable.

1.22.1 Endangered Species of India

A species is said to be endangered, when its number has been reduced to a critical level. Unless it is protected and conserved, it is in immediate danger of extinction.

In India 450 plant species have been identified as endangered species. About 100 mammals and 150 birds are estimated to be endangered species. But India's biodiversity is threatened due to habitat destruction, degradation and over exploitation of resources.

Table 1.8. Number of threatened species of India.

Group of Threatened species	Number of Threatened species
Plants	250
Birds	70
Mammals	86
Reptiles	25
Amphibians	3
Fishes	3
Molluscs	2
Insects	50

Important endangered Species

A few species of endangered reptiles, mammals, birds and plants are given below.

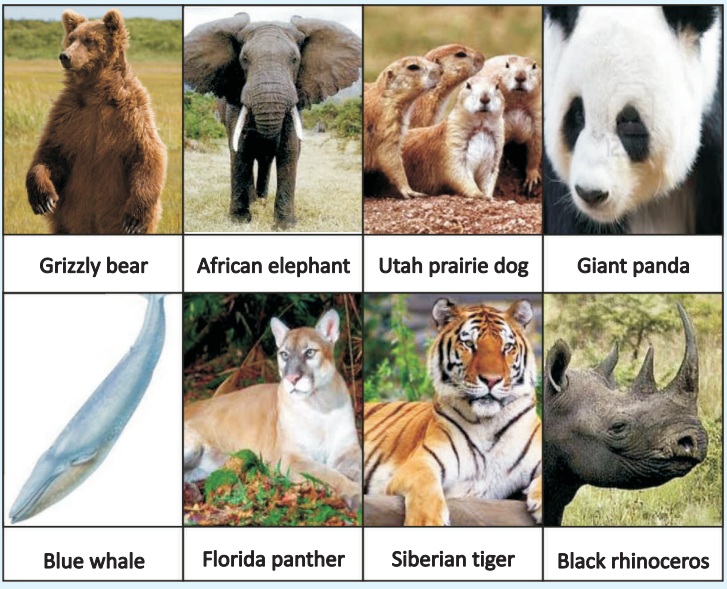


Fig. 1.5 Some endangered species

1.	Reptiles	Tortoise, green sea turtle, gharial, python.
2.	Birds	Peacock, siberian white crane, pelican, Indian bustard.
3.	Mammals	Indian wolf, red fox, sloth bear, tiger, Indian lion, golden cat, desert cat.
4.	Primates	Hoolock gibbon, lion-tailed macaque, capped monkey, golden monkey.
5.	Plants	A large number of medicinal plants (like rauvol fia serpentina), sandal wood tree (like santalum, cycas bed donei).

RED - data book: RED - data book contains the list of endangered species of plants and animals. The RED - data gives the warning signal for those species which are endangered and if not protected they become extinct in near future.

Factors affecting Endangered species

1. Pollution: Humans dispose their waste products on nature. So, the land, river, and air get polluted severely. These pollutants enter our environment and travel through the food chain and accumulate in the tissues of the living things, finally it leads to death.

2. Over - exploitation: Over - exploitation of the natural resources and poaching of wild animals also leads to extinct of wild animals.

3. Climate change: Climate change is brought about by the accumulation of greenhouse gases in the atmosphere. Climate change threatens organisms and ecosystems, which cannot accommodate the change of environmental conditions.

Remedial measures

International treaties on Endangered Species (ITES)

Several international treaties and conventions help to protect endangered wild species. One of the most reaching treaty is, "Convention on International Trade in Endangered Species 1975 " (CITES). This treaty is now signed by 160 countries.

1. This treaty lists some 900 species that cannot be commercially traded as live specimens (or) wildlife products, because they are in danger of extinction.
2. The treaty also restricts international trade of 2900 other species, because they are endangered.

Draw backs of this treaty

1. The bad news of this treaty is that the effect of this treaty is limited because enforcement is difficult and convicted violators often pay only small fines.
2. Also, member countries can exempt themselves from protecting any listed species.

1.22.2 Endemic Species

The species, which are found only in a particular region are known as endemic species. In India of 47,000 species 7000 plants are endemic. Nearly 62% of our endemic species are found available in Himalayas and Western Ghats.

1. Fauna

Animals present in a particular region (or) period.

Examples for endemic fauna species

Sapria himalayana, Ovaria lurida, Nepenthes khasiana, Pedicularis Parroter, etc.,

Out of 81,000 species of animals in our country a large number is endemic. The Western Ghats are particularly rich in (a) amphibians (frogs, toads, etc.,) and (b) reptiles (lizards, crocodiles, etc.,).

About 62% amphibians and 50% lizards are endemic to Western Ghats.

2. Flora

Plants present in a particular region (or) period.

It also refers to friendly bacteria which helps to protect the human body against invasion by pathogens.

Examples for endemic flora species

Monitor lizards (varanus), reticulated python, Indian salamander and viviparous toad (Nectophhryne).

Endemic species in India

The following species are considered as endemic in India.

Table 1.9 Endemic Species of Plants

Group	No. of Species
Pteridophyta	200
Angiosperms	4950

Table 1.10 Endemic Species of Animals

Group	No. of Species
Land	878
Freshwater	89
Insecta	16214
Amphibia	110
Reptilia	214
Aves	69
Nannakua	38

Factors affecting endemic species

There are number of factors, which affect amphibians (frogs) at various points in their life cycle.

1. Habitat loss and fragmentation, because of the draining and filling of inland wetlands.
2. Pollution also play an important role.

Examples

1. Frog eggs, tadpoles and adults are very sensitive to many pollutants especially pesticides.
2. Overhunting of frog legs in Asia and France.

3. Populations of same can also be reduced by introduction of non-active predators and competitors (like fish) and disease producing organism.

1.23 CONSERVATION OF BIODIVERSITY

Biodiversity is one of the important tool for sustainable development. The enormous value of biodiversity due to their commercial, medical, genetic, aesthetic and ecological importance emphasizes the need to conserve biodiversity.

Conservation

Conservation is defined as, ***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***.

1.23.1 Factors affecting biodiversity

1. Biodiversity is generally disturbed by human activities such as construction of dams in forest areas, release of industrial wastes, using pesticides and insecticides in the crop fields, urbanisation, etc..

2. Poaching of wild animals, over exploitation of natural resources, degradation of habitats, affect biodiversity.

3. The marine ecosystems are also disturbed due to oil spills and discharge of effluents.

4. The climatic factors like global warming, ozone depletion, acid rain also affect the biodiversity.

1.23.2 Advantages (or) need of biodiversity conservation

1. It provides immediate benefits to the society such as recreation and tourism.
2. Drugs, herbs, food and other important raw materials can be derived from plants and animals.
3. It also preserves the genetic diversity of plants and animals.
4. Ensures the sustainable utilization life supporting systems on earth.
5. It leads to conservation of essential ecological diversity and life supporting systems.
6. Since the biodiversity loss results in ecological and environmental deterioration, it is essential to conserve the biodiversity.

1.24 TYPES (OR) STRATEGY OF BIODIVERSITY CONSERVATION

There are two types of biodiersity conservation.

1. In-situ conservation (within habitat)
2. Ex-situ conservation (outside habitat)

1.24.1 In - situ conservation

In - situ conservation involves protection of fauna and flora within its natural habitat, where the species normally occurs is called in - situ conservation.

The natural habitats (or) ecosystems maintained under in-situ conservation are called "**protected areas**".

Important In-situ conservation

Biosphere reserves, National parks, wildlife sanctuaries, Gene sanctuary etc.,

Methods of In-situ conservation

Around 4% of the total geographical area of the country is used for in-situ conservation. The following methods are presently used for in-situ conservation. It is the best method for the long term protection of biodiversity.

In-Situ conservation	Numbers available
Biosphere reserves	7
National parks	80
Wild - life sanctuaries	420
Botanical gardens	120

1. Biosphere Reserves

Biosphere reserves cover large area, more than 5000 sq. km. It is used to protect species for long time.

Table 1.11. Some important Biosphere Reserves in India

Name of Biosphere	State
Nanda Devi	U.P
Nokrek	Meghalaya
Manas	Assam
Sunderbans	West Bengal
Gulf of Mannar	Tamil Nadu
Nilgiri	Karnataka, Kerala, Tamil Nadu
Great Nicobars and Similipal	Orissa

Role of biosphere reserves

1. It gives long - term survival of evolving ecosystem.
2. It protects endangered species.
3. It protects maximum number of species and communities.
4. It serves as site of recreation and tourism.
5. It is also useful for educational and research purposes.
6. It remains and functions as an open system and changes in land use are not allowed.

Restriction: No tourism and explosive activities are permitted in the biosphere reserves.

2. National park

A national park is an area dedicated for the conservation of wildlife along with its environment. It is usually a small reserves covering an area of about 100 to 500 sq. kms. Within the biosphere reserves, one (or) more national parks are also exists.

Table 1.12. Some important National parks in India

Name of National Park	State	Important Wildlife
Kaziranga	Assam	One horned Rhino
Gir National Park	Gujarat	Indian Lion
Bandipur	Karnataka	Elephant
Dachigam	J & K	Hangul
Corbett	U.P	Tiger
Kanha	M.P	Tiger
Periyar	Kerala	Tiger, Elephant
Dudwa	U.P	Tiger
Sariska	Rajasthan	Tiger
Ranthambore	Rajasthan	Tiger

Role of a national park

1. It is used for enjoyment through tourism, without affecting the environment.
2. It is used to protect, propagate and develop the wildlife.

Restrictions

1. Grazing of domestic animals inside the national park is prohibited.
3. All private rights and forestry activities are prohibited within a national park.

3. Wildlife Sanctuaries

A wildlife sanctuary is an area, which is reserved for the conservation of animals only. At present, there are 492 wildlife sanctuaries in our country.

Table 1.13. Some Important Wildlife Sanctuaries in India

Name of Sanctuary	State	Major Wild Life
Hazaribagh Sanctuary	Bihar	Tiger, Leopard
Ghana Bird Sanctuary	Rajasthan	300 species of birds
Sultanpur Bird Sanctuary	Haryana	Migratory birds
Abohar Wildlife Sanctuary	Punjab	Black buck
Nal Sarovar Bird Sanctuary	Gujarat	Water birds
Mudumalai Wildlife Sanctuary	Tamil Nadu	Tiger, Elephant, Leopar

Name of Sanctuary	State	Major Wild Life
Vedanthangal Bird Sanctuary	Tamil Nadu	Water birds
Wild Ass Sanctuary	Gujarat	Wild ass, Wolf, Chinkara
Jaldapara Wildlife Sanctuary	W.Bengal	Rhinoceros, Elephant, Tiger

Role of wildlife Sanctuaries

1. It protects animals only.
2. It allows the operations such as harvesting of timber, collection of forest products, private ownership rights and forestry operations provided it does not affect the animals adversely.

Restrictions

Killing, hunting, shooting, (or) capturing of wildlife is prohibited except under the control of higher authority.

4. Gene Sanctuary

A gene sanctuary is an area, where the plants are conserved.

Examples

In Northern India, two gene sanctuary are found available.

(a) One gene sanctuary for citrus (Lemon family), and

(b) One gene sanctuary for pitcher plant (an insect eating plant).

5. Other projects for conservation of animals

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

Examples *Project Tiger; Gir Lion project; Crocodile Breeding project; Project Elephant, etc.,*

Advantages (or) merits of In-situ Conservation

1. It is very cheap and convenient method.
2. The species gets adjusted to the natural disasters like drought, floods, forest fires.

Disadvantages (or) limitations of In-situ Conservation

1. A large surface area of the earth is required to preserve the biodiversity.
2. Maintenance of the habitats is not proper, due to shortage of staff and pollution.

1.24.2 Ex-situ conservation

Ex-situ conservation involves protection of fauna and flora outside the natural habitats.

This type of conservation is mainly done for conservation of crop varieties and the wild relatives of crops.

Role of Ex-situ conservation

1. It involves maintenance and breeding of endangered plant and animal species under controlled conditions.
2. It identifies those species which are at more risk of extinction.
3. It prefers the species, which are more important to man in near future among the endangered species.

Important Ex-situ conservation

Botanical gardens, seed banks, microbial culture collections, tissue and cell cultures, museums, zoological gardens.

Methods of Ex-situ Conservation

The following important gene bank (or) Seed bank facilities are used in Ex-situ conservation.

(i) Nationl Bureau of Plant Genetic Resources (NBPGR)

It is located in New Delhi. It uses cryo preservation techniques to preserve agricultural and horticultural crops.

Cryo preservation technique: It involves the preservation of seeds, pollen of some important agricultural and horticultural crops by using liquid nitrogen at a temperature as low as - 196°C. Varieties of rice, pearl millet, Brassica, turnip, radish, tomato, onion, carrot, chilli, tobacco, etc., have been preserved successfully in liquid nitrogen for several years.

(ii) National Bureau of Animal Genetic Resources (NBAGR)

It is located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.

(iii) National Facility for Plant Tissue Culture Repository (NFPTCR)

It develops the facility for conservation of varieties of crop plants (or) trees by tissue culture. This facility has been created within the NBPGR.

Advantages (or) merits of Ex-situ Conservation

1. Survival of endangered species is increasing due to special care and attention.
2. In captive breeding, animals are assured food, water, shelter and also security and hence longer life span.
3. It is carried out in cases of endangered species, which donot have any chances of survival, in the world.

Disadvantages (or) limitations of Ex-situ Conservation

1. It is expensive method.
2. The freedom of wildlife is lost.
3. The animals cannot survive in natural environment.
4. It can be adopted only for few selected species.

1.25 PART B QUESTIONS

1. Explain briefly the structure of atmosphere. *(A.U. Dec-2005)*
2. What are the components of environment. Explain their role.
3. Explain the scope and significance of environmental studies.
4. Write briefly on the community participation in environment management programmes. *(A.U. Dec-2005)*
5. Explain the importance of environmental protection and justify the needs for public awareness. *(Mdu. AUT. Nov. 2011)*
6. Explain ecosystem. *(A.U. Dec-2005)*
7. What is an ecosystem? Describe the structure and functions of various components of an ecosystem. *(Coim AUT Dec 2009, A.U. June 2016, Jan-2006, May 2008)*
8. Discuss the components of ecosystem. *(A.U. May 2007, Dec-2005)*
9. State the four components of ecosystem. *(A.U. Dec 2006)*

10. Describe the structural features of ecosystem.
(Chennai A.U. Dec 2009)

11. Describe the biotic component of an ecosystem.
(Chennai A.U. Dec 2009)

12. Briefly explain the energy flow through ecosystem.
(A.U. Dec-2005)

13. Discuss energy flow in ecosystem.
(A.U. Dec 2015, TCY AUT, Dec 2011)

14. Explain the stages in ecological succession using appropriate terminology. *(AU. Nov/Dec 2016)*

15. What is biodiversity? How is it classified? Explain the values of biodiversity. *(TCY AUT June 2009)*

16. What is biodiversity? Discuss the genetic biodiversity and values of biodiversity.
(AU Dec 2014)(TCY AU Dec'08)

17. Write the uses of biodiversity to mankind.
(TNV AUT Dec. 2010)

18. What are the values of biodiversities? Explain.
(Chen AUT Dec. 2010)

19. Classify and explain the value of biodiversity.
(Chen AUT Dec. 2010)

20. Discuss the importance of biodiversity.
(Che A.U. Dec 2009)

21. Discuss the status of India as a mega diverse nation of biodiversity.
(TCY A.U. Dec 2009) (AU Dec 2016, May 2017)

23. What are the various hot spots of Bio Diversity in India? *(Che AU Dec'08, Dec 2012)*

23. Describe the term hot spot in biodiversity.
(A.U. Dec 2007)

24. What do you understand by 'Hot spots of biodiversity'? Name and briefly describe the two hotspots of biodiversity that extend into India. *(TCY A.U. Dec 2009), TNV AUT Dec 2005)*

25. Which are the biodiversity hotspots in India? What are the threats they face? *(AU. Nov/Dec 2017)*

26. What do you understand by hot spots of biodiversity? Name and briefly describe two hot spots of biodiversity that extend in India. *(A.U. May 2008)*

27. Discuss the biodiversity hot-spots identified in India. *(TNV AUT June 2010)*

28. Identify and explain the present day major threats to the biodiversity of India. *(TNV A.U. Dec 2009)(TCY AUT June 2011)*

29. What are the major causes of man-wild conflicts? Discuss the remedial steps that can curb the conflict. *(Coim AUT Dec 2011, AU. May 2015, Dec. 2015)*

30. Explain the factors that give threat to biodiversity. *(AU. May/June 2016)*

31. Discuss the human-animal conflict with special reference to media coverage. *(AU. Nov/Dec 2017)*

32. Discuss the endangered and endemic species of India. *(Che AU Dec'08)*

33. Write a note on endangered and endemic species of India. *(Coim AUT May 2011)(Che A.U. Dec 2009)*

34. List the important sites in India identified for the conservation of endemic species. Mention the major endemic species of India. *(TNV AUT June 2010)*

35. What are the main objectives of conservation of biodiversity? Discuss the strategies for conservation of biodiversity. *(AU. Dec. 2013)*

36. Explain the strategy adopted to conserve biodiversity. *(A.U. Jan-2006)*

37. Briefly explain the conservation of bio-diversity. *(TCY AUT Dec 2010)(A.U. May 2006)*

38. How is biodiversity conserved in India? Explain. *(Che AU June 2016, Dec'08)(Coim AUT June 2010)*

39. How is conservation of biodiversity achieved? Give details. *(TNV AU Dec'08)*

40. Write a note on importance of conservation of biodiversity. *(Che A.U. Dec 2013, June 2010)(Coim AUT Dec 2010)*

41. What do you mean by conservation of biodiversity? State and explain the basic approaches to wild life conservation. *(AU. Dec. 2014)*

42. Suggest suitable steps that should be taken to conserve biodiversity in India. *(TNV AUT June 2010)*

43. Explain any one of the strategy adopted to conserve biodiversity. *(Coim A.U. Dec 2009)*

44. What do you understand by conservation of biodiversity? Explain the Insitu and Exsitu conservation along with their merits and limitations. *(TCY AU May 2010, Dec'08) (AU Dec 2016)*

45. Write informative notes on 'Insitu' conservation. *(Che A.U. Dec 2009)*

46. Explain different methods of In-Situ conservation of Biodiversity. *(Chen AUT Dec. 2011)*

Unit - II

Environmental Pollution

2.1 INTRODUCTION

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

Pollution are of different kinds depending on the nature of pollutant generated from different sources.

Examples *Industry, automobiles, thermal power plants, farming, nuclear reactors, generate different types of pollutants causing pollution to air, water bodies and land.*

2.1.1 Types of Pollutants

1. Biodegradable pollutants: Biodegradable pollutants decompose rapidly by natural processes.

2. Non-degradable pollutants: Non-degradable pollutants do not decompose (or) decompose slowly in the environment.

The slowly decomposed materials are more dangerous because it is more difficult to remove them.

2.1.2 Classification of Pollution

The different kinds of pollution that affects the environment are,

1. Air Pollution
2. Water Pollution
3. Soil Pollution and
4. Noise Pollution

2.2 AIR POLLUTION

Definition

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.***"

The rapid industrialization, fast urbanization, rapid growth in population, drastic increase in vehicles on the roads and other activities of human beings have disturbed the balance of natural atmosphere.

Composition of Atmospheric Air

During several billion years of chemical and biological evolution, the composition of the earth's atmosphere has varied. Today, about 99% of the volume of air we inhale consists of two gases: Nitrogen and Oxygen.

Table 2.1 Composition of atmospheric air

Constituents	%
Nitrogen	78
Oxygen	21
Argon (Ar)	< 1
CO_2	0.037
Water vapour	Remaining
O_3, He, NH_3	Traceamount

2.2.1 Sources of Air Pollution

The sources of air pollution are of two types

1. Natural sources

Examples *Volcanic eruptions, forest fires, biological decay, pollen grains, marshes, radioactive materials etc.*

These pollutants are caused by the natural sources.

2. Man-made (anthropogenic) activities

Examples *Thermal power plants, vehicular emissions, fossil fuel burning, agricultural activities etc.,*

2.2.2 Classification of Air Pollutants

Depending upon the form (origin) of pollutants present in the environment, they are classified as

(i) Primary air pollutants.

(ii) Secondary air pollutants.

1. Primary air pollutants

Primary air pollutants are those emitted directly in the atmosphere in harmful form.

Examples *CO, NO, SO_2, etc.,*

Indoor Air Pollutants

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

Sources (causes) of indoor air pollutants

1. Radon gas is emitted from the building materials like bricks, concrete, tiles, etc., which are derived from soil containing radium.
2. It is also present in natural gas and ground water and is emitted indoors while using them.
3. Burning of fuels in the kitchen, cigarette smoke, liberates the pollutants like CO, SO_2, formaldehyde, BAP (benzo-(a) pyrene).

2. 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.

Example

$$NO/NO_2 \xrightarrow{Moist} (HNO_3/NO_3) \text{ etc.,}$$

2.2.3 Common air pollutants sources (causes) and their effects

According to the World Health Organization (WHO), more than 1.1 billion people live in urban areas where outdoor air is unhealthy to breathe. Some of the common air pollutants are described below.

1. Carbon monoxide (CO)

Description

It is a colourless, odourless gas that is poisonous to air-breathing animals. It is formed during the incomplete combustion of carbon containing fuels.

$$2C + O_2 \longrightarrow 2CO$$

Human Sources (causes)

Cigarette smoking, incomplete burning of fossil fuels. About 77% comes from motor vehicle exhaust.

Health Effects

Reacts with heamoglobin in red blood cells and reduces the ability of blood to bring oxygen to body cells and tissues, which causes headaches and anemia. At high levels it causes coma, irreversible brain cell damage and death.

Environmental Effects

It increases the globe temperature.

2. Nitrogen dioxide (NO_2)

Description

It is a reddish-brown irritating gas that gives photochemical smog. In the atmosphere it can be converted into nitric acid (HNO_3).

$$NO_2 + \text{Moisture} \longrightarrow HNO_3$$

Human Sources (causes)

Fossil fuel burning in motor vehicles (49%) and power industrial plants (49%).

Health Effects

Lung irritation and damage.

Environmental Effects

Acid deposition of HNO_3 can damage trees, soils and aquatic life in lakes, HNO_3 can corrode metals and eat away stone on buildings, statues and monuments. NO_2 can damage fabrics.

3. Sulphur dioxide (SO_2)

Description

It is a colourless and irritating gas. It is formed mostly from the combustion of sulphur containing fossil fuels such as coal and oil. In the atmosphere it can be converted to sulphuric acid (H_2SO_4) which is a major component of acid deposition.

Human Sources (causes)

Coal burning in power plants (88%) and industrial processes (10%).

Health Effects

Breathing problems for healthy people.

Environmental Effects

Reduce visibility, acid deposition of H_2SO_4 can damage trees, soils and aquatic life in lakes.

4. Suspended particulate matter (SPM)

Description

It includes variety of particles and droplets (aerosols). They can be suspended in atmosphere for short periods to long periods.

Human Sources (causes)

Burning coal in power and industrial plants (40%), burning diesel and other fuels in vehicles (17%), agriculture, unpaved roads, construction etc.,

Health Effects

Nose and throat irritation, lung damage, bronchitis, asthma, reproductive problems and cancer.

Environmental Effects

Reduces visibility, acid deposition and H_2SO_4 droplets can damage trees, soils and aquatic life in lakes.

5. Ozone (O_3)

Description

Highly reactive irritating gas with an unpleasant odour that forms in the troposphere. It is a major component of photochemical smog.

Human Sources (causes)

Chemical reaction with volatile organic compounds (emitted mostly by cars and industries) and nitrogen oxides.

Environmental Effect

Moderates the climate.

6. Photochemical smog

Description

The brownish smoke like appearance that frequently forms on clear, sunny days over large cities with significant amounts of automobile traffic.

Sources (causes)

It is mainly due to chemical reactions among nitrogen oxides and hydrocarbon by sunlight.

Health Effects

Breathing problems, cough, eye, nose and throat irritation, heart diseases, reduces resistance to colds and pneumonia.

Environmental Effects

Ozone can damage plants and trees. Smog can reduce visibility.

7. Lead (Pb)

Description

Solid toxic metal and its compounds, emitted into the atmosphere as particulate matter.

Human Sources (causes)

Paint, smelters (metal refineries), lead manufacture, storage batteries, leaded petrol.

Health Effects

Accumulates in the body, brain and other nervous system damage and mental retardation (especially in children); digestive and other health problems, some lead-containing chemicals cause cancer in test animals.

Environmental Effect

Can harm wild life.

8. Hydrocarbons (aromatic and aliphatic)

Description

Hydrocarbons especially lower hydrocarbons get accumulated due to the decay of vegetable matter.

Human sources (causes)

Agriculture, decay of plants, burning of wet logs.

Health Effects

Carcinogenic.

Environmental effect

It produces an oily film on the surface and do not as such causes a serious problem until they react to form

secondary pollutants. Ethylene causes plant damage even at low concentrations.

9. Chromium (Cr)

Description

It is a solid toxic metal, emitted into the atmosphere as particulate matter.

Human Sources (causes)

Paint, smelters, chromium manufacture, chromium plating.

Health effects

Perforation of nasal septum, chrome holes, gastro intestinal ulcer, central nervous system disease and cancer.

2.2.4 Control (or) Preventive Measures of air pollution

The atmosphere has several built-in self cleaning processes such as dispersion, gravitational settling, flocculation, absorption, rain washout and so on, to cleanse the atmosphere. In terms of a long range control of air pollution, control of contaminants at their source is a more desirable and effective method through preventive (or) control technologies.

I. Source control

Since we know the substances that causes air pollution, the first approach to its control will be through source reduction. Some actions that can be taken in this regard are as follows:

1. Use only unleaded petrol.
2. Use petroleum products and other fuels that have low sulphur and ash content.

3. Reduce the number of private vehicles on the road by developing an efficient public-transport system and encouraging people to walk (or) use cycles.
4. Ensure that houses, schools, restaurants and places where children play are not located on busy streets.
5. Plant trees along busy streets because they remove particulates and carbon monoxide, and absorb noise.
6. Industries and waste disposal sites should be situated outside the city centre preferably downwind of the city.
7. Use catalytic converters to help control the emissions of carbon monoxide and hydrocarbons.

