Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal
New Scheme Based On AICTE Flexible Curriculum
Branch- Common to All Discipline

BT301	Energy & Environmental Engineering	3L-1T-0P	4 Credits

The objective of this Course is to provide *an introduction to energy systems and renewable energy resources, with a scientific examination of the energy field and an emphasis on alternative energy sources and their technology and application.*

Module 1: Introduction to Energy Science:
Introduction to energy systems and resources; Introduction to Energy, sustainability & the environment; Overview of energy systems, sources, transformations, efficiency, and storage; Fossil fuels (coal, oil, oil-bearing shale and sands, coal gasification) - past, present & future, Remedies & alternatives for fossil fuels - biomass, wind, solar, nuclear, wave, tidal and hydrogen; Sustainability and environmental trade-offs of different energy systems; possibilities for energy storage or regeneration (Ex. Pumped storage hydro power projects, superconductor-based energy storages, high efficiency batteries)

***Module2*: Ecosystems**
• Concept of an ecosystem; Structure and function of an ecosystem; Producers, consumers and decomposers; Energy flow in the ecosystem; Ecological succession; Food chains, food webs and ecological pyramids; Introduction, types, characteristic features, structure and function of the following ecosystem (a.)Forest ecosystem (b) Grassland ecosystem (c) Desert ecosystem (d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

***Module 3*: Biodiversity and its conservation**
• Introduction – Definition: genetic, species and ecosystem diversity; Bio-geographical classification of India; Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values; Biodiversity at global, National and local levels; India as a mega-diversity nation; Hot-sports of biodiversity; Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts; Endangered and endemic species of India; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

***MODULE 4:* Environmental Pollution**
Definition, Cause, effects and control measures of Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards; Solid waste Management: Causes, effects and control measures of urban and industrial wastes; Role of an individual in prevention of pollution; Pollution case studies; Disaster management: floods, earthquake, cyclone and landslides.

***MODULE 5:* Social Issues and the Environment**
• From Unsustainable to Sustainable development; Urban problems related to energy; Water conservation, rain water harvesting, watershed management; Resettlement and rehabilitation of people; its problems and concerns. Case Studies
Environmental ethics: Issues and possible solutions. Climate change, global
warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies Wasteland reclamation; Consumerism and waste products; Environment Protection Act; Air (Prevention and Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act; Issues involved in enforcement of environmental legislation; Public awareness.

MODULE 6: FIELD WORK
• Visit to a local area to document environmental assets-river/forest/grassland/hill/mountain
• Visit to a local polluted site-Urban/Rural/Industrial/Agricultural
• Study of common plants, insects, birds.
• Study of simple ecosystems-pond, river, hill slopes, etc.

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1. Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc.
2. Clark R.S., Marine Pollution, Clanderson Press Oxford (TB).
3. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publ. House, Mumabai,
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6. Boyle, Godfrey, Bob Everett, and Janet Ramage (Eds.) (2004), Energy Systems and Sustainability: Power for a Sustainable Future. Oxford University Press.
7. Schaeffer, John (2007), Real Goods Solar Living Sourcebook: The Complete Guide to Renewable Energy Technologies and Sustainable Living, Gaiam

Unit 1

Introduction to Energy Science:

Introduction to energy systems and resources; Introduction to Energy, sustainability & the environment; Overview of energy systems, sources, transformations, efficiency, and storage; Fossil fuels (coal, oil, oil-bearing shale and sands, coal gasification) - past, present & future, Remedies & alternatives for fossil fuels - biomass, wind, solar, nuclear, wave, tidal and hydrogen; Sustainability and environmental trade-offs of different energy systems; possibilities for energy storage or regeneration (Ex. Pumped storage hydro power projects, superconductor-based energy storages, high efficiency batteries)

Energy

Energy is the capacity to do work and is required for life processes. An energy resource is something that can produce heat, power life, move objects, or produce electricity. Matter that stores energy is called a fuel. Human energy consumption has grown steadily throughout human history. Early humans had modest energy requirements, mostly food and fuel for fires to cook and keep warm. In today's society, humans consume as much as 110 times as much energy per person as early humans. Most of the energy we use today comes from fossil fuels (stored solar energy). But fossils fuels have a disadvantage in that they are non-renewable on a human time scale, and because other potentially harmful effects on the environment. In any event, the exploitation of all energy sources (with the possible exception of direct solar energy used for heating), ultimately rely on materials on planet Earth.

Sustainability & The Environment

The definition of "sustainability" is the study of how natural systems function, remain diverse and produce everything it needs for the ecology to remain in balance. It also acknowledges that human civilization takes resources to sustain our modern way of life. The Three Pillars of Sustainability.

Economic Development

This is the issue that proves the most problematic as most people disagree on political ideology what is and is not economically sound, and how it will affect businesses and by extension, jobs and employability. It is also about providing incentives for businesses and other organizations to adhere to sustainability guidelines beyond their normal legislative requirements. Also, to encourage and foster incentives for the average person to do their bit where and when they can; one person can rarely achieve much, but taken as a group, effects in some areas are cumulative. The supply and demand market is consumerist in nature and modern life requires a lot of resources every single day; for the sake of the environment, getting what we consume under control is the paramount issue. Economic development is about giving people what they want without compromising quality of life, especially in the developing world, and reducing the financial burden and "red tape" of doing the right thing.

Social Development

There are many facets to this pillar. Most importantly is awareness of and legislation protection of the health of people from pollution and other harmful activities of business and other organizations. In North America, Europe and the rest of the developed world, there are strong checks and programmers of legislation in place to ensure that people's health and wellness is strongly protected. It is also about maintaining access to basic resources without

compromising the quality of life. The biggest hot topic for many people right now is sustainable housing and how we can better build the homes we live in from sustainable material. The final element is education - encouraging people to participate in environmental sustainability and teaching them about the effects of environmental protection as well as warning of the dangers if we cannot achieve our goals.

Environmental Protection

We all know what we need to do to protect the environment, whether that is recycling, reducing our power consumption by switching electronic devices off rather than using standby, by walking short journeys instead of taking the bus. Businesses are regulated to prevent pollution and to keep their own carbon emissions low. There are incentives to installing renewable power sources in our homes and businesses. Environmental protection is the third pillar and to many, the primary concern of the future of humanity. It defines how we should study and protect ecosystems, air quality, integrity and sustainability of our resources and focusing on the elements that place stress on the environment.

Primary Goals of Sustainability

- The end of poverty and hunger
- Better standards of education and healthcare - particularly as it pertains to water quality and better sanitation
- To achieve gender equality
- Sustainable economic growth while promoting jobs and stronger economies
- All of the above and more while tackling the effects of climate change, pollution and other environmental factors that can harm and do harm people's health, livelihoods and lives.
- Sustainability to include health of the land, air and sea

Energy Sources

There are 5 fundamental sources of energy:

1. Nuclear fusion in the Sun (solar energy)
2. Gravity generated by the Earth & Moon.
3. Nuclear fission reactions.
4. Energy in the interior of the Earth.
5. Energy stored in chemical bonds.

Other than this it can be classified in two broad terms:-

1. Renewable resources
    a. Solar energy
    b. Wind energy
    c. Geothermal energy
    d. Hydropower energy
    e. Biomass
    f. Hydrogen and fuel cells
2. Non renewable Resources
    a. Nuclear energy
    b. Fuel energy (Coal/ Petroleum)

1. Renewable resources-: A renewable resource is a resource which can be used repeatedly and replaced naturally. Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally

replenished). In 2008, about 19% of global final energy consumption came from renewable, with 13% coming from traditional biomass, which is mainly used for heating, and 3.2% from hydroelectricity. New renewable (small hydro, modern biomass, wind, solar, geothermal, and bio-fuels) accounted for another 2.7% and are growing very rapidly. The share of renewable in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3% from new renewable.

Types of Renewable resources

1. **Solar. This form of energy relies on the nuclear fusion power from the core of the Sun. This energy can be collected and converted in a few different ways. The range is from solar water heating with solar collectors or attic cooling with solar attic fans for domestic use to the complex technologies of direct conversion of sunlight to electrical energy using mirrors and boilers or photovoltaic cells. Unfortunately these are currently insufficient to fully power our modern society.**

2. **Wind The movement of the atmosphere is driven by differences of temperature at the Earth's surface due to varying temperatures of the Earth's surface when lit by sunlight. Wind energy can be used to pump water or generate electricity, but requires extensive areal coverage to produce significant amounts of energy.**

3. **Hydroelectric energy this form uses the gravitational potential of elevated water that was lifted from the oceans by sunlight. It is not strictly speaking renewable since all reservoirs eventually fill up and require very expensive excavation to become useful again. At this time, most of the available locations for hydroelectric dams are already used in the developed world.**

4. **Biomass is the term for energy from plants. Energy in this form is very commonly used throughout the world. Unfortunately the most popular is the burning of trees for cooking and warmth. This process releases copious amounts of carbon dioxide gases into the atmosphere and is a major contributor to unhealthy air in many areas. Some of the more modern forms of biomass energy are methane generation and production of alcohol for automobile fuel and fueling electric power plants.**

5. **Hydrogen and fuel cells these are also not strictly renewable energy resources but are very abundant in availability and are very low in pollution when utilized. Hydrogen can be burned as a fuel, typically in a vehicle, with only water as the combustion product. This clean burning fuel can mean a significant reduction of pollution in cities. Or the hydrogen can be used in fuel cells, which are similar to batteries, to power an electric motor. In either case significant production of hydrogen requires abundant power. Due to the need for energy to produce the initial hydrogen gas, the result is the relocation of pollution from the cities to the power plants. There are several promising methods to produce hydrogen, such as solar power, that may alter this picture drastically.**

6. **Geothermal power Energy left over from the original accretion of the planet and augmented by heat from radioactive decay seeps out slowly everywhere, everyday. In certain areas the geothermal gradient (increase**

in temperature with depth) is high enough to exploit to generate electricity. This possibility is limited to a few locations on Earth and many technical problems exist that limit its utility. Another form of geothermal energy is Earth energy, a result of the heat storage in the Earth's surface. Soil everywhere tends to stay at a relatively constant temperature, the yearly average, and can be used with heat pumps toheat a building in winter and cool a building in summer. This form of energy can lessen the need for other power to maintain comfortable temperatures in buildings, but cannot be used to produce electricity.

2. Non renewable Resources
    1. Nuclear Fission Reactions Radioactive Uranium is concentrated and made into fuel rods that generate large amounts of heat as a result of radioactive decay. This heat is used to turn water into steam. Expansion of the steam can then be used to drive a turbine and generate electricity. Once proposed as a cheap, clean, and safe way to generate energy, Nuclear power has come under some disfavor. Costs of making sure nuclear power plants are clean and safe and the problem of disposing of radioactive wastes, which are unsafe, as well as questions about the safety of the plants under human care, has contributed to this disfavor.
    2. Energy in the Interior of the Earth Decay of radioactive elements has produced heat throughout Earth history. It is this heat that causes the temperature to increase with depth in the Earth and is responsible for melting of mantle rocks to form magmas. Magmas can carry the heat upward into the crust. Groundwater circulating in the vicinity of igneous intrusions carries the heat back toward the surface. If this hot water can be tapped, it can be used directly to heat homes, or if trapped at great depth under pressure it can be turned into steam which will expand.
    3. Fossil Fuels The origin of fossil fuels and biomass energy in general, starts with photosynthesis. Photosynthesis is the most important chemical reaction to us as human beings, because without it, we could not exist. Photosynthesis is the reaction that combines water and carbon dioxide from the Earth and its atmosphere with solar energy to form organicmolecules that make up plants and oxygen essential for respiration. Because all life forms depend on plants for nourishment, either directly or indirectly, photosynthesis is the basis for life on Earth.Thus when oxygen is added to organic material, either through decay by reaction with oxygen in the atmosphere, or by adding oxygen directly by burning, energy is produced, and water and carbon dioxide return to the Earth or its atmosphere.
    4. Petroleum To produce a fossil fuel, the organic matter must be rapidly buried in the Earth so that it does not oxidize (react with oxygen in the atmosphere). Then a series of slow chemical reactions occur which turn the organic molecules into hydrocarbons- Oil and Natural Gas, together called Petroleum. Hydrocarbons are complex organic molecules that consist of chains of hydrogen and carbon.

<u>Energy transformation</u>

Energy transformation also termed as energy conversion, is the process of changing energy from one of its forms into another. In physics, energy is a quantity that provides the capacity

to perform many actions—think of lifting or warming an object. In addition to being convertible, energy is transferable to a different location or object, but it cannot be created or destroyed. Energy in many of its forms may be used in natural processes, or to provide some service to society such as heating, refrigeration, lightening or performing mechanical work to operate machines. For example, in order to heat your home, your furnace can burn fuel, whose chemical potential energy is thus converted into thermal energy, which is then transferred to your home's air in order to raise its temperature.

Conversion of thermal energy to other types:-

Conversions to thermal energy (thus raising the temperature) from other forms of energy, may occur with essentially 100% efficiency[citation needed] (many types %, such as when potential energy is converted to kinetic energy as an object falls in vacuum, or when an object orbits nearer or farther from another object, in space.

