MODULE 5

UTILITY OF SOLAR ENERGY IN BUILDINGS & GREEN COMPOSITES FOR BUILDINGS

UTILITY OF SOLAR ENERGY IN BUILDINGS:-

By using the latest Solar Energy Technologies, buildings can save around 30-40% on their energy use. We can also become a net-zero Energy Building owner when we create more energy than we utilize. Undoubtedly, Solar Powered Buildings with proper use of technology are more efficient in energy consumption.

REASONS BEHIND BUILDINGS OPTING FOR SOLAR SOURCES:-

- Increasing energy consumption.
- Environmental consciousness.
- Global climate change.
- Corporate Social Responsibility (CSR) implication/ advantage for corporate buildings.
- Attraction towards cleanest, renewable energy.
- High social value and an increase in the value of the property.

BENEFITS OF SOLAR ENERGY IN BUILDINGS :-

- **Reduction in Energy Costs**: Solar energy can significantly reduce electricity bills by providing an alternative to conventional grid power.
- **Reduction in Carbon Footprint**: Solar energy production emits no greenhouse gases, contributing to sustainability efforts.
- **Energy Independence**: Buildings with solar installations can operate independently of the power grid, reducing vulnerability to energy price fluctuations.

- **Increased Property Value**: Buildings with solar energy systems are often more attractive to buyers due to the long-term cost savings and sustainability features.

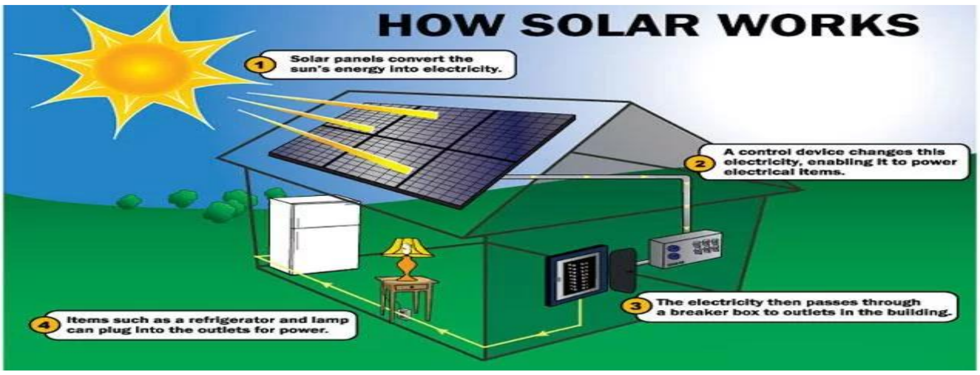
TYPES OF SOLAR ENERGY TECHNOLOGIES:-

Currently, solar energy is harnessed using three primary technologies.
1) **Photovoltaic (PV)** – directly convert light to electricity.
2) **Concentrating solar power (CSP)** – heat is being used from the sun (thermal energy) to drive electric turbines, utility-scale.
3) **Solar heating and cooling (SHC) systems** – accumulate thermal energy to supply hot water and air heating and/ or conditioning.

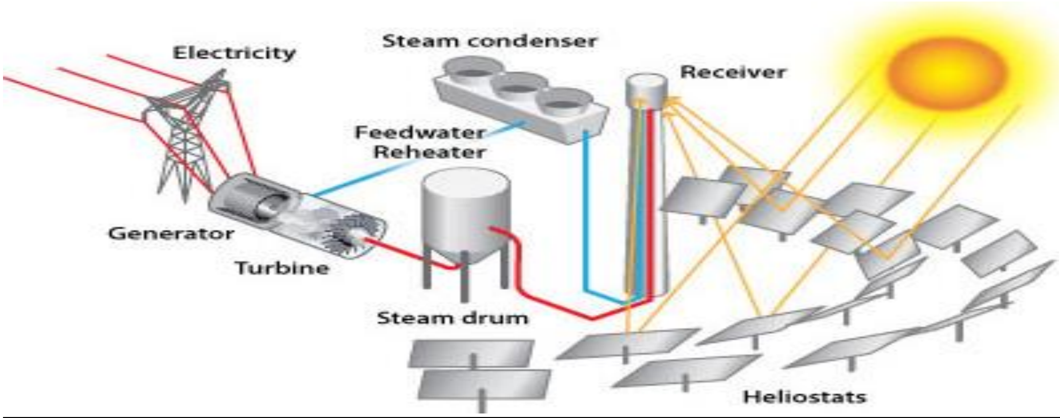
Photovoltaic (PV):- A **photovoltaic (PV) cell**, commonly known as a **solar cell**, is a device that converts sunlight directly into electricity using the photovoltaic effect. These cells are the fundamental building blocks of solar panels.

Working Principle:

1. **Absorption of Light**: When sunlight hits the surface of the photovoltaic cell, energy from the sunlight is absorbed by the semiconductor material (usually silicon).
2. **Generation of Electron-Hole Pairs**: The absorbed energy excites electrons in the semiconductor, causing them to break free from their atoms. This creates free electrons and "holes" (the absence of an electron in a position where one could exist).
3. **Creation of Electric Current**: The design of the photovoltaic cell has built-in electric fields that push the free electrons and holes in opposite directions. This movement creates an electric current.
4. **Flow of Electricity**: Metal contacts on the top and bottom of the cell allow the electrons to flow out of the cell and into an external circuit, providing electrical power.



<u>Concentrating solar power (CSP)</u>:- CSP technologies use mirrors to reflect and concentrate sunlight onto a receiver. The energy from the concentrated sunlight heats a high temperature fluid in the receiver. This heat – also known as thermal energy - can be used to spin a turbine or power an engine to generate electricity.



<u>Here's how CSP works in a nutshell:</u>

1. Solar Concentration:

- **Mirrors or lenses** concentrate sunlight onto a small area, usually a receiver.
- The most common methods to concentrate sunlight include:
  - **Parabolic troughs**: Long, curved mirrors that focus sunlight onto a pipe running along their length, where a fluid is heated.
  - **Power towers**: Large fields of mirrors (heliostats) focus sunlight onto a central tower, where the heat is absorbed by a receiver.
  - **Dish systems**: Parabolic dishes that focus sunlight onto a receiver at the focal point.