II. Control measures in industrial centers

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

Equipments used to control air pollution

Air pollution can be reduced by adopting the following approaches.

(i) To ensure sufficient supply of oxygen to the combustion chamber and adequate temperature so that the combustion is complete, eliminating much of the smoke consisting of partly burnt ashes and dust.

(ii) To use mechanical devices such as scrubbers, cyclones, bag houses and electro-static precipitators, reducing particulate pollutants..

The four figures (fig 2.1) are commonly used control methods for removing particulates from the exhaust gases

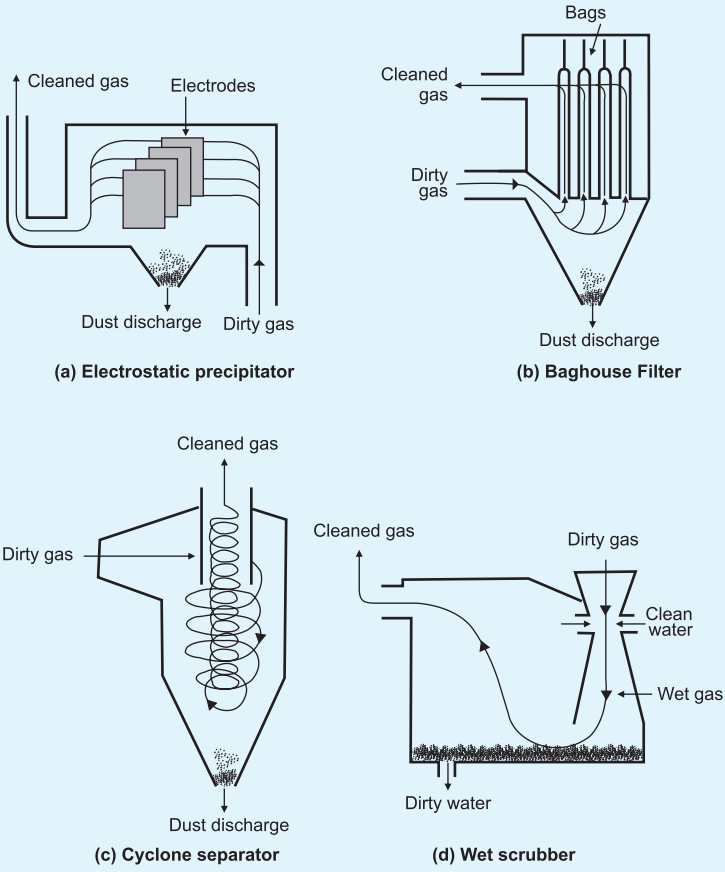


Fig. 2.1 Control methods for removing particulates from exhaust gases

of electric power and industrial plants. All these methods retain hazardous materials that must be disposed of safely. The wet scrubber can also reduce sulphurdioxide emissions.

(iii) Chemical treatment to deal with factory fumes.

The disposal of the collected air pollutants is equally important for successful control of air pollution.

2.3 WATER POLLUTION

Definition

Water pollution may be defined as, ***"the alteration in physical, chemical and biological characteristics of water which may cause harmful effects on humans and aquatic life.***"

The pollutants include sewage, industrial chemicals and effluents, oil and other wastes. Besides, chemicals from the air dissolved in rain water, and fertilizers, pesticides and herbicides leached from the land also pollute water.

2.3.1 Types, effects and sources (causes) of water pollution

Water pollution is any chemical, biological (or) physical change in water quality that has a harmful effect on living organisms (or) makes water unsuitable for desired uses.

1. Infectious Agents

Example *Bacteria, viruses, protozoa and parasitic worms.*

Human Sources (causes)

Human and animals wastes.

Effects

Variety of diseases.

2. Oxygen Demanding Wastes (Dissolved oxygen)

Example *Organic wastes such as animal manure and plant debris that can be decomposed by aerobic (oxygen-requiring) bacteria.*

This degradation consumes dissolved oxygen in water. Dissolved oxygen (DO) is the amount of oxygen

dissolved in a given quantity of water at a particular pressure and temperature.

The saturated point of DO varies from 8-15 mg/lit.

Human Sources (causes)

Sewage, animal feedlots, paper mills, and food processing facilities.

Effects

Large populations of bacteria decomposing these wastes can degrade water quality by depleting water of dissolved oxygen. This causes fish and other forms of oxygen-consuming aquatic life to die.

3. Inorganic Chemicals

Example *Water soluble inorganic chemicals.*

(i) acids,

(ii) compounds of toxic metals such as lead (Pb), arsenic (As) and selenium (Se) and

(iii) salts such as NaCl in ocean water and fluorides (F^-) found in some soils.

Human Sources (causes)

Surface runoff, industrial effluents and household cleansers.

Effects

(i) Can make fresh water unusable for drinking (or) irrigation.

(ii) Causes skin cancers and neck damage.

(iii) Damage the nervous system, liver and kidneys.

(iv) Harm fish and other aquatic life.

(v) Lower crop yields.

(vi) Accelerates corrosion of metals exposed to such water.

4. Organic Chemicals

Examples *Oil, gasoline, plastics, pesticides, cleaning solvents, detergents.*

Human Sources (causes)

Industrial effluents, household cleansers, surface runoff from farms.

Effects

(i) Can threaten human health by causing nervous system damage and some cancers.

(ii) Harm fish and wild life.

5. Plant Nutrients

Examples *Water-soluble compounds containing nitrate* (NO_3^-), *phosphate* (PO_4^{3-}) *and ammonium* (NH_4^+) *ions.*

Human Sources (causes)

Sewage, manure, and runoff of agricultural and urban fertilizers.

Effects

(i) Can cause excessive growth of algae and other aquatic plants, which die, decay, deplete dissolved oxygen in water and kill the fish.

(ii) Drinking water with excessive levels of nitrates lower the oxygen carrying capacity of the blood and can kill urban children and infants.

6. Sediment

Examples *Soil, silt, etc.,*

Human Sources (causes)

Land erosion.

Effects

(i) Can reduce photosynthesis and cloud water.

(ii) Disrupt aquatic food webs.

(iii) Carry pesticides, bacteria, and other harmful substances.

(iv) Settle out and destroy feeding and spawning rounds of fish.

(v) Clog and fill lakes, artificial reservoirs, stream channels and harbours.

7. Radioactive Materials

Examples *Radioactive isotopes of iodine, radon, uranium, cesium, and thorium.*

Human Sources (causes)

Nuclear power plants, mining and processing of uranium and other ores, nuclear weapons production and natural sources.

Effects

Genetic mutations, birth defects, and certain cancers.

8. Heat (Thermal Pollution)

Example *Excessive heat*

Human Sources (causes)

Water cooling of electric power plants and some types of industrial plants. Almost half of all water withdrawn in United States each year is for cooling electric power plants.

Effects

(i) Lowers dissolved oxygen levels and makes aquatic organisms more vulnerable to disease, parasites and toxic chemicals.

(ii) When a power plant first opens (or) shuts down for repair, fish and other organisms adapted to a particular temperature range can be killed by the abrupt change in water temperature known as thermal shock.

9. Point and Non-point Sources of Water Pollution

(i) Point Sources

Point sources are discharged pollutants at specific locations through pipes, ditches (or) sewers into bodies of surface water.

Examples *Includes factories, sewage treatment plants, abandoned underground mines and oil tankers.*

(ii) Non-point sources

They are usually large land areas (or) air sheds that pollute water by runoff, subsurface flow (or) deposition from the atmosphere. Location of which cannot be easily identified.

Examples *Include acid deposition and runoff of chemicals into surface water from croplands, livestock feedlots, logged forests, urban street, lawn, golf courses and parking lots.*

2.3.2 Characteristics (or) Testing of river water (waste water)

1. Dissolved oxygen (DO)

Dissolved oxygen (DO) is the amount of oxygen dissolved in a given quantity of water at a particular pressure and temperature.

Significance of DO

(i) DO is vital for the support of fish and other aquatic life in river water.

(ii) It determines whether the biological changes are brought about by aerobic (or) anaerobic micro-organisms.

(iii) DO determinations serve as the means of control of river pollution.

(iv) A minimum level of DO (4 mg/lit) must be maintained in rivers so as to support the aquatic life in a healthy condition. Thus, it is necessary to ensure that the treated water must have atleast 4 mg/lit of DO before its disposal into river.

2. Biochemical Oxygen Demand (BOD)

BOD is the amount of oxygen required for the biological decomposition of organic matter present in the water.

Significance of BOD

(i) It is an important indication of the amount of organic matter present in the river water.

(ii) Since complete oxidation occurs in indefinite period, the reaction period is taken as 5 days at 20°C. For all practical purposes, it is written as BOD_5.

(iii) The rate of oxidation and demand depends on the amount and type of organic matter present in river water.

3. Chemical Oxygen Demand (COD)

COD is the amount of oxygen required for chemical oxidation of organic matter using some oxidising agent like $K_2Cr_2O_7$ and $KMnO_4$.

Significance of COD

(i) It is carried out to determine the pollutional strength of river water.

(ii) It is rapid process and takes only 3 hours.

2.3.3 Control (or) Preventive measures (methods) of water pollution

1. The administration of water pollution control should be in the hands of State (or) Central Government.
2. Scientific techniques are necessary to be adopted for the environmental control of catchment areas of rivers, ponds (or) streams.
3. The industrial plants should be based on recycling operations, because it will not only stop the discharge of industrial wastes into natural water sources but by products can be extracted from the wastes.
4. Plants, trees and forests control pollution and they acts as natural air conditioners.
5. Forests in and around big cities and industrial establishments are capable of reducing the sulphur dioxide and nitric oxide pollutants to a greater extent from the atmosphere. Hence the national goal should be "Conservation of Forests" and campaign should be "Plant more trees". The global destruction of forests should be discouraged (or) atleast minimized and afforestation should be encouraged because no one on this earth will escape from the adverse effects of a balding earth.
6. It is not advisable to discharge any type of waste, either treated, partially treated (or) untreated, into streams, rivers, lakes, ponds and reservoirs. The industries are expected to develop close-loop water

supply schemes and domestic sewage may be used for irrigation.

7. Highly qualified and experienced persons should be consulted from time to time for effective control of water pollution.
8. Public awareness regarding adverse effects of water pollution is a must. So there should be propaganda for water pollution control on radios, TVs etc.,
9. Suitable laws, standards and practices should be framed to regulate the discharge of undesirable flow of water in water bodies and such regulations should be modified from time to time in order to accommodate the changing requirements and technological advancements.
10. Basic and applied research in public health engineering should be encouraged.
11. The possible reuse (or) recycle of treated sewage effluents and industrial wastes should be emphasized and encouraged.

2.3.4 Waste Water (or) Sewage Treatment

Objectives of waste water treatment

The main objectives of waste water treatment are

(i) to convert harmful compounds into harmless compounds.

(ii) to eliminate the offensive smell.

(iii) to remove the solid content of the sewage.

(iv) to destroy the disease producing microorganisms.

Treatment process

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

I. Preliminary Treatment

In this treatment, coarse solids and suspended impurities are removed by passing the waste water through bar and mesh screens.

II. Primary treatment (or) Settling process

In this treatment, greater proportion of the suspended inorganic and organic solids are removed from the liquid sewage by settling. In order to facilitate quick settling coagulants like alum, ferrous sulphate are added. These produce large gelatinous precipitates, which entrap finely divided organic matter and settle rapidly.

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

III. Secondary (or) Biological treatment

In this treatment, biodegradable organic impurities are removed by aerobic bacteria. It removes upto 90% of the oxygen demanding wastes. This is done by trickling filter (or) activated sludge process.

(a) Trickling filter process

It is a circular tank and is filled with either coarse (or) crushed rock. Sewage is sprayed over this bed by means of slowly rotating arms (Fig. 2.2).

When sewage starts percolating downwards, microorganisms present in the sewage grow on the surface of filtering media using organic material of the sewage as food. After completion of aerobic oxidation the treated sewage is taken to the settling tank and the sludge is removed. This process removes about 80-85% of BOD.

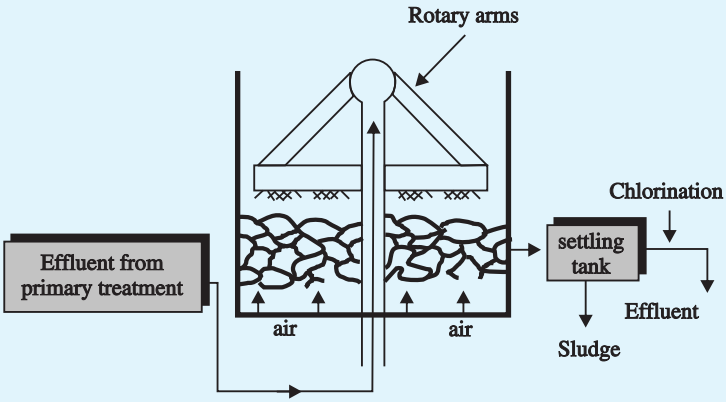


Fig. 2.2 Trickling filter

(b) Activated sludge process

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

The sewage effluent from primary treatment is mixed with the required amount of activated sludge. Then the mixture is aerated in the aeration tank (Fig. 2.3). Under these condition, organic impurities of the sewage get oxidised rapidly by the microorganisms.

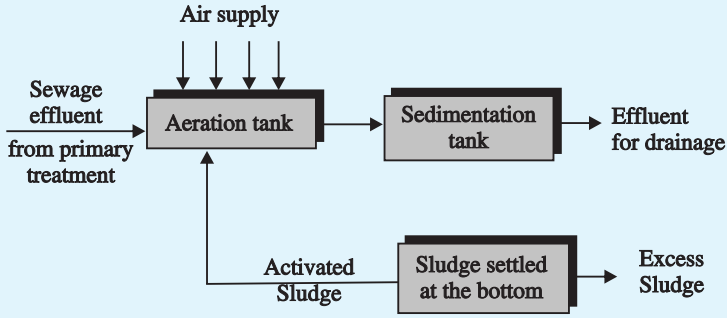


Fig. 2.3 Activated Sludge Process

After aeration, the sewage is taken to the sedimentation tank. Sludges settle down in this tank, called activated sludge, a portion of which is used for seeding fresh batch of the sewage. This process removes about 90-95% of BOD.

IV. Tertiary treatment

After the secondary treatment, the sewage effluent has a lower BOD (25 ppm), which can be removed by the tertiary treatment process.

In the tertiary treatment, the effluent is introduced into a flocculation tank, where lime is added to remove phosphates. From the flocculation tank the effluent is led to ammonia stripping tower, where pH is maintained to 11 and the $NH_4^{\oplus}$ 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).

V. Disposal of sludge

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

(i) dumping into low-lying areas.

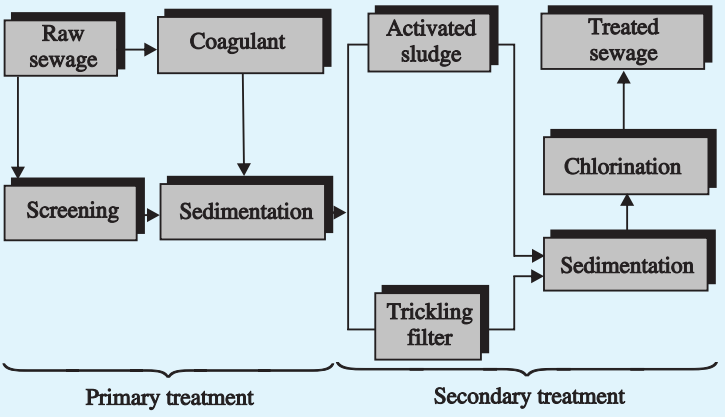
(ii) burning of sludge (incineration),

(iii) dumping into the sea,

(iv) using it as low grade fertilizers.

The flow sheet diagram of sewage treatment

Flow Chart



2.3.5 Specifications for Drinking Water

The common specifications recommended by the U.S Public Health for Drinking Water are given below.

(i) Water should be clear and odourless.

(ii) It should be cool.

(iii) It should be pleasant to taste.

(iv) Turbidity of the water should not exceed 10 ppm.

(v) pH of the water should be in the range of 7.0 - 8.5.

(vi) Chloride and sulphate contents should be less than 250 ppm.

(vii) Total hardness of the water should be less than 500 ppm.

(viii) Total dissolved solids should be less than 500 ppm.

(ix) Fluoride content of the water should be less than 1.5 ppm.

(x) The water must be free from disease-producing bacteria.

(xi) Water should be free from objectionable dissolved gases like H_2S.

(xii) Water should be free from objectionable minerals such as lead, chromium, manganese and arsenic salts.

2.3.6 Water Quality Standards

Water used for drinking should have certain quality. The following table 2.2 summarises several quality criteria and their standards for drinking water.

Table 2.2 Standards for drinking water

S. No.	Parameter	WHO standard in mgs/litre	ISI standard in mgs/litre.
1.	Colour, odour and taste.	Colourless, odourless and tasteless.	Colourless, odourless and tasteless.
2.	pH	6.9	6.9
3.	Total dissolved solids	1,500	-
4.	Dissolved oxygen	-	3.0
5.	Chloride	250	600
6.	Sulphate	400	1,000
7.	Nitrate	45	-
8.	Cyanide	0.2	0.01
9.	Fluoride	1.5	3.0
10.	Chromium	0.05	0.05
11.	Lead	0.05	0.1
12.	Arsenic	0.05	0.2

Significance of the parameters

1. Chlorides: Although chlorides are not considered as harmful as such, their concentrations over 250 mg/lit impart peculiar taste to water, which is unacceptable for drinking purposes.

2. Sulphates: When sulphates are present in excess amount in drinking water, they may produce a cathartic effect on the people consuming such water.

3. Nitrates: Excessive concentrations of nitrates are undesirable especially for infants. The maximum contaminant level for nitrate is 10 mg/lit.

4. Fluorides: Optimum fluoride concentrations prescribed in drinking water is in the range of 0.7 to 1.2 mg/lit. Low concentration of fluoride in drinking water causes dental problem in children. Excessive concentration causes fluorosis (discoloration and chipping of teeth).

5. Arsenic: Arsenic is a toxic heavy metal even a very small dose can result in severe poisoning. Only 0.05 mg/lit has been recommended for arsenic in drinking water.

2.4 SOIL POLLUTION

Definition

Soil pollution is defined as, ***"the contamination of soil by human and natural activities which may cause harmful effects on living beings."***

Table 2.3 Composition of soil

Components	%
Mineral matter (inorganic)	45
Organic matter	5
Soil water	25
Soil air	25

2.4.1 Types, effects and sources (causes) of soil pollution

Soil pollution mainly results from the following sources

1. Industrial wastes.
2. Urban wastes.
3. Agricultural practices.
4. Radioactive pollutants.
5. Biological agents.

1. Industrial wastes

Disposal of industrial wastes is the major problem for soil pollution.

Sources

The industrial pollutants are mainly discharged from the various origins such as pulp and paper mills, chemical industries, oil refineries, sugar factories, tanneries, textiles, steel, distilleries, fertilizers, pesticides, coal and mineral mining industries, drugs, glass, cement, petroleum and engineering industries etc.,

Effect

These pollutants affect and alter the chemical and biological properties of soil.

As a result, hazardous chemicals can enter into human food chain from the soil (or) water and disturb the biochemical process and finally lead to serious effects on living organisms.

2. Urban wastes

Urban wastes comprises both commercial and domestic wastes consisting of dried sludge of sewage. All the urban solid wastes are commonly referred to as refuse.

Constituents of urban refuse

This refuse contains garbage and rubbish materials like plastics, glasses, metallic cans, fibres, paper, rubbers, street sweepings, fuel residues, leaves, containers, abandoned vehicles and other discarded manufactured products. Urban domestic wastes though disposed off separately from the industrial wastes, can still be dangerous. This is so because they cannot be easily degraded.

3. Agricultural practices

Modern agricultural practices pollute the soil to a large extent. Today with the advancing agro-technology, huge quantities of fertilizers, pesticides, herbicides, weedicides are added to increase the crop yield. Apart from these farm wastes, manure, slurry, debris, soil erosion containing mostly inorganic chemicals are reported to cause soil pollution.

4. Radioactive pollutants

Radioactive substances resulting from explosions of nuclear dust and radioactive wastes (produced by nuclear testing laboratories and industries) penetrate the soil and accumulate there by creating land pollution.

Examples

1. Radio nuclides of radium, thorium, uranium, isotopes of potassium (K-40) and carbon (C-14) are very common in soil, rock, water and air.
2. Explosion of hydrogen weapons and cosmic radiations induce neutron, proton reactions by which nitrogen (N-15) produces C-14. This C^{14} participates in the carbon metabolism of plants which is then introduced into animals and man.
3. Radioactive waste contains several radio nuclides such as Strontium-90, Iodine-129, Cesium-137 and isotopes of iron which are most injurious. Sr-90 gets deposited in bones and tissues instead of calcium.
4. Nuclear reactor produces waste containing Ruthenium-106, Iodine-131, Barium-140 and Lanthanum-140, Cesium-144 along with the primary nuclides Sr-90 and Cs-137 has a half life of 30 years while Sr-90 has 28 years. Rain water carries Sr-90 and Cs-137 to be deposited on the soil where they are held firmly with the soil particles by electrostatic forces. All these radio nuclides deposited on the soil emit gamma radiations.

5. Biological agents

Soil gets large quantities of human, animal and bird's excreta which constitute the major source of land pollution by biological agents.

Examples

1. Heavy application of manures and digested sludges could cause serious damage to plants within a few years. Because the sludges are containing more live viruses and viable intestinal worms.

2. In addition to these excreta, faulty sanitation, municipal garbage, waste water and wrong methods of agricultural practices also induce heavy soil pollution.

Table 2.4 Major physico-chemical characteristics of untreated wastes of Organic chemical industries in Soil

S. No.	Industry	Physico-chemical characteristics
1.	Pulp and paper	Suspended solids, high (or) low pH, colour, fibres, BOD, COD, high temperature, fibres.
2.	Rubber industry	Chlorides, suspended and dissolved solids, variable pH and high BOD.
3.	Oil refineries	Acids, alkalis, phenols, resinous materials and petroleum oils.
4.	Antibiotics	Toxic organics and high acidity (or) alkalinity.
5.	Synthetic drugs	High suspended and dissolved organic matter including vitamins.
6.	Distillery	Very high COD, low pH, high organic matter, high suspended and dissolved solids containing nitrogen, high potassium.
7.	Organic chemical industry	Toxic compounds, phenols, high acidity, alkalinity.

Table 2.5 Major physico-chemical characteristics of untreated wastes of Inorganic chemical industries in Soil

S. No.	Industry	Physico-chemical characteristics
1.	Thermal Power Plants	Heat, heavy metals, dissolved solids and inorganic compounds.
2.	Steel Mills	Acids, phenols, low pH, alkali, limestone, oils, fine suspended solids, cyanides, cyanates, iron salts, ores and coke.
3.	Cotton Industry	Sodium, organic matter, colour, high pH and fibres.
4.	Metal Plating	Metallics, toxic cyanides, cadmium, chromium, zinc, copper, aluminium and low pH.
5.	Iron Foundry	Coal, clay, suspended solids and iron.
6.	Pesticides	Aromatic compounds, acidity and high organic matter.
7.	Acids	Low pH and organic content.
8.	Tanneries	Calcium, chromium, high salt content, colour, dissolved and suspended matter.
9.	Explosives	Alcohol, metals, TNT and organic acids.

2.4.2 Control (or) Preventives measures of soil pollution

The pressure on intensification of farm activities increases for two reasons.

1. Population growth.
2. Decrease of the available farm land due to urbanization.

1. Control of Soil erosion

Soil erosion can be controlled by a variety of forestry and farm practices.

Example

(a) Trees may be planted on barren slopes.

(b) Contour cultivation and strip cropping may be practiced instead of shifting cultivation.

(c) Terracing and building diversion channels may be undertaken.

Reducing deforestation and substituting chemical manures by animal wastes would also help to arrest soil erosion in the long term. Maintaining soil productivity is vital and essential for sustainable agriculture.

2. Proper dumping of unwanted materials

Excess of waste products by man and animals cause chronic disposal problem. Open dumping is most commonly practiced method. Recently controlled tipping is followed for solid waste disposal. The surface so obtained then can be used for housing (or) sports field.

3. Production of natural fertilizers

Excessive use of chemical fertilizers and insecticides should be avoided. Biopesticides should be used in place of toxic chemical pesticides.

Example *Organic wastes contained in animals dung can be used for preparing compost manure and biogas rather than throwing them wastefully polluting the soil.*

4. Proper Hygienic condition

People should be trained regarding the sanitary habits.

Example *Lavatories should be equipped with quick and effective disposal methods.*

5. Public Awareness

Informal and formal public awareness programs should be imparted to educate people on health hazards by environmental pollution.

Example *Mass media, educational institutions and voluntary agencies can achieve this.*

6. Recycling and Reuse of wastes

To minimize soil pollution, the wastes such as paper, plastics, metals, glasses, organics, petroleum products and industrial effluents etc., should be recycled and reused.

Example *Industrial wastes should be properly treated at source. Integrated waste treatment method should be adopted.*

7. Ban on Toxic Chemicals

Ban should be imposed on chemicals and pesticides like DDT, BHC etc., which are fatal to plants and animals.

Nuclear explosions and the improper disposal of radioactive wastes should be banned.

2.5 NOISE POLLUTION

Definition

Noise pollution is defined as, ***"the unwanted, unpleasant (or) disagreeable sound that causes discomfort for all living beings."***

Unit of Noise (Decibel)

The sound intensity is measured in decibel (dB), which is one tenth of the longest unit Bel. One dB is equal to the faintest sound, a human ear can hear.

Noise level

Normal conversation sound ranges from 35 dB to 60 dB. Impairment of hearing takes place due to exposure to noise of 80 dB (or) more. Noise above 140 dB becomes painful.