Though, conversion of thermal energy to other forms, thus reducing the temperature of a system, has strict limitations, often keeping its efficiency much less than 100% (even when energy is not allowed to escape from the system). This is because thermal energy has already been partly spread out among many available states of a collection of microscopic particles constituting the system, which can have enormous numbers of possible combinations of momentum and position (these combinations are said to form a phase space). In such circumstances, a measure called entropy, or evening-out of energy distributions, dictates that future states of an isolated system must be of at least equal evenness in energy distribution. In other words, there is no way to concentrate energy without spreading out energy somewhere else.

Transformation of kinetic energy of charged particles to electric energy:-

In order to make the energy transformation more efficient, it is desirable to avoid the thermal conversion. For example, the efficiency of nuclear energy reactors, where kinetic energy of nuclei is first converted to thermal energy and then to electric energy, lies around 35%.By direct conversion of kinetic energy to electric, i.e. by eliminating the thermal energy transformation, the efficiency of energy transformation process can be dramatically improved.

Energy Transformation From The Early Universe

Energy transformations in the universe over time are (generally) characterized by various kinds of energy which has been available since the Big Bang, later being "released" (that is, transformed to more active types of energy such as kinetic or radiant energy), when a triggering mechanism is available to do it.

- **Release of energy from gravitational potential**
- **Release of energy from radioactive potential**
- **Release of energy from hydrogen fusion potential**

Examples of sets of energy conversions in machines

- **For instance, a coal-fired power plant involves these energy transformations:**
- **Chemical energy in the coal converted to thermal energy in the exhaust gases of combustion.**

- **Thermal energy of the exhaust gases converted into thermal energy of steam through the heat exchanger.**
- **Thermal energy of steam converted to mechanical energy in the turbine.**
- **Mechanical energy of the turbine converted to electrical energy by the generator, which is the ultimate output**
- **In such a system, the first and fourth step are highly efficient, but the second and third steps are less efficient. The most efficient gas-fired electrical power stations can achieve 50% conversion efficiency. Oil- and coal-fired stations achieve less.**

In a conventional automobile, these energy transformations are involved:

- **Chemical energy in the fuel converted to kinetic energy of expanding gas via combustion**
- **Kinetic energy of expanding gas converted to linear piston movement**
- **Linear piston movement converted to rotary crankshaft movement**
- **Rotary crankshaft movement passed into transmission assembly**
- **Rotary movement passed out of transmission assembly**
- **Rotary movement passed through differential**
- **Rotary movement passed out of differential to drive wheels**
- **Rotary movement of drive wheels converted to linear motion of the vehicle.**

Energy storage

Energy storage is the capture of energy produced at one time for use at a later time. A device that stores energy is sometimes called an accumulator or battery. Energy comes in multiple forms including radiation, chemical, gravitational potential, electrical potential, electricity, elevated temperature, latent heat and kinetic. Energy storage involves converting energy from forms that are difficult to store to more conveniently or economically storable forms. Bulk energy storage is currently dominated by hydroelectric dams, both conventional as well as pumped.

Some technologies provide short-term energy storage, while others can endure for much longer.

A wind-up clock stores potential energy (in this case mechanical, in the spring tension), a rechargeable battery stores readily convertible chemical energy to operate a mobile phone, and a hydroelectric dam stores energy in a reservoir as gravitational potential energy. Fossil fuels such as coal and gasoline store ancient energy derived from sunlight by organisms that later died, became buried and over time were then converted into these fuels. Food (which is made by the same process as fossil fuels) is a form of energy stored in chemical form.

Ice storage tanks store ice frozen by cheaper energy at night to meet peak daytime demand for cooling. The energy isn't stored directly, but the work-product of consuming energy (pumping away heat) is stored, having the equivalent effect on daytime consumption.

Fossile fuel:-

a fossil fuel is a fuel formed by natural processes, such as anaerobic decomposition of buried dead organisms, containing energy originating in ancient photosynthesis. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years. Fossil fuels contain high percentages of carbon and include petroleum, coal,

and natural gas. Other commonly used derivatives include kerosene and propane. Fossil fuels range from volatile materials with low carbon to hydrogen ratios like methane, to liquids like petroleum, to non-volatile materials composed of almost pure carbon, like anthracite coal. Methane can be found in hydrocarbon fields either alone, associated with oil, or in the form of methane catharses.

Advantages of Fossil Fuels

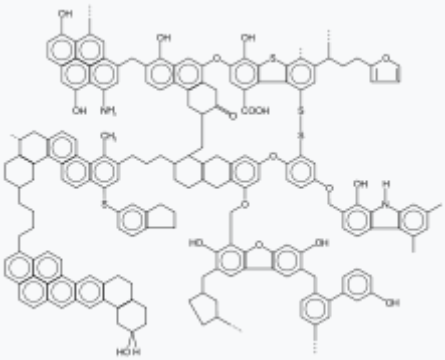
- **A major advantage of fossil fuels is their capacity to generate huge amounts of electricity in just a single location.**
- **Fossil fuels are very easy to find.**
- **When coal is used in power plants, they are very cost effective. Coal is also in abundant supply.**
- **Transporting oil and gas to the power stations can be made through the use of pipes making it an easy task.**
- **Power plants that utilize gas are very efficient.**
- **Power stations that make use of fossil fuel can be constructed in almost any location. This is possible as long as large quantities of fuel can be easily brought to the power plants.**

Disadvantages of Fossil Fuels

- **Pollution is a major disadvantage of fossil fuels. This is because they give off carbon dioxide when burned thereby causing a greenhouse effect. This is also the main contributory factor to the global warming experienced by the earth today.**
- **Coal also produces carbon dioxide when burned compared to burning oil or gas. Additionally, it gives off sulphur dioxide, a kind of gas that creates acid rain.**
- **Environmentally, the mining of coal results in the destruction of wide areas of land. Mining this fossil fuel is also difficult and may endanger the lives of miners. Coal mining is considered one of the most dangerous jobs in the world.**
- **Power stations that utilize coal need large amounts of fuel. In other words, they not only need truckloads but trainloads of coal on a regular basis to continue operating and generating electricity. This only means that coal-fired power plants should have reserves of coal in a large area near the plants location.**
- **Use of natural gas can cause unpleasant odors and some problems especially with transportation.**
- **Use of crude oil causes pollution and poses environmental hazards such as oil spills when oil tankers, for instance, experience leaks or drown deep under the sea. Crude oil contains toxic chemicals which cause air pollutants when combusted.**

Coal is a combustible black or brownish-black sedimentary rock usually occurring in rock strata in layers or veins called coal beds or coal seams. The harder forms, such as anthracite coal, can be regarded as metamorphic rock because of later exposure to elevated temperature and pressure. Coal is composed primarily of carbon, along with variable quantities of other elements, chiefly hydrogen, sulfur, oxygen, and nitrogen.[1] Coal is a fossil fuel that forms when dead plant matter is converted into peat, which in turn is converted into lignite, then sub-bituminous coal, after that bituminous coal, and lastly anthracite. This involves biological and geological processes. The geological processes take place over millions of years.

Formation



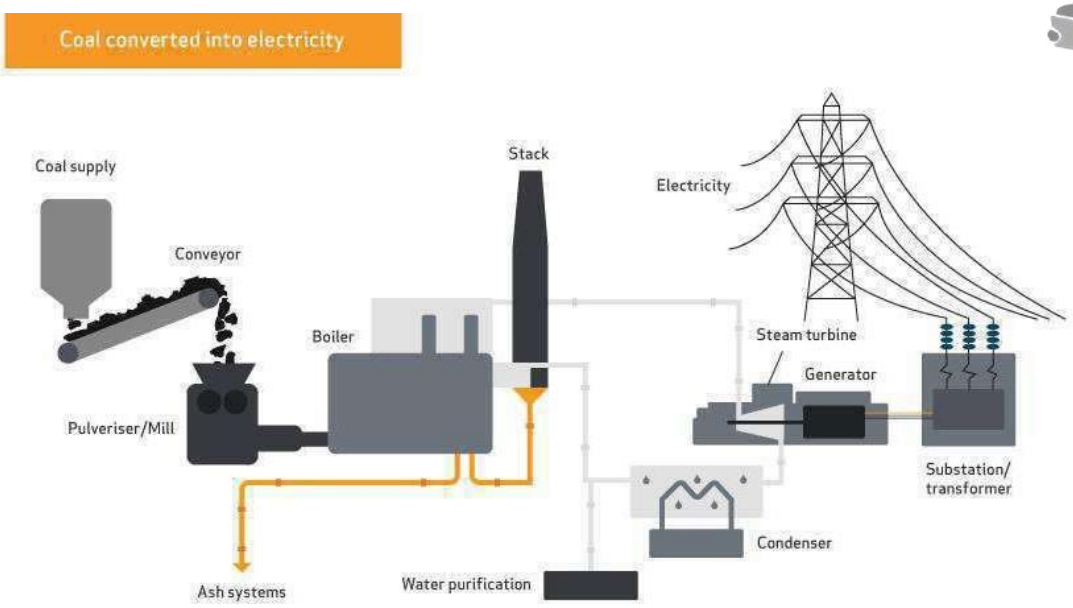
Example chemical structure of coal

At various times in the geologic past, the Earth had dense forests[8] in low-lying wetland areas. Due to natural processes such as flooding, these forests were buried underneath soil. As more and more soil deposited over them, they were compressed. The temperature also rose as they sank deeper and deeper. As the process continued the plant matter was protected from biodegradation and oxidation, usually by mud or acidic water. This trapped the carbon in immense peat bogs that were eventually covered and deeply buried by sediments. Under high pressure and high temperature, dead vegetation was slowly converted to coal. As coal contains mainly carbon, the conversion of dead vegetation into coal is called carbonization

Production of electricity from coal

Steam coal, also known as thermal coal, is used in power stations to generate electricity. Coal is first milled to a fine powder, which increases the surface area and allows it to burn more quickly. In these pulverised coal combustion (PCC) systems, the powdered coal is blown into the combustion chamber of a boiler where it is burnt at high temperature (see diagram). The hot gases and heat energy produced converts water – in tubes lining the boiler – into steam. The high pressure steam is passed into a turbine containing thousands of propeller-like blades. The steam pushes these blades causing the turbine shaft to rotate at high speed. A generator is mounted at one end of the turbine shaft and consists of carefully wound wire coils. Electricity is generated when these are rapidly rotated in a strong magnetic field. After passing through the turbine, the steam is condensed and returned to the boiler to be heated once again.

The electricity generated is transformed into the higher voltages (up to 400,000 volts) used for economic, efficient transmission via power line grids. When it nears the point of consumption, such as our homes, the electricity is transformed down to the safer 100-250 voltage systems used in the domestic market.



Efficiency improvements

Improvements continue to be made in conventional PCC power station design and new combustion technologies are being developed. These allow more electricity to be produced from less coal - known as improving the thermal efficiency of the power station. Efficiency gains in electricity generation from coal-fired power stations will play a crucial part in reducing CO2 emissions at a global level. A one percentage point improvement in the efficiency of a conventional pulverised coal combustion plant results in a 2-3% reduction in CO2 emissions.

Shale oil

Shale oil is unconventional oil produced from oil shale rock fragments by pyrolysis, hydrogenation, or thermal dissolution. These processes convert the organic matter within the rock (kerogen) into synthetic oil and gas. The resulting oil can be used immediately as a fuel or upgraded to meet refinery feedstock specifications by adding hydrogen and removing impurities such as sulfur and nitrogen. The refined products can be used for the same purposes as those derived from crude oil.

The term "shale oil" is also used for crude oil produced from shale's of other very low permeability formations. However, to reduce the risk of confusion of shale oil produced from oil shale with crude oil in oil-bearing shale's, the term "tight oil" is preferred for the latter.

Shale oil extraction

Shale oil is extracted by pyrolysis, hydrogenation, or thermal dissolution of oil shale. The pyrolysis of the rock is performed in a retort, situated either above ground or within the rock formation itself. As of 2008, most oil shale industries perform the shale oil extraction process after the rock is mined, crushed and transported to a retorting facility, although several experimental technologies perform the process in place (in-situ). The temperature at which the kerogen decomposes into usable hydrocarbons varies with the time-scale of the process; in the above-ground retorting process decomposition begins at 300 °C (570 °F), but proceeds

more rapidly and completely at higher temperatures. Decomposition takes place most quickly at a temperature between 480 and 520 °C (900 and 970 °F).

Hydrogenation and thermal dissolution (reactive fluid processes) extract the oil using hydrogen donors, solvents, or a combination of these. Thermal dissolution involves the application of solvents at elevated temperatures and pressures, increasing oil output by cracking the dissolved organic matter. Different methods produce shale oil with different properties.