2. Heat Transfer:

- The concentrated sunlight heats a fluid (usually a molten salt, oil, or water), which then carries the heat to a power generation system.

3. Power Generation:

- The heated fluid is used to produce steam, which drives a turbine connected to a generator, ultimately producing electricity.

4. Storage and Efficiency:

- Some CSP systems incorporate thermal energy storage, such as using molten salts, which allows the energy to be stored and used when the sun isn't shining. This makes CSP more reliable compared to conventional solar photovoltaic systems.
- CSP is more efficient than traditional photovoltaic (PV) solar at large scales, as it can operate at higher temperatures and convert solar energy into thermal energy, which is easier to store and manage.

Advantages:

- **Energy Storage**: With thermal storage, CSP can provide power even after sunset.
- **Scalability**: CSP is more suitable for utility-scale power plants.
- **High Efficiency**: CSP can operate more efficiently than traditional solar PV in certain conditions.

Challenges:

- **Location Dependent**: CSP systems need high direct sunlight, making them most effective in regions like deserts.
- **High Initial Cost**: CSP plants are expensive to build and require significant infrastructure.
- **Land Use**: CSP requires large amounts of land, which can be a limiting factor.

CSP is a promising renewable energy technology, especially for regions with ample sunlight, and is considered one of the solutions to meet large-scale, sustainable energy demands.

3) <u>Solar heating and cooling (SHC) systems:</u> These systems collect the sun's thermal **energy** and use it to provide hot water, space heating, cooling, and pool heating for residential, commercial, and industrial applications.

Solar Passive Cooling and Heating of Buildings

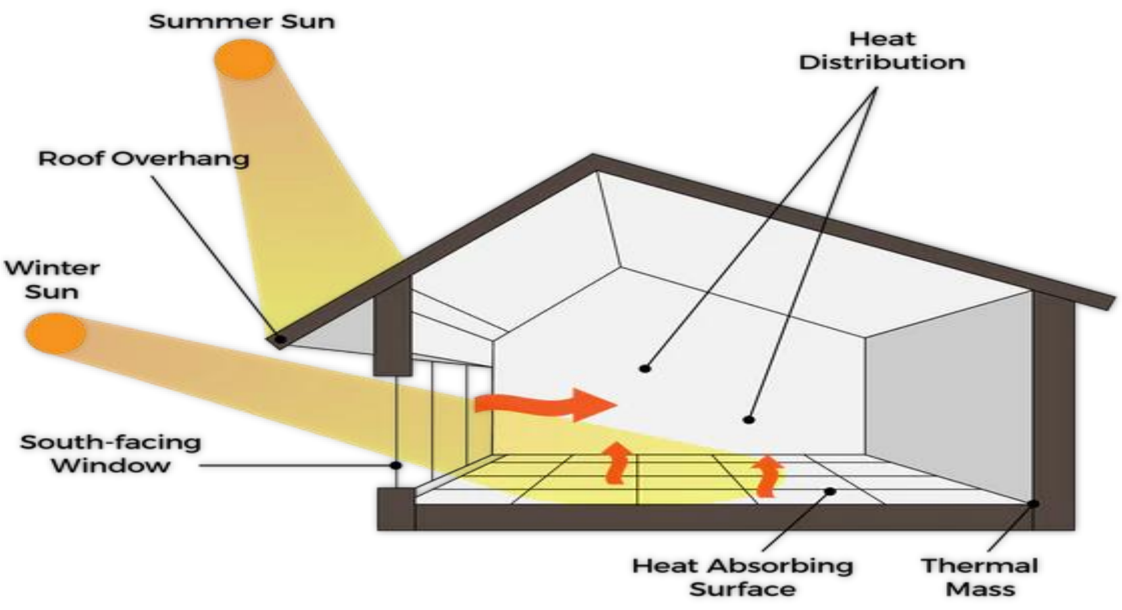
- It is the least expensive means of cooling a home which maximizes the efficiency of building without any use of mechanical devices.

- It relies on natural heat sinks to remove heat from the building. They derive cooling directly from evaporation, convection, and radiation without using any intermediate electrical devices.

- The engineering required to create these systems includes carefully selecting materials for the building envelope- including the building's walls, floors, roofs, windows, and glazing materials - and determining their proper orientation.

- Passive heating and cooling strategically capture or shade against solar radiation.

- Technologies include windows, ventilators, solar chimneys, and Trombe walls.



<u>ELEMENTS OF PASSIVE SOLAR DESIGN</u>

Following are the elements of passive solar design

1) <u>The light collector – 'Aperture'</u>:- The light collector refers to large, sun-facing glassed (windowed) areas in the home at which sunlight can enter the building.

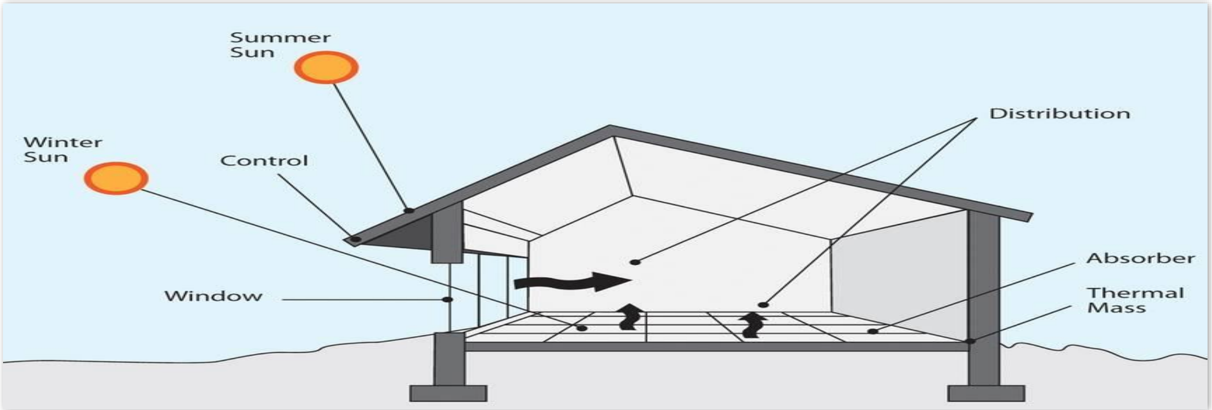
Natural light streaming through your home is not only beautiful and a natural mood enhancer, but it serves two purposes for energy efficiency. Great use of natural lighting means we can use artificial lighting less, and sunlight also adds warmth, reducing the need for additional heating in winter. In summer, the sun sits higher in the sky, so wide eaves help to reduce the amount of sunlight and heat entering the home.