2.5.1 Types and sources (causes) of noise

It has been found that environmental noise is doubling every 10 years. Generally noise is described as,

1. Industrial noise.
2. Transport noise.
3. Neighbourhood noise.

1. Industrial Noise

Highly intense sound (or) noise pollution is caused by many machines. There exists a long list of sources of noise pollution including different machines of numerous factories, industries and mills. Industrial noise, particularly

from mechanical saws and pneumatic drill is unbearable and is a nuisance to public.

Recently, it has been observed by the Institute of Oto-Rino Laryngology, Chennai that enormously increasing industrial pollution has damaged the hearing of about 20% workers.

Example *In the steel industry, the workers near the heavy industrial blowers are exposed to 112 dB for eight hours and suffer from the occupational pollution.*

2. Transport Noise

The main noise, comes from transport. It mainly includes road traffic noise, rail traffic noise and air craft noise. The number of road vehicles like motors, scooters, cars, motor cycles, buses, trucks and particularly the diesel engine vehicles have increased enormously in recent years.

That is why, this form of pollution is gaining importance, especially in large and over crowded towns and cities. According to experts, the noise level in most of the residential areas in metropolitan cities is already hovering on the border line because of vehicular noise pollution.

A survey conducted in metropolitan cities has shown that noise level in Delhi, Bombay and Calcutta is as high as 90 dB. Inhabitants of cities are subjected to this most annoying form of transport noise which gradually deafen them.

3. Neighbourhood Noise

This type of noise includes disturbance from household gadgets and community. Common noise makers are musical instruments, TV, VCR, radios, transistors, telephones, and loudspeakers etc., Ever since the industrial

revolution, noise in environment has been doubling every ten years.

2.5.2 Effects of Noise Pollution

1. Noise Pollution affects human health, comfort and efficiency. It causes contraction of blood vessels, makes the skin pale, leads to excessive secretion of adrenalin hormone into blood stream which is responsible for high blood pressure. Blaring sounds have known to cause mental distress, heart attacks neurological problems, birth defects and abortion.
2. It causes muscles to contract leading to nervous breakdown, tension etc.,
3. These adverse reactions are coupled with a change in hormone content of blood, which in turn increase the rate of heart beat, contraction of blood vessels, and dilation of pupil of eye.
4. It affects health efficiency and behaviour. It may cause damage to heart, brain, kidneys, liver and may also produce emotional disturbances.
5. The most immediate and acute effect of noise is the impairment of hearing which diminishes by the damage of some part of auditory system. When exposed to very loud and sudden noise acute damage occurs to the ear drum. Prolonged exposure to noise of certain frequency pattern will lead to chronic damage to the hair cells in the inner ear.
6. In addition to serious loss of hearing due to excessive noise, impulsive noise also causes psychological and pathological disorders.
7. Ultrasonic sound can affect the digestive, respiratory, cardio vascular systems and semicircular canals of the internal ear. The rate of heart beat may also be

affected. It may decrease (or) increase depending on the type of noise.

8. Brain is also adversely affected by loud and sudden noise as that of jet and aeroplane noise etc. People are subjected to Psychiatric illness.
9. Recently it has been reported that blood is also thickened by excessive noises.
10. It is quite surprising that our optical system is also a prey for noise pollution. Pupillary dilation, impairment of night vision and decrease in the rate of colour perception are some of its severe effects.

2.5.3 Control (or) Preventive measures of noise pollution

1. Source Control

This may include source modification such as acoustic treatment to machine surface, design changes, limiting the operational timings and so on.

2. Transmission Path Intervention

This may include containing the source inside a sound insulating enclosure, construction of a noise barrier (or) provision of sound absorbing materials along the path.

3. Receptor control

This includes protection of the receiver by altering the work schedule (or) provision of personal protection devices such as ear plugs for operating noisy machinery. The measure may include dissipation and deflection methods.

4. Oiling

Proper oiling will reduce the noise from the machines.

5. Planting trees around houses can also act as effective noise barriers.

6. Different types of absorptive materials can be used to control interior noise.

2.5.4 Other Preventive measures

Noise can be reduced by prescribing noise limits for vehicular traffic, ban on honking of horns in certain areas and creation of silent zones near schools and hospitals and redesigning of buildings to make them noise proof. Other measures can involve reduction of traffic density in residential areas and giving preferences to mass public transport system.

Table 2.6: 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

2.6 SOLID WASTE MANAGEMENT (OR) WASTE SHED MANAGEMENT

Rapid population growth and urbanization in developing countries have led to the generations of enormous quantities of solid wastes and consequential environmental degradation. An estimated 7.6 million tonnes of municipal solid waste is produced per day in developing countries. These wastes are disposed in open dumps

creating considerable nuisance and environmental problems. These are potential risks to health and to the environment from improper management of solid wastes. Management of solid waste is therefore, become very important in order to minimize the adverse effects of solid wastes.

Definition

Solid waste management is the process of collecting, treating and disposing of solid waste.

2.6.1 Types and sources of solid wastes

Depending upon the nature, solid wastes can be broadly classified into three types

1. Urban (or) Municipal wastes.
2. Industrial wastes.
3. Hazardous wastes.

I. Sources of Urban (Municipal) Wastes

Urban (or) municipal wastes include the following wastes

(a) Domestic wastes

It contains a variety of materials thrown out from the homes.

Examples *Food waste, cloth, waste paper, glass bottles, polythene bags, waste metals, etc.,*

(b) Commercial wastes

It includes the wastes coming out from the shops, markets, hotels, offices, institutions, etc.,

Examples *Waste paper, packing material, cans, bottle, polythene bags, etc.,*

(c) Construction wastes

It includes the wastes of construction materials.

Examples *Wood, concrete, debris etc.,*

(d) Biomedical wastes

It includes mostly the waste organic materials.

Examples *Anatomical wastes, infectious wastes, etc.,*

Type and characteristics of Urban (municipal) Wastes

(i) Bio-degradable wastes

The urban solid waste materials, that can be degraded by micro organisms are called biodegradable wastes.

Examples *Food, vegetables, tea leaves, egg shells, dry leaves, etc.,*

(ii) Non - Biodegradable wastes

The urban solid waste materials that cannot be degraded by micro organisms are called non-biodegradable wastes.

Examples Polythene bags, scrap metals, glass bottles, etc.,

II Source and Characteristics of Industrial Wastes

The main sources of industrial wastes are chemical industries, metal and mineral processing industries.

Examples

(i) Nuclear power plants

It generates radioactive wastes.

(ii) Thermal power plants

It produces fly ash in large quantities.

(iii) Chemical industries

It produces large quantities of hazardous and toxic materials.

(iv) Other industries

Other industries produce, packing materials, rubbish, organic wastes, acids, alkalis, scrap metals, rubber, plastic, paper, glass, wood, oils, paints, dyes, etc.,

2.6.2 Effect of Solid Wastes (or) Effect of Improper Solid Waste Management

1. 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.

2. Industrial solid wastes are the sources of toxic metals and hazardous wastes, which affect the soil characteristics and productivity of soils when they are dumped on the soil.

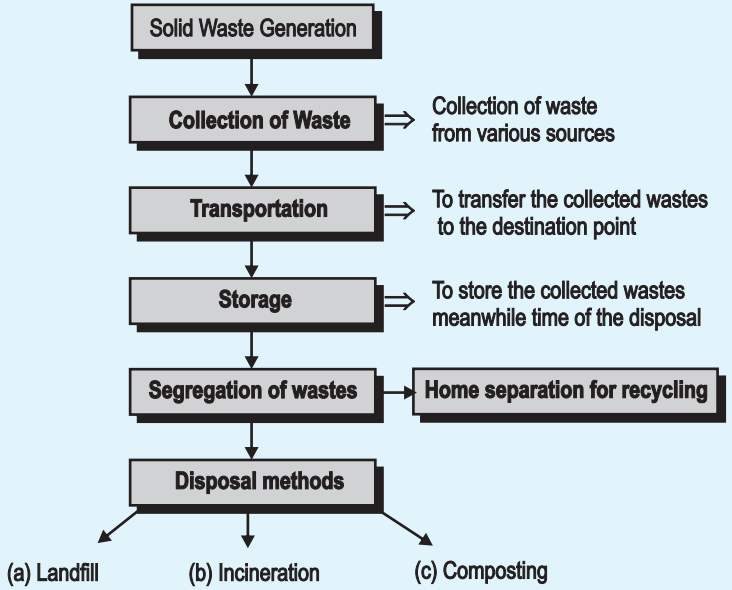
3. Toxic substances may percolate into the ground and contaminate the ground water.

4. Burning of some of the industrial wastes (or) domestic wastes (like cans, pesticides, plastics, radioactive materials, batteries) produce furans, dioxins and polychlorinated biphenyls, which are harmful to human beings.

2.6.3 Process of Solid Waste Management (or) Process of preventing solid waste generation in urban areas (or) Waste Shed Management

Solid waste management includes, the waste generation, mode of collection, transportation, segregation of wastes and disposal techniques.

Flow Chart



Steps Involved in Solid Waste Management (or) Waste Shed Management

Two important steps of solid waste (waste shed) management is

Reduce, reuse and recycle, before destruction and safe storage of wastes.

I Reduce, Reuse and Recycle (3R)

(a) Reduce the usage of raw materials

If the usage of raw materials are reduced, the generation of waste also gets reduced.

(b) Reuse of waste materials

(a) The refillable containers, which are discarded after use, can be reused.

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

(c) Recycling of materials

Recycling is the reprocessing of the discarded materials into new useful products.

Examples

(a) Old aluminium cans and glass bottles are melted and recast into new cans and bottles.

(b) Preparation of cellulose insulation from paper.

(c) Preparation of fuel pellets from kitchen waste.

(d) Preparation of automobiles and construction materials from steel cans.

The above process saves money, energy, raw materials, and reduces pollution.

II Discarding wastes

For discarding solid wastes the following methods can be adopted.

Methods of disposal of solid waste

1. Landfill 2. Incineration (Thermal) 3. Composting

1. Landfill

Solid wastes are placed in sanitary landfill system in alternate layers of 80 cm thick refuse, covered with selected earth fill of 20 cm thickness. After two (or) three years, solid waste volume shrinks by 25-30% and the land is used for parks, roads and small buildings.

The most common and cheapest method of waste disposal is dumping in sanitary land-fills which is invariably employed in Indian cities. Land-fill structure is built either into the ground (or) on the ground into which the waste is dumped. The method involves spreading the solid waste on the ground, compacting it and then covering it with soil at suitable intervals.

Advantages

1. It is simple and economical.
2. Segregation not required.
3. Landfilled areas can be reclaimed and used for other purposes.
4. Converts low-lying, marshy waste-land into useful areas.
5. Natural resources are returned to soil and recycled.

Disadvantages

1. A large area is required.
2. Since land is available away from town, transportation cost is heavy.
3. Bad odours, if landfills are not properly managed.
4. The land filled areas will be the sources of mosquitoes and flies and hence insecticides and pesticides are to be applied at regular intervals.
5. Causes fire hazard due to the formation of methane in wet weather.

2. Incineration (or) Thermal process

It is a hygienic way of disposing solid waste. It is more suitable if the waste contains more hazardous material and organic content. It is a thermal process and is very effective for detoxification of all combustible pathogens. It is an expensive technology compared to land-fill and composting because incinerators are costly.

In this method the municipal solid wastes are burnt in a furnace called incinerator. The combustible substances such as rubbish, garbage, dead organisms and the noncombustible matter such as glass, porcelain, metals are separated before feeding to incinerators. The noncombustible materials can be left out for recycling and reuse. The left out ashes and clinkers from the incinerators may be accounted for only about 10 to 20% which need further disposal either by sanatory landfill (or) by some other means.

The heat produced in the incinerator during the burning of refuse is used in the form of steam power for generation of electricity throughout turbines. The municipal solid waste is generally wet but has a very high calorific value so it has to be dried up first before burning. The waste is dried in preheater from where it is taken into large incinerating furnace called destructors which can incinerate about 100 to 150 tonnes per hour. The temperature normally maintained in a combustion chamber is about 700°C and may be increased to about 1000°C when electricity is to be generated.

Advantages

1. The residue is only 20-25% of original weight, the clinker can be used after treatment.
2. It requires very little space.

3. Cost of transportation is not high as incinerators located within city limits.
4. Safest from hygienic point of view.
5. An incinerator plant of 300 tonnes per day capacity can generate 3MW of power.

Disadvantages

1. Its capital and operating cost is high.
2. Needs skilled personnel.
3. Formation of smoke, dust and ashes needs further disposal, due to which air pollution may be caused.

3. Composting

It is another popular method practiced in many cities in our country. In this method, bulk organic waste is converted into a fertilising manure by biological action.

The separated compostable waste is dumped in underground earthern trenches in layers of 1.5 m and is finally covered with earth of about 20 cm and left over for decomposition. Sometimes certain microorganisms such as actinomycetes are introduced 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 75°C and finally the refuse is converted to powdery brown coloured odourless mass known as humus and has a fertilizing value which can be used for agricultural field. The compost contains lot of nitrogen essential for plant growth apart from phosphates and other minerals.

World Health Organisation (WHO) has set up a compost plant in New Delhi in 1981 with a capacity to handle 90 to 100 tonnes of waste everyday. The prepared compost was supplied to nurseries, kitchen gardens and

horticulture department. The composting technology is widely employed in developing countries.

Advantages

1. When the manure is added to soil, it increases the water retention and ion-exchange capacity of soil.
2. A number of industrial solid wastes can also be treated by this method.
3. It can (manure) be sold thereby reducing the cost of disposing of wastes.
4. Recycling - occurs.

Disadvantages

1. The non-consumables have to be disposed separately.
2. Use of compost has not yet caught up with farmers and hence no assured market.

2.7 HAZARDOUS WASTE

It is the waste that has potential threats to public health (or) the environment.

Examples

(i) Cleaning solvents (acids and bases).

(ii) Spent acids and bases.

(iii) Metal finishing wastes.

(iv) Painting wastes.

(v) Sludges from air and water pollution control units.

(vi) Disinfectants and pesticides.

2.7.1 Types and characteristics of hazardous wastes

1. Toxic wastes

These are poisonous even in very small (or) trace amounts. They may have

(i) Acute effects

Causing death (or) violent illness

(ii) Chronic effects

Slowly causing irrseparable harm.

2. Carcinogenic waste

It causes cancer after many years of exposure.

3. Mutagenic

It causes major biological changes in the off-spring of exposed humans and wild life.

4. Reactive wastes

These are chemically unusable and react violently with air (or) water. They cause explosions (or) form toxic vapours.

5. Ignitable wastes

They burn at relatively low temperatures and cause an immediate fire hazard.

6. Corrosive wastes

These include strong acidic (or) alkaline substances. They destroy solid material and living tissue upon contact.

7. Infectious wastes

These include used bandages, hypodermic needles from hospitals (or) biological research facilities.

8. Radioactive wastes

These emit ionizing energy that can harm living organisms.

2.7.2 Hazardous waste management

Definition

It is the collection, treatment and disposal of waste materials that can cause substantial harm to human health (or) to the environment.

Improper hazardous-waste storage (or) disposal contaminates surface water and ground water supplies as harmful water pollution and land pollution. People living in homes, built near waste disposal sites, may be in a vulnerable position. The best remedy for this problem is to regulate the practice of hazardous - waste management.

2.7.3 Various steps of hazardous waste management

Hazardous waste management involves the following 4 steps

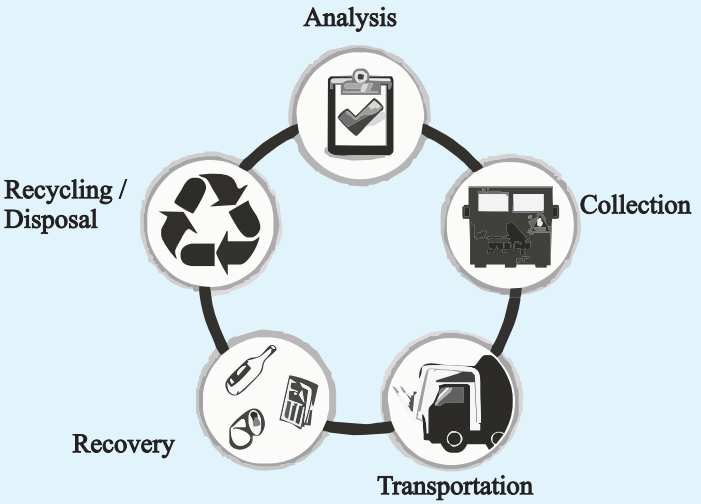


Fig 2.4 Steps of hazardous waste management

Step 1: Analysis:

Physical and chemical properties of hazardous waste must be analysed before collection and recovery of useful components. It is essential because it can be used as a fertilizer, liming material (or) soil amendment.

Step 2: Collection and transport

Hazardous waste, generated at a particular place, is generally collected and transported by truck over public highways. It can also be shipped in tank trucks, made of steel (or) aluminium alloy, with capacities upto about 34,000 litres. It can be containerized and shipped in 200 litre drums.

Step 3: Treatment (or) Recovery

Hazardous waste can be treated (or) recovered by

(i) Chemical method.
(ii) Thermal method.
(iii) Biological method.
(iv) Physical method.

1. Chemical method

It includes ion-exchange, precipitation, oxidation and reduction and neutralization.

2. Thermal method

High temperature incineration

It not only can detoxify certain organic wastes but also can destroy them.

Special type of thermal equipment

Examples

Fluidized-bed incinerator, multiple hearth furnace, rotary kiln and liquid-injection incinerator.

Problem

Hazardous-waste incineration is the source of air pollution.

3. Biological treatment

Example *Land farming*

Land farming is one method of treating hazardous waste biologically, in which waste is mixed with surface soil on a suitable land. Microbes that can metabolize the waste may be added, along with nutrients.

Bio-remediation

Microbes can also be used for stabilizing hazardous wastes on previously contaminated sites. This process is called bio-remediation.

4. Physical treatment

Example

Evaporation, sedimentation, solidification, flotation and filtration.

The above treatment concentrates, solidifies (or) reduces the volume of the waste. Solidification is achieved by encapsulating waste in concrete, asphalt (or) plastic container. Encapsulation produces a solid mass of material that is resistant to leaching.

Step 4: Storage and disposal

Hazardous wastes that are not destroyed by incineration (or) other chemical processes need to be disposed properly. This can be done by the following methods.

1. Surface storage (or) containment systems - Temporary method

It includes

(i) New waste piles

(ii) Ponds (or) lagoons.

(i) New waste piles

It is carefully constructed over an impervious base. The piles must be protected from wind dispersion, erosion and leaching. Only non-containerized solid, non-flowing waste material can be stored in a new waste pile.

(ii) Ponds (or) lagoons

It is lined with impervious clay soils and flexible membrane liners inorder to protect ground water. Leachate collection systems is installed between the liners.

2. Deep-well injection

It involves pumping liquid waste through a steel casing into a porous layer of limestone (or) sandstone. High pressure is applied to force the liquid into the pores, where it is permanently stored.

3. Land fills

It provides at least 3 metres (10 ft) of separation between the bottom of the landfill and the underlying bed rock (or) ground water table. It is also provided with two impermeable liners and leachate collection system, which pumps the collected leachate to a treatment plant.

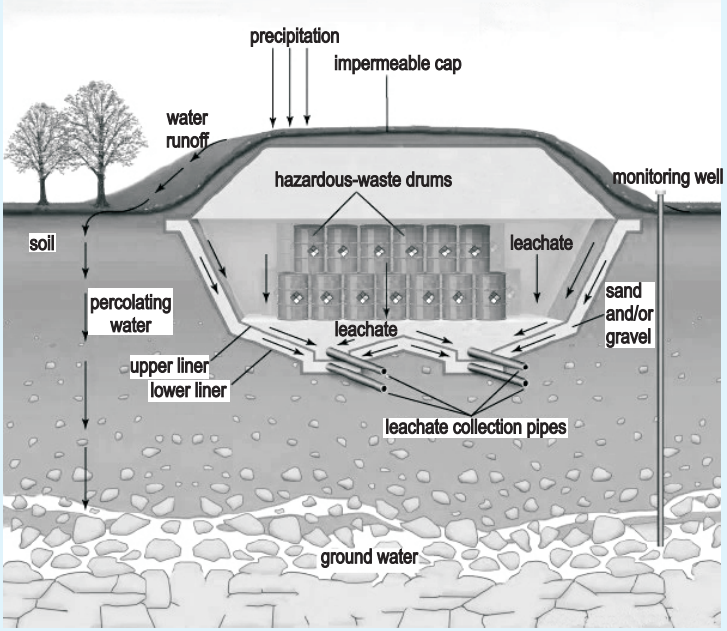


Fig. 2.5 Storage of Hazardous waste in Land fill

2.8 e - WASTE (Electronic Waste)

Definition

e-waste describes discarded electrical (or) electronic devices.

e-wastes are considered dangerous because they contain hazardous chemicals. The hazardous content of e-waste pose a threat to human health and environment.

Fig. 2.6 e-waste logo

2.8.1 Hazardous chemicals in e-wastes (or) Causes of e-wastes

Some of the hazardous chemicals present in some e-wastes are

1. Circuit boards in computer have heavy metals like lead and cadmium.
2. Batteries have cadmium.
3. Cathode ray tubes have lead oxide and barium.
4. Most of the electronic products have polyvinyl chloride.
5. Plastics have dioxins and furans.

So, if these waste electronic products are not properly disposed, they can leach hazardous elements such as lead, cadmium and other chemicals into the soil and ground water and cause severe threat to environment.

2.8.2 e-waste management

Definition

e-waste management is defined as a holistic method of cutting down e-waste from the earth to prevent its harmful toxic to deteriorate earth.

Management of e-waste should begin at the point of generation. This can be done by waste minimisation techniques and by sustainable product design.

Some e-waste management techniques

Waste management in industries involves adopting,

(a) inventory management,

(b) production process modification,

(c) sustainable product design,

(d) use of renewable raw materials.

1. Inventory management

Proper control over the materials, used in the manufacturing process, is an important way to reduce waste generation. By reducing the quantity of hazardous materials, used in the process, e-waste could be reduced.

2. Production process modification

By changing the production process e-waste generation can be minimised.

3. Sustainable product design

Efforts should be made to design a product with less amount of hazardous material.

Example

New computer designs that are lighter and more integrated.

4. Use of renewable materials

Bio based plastics are plastics made with plant based chemistry (or) plant producted polymers. Most e-waste have non-degradable polymers in them. By using these bio polymers we can reduce 'e'-wastes. Like wise bio based toners, glues and inks are new development e-wastes.

2.9 OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM (OHASMS)

An occupational health and safety management system (OHASMS) is a fundamental part of an organization's risk management strategy. It enables an organization to protect its work force and others under its control.

Importance

It reduces risk (or) accidents (or) injuries by identifying and mitigating hazards.

2.9.1 Case studies on OHASMS

1. A footwear manufacturing industry in Ambur, Tamil Nadu

Objective

The main objective of this case study is to assess the status of occupational health and safety of a footwear manufacturing industry with respect to the social compliance.

Observation

We have visited Azim leather and footwear industries. Ambur, Tamil nadu. Overall occupational health and safety management practice in Azim leather and footwear industries was found to be good.

Production Process

Production process of Azim industries starts after collecting the raw materials, cutting them, assembling, joining the insole and outsole to the shoe, finishing and packing. Lots of people engaged during this production process. About 70% of total workers are female. In every section, Azim industries have employed experts to look after the work of the worker and improve the efficiency.

Some of the encouraging approaches observed in Azim industry

(i) Positive attitude of owner towards welfare of the workers.

(ii) Dedicated work force.

(iii) Experienced and professional management team.

(iv) Good relationship between management and workers.

(v) Disbursement of salary and wages to workers.

(vi) First aid box is found in all floors according to requirements of Indian labour rules.

(vii) Factory has own health centre to provide primary treatment.

(viii) Certified physician and nurse were available during the visit.

(ix) Factory has its child care centre.

(x) Factory has well maintained hygienic canteen.

(xi) Factory is conducting fire drill regularly.

(xii) Regular testing of drinking water, etc., is carried out.

Deficiency observed in Azim Industry and solution

According to environmental conservation rules, labour rules of Indian Government and International guide lines, below findings are observed during factory visit and discussed the solutions with management.

1. Management should maintain cleanliness of the area.
2. Management should place temperature and humidity measuring device in workplace because excessive heat and humidity are injurious for workers health.
3. Management should monitor and maintain sufficient and suitable lightings.
4. Factory must display material safety data sheet at all chemical storage areas.
5. Factory should confirm risk assessment for entire work place health and safety.

Report (or) Conclusion

Overall occupational health and safety management practice in Azim industries was found good. Though some deficiency were found during this visit, but commitment of top management towards occupational health and safety was impressive.

2. Fire works industry in Sivakasi, Tamilnadu

Safety and well-being is very essential for firework employees because in fireworks they are handling dangerous materials every day. So the safety measures are most important in the firework industry. They are handling chemicals which will affect their health too. According to the factories Act, safety and well-being is very necessary.

For well-being first aid kit, toilet facilities, cleanliness and medical camp are very essential.

Objectives of this study

The main objective of this study is to analyze the industrial safety and well-being of firework employees in "Kumaran fireworks" in Sivakasi.

We have visited "Kumaran fireworks" and analyzed overall occupational health and safety management practices of 257 employees and selected 30 respondents and conducted survey question regarding safety measures of the employees.

Some of the encouraging approaches observed in "Kumaran fireworks"

(i) 100% of respondent feels that adequate safety measures are taken during fire accidents.

(ii) 93.3% of respondent said limited safety materials are provided during the work.

(iii) 100% of respondent said the air circulation is perfect in the industry.

(iv) 90% of respondent said first aid box is available all the time.

(v) 80.5% of respondent felt the work place is always clean and neat.

(vi) 85% of respondent said the building and machines are maintained in proper way.

Deficiency observed in Kumaran fireworks and solution

(i) Management should conduct medical camp once in 6 months, in the industry.

(ii) Management must provide separate toilet facilities for men and women.

(iii) Proper rest room must be provided to the workers for taking rest in the break time.