Properties of Shale

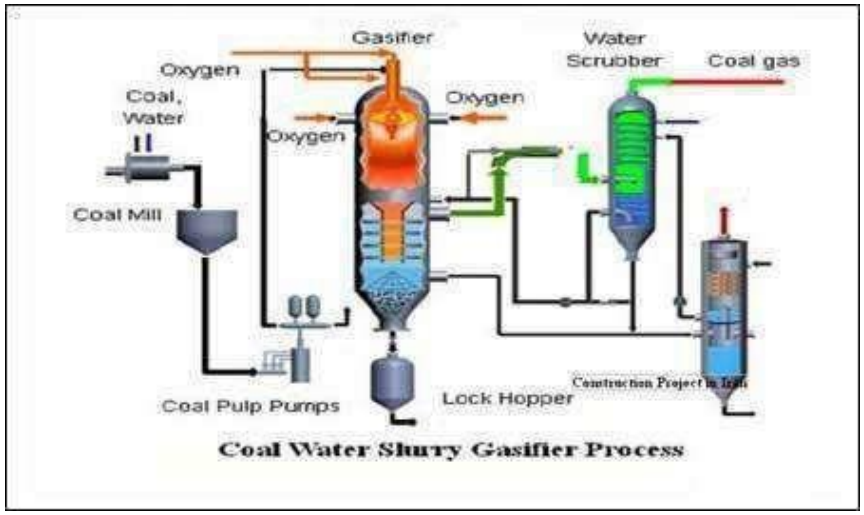
Properties of raw shale oil vary depending on the composition of the parent oil shale and the extraction technology used. Like conventional oil, shale oil is a complex mixture of hydrocarbons, and it is characterized using bulk properties of the oil. Shale oil usually contains large quantities of olefinic and aromatic hydrocarbons. Shale oil can also contain significant quantities of heteroatoms. A typical shale oil composition includes 0.5–1% of oxygen, 1.5–2% of nitrogen and 0.15–1% of sulfur, and some deposits contain more heteroatoms. Mineral particles and metals are often present as well. Generally, the oil is less fluid than crude oil, becoming pourable at temperatures between 24 and 27 °C (75 and 81 °F), while conventional crude oil is pourable at temperatures between -60 to 30 °C (-76 to 86 °F); this property affects shale oil's ability to be transported in existing pipelines

Coal Gasification

Coal gasification is the process of producing syngas–a mixture consisting primarily of carbon monoxide (CO), hydrogen (H_2), carbon dioxide (CO_2), methane (CH_4), and water vapour (H_2O)–from coal and water, air and/or oxygen.

coal was gasified using early technology to produce coal gas (also known as "town gas"), which is a combustible gas traditionally used for municipal lighting and heating before the advent of industrial-scale production of natural gas.

In current practice, large-scale instances of coal gasification are primarily for electricity generation, such as in integrated gasification combined cycle power plants, for production of chemical feedstocks, or for production of synthetic natural gas. The hydrogen obtained from coal gasification can be used for various purposes such as making ammonia, powering a hydrogen economy, or upgrading fossil fuels.



Coal Water Slurry Gasifier Process

During gasification, the coal is blown through with oxygen and steam (water vapor) while also being heated (and in some cases pressurized). If the coal is heated by external heat sources the process is called "allothermal", while "autothermal" process assumes heating of the coal via exothermal chemical reactions occurring inside the gasifier itself. It is essential that the oxidizer supplied is insufficient for complete oxidizing (combustion) of the fuel. During the reactions mentioned, oxygen and water molecules oxidize the coal and produce a gaseous mixture of carbon dioxide (CO_2), carbon monoxide (CO), water vapour (H_2O), and molecular hydrogen (H_2). (Some by-products like tar, phenols, etc. are also possible end products, depending on the specific gasification technology utilized.) This process has been conducted in-situ within natural coal seams (referred to as underground coal gasification) and in coal refineries. The desired end product is usually syngas (i.e., a combination of H_2 + CO), but the produced coal gas may also be further refined to produce additional quantities of H_2:

$$3C \text{ (i.e., coal)} + O_2 + H_2O \rightarrow H_2 + 3CO$$

If the refiner wants to produce alkanes (i.e., hydrocarbons present in natural gas, gasoline, and diesel fuel), the coal gas is collected at this state and routed to a Fischer-Tropsch reactor. If, however, hydrogen is the desired end-product, the coal gas (primarily the CO product) undergoes the water gas shift reaction where more hydrogen is produced by additional reaction with water vapor:

$$CO + H_2O \rightarrow CO_2 + H_2$$

Although other technologies for coal gasification currently exist, all employ, in general, the same chemical processes. For low-grade coals (i.e., "brown coals") which contain significant amounts of water, there are technologies in which no steam is required during the reaction, with coal (carbon) and oxygen being the only reactants. As well, some coal gasification technologies do not require high pressures. Some utilize pulverized coal as fuel while others work with relatively large fractions of coal. Gasification technologies also vary in the way the blowing is supplied.

"Direct blowing" assumes the coal and the oxidizer being supplied towards each other from the opposite sides of the reactor channel. In this case the oxidizer passes through coke and (more likely) ashes to the reaction zone where it interacts with coal. The hot gas produced then passes fresh fuel and heats it while absorbing some products of thermal destruction of the fuel, such as tars and phenols. Thus, the gas requires significant refining before being used in the Fischer-Tropsch reaction. Products of the refinement are highly toxic and require special facilities for their utilization. As a result, the plant utilizing the described technologies has to be very large to be economically efficient. One of such plants called SASOL is situated in the Republic of South Africa (RSA). It was built due to embargo applied to the country preventing it from importing oil and natural gas. RSA is rich in Bituminous coal and Anthracite and was able to arrange the use of the well known high pressure "Lurgi" gasification process developed in Germany in the first half of 20th century.

"Reversed blowing" (as compared to the previous type described which was invented first) assumes the coal and the oxidizer being supplied from the same side of the reactor. In this case there is no chemical interaction between coal and oxidizer before the reaction zone. The gas produced in the reaction zone passes solid products of gasification (coke and ashes), and CO_2 and H_2O contained in the gas are additionally chemically restored to CO and H_2. As compared to the "direct blowing" technology, no toxic by-products are present in the gas: those are disabled in the reaction zone.

<u>Underground coal gasification</u>

Underground coal gasification is an industrial gasification process, which is carried out in non-mined coal seams using injection of a gaseous oxidizing agent, usually oxygen or air, and bringing the resulting product gas to surface through production wells drilled from the surface. The product gas could to be used as a chemical feedstock or as fuel for power generation. The technique can be applied to resources that are otherwise not economical to extract and also offers an alternative to conventional coal mining methods for some resources. Compared to traditional coal mining and gasification, UCG has less environmental and social impact, though some concerns including potential for aquifer contamination are known

Carbon capture technology

Carbon capture, utilization, and sequestration (or storage) is increasingly being utilized in modern coal gasification projects to address the greenhouse gas emissions concern associated with the use of coal and carbonaceous fuels. In this respect, gasification has a significant advantage over conventional coal combustion, in which CO_2 resulting from combustion is considerably diluted by nitrogen and residual oxygen in the near-ambient pressure combustion exhaust, making it relatively difficult, energy-intensive, and expensive to capture the CO_2 (this is known as "post-combustion" CO_2 capture).

CO_2 capture technology options

All coal gasification-based conversion processes require removal of hydrogen sulfide (H_2S; an acid gas) from the syngas as part of the overall plant configuration. Typical acid gas removal (AGR) processes employed for gasification design are either a chemical solvent system (e.g., amine gas treating systems based on MDEA, for example) or a physical solvent system (e.g., Rectisol or Selexol). Process selection is mostly dependent on the syngas cleanup requirement and costs. Conventional chemical/physical AGR processes using MDEA, Rectisol or Selexol are commercially proven technologies and can be designed for selective removal of CO_2 in addition to H_2S from a syngas stream. For significant capture of CO_2 from a gasification plant (e.g., > 80%) the CO in the syngas must first be converted to CO_2 and hydrogen (H_2) via a water-gas-shift (WGS) step upstream of the AGR plant.

For gasification applications, or IGCC, the plant modifications required to add the ability to capture CO_2 are minimal. The syngas produced by the gasifiers needs to be treated through various processes for the removal of impurities already in the gas stream, so all that is required to remove CO_2 is to add the necessary equipment, an absorber and regenerator, to this process train. In combustion applications, smodifications must be done to the exhaust stack and because of the lower concentrations of CO_2 present in the exhaust, much larger volumes of total gas require processing, necessitating larger and more expensive equipment.

By-products

he by-products of coal gas manufacture included coke, coal tar, sulfur and ammonia; all useful products. Dyes, medicines, including sulfa drugs, saccharin and many organic compounds are therefore derived from coal gas.

Coke is used as a smokeless fuel and for the manufacture of water gas and producer gas. Coal tar is subjected to fractional distillation to recover various products, including

- **tar, for roads**
- **benzole, a motor fuel**
- **creosote, a wood preservative**

- **phenol, used in the manufacture of plastics**
- **cresols, disinfectants**

Sulfur is used in the manufacture of sulfuric acid and ammonia is used in the manufacture of fertilisers.

Indian Scenario

India is one of the countries where the present level of energy consumption, by world standards, is very low. The estimate of annual energy consumption in India is about 330 Million Tones Oil Equivalent (MTOE) for the year 2004. Accordingly, the per capita consumption of energy is about 305 Kilogram Oil Equivalent (KGOE). As compared to this, the energy consumption in some of the other countries is of the order of over 4050 for Japan, over 4275 for South Korea, about 1200 for China, about 7850 for USA, about 4670 for OECD countries and the world average is about 1690.

In so far as electricity consumption is concerned, India has reached a level of about 600-kilowatt hour (kwh) per head per year. The comparable figures for Japan are about 7,800, for South Korea about 7,000, for China about 1380, for USA about 13,000, for OECD countries about 8050 and world average are about 2430. Thus, both in terms of per capita energy consumption and in terms of per capita electricity consumption, India is far behind many countries, and as a matter of fact, behind even the world average. Therefore, to improve the standards of living of Indian people and to let them enjoy the benefit of economic development, it is imperative that both energy consumption and electricity consumption level is enhanced. India is targeting a growth rate of 9 – 10%, having already reached a level of almost 8%. To sustain the double-digit growth rate for next 10-15 years, it would be essential that the level of energy availability and consumption, and electricity consumption in particular, is enhanced substantially.In the profile of energy sources in India, coal has a dominant position. Coal constitutes about 51% of India's primary energy resources followed by Oil (36%), Natural Gas (9%), Nuclear (2%) and Hydro (2%). To address the issue concerning energy consumption, and more particularly, the need for enhancing the energy supply, India has accorded appropriate priority to both - supply side management and demand side management.

Non-Conventional Energy Sources

	Potential (MW)	Existing capacity (MW)
Wind	45,000	4,400
Small Hydro (upto 25 MW)	15,000	1,700
Solar (PV)	20 MW/Sq.Km	Very little
Biogas plants	12 million	3.8 million
Urban/Industrial waste based plant	2,700	Very little

Indian Government has accorded very high priority to develop and expand installed capacity base through non-conventional sources of electricity generation. There is a separate Ministry in the Government of India to exclusively focus on this important area of power generation. National Electricity Policy notified in 2005 in pursuance of the Electricity Act, 2003, prescribes that State Electricity Regulatory Commissions should prescribe a proportion of power which should be produced and supplied to the grid through the non-conventional sources. Some of the Regulatory Commissions have come out with specific policy guidelines with a different approach on tariff for these plants in order to encourage these technologies and plants. National Electricity Tariff Policy mandates that State Commissions should fix such minimum percentage latest by April, 2006. India has very high potential for these capacities:

It may be seen from the above that India has achieved substantial success on wind turbine based power generation. Ministry of Non-conventional Energy Sources (MNES) has set a target of achieving at least 10,000 MW capacity through various non-conventional sources, by the year 2012.

Conventional Sources of Electricity Generation

Fossil fuel based thermal power, hydro-electric, and nuclear constitute the conventional sources of power. Non-conventional sources are less than 5% of total installed capacity in India. The present installed capacity (as in March 2006) is about 1,25,000 MW, consisting of coal based plants (56%), gas based plants (10%), hydro-electric (26%), nuclear (3%) non-conventional (5%).

Indian Power Sector was opened up for private power generation in 1991. In terms of ownership structure, the profile consists of Central Government owned companies (32%), State Government owned companies/Electricity Boards (57%) and Private Sector (11%). 100% FDI is permitted in all segments of electricity industry – viz. Generation, Transmission, Distribution, Trading.

In the last three years far-reaching structural changes have been introduced in the Indian Electricity Sector. Electricity Act 2003 is an historic legislative initiative with powerful potential to transform the power sector industry and market structure.

Most important features of the Electricity Act 2003 are as follows:

1. **The Act creates a liberal and transparent framework for power development**
2. **It facilitates investment by creating competitive environment and reforming distribution segment of power industry.**
3. **Entry Barriers have been removed/reduced in following areas:**
   a) **Delicensed generation.**
   b) **Freedom to captive generation including group captive**
   c) **Recognizing trading as an independent activity**
   d) **Open access in transmission facilitating multi buyer and seller model.**
4. **Open access to consumers above 1 MW within five years commencing from 27th January, 2004 (date of enforcement of amendment to Electricity Act) Regulators have been mandated to ensure this.**
5. **Multiple licenses in distribution in the same area of supply so that competition could yield better services to consumers.**
6. **Regulatory Commissions – to develop market and to fix tariff.**

Biomass Energy

Renewable energy from plants and animals/ biomass is a renewable energy source from living or recently living plant and animal materials which can be used as fuel. An example of biomass is plant material that produces electricity with steam. An example of biomass is animal fossil fuel.