2) The Heat Absorber: - This is a hard, darkened surface, which could be a masonry wall, floor, or water container that sits in the direct path of the sunlight and absorbs heat throughout the day, storing it in the 'thermal masses behind.

3) The Thermal mass: - The thermal mass is the material that retains or stores the heat produced by sunlight. This could be a sun-facing brick wall or a concrete slab. The 'absorber' is the dark outer surface exposed to the sun, and the thermal mass is the material beneath this surface that retains the sun's energy (heat) that it will release into the home throughout the day.

4) The Distribution is the method by which the stored energy or heat collected in the thermal mass circulates throughout the house. This may include fans or ducts, or just the natural behaviour of the thermal material – a wall, for example – which radiates warmth collected throughout the day into the home overnight.

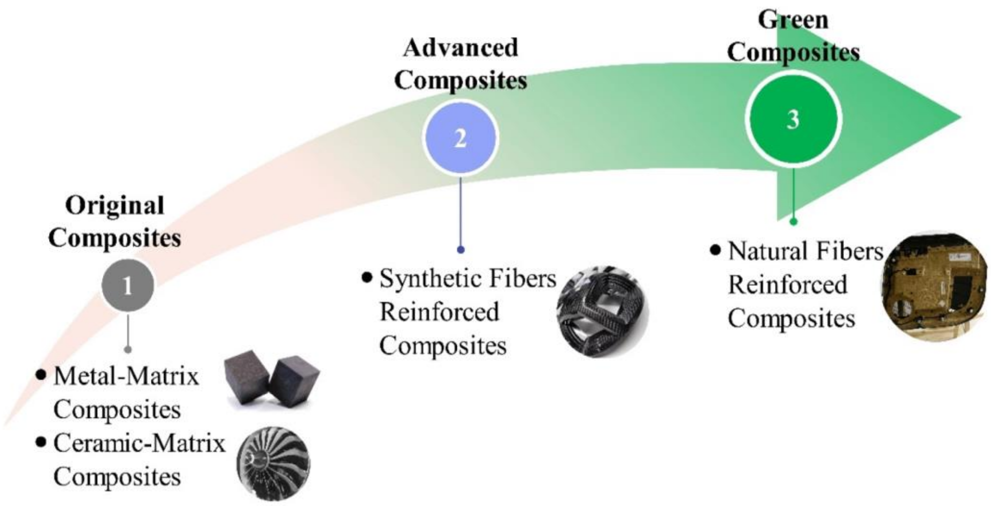
5) Control: - Here's where the design is controlled to suit the season. The sun hangs lower in winter, so although the climate is cooler, sunlight can penetrate through sun-facing windows well. In summer, the sun sits higher in the sky, so the home's eaves (roof overhang) shade the sun from the light collector and heat absorber, allowing less heat to penetrate inside. Another example of the control element is airflow and ventilation. Take advantage of the breeze by placing windows to capture and circulate the cool air throughout the home.



GREEN COMPOSITES:- Green composites are materials made from renewable resources, which have minimal environmental impact during production and use. They combine natural fibers (e.g., bamboo, flax, jute) with biodegradable resins to create eco-friendly alternatives to traditional building materials.

TYPES OF GREEN COMPOSITES:-

- **Natural Fibre Composites (NFCs)**: These composites are made from natural fibers, such as hemp, flax, or sisal, combined with a polymer matrix. They are lightweight, biodegradable, and provide better thermal insulation than conventional materials.
- **Recycled Composites**: These use waste products, such as plastic or glass fibers, mixed with natural fibers. They offer the advantage of reusing industrial by-products while contributing to sustainability.



Benefits of Green Composites in Buildings

- **Sustainability**: Green composites are renewable, biodegradable, and often require less energy to produce than traditional construction materials.
- **Improved Thermal and Acoustic Insulation**: Many green composites have superior thermal and acoustic insulating properties, making them ideal for creating energy-efficient buildings.
- **Durability and Strength**: Green composites can be as strong and durable as conventional materials like concrete and steel, depending on their formulation.

CHALLENGES OF GREEN COMPOSITES:-

- **Material Strength Variability**: The strength and durability of green composites can vary depending on the fiber and resin used, which might limit their use in certain structural applications.
- **Cost**: Although green composites are generally considered more sustainable, the cost of production may be higher compared to conventional materials.
- **Limited Awareness**: The use of green composites in construction is still evolving, and there is a need for greater awareness and research on their performance and benefits.
- **Carbon Footprint Reduction**: Using natural fibers and biopolymers in composites reduces the carbon footprint compared to using synthetic materials derived from fossil fuels.

ADVANTAGES AND DISADVANTAGES OF GREEN COMPOSITES:-

Advantages	Disadvantages
Renewable resources	Inhomogeneous structure of fibres
Lower production costs	Dimensional instability as a negative consequence of water absorption
Good specific mechanical properties	Lower water and thermal resistance
Lower density of composites	Susceptibility to microbial attacks and rotting
Reduced energy consumption during manufacturing	Insufficient adhesion and incompatibility with the polymer matrix
Biodegradability and eco-friendly materials	Degradation and aging
Lower risk to human health	Restricted processing temperature (to avoid thermal degradation)

MANAGEMENT OF SOLID WASTE:-

Different types of Wastes

- **Solid wastes** – These are the unwanted substances that are discarded by human society. These include urban wastes, industrial wastes, agricultural wastes, biomedical wastes and radioactive wastes.