(iv) Enough safety materials like gloves, face mask must be provided while they are working near chemicals and machines in the factory.

(v) More safety guards around the machines must be provided.

Report (or) Conclusion

Overall occupational health and safety management practice in "Kumaran fireworks" was found good. Though some deficiency were found during this visit, commitment of top management towards occupational health and safety was impressive.

2.10 ENVIRONMENTAL PROTECTION

Definition

Environmental protection is the practice of protecting the natural environment by individuals, organizations and governments.

Objectives

Its objectives are

(i) to conserve natural resources,

(ii) to conserve the existing natural environment,

(iii) to repair damage and reverse trends.

Due to the pressures of over consumption, population growth and technology, the biophysical environment is being degraded. This has been recognized and governments have begun placing restraints on activities that cause environmental degradation.

Importance (or) Goal of environmental protection

(i) To reduce air, water and land pollution.

(ii) To facilitate the conservation of natural resources for our future generations.

(iii) To ensure the protection of biodiversity.

(iv) To implement sustainable development.

(v) To restore the ecological balance.

(vi) To save our planet from harmful effects of global warming.

2.10.1 Environment (Protection) Act, 1986

This is a general legislation law in order to rectify the gaps and laps in the above Acts. This Act empowers the Central government to fix the standards for quality of

air, water, soil and noise and to formulate procedures and safe guards for handling of hazard substances.

Objectives of environmental act

(i) to protect and improvement of the environment,

(ii) to prevent hazards to all living creatures and property,

(iii) to maintain harmonious relationship between humans and their environment.

Important features of Environment Act

1. The Act further empowers the Government to lay down procedures and safe guards for the prevention of accidents which cause pollution and remedial measures if an accident occurs.
2. The Government has the authority to close (or) prohibit (or) regulate any industry (or) its operation, if the violation of the provisions of the Act occur.
3. The penal sections of the Act contain more stringent penalties. Any person who fails to comply (or) who contravenes any provision of the Act shall be punishable with imprisonment for a term extending to five years (or) be punishable with fine up to Rupees one lakh (or) both.
4. If the violation continues, an additional fine of Rupees five thousands per day may be imposed for the entire period of violation of rules.
5. The Act fixes the liability of the offence punishable under Act on the person who is directly in charge.

   Whether he/she is the director (or) Manager (or) Secretary (or) any other officer, unless he/she proves that it was committed without his/her knowledge (or) consent.

6. The Act empowers the officer of Central government to inspect the site (or) the plant (or) the machinery for preventing pollution and 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.

2.10.2 Water (Prevention and Control of Pollution) Act, 1974

This act provides for maintaining and restoring the sources of water. It also provides for preventing and controlling water pollution.

Objectives of the water act

(i) prevention and control of water pollution,

(ii) maintaining (or) restoring the wholesomeness of water,

(iii) establishing central and state boards for the prevention and control of water pollution.

Important features of Water Act

1. This Act aims at, to protect the water from all kinds of pollution and to preserve the quality of water in all aquifers.
2. The Act further provides for the establishment of Central Board and State Boards for prevention of water pollution.
3. 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.

4. Any contravention of the guidelines (or) standards would attract penal action including prison sentence ranging from three months to six years.
5. The Act is not clear about the definition of pollutant, discharge of pollutant, toxic pollutant which allows scope for misinterpretation at the time of decision whether the law is violated (or) not.

The Amendment Act of 1988 requires permission to set up an industry which may discharge effluent.

State Pollution Control Board

The consent of the State Pollution Control Board is needed to

(i) Take steps to establish any industry (or) any treatment and disposal system (or) any extension (or) addition there to, which is likely to discharge (or) trade effluent into a stream (or) well (or) river (or) on land.

(ii) Use any new (or) altered outlet for the discharge of a sewage.

(iii) Begin to make any new discharge of sewage.

In the event of a violation of the conditions imposed, the State Board may serve on the offender a notice imposing any such conditions as it might establishment, such outlet (or) discharge that is a violation of the conditions.

The Act further empowers the State Board to order closure (or) stoppage of supply (or) electricity, water (or) any other services to the polluting unit. Non-compliance of the order may attract imprisonment for a term of one and half years to six years and fine which may extend to Rupees five thousand for every day, if the default continues.

2.10.3 Air (Prevention and Control of Pollution) Act, 1981

This Act was enacted in the Conference held at Stockholm in 1972. It deals with the problems relating to air pollution. It envisages the establishment of Central and State Control Boards endowed with absolute powers to monitor air quality and pollution control.

Objectives of air act are

(i) to prevent, control and abatement of air pollution,

(ii) to maintain the quality of air,

(iii) to establish a board for the prevention and control of air pollution.

Important features of Air Act

(a) The Central Board may lay down the standards for the quality of air.

(b) The Central Board co-ordinates and settle disputes between state boards, in addition to providing technical assistance and guidance to State Boards.

(c) The State Boards are empowered to lay down the standards for emissions of air pollutants from industrial units (or) automobiles (or) other sources.

(d) The State Boards are to collect and disseminate information related to air pollution and also to function as inspectorates of air pollution.

(e) The State Boards are to examine the manufacturing processes and the control of equipment to verify whether they meet the standards prescribed.

(f) The State Board can advise the State Government to declare certain heavily polluted areas as pollution control areas and can advice to avoid the burning of waste products which cause air pollution in such areas.

(g) The directions of the Central Board are mandatory on State Boards.

(h) The operation of an industrial unit is prohibited in a heavily polluted areas without the consent of the Central Board'.

(i) Violation of law is punishable with imprisonment for a term which may extend to three months (or) fine up to Rupees ten thousand (or) both.

This Act applies to all pollution industries. The Air Act, like Water Act, confers wide powers on State Boards to order closure of any industrial unit (or) stoppage (or) regulation of supply of water, electricity (or) other services, if it is highly polluting.

2.10.4 Forest (Conservation (or) Preservative) Act, 1980

This act provides conservation of forests and related aspects. This act also covers all type of forests including reserved forests, protected forests and any forested land.

This Act is enacted in 1980. It aims at to arrest deforestation.

Objectives of forest act

(i) to protect and conserve the forest,

(ii) to ensure judicious use of forest products.

Important features of Forest Act

(i) The reserved forests shall not be diverted (or) dereserved without the prior permission of the central government.

(ii) The land that has been notified (or) registered (or) forest land may not be used for non-forest purposes.

(iii) Any illegal non-forest activity within a forest area can be immediately stopped under act.

Important features of Amendment Act of 1988

(i) 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.

(ii) Clearance of any forest land of naturally grown trees for the purpose of re-afforestation is forbidden.

(iii) The diversion of forest land for non-forest uses is cognisable offence and any one who violates the law is punishable.

2.10.5 Wildlife (Protection) Act, 1972, Amended in 1983, 1986 and 1991

This act is aimed to protect and preserve wildlife. Wild life refers to all animals and plants that are not domesticated. India has rich wildlife heritage. It has 350 species of mammals, 1200 species of birds and about 20,000 known species of insects. Some of them are listed as 'endangered species' in the Wildlife (Protection) Act.

Wildlife is an integral part of our ecology and plays an essential role in its functioning. The wildlife is declining due to human actions, the wildlife products - skins, furs, feathers, ivory etc., have decimated the populations of many species.

Wildlife populations are regularly monitored and management strategies formulated to protect them.

Objectives of the wildlife act

(i) to maintain essential ecological processes and life-supporting systems,

(ii) to preserve biodiversity,

(iii) to ensure a continuous use of species.

Important features

1. The act covers the rights and non-rights of forest dwellers.
2. It provides restricted grazing in sanctuaries but prohibits in national parks.
3. It also prohibits the collection of non-timber forest.
4. The rights of forest dwellers recognized by the Forest Policy of 1988 are taken away by the Amended Wild life Act of 1991.

2.11 PART B QUESTIONS

1. Explain the effect of CO, SO_2, Hydrocarbons and chromium on human beings. *(A.U. May 2006)*
2. Discuss the major sources air pollutants and their impact and methods of controlling air pollution. *(A.U. Dec 2013, June 2016, Dec 2015)*
3. Explain the causes, effects and control measures of air pollution. *(Che AU June 2010 Dec'08 May 2015, June 2010)*
4. Explain the effects of air pollution on human health, plants and animals. *(TCY AU Dec'08)*
5. Discuss the causes and effects of
   (i) Air pollution
   (ii) Water pollution *(AU May 2008, TNV AU Dec'08)*
6. Suggest measures to control air pollution. *(Che A.U. Dec 2009)(Coim AUT May 2011, TCY AUT June 2011)*

7. Explain the causes, effects and control measure of water pollution. *(A.U. June - 2005) (TCY AUT May 2010)(Coim AUT Dec 2010)*

8. Name and discuss the effects of water pollution. Suggest the various control and remedial measures to curb water pollution. *(AU May 2016, TCY AU Dec'08)*

9. Discuss the major causes and effects of soil pollution. *(TNV AUT June 2010)*

10. Discuss the sources and effects of soil pollution. *(TCY AUT Dec. 2010)*

11. Explain the concept of source, path receiver in the control of noise pollution. *(A.U. Dec 2007)*

12. Explain the sources, effects and control of industrial noise pollution. *(TNV AUT Dec 2010, Che AU Dec 2010, Dec 2014)*

13. Explain the methods of disposal of municipal solid waste. *(A.U. Dec-2005, May 2011)(Coim AUT Dec 2010)*

14. What are the effects of improper municipal solid wastes management? State the measures recommended for proper management of the solid wastes. *(A.U. June - 2005)*

15. How will you take care of solid wastes generated in urban areas? *(A.U. Jan-2006, Dec 2012)*

16. Discuss briefly the disposal of municipal solid waste. *(A.U. Dec 2006)*

17. Discuss about the significance of hazardous waste management. *(Che AU Dec'08)*

18. Give a comparative account of urban and industrial wastes in terms of their sources, characteristics and management and disposal methods. *(Coim AUT Dec 2011, Che AU Dec'08)*

19. Write brief notes on solid waste management. *(Chen AUT June 2010, TCY AU Dec'08)*

20. Explain the Methods of disposal of municipal solid wastes. *(Coim AUT June 2010)*

21. What are the types of solid waste? Explain the concept of solid waste processing and solid waste management. *(TCY AUT June 2011)*

22. Explain the various steps involved in hazardous waste management.

23. What are e-wastes? Explain its preventive measures?

24. What is OHASMS? Explain it with any one case study.

Unit - III

Renewable Sources of Energy

3.1 ENERGY MANAGEMENT AND CONSERVATION

3.1.1 Energy management

Definition

Energy management is planning and operation of energy production and energy consumption units as well as energy distribution and storage.

For the paste decades, energy generation has been shifted to alternative energy sources like renewable energy forms such as solar, wind and biomass energy, etc., instead of the conventional fossil fuel sources. Apart from the growth in the energy sector, there has been an equivalent increase in business and organizations, which has brought tremendous competition in the market in terms of increasing environmental standards and reducing global warming, carbon foot print and green house gas emissions.

Energy management introduced in an organization, can effectively manage how much energy they produce and how to controls and monitor. A large amount of energy and money can be saved by employing energy management principles. It can also help companies by not only improving productivity but also the quality that they offer using energy efficiency techniques and better materials and manufacturing processes.

Objectives (or) Aims of energy management

(i) Resource conservation.

(ii) Climate protection.

(iii) Cost savings / minimize waste.

(iv) Minimize environmental effects.

The ultimate aim (or) objectives of this process is not only to save the cost but also to achieve complete environmental sustainability.

Principles of energy management

1. It controls the costs of the energy function and not Btu of energy.
2. The second principle is to control energy functions as a product cost.
3. The third principle is to control and meter only the main functions, which accounts for only 20% functions which make up 80% of the costs.
4. The last principle states that the major effort of an energy management program should be put into installing controls and achieving results.

Steps involved in the process of energy management

The following 5 steps are important in the process of energy management.

Step 1: Collecting and analyzing continuous data.

Step 2: Identify optimizations in equipment schedules, set points and flow rates to improve energy efficiency.

Step 3: Calculate return on investment. Units of energy saved can be metered and calculated just like units of energy delivered.

Step 4: Execute energy optimization solutions.

Step 5: Repeat step 2 to continue optimizing energy efficiency.

3.1.2 Energy conservation

Definition

Energy conservation is the practice of using less energy inorder to lower the costs and reduce environmental impact.

This can be achieved either by using

(i) energy more efficiently (using less energy for a constant service),

(ii) by reducing the amount of service used (by driving less).

Objectives (or) Aims of energy conservation

Energy conservation is the key element. The main objectives are

(i) to reduce overall energy demand,

(ii) to lower energy cost,

(iii) to reduce energy consumption,

(iv) to lower the overall green house gas emission.

Principle (or) Law of conservation of energy

The principle of energy of conservation states that energy can neither be created nor destroyed but it can be transformed from one type to another.

According to this the total energy of an isolated system remains constant.

Importance of energy conservation

Energy conservation is very important because of the following reasons.

1. It reduces our usage of non-renewable energy resources (like fossil fuels).
2. It also helps you to save money on energy costs including utility bills and other energy bills.
3. It also cuts down on expanding development, where natural resource extraction is impacting natural areas.
4. When we conserve energy more efficiently, we directly reduce the amount of green house gas emissions entering the earth's atmosphere.
5. It insists us to replace the energy, used, with an alternate energy source.

15 ways to conserve energy (or) conservation

There are 15 ways to start conserving energy.

1. Adjust your day-to-day behaviors

Example

Switch off lights (or) appliances when you do not need them.

2. Replace your light bulbs

Traditional incandescent light bulbs consume more amount of electricity and must be replaced by energy efficient alternatives like CFL and LED bulbs.

3. Use smart power strips

"Phantom loads" (or) the electricity used by electronics, when they are turned off (or) stand by mode, are the major source of energy waste. Smart power strips, eliminate this problem, when they are not in use.

4. Install a programmable (or) smart thermostat

It automatically turn-off (or) reduce heating and cooling during the time when you are asleep (or) away.

5. Purchase energy efficient appliances

These will consume less energy during use.

6. Reduce your water heating expenses

Efficient water heaters can be 8% to 300% more energy efficient than a conventional storage water heater.

7. Install energy efficient windows

To prevent heat loss through your windows,

(i) you can replace single-pane windows with double-pane windows,

(ii) gas filled windows with "low-e" coatings can be fixed.

8. Upgrade your HVAC system

Most energy efficient way to upgrade your home's HVAC system is installing air source heat pump. In order to heat and cool your home a heat pump transfers heat from one place to another.

9. Weatherize your home

Air leaks into your home are windows, doors and vents. To prevent these leaks, care must be taken in such a way that no cracks (or) opening between the walls and windows is present.

10. Insulate your home

Insulation retains heat during the winter and keeping heat out of your home during the summer.

11. Wash your clothes in cold water.

12. Replacing dirty air filters regularly can reduce energy consumption upto 15%.

13. As microwave is more energy efficient, microwave oven can be used instead of ordinary stove.

14. Using natural light, like sun, we can reduce the energy consumption.
15. Dress appropriately for the weather inside and outside.

3.2 NEW ENERGY SOURCES

3.2.1 Need

Fossil fuels and nuclear energy are the important resources used to meet most of our energy needs today. These are expected to be widely used in the near future. However, fossil and nuclear energy resources are non-renewable and will someday be exhausted, while their continued use possess environmental risks related to air pollution, global climate change, land use and waste disposal. These issues have stimulated the search for new energy sources for producing and using energy.

3.2.2 Different types of new energy sources

New energy sources (or) Renewable energy resources that are being developed include

(i) Hydrogen energy.
(ii) Ocean thermal energy conversion.
(iii) Tidal and wave energy.
(iv) Geothermal energy.
(v) Solar energy.
(vi) Wind energy.
(vii) Bio-mass energy.
(viii) Artificial Intelligence (AI).
(ix) Photovoltaics (PV).
(x) Distributed energy storage systems (DESS).

(xi) Grid integration.
(xii) Space technologies.
(xiii) Norwegian Crystals.
(xiv) Algal bio-fuels.
(xv) Body heat.
(xvi) Dance flowers.

1. Hydrogen

The fuel that has potential of being widely used in the future is hydrogen gas (H_2). Like natural gas hydrogen can be burned to heat buildings, cook food and produce electricity in power plants.

Hydrogen possess high calorific value. It is non-polluting, because the combustion product is water.

$$2H_2 + O_2 \longrightarrow 2H_2O + 150 \text{ kJ}$$

H_2 gas can be compressed in a fuel tank and used to power cars and buses.

Sources of hydrogen

(i) Plentiful hydrogen is available from water (H_2O). Water can be split into gaseous H_2 and O_2 by an electrolysis process.

(ii) Hydrogen can also be produced from natural gas and biomass resources.

(iii) Ethanol reacts with high-temperature steam to produce hydrogen.

(iv) Biomass is converted into sugar-rich feed stocks that can be fermented to produce hydrogen.

(v) Microbes such as green algae, consume water in the presence of sun light and produce hydrogen as a by-product.

Hydrogen fuel cell

Hydrogen can be used in fuel cells. The electrons in hydrogen atoms generate electricity in the fuel cell. The combination of H_2 and O_2 creates water and heat from the reaction. The heat may be used to produce electricity.

At anode, hydrogen is split into protons and electrons. The electrons moves to cathode and generates electricity.

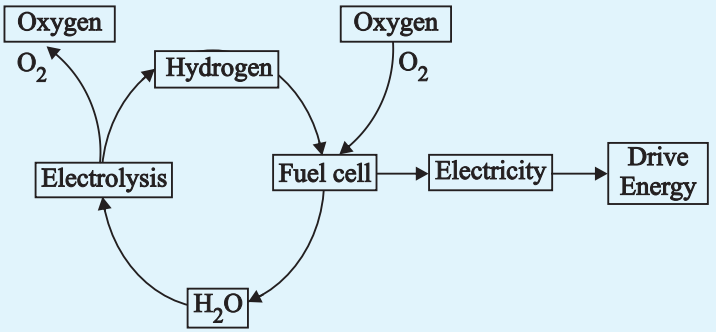


Fig. 3.1 Hydrogen fuel cell Technology

Electrical power plants can be built using large banks of fuel cells, but small groups of cells provide electricity for individual home and commercial buildings.

Problem

(i) Difficulties in storing enough hydrogen for motor vehicles to run long distances.

(ii) Infrastructure to refuel these vehicles.

(iii) Highly inflammable and explosive in nature.

(iv) Safe handling is required.

2. Ocean thermal energy (OTE)

There is often large temperature difference between the surface level and deeper level of the tropical oceans.

This temperature difference can be utilized to generate electricity. The energy available due to the difference in temperature of water is called ocean thermal energy.

Condition

The temperature difference should be of 20°C (or) more is required between surface water and deeper water.

Significance of OTE

(a) OTE is continuous, renewable and pollution free.

(b) The use of cold deep water, as the chiller fluid in air-conditioning, has also been proposed.

(c) Electric power generated by OTE can be used to produce hydrogen.

3. Tidal energy (or) Tital power

Tidal energy is a renewable energy powered by the natural rise and fall of ocean tides and currents.

Significance of tidal energy

(i) Tidal power plants do not require large areas of valuable lands as they are on the bays (or) estuaries.

(ii) As the sea water is inexhaustible, it is completely independent of the uncertainty of precipitation (rainfall).

(iii) It is pollution-free energy source, as it does not use any fuel and also does not produce any wastes.

4. Geo-thermal energy

The heat produced deep in the Earth's core is called Geothermal energy. The energy harnessed from the high temperature present inside the earth can be used to produce electricity.

Significance of geothermal energy

(i) The power generation level is higher for geothermal than for solar and wind energies.

(ii) Geothermal power plants can be brought on line more quickly than most other energy sources.

(iii) GTE is effectively and efficiently used for direct uses such as hot water bath, resorts, aquaculture, greenhouses.

5. Solar energy

Solar energy is derived by capturing radiant energy from sunlight and converting it into heat, electricity (or) hot water.

Significance of solar energy

(i) Solar cells are noise and pollution free.

(ii) Solar water heaters, cookers, require neither fuel nor attention while cooking food.

(iii) Solar cells can be used in remote and isolated areas, forests, hilly regions.

6. Wind energy

Moving air is called wind. Energy recovered from the force of wind is called wind energy. The energy possessed by wind is because of its high speed. The wind energy is harnessed by making use of wind mills.

Significance of wind energy

(i) The generation period of wind energy is low and power generation starts from comissioning.

(ii) It is recommended to broaden the nation's energy options for new energy sources.

(iii) It is made available easily in many off-shore, on-shore and remote areas.

7. Bio-mass energy

Biomass is the organic matter, produced by plants (or) animals, used as sources of energy. Most of the biomass is burned directly for heating, cooling and industrial purposes.

Examples *Wood, crop residues, seeds, cattle dung, sewage, agricultural wastes, etc.,*

Significance of bio-mass energy

1. The cost of obtaining bio-energy through bio-gas plant is less than the cost of obtaining energy from fossil fuels.
2. Biomass consumes more CO_2 than is released during combustion of biomass.
3. It provides a stored form of energy and in many cases in a form suitable for vehicle propulsion.

8. Artificial intelligence (AI) in the energy sector

Artificial intelligence (AI) is used to forecast demand and manage the distribution of resources, to ensure that power is available at the time and place it's needed with a minimum of waste. AI plays an essential role in the world's transition to clean energy. Artificial intelligence is particularly important in the renewable energy industry, where it often can't be stored for long periods of time and has to be used close to the time and location where it is generated.

9. Photo Voltaics (PV)

Solar companies are integrating PV systems to minimize the need for additional land usage. As a result, integrated PV, floatovoltaics and agrivoltaics are logical shift in trends. Now thin film PV cells are being developed

to make solar panels flexible, cost-effective, light weight and environment friendly.

10. Distributed energy storage systems (DESS)

A distributed energy storage system (DESS) is a packaged solution that stores energy for use at a later time. The system is provided with two main components.

(i) DC charged batteries and

(ii) Bi-directional inverter.

It's major role is to prevent power fluctuation and power quality problems.

11. Grid integration

Grid integration is the practice of developing efficient ways to deliver variable renewable energy to the grid.

12. Space technologies

Space-based energy technologies like

(i) harvesting hydrogen from the moon to power fuel cell on earth,

(ii) orbiting solar rays that absorb around-the-clock direct sunlight and send the energy back down to stations on the ground via radio (or) microwaves,

are being developed as the new energy technology.

13. Norwegian crystals

(i) Low carbon mono crystalline silicon ingots, is a type of crystal, used for high performance photovoltaic devices.

(ii) Gallium-doped ingots, that increases the lifetime of the solar cells.

Through this, Norwegian crystals controls the carbon footprint of solar panel components at ultra low levels.

14. Algal bio-fuels

Algae is an alternative to liquid fossil fuels. It offers huge commercial potential. Like fossil fuel, algae fuel releases CO_2 when burnt. But unlike fossil fuel, the CO_2 released by algae fuel is removed from the atmosphere via., photosynthesis as the algae (or) plant grew.

The impact of algal bio-fuels on the atmosphere is much lower. Algal fuel production has a minimal impact on land and water resources. It can be produced using seawater (or) even grey waste water.

15. Body heat

The body heat, liberated by humans in the crowded area like central station, market place, is channelled through the station's vent system. Then it is used to warm up water in underground tanks and pumped through the heating system.

16. Dance floors

The kinetic energy of the dance floor is converted to electricity that lights up the dance floor itself.

Pavegen, a london based company is demonstrating this with its development of the energy harvesting "smart street".

3.3 APPLICATIONS OF HYDROGEN ENERGY

1. Hydrogen is a reagent, used in many industries, including chemicals, textile fiber manufacturing, glass, electronics and metallurgy.
2. It is also used as a fuel for rocket launchers.

3. In electronics, hydrogen is used as a carrier gas, for the manufacture of electronic components.
4. Hydrogen is used in industries for many applications.

Examples

(i) It combines with nitrogen to produce ammonia, a base for fertilizers.

(ii) It is a good reagent for textile fibers like nylon, polyurethane foam.

5. Hydrogen is used in metallurgy for heat treatment process to produce mechanical parts (or) to alter their properties.
6. Hydrogen is used during fuel refining to remove this sulphur via a process of desulphurization.
7. Atomic hydrogen welding (AHW) is a type of arc welding which utilizes a hydrogen environment.
8. A mixture of hydrogen and nitrogen is used to prevent oxidation in flat glass production.
9. As an efficient reducing and etching agent, hydrogen is used to create semiconductors, LEDs, displays.
10. Hydrogen gas is used as a therapeutic gas for a number of different diseases.
11. **Hydrogen fuel cell**

Hydrogen fuel cell uses hydrogen as a fuel in an electrochemical process that combines H_2 and O_2 to produce electrical energy with water and heat as the only by-product. Two main applications of fuel cells are,

(i) Stationary power sources.

(a) These are used to power office buildings, data centres, grocery stores and off-grid telecommunication towers.

(b) It is used as a part of uninterruptible power supply (UPS) system, where continuous uptime is critical.

(ii) Hydrogen fuel cell vehicles (FCVs)

(a) The heat produced by the hydrogen fuel cell can be used for space and water heating (or) industrial process.

(b) Hydrogen fuel cells power clean trucks, fork lifts, etc.,

(c) Hydrogen power is being considered for transportation applications including hydrogen fuel cell buses.

(d) Hydrogen fuel cell trains have now appeared.

(e) Hydrogen offers versatile options for mobile power generation. Some of the hydrogen fuel cells were developed by NASA to provide electricity for rockets and shuttles in space.

(f) Hydrogen fuel cells have found a number of marine applications (used in boats and submarines).

3.3.1 Advantages and disadvantages of hydrogen fuel cells

Advantages

1. Hydrogen is readily available.
2. It does not produce harmful emissions.
3. It is environmentally friendly.
4. It can be used as fuel in rocket.
5. It is energy efficient and more powerful than fossil fuels.
6. It is renewable.
7. It reduces carbon foot prints.