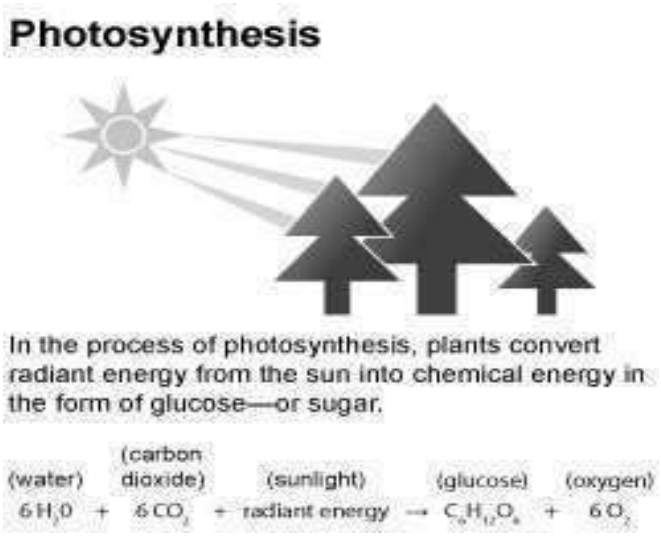
Biomass is organic material that comes from plants and animals, and it is a renewable source of energy.

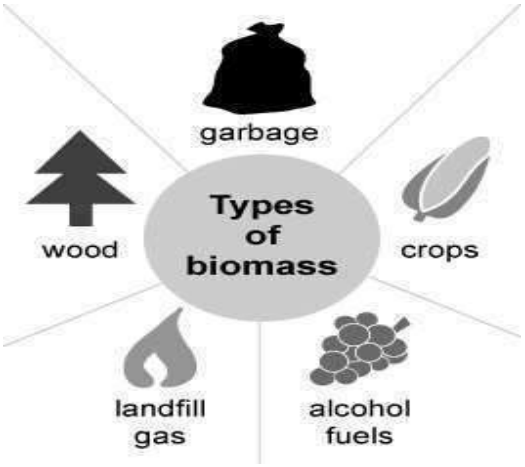
Biomass contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis. When biomass is burned, the chemical energy in biomass is released as heat. Biomass can be burned directly or converted to liquid biofuels or biogas that can be burned as fuels.

Or

Biomass energy is the energy which is contained inside plants and animals. This can include organic matter of all kinds: plants, animals, or waste products from organic sources. These sorts of energy sources are known as biofuels and typically include wood chips, rotted trees,

manure, sewage, mulch, and tree components. Chlorophyll present in plants absorbs carbon dioxide from the atmosphere and water from the ground through the process of photosynthesis. The same energy is passed to animals when they eat them. It is considered to be as renewable source of energy because carbon dioxide and water contained inside plants and animals are released back in to the atmosphere when they are burned and we can grow more plants and crops to create biomass energy.





<u>Types of Biomass</u>

We use four types of biomass today: 1) wood and agricultural products; 2) solid waste; 3) landfill gas; and 4) alcohol fuels.

1. Wood and Agricultural Biomass:- Most biomass used today is home grown energy. Wood-logs, chips, bark, and sawdust-accounts for about 79 percent of biomass energy. But any organic matter can produce biomass energy. Other biomass sources include agricultural waste products like fruit pits and corn cobs.

2. Solid Waste:- There is nothing new about people burning trash. What's new is burning trash to generate electricity. This turns waste into a usable form of energy. A ton (2,000 pounds) of garbage contains about as much heat energy, as pounds of coal. Power plants that burn garbage for energy are called waste-to-energy plants. These plants generate electricity much as coal-fired plants do except that garbage-not coal-is the fuel used to fire an industrial boiler. Making electricity from garbage costs more than making it from coal and other energy sources. The main advantage of burning solid waste is it reduces the amount of garbage dumped in landfills by 60 to 90 percent, and reduces the cost of landfill disposal.

3. Landfill Gas:- Bacteria and fungi are not picky eaters. They eat dead plants and animals, causing them to rot or decay. Even though this natural process is slowed in the artificial environment of a landfill, a substance called methane gas is still produced as the waste decays. New regulations require landfills to collect methane gas for safety and environmental reasons. Methane gas is colorless and odorless, but it is not harmless. The gas can cause fires or explosions if it seeps into nearby homes and is ignited. Landfills can collect the methane gas, purify it, and then use it as an energy source. Methane, which is the same thing as natural gas, is a good energy source. Most gas furnaces and

gas stoves use methane supplied by natural gas utility companies. The city landfill in Florence, Alabama recovers 32 million cubic feet of methane gas a day. The city purifies the gas and then pumps it into natural gas pipelines.

4. Alcohol Fuels:- Wheat, corn, and other crops can be converted into a variety of liquid fuels including ethanol and methanol. Using ethanol as a motor fuel is nothing new. Its use is almost as old as the automobile. Gasohol does have some advantages over gasoline. It has a higher octane rating than gasoline (provides your car with more power), and it is cleaner-burning than unleaded gasoline, with one-third less carbon monoxide emissions. Gasohol may also help reduce America's dependence on foreign oil.

Sources of Biomass

Here are various biomass sources, which are a great source of energy that can be used for various applications:

1) Wood and waste wood: Wood is the most commonly used type of biomass. Since the earliest days the fuel being used for cooking and heating is the wood. Even at present wood as the biomass material is major source of energy in a number of developing countries.

Wood as a biomass can be used in various forms like large wooden blocks obtained from the trees, wooden chips, and saw dust. The wasted wood and wooden scrap are also the source of biomass.

2) Leaves of the plants: In the densely planted places lots of leaves fall from the trees. These can be dried, powdered and converted into small pieces, which can be used as the biomass fuel to generate heat used usually for cooking food.

3) Broken branches and twigs of the trees: No part of the plant goes wasted when it leaves the main body of the tree. Large and small branches and even all the small twigs are the source of biomass energy.

4) Agricultural waste: Lots of waste materials obtained from the farms are a great source of biomass materials. Livestock waste can also be used to generate methane gas.

5) Waste paper: Tons of waste paper is produced every day. These can be burnt to produce lots of heat. The paper is manufactured from the plants, so it is considered to be biomass material.

6) Garbage: The garbage, also called as municipal solid waste is another source of biomass. The garbage can be in the form of food scrap, lawn clippings, waste paper, fallen leaves etc all mixed together or collected individually.

7) Human waste: The human wastes are also considered to the source of biomass. These can used to generate methane gas which is the major component of natural gas.

<u>Biomass Gasification</u>

Biomass gasification, or producing gas from biomass, involves burning biomass under restricted air supply for the generation of producer gas. Producer gas is a mixture of gases:

18%–22% carbon monoxide (CO), 8%–12% hydrogen (H_2), 8%–12% carbon dioxide (CO_2), 2%–4% methane (CH_4) and 45%–50% nitrogen (N_2) making up the rest.

Gasification reactions

Producing gas from biomass consists of the following main reactions, which occur inside a biomass gasifier.

1. **Drying: Biomass fuels usually contain 10%–35% moisture. When biomass is heated to about 100 °C, the moisture is converted into steam.**
2. **Pyrolysis: After drying, as heating continues, the biomass undergoes pyrolysis. Pyrolysis involves burning biomass completely without supplying any oxygen. As a result, the biomass is decomposed or separated into solids, liquids, and gases. Charcoal is the solid part, tar is the liquid part, and flue gases make up the gaseous part.**
3. **Oxidation: Air is introduced into the gasifier after the decomposition process. During oxidation, which takes place at about 700–1,400 °C, charcoal, or the solid carbonized fuel, reacts with the oxygen in the air to produce carbon dioxide and heat.**

$$C + O_2 \rightarrow CO_2 + \text{heat}$$

4. **Reduction: At higher temperatures and under reducing conditions, that is when not enough oxygen is available, the following reactions take place forming carbon dioxide, hydrogen, and methane.**

$$C + CO_2 \rightarrow 2\,CO$$
$$C + H_2O \rightarrow CO + H_2$$
$$CO + H_2O \rightarrow CO_2 + H_2$$
$$C + 2H_2 \rightarrow CH_4$$

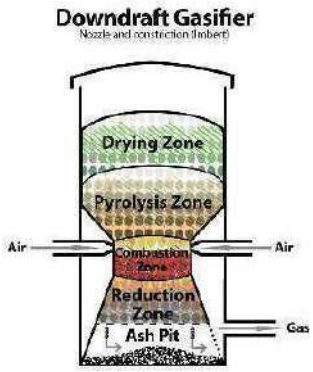
Types of gasifiers

Gasifiers can be classified based on the density factor, which is a ratio of the solid matter (the dense phase) a gasifier can burn to the total volume available. Gasifiers can be (a) dense phase reactors, or (b) lean phase reactors.

Dense phase reactors

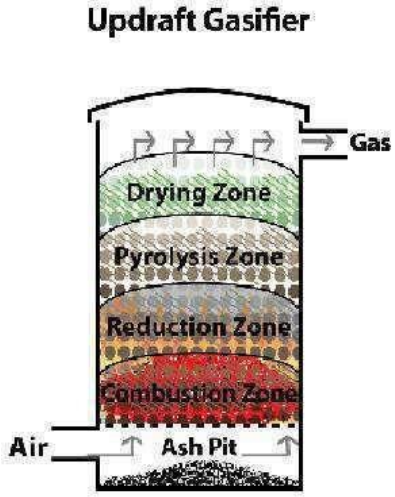
In dense phase reactors, the feedstock fills most of the space in the reactor. They are common, available in different designs depending upon the operating conditions, and are of three types: downdraft, updraft, and cross-draft.

1. **Downdraft or co-current gasifiers:- The downdraft (also known as co-current) gasifier is the most common type of gasifier. In downdraft gasifiers, the pyrolysis zone is above the combustion zone and the reduction zone is below the combustion zone. Fuel is fed from the top. The flow of air and gas is downwards (hence the name) through the combustion and reduction zones. The term co-current is used because air moves in the same direction as that of fuel, downwards. A downdraft gasifier is so designed that tar, which is produced in the pyrolysis zone, travels through the combustion zone, where it is broken down or burnt. As a result, the mixture of gases in the exit stream is relatively clean. The position of the combustion zone is thus a critical element in the downdraft gasifier, its main advantage being that it produces gas with low tar content, which is suitable for gas engines.**



Updraft or counter-current gasifier

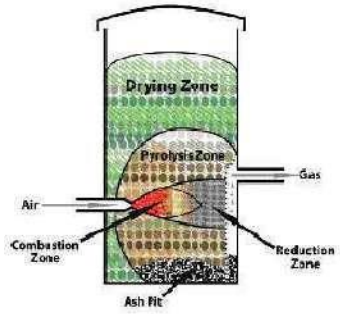
In updraft gasifiers (also known as counter-current), air enters from below the grate and flows upwards, whereas the fuel flows downwards. An updraft gasifier has distinctly defined zones for partial combustion, reduction, pyrolysis, and drying. The gas produced in the reduction zone leaves the gasifier reactor together with the products of pyrolysis from the pyrolysis zone and steam from the drying zone. The resulting combustible producer gas is rich in hydrocarbons (tars) and, therefore, has a higher calorific value, which makes updraft gasifiers more suitable where heat is needed, for example in industrial furnaces. The producer gas needs to be thoroughly cleaned if it is to be used for generating electricity.



Cross-draft gasifier

In a cross-draft gasifier, air enters from one side of the gasifier reactor and leaves from the other. Cross-draft gasifiers have a few distinct advantages such as compact construction and low cleaning requirements. Also, cross-draft gasifiers do not need a grate; the ash falls to the bottom and does not come in the way of normal operation.

Crossdraft Gasifier

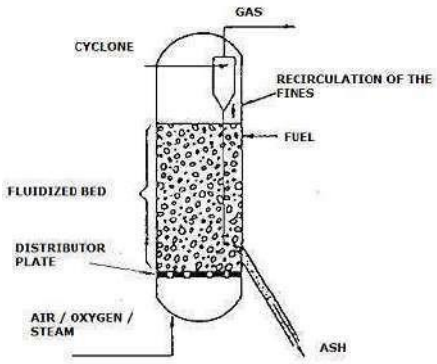


Lean phase reactors

Lean phase gasifiers lack separate zones for different reactions. All reactions – drying, combustion, pyrolysis, and reduction – occur in one large reactor chamber. Lean phase reactors are mostly of two types, fluidized bed gasifiers and entrained-flow gasifiers.