- **Liquid wastes** – Wastes generated from washing, flushing or manufacturing processes in industries are called liquid wastes.

- **Gaseous wastes** – These are the wastes that are released in the form of gases from automobiles, factories, or burning of fossil fuels like petroleum. They get mixed in the other gases in the atmosphere and occasionally cause events such as smog and acid rain.

Types of Solid Wastes

Broadly there are 3 types of waste which are as follows.

(1) Household waste is generally classified as Municipal waste

(2) Industrial waste as Hazardous waste

(3) Biomedical waste or Hospital waste as Infection waste.

1. Household Waste (Municipal Waste):

- **Description**: This refers to waste generated from households, which is typically managed by local municipalities. It includes a broad range of materials discarded daily.
- **Components**:
    - **Organic waste**: Food scraps, garden waste, and yard trimmings.
    - **Recyclable materials**: Paper, plastics, glass, and metals.
    - **Non-recyclable waste**: Mixed packaging, broken household items, etc.
- **Challenges**: The high volume and mix of different materials can make recycling and disposal more complex. Proper segregation of recyclables from non-recyclables is crucial to reduce environmental impact.

2. Industrial Waste (Hazardous Waste):

- **Description**: Waste generated from manufacturing processes, construction, and other industrial activities. Some of these wastes can be hazardous to both human health and the environment.
- **Components**:
    - **Toxic waste**: Chemicals, solvents, and heavy metals like mercury, lead, and cadmium.
    - **Radioactive waste**: By-products from nuclear processes or equipment.
    - **Corrosive materials**: Acids, alkalis, and other substances that can damage materials or living tissues.
- **Challenges**: Industrial waste often requires specialized disposal methods, such as chemical treatment, neutralization, or high-temperature incineration, to avoid contamination of air, soil, or water.

3. Biomedical Waste (Infection Waste):

- **Description**: Waste generated by healthcare facilities like hospitals, clinics, dental offices, and laboratories. This waste can pose a risk of infection or injury.
- **Components**:
    - **Infectious waste**: Contaminated materials like used needles, syringes, bandages, and body fluids.
    - **Pharmaceutical waste**: Expired or unused medicines and vaccines.
    - **Sharps waste**: Needles, syringes, scalpels, and other objects that can cause punctures or cuts.
- **Challenges**: Biomedical waste must be properly segregated, disinfected, and disposed of to prevent the spread of disease. This often involves autoclaving, incineration, or safe landfilling with special precautions.

CAUSES OF SOLID WASTE:-

The increase in the quantity of solid waste is due to:

- Overpopulation: with rising urbanization and changes in lifestyle and food habits, amount of solid waste has been increasing rapidly and its composition changing.
- Affluence (material comfort)
- Technological advancement.

1. Overpopulation:

- **Description**: As the global population continues to grow, particularly in urban areas, the amount of waste generated per capita increases as well. Overpopulation leads to greater demand for goods, services, and housing, which in turn generates more waste.
- **Impact**:
  - **Increased Consumption**: More people mean higher consumption of food, water, energy, and products, all of which produce waste.
  - **Urbanization**: People migrating to urban areas for better opportunities typically adopt more consumer-driven lifestyles, which leads to more packaging waste, food waste, and non-recyclable materials.
  - **Shifting Diets**: Changing food habits in urban areas (e.g., more processed, packaged, and convenience foods) also result in more packaging waste, such as plastics and wrappers.

2. Affluence (Material Comfort):

- **Description**: As countries or regions experience economic growth, there is a rise in affluence, meaning more disposable income and a shift toward a consumer-oriented society. This increased purchasing power leads to greater production and disposal of goods.
- **Impact**:
  - **Higher Consumption of Goods**: With more money, people buy more products, especially single-use and disposable items. This leads to an increase in packaging waste, such as plastic containers, food wrappers, and electronics.
  - **Durable Goods**: The tendency to buy more durable goods (electronics, home appliances, vehicles, etc.) increases the volume of waste at the end of their lifecycle, contributing to e-waste and bulky waste.

- **Packaging**: Affluence encourages the use of non-biodegradable packaging, leading to a significant rise in plastic and other non-recyclable materials.


3. Technological Advancement:

- **Description**: While technological advancements lead to improvements in many sectors, they also contribute to the growth of solid waste in several ways, particularly through the development of new materials, products, and processes.
- **Impact**:
  - **Short Product Lifespan**: Technology-driven products (especially electronics) often have a short lifespan, leading to the rapid disposal of items such as smartphones, computers, and other devices. This contributes to the rise in **e-waste**.
  - **Obsolescence of Old Technologies**: As new and improved versions of products and technologies are introduced, older models quickly become obsolete and are discarded, adding to the waste stream.

SOLID WASTE MANAGEMENT PROCESS: -

The process typically includes the following stages:

1. Waste Generation:

- **Description**: The first stage occurs when waste is produced as a result of daily human activities, such as household consumption, industrial production, agricultural practices, and medical services.
- **Types of Waste**: Household waste, industrial waste, biomedical waste, agricultural waste, construction debris, and hazardous materials.

2. Waste Collection:

- **Description**: Once waste is generated, it is collected from various sources (homes, businesses, industries, hospitals) by municipal authorities or private waste management companies.
- **Methods**:
    - **Kerbside collection**: Waste is collected directly from homes and businesses.
    - **Bins and containers**: Different containers (often color-coded) are provided for segregating waste types like recyclables, organic waste, and non-recyclable waste.
    - **Commercial and industrial collection**: Larger containers or dumpsters are used for industries, offices, and larger commercial spaces.

3. Waste Segregation:

- **Description**: Waste is segregated into different categories to facilitate recycling, composting, and safe disposal. This step can occur at the source (homes, offices) or at a waste sorting facility.
- **Categories**:
    - **Biodegradable (Organic) Waste**: Food scraps, garden waste, and other organic materials.
    - **Recyclable Waste**: Paper, plastic, glass, metal, etc.
    - **Non-Recyclable Waste**: Items that cannot be recycled, such as certain plastics and mixed materials.