8. Charging times is fast.
9. It does not make noise and visual pollution.
10. It can be used for long time.

Disadvantages

1. It is expensive.
2. It is difficult to store.
3. It is highly inflammable.
4. Infra-structure.
5. Regulatory issues.

3.4 APPLICATIONS OF OCEAN ENERGY RESOURCES

Tidal energy (or) tidal power is a form of ocean energy that is harnessed by converting tide energy into useful forms of power. Tidal energy is obtained from the rise and fall of tides. Tidal barrages and dams are constructed across a narrow opening to the sea. Water rushes into the dam when the sea level rises which moves the blade of the turbines which helps in the generation of electricity.

Below are some important applications of ocean energy.

1. Ocean waves

Potential energy associated with ocean waves can be harnessed using modular technologies.

2. Temperature gradients

Difference in thermal energy between sea surface and deep water can be harnessed by Ocean Thermal Energy Conversion (OTEC) process.

3. Salinity gradient

At the mouth of rivers, where fresh water mixes with salt water, energy associated with the salinity gradient can be harnessed using pressure retarded reverse osmosis process and associated conversion technologies.

4. Ocean wave energy convertors

These are the technology used to trap the mechanical energy of the wave to convert it to electrical power.

5. Oscillating bodies

Oscillating waves uses hydraulic motors (or) electrical generators as a power take-off system.

6. Overtopping wave energy convertors

The overtopping wave energy convertors (or) terminators, using the low head hydraulic turbines, converts the potential energy formed by the height of accumulated water over the wave surface to electrical power.

7. Ocean thermal energy (OTE)

The temperature difference, between the surface level and deeper level of the tropical oceans, can be utilized to generate electricity.

3.4.1 Advantages and disadvantages of ocean energy

Advantages (or) Benefits

(i) Ocean energy is cheaper and efficient.

(ii) It is environment - friendly.

(iii) The source of ocean energy is inexhaustible

(iv) Operational and maintenance costs are low.

(v) Tidal energy sources can last for decades.

(vi) It protects coastal floodings due to the stability of rock armor.

Disadvantages (or) limitations

(i) Construction of tidal power plant is expensive and requires high capital investment.

(ii) Maintenance and equipment repairing is a challenge.

(iii) Negative influence on marine life forms.

(iv) Storage capacity is required.

(v) Environmental problems like habitat change arises.

3.5 APPLICATIONS OF TIDAL ENERGY CONVERSION

1. Electricity can be generated from the tidal energy.
2. Tidal energy is used in grining mills for the mechanical crushing of grains.
3. Tidal energy is used to rotate a turbine.
4. Tidal energy is used to store energy in a hydroelectric dam, acting as large energy storage.
5. Tidal barrages and reservoirs can be modified to store energy.
6. Tidal barrages are capable of preventing damages to the coast during high storms.
7. Tidal barrages also help to create easy transport between the two arms of an estuary (or) a bay.

3.5.1 Advantages and disadvantages

Advantages (or) Merits

1. It is environment friendly.
2. It is cheaper and efficient.
3. Low operating and maintenance costs.

4. The source of energy is inexhaustible.
5. Protects coastal flooding.
6. Tidal energy sources can last for decades.
7. Power output is highly predictable.

Disadvantages

1. Construction of tidal power plants is expensive and requires high capital investment.
2. Equipment repairing and maintenance is difficult.
3. Environment problems, like habitat change, arises.
4. Storage capacity is required.
5. Negative influence on marine life forms.
6. Location limited.

3.6 GEOTHERMAL POWER PLANT (GTE)

3.6.1 Definitions

1. Geothermal Power

It is the electrical power generated from geothermal energy.

2. Geothermal Energy

It is the heat produced deep in the earth's core.

3.6.2 Origin

Geothermal energy is the thermal energy found in the earth's crust which originates from the formation of the planet and from radioactive decay of materials. The high temperature and pressure in earth's interior cause some rock to melt and solid mantle to behave plasmically. This results in parts of the mantle convecting upward since

it is lighter than the surrounding rock. Temperatures at the core mantle boundary can reach over 400°C.

3.6.3 Concept

Geothermal technology extracts the heat found within the subsurface of the earth, which can be used directly for heating and cooling (or) converting it to electricity.

The steam comes from the reservoirs of hot water, found a few miles (or) more below the earth's surface, rotates a turbine that activates a generator, which produces electricity.

3.6.4 Power plants of GTE

Geothermal power plant uses hydrothermal resources that have both water (hydro) and heat (thermal). Geothermal power plants requires high temperature (300°F to 700°F) hydrothermal resources that come from either dry steam wells (or) from hot water wells.

Generally we use these resources by drilling wells into the earth and then piping steam (or) hot water to the surface. The hot water (or) steam rotates a turbine that generates electricity. The depth of the geothermal wells is as much as 2 miles.

Types of geothermal power plants

There are three basic types of geothermal power plants.

1. Dry steam power plant

It uses steam directly from a geothermal reservoir to drive generator's turbines.

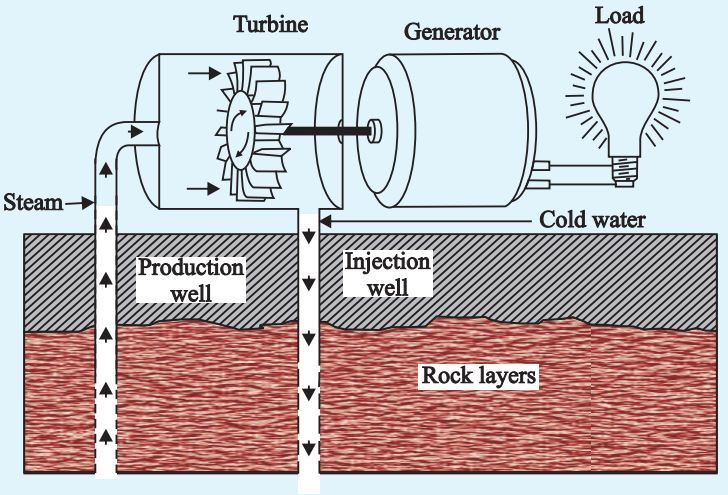


Fig. 3.2 Dry steam power plant

2. Flash steam power plant

It takes high-pressure hot water from deep inside the earth and converts it into steam to drive generator's turbine.

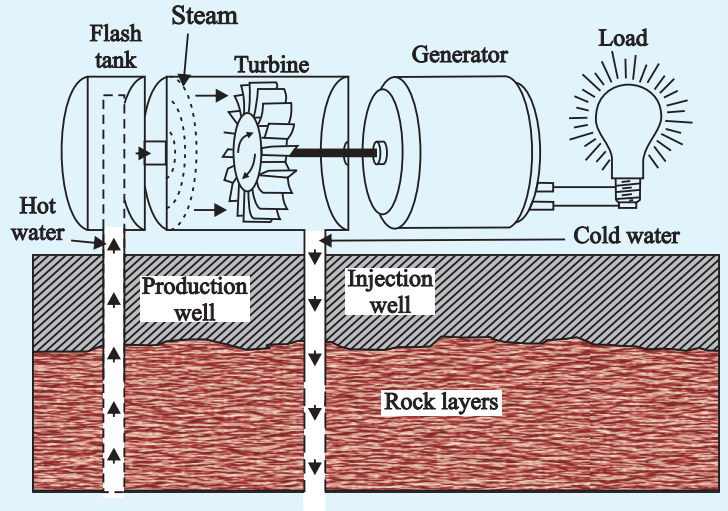


Fig. 3.3 Flash steam power plant

When the steam cools, it condenses to water and is injected back into the ground to be used again. Most geothermal power plants are flash steam plants.

3. Binary cycle power plants

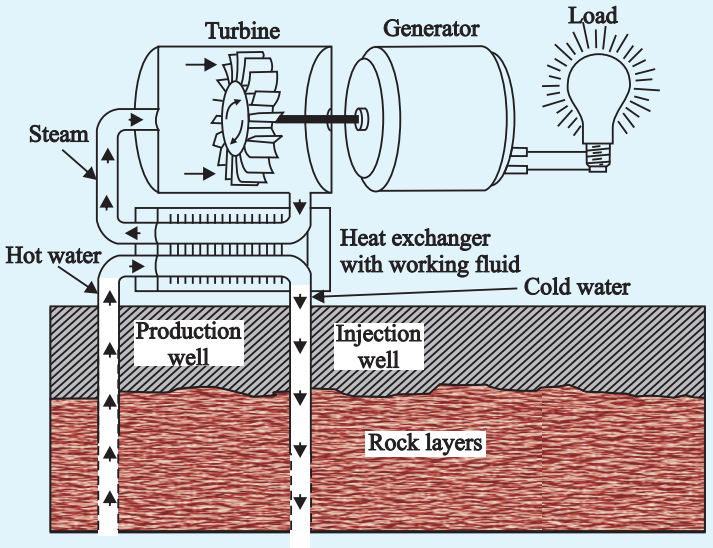


Fig. 3.4 Binary cycle power plants

It transfers the heat from geothermal hot water to another liquid. The heat causes the second liquid to convert it into steam, which is used to drive a generator's turbine.

3.6.5 Advantages and disadvantages of GTE

Advantages

1. GTE is environmentally friendly.
2. GTE is a source of renewable energy.
3. It is the sustainable form of energy.

4. The potential of GTE is huge.
5. Energy generated from this resource is reliable.
6. As GTE is natural, no fuel is required.

Disadvantages

1. Location is restricted.
2. As GTE does not release green house gases, there are many other gases released into the atmosphere (cause side effects).
3. May cause earthquakes.
4. It is expensive resource.
5. Management is required to maintain sustainability.

3.6.6 Applications of GTE

1. GTE is used for space heating and cooling.
2. GTE is used to generate electricity.
3. It is also used for industrial process heat.
4. It is used for desalination of geothermal water and heavy water production.
5. It is also used in the extraction of minerals from geothermal fluids.
6. Geothermal Heat Pumps (GHPs) are used to heat buildings in the winter and cool them in summer.
7. The direct use of GTE involves the use of heated water from the ground without the need for any other sources.

3.7 PART B QUESTIONS

1. Explain the principle and various steps involved in the energy management.
2. What are the objectives, principle and importance of energy consersion.
3. Explain the ways through which conservation of energy is made.
4. Write detailed notes on new energy sources.
5. Explain the applications of hydrogen energy.
6. Explain the applications of ocean energy.
7. Write notes on advantages and disadvantages of
   (i) hydrogen energy (ii) ocean energy
8. Explain the origin, concept and advantage and disadvantages of GTE.
9. What is meant by GTE and how is it manufactured.
10. Explain the applications and advantages and disadvantages of GTE.

Unit - IV

Sustainability and Management

4.1 DEVELOPMENT

A true development does not mean a high standard of living with all benefits and an increase in the GNP (Gross National Product) of few countries. But it brings benefits to all, not only for the present generation, but also for the future generation.

Definition

Development is a process that creates growth progress, positive change in economic, environmental and social component without damaging the resources of the environment.

4.1.1 Types of development

1. National development

National development starts from the national planning frame work. These are developments that would make a significant contributions to overall success (or) its international role.

2. Major development

Some categories falling under "major development" includes fish farms, offices, storage and distribution centres, housing estates, renewables, waste management (or) disposal facilities, mineral extraction sites, etc.,

3. Local development

This is the most common form of development and comprises of small scale developments including house extensions, conversions, small and medium housing, industrial development and small scale renewable developments.

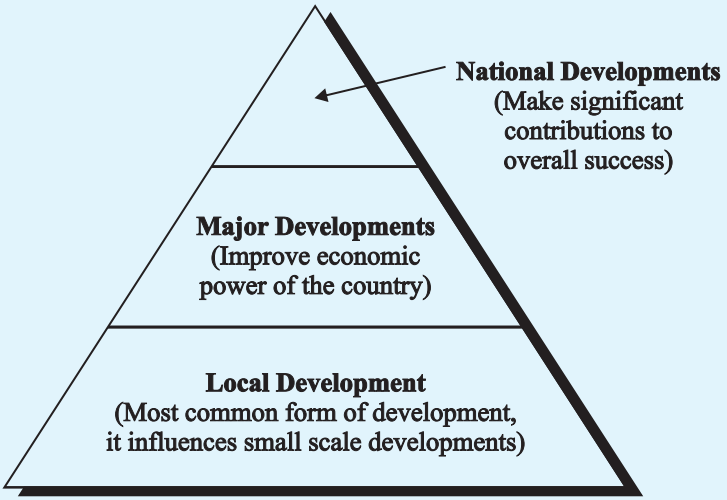


Fig. 4.1 Types of developments

4.1.2 Principles of development

The following 7 principles are the important for the development.

1. Equitable use.
2. Flexibility in use.
3. Simple and intuitive use.
4. Perceptible information.
5. Tolerance for error.

6. Low physical effort.
7. Size and space for approach and use.

4.1.3 Characteristics of development

1. It is a continuous process.
2. It is the result of interaction of individual and environment.
3. It is predictable.
4. It is both quantitative and qualitative.
5. It follows a particular pattern like infancy, childhood, adolescence and maturity.

4.1.4 Steps involved in concept development

There are 5 important steps involved, in the development process.

Step 1: Brain storming to create a pool of potential product (or) service concept.

Step 2: Performing customer research to target your ideal customer.

Step 3: Estimating the market potential for your product (or) service concept.

Step 4: Creating a prototype for your product.

Step 5: Devising a marketing strategy.

4.1.5 Effects of development

1. It increases wealth (or) reduces poverty.
2. It improves standards of living, health, education, infrastructure and technology.

4.1.6 Factors affecting development

Followings are the important economic factors affecting development.

1. Natural resources

Examples Trees, soil, water, minerals, coal, oil, etc.,

They help countries develop by creating jobs and increasing their wealth through the sales.

2. Power and energy resources

Examples Oil, gas, coal and water.

They, being natural, can be mined and sold quickly. They are important for producing power and energy within the country.

3. Capital accumulation

If a country has more capital, it can creates more job. Low capital countries may have a low living wage and high unemployment.

4. Technological resources

Examples Computers, cell phones, etc.,

It refers to ability to use advanced technologies within a country. It increases business capabilities and economic development of the country. Countries with low technological resources have poor economic development.

5. Available labour force

Number of skilled labours within the country increases the development.

6. Transportation and communications.

7. Education and training.

4.1.7 Advantages and disadvantages of development

Advantages of development

1. Increased job satisfaction and morale among employees.
2. Increased employee motivation.
3. Increased efficiencies in processes, resulting in financial gain.
4. Increased capacity to adopt new technologies and methods.
5. Economic growth increases state capacity and the supply of public goods.

Disadvantages of development.

(i) Population growth.

(ii) Weak governance and rapid urbanization.

(iii) Poverty.

(iv) Pollution like smog, acid rain, green house effect, depletion of ozone layer, sewage and garbage.

4.2 GDP (GROSS DOMESTIC PRODUCT)

GDP is the total market value of the goods and services, produced within a country, during the specified period of time (usually 12 months (or) a year)

It is the broadest financial measurement of a nation's total economic activity.

4.2.1 Types of GDP

1. Normal GDP

It is the total value of all goods and services produced at current market prices.

2. Real GDP

It is the sum of all goods and services produced at constant prices.

3. Actual GDP

It is the real-time measurement of all outputs at any interval (or) any given time.

4.2.2 Significance (or) importance of GDP

(i) It identifies the present state of economy.

(ii) It is used to compare the economics between countries.

(iii) GDP is objective of policy formulation.

(iv) GDP is the root cause.

(v) It gives information about the size of economy and how an economy is performing.

(vi) It is used to determine the development and performance of the economy.

4.2.3 Calculation of GDP

There are three different ways of calculating GDP

(i) The value added approach.

(ii) The income approach (how much is earned as income on resource used to make stuff).

(iii) Expenditure approach (how much is spent on stuff).

Of three, the expenditure approach is followed.

Expenditure approach

The expenditure approach calculates the GDP by calculating the sum of all the services and goods produced in an economy. It is calculated with the following formulae.

$$\text{GDP} = \begin{cases} \text{Private consumption} + (\text{Gross private investment} + \\ \text{Government investment}) + \text{Government spending} + \\ (\text{Exports} - \text{Imports}) \end{cases}$$

$$Y = C + I + G + (X - M)$$

where, Y = Gross Domestic Product.

C = Consumption.

I = Investment.

G = Government spending.

X = Exports.

M = Imports.

4.2.4 Advantages and disadvantages of GDP

Advantages of GDP

(i) GDP is a broad indicators of development.

(ii) It is easy to measure growth in percentage.

(iii) It is easy to compare to itself and other countries.

(iv) GDP is easy and cheap to collect.

(v) GDP is calculated from a formula which all countries use therefore it is reliable indicator.

(vi) It is the very good way for government to know whether economic policies have been successful.

(vii) It can be broken up into GDP per capita which accounts for the population of the country when it is calculated.

Disadvantages of GDP

(i) It does not include non-market transactions.

(ii) It is narrow indicator that fails to show quality of life, standard of living, happiness, health care.

(iii) It fails to indicate whether the growth of a nation is sustainable.

(iv) GDP does not account inequality.

(v) It doesn't account for environmental impacts of the economic policies.

(vi) It doesn't include the activity of informal sector (black market).

(v) Overseas income not taken into account.

(vi) High inflation may be behind a high GDP rate.

(vii) Government could adjust the figures to gain power.

(viii) Production process could be immoral.

(ix) It measures the growth in the past are not hugely relevant.

4.3 SUSTAINABILITY

It is defined as ***"meeting our own needs without compromising the ability of future generations to meet their own needs".***

4.3.1 Need of sustainability

1. Sustainability is key to preserving our planet.
2. Sustainability helps reduce pollution and conserve resources.
3. Sustainability creates jobs and stimulates the economy.
4. Sustainability improves public health.

5. It protects biodiversity.
6. It protects the natural environment.
7. It is the choice of non-toxic materials.
8. It reduces and reuses the resources.
9. It minimizes waste.
10. It is used for life-cycle analysis.

4.3.2 Concept (or) Approaches (or) Significance of Sustainability

To build up the sustainability development, the following approaches (or) methods are proposed.

1. Developing appropriate technology: It is the one, which is locally adaptable, eco-friendly, resource-efficient and culturally suitable. It uses local labours, less resources, and produces minimum waste.

2. Reduce, Reuse, Recycle (3-R) approach: It insists optimum use of natural resources, using it again and again instead of throwing it on the waste land (or) water and recycling the material into further products. It reduces pressure on our natural resources and reduces waste generation and pollution.

3. Providing environmental education and awareness: By providing environmental education and awareness, the thinking and attitude of people towards our earth and the environment can be changed.

4. Consumption of Renewable Resources: In order to attain sustainability, it is very important to consume the natural resources in such a way that the consumption should not exceed regeneration capacity.

5. Conservation of non renewable resources: Non-renewable resources should be conserved by recycling and reusing.

6. Population Control: By controlling population growth, we can make very good sustainability development.

4.3.3 Economic and Social Challenges of Sustainability

1. Economic sustainability

It refers to the organisation's ability to manage its resources and responsibly generate profits in the long term.

Examples

1. A company uniliver

It has followed a strategy to achieve a balance between sustainability and the company's economic performance. So, it implemented several measures like increasing package recycling, promoting the use of recycled materials and responsible consumption awareness campaigns.

2. A company suez

It has reduced its emissions, related to electricity consumption, by 95% by using renewable energy and conservation of natural habitats.

Economic challenges

(i) High rates of unemployment (or) under employment.

(ii) High rates of poverty and low growth.

(iii) Increasing inequality, with many not being included in the growth process.

(iv) Disruption of major economic activities due to pandemic situation like tourism.

(v) Volatile growth dependent on one source.

(vi) Low productivity due to poor human capital development.

(vii) Skills mismatch between skills you have and the jobs you want to create.

(viii) Lack of quality jobs.

(ix) Macroeconomic instability and recurrent balance of payments shocks.

2. Social sustainability

It refers to strengthening the cohesion and stability of specific social groups.

Examples

1. A Company CEMEX

It is working to contribute to the social development of communities. Thus, it offers decent housing through self-building programmes and loans with favourable access conditions.

2. A Gigante group

It contributes funds and resources to a range of social causes like school materials for collaborators and grants to improve visual health.

Social Challenges

Though social impact, social sustainability challenges, issues are not easily measurable, they are easier to identify. Social sustainability performance challenges include

(i) Human rights.

(ii) Fair labour practices.

(iii) Living conditions.

(iv) Health and safety.

(v) Wellness, diversity and equity.

(vi) Work-life balance.

(vii) Empowerment.

(viii) Community engagement.

4.3.4 Aspects of sustainability

There are 4 aspects of sustainability, of them environmental sustainability is the fundamental and important aspect.

1. Environmental aspect

Environmental aspect acknowledges the need to enhance and maintain the biophysical systems that sustain all the life on earth. It includes the structure and function of natural ecosystems and the interactions between them and people and calls for guardianship (or) kaitiakitanga of our environment.

2. Social aspect

Social aspect acknowledges the need for equity

(i) within and between generations, and

(ii) within and between ethnic and social groups.

It is inclusive of people's mental and physical well-being and the cohesion of their communities based on a fair distribution of resources.

3. Cultural aspect

Cultural aspect acknowledges the need to nourish and share attitudes and values that represent diverse world views and the political need for all people to express their views freely and to participate in decision making. Addressing these needs can build resilience for the future.

4. Economic aspect

Economic aspect acknowledges the interactions of humans with the natural environment in using resources to create goods and services which add value to their lives. It acknowledges the resource use and waste disposal must occur within the capacity of our planet. It encourages a fair trading system that equitably distributes benefits and costs. It further encourages innovation and creativity in developments that lead to a sustainable future.

Relationship between these aspects

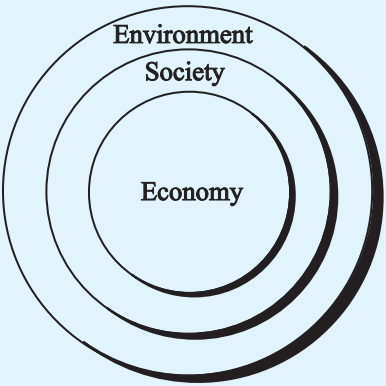


Fig. 4.2: Strong sustainability aspects

This model shows how our economy is a subset of our society. It also shows that everything in our economy and everything in our society entirely dependent on our environment.

This relationship means that any impact (or) change to our environment will impact on society and the economy. Therefore any sustainability related issue must be considered holistically and recognise their interdependence.

4.4 FROM UNSUSTAINABILITY TO SUSTAINABILITY

4.4.1 Unsustainability

Our ancestors have left a lot of resources for us. They used their resources sensibly and not for their greed. But we are exploiting limited resources. Instead of using it for our needs, we are exploiting it for our greeds.

Characteristics of Unsustainability

(i) Unsustainability is one in which we forget our responsibility towards the environment.

(ii) In unsustainability, we degrade the available resources.

(iii) It not at all cares about the needs of future generations.

(vi) Unsystematic planning can lead to damage to natural as well as human-made resources.

(v) Unsustainability leads to extreme degradation of the environment as well as the living organism.

Causes for unsustainability

(i) Developing countries are responsible for the degradation.

(ii) The rate of increase of National pollution. In this regard, developed countries contribute much more than developing countries.

(iii) Raising population.

(iv) People should look at environment as not only reserve of man but of all living organism.

(v) People built so many buildings, roads and dams for a luxurious life-style. We neglected the needs of animals and destroy their habitats.

(vi) We extract a lot of material from the lithosphere than what we need.

(vii) We create a lot of chemical compounds, which break down in the environment and becomes problematic.

(viii) We cut trees at a faster rate than they can grow, which causes global warming.

(ix) Purchasing and using polythene bags contribute to growth of pollution.

4.4.2 Characteristics of Sustainability

1. It reduces emission of greenhouse gases, which will reduce global warming and helps in preserving the environment.
2. It uses natural and biodegradable materials for reducing the impact on the environment.
3. It emphasis on using renewable energy sources such as wind and solar energy.
4. It follows non-polluting construction practices.
5. It protects the natural habitats.
6. It improves the quality of human life.
7. It minimises the depletion of natural resources.
8. It teaches us to respect and care for all the life forms.
9. It makes arrangements, so that the future generations are able to meet their own demands.

Table 4.1 Differences between sustainability and unsustainability

S.No.	Sustainability	Unsustainability
1.	Prevention of natural resources.	Exploitation of natural resources is faster than the planet can handle and replenish.
2.	Long-term economic growth without negatively impacting our environment (or) society.	Not quantifying ecosystem services and increased vulnerability to crises.
3.	Equality, diversity, social cohesion and democracy.	Labour laws, human rights, gender inequality and poor treatment of indigenous people.

4.5 MILLENNIUM DEVELOPMENT GOALS

The Millennium Development Goals (MDGs) were 8 international development goals.

1. To eradicate extreme poverty and hunger.
2. To achieve universal primary education.
3. To promote gender equality and empower women.
4. To reduce child mortality.
5. To improve maternal health.
6. To combat HIV/AIDS, malaria, and other diseases.
7. To ensure environmental sustainability.
8. To develop a global partnership for development.

4.6 SUSTAINABILITY PROTOCOLS

Sustainability protocols are sustainability standards and certifications. These are voluntary guidelines used by producers, manufacturers, traders, retailers and service providers to demonstrate their commitment to good environmental, social, ethical and food safety practices.

There are over 400 such standards across the world. The sustainability protocols listed below are important because they build awareness and policy support, create clear guideline and goals. They have third-party verification and maintain consistency within a portfolio while developing Green economy.

Few sustainability protocols

1. LEED
2. WELL
3. Fitwel
4. Living building challenge
5. BREAM
6. Passive house
7. National Green Building Standard
8. Built green
9. Evergreen sustainable development standard (ESDS)

(a) Introduction of eco-labels and standards for organic food and other food products.

(b) Triple bottom line, it includes a set of practices (or) criteria for how a crop should be sustainably grown (or) a resource should be ethically harvested.

(c) It includes, responsible fishing practices that do not endanger marine biodiversity (or) respect for human

rights and the payment of fair wages on a coffee (or) tea plantation.