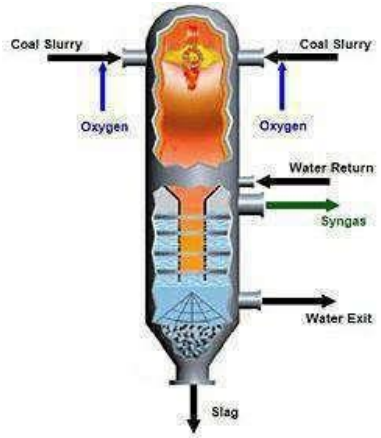
Fluidized bed gasifiers

In fluidized bed gasifiers, the biomass is brought into an inert bed of fluidized material (e.g. sand, char, etc.). The fuel is fed into the fluidized system either above-bed or directly into the bed, depending upon the size and density of the fuel and how it is affected by the bed velocities. During normal operation, the bed media is maintained at a temperature between 550 °C and 1000 °C. When the fuel is introduced under such temperature conditions, its drying and pyrolyzing reactions proceed rapidly, driving off all gaseous portions of the fuel at relatively low temperatures. The remaining char is oxidized within the bed to provide the heat source for the drying and devolatilizing reactions to continue. Fluidized bed gasifiers are better than dense phase reactors in that they produce more heat in short time due to the abrasion phenomenon between inert bed material and biomass, giving a uniformly high (800–1000 ºC) bed temperature. A fluidized bed gasifier works as a hot bed of sand particles agitated constantly by air. Air is distributed through nozzles located at the bottom of the bed.



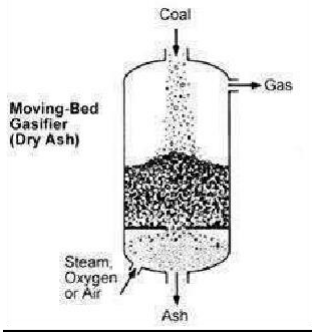
Entrained-flow gasifiers

In entrained-flow gasifiers, fuel and air are introduced from the top of the reactor, and fuel is carried by the air in the reactor. The operating temperatures are 1200–1600 °C and the pressure is 20–80 bar. Entrained-flow gasifiers can be used for any type of fuel so long as it is dry (low moisture) and has low ash content. Due to the short residence time (0.5–4.0 seconds), high temperatures are required for such gasifiers. The advantage of entrained-flow gasifiers is that the gas contains very little tar.

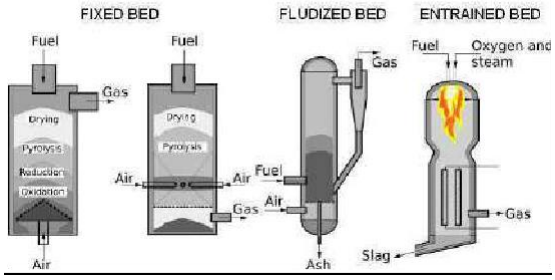


The fixed bed

The fixed bed gasification system consists of a reactor/gasifier with a gas cooling and cleaning system. The fixed bed gasifier has a bed of solid fuel particles through which the gasifying media and gas move either up or down. It is the simplest type of gasifier consisting of usually a cylindrical space for fuel feeding unit, an ash removal unit and a gas exit. In the fixed bed gasifier, the fuel bed moves slowly down the reactor as the gasification occurs. The fixed bed gasifiers are of simple construction and generally operate with high carbon conversion, long solid residence time, low gas velocity and low ash carry over. In fixed bed gasifiers, tar removal used to be a major problem, however recent progress in thermal and catalytic conversion of tar has given credible options.



Comperitive diagram of gasifiers



Types Of Conversion Technologies

There are four types of conversion technologies currently available, each appropriate for specific biomass? types and resulting in specific energy products:

1. **Thermal conversion is the use of heat, with or without the presence of oxygen, to convert biomass materials or feedstocks into other forms of energy. Thermal conversion technolgies include direct combustion, pyrolysis, and torrefaction.**

As the term implies, thermal conversion involves the use of heat as the primary mechanism for converting biomass into another form. Combustion, pyrolysis, torrefaction, and gasification are the basic thermal conversion technologies either in use today or being developed for the future.

1. **Combustion**

Direct combustion is the burning of biomass in the presence of oxygen. Furnaces and boilers are used typically to produce steam for use in district heating/cooling systems or to drive turbines to produce electricity. In a furnace, biomass burns in a combustion chamber converting the biomass into heat. The heat is distributed in the form of hot air or water. In a boiler, the heat of combustion is converted into steam. Steam can be used to produce electricity, mechanical energy, or heating and cooling. A boiler's steam contains 60-85% of the energy in biomass fuel.

Co-firing – This is a sub-set of combustion based power production. Some of the modern coal fired power plants use biomass for co-firing along with coal. It is quite efficient, cost-effective and requires moderate additional investment. In general, combustion efficiency of biomass can be 10 percentage points lower than for coal at the same installation, but co-firing efficiency in large-scale coal plants (35%-45%) is higher than the efficiency of biomass-dedicated plants. In the case of co-combustion of up to 5%-10% of biomass (in energy terms) only minor changes in the handling equipment are needed and the boiler is not noticeably de-rated.

2. **Pyrolysis**

These processes do not necessarily produce useful energy directly, but under controlled temperature and oxygen conditions are used to convert biomass feedstocks into gas, oil or forms of charcoal. These energy products are more energy dense than the original biomass, and therefore reduce transport costs, or have more predictable and convenient combustion characteristics allowing them to be used in internal combustion engines and gas turbines. Pyrolysis is a processes of subjecting a biomass feedstock to high temperatures (greater than 430 °C) under pressurized environments and at low oxygen levels. In the process, biomass undergoes partial combustion. Processes of pyrolysis result in liquid fuels and a solid residue called char, or biochar. Biochar is like charcoal and rich in carbon. Liquid phase products result from temperatures which are too low to destroy all of the carbon molecules in the biomass so the result is production of tars, oils, methanol, acetone, etc.

- **The two main methods of pyrolysis are "fast" pyrolysis and "slow" pyrolysis. Fast pyrolysis yields 60% bio-oil, 20% biochar, and 20% syngas, and can be done in seconds, whereas slow pyrolysis can be optimized to produce substantially more char (~50%) along with organic gases, but takes on the order of hours to complete. In either case, the gas or oil can be used as a fuel for firing the boiler for steam production and subsequent power production.**
- **Typically pyrolysis plants work well beyond 2 MW scale, while gasification plants work well until 2 MW scale, at the current technological progress. Thus, it can be said that pyrolysis takes off where gasification ends.**
- **Slow Pyrolysis**
- **In the case of slow pyrolysis when you get an organic gas and charcoal. The gas can be cooled and fed to a gas engine for power production. Cooling this gas however results in a significant amount of hydrocarbons being removed. Thus most of the energy is wasted away. A more efficient idea that is being explored is to use this heterogeneous gas straight for combustion of boilers and running a steam cycle. Charcoal is a valuable product, which fetches anywhere between Rs 10-Rs 25 per Kg. It**

has a much better calorific value than coal and people in many places use charcoal because coal might not be available in those places.

- Fast Pyrolysis
- Fast pyrolysis is a process in which organic materials are rapidly heated to 450 - 600°C in absence of air. Under these conditions, organic vapors, permanent gases and charcoal are produced. The vapors are condensed to pyrolysis oil. Typically, 50 - 75 wt % of the feedstock is converted into pyrolysis oil. The pyrolysis oil can be used as a replacement for furnace oil.

3. Torrefaction:- Like pyrolysis, is the conversion of biomass with the application of heat in the absence of oxygen, but at lower temperatures than those typically used in pyrolysis. In torrefaction temperatures typically range between 200-320 °C. In the torrefaction process water is removed and cellulose?, hemicellulose and lignins are partially decomposed. The final product is an energy dense solid fuel frequently referred to as "bio-coal".

2. Thermochemical conversion is the application of heat and chemical processes in the production of energy products from biomass. A key thermochemical conversion process if gasification.

Gasification

Gasification is the use of high temperatures and a controlled environment that leads to nearly all of the biomass being converted into gas. This takes place in two stages: partial combustion to form producer gas and charcoal, followed by chemical reduction. These stages are spatially separated in the gasifier, with gasifier design very much dependant on the feedstock characteristics. Gasification requires temperatures of about 800°C. Gasification technology has existed since the turn of the century when coal was extensively gasified in the UK and elsewhere for use in power generation and in houses for cooking and lighting. A major future role is envisaged for electricity production from biomass plantations and agricultural residues using large scale gasifiers with direct coupling to gas turbines.

3. Biochemical conversion involves use of enzymes, bacteria or other microorganisms to break down biomass into liquid fuels, and includes anaerobic digestion, and fermentation.

Anaerobic digestion

Anaerobic digestion is the use of microorganisms in oxygen-free environments to break down organic material. Anaerobic digestion is widely used for the production of methane- and carbon-rich biogas from crop residues, food scraps, and manure (human and animal). Anaerobic digestion is frequently used in the treatment of wastewater and to reduce emissions from landfills. Anaerobic digestion involves a multi-stage process. First, bacteria are used in hydrolysis to break down carbohydrates, for example, into forms digestible by other bacteria. The second set of bacteria convert the resulting sugars and amino acids into carbon dioxide, hydrogen, ammonia and organic acids. Finally, still other bacterias convert these products into methane and carbon dioxide. Mixed bacterial cultures are characterized by optimal temperature ranges for growth. These mixed cultures allow digesters to be operated over a wide temperature range, for example, above 0° C and up to 60° C. When functioning well, the bacteria convert about 90% of the biomass feedstock into biogas (containing about 55% methane), which is a readily useable energy source. Solid remnants of the original biomass input are left over after the digestion process. This by-product, or digestate, has many potential uses. Potential uses include fertilizer (although it should

be chemically assessed for toxicity and growth-inhibiting factors first), animal bedding and low-grade building products like fiberboard.

Fermentation

At its most basic, fermentation is the use of yeasts to convert carbohydrates into alcohol – most notably ethanol, also called bioethanol. The total process involves several stages. In the first stage crop materials are pulverized or ground and combined with water to form a slurry. Heat and enzymes are then applied to break down the ground materials into a finer slurry. Other enzymes are added to convert starches into glucose sugar. The sugary slurry is then pumped into a fermentation chamber to which yeasts are added. After about 48-50 hours, the fermented liquid is distilled to divide the alcohol from the solid materials left over.

3. Chemical conversion involves use of chemical agents to convert biomass into liquid fuels.

ADVANTAGES

1) Biomass used as a fuel reduces need for fossil fuels for the production of heat, steam, and electricity for residential, industrial and agricultural use.
2) Biomass is always available and can be produced as a renewable resource.
3) Biomass fuel from agriculture wastes maybe a secondary product that adds value to agricultural crop.
4) Growing Biomass crops produce oxygen and use up carbon dioxide.
5) The use of waste materials reduce landfill disposal and makes more space for everything else.
6) Carbon Dioxide which is released when Biomass fuel is burned, is taken in by plants.
7) Less money spent on foreign oil.

DISADVANTAGES

1) Agricultural wastes will not be available if the basic crop is no longer grown.
2) Additional work is needed in areas such as harvesting methods.
3) Land used for energy crops maybe in demand for other purposes, such as faming, conservation, housing, resort or agricultural use.
4) Some Biomass conversion projects are from animal wastes and are relatively small and therefore are limited.
5) Research is needed to reduce the costs of production of Biomass based fuels.
6) Is in some cases is a major cause of pollution.

Or

Advantages of Biomass Energy

In many ways, biomass is a new source of power. While wood has always served as a fuel source for fires and ovens and conventional heating methods, biomass energy advancements are a few steps beyond that. Now these biomass fuel products are harvested and mass-produced and used in everything from engines to power plants.

1. No Harmful Emissions: Biomass energy, for the most part, creates no harmful carbon dioxide emissions. Many energy sources used today struggle to control their carbon dioxide emissions, as these can cause harm to the ozone layer and increase the effects of greenhouse gases, potentially warming the planet. It is completely natural, has no such carbon dioxide side effects in its use.

2. Clean Energy: Because of its relatively clean use, biomass energy, when used in commercial businesses such as airlines, receives tax credit from the US government. This is good for the environment and good for business. It does release carbon dioxide but captures carbon dioxide for its own growth. Carbon dioxide released by fossil fuel are released into the atmosphere and are harmful to the environment.

3. Abundant and Renewable: Biomass products are abundant and renewable. Since they come from living sources, and life is cyclical, these products potentially never run out, so long as there is something living on earth and there is someone there to turn that living things components and waste products into energy. In the United Kingdom, biomass fuels are made from recycled chicken droppings. In the United States and Russia, there are plentiful forests for lumber to be used in the production of biomass energy.

4. Reduce Dependency on Fossil Fuels: It has developed as an alternate source of fuel for many homeowners and have helped them to reduce their dependency on fossil fuels.

5. Reduce Landfills: Another benefit of this energy is that it can take waste that is harmful to the environment and turn it into something useful. For instance, garbage as landfill can, at least partially, be burned to create useable biomass energy.

6. Can be used to Create Different Products: Biomass energy is also versatile, as different forms of organic matter can be used to create different products. Ethanol and similar fuels can be made from corn and other crops. With so many living things on the planet, there is no limit to how many ways it can be found and used.

Biomass energy power plant

Disadvantages of Biomass Energy

Besides above advantages, there are also some downsides to it. Let's see below some of its disadvantages.

1. Expensive: Firstly, its expensive. Living things are expensive to care for, feed, and house, and all of that has to be considered when trying to use waste products from animals for fuel.