- **Hazardous Waste**: Waste that can be dangerous to health and the environment (e.g., batteries, chemicals).
- **Biomedical Waste**: Waste generated by healthcare facilities, such as used syringes, bandages, and medical instruments.

4. Transportation:

- **Description**: After waste is collected and segregated, it is transported to appropriate facilities for further processing. This may involve different trucks for different types of waste (e.g., compostable, recyclable, hazardous).
- **Challenges**: Proper and timely transportation is crucial to prevent overflow and contamination. Inadequate transport infrastructure can lead to inefficiencies.

5. Waste Processing and Recycling:

- **Description**: Waste is processed to either recover valuable materials or treat it in a way that reduces its volume and environmental impact.
- **Methods**:
  - **Recycling**: Reuse of materials such as paper, plastics, metals, and glass to make new products. This reduces the need for raw materials and reduces energy consumption.
  - **Composting**: Biodegradable organic waste is decomposed to produce compost, which can be used as a soil conditioner.
  - **Incineration**: Waste is burned at high temperatures to reduce its volume and generate energy. However, this method must be carefully controlled to avoid air pollution.
  - **Waste-to-Energy (WTE)**: Technologies that convert non-recyclable waste into usable energy (e.g., electricity or heat) through processes like incineration or anaerobic digestion.

6. Disposal (Landfilling and Other Methods):

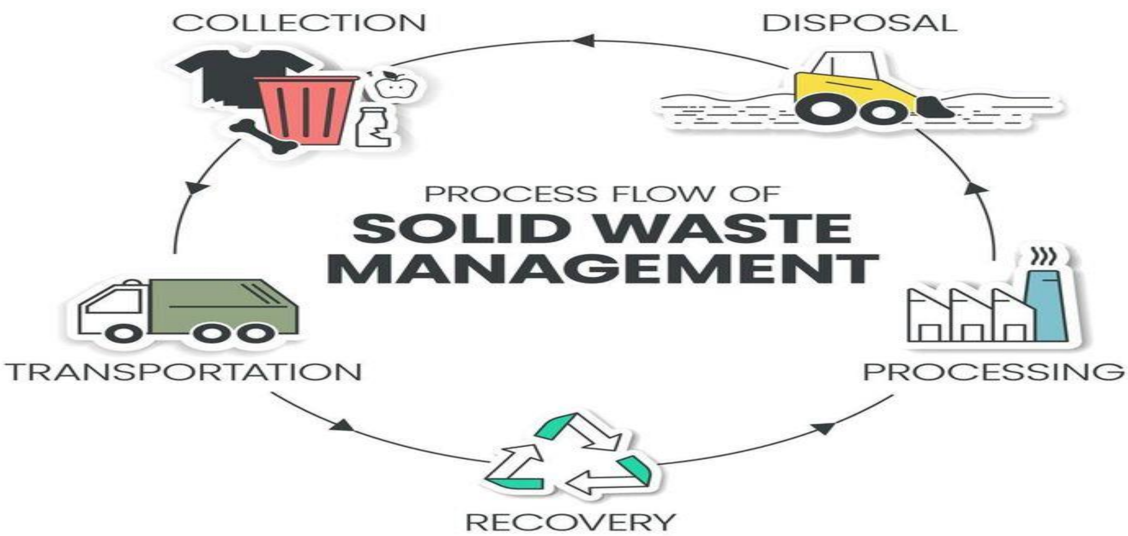
- **Description**: Waste that cannot be recycled or processed further is sent to landfills, where it is buried in designated areas. This is usually the last resort for waste disposal.
- **Landfilling**:

- Waste is compacted in layers and covered with soil to reduce odors and prevent contamination of the surrounding environment.
- Modern landfills are designed with liners and leachate collection systems to prevent groundwater contamination.

- **Other Disposal Methods**:
  - **Deep-well injection**: Hazardous liquid waste is injected into deep wells beneath the earth's surface.
  - **Ocean dumping**: A method used in some regions to dispose of waste in the ocean (though controversial and largely banned due to environmental concerns).

7. Waste Monitoring and Disposal Management:

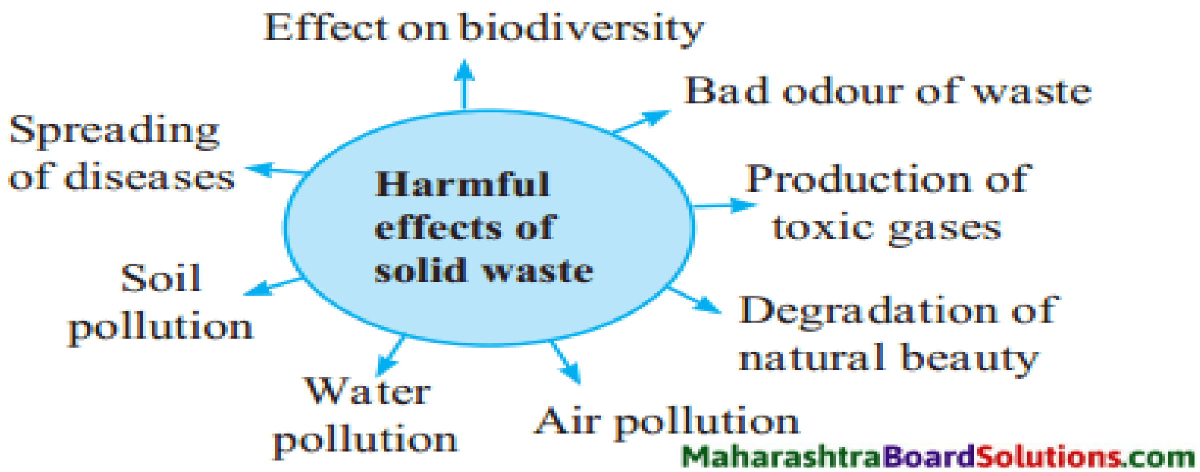
- **Description**: Continuous monitoring of waste management systems is necessary to ensure compliance with regulations, reduce environmental impacts, and improve efficiency.
- **Methods**:
  - **Data collection**: Monitoring the volume and types of waste generated to optimize collection schedules and improve recycling rates.
  - **Environmental monitoring**: Ensuring that landfills and waste treatment plants do not contaminate air, water, or soil.
  - **Public awareness**: Educating communities about waste reduction, recycling, and proper disposal practices.