(d) Sustainability protocols are accompanied by a verification process (certification) to evaluate that an enterprise complies with a standard as well as a traceability process for certified products to be sold along the supply chain, often resulting in a consumer-facing label.

(e) It also focus on capacity building and working with partners and other organizations to support small holders (or) disadvantages producers to make the social and environmental improvements needed to meet the standard.

4.7 SUSTAINABLE DEVELOPMENT

Definition

Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

4.7.1 Aim of true sustainable development

It aims at optimum use of natural resources with high degree of sustainability, minimum wastage, least generation of toxic by-products and maximum productivity.

1. **Inter - generational equity:** It states that we should hand over a safe, healthy and resourceful environment to our future generations.
2. **Intra - generational equity:** It states that the technological development of rich countries should support the economic growth of the poor countries and help in narrowing the wealth gap and lead to sustainability.

3. Place more emphasis on pollution prevention and waste reduction.
4. Recycle and reuse as many of our waste products and resources possible.
5. Make more goods that last longer and easy to use, recycle and repair.
6. Depends on renewable sources of energy (sun, wind, water, bio-mass).
7. Sustain earths biodiversity.
8. Earth degrading activities should be discouraged.
9. Reduce poverty and rate of population growth.
10. Don't use high quality energy to do a job.

4.7.2 Goals of Sustainable Development

There are a total of 17 goals

1. End poverty everywhere, in all its forms.
2. End hunger, achieve food security and improved nutrition.
3. Ensuring good health and promote the well-being of all age groups.
4. Ensuring inclusive and equitable quality education.
5. Achieving gender quality and empowering all women and children.
6. Ensuring the availability and sustainable management of water and sanitation for all.
7. Ensuring access to affordable, reliable, clean and modern energy for all.
8. Promoting sustainable economic growth.
9. Building resilient infrastructure and promoting sustainable industrialisation.

10. Reducing inequality within and among countries.
11. Making cities and human settlements inclusive, safe resilient and sustainable.
12. Ensuring sustainable consumption and production patterns.
13. Taking urgent action to combat climate change and its impacts.
14. Conserving and sustainabily using the oceans, seas and marine resources for sustainable development.
15. Protecting, restoring and promoting the sustainable use of terrestrial ecosystems.
16. Promoting peaceful societies for sustainable development.
17. Strengthening the means of implementation and revitalising the global partnership for sustainable development.

4.7.3 Sustainable development targets

1. Eradicate extreme poverty for all the people everywhere.
2. Reduce at least by half the proportion of men, women and children of all ages living in poverty.
3. Implement nationally appropriate social protection systems and measures for all including floors.
4. Ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, natural resources and new technology and financial services.
5. Built the resilience of the poor and those in vulnerable situations and reduce their exposure to climate related events and disasters.

6. Ensure significant mobilization of resources from a variety of sources from developed countries to less developed countries.
7. End hunger and ensure access by all people, in particular the poor people and people in vulnerable situations.
8. End all forms of malnutrition.
9. Double the agricultural productivity and income of small scale food producers.
10. Ensure sustainable food production systems and implement resilient agricultural practices.
11. Maintain the genetic diversity of seeds, cultivated plants and farmed animals.
12. Increase investment in rural infrastructure, agricultural research and technological development to enhance agricultural productive capacity.
13. Correct and prevent trade restrictions and distortions in world agricultural markets.
14. Adopt measures to ensure the proper functioning of food commodity markets.
15. Reduce the global maternal mortality ratio to less than 70 per 1,00,000 live births.
16. End preventable deaths of new borns and children under 5 years of age.
17. End the epidemics of AIDS, tuberculosis, malaria, hepatities, water-borne diseases.
18. Reduce by one third premature mortality from non-communicable diseases through prevention and treatment.
19. Strengthen the prevention and treatment of substance abuse like narcotic drug abuse and harmful use of alcohol.

20. Halve the number of global death and injuries from road accidents.
21. Ensure universal access to sexual and reproductive healthcare services like family planning.
22. Achieve universal health coverage including financial risk protection.
23. Reduce the number of deaths and illnesses from hazardous chemicals and air, water, soil pollution.

4.7.4 Sustainable development indicators

1. Proportion of the population living **below the international poverty line** by sex, age, employment status.
2. Proportion of the population living **below the national poverty** line by sex and age.
3. Proportion of population covered by social protection floors.
4. Proportion of total adult population with secure tenure rights to land with legally recognized documentation.
5. Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies.
6. Proportion of total government spending on essential services.
7. Prevalence of under nourishment.
8. Prevalence of stunting and mal-nutrition among children and 5 years of age and prevalence of anaemia in women aged 15 to 49 years.
9. Average income of small-scale food producers.
10. Proportion of agricultural area under productive and sustainable agricultural practices.

11. Proportion of local breeds classified as being at risk of extinction.
12. Total official flows to the agricultural sector.
13. Agricultural export subsidies.
14. Indicator of food price anomalies.
15. Maternal mortality ratio.
16. Under - 5 mortality rate.
17. Hepatities B (or) Tuberculosis incidence per 100,000 population. Malaria incidence (or) HIV infections per 1000 population.
18. Suicide mortality rate.
19. Alcohol per capital consumption within a calendar year in litres of pure alcohol.
20. Death rate due to road traffic injuries.
21. Proportion of women of reproductive age, who have their need for family planning.
22. Coverage of essential health services.
23. Mortality rate due to unsafe water, sanitation and lack of hygiene.

4.7.5 Intervention areas of sustainable development goals

Implementation of sustainable development goals are some what difficult because of the following interventions.

1. Climate change.
2. Use of natural resources.
3. Waste production.
4. Water pollution.
5. Deforestation.

6. Over fishing.
7. Poverty.
8. Ocean acidification.
9. Air pollution.

4.8 CLIMATE CHANGE

Climate change refers to the long-term shifts in temperatures and weather pattern. These changes may be natural (through variations in solar cycle) (or) artificial (human activities like burning of fossil fuels like coal, oil and gases).

4.8.1 Causes of climate change

1. Presence of green house gases in the atmosphere increases the global temperature.
2. Depletion of ozone layer also increases the global temperature.
3. Uneven distribution of rainfall.
4. Rotation of earth on its axis.
5. Seasonal changes.

4.8.2 Effect (or) Issues of climate change

1. Even small changes in climatic conditions may disturb agriculture that would lead to migration of animals including humans.
2. Climate change may upset the hydrological cycle, results in floods and droughts in different regions of the world.
3. Global pattern of winds and ocean currents also gets disturbed by climate.

4. More frequent and intense drought.
5. Sea levels gets raised.
6. Melting glaciers and warming oceans can directly harm animals and destroy the places they live.
7. Higher temperature increases heat related illnesses and make working outdoors more difficult.
8. If conditions are hot wild fires start more easily and spread more rapidly.
9. As green house concentration increases, global surface temperature also increases.

4.8.3 Possible solutions to climate change

1. Burning of fossil fuels like coal, oil and gas must be avoided.
2. Renewable energy sources like solar, wind, tidal and geothermal power must be used instead of fossil fuels.
3. Reducing petrol and diesel vehicles, planes and ships and switching to electric vehicles stop climate change.
4. Heat our homes in a green way, by insulating walls and roofs and switching away from oil (or) gas boilers to heat pumps.
5. The best way for individuals to help stop climate change is by reducing their meat and dairy consumption (or) by going fully vegetarian.
6. Planting more trees in the right place will absorb more carbon from the emissions.
7. Protect forests, which fight against climate change.
8. Oceans also absorb large amounts of CO_2 from the atmosphere, which helps to keep our climate stable.

9. Reducing overall consumption in more wealthy countries can help put less strain on the planet.
10. Avoid of using plastics.
11. Reduce carbon pollution to avoid the worst consequence of climate change.
12. Provide financial support to developing countries, so people and nature can successfully adapt.

4.9 CASE STUDIES

4.9.1 Climate change on Chennai, East Coast Road (ECR) and Old Mahabalipuram Road (OMR)

ECR and OMR are the today's landmark will receive the highest climate impact. Due to Chennai's land use patterns, population stress and abuse of natural resources, climate has changed drastically in the last few years. Climate induced impacts like drought, floods, heavy rains and winds are becoming increasingly evident in the city.

On one end of the continuum is summer water crises and on the other end is monsoonal flood disasters.

Reason for flood in Chennai

Increasing population and building / Land use pattern have changed the natural hydrology of the city. The water which needs to naturally drain into the sea via, the regional watershed are now blocked by buildings and artificial man-made structures. These are all reason for flood in Chennai city.

Remedy

Researchers predicts that Chennai's climate is more unpredictable and aggressive. Climate change will affect

people and the environment. People need to take action to reduce the emission of green house gases that is the root cause for climate change.

4.9.2 Climate change on Chennai, Ennore

Ennore thermal power station (ETPS), a 660 MW coal-fired thermal power plant in Ennore at north Chennai, CPCL's oil refinery, Madras Fertilizers Ltd, Tamil Nadu Petroproducts Ltd and Madras Petrochemical Ltd. These six factories were, operating in violation of prescribed air pollution norms for nearly 60%, responsible for drastic climate change.

More than 56 lakh tonnes of coal ash is spread over the river bed with flyash deposits ranging in depth from 1 ft to 8 ft.

Issues (or) effects

1. Ground-level particulate matter pollution due to emissions, from above said 6 factories at around Ennore, exceeded the carrying capacity of the area in the vicinity of the plant.
2. Ground-level SO_2 and NO_2 pollution exceeded the carrying capacity of the area.
3. In Ennore, children and women are particularly affected and gynecological problems were particularly reported by respondents.
4. Natural drainage pattern have been considerably altered due to fly ash pond construction and ash contamination. This will have an impact on local hydrology and flooding.
5. Climate change manifeasts in the form of rising sea levels, increased heat stress, intense rain events and

droughts and ocean desertification due to warming seas.

6. More than 120 million litres of hot waste water is discharged daily, from Ennore power plant, into the Ocean. Such discharge in an already warming Ocean will create localised marine deserts.

4.10 CARBON CREDIT

4.10.1 Definition

A carbon credit is a tradable permit (or) certificate that represents the right to emit a set amount of CO_2 (or) 1 tone of CO_2 (or) the equivalent amount of green house gas.

4.10.2 Concept

Kyoto protocol is an international agreement that aims to manage and reduce carbon dioxide emissions and green house gases. Kyoto protocol introduced the concept of carbon credits.

According to this, a country should reduce carbon emissions in the atmosphere.

(i) A carbon credit is a tradable certificate that allows its holder to emit green house gases.

(ii) One carbon credit is equal to one ton of carbon dioxide.

(iii) Countries need to reduce their emissions by 5.2% compared to the numbers recorded.

(iv) Countries and companies need to be designed to reduce carbon emissions without the need to buy credits.

(v) Less the purchase, less will be the carbon release into the atmosphere.

4.10.3 Types of carbon credits

There are two types of carbon credits.

1. Voluntary emissions reduction (VER)

It is a carbon offset that is exchanged in the over-the-counter (or) voluntary market for credits.

2. Certified emissions reduction (CER)

It relies on emission credits created through a regulatory frame work with the purpose of off-setting a project's emissions.

4.10.4 How to get carbon credit

Carbon credits and carbon markets are a component of a national and international attempts to mitigate the growth in concentrations of green house gases (GHGs). One carbon credit is equal to one ton of CO_2 (or) CO_2 equivalent gases.

There are many companies, that sell carbon credits to commercial and individual customers who are interested in lowering their carbon foot print. Buyers and sellers can also use an exchange platform to trade, which is like a stock exchange for carbon credits.

4.10.5 Advantages and Disadvantages of Carbon Credits

Advantages of Carbon Credit

1. Each carbon credit corresponds to one ton of carbon that was not emitted into the atmosphere.

2. The company that does not have an alternative to reduce its emission finds an advantage in the purchase of this credit.

3. The purchase of carbon credits by companies that are environmentally conscious is favorable for their image.

4. Sometimes the company behaves sustainably, but it cannot stop emitting some amount of carbon. In this case, the purchase of credit shows how much the company cares about encouraging sustainable activities.

5. It enables companies to support decarbonization beyond their own carbon footprint.

Disadvantages of Carbon Credit

1. Some institutions and countries can accommodate themselves in the exchange market to continue emitting their greenhouse gases.

2. Companies do not invest in action to avoid emissions because they are able to buy unlimited credits.

3. The reduction of 1 ton of carbon that is 1 credit, will never be enough.

4. It is an alternative for emergency needs, not to rest on the fact that the other has saved.

5. Main focus of carbon credit is to reduce green house gas emissions, but it is not possible to stop the negative impacts caused by the globle warming.

4.11 CARBON FOOTPRINT

Definition

It is the total amount of green house gases (including CO_2 and CH_4) that are generated (emitted) by our direct and indirect activities.

Individual carbon footprint

It is the sum total of their direct and indirect carbon emissions over the course of a year.

i.e.,	Smaller your carbon footprint	:	better for the future
	Bigger your carbon footprint	:	Have bigger negative impact in environment

The average carbon footprint for a person in united state is 16 tons. Globally, the average is closer to 4 tones. To avoid 2°C rise in global temperatures, the average global carbon footprint per year needs to drop under 2 tons by 2050.

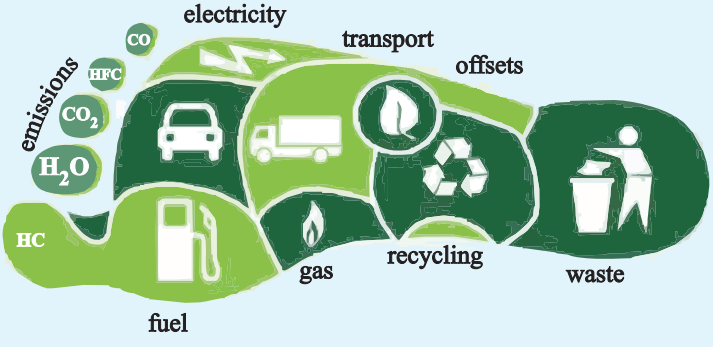


Fig. 4.3 Carbon Footprint

4.11.1 Sources of carbon footprint

1. Climate change.
2. Natural process like volcanos.
3. Green house gases emitted from human activities.
4. Pollution released by human beings doing human things.
5. Transportation accounted for about 28% of total country.
6. Electricity generation accounted for about 28%.
7. Industrial activities 22%.
8. Heating and cooling in homes and businesses contribute 11%.

4.11.2 Causes of a carbon footprint

The major contributors to carbon footprints are

(i) food: (especially meat (beef))

(ii) consumption

(iii) transportation

(iv) house hold energy

4.11.3 How to lower (control) carbon footprint (or) 15 ways to reduce your carbon footprint

Lowering individual carbon footprint from 16 tons to 2 tons does not happen over night. But, by making small changes in our action we can reduce carbon footprint.

Once you understand where your emission comes from, you can take steps to reduce your impact.

1. Calculate your carbon footprint.
2. Drive less.
3. Switch to an electric (or) hybrid car.

4. Travel smart.
5. Switch to renewable energy.
6. Consider solar panels.
7. Make your home more efficient.
8. Turn your thermostat just 2 degrees cooler in winter and 2 degrees warmer in summer.
9. Get energy efficient appliances.
10. Unplug electrical devices when not in use.
11. Buy locally - sourced food.
12. Start a home garden.
13. Eat less meat.
14. Don't waste water.
15. Reduce, reuse and recycle.

4.12 ENVIRONMENTAL MANAGEMENT

Environmental management is a set of practices and processes that enable any organization, whether private (or) public, to reduce its environmental impacts and increasing its operating efficiency.

4.12.1 Objective (or) Aim of EM

1. To mitigate adverse impacts on various environmental components, which have been identified during the rapid environmental impact assessment study.
2. To protect environmental resources.
3. To enhance the value of environmental components where possible.
4. To monitoring plan to enable evaluation of the success (or) failure of environmental management measures.

5. To carry out reorientation of the plan if found necessary.
6. To implement the protective and enhancement measures by adopting suitable planning and design criteria for construction of the project.
7. To improve the quality of human life.
8. To prevent and solve environmental problems.
9. To establish limits and standards.
10. To warn against threats and identify opportunities.
11. To develop strategy for improving quality of life.
12. To identify new eco-friendly technologies for sustainable development.
13. To protect the environment from the effects of manufacturing byproducts.
14. To protect your business from non compliance fines and penalties.

4.12.2 Principles of environmental management

There are 7 basic principles, which are some guiding principles of environmental management. These principles are helpful in environmental decision making.

1. Polluter pays principle (PPP)

It states that firms discharge polluting effluent to the environment. If measures are adopted to reduce pollution, the cost should be paid by the polluters (firms).

2. The user pays principle (UPP)

It states that all resource users should pay the cost of the use of a resource and related services.

3. The precautionary principle (PP)

It states that a substance (or) activity, posing a threat to the environment, is prevented from adversely affecting the environment.

4. Principle of effectiveness and efficiency

The efficiency of resource use may be accomplished by the use of policy instruments that create incentive to minimize wasteful use.

5. The principle of responsibility

It is the responsibility of all persons, to use the environmental resources in an ecological sustainable, economically efficient and socially fair manner.

6. The principle of participation

It is the duty of all the persons to participate in collectively environmental decision making activities.

7. The principle of proportionality

It is based on the concept of balance. A balance is to maintain between the economic development on the one hand and environmental protection on the other hand.

4.12.3 Steps involved in environmental management

The following 5 steps are involved in environmental management.

Flow Chart

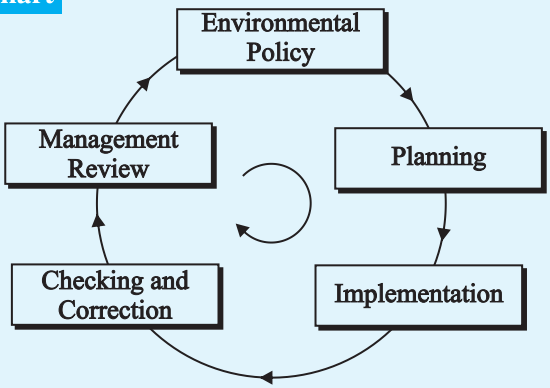


Fig. 4.4 Environmental Management

Step 1: Environmental policy

It is the mission of an organization, which starts with establishing an environmental policy.

Step 2: Planning

It involves identifying the resources, processes, significant impacts and pollution prevention opportunities. It also includes objectives and targets for improvement efforts.

Step 3: Implementation

This step consists of defining the structure, responsibilities and programs. It also develops and implements standard operating procedures and training.

Step 4: Checking and correction

It includes monitoring and measuring problems identification and corrective and preventive action implementation.

Step 5: Management review

It involves modification of environmental management system to ensure solutions on compliance. Based on the result of checking and correction, management must take corrective actions.

4.12.4 Characteristics of environmental management

1. Environmental management supports sustainable development.
2. It demands the multidisciplinary approach.
3. It has to integrate different development view points.
4. It seeks to integrate natural and social science.
5. It can extend from short-term to long-term and from local to global level.
6. It deals with a world affected by humans.

4.12.5 Benefits of Environmental Management

1. Improved environmental performance
2. Enhanced compliance
3. Pollution prevention
4. Resource conservation
5. Attracts new customers/markets
6. Increased efficiency/reduced costs
7. Enhanced employee morale
8. Enhanced image with public, regulators, lenders and investors.

4.13 CASE STUDIES

4.13.1 Electronic waste (E-waste) Recycling, Dell company

Dell company, through its "legacy of good" programme, the technology giant has plan to cut waste, create more eco-friendly products. It plans to use 50 m pounds of recycled plastic and other sustainable materials, create 100% recyclable (or) compostable packaging and recover 2 bn pounds of electronic waste. Dell sourced 4.5 m kilos of recycled plastic to make monitors and desktops.

Dell eliminated 20 m pounds of packaging waste and generating more than 18 m in cost savings. Its intention to reduce packaging waste, replacing non-biodegradable, oil-base material with organic alternatives such as bamboo and mushrooms.

As a part of its effort to encourage others to see waste as a valuable resource. Finally, the most appropriate environmental management strategy to control environmental pollution is cleaner production. So, according to environmental management principles, cleaner production is a proactive approach where companies take preventive measure to reduce waste production at source.

4.13.2 Biomedical waste management in Nepal

Due to improper environment management techniques, Nepal has many problems with medical waste, which impact adversely the environment including human health. Nepal Health Resource council in collaboration with world health organization (WHO) has developed national health care waste management guidelines and training manuals for medical professionals, but it has not been

functioning well. As a result, many hospitals use small scale incinerators (or) open burn (or) dump the waste in their premises until the garbage pickers comes and dispose in the landfill.

Incinerator facilities, if properly implemented, not only reduce final disposal of waste, but also produce electricity/heat, saving (energy) resources. This situation in Nepal is much worsen because it was not properly built and there are residents who could directly be affected by emissions resulted from the smoke around the burning equipment.

4.13.3 Municipal solid waste management in solapur city, Maharashtra, India

Total waste generated in solapur corporation area is 420 MT/day, of which 50% is biodegradable, 25% is recyclable, 15.3% is green and 9.9% is debris and slit. About 51% of the total solid waste, collected from entire city, is biodegradable.

The waste is disposed daily to the landfill site located on Tuljapur road and Bhogaon. The disposal site is open and gives rise to contamination and the treatment process is not followed. The landfill sites are not well maintained, which create the threat of groundwater contamination due to leachate percolation. Most of the waste remains lying down in open causing pollution with the odour and smell unless degrades naturally.

A treatment plant of anaerobic digestion is in progress to extract energy from organic waste generating the biogas.

4.14 PART B QUESTIONS

1. Explain the types, characteristics and steps of development.
2. What is GDP? How is it calculated? Explain its merits.
3. Define sustainability? What is the need of sustainability.
4. Explain the economic and social challenges of sustainability.
5. Explain the various aspects and relationship of sustainability.
6. Explain the causes and characteristics of unsustainability.
7. Explain the differences between sustainability and unsustainability.
8. Write notes on concept, goal and aim of sustainable development.
9. Write notes on
   (i) Millennium Development Goals.
   (ii) Sustainability protocols.
10. Explain the sustainable development targets.
11. Explain the sustainable development indicators.
12. What are the causes, effects and possible solutions of climate change?
13. What is meant by carbon credit? Explain its types and merits.
14. Explain the sources, causes and remedy measures of carbon foot print.
15. What is environmental management? Explain the various steps of environmental management.
16. Explain the objectives and principles of environmental management.

Unit - V

Sustainability Practices

5.1 ZERO WASTE

Definition

Zero waste is a set of principles, focused on waste prevention, that encourages redesigning resource life cycles, so that all products are reused.

5.1.1 Goal

1. The material should be reused until the optimum level of consumption is reached.
2. It provides guidelines for continually working towards eliminating waste.
3. To avoid sending trash to landfills, incinerators (or) the ocean.

5.1.2 Concept

The conservation of all the resources by means of responsible production, consumption, reuse and recovery of products, packaging and materials without burning and with no discharges to land, water (or) air that threaten the environment (or) human health.

Fig. 5.1 Logo for zero waste

Examples of zero waste

(i) one - way recyclable glass bottles.

(ii) one - way milk bags.

(iii) one - way aseptic cartons.

(iv) one - way table - top paper board cartons.

5.1.3 Principles of zero waste

1. **Refuse what you don't need:**

   It prevents unwanted items from coming into your home.

2. **Reduce what you do use:**

   It is equal to less waste at the end.

3. Reuse whatever you can.

4. Recycle what you can't refuse (or) reduce.

5. **Regulate of what's left over:**

Composting food scraps, paper pieces and wooden (or) bamboo tooth brushes returns nutrients and fiber back to the earth.

Flow Chart

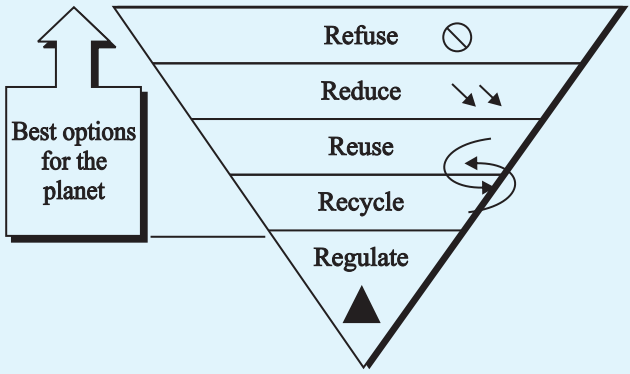


Fig. 5.2 Zero waste Hierarchy

5.1.4 Steps to achieve zero waste

1. Identify the high waste areas of our life-style.
2. Know where to apply the principle of zero waste, if the waste cannot be removed (or) reduced.
3. Substitute single use plastic with eco-friendly zero waste options.
4. Buy zero waste (or) eco-friendly products.
5. Support eco-friendly businesses.
6. Put all your kitchen waste to good use (compositing).
7. Reuse, upcycle and re-purpose.

5.1.5 Advantages and Disadvantages of zero waste

Advantages (or) Benefits

(i) Zero waste reduces our climate impact.

(ii) It conserves resources and minimizes pollution.

(iii) It promotes social equity and builds community.

(iv) It supports a local circular economy and creates jobs.

(v) Zero waste needs businesses to play a key role.

Disadvantages (or) problem of zero waste

(i) Since zero wastes are solids, it is difficult to store.

(ii) It is more expensive.

(iii) Zero waste in time-consuming.

(iv) It can cause anxiety.

(v) Zero waste can be misleading.

(vi) It can be difficult for a large household.

(vii) Zero waste products are hard to find.

5.2 R CONCEPT (OR) 3R CONCEPT (REDUCE, REUSE AND RECYCLE)

Definition

The principle of reducing waste, reusing and recycling resources and products is often called 3Rs.

1. Reduce

Reducing means choosing to use things with care to reduce the amount of waste generated.

If the usage of raw materials are reduced, the generation of waste also gets reduced.

2. Reuse

Reusing involves the repeated use of items (or) parts of items which still have usable aspects.

(a) The refillable containers, which are discarded after use, can be reused.

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

3. Recycle

Recycling means the use of waste itself as the resources.