2. Inefficient as Compared to Fossil Fuels: Secondly, and connected to the first, is the relative inefficiency of biomass energy. Ethanol, as a biodiesel is terribly inefficient when compared to gasoline, and it often has to be mixed with some gasoline to make it work properly anyway. On top of that, ethanol is harmful to combustion engines over long term use.

3. Harmful to Environment: Thirdly, using animal and human waste to power engines may save on carbon dioxide emissions, but it increases methane gases, which are also harmful to the Earth's— ozone layer. So really, we are no better off environmentally for using one or the other. And speaking of using waste products, there is the smell to consider. While it is not physically harmful, it is definitely unpleasant, and it can attract unwanted pests (rats, flies) and spread bacteria and infection.

4. Consume More Fuel: Finally, using trees and tree products to power machines is inefficient as well. Not only does it take a lot more fuel to do the same job as using conventional fuels, but it also creates environmental problems of its own. To amass enough lumber to power a nation full of vehicles or even a power plant, companies would have to clear considerable

forest area. This results in major topological changes and destroys the homes of countless animals and plants.

5. Require More Land: Combustion of biomass products require some land where they can easily be burnt. Since, it produces gases like methane in atmosphere; therefore it can be produced in those areas which are quite far from residential homes.

Wind – Energy

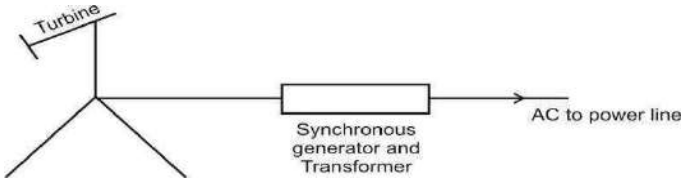


Fig. 1.3 (A): Wind Power Direct Feed to Main Power line

Wind result from air in motion due to pressure gradient. Wind is basically caused by the solar energy irradiating the earth. This is why wind utilization is considered a part of solar technology.

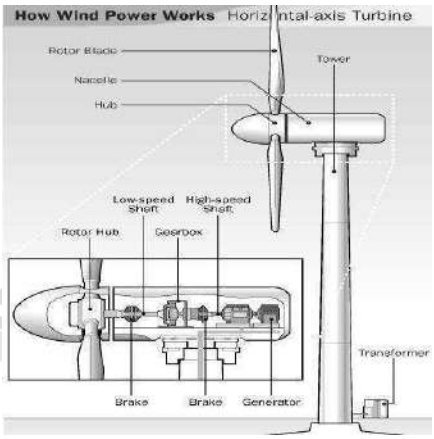


Fig. 1.3 (B): Wind Power Direct Feed to Main Power line

Energy of wind can be economically used for the generation of electrical energy.
Winds are caused from two main factors:

1) **Heating and cooling of the atmosphere which generates convection currents.**
   Heating is caused by the absorption of solar energy on the earth's surface and in the atmosphere.
2) **The rotation of the earth with respect to atmosphere and its motion around the sun. Wind mill consists of wind turbine head, transmission and another supporting structure. Wind energy conversion devices like wind turbines are used for converting wind energy into mechanical energy.**
   Wind turbine consists basically of a few sails, vans and blades radiating from a central axis when wind blows against the blades or vans they rotate about the axis. The rotational motion is utilized to perform some useful work. By connecting the wind turbine to an electric generator wind energy can be converted into electric energy. Wind densities upto 10 KW/m^3/day are available. More than 20,000 MW electricity can be generated in India from wind.

Three factors which determine the output from a wind energy converter:

1. **The wind speed.**
2. **The Cross-section of wind swept by rotor.**
3. **Conversion efficiency of the rotor transmission system and generator or pump.**

A. Horizontal axis

B. Vertical axis

Wind power is the use of air flow through wind turbines to mechanically power generators for electric power. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land.[2] The net effects on the environment are far less problematic than those of nonrenewable power sources.

Wind farms consist of many individual wind turbines which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants.[3][4][5]Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.

Wind power gives variable power which is very consistent from year to year but which has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply. As the proportion of wind power in a region increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur. Power management techniques such as having excess capacity, geographically distributed turbines, dispatchable backing sources, sufficient hydroelectric power, exporting and importing power to neighboring areas, or reducing demand when wind production is low, can in many cases overcome these problems. In addition, weather forecasting permits the electric power network to be readied for the predictable variations in production that occur.

Wind turbines mainly are of two types: vertical axis(VAWT) and horizontal axis(HAWT). HAWT are the most common type of wind turbines built across the world. VAWT is a type of wind turbine which have two or three blades and in which the main rotor shaft runs vertically. They are however used less frequently as they are not as effective as HAWT.
The Vertical Axis Wind Turbine (VAWT) is the most popular of the turbines that people are adding to make their home a source of renewable energy. While it is not as commonly used as the Horizontal Axis Wind Turbine, they are great for placement at residential locations and more. Here we will take a look at the VAWT, and fill you in on the pros and the cons as well as other important information that will alleviate stress and headache when you simply want to do your part to keep the environment protected.

Vertical turbines spin on the vertical axis and comes in various shapes sizes and colors. It's movement is similar to a coin spinning on the edge. The main difference between the VAWT and HAWT is the position of blades. In HAWT, blades are on the top, spinning in the air while in VAWT, generator is mounted at the base of the tower and blades are wrapped around the shaft. Vertical Axis Wind Turbines are designed to be economical and practical, as well as quiet and efficient. They are great for use in residential areas whereas the HAWT is best for use at a business location. There are two different styles of vertical wind turbines out there. One is the Savonius rotor, and the second is the Darrieus model. The first model looks like a 55 gallon drum that is been cut in half with the halves placed onto a rotating shaft. The second model is smaller and looks much like an egg beater. Most of the wind turbines being used today are the Savonius models. We will take a look more in- depth at both of these types of turbines available.
A wind turbine secures air into a hub, which them turns into a generator. The air that passes through the blades of the wind turbine is spun into the generator through rotational momentum. The VAWT, as the turbines are oftener shortened, feature the following qualities:

- **Two to three blades with a vertically operating main rotor shaft – the more blades that you have on the unit, the more wind energy it will receive and the more efficiency it will offer**
- **Used less frequently than a horizontal wind turbine**
- **The position of the blades is different in the VAWT. On this model, the base of the tower holds the generator, and the blades then wrap themselves around the shaft. People use the VAWT because they can be placed closer to the ground, which makes them acceptable and effective for use at a residential location.**
- **With the vertical axis wind turbine, the rotor shaft is arranged in a vertical pattern**
- **The VAWT are easier and more affordable to maintain than horizontal units**
- **One complain that some users have with the VAWT is that is creates less wind energy, which may cause a number of different noises to be heart. Turbulent air flow is also a possibility that can shorten the life of the system.**
- **Installation of the VAWT onto the roof will cause the wind speed to double for maximum wind turbulence and wind energy usage.**

Types of Vertical Axis Wind Turbines

there are two different types of VAWTs that you can choose from. While we looked at these types briefly above, now we will take a look at more information about each type and discuss the important factors that you should know. First, let's take a look at the Darrieus wind turbine mode.

Darrieus Wind Turbine

Darrieus Wind Turbine is commonly known as an "Eggbeater" turbine. It was invented by Georges Darrieus in 1931. A Darrieus is a high speed, low torque machine suitable for generating alternating current (AC) electricity. Darrieus generally require manual push therefore some external power source to start turning as the starting torque is very low. Darrieus has two vertically oriented blades revolving around a vertical shaft.

The Darrieus wind turbine offers the following features:

- **These eggbeater shaped turbines are great at efficiency, however, they are not as reliable.**
- **In order to use the Darrieus wind turbine you must have an outside source of power in order to start them**
- **It is in your best interest to choose a wind turbine that has at least three blades.**
- **To support such a wind turbine it is necessary that you have a superstructure which will connect it near the top bearing.**

Savonius Wind Turbine: A Savonius vertical-axis wind turbine is a slow rotating, high torque machine with two or more scoops and are used in high-reliability low-efficiency power turbines. Most wind turbines use lift generated by airfoil-shaped blades to drive a rotor, the Savonius uses drag and therefore cannot rotate faster than the approaching wind speed. Now let's take a look at the second type, which is also the most popular of the two. The Savonius wind turbine is the most popular of the two types. Let's go ahead and look at some of the features these VAWT offer to the homeowner.

- **As a drag type of turbine, these units are less efficient.**
- **When you live in an area that has strong and gusting winds or when you need a unit that self-starts, this is the best type available to you.**
- **This unit is larger than the Darrieus model.**

Savonius vertical axis wind turbine needs to be manually started. The slow speed of Savonius increases cost and produces less efficiency.

Advantages of Vertical Axis Wind Turbines

You might be wondering why you would consider using a VAWT instead of a HAWT. There are actually a number of reasons that this decision is made. Let's take a look at some of the advantages that you can enjoy with this type of wind turbine in use at your home.

- **You can build your wind turbine close to the ground so if you do not have a suitable rooftop for placement, or if you live where there are hills, ridges, etc. that prohibit the flow of air, they work wonderfully for your needs.**
- **Since VAWT are mounted closer to the ground they make maintenance easier, reduce the construction costs, are more bird friendly and does not destroy the wildlife.**
- **You do not need any mechanisms in order to operate the wind turbine**
- **Lower wind startup speed**
- **The main advantage of VAWT is it does not need to be pointed towards the wind to be effective. In other words, they can be used on the sites with high variable wind direction.**
- **You can use the wind turbine where tall structures are not allowed.**
- **VAWT's are quiet, efficient, economical and perfect for residential energy production, especially in urban environments.**
- **They are cost effective when compare to the HAWTs. It is still best to shop around and check prices before making a purchase, however.**
- **Many of the turbines are resistant to many of the different weather elements that you may experience. It is imperative to choose a unit that offers this valuable protection and extra durability when you need it the most.**

Disadvantages of Vertical Axis Wind Turbines

There are also disadvantages that come with the use of this type of wind turbine. While the many advantages are certainly great, it is imperative that you are aware of the disadvantages. Before deciding which type of wind turbine is best for you it is good idea to take a look at both the pros and the cons. What is right for one person may not be right for you, although it is safe to say that a VAWT is great for almost any residential setting.

Let's take a look at some of the disadvantages of using a VAWT:

- **Decreased level of efficiency when compared to the HAWT. The reason for the reduced amount of efficiency is usually due to the drag that occurs within the blades as they rotate.**
- **You are unable to take advantage of the wind speeds that occur at higher levels.**
- **VAWT's are very difficult to erect on towers, which means they are installed on base, such as ground or building.**

Solar energy

Solar panels converts the sun's light in to usable solar energy using N-type and P-type semiconductor material. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. This process of converting light (photons) to electricity (voltage) is

called the photovoltaic (PV) effect. Currently solar panels convert most of the visible light spectrum and about half of the ultraviolet and infrared light spectrum to usable solar energy. Solar energy technologies use the sun's energy and light to provide heat, light, hot water, electricity, and even cooling, for homes, businesses, and industry.
There are a variety of technologies that have been developed to take advantage of solar energy.

Solar Energy Technologies:

a) Solar Water heating.
b) Solar Heating of Building.
c) Solar – Distillation
d) Solar Furnaces
e) Solar Cooking
f) Solar Electric Power Generation (Photovoltaic System)
g) Solar Thermal Power Production.
h) Production of Power through Solar Ponds.

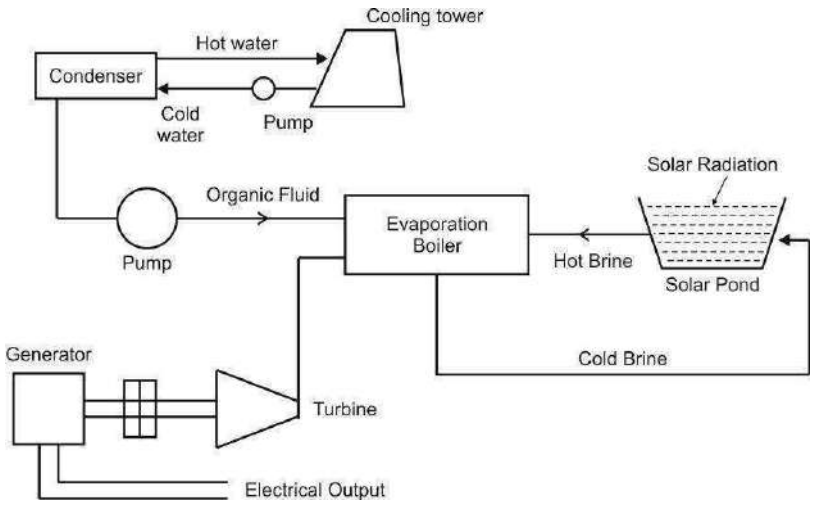


Fig. 1.2 : Solar Pond Electric Power Plant

- India receives 5000 Trillion KW/hr of sun shine in an year. India receives abundant sunshine with about 1648-2108 KWhr/m^2/yr with nearly 250-300 days of useful sunshine in a year. The daily solar energy incidence is between 4 to 7 KWhr/m^2.
- Energy radiated by the sun as electromagnetic waves (Wavelength 0.2 to 0.4 um).
- Due to absorption and scattering in the atmosphere the maximum flux density is 1 KW/sq.m. 45% energy in the form of visible rays and 44% as infra-red radiation.The enormous solar energy resource may be converted into other forms of energy through thermal photovoltaic conversion routes. The solar thermal route uses radiation in the form of heat in turn may be converted to mechanical.