EFFECTS OF SOLID WASTE:-

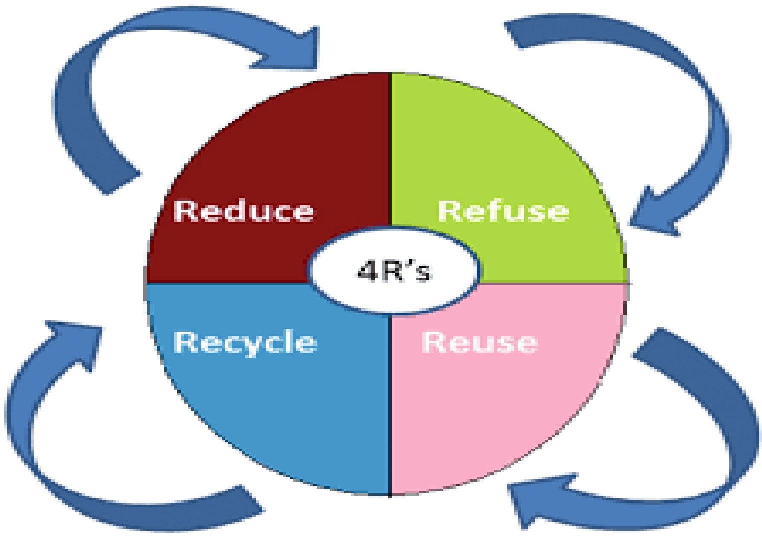
Solid waste can have many negative effects on the environment and human health, including:

- **Air pollution**: Burning waste and plastic can create air pollution.
- **Water pollution**: Improper disposal of solid waste and wastewater can pollute surface water, such as rivers and streams.
- **Soil pollution**: Improperly disposing of toxic industrial or chemical waste can pollute soil and groundwater.
- **Methane emissions**: Landfills are a source of methane emissions, which contribute to climate change.
- **Climate change**: The greenhouse gases emitted from solid waste increase the amount of carbon dioxide in the atmosphere, which contributes to climate change.
- **Communicable diseases**: Contact with solid waste can spread infectious diseases like cholera and dysentery.
- **Environmental degradation**: Solid waste can degrade the natural beauty of the environment.
- **Effect on biodiversity**: Solid waste can impact biodiversity.
- **Occupational health hazards**: Workers who handle, transport, or process waste can experience toxic exposure.
- **Breeding of disease vectors**: Solid waste can attract disease-carrying flies and rats.
- **Hazardous materials escaping into the environment**: Hazardous materials can escape from waste processing facilities and accumulate in the environment.



Harmful effects of solid waste

4R'S CONCEPT IN SOLID WASTE MANAGEMENT:-



Many waste prevention techniques are available, and they are commonly summarized as popularly known as **4R: Refuse, Reuse, Recycle, and Reduce**. To overcome the problem of solid wastes, the following steps need to be taken:

(1)Wherever possible, waste reduction should be preferred.

(2) Every effort should be made to reuse produced wastes.

(3)Recycling should be the third option for the waste.

(4)There are several options for recycling. Such options should be selected taking into view social and economic acceptability.

(5) Attempts should be made to recover materials or energy from waste which cannot be reduced, reused, or recycled.

MANAGEMENT OF SULLAGE WATER AND SEWAGE:-

Sullage or Gray Water:- Water that already has been used domestically, commercially, and industrially and is the leftover, untreated water generated from washing machines, showers, bathtubs, bathrooms, and wash basins.

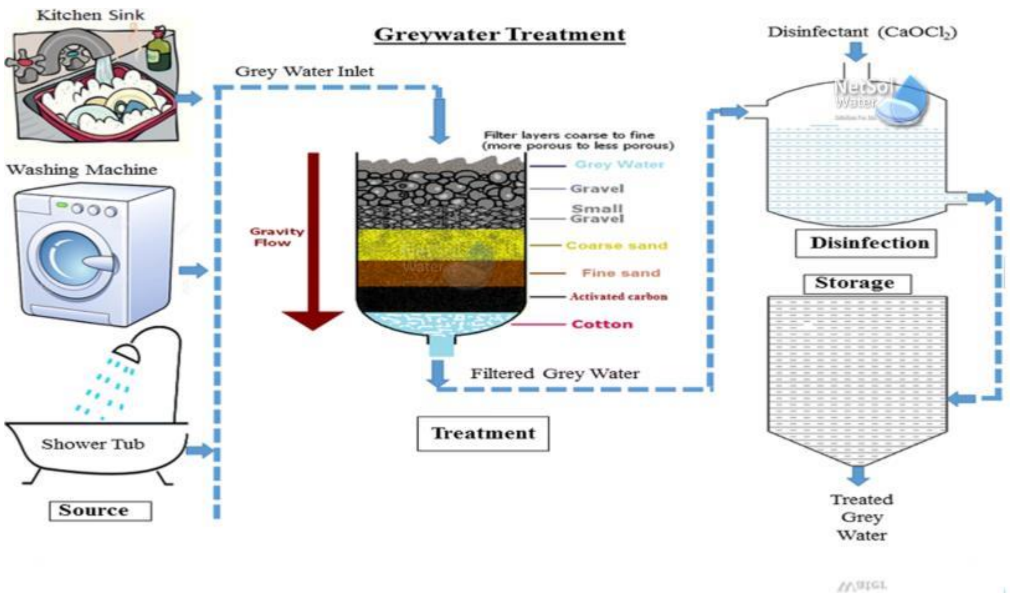
Aerobic and biological treatments are used as primary greywater treatment to remove dissolved and suspended biological matter, followed by ultra-filtration to prevent particles, bacteria and viruses that pass through.