It involves reprocessing of the discarded materials into new useful products.

Examples

(i) Old aluminium cans and glass bottles are melted and recast into new cans and bottles.

(ii) Preparation of cellulose insulation from paper.

(iii) Preparation of fuel pellets from kitchen waste.

(iv) Preparation of automobiles and construction materials from steel cans.

The above process saves money, energy, raw materials, and reduces pollution.

5.2.1 Concept of 3R

The concepts of 3R refers to reduce, reuse and recycle, particularly in the topic of production and consumption. It forces for an increase in the ratio of recyclable materials, further reusing of raw materials and manufacturing wastes and overall reduction in resources and energy used.

Fig. 5.3 3R Concept

5.2.2 Principle

3R is the order of priority of actions to be taken to reduce the amount of waste generated and to improve overall waste management processes and programs.

5.2.3 Importance of 3 Rs

(i) The most effective way to reduce the garbage is reducing the amount of solid waste produced.

(ii) By reducing waste at the source, the resources like water and energy can be saved.

(iii) Like reducing, reusing avoids creating waste rather than trying to recycle it once it's already there.

(iv) Operating a well-run recycling program costs less than waste collection and land filling.

(v) Recycling helps families save money because they pay for less disposal costs.

(vi) recycling produces less air and water pollution than manufacturing with new materials.

(vii) By recycling less materials are sent to landfills, which will keep them for future.

(viii) Proper disposal and recycling will prevent water and soil contamination.

5.2.4 Advantages and disadvantages of 3 Rs

Advantages (or) Benefits of 3 Rs

(i) Reduce greenhouse gas emissions.

(ii) Saves energy.

(iii) Helps sustain the environment for future generations.

(iv) Reduces the amount of waste that will need to be recycled (or) sent to landfills and incinerators.

(v) Save money.

(vi) Prevent pollution.

Disadvantages of 3 Rs

1. High upfront capital cost.
2. Recycling sites are always unhygienic, unsafe and unsightly.
3. Products from recycled waste may not be durable.
4. Recycling might not be inexpensive.
5. 3R is more energy consumption and pollution.
6. 3R generates pollutants.
7. Processing cost is high.
8. Quality of resultant product is low.

5.3 CIRCULAR ECONOMY

Definition

Circular economy ***is a new production and consumption model that ensures sustainable growth over time. It reduces the consumption of raw materials and recover wastes by recycling (or) giving it a second life as a new product.***

5.3.1 Aim (or) Purpose

Aim of the circular economy is to make the most of the material resources available to us by applying three basic principles reduce, reuse and recycle.

In this way the life cycle of products is extended, waste is used and a more efficient and sustainable production model is established over time.

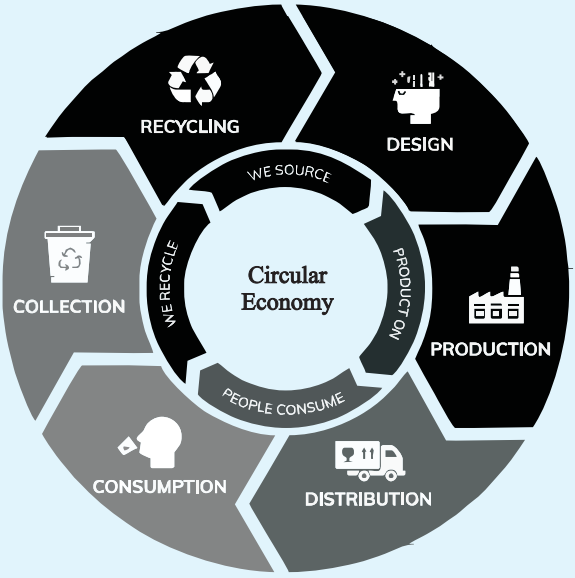


Fig. 5.4 Circular Economy

5.3.2 Benefits of circular economy

(i) It protects environment.

(ii) Circular economy benefits the local economy.

(iii) It drives employment growth.

(iv) It promotes resource independence.

5.3.3 Necessary steps (7Rs) to achieve a circular economy

1. Redesign

Redesigning process consumes fewer raw materials, extends their life cycle and generates less waste.

2. Reduce

If we reduce consumption, waste generation and use of raw materials, impact on the environment gets reduced.

3. Reuse

Reusing the products extends their life cycle.

4. Repair

Repairing avoids the use of new raw materials, saves energy and does not generate environmental waste.

5. Renovate

Update old objects, so that they can be reused.

6. Recycle

Waste product can be used as raw material to manufacture new products.

7. Recover

The products that are going to be discarded, can be used for new uses.

Example for Circular Economy

(i) Manufacturers design products to be reusable.

(ii) Electrical devices are designed in such a way that they are easier to repair. Products and raw materials are also reused as much as possible.

5.4 ISO 14000 SERIES

ISO

ISO is an International Organization for Standardization. It is composed of representatives from various national standard organizations. It provides standards and guidelines for a variety of businesses and purposes and publishes technical reports.

ISO 14000 series

It is a family of standards related to environmental management that exist to help organizations.

(a) minimize how their operations negatively affect the environment.

(b) comply with applicable laws, regulations and other environmentally oriented requirements.

(c) continually improve with above.

5.4.1 Objective of ISO14000 series

The primary objective of ISO14000 series of standard is to promote effective environmental management systems in organizations.

Fig. 5.5 Logo of ISO

5.4.2 List of ISO 14000 Series Standards

It includes a catalogue of over 50 Environmental management and performance related standards. But some important ISO14000 series standards are listed here.

Standard	Title	Applications
ISO14001	Environmental management system.	Requirements with guidance for use.
ISO14004	Environmental management system.	General guidelines on implementation.
ISO14005	Environmental management system.	Guidelines for flexible approach to implementation.
ISO14015	Environmental management.	Environmental assessment of sites.
ISO14020 to 14025	Environmental management.	Environmental labels and declarations.
ISO14030	Green bonds.	Environmental performance of nominated projects and assets.
ISO14031	Environmental management.	Environmental performance evaluation & Guidelines.
ISO14040 to 14049	Environmental management.	Discusses pre-production planning.
ISO14050	Environmental management.	Vocabulary, terms and definitions.
ISO14062	Environmental management.	Product design and development.
ISO14063	Environmental management.	Guidelines and examples.

Standard	Title	Applications
ISO14064	Environmental management.	Reducing green house gas emissions.
ISO14090	Environmental management.	Adaptation of climate change.

5.4.3 Core elements of ISO 14000

It contains the following six key elements.

(i) Environmental policy.
(ii) Planning.
(iii) Implementation and operation.
(iv) Checking and corrective action.
(v) Management review.
(vi) Continuous improvement.

5.4.4 Advantages and disadvantages of ISO14000

Advantages (or) Benefits

The following five important benefits of quality management system

(i) It identifies risks and opportunities.
(ii) It prevents problems from reoccurring.
(iii) It boosts your marketing and sales efforts.
(iv) It improves employee performance.
(v) It improves your control over the business.
(vi) It lowers costs like energy bills, tax and insurance bills.
(vii) It helps to reduce waste.

(viii) It helps to minimize the carbon footprint of a company.

(ix) It is recognised internationally.

(ix) It gives immediate notice about the environmental performance of a company.

Disadvantages (or) limitations

1. It is extremely costly to implement if not done properly.
2. It requires a lot of administrative work.
3. No improvement in environmental performance.
4. Organizations face a lot of challenges while implementing this standards.

5.5 MATERIAL LIFE CYCLE ASSESSMENT

Definition

Life cycle assessment (LCA) ***is a process of evaluating the effects of a material on the environment over the entire period of its life, there by increasing resource use efficiency and decreasing liabilities.***

Generally LCA is used to study the environmental impact of a material. LCA is commonly referred to as a cradle-to-grave analysis.

5.5.1 Stages of a life cycle assessment

The followings are the 5 stages of a life cycle assessment

Step 1: Raw materials (Resources) extraction and processing.

Step 2: Manufacturing.

Step 3: Transportation.

Step 4: Distribution.

Step 5: Usage and retail.

Step 6: Waste disposal (end of life).

Flow Chart

Fig 5.6 Life cycle assessment

In the manufactured product, environmental impacts are assessed from raw material extraction and processing, through the product's manufacture, distribution and use, to the recycling (or) final disposal of the materials.

5.5.2 Benefits (or) Advantages of LCA

1. LCA is widely used to support sustainable development.

2. LCA allows decision makers to compare two products and to select the product that has lowest impact on the environment.
3. It is a modelling tool to assess environmental impacts of a product during its entire lifespan.
4. LCA provides a holistic view on the environmental impacts, to avoid optimizing one environmental indicator without considering the effects on the other indicators.
5. LCA identifies hotspots in the environmental impact.
6. LCA is purely based on internationally accepted standards.

5.5.3 Disadvantages (or) Limitations

1. LCA assesses the real world in a simplified model.
2. The assumptions, scenaries and scope may vary from one study to the other leading to different LCA results.
3. Variations in LCA approaches and results may be confusing especially for non-experts.
4. LCA study requires large amount of data.
5. If data collection is poor, the study will not lead to solid conclusions.
6. It is not easy to communicate the results of a LCA study.

5.6 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.

5.6.1 Purpose (or) Aim of EIA

The main purpose of EIA is to determine the potential environmental, social and health effects of a proposed developmental projects.

5.6.2 Objectives of EIA

1. To identify the main issues and problem 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.

5.6.3 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 minimised.
4. Usages of resources are decreased.
5. Biodiversity is maintained.
6. Human health is improved.
7. It helps in preventing natural calamities like earthquake, cyclone, etc.,

5.6.4 Process of EIA (or) Key Elements of EIA

The key elements used in the process of EIA are

1. Scoping
2. Screening
3. Identifying and evaluating alternatives

4. Mitigating measures dealing with uncertainty
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 uncertainty

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.

5.7 SUSTAINABLE HABITAT

Sustainable habitat means the maintenance of our natural home.

Definition

A sustainable habitat is an ecosystem that produces food and shelter for people and other organisms without resource depletion ie., no external waste is produced.

5.7.1 Features (or) Characteristics of sustainable habitat

(i) Proper waste management.

(ii) Affordable housing.

(iii) Waste water treatment and facility of recycling waste water.

(iv) Green transportation using green fuel like biodiesel.

5.7.2 Objectives of national mission on sustainable habitat

1. To reduce energy demand by promoting alternative technologies and energy conservation practices in both residential and commercial areas.
2. Better urban planning like
   (i) using better disaster management
   (ii) lesser use of private transport
   (iii) more usage of public transport
3. Encourage community involvement and participation of stake holders.
4. Conservation of natural resources such as clean air, water, flora and fauna.
5. Facilitate the growth of small and medium cities.
6. To create sustainable habitats, engineers and architects should not consider any element as a waste product.

How to maintain sustainable habitat

For maintaining our sustainable habitat, we should

(i) Promote energy efficiency.

(ii) Promote the use of eco-friendly fuels.

(iii) Better manage municipal solid waste.

(iv) Promote to public transport.

5.8 GREEN BUILDINGS

Definition

Green building is an efficient method of construction that produces healthier buildings, which have less impact on the environment and climate. It requires less cost to maintain.

Green buildings preserve previous natural resources and improve our quality of life.

5.8.1 Criteria for green building

1. Green builders are encouraged to build on previously developed land rather than developing new land.
2. It is also important to build near existing infrastructure like bus routes, market, libraries.
3. The building site should be smaller because there is less environmental foot print.
4. Sites must be sustainably landscaped and don't suffer from soil erosion (or) light pollution.
5 Water reduction is built in by design using low-flow toilets, grey water systems.
6. Green buildings are constructed using clean energy like geothermal, solar, wind energies.
7. Green builders reduce material usage wherever possible. Mainly they use natural, renewable sources.
8. Selecting low emitting materials and products not only improves human health but also protect the overall environment.

5.8.2 Features of green building

(i) Efficient use of energy, water and other resources.

(ii) Use of renewable energy such as solar energy.

(iii) Pollution and waste reduction measures ie., reuse and recycling.

(iv) Good indoor environmental air quality.

(v) Use of materials that are non-toxic, ethical and sustainable.

(vi) A design that enables adaptation to a changing environment.

(vii) Consideration of the quality of life of occupants in design, construction and operation.

(viii) Construction of the environment in design, construction and operation.

Thus, any building can be a green building whether it is a home, an office, a school, a hospital, a community centre provided it includes features listed above.

5.8.3 Principles of green building

The five principles of green building are

(i) Livable communities.

(ii) Energy efficiency.

(iii) Indoor air quality.

(iv) Resource conservation.

(v) Water conservation.

5.8.4 Components of green building

Seven important components of green buildings are

1. Aluminium weather resistant insulated access panel. It helps regulate in door temperature and prevent moisture and pest from entering.
2. Energy efficient windows.
3. Green roof.
4. Solar power.
5. Water conservation.
6. Recycling.
7. Landscaping.

5.8.5 Advantages and Disadvantages of green building

Advantages of green buildings

1. Green buildings are energy efficient.
2. Higher fraction of eco-friendly materials.
3. Water - efficient devices.
4. Reduction in waste.
5. Less air pollution.
6. Reduction in green house gas emissions.
7. Protection of our natural resources.
8. Indoor air quality is improved.
9. Use of recycled metal and other construction materials.
10. Emphasis on renewable energies.
11. Day lighting is utilized as best as possible.
12. Use of renewable plant materials.
13. Higher market value.

14. Rainwater collection and use of compost bins.
15. Overall health improvements.

Disadvantages of green building

1. High initial costs.
2. Energy supply may depend on weather condition.
3. Technology problems are more.
4. Maintenance may be difficult.
5. Indoor air temperature may greatly vary over time.
6. Experienced green construction workers may be rare.
7. Green construction is not suitable for all locations.
8. Availability of green construction materials.
9. Funding problems for green buildings.

5.9 GREEN MATERIALS

Definition

Green materials also called eco-friendly materials, building construction materials that have low impact on the environment. Due to the properties of non-toxic, organic and recycling, green materials are widely used in various industrial applications.

Examples Naturally occurring materials like wood, ceramics, glass, clay, sand, stone.

5.9.1 Criteria for green materials

Following criteria can be used to identify the green materials.

(i) Local availability of materials.
(ii) Embodied energy of materials.
(iii) % of recycled (or) waste materials used.

(iv) Rapidly renewable materials.

(v) Contribution in energy efficiency of building.

(vi) Recyclability of materials.

(vii) Durability.

(viii) Environmental impact.

Evolution of the material can be made using the mentioned criteria.

5.9.2 Characteristics of green materials

Common characteristics of green materials are

1. Green materials are energy efficient products, it uses less energy to do the same task.
2. It lowers energy cost and lessen pollution.
3. Green materials are mostly renewable, can be regenerated again and again.

Example Bamboo grows quickly while pine grows more slowly, but both are renewable.

4. Green materials are recyclable (or) made from recycled material. So, they save energy and reduce waste.
5. Green materials are non-toxic, they do not emit odors, irritants (or) hazardous compounds that affect human health.
6. They are durable and no need to upgrade (or) repair. They preserve resources and energy.
7. They are cost-effective.
8. They can be locally sourced, so transport cost can be reduced.

5.9.3 Important green building materials

Green building is construction that primarily uses natural materials and renewable resources. These structures look really cool.

1. **Stone:** It is low maintenance and durable.

2. **Cob:** (mud mixture of natural ingredients like soil, sand, straw and lime). It is cheap and energy efficient.

3. **Bamboo**

   It is durable and light weight.

4. **Cork: (Cork canes from oak trees).**

   It is a very good thermal insulator and mold resistant

5. **Adobe brick: (brick made of clay and straw).**

   Natural noise protection and posses unique design (can be easily cut and transformed).

6. **Straw bale**

   Easily renewable and cheap.

7. **Cord wood**

   Affordable (cheap and easy construction), thermal efficiency.

8. **Earth bags (or) sand bags**

   Locally sourced and provide natural insulation.

9. **Mycelium (or) mushroom roots**

   Strong and light weight.

5.9.4 Examples of green materials

(i) Bamboo floorings.

(ii) LED lightings.

(iii) Reclaimed wood.
(iv) Energy efficient appliances.
(v) High-efficiency glass windows.
(vi) Solar panels.
(vii) Recycled steel.
(viii) Cork.
(ix) Precast concrete slabs.
(x) Low VOC paint.

5.10 ENERGY EFFICIENCY

Definition

Energy efficiency is the use of less energy to perform the same task (or) produce the same result. Energy efficient homes and buildings use less energy to heat, cool and run appliances and electronics.

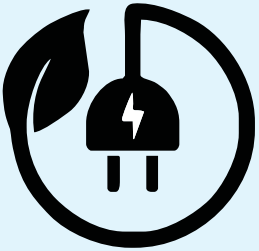


Fig. 5.7 Energy efficiency logo

5.10.1 Methods of achieving energy efficiency

Energy efficiency can be achieved by the following methods.

(i) Alternative waste treatment.

(ii) Avoided emissions from diverting legacy waste from landfill for process engineered fuel manufacture.

(iii) Avoided emissions from diverting legacy waste from landfill through a composting alternative waste technology.

(iv) Capture and combustion of landfill gas.

5.10.2 Calculation of energy efficiency

Energy efficiency can be calculated using the following relation.

$$\text{Energy efficiency} = \frac{\text{energy output}}{\text{energy input}} \times 100\%$$

$$\eta = \frac{w_{out}}{w_{in}} \times 100\%$$

5.10.3 Advantages (or) Benefits of energy efficiency

1. Using energy more efficiently is one of the fastest, most cost - effective ways to save money.
2. Increased energy efficiency can lower greenhouse gas emissions and other pollutants.
3. Energy efficiency also decreases water use.
4. It can lower individual utility bills, create jobs and help stabilize electricity prices.
5. It provides long-term benefits by lowering overall electricity demand, thus reducing the need to invest in new electricity generation and transmission infrastructure.
6. Energy efficient construction is environmentally - friendly as it does not emit harmful carbon dioxide into the atmosphere.

Example

Energy - efficient LED light bulbs are able to produce the same amount of light as incandescent light bulbs by using 75 to 80% less electricity.

5.10.4 Disadvantages (or) limitations of energy efficiency

1. Energy efficient construction is the high cost of enforcing ie., addition cost is required to build and plan such buildings.
2. Building materials are not always available.
3. Although energy efficient construction is environmentally friendly, it produces less carbon emissions and has slight unfavorable effects on the human health.
4. Indoor air is 3 to 7 times more polluted than outdoor air.

5.11 SUSTAINABLE TRANSPORT

Definition

Sustainable transport refers to ***any means of transportation that is "green" and has low impact on the environment.***

Examples

1. walking
2. cycling
3. transit
4. carpooling
5. car sharing
6. green vehicles

Sustainable transport can carry people for more efficiently than cars. Electric cars pollute less and reduce individual carbon foot prints.

Fig. 5.8 Sustainable transport

5.11.1 Importance of sustainable transport

(i) Sustainable transport contributes to reduction in damaging CO_2 emission and therefore to a reduction in atmospheric pollution and improved air quality in cities.

(ii) The aim of this type of transport is to reduce the negative impacts on the environment.

5.11.2 Key elements of sustainable transport

1. Fuel economy

The better fuel economy gets the lower emissions go. By improving fuel economy we can get the same mileage while generating fewer emissions. It is achieved by

(i) making engines more efficient.

(ii) vehicles lighter and bodies more aerodynamic.

2. Occupancy

The cheapest and simplest way to lower the carbon intensity of a vehicle is to stick more people in the vehicle.

Example

Local bus has emissions 7 times higher than the school bus. The main difference is that the school bus has very high occupancy.

3. Electrification

Electrification is the most important pathway to low carbon transport.

4. Pedal power

Bicycles reduces the carbon emissions.

5. Urbanization

It is a huge opportunity for lowering both distance travelled per person and the carbon intensity of that travel.

5.11.3 How to Promote sustainable transport

Followings are steps for promoting sustainable transport.

1. ***Enhancing public transportation:***

   It is not only less polluting means of transportation, but also promoting HSE (Health, safety and environment) policy.

2. ***Encouraging car pooling:*** It reduces the volume of CO_2, emitted per inhabitant.

3. ***Encouraging bicycle use:*** It is reliable and non-polluting means of transportation.

4. ***Teleworking:*** It reduces employee travel and therefore their carbon food print.

5. ***Improving the parking experience:*** It can be done effectively with the help of a parking management software.

5.11.4 Advantages and Disadvantages of sustainable transport

Advantages (or) benefits

1. It creates job.
2. Provides safer transportation.
3. Emits less pollution.
4. Promotes health (sustainable transit reduces emissions and air pollution)
5. It saves energy.
6. Saves money.
7. ***Decreases congestion:*** When people choose sustainable transportation, over driving themselves, congestion also decreases.
8. ***It conserves land.*** It encourages compact development, fewer roadways in country areas results in less runoff, thereby protecting the land and the biodiversity.

Disadvantages (or) limitations

(i) Modifications to handling and transport facilities.

(ii) The initial purchase of reusable containers.

(iii) Additional costs of the tracking system e.g., software packages, reading equipments, electronic chips, barcode labelling, detector's etc.,

5.12 SUSTAINABLE ENERGY

Definition

Sustainable energy is the energy which meets the needs of present without compromising the ability of future generations to meet their own needs.

It should be encouraged as it does not cause any harm to the environment and is available widely at free of cost.

5.12.1 Sources of sustainable energy

Followings are the sustainable enery sources as they are stable and available in plenty.

1. Wind energy.
2. Solar energy.
3. Ocean energy.
4. Hydro power.
5. Geothermal energy.

5.12.2 Advantages and disadvantages of sustainable energy

Advantages (or) Benefits

1. Improves public health

Burning of fossil fuels produces serious public health issues like neurological damage, cancer, heart attacks, breathing problems and premature death. However these problems can be eliminated by using sustainable energy sources, which emit no air (or) water pollutants.

2. Creates local jobs

Since most of the sustainable energy infrastructure is built locally (or) in the same country, it helps creates jobs and improves the economy.

3. Decrease your carbon footprint

Sustainable energy like wind and solar energy creates zero carbon emissions.

4. Cost saving

As it is easily available they are much more cost-effective than traditional energy resources, such as power plants

5. Energy security

It helps to conserve the planet's natural resources and reduce the pollution.

Disadvantages (or) limitations

1. Sustainable energy sources are not available round the clock.
2. The efficiency of sustainable energy technologies is low.
3. The initial cost of sustainable energy is high.
4. Sustainable energy sites require a lot of space.
5. Sustainable energy devices need recycling.

5.13 NON-CONVENTIONAL SOURCES (OR) RENEWABLE ENERGY SOURCES

Non-conventional sources are natural resources which can be regenerated continuously and are inexhaustible. They can be used again and again in an endless manner.

Examples *Wood, solar energy, wind energy, hydropower, tidal energy, etc.,*

Merits of Non-conventional energy resources

1. Unlimited supply.
2. Provides energy security.
3. Fits into sustainable development concept.
4. Reliable and the devices are modular in size.
5. Decentralized energy production.

5.13.1 Solar energy

The energy that we get directly from the sun is called solar energy.

The nuclear fusion reactions occurring inside the sun release enormous amount of energy in the form of heat and light. Several techniques are available for collecting, converting and using solar energy.

Methods of Harvesting Solar Energy

Some important solar energy harvesting devices are given below.

1. Solar cells (or) photovoltaic cells (or) PV cells

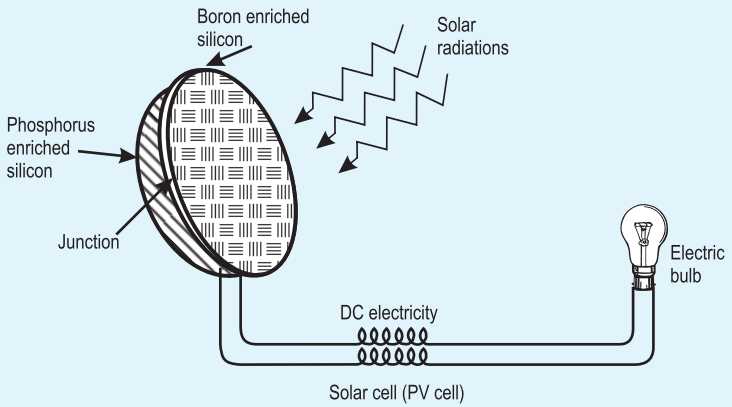


Fig. 5.9 Solar cell

Solar cells consists of a p-type semiconductor (such as Si doped with B) and n-type semiconductor (such as Si doped with P). They are in close contact with each other. When the solar rays fall on the top layer of p-type semiconductor, the electrons from the valence band get promoted to the conduction band and cross the p-n junction into n-type semiconductor. There by potential difference between two layers is created, which causes flow of electrons (ie., an electric current).

Uses

Used in calculators, electronic watches, street lights, water pumps to run radios and TVs.

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 run water pump, to run

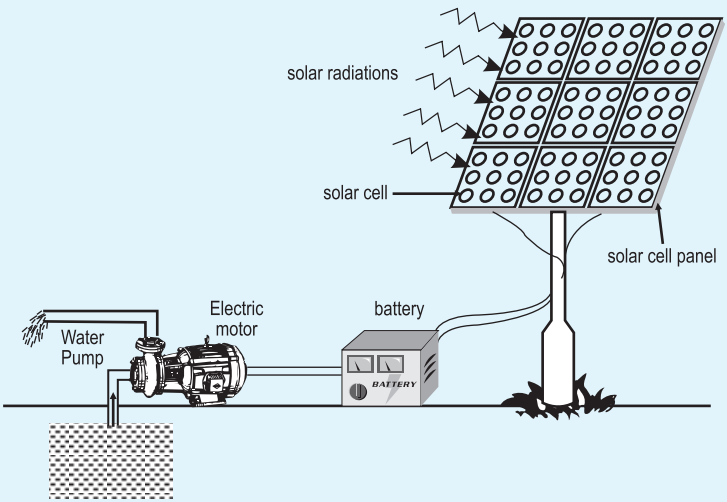


Fig. 5.10 Solar pump run by solar cells (Battery)

street-light, etc., They are used in remote areas where conventional electricity supply is a problem.