1. Solar Water heating

Solar water heating (SWH) is the conversion of sunlight into heat for water heating using a solar thermal collector. A variety of configurations are available at varying cost to provide solutions in different climates and latitudes. SWHs are widely used for residential and some industrial applications.

A sun-facing collector heats a working fluid that passes into a storage system for later use. SWH are active (pumped) and passive (convection-driven). They use water only, or both water and a working fluid. They are heated directly or via light-concentrating mirrors. They

operate independently or as hybrids with electric or gas heaters. In large-scale installations, mirrors may concentrate sunlight onto a smaller collector.

Active Solar Water Heating Systems

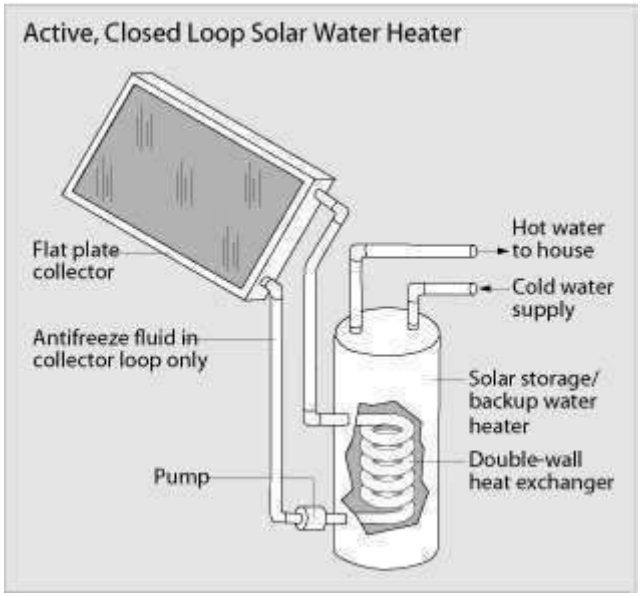
There are two types of active solar water heating systems:

Direct circulation systems

Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.

Indirect circulation systems

Pumps circulate a non-freezing, heat-transfer fluid through the collectors and a heat exchanger. This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.



Active Solar Heating System

Passive Solar Water Heating Systems

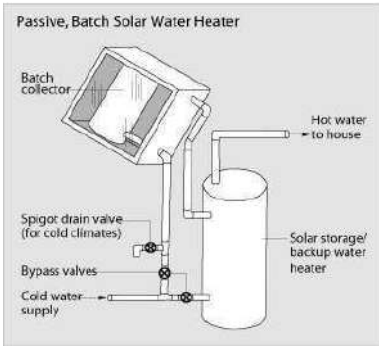
Passive solar water heating systems are typically less expensive than active systems, but they're usually not as efficient. However, passive systems can be more reliable and may last longer. There are two basic types of passive systems:

Integral collector-storage passive systems

These work best in areas where temperatures rarely fall below freezing. They also work well in households with significant daytime and evening hot-water needs.

Thermosyphon systems

Water flows through the system when warm water rises as cooler water sinks. The collector must be installed below the storage tank so that warm water will rise into the tank. These systems are reliable, but contractors must pay careful attention to the roof design because of the heavy storage tank. They are usually more expensive than integral collector-storage passive systems.



Passive Solar Water Heating Systems

Solar space heating systems are an effective and excellent way to reduce costly energy bills during your heating season.

A solar space heater works alongside your current heating system to use the sun's energy to reduce your consumption of oil, propane, or other fossil fuels.

Traditionally used with solar evacuated tube collectors, these systems work to provide free, solar heating for your home throughout your entire heating system. These solar heating systems can also be combined with our solar-ready ultra high efficiency DC-Inverter heat pump chiller.

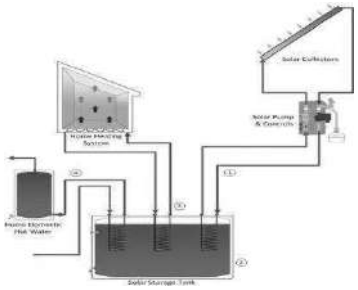
Benefits of Solar Space Heating

The average American family spends over $2,000 a year in heating costs. Heating systems that rely on fossil fuels, such as oil, propane, and natural gas will continue to rise in cost.

By using a solar space heating system, you can take advantage of the sun's free, abundant energy to heat your home for free. Heating your home with a solar heating system can significantly reduce your winter fuel bills. Another excellent benefit is that a solar space heating system also heats domestic hot water.

A solar space heating system will also reduce the amount of air pollution and greenhouse gases that result from your use of fossil fuels such as oil, propane, and other petroleum products.

Solar Heating Tank



Solar space heating and cooling

Many large buildings need ventilated air to maintain indoor air quality. In cold climates, heating this air can use large amounts of energy. A solar ventilation system can preheat the air, saving both energy and money. This type of system typically uses a transpired collector , which consists of a thin, black metal panel mounted on a south-facing wall to absorb the sun's heat. Air passes through the many small holes in the panel. A space behind the perforated wall allows the air streams from the holes to mix together. The heated air is then sucked out from the top of the space into the ventilation system.

Solar process heating systems are designed to provide large quantities of hot water or space heating for nonresidential buildings. A typical system includes solar collectors that work along with a pump, a heat exchanger, and/or one or more large storage tanks. The two main types of solar collectors used - an evacuated-tube collector and a parabolic-trough collector - can operate at high temperatures with high efficiency. An evacuated-tube collector is a shallow box full of many glass, double-walled tubes and reflectors to heat the fluid inside the tubes. A vacuum between the two walls insulates the inner tube, holding in the heat. Parabolic troughs are long, rectangular, curved (U-shaped) mirrors tilted to focus sunlight on a tube, which runs down the center of the trough. This heats the fluid within the tube.

The heat from a solar collector can also be used to cool a building. It may seem impossible to use heat to cool a building, but it makes more sense if you just think of the solar heat as an energy source. Your familiar home air conditioner uses an energy source, electricity, to create cool air. Solar absorption coolers use a similar approach, combined with some very complex chemistry tricks, to create cool air from solar energy. Solar energy can also be used with evaporative coolers (also called "swamp coolers") to extend their usefulness to more humid climates, using another chemistry trick called desiccant cooling.

Wave Energy:

Wave Energy also known as Ocean Wave Energy, is another type of ocean based renewable energy source that uses the power of the waves to generate electricity. Unlike tidal energy which uses the ebb and flow of the tides, wave energy uses the vertical movement of the surface water that produce tidal waves. Wave power converts the periodic up-and-down movement of the oceans waves into electricity by placing equipment on the surface of the oceans that captures the energy produced by the wave movement and converts this mechanical energy into electrical power.

A multipurpose wave regulator system in the form of a long barrier results in the formation of a calm pool between the barrier and shore and this can be used as harbor. Space of aquaculture space for coastal transport with light and faster crafts shore protection against the erosion by sea. It is pollution free.

Waves are generated by wind passing over the surface of the sea. As long as the waves propagate slower than the wind speed just above the waves, there is an energy transfer from the wind to the waves. Both air pressure differences between the upwind and the lee side of a wave crest, as well as friction on the water surface by the wind, making the water to go into the shear stress causes the growth of the waves.[5]

Wave height is determined by wind speed, the duration of time the wind has been blowing, fetch (the distance over which the wind excites the waves) and by the depth and topography of the seafloor (which can focus or disperse the energy of the waves). A given wind speed has a matching practical limit over which time or distance will not produce larger waves. When this limit has been reached the sea is said to be "fully developed".

Wave power devices are generally categorized by the method used to capture the energy of the waves, by location and by the power take-off system. Locations are shoreline, nearshore and offshore. Types of power take-off include: hydraulic ram, elastomeric hose pump, pump-to-shore, hydroelectric turbine, air turbine,[22] and linear electrical generator. When evaluating wave energy as a technology type, it is important to distinguish between the four most common approaches: point absorber buoys, surface attenuators, oscillating water columns, and overtopping devices.

Wave energy is actually a concentrated form of solar power generated by the action of the wind blowing across the surface of the oceans water which can then be used as a renewable source of energy. As the sun rays strike the Earth's atmosphere, they warm it up. Differences

in the temperature of the air masses around the globe causes the air to move from the hotter regions to the cooler regions, resulting in winds.

As the wind passes over the surface of the oceans, a portion of the winds kinetic energy is transferred to the water below, generating waves. In fact, the ocean could be viewed as a vast storage collector of energy transferred by the sun to the oceans, with the waves carrying the transferred kinetic energy across the surface of the oceans. Then we can say that waves are actually a form of energy and it is this energy and not water that moves along the ocean's surface.

These waves can travel (or "propagate") long distances across the open oceans with very little loss in energy, but as they approach the shoreline and the depth of the water becomes shallower, their speed slows down but they increase in size. Finally, the wave crashes onto the shoreline, releasing an enormous amount of kinetic energy which can be used for electricity production. A breaking waves energy potential varies from place to place depending upon its geographic location and time of year, but the two main factors which affect the size of the wave energy are the winds strength and the uninterrupted distance over the sea that the wind can blow.

Then we can say that "Wave Energy" is an indirect form of wind energy that causes movement of the water on the surface of the oceans and by capturing this energy the motion of the waves is converted to mechanical energy and used to drive an electricity generator. In many respects, the technology used for capturing this wave energy is similar to tidal energy or hydroelectric power.

The kinetic energy of the wave turns a turbine attached to a generator, which produces electricity. However, the open oceans can be a stormy and violent environment, resulting in the wave energy machines being destroyed by the very energy they were designed to capture.

In its simplest terms, an ocean wave is the up-and-down vertical movement of the sea water which varies sinusoidally with time. This sinusoidal wave has high points called crests and low points called troughs. The difference in height of a wave between the crest and the trough is called the peak-to-peak amplitude, then the waves amplitude or height is the centre of these two points and corresponds to the actual sea level when there is no movement of the water, in other words, a calm sea.

The amplitude of an ocean wave depends on the weather conditions at that time, as the amplitude of a smooth wave, or swell, will be small in calm weather but much larger in stormy weather with strong gales as the sea water moves up and down.

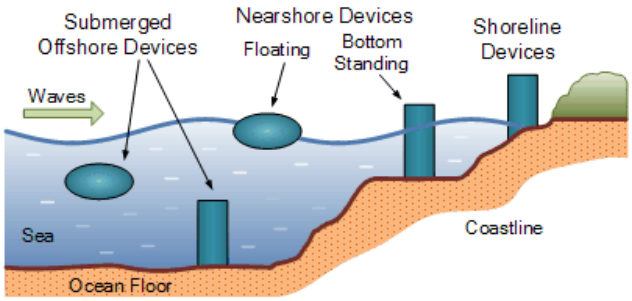
As well as the amplitude of the wave, another important characteristic is the distance between each successive crest, or trough, known as the wave period, (T). This wave period is the time in seconds between each crest of the wave. Then for a gentle swell this time period may be very long, but for a stormy sea this time period may be very short as each wave crashes onto the one in front.

The reciprocal of this time (1/T) gives us the fundamental frequency of the ocean wave relative to some static point. Smaller periodic waves generated or superimposed onto this fundamental wave such as reflected waves are called harmonic waves. Then the frequency and amplitude characteristics of a wind-generated wave depend on the distance the wind blows over the open water (called the fetch), the length of time the wind blows, the speed of the wind and the water depth.

Waves transport energy from where they were created by storms far out in the ocean to a shoreline. But a typical ocean wave does not resemble a perfect sinusoid, they are more irregular and complex than a simple sinusoidal wave. Only the steady up-and-down movement of a heavy swell resembles a sinusoidal wave much more than the chaotic nature of locally generated wind waves, as real sea waves contain a mixture of waves with different frequencies, wave heights and directions.

Wave Power Devices

Ocean wave energy has many advantages over ocean wind energy in that it is more predictable, less variable and offers higher available energy densities. Depending on the distance between the energy conversion device and the shoreline, wave energy systems can be classified as being either Shoreline devices, near shore devices or offshore devices.



Shoreline devices are wave energy devices which are fixed to or embedded in the shoreline, that is they are both in and out of the water. Nearshore devicesare characterised by being used to extract the wave power directly from the breaker zone and the waters immediately beyond the breaker zone, (i.e. at 20m water depth).

Offshore devices or deep water devices are the farthest out to sea and extend beyond the breaker lines utilising the high-energy densities and higher power wave profiles available in the deep water waves and surges.

One of the advantages of offshore devices is that there is no need for significant coastal earthworks, as there is with onshore devices.

As most of the energy within a wave is contained near the surface and falls off sharply with depth. There is a surprising range of designs available that maximise the energy available for capture. These wave energy devices are either fixed bottom standing designs used in shallow water and which pierce the waters surface, or fully floating devices that are used to capture the kinetic energy content of a waves movement and convert each movement into electricity using a generator.