Sources of Sullage Water:

- **Kitchen sinks**: Wastewater from cooking, dishwashing, etc.
- **Bathroom sinks and showers**: Water from washing hands, bathing, and showering.
- **Laundry water**: Wastewater from washing clothes.

Sullage treatment processes

- **Screening**: Large particles and debris are removed from the water
- **Sedimentation**: Sedimentation is used to treat the water
- **Biological treatment**: Biological processes are used to treat the water
- **Disinfection**: Disinfection is used to treat the water



SEWAGE MANAGEMENT

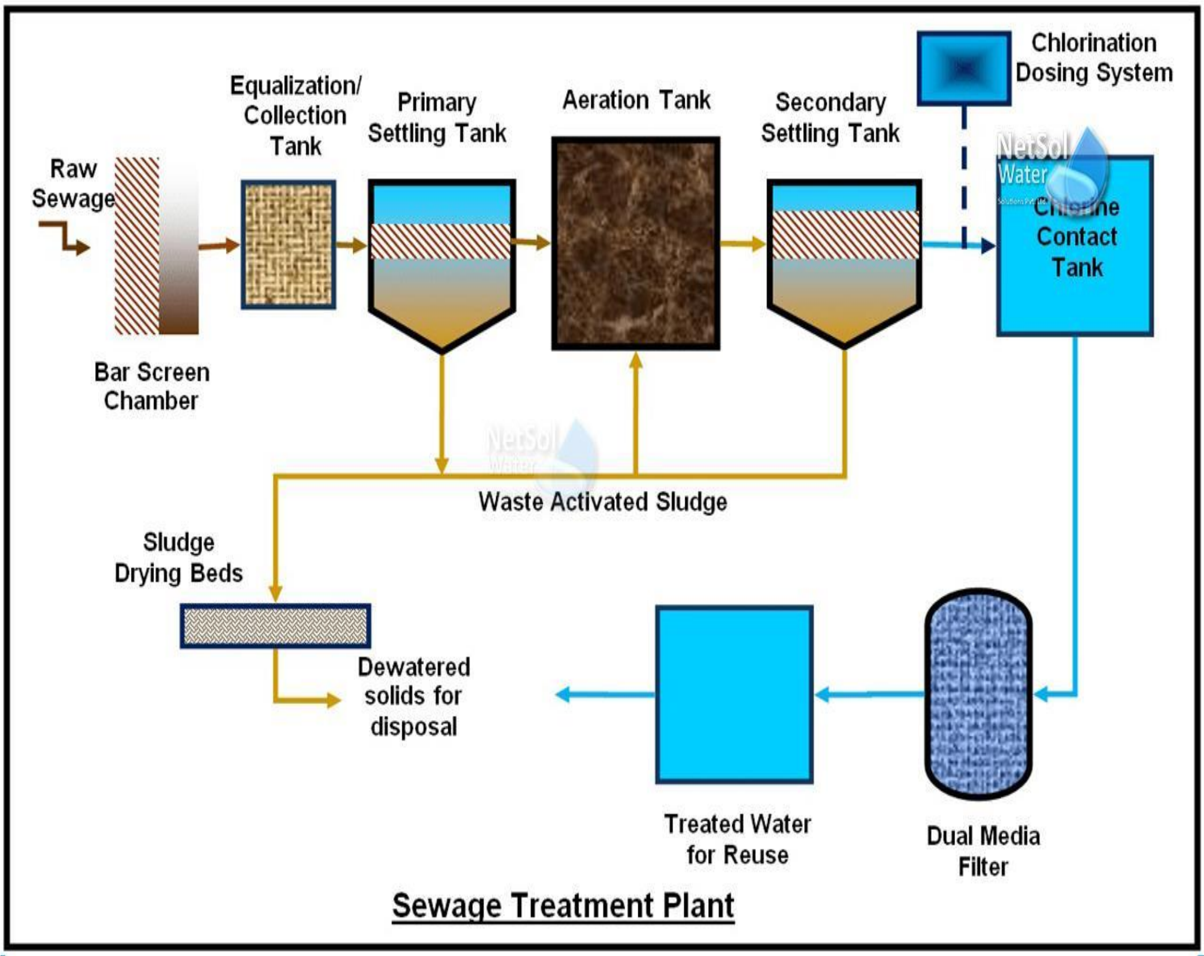
Sewage is the wastewater produced from toilets, bathrooms, and industrial processes that may contain harmful bacteria, viruses, chemicals, and other contaminants. It needs to be treated thoroughly before it can be safely released into the environment or reused.

Sources of Sewage:

- **Residential**: Toilets, sinks, baths, and washing facilities.
- **Industrial**: Wastewater from factories and industrial activities, often containing hazardous materials.
- **Commercial**: Waste from businesses like restaurants and laundromats.
- **Storm water runoff** (in combined sewer systems).

Sewage Treatment Process:

1. **Preliminary Treatment**: Screening and grit removal.
2. **Primary Treatment**: Sedimentation to remove large particles and solids.
3. **Secondary Treatment**: Biological treatment (activated sludge, trickling filters) to break down organic matter.
4. **Tertiary Treatment**: Advanced filtration, chemical treatment, nutrient removal, and disinfection to further improve water quality.
5. **Sludge Treatment**: Thickening, digestion, dewatering, and disposal or beneficial reuse.
6. **Final Disposal or Reuse**: Safe discharge into water bodies or reuse for non-potable purposes or further treated for potable use.