2. Solar heat collectors

Solar heat collectors consist of natural materials like stones, bricks (or) materials like glass, which can absorb heat during the day time and release it slowly at night.

Uses

It is generally used in cold places, where houses are kept in hot condition using solar heat collectors.

3. Solar water heater

It consists of an insulated box inside of which is painted with black paint. 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

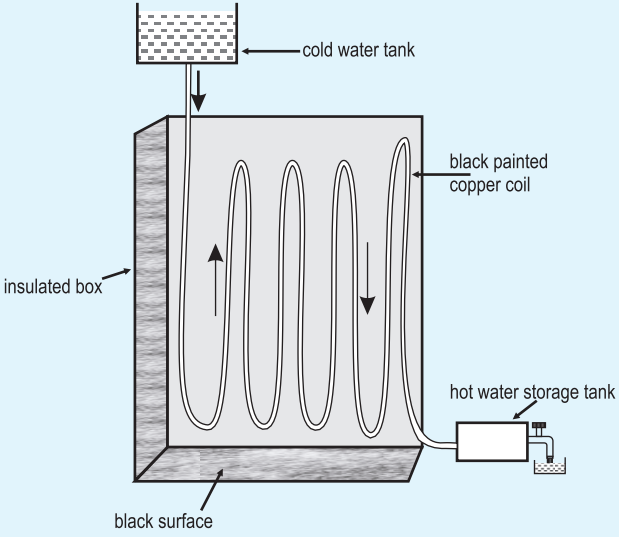


Fig. 5.11 Solar water heater

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.

5.13.2 Wind energy

Moving air is called wind. Energy recovered from the force of the wind is called wind energy. The energy possessed by wind is because of its high speed. The wind energy is harnessed by making use of wind mills.

1. Wind mills

The strike of blowing wind on the blades of the wind mill makes it rotating continuously. The rotational motion of the blade drives a number of machines like water pump, flour mills and electric generators.

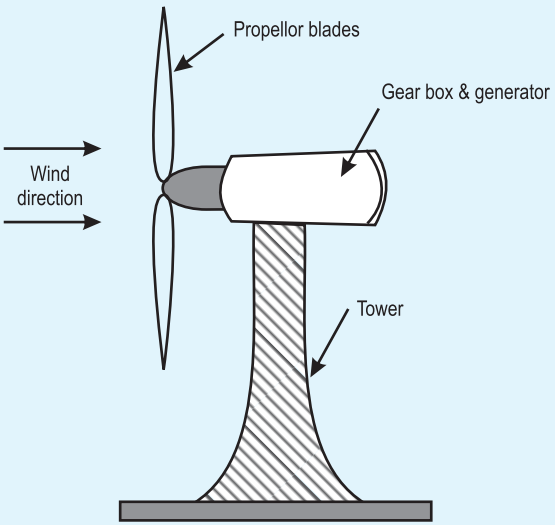


Fig. 5.12 Wind mill

2. Wind farms

When a large number of wind mills are installed and joined together in a definite pattern it forms a wind farm. The wind farms, produce a large amount of electricity.

Condition

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

Advantages

(i) It does not cause any air pollution.

(ii) It is very cheap.

5.13.3 Ocean energy

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

1. Tidal energy (or) Tital power

Ocean tides, produced by gravitational forces of sun and moon, contain enormous amount of energy. The '**high tide**' and **'low tide'** refer to the rise and fall of water in

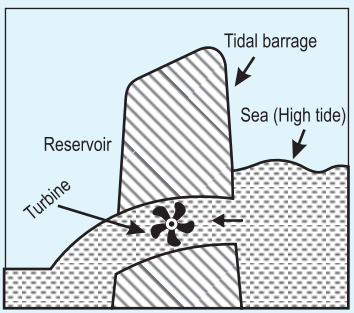


Fig. 5.13(a)

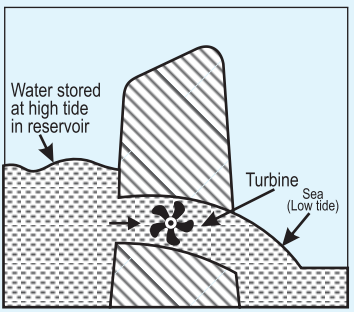


Fig. 5.13(b)

Fig. 5.13 (a) Water flows into the reservoir from sea.
Fig. 5.13 (b) Water flows out from the reservoir to the sea.

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

(a) During high tide, the sea-water is allowed to flow into the reservoir of the barrage and rotates the turbine, which inturn produces electricity by rotating the generators.

(b) During low tide, when the sea level is low, the sea water stored in the barrage reservoir is allowed to flow into the sea and again rotates the turbine.

2. Ocean thermal energy (OTE)

There is often large temperature difference between the surface level and deeper level of the tropical oceans. This temperature difference can be utilized to generate electricity. The energy available due to the difference in temperature of water is called ocean thermal energy.

Condition

The temperature difference should be of 20°C (or) more is required between surface water and deeper water.

Process

The warm surface water of ocean is used to boil a low boiling liquid like ammonia. The high vapour pressure of the liquid, formed by boiling, is then used to turn the turbine of the generator and generates electricity. The cold water from the deeper ocean is pumped to cool and condense the vapour into liquid.

3. Geo-thermal energy

Temperature of the earth increases at a rate of 20 – 75°C per km, when we move down the earth surface. High temperature and high pressure steam fields exist below the earth's surface in many places. The energy

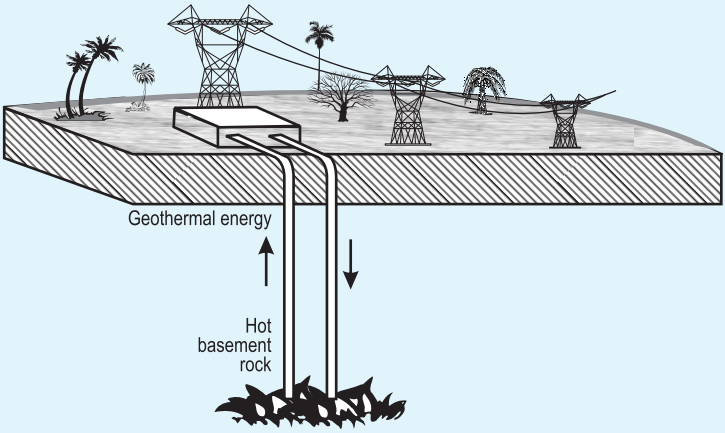


Fig. 5.14 Geo-thermal Energy

harnessed from the high temperature present inside the earth is called geothermal energy.

1. Natural geysers

In some places, the hot water (or) steam comes out of the ground through cracks naturally in the form of natural geysers.

2. Artificial geysers

In some places, we can artificially drill a hole up to the hot region and by sending a pipe in it, we can make the hot water (or) steam to rush out through the pipe with very high pressure.

Thus, the hot water (or) steam coming out from the natural (or) artificial geysers is allowed to rotate the turbine of a generator to produce electricity.

5.13.4 Biomass energy

Biomass is the organic matter, produced by plants (or) animals, used as sources of energy. Most of the

biomass is burned directly for heating, cooling and industrial purposes.

Examples *Wood, crop residues, seeds, cattle dung, sewage, agricultural wastes, etc., Biomass energies are of any one of the following types.*

1. Biogas

Biogas is a mixture of gases such as methane, carbon dioxide, hydrogen sulphide, etc., It contains about 65% of methane gas as a major constituent.

Biogas is obtained by the anaerobic fermentation of animal dung (or) plant wastes in the presence of water.

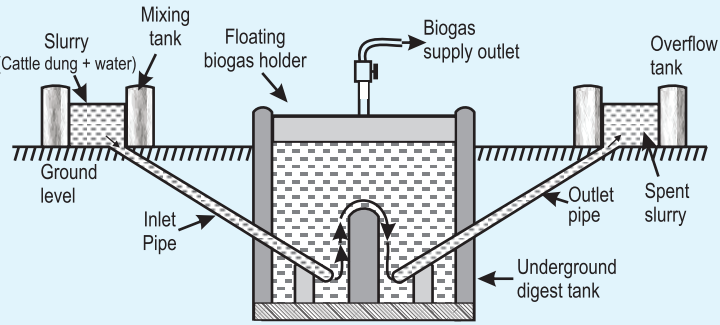


Fig. 5.15 Biogas Plant

2. Biofuels

Biofuels are the fuels, obtained by the fermentation of biomass.

Example *Ethanol, methanol.*

(a) Ethanol: Ethanol can be produced from the sugarcane. Its calorific value is less when compared to petrol, and produces much less heat than petrol.

(b) Methanol: Methanol can be easily obtained from ethanol (or) sugar-containing plants. Its calorific value is also too low when compared to gasoline and diesel.

(c) Gasohol: Gasohol is a mixture of ethanol + gasoline. In India trial is being carried out to use Gasohol in cars and buses.

3. Hydrogen Fuel

Hydrogen can be produced by thermal dissociation (or) photolysis (or) electrolysis of water. It possess high calorific value. It is non -polluting, because the combustion product is water.

$$2H_2 + O_2 \longrightarrow 2H_2O + 150\ kJ$$

Disadvantages of hydrogen fuel

1. Hydrogen is highly inflammable and explosive in nature.
2. Safe handling is required.
3. It is difficult to store and transport.

5.14 ENERGY CYCLES

Energy cycle, is the interactions between energy sources within the Earth's environment.

These interactions are very complex and even small changes in them can lead to significant changes in long-term climate behavior.

Illustration

A simple illustration of the major elements of the energy cycle is shown in the figure. 5.16

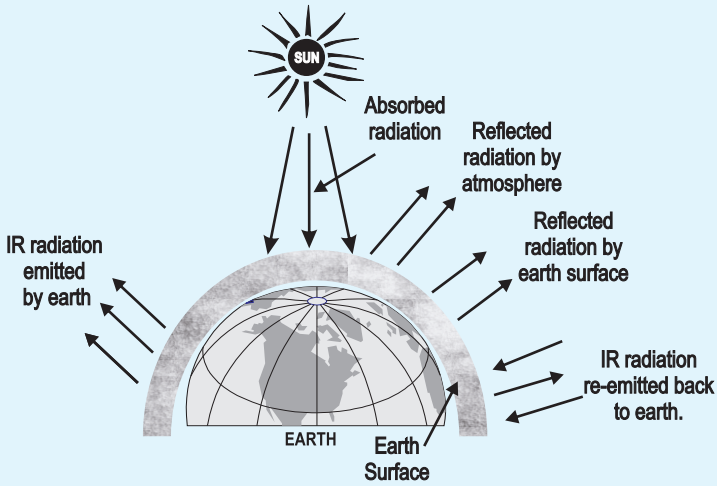


Fig. 5.16: Energy Cycles

Soil moisture is an important factor in the absorption and reflection of the sun's energy by the earth's surface.

Important energy cycles

(i) Carbon cycle.

(ii) Nitrogen cycle.

(iii) Phosphorus cycle.

5.14.1 Carbon cycle

Definition

Carbon cycle is the movement of carbon (or) carbon compounds continuously from the atmosphere to the earth and then back into the atmosphere.

(Or)

Carbon cycle is the process where carbon compounds are interchanged among the biosphere, geosphere, hydrosphere and atmosphere of the earth.

Carbon in the atmosphere is present in the form of carbon dioxide. Carbon enters the atmosphere through natural process such as respiration and industrial applications such as burning of fossil fuels

Sources of CO_2 in atmosphere

1. During respiration, plants and animals liberates CO_2 in the atmosphere.
2. Combustion of fuels also release CO_2.
3. Volcanic eruptions also release CO_2.

Various steps involved in carbon cycle

Carbon cycle involves the following 5 important steps.

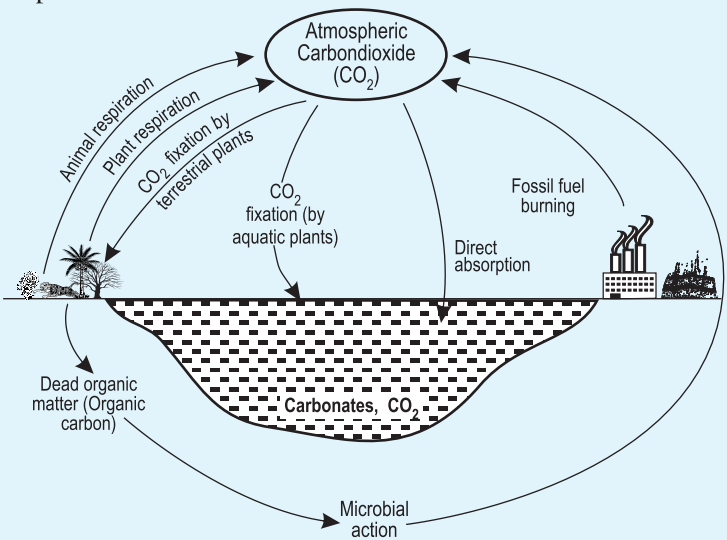


Fig. 5.13 Carbon cycle

Step I: Carbon present in the atmosphere is absorbed by plants by the processes photosynthesis, which involves the absorption of CO_2 by plants to produce carbohydrates (producers).

$$CO_2 + H_2O + \text{energy} \longrightarrow (CH_2O)_n + O_2$$

Step II: These plants are then consumed by animals and carbon gets bioaccumulated into their bodies (consumers).

Step III: These animals and plants eventually die and decomposers eat the dead organism and return the carbon from their body back into the atmosphere (decomposers)

$$(CH_2O)_n + O_2 \longrightarrow CO_2 + H_2O + \text{energy}$$

Step IV: Some of the carbon that is not released back into the atmosphere eventually become fossil fuels.

Step V: These fossil fuels are then used for man-made activities, which pump more carbon back into the atmosphere.

Importance (or) benefits of carbon cycle

1. It plays a vital role in balancing the energy and traps the long-wave radiations from the sun ie., it acts like a blanket over the planet, avoids global warming.
2. Carbon cycle is an important aspect of the survival of all life on earth.
3. Carbon is the building block of life and forms bonds with other elements necessary for life.

5.15 CARBON EMISSION AND SEQUESTRATION

5.15.1 Carbon emission

Carbon emission is the release of green house gases and their precursors into the atmosphere over a specified area and period of time.

Types of carbon emissions

Carbon (Green house gas) emissions are classified into two scopes.

I. Scope 1 emissions (or) Direct emissions

Scope 1 emissions are direct emissions from company. It is divided into 4 categories.

(a) Stationary combustion

All fuels that produce GHG.

(b) Mobile combustion

All vehicles owned by a firm, burning fuel.

Example: cars, vans, trucks.

(c) Fugitive emissions

These are leaks from green house gases (GHG).

Example

Refrigeration, air-conditioning units.

(d) Process emissions

These are from industrial processes and on-site manufacturing.

Example

Cement manufacturing, chemical manufacturing.

II. Scope 2 emissions (or) Indirect emissions

Scope 2 emissions are indirect emissions from the generation of purchased energy (purchased electricity steam, heat and cooling) from a utility provider (end user).

Sources (or) Causes of carbon emissions

1. Natural sources of CO_2 emission

It includes

(a) Decomposition of matter.

(b) Ocean release.

(c) Respiration.

(d) Most animals, which exhale CO_2 as a waste product.

(e) Carbonate rocks.

2. Human sources of CO_2 emission

It includes

(i) Burning of fossil fuels like coal, natural gas and oil.

(ii) Deforestation.

(iii) Industrial activities like cement manufacture, oil refineries and leather industries.

(iv) Transportation sector generates largest amount of CO_2 in the atmosphere.

Harmful effects of carbon emissions

1. Carbon emission, nothing but emission of green house gas, affects the planet significantly.
2. It causes global warming and affects climate change.

Reduction of carbon emission

There are many ways to reduce green house gas emissions like

1. energy efficiency.
2. fuel switching.
3. combined heat and power.
4. use of renewable energy.
5. more efficient use.
6. recycling of materials.
7. plant more trees.
8. reduce air travel.
9. driving more efficient.

5.15.2 Carbon sequestration

It is the process of capturing and storing atmospheric carbondioxide. It is one method of reducing the amount of CO_2 in the atmosphere. Goal of carbon sequestration is to reduce global climate change.

25% of our carbon emissions have been captured by earth's forests, farms and grassland. Scientists and land managers are working to keep landscapes vegetated and soil hydrated for plants to grow and sequester carbon.

30% of the carbon dioxide, we emit from burning fossil fuels, is absorbed by the upper layer of the ocean.

45% of carbon dioxide stays in the atmosphere the rest in sequestered naturally by the environment.

Concept (or) Aim of carbon sequestration

The concept of carbon sequestration is to stabilize carbon in solid and dissolved forms so that it doesn't cause the atmosphere to warm. The process shows tremendous promise for reducing the human "carbon foot print".

Methods (or) Types of carbon sequestration

There are three main types of carbon sequestration.

1. Biological carbon sequestration

It is the storage of CO_2 in vegetation like grassland, forests, soils and oceans.

2. Geological carbon sequestration

It is the process of storing CO_2 in underground geologic formations (or) rocks.

Typically, CO_2 is captured from an industrial sources like steel (or) cement production, power plant and injected into the porous rocks for long-term storage.

3. Technological carbon sequestration

Scientists are using innovative technologies to remove and store carbon from the atmosphere using innovative technologies.

Example *Graphene production*

The use of CO_2 as a raw material to produce graphene (a technological material). Graphene is used to create screens for smart phones and other technical devices. Graphene production is an example of how CO_2 can be used as a resource and a solution in reducing emissions from atmosphere.

Advantages and disadvantages of carbon sequestration

Advantages (or) merits

1. Carbon sequestration prevents the occurrence of climate change.

2. Deep injection of CO_2 improves the extraction of fuels like oil and methane from their reserves in addition to removing excess pollutants from the air.

3. Since the gas can be easily liquefied, it can be easily transmitted through pipelines.

4. No CO_2 leaking out from the injection site.

5. It lowers carbon emission by 80% to 85% while using fossil fuels.

Disadvantages (or) limitations

1. Due to carbon sequestration, in power plants, 40% additional coal is consumed and hence cost of energy gets increased by 1 to 5% per kilowatt hour.

2. CO_2 from power plant emissions must be captured and liquified, which uses a lot of electrical power.

3. It can be disastrous if the injected gas leaks due to structural flaws in the geological formation.

4. The ocean can become acidic due to the large amounts of carbon dioxide being injected into it, endangering aquatic life.

5. Planting trees, with the intention of storing and absorbing carbon, requires more time for the trees to mature.

6. There is no enough available geological resources to sequester carbon.

7. The concentration of CO_2, from power plant exhaust is too low for being effectively liquified.

5.16 GREEN ENGINEERING

5.16.1 Definition

Green engineering is the design, commercialization and use of processes and products that minimizes pollution, promotes sustainability and promotes human health without affecting environment.

5.16.2 Examples for green engineering

1. Biodegradable cups and straws.
2. Enhanced industrial emission filters.
3. Waste water treatment.
4. Radiant floors (heat homes efficiently by installing warming tubes under a floor).
5. Plant-based cooling (an alternate cooling solution using plants and trees installed around (or) on a building)

5.16.3 Goal of green engineering

1. Decrease in the amount of pollution that is generated by a construction.
2. Minimization of human population exposure to potential hazards (reducing toxicity).
3. Improved uses of matter and energy throughout the life cycle of the product.
4. Maintaining economic efficiency and viability.
5. Reduces energy and water consumption.
6. Reduces waste and our carbon footprint.
7. Improves business efficiency by lowering costs while improving the product design and creating new jobs.

5.16.4 Principles of green engineering

1. All materials and energy inputs and outputs are inherently non-hazardous as possible.
2. It is better to prevent waste that to treat (or) clean up waste after it is formed.
3. Separation and purification operations should be designed to minimize energy consumption and material use.
4. Products, processes and systems must be designed to maximize mass, energy, space and time efficiency.
5. Products, processes and system should be "output pulled" rather than "input pushed" through the use of energy and materials.
6. Complexity must be viewed as an investment when making design choices on recycle, reuse.
7. Durability rather than immortality should be a design goal.
8. Material diversity in multi-component products should be minimized.
9. Design of products, processes and system must include integration and inter-connectivity with available energy and materials flow.
10. Products should be designed for performance in a commercial "after life".
11. Material and energy inputs should be renewable rather than depleting.

5.16.5 Benefits of green engineering

1. This process enhances business practices by eliminating improper production methods.
2. It improves a company's reputation by showing consumers it cares about the environment.
3. It minimizes energy (or) production waste.

4. It provides tax incentives.
5. It helps the global environment.
6. It reduces air, water and soil pollutions.
7. It provides new business opportunities.

5.16.6 Limitations (or) disadvantages of green engineering

1. R & D costs, production and implementation costs are high.
2. Implementation will take many years.
3. Green technology is still quite immature.
4. Some companies may go out of business.
5. Job losses.
6. Sophisticated regulatory frame work needed.
7. Not everything that is labeled as green is actually green.

5.17 SUSTAINABLE URBANIZATION

Urbanization is the movement of human population from rural areas to urban areas for the want of better education, communication, health, employment, etc., without affecting the environment and needs of future generations.

5.17.1 Rules to develop a sustainable urbanization

1. Sustainable transportation.
2. Sustainable urban development.
3. Climate change mitigation and landscape architecture.
4. Resilient design (regarding natural hazards).
5. Applying ecological design.

6. Improving water efficiency.
7. Increasing energy efficiency.
8. Using low-impact materials.

By following the above rules, urbanization can be made into sustainable.

5.17.2 Pillars of sustainable urbanization

Sustainability is based on three functional areas ie., social, environmental and financial/economical. These functional areas are interconnected and must be considered together. The place where these all meet and are balanced is the goal of sustainability.

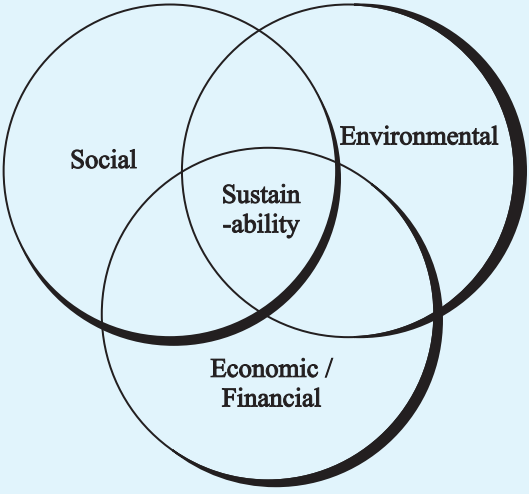


Fig. 5.18 Functional areas of urban sustainability

The goal of urban sustainability is to prevent resource availability issues for existing (or) future generations. It also minimizes an urban area's impact on its ecosystem.

5.17.3 Advantages and disadvantages of sustainable urbanization

Advantages

1. Urbanization creates convenience.
2. Urban economies can be better than rural ones.
3. Provides better education.
4. Get better housing.
5. Provides better social life.
6. Provides better healthcare services.
7. More security and police availability.
8. More entertainment options.
9. More tourist attractions.
10. More places to shop in urban areas.

Disadvantages

1. Over crowding in urban areas.
2. Buying a house might be a challenge.
3. Decline in rural area.
4. Too much crime occurs in urban area.
5. Unemployment problem is more.
6. Cost of living is higher.
7. No privacy.
8. Pollution problem is more.

5.18 SOCIO-ECONOMICAL CHANGE ON SUSTAINABLE URBANIZATION

Urbanization has many adverse effects on the structure of society because,

(i) gigantic concentrations of people compete for limited resources.

(ii) rapid housing construction leads to overcrowding.

(iii) slums, which experience major problems such as poverty, poor sanitation, unemployment.

(iv) it leads to higher crime rates and pollution.

(v) it also leads to increased levels of inequality and social exclusion.

(vi) environmental degradation is occurring very rapidly causing problems like land insecurity, excessive air pollution, waste disposal problems.

5.18.1 Technological change on sustainable urbanization

Technological change involves the introduction of something new (or) a new idea, method (or) device. Technological innovations, as part of technological change, allows organisations to test new ideas at speeds and prices that were newer anticipated a decade ago.

1. Technological innovation has changed the overall effectiveness and benevolence over time and with regard to sustainability.
2. Upgrading of industrial structure improves the sustainable urbanization.
3. Technological change and sustainability are closely related to each other.

4. Both factors form the innovation inorder to improve the effectiveness of environmental and social development and economic progress.
5. The combination of digital technology in the business model will establish and empower a city to be more sustainable.

5.19 PART B QUESTIONS

1. What is zero waste? Explain its concept and principles.
2. Explain the various steps to achieve zero waste? and advantages and disadvantages of zero waste.
3. What is *R* concept? Explain its concept and advantages and disadvantages of *R* concept.
4. What is circular economy? Explain various steps involved in achieving a circular economy.
5. What are ISO and ISO14000 series? List out any 5 ISO14000 series standards.
6. What are the core elements of ISO14000? Explain its merits and demerits.
7. What is life cycle assessment? Explain the various steps involved in life cycle assessment.
8. What is environmental impact assessment? Explain the objectives and benefits of EIA.
9. Explain the various elements of EIA.
10. What is sustainable habitat? Explain its characteristics and objectives of it.
11. What is green building? Explain its criteria and features.
12. Explain the principles, components, merits and demerits of green building.

13. What are green materials? Give examples. Explain important green building materials.
14. What is energy efficiency? Explain methods of achieving energy efficiency? How to calculate it.
15. Explain the advantages and disadvantages of energy efficiency.
16. What is sustainable transport? Explain the key elements of sustainable transport.
17. What is sustainable energy? Explain advantages and disadvantages of it.
18. Write notes on non-conventional sources of energy.
19. What is energy cycle? Explain the carbon cycle with a neat diagram.
20. What is carbon emission? Explain its types and remedy.
21. Define carbon sequestration. Explain the various types of carbon sequestration.
22. Explain the principle, goal and benefits of green engineering.
23. What is sustainable urbanization? Explain the rules to develop sustainable urbanization.
24. Write notes on socio-economical change on sustainable urbanization.