Key Differences between Sullage Water and Sewage Management:

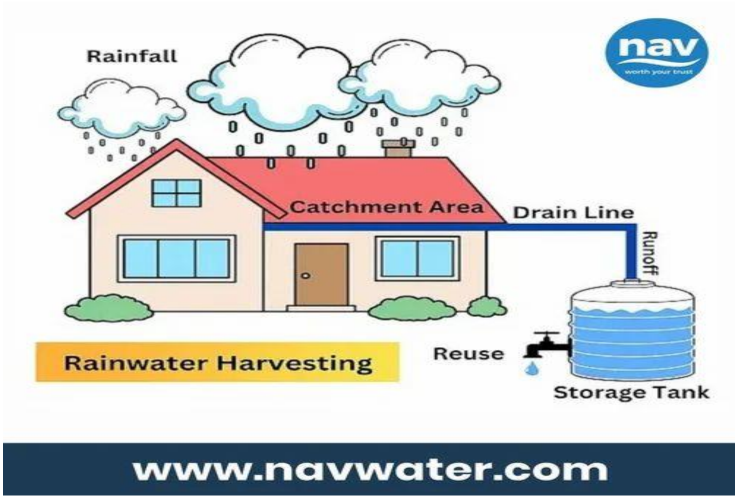
Aspect	Sullage Water Management	Sewage Management
Source	Wastewater from kitchens, bathrooms, laundry (non-toilet water)	Wastewater from toilets, industrial processes, and sewage systems
Contaminants	Lower level of contaminants (detergents, oils, food scraps)	Contains harmful pathogens, bacteria, viruses, and organic waste
Treatment Methods	Simple filtration, biological treatment, and disinfection	Advanced filtration, biological treatment, nutrient removal, disinfection
Reuse Potential	Can be reused for irrigation, landscape watering, or non-potable uses	Typically treated to ensure safe disposal or reuse for non-potable uses
Wastewater Type	Non-sewage, typically biodegradable	High in pathogens, chemicals, and pollutants

VARIOUS LOW-ENERGY APPROACHES TO WATER MANAGEMENT:-

- Rainwater harvesting
- Groundwater recharge
- Drip irrigation
- Sewage water treatment

1) Rainwater harvesting

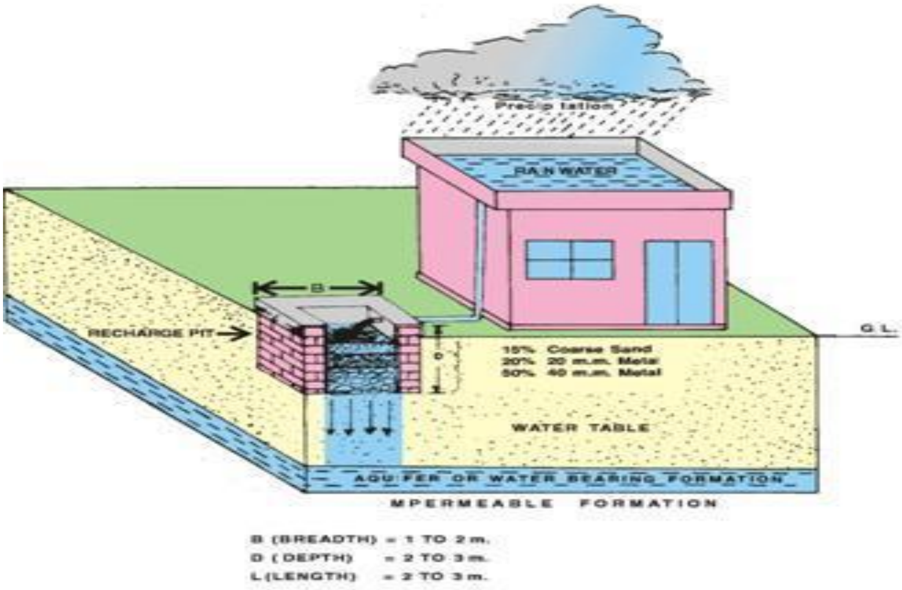
Rainwater harvesting (RWH) is the collection and storage of rain, rather than allowing it to runoff. Rainwater is collected from a roof-like surface and redirected to a tank, cistern, deep pit (well, shaft, or borehole), aquifer, or reservoir with percolation. Dew and fog can also be collected with nets or other tools. Rainwater harvesting differs from storm water harvesting as the runoff is collected from roofs, rather than creeks, drains, roads, or any other land surfaces. Its uses include watering gardens, livestock, irrigation, domestic use with proper treatment, and domestic heating. The harvested water can also be committed to longer-term storage or groundwater recharge.



2) **Groundwater recharge :-**

Groundwater recharge is the enhancement of natural groundwater supplies using man-made conveyances such as infiltration basins, trenches, dams, or injection wells. Aquifer storage and recovery (ASR) is a specific type of groundwater recharge practiced with the purpose of both augmenting groundwater resources and recovering the water in the future for various uses.

Groundwater is recharged naturally by rain and snowmelt and to a smaller extent by surface water (rivers and lakes). Recharge may be impeded somewhat by human activities including paving, development, or logging. These activities can result in loss of topsoil resulting in reduced water infiltration, enhanced surface runoff and reduction in recharge. The use of groundwater, especially for irrigation, may also lower the water tables. Groundwater recharge is an important process for sustainable groundwater management since the volume rate abstracted from an aquifer in the long term should be less than or equal to the volume rate that is recharged. Recharge can help move excess salts that accumulate in the root zone to deeper soil layers, or into the groundwater system. Tree roots increase water saturation into groundwater reducing water runoff. Flooding temporarily increases riverbed permeability by moving clay soils downstream, and this increases aquifer recharge.



3) Drip irrigation

Drip irrigation is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. The goal is to place water directly into the root zone and minimize evaporation. Drip irrigation systems distribute water through a network of valves, pipes, tubing, and emitters. Depending on how well designed, installed, maintained, and operated it is, a drip irrigation system can be more efficient than other types of irrigation systems, such as surface irrigation or sprinkler irrigation.

4) Sewage water treatment

Sewage treatment is the process of removing contaminants from municipal wastewater, containing mainly household sewage plus some industrial wastewater. Physical, chemical, and biological processes are used to remove contaminants and produce treated wastewater (or treated effluent) that is safe enough for release into the environment. A by-product of sewage treatment is a semi-solid waste or slurry, called sewage sludge. The sludge has to undergo further treatment before being suitable for disposal or application to land.