There are currently four basic "capture" methods:

- **Point Absorbers – These are small vertical devices either fixed directly to the ocean floor or tethered via a chain that absorb the waves energy from all directions. These devices generate electricity from the bobbing or pitching action of a floating device. Typical wave energy devices include, floating buoys, floating bags, ducks, and**

articulated rafts, etc. These devices convert the up-and-down pitching motion of the waves into rotary movements, or oscillatory movements in a variety of devices to generate electricity. One of the advantages of floating devices over fixed devices it that they can be deployed in deeper water, where the wave energy is greater.

- Wave Attenuators – also known as "linear absorbers", are long horizontal semi-submerged snake-like devices that are oriented parallel to the direction of the waves. A wave attenuator is composed of a series of cylindrical sections linked together by flexible hinged joints that allow these individual sections to rotate and yaw relative to each other. The wave-induced motion of the device is used to pressurise a hydraulic piston, called a ram, which forces high pressure oil through smoothing accumulators to turn a hydraulic turbine generator producing electricity. Then wave attenuators convert the oscillating movement of a wave into hydraulic pressure.
- Oscillating Water Column – is a partly submerged chamber fixed directly at the shoreline which converts wave energy into air pressure. The structure could be a natural cave with a blow hole or a man made chamber or duct with an wind turbine generator located at the top well above the waters surface. The structure is built perpendicular to the waves so that the ebbing and flowing motion of the waves force the trapped water inside the chamber to oscillate in the vertical direction.
    - As the waves enter and exit the chamber, the water column moves up and down and acts like a piston on the air above the surface of the water, pushing it back and forth. This air is compressed and decompressed by this movement and is channelled through a wind turbine generator to produce electricity. The speed of air in the duct can be enhanced by making the cross-sectional area of the duct much less than that of the column.
    - Overtopping Devices – also known as "spill-over" devices, are either fixed or floating structures that use ramps and tapered sides positioned perpendicular to the waves. The sea waves are driven up the ramp and over the sides filling-up a small tidal reservoir which is located 2 to 3 metres above sea level. The potential energy of the water trapped inside the reservoir is then extracted by returning the water back to the sea through a low head Kaplan turbine generator to produce electricity.

    Then overtopping devices convert the potential energy available in the head of water into mechanical energy. The disadvantage of onshore overtopping schemes is that they have a relatively low power output and are only suitable for sites where there is a deep water shoreline and a low tidal range of less than about a metre.

The idea of harnessing the tremendous power of the oceans waves is not new. Like other forms of hydro power, wave energy does not require the burning of fossil fuels, which can pollute the air, contributing to acid rain and global warming. The energy is entirely clean and endlessly renewable. Wave power has many advantages compared to other forms of renewable energy with its main advantage being that it is predictable.

However, like many other forms of renewable energy, ocean wave energy also has its disadvantages such as its inflexible generation times dependant upon the tides, the visual impact of wave devices on the seas surface, as well as the threat of collision to shipping and navigation.

<u>Wave Energy Advantages</u>

- Wave energy is an abundant and renewable energy resource as the waves are generated by the wind.

- **Pollution free as wave energy generates little or no pollution to the environment compared to other green energies.**
- **Reduces dependency on fossil fuels as wave energy consumes no fossil fuels during operation.**
- **Wave energy is relatively consistent and predictable as waves can be accurately forecast several days in advance.**
- **Wave energy devices are modular and easily sited with additional wave energy devices added as needed.**
- **Dissipates the waves energy protecting the shoreline from coastal erosion.**
- **Presents no barriers or difficulty to migrating fish and aquatic animals.**

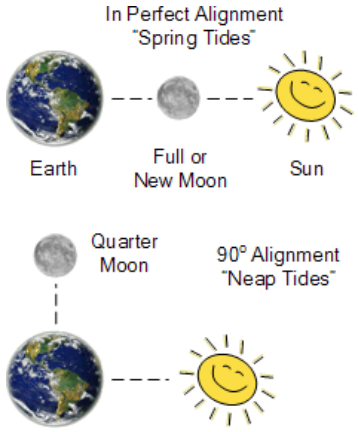
Wave Energy Disadvantages

- **Visual impact of wave energy conversion devices on the shoreline and offshore floating buoys or platforms.**
- **Wave energy conversion devices are location dependent requiring suitable sites were the waves are consistently strong.**
- **Intermittent power generation as the waves come in intervals and does not generate power during calm periods.**
- **Offshore wave energy devices can be a threat to navigation that cannot see or detect them by radar.**
- **High power distribution costs to send the generated power from offshore devices to the land using long underwater cables.**
- **They must be able to withstand forces of nature resulting in high capital, construction and maintenance costs.**

Tidal energy

Tidal Energy or Tidal Power as it is also called, is another form of hydro power that utilises large amounts of energy within the oceans tides to generate electricity. Tidal Energy is an "alternative energy" that can also be classed as a "renewable energy source", as the Earth uses the gravitational forces of both the moon and the sun everyday to move vast quantities of water around the oceans and seas producing tides.

As the Earth, its Moon and the Sun rotate around each other in space, the gravitational movement of the moon and the sun with respect to the earth, causes millions of gallons of water to flow around the Earth's oceans creating periodic shifts in these moving bodies of water. These vertical shifts of water are called "tides".



When the earth and the moons gravity lines up with each other, the influences of these two gravitational forces becomes very strong and causes millions of gallons of water to move or flow towards the shore creating a "high tide" condition. Likewise when the earth and the moons gravity are at 90o to each other, the influences of these two gravitational forces is weaker and the water flows away from the shore as the mass of water moves to another location on the earth, creating a "low tide" condition. This ebbing and flowing of the tides happens twice during each period of rotation of the earth with stronger weekly and annual lunar cycles superimposed onto these tides.

When the moon is in perfect alignment with the earth and the sun, the gravitational pull of the moon and sun together becomes much stronger than normal with the high tides becoming very high and the low tides becoming very low during each tidal cycle. Such tides are known as spring tides (maximum). These spring tides occur during the full or new moon phase.

The other tidal situation arises during neap tides (minimum) when the gravitational pull of the moon and the sun are against each other, thus cancelling their effects. The net result is a smaller pulling action on the sea water creating much smaller differences between the high and low tides thereby producing very weak tides. Neap tides occur during the quarter moon phase. Then spring tides and neap tides produce different amounts of potential energy in the movement of the sea water as their effects differ from the regular high and low sea levels and we can use these tidal changes to produce renewable energy. So we can say that the tides are turning for alternative energy.

So we now know that the constant rotational movement of the earth and the moon with regards to each other causes huge amounts of water to move around the earth as the tides go in and out. These tides are predictable and regular resulting in two high tides and two low tides each day with the level of the oceans constantly moving between a high tide and a low tide, and then back to a high tide again. The time taken for a tidal cycle to happen is about 12 hours and 24 minutes (called the "diurnal cycle") between two consecutive high tides allowing Oceanographers and Meteorologist to accurately predict the ebb and flow of the tides around the oceans many years in advance.

The main big advantage of this is that the tides are therefore perfectly predictable and regular unlike wind energy or solar energy, allowing miles of coastline to be used for tidal energy exploitation and the larger the tidal influence, the greater the movement of the tidal water and therefore the more potential energy that can be harvested for power generation. Therefore Tidal Energy can be considered as a renewable energy source as the oceans

energy is replenished by the sun as well as through tidal influences of the moon and suns gravitational forces.

Tidal Energy Generation

Since the position of the earth and the moon with respect to the sun changes throughout the year, we can utilise the potential energy of the water contained in the daily movement of the rising and falling sea levels to generate electricity. The generation of electricity from tides is similar in many ways to hydro-electric generation we looked at in the hydro energy tutorials. The difference this time is that the water flows in and out of the turbines in both directions instead of in just one forward direction.

Tidal energy, just like hydro energy transforms water in motion into a clean energy. The motion of the tidal water, driven by the pull of gravity, contains large amounts of kinetic energy in the form of strong tidal currents called tidal streams. The daily ebbing and flowing, back and forth of the oceans tides along a coastline and into and out of small inlets, bays or coastal basins, is little different to the water flowing down a river or stream.

The movement of the sea water is harnessed in a similar way using waterwheels and turbines to that used to generate hydro electricity. But because the sea water can flow in both directions in a tidal energy system, it can generate power when the water is flowing in and also when it is ebbing out. Therefore, tidal generators are designed to produce power when the rotor blades are turning in either direction. However, the cost of reversible electrical generators are more expensive than single direction generators.

<u>Different Types of Tidal Energy Systems</u>

1. **Tidal Barrage :- A Tidal Barrage is a type of tidal power generation that involves the construction of a fairly low dam wall, known as a "barrage" and hence its name, across the entrance of a tidal inlet or basin creating a tidal reservoir. This dam has a number of underwater tunnels cut into its width allowing sea water to flow through them in a controllable way using "sluice gates". Fixed within the tunnels are huge water turbine generators that spin as the water rushes past them generating tidal electricity.**

Tidal barrages generate electricity using the difference in the vertical height between the incoming high tides and the outgoing low tides. As the tide ebbs and flows, sea water is allowed to flow in or out of the reservoir through a one way underwater tunnel system. This flow of tidal water back and forth causes the water turbine generators located within the tunnels to rotate producing tidal energy with special generators used to produce electricity on both the incoming and the outgoing tides.

The one disadvantage of Tidal Barrage Generation, is that it can only generate electricity when the tide is actually flowing either "in" or "out" as during high and low tide times the

tidal water is stationary. However, because tides are totally predictable, other power stations can compensate for this stationary period when there is no tidal energy being produced. Another disadvantage of a tidal barrage system, is the environmental and ecological effects that a long concrete dam may have on the estuaries they span.

Tidal Stream:- A Tidal Stream Generation system reduces some of the environmental effects of tidal barrages by using turbine generators beneath the surface of the water. Major tidal flows and ocean currents, like the Gulf Stream, can be exploited to extract its tidal energy using underwater rotors and turbines.

Tidal stream generation is very similar in principal to wind power generation, except this time water currents flow across a turbines rotor blades which rotates the turbine, much like how wind currents turn the blades for wind power turbines. In fact, tidal stream generation areas on the sea bed can look just like underwater wind farms.

Unlike off-shore wind power which can suffer from storms or heavy sea damage, tidal stream turbines operate just below the sea surface or are fixed to the sea bed. Tidal streams are formed by the horizontal fast flowing volumes of water caused by the ebb and flow of the tide as the profile of the sea bed causes the water to speed up as it approaches the shoreline.

As water is much more denser than air and has a much slower flow rate, tidal stream turbines have much smaller diameters and higher tip speed rates compared to an equivalent wind turbine. Tidal stream turbines generate tidal power on both the ebb and flow of the tide. One of the disadvantages of Tidal Stream Generation is that as the turbines are submerged under the surface of the water they can create hazards to navigation and shipping.

Other forms of tidal energy include tidal fences which use individual vertical-axis turbines that are mounted within a fence structure, known as the caisson, which completely blocks a channel and force water through them. Another alternative way of harnessing tidal power is by using an "oscillating tidal turbine". This is basically a fixed wing called a Hydroplane positioned on the sea bed. The hydroplane uses the energy of the tidal stream flowing past it to oscillate its giant wing, similar to a whales flipper, up and down with the movement of the tidal currents. This motion is then used to generate electricity. The angle of the hydroplane to the flow of the tide can be varied to increase efficiency.

Tidal energy is another form of low-head hydro power that is completely carbon neutral like wind and hydro energy. Tidal power has many advantages compared to other forms of renewable energy with its main advantage being that it is predictable. However, like many other forms of renewable energy, tidal energy also has its disadvantages such as its inflexible generation times dependant upon the tides and the fact that it operates in the hostile conditions of the oceans and seas. So here are some of the advantages and disadvantages associated with "tidal energy".

Advantages of Tidal Energy

1. **Tidal energy is a renewable energy resource because the energy it produces is free and clean as no fuel is needed and no waste bi-products are produced.**
2. **Tidal energy has the potential to produce a great deal of free and green energy.**
3. **Tidal energy is not expensive to operate and maintain compared to other forms of renewable energies.**
4. **Low visual impact as the tidal turbines are mainly if not totally submerged beneath the water.**
5. **Low noise pollution as any sound generated is transmitted through the water.**
6. **High predictability as high and low tides can be predicted years in advance, unlike wind.**
7. **Tidal barrages provide protection against flooding and land damage.**
8. **Large tidal reservoirs have multiple uses and can create recreational lakes and areas where before there were none.**

Disadvantages of Tidal Energy

1. **Tidal energy is not always a constant energy source as it depends on the strength and flow of the tides which themselves are effected by the gravitational effects of the moon and the sun.**
2. **Tidal Energy requires a suitable site, where the tides and tidal streams are consistently strong.**
3. **Must be able to withstand forces of nature resulting in high capital, construction and maintenance costs.**
4. **High power distribution costs to send the generated power from the submerged devices to the land using long underwater cables.**
5. **Intermittent power generation, only generates power ten hours a day during the ebb and flow of the tides Changes to estuary ecosystem and an increase in coastal erosion where the tides are concentrated.**
6. **Build up of silt, sediments and pollutants within the tidal barrage from rivers and streams flowing into basin as it is unable to flow out into the sea.**
7. **Danger to fish and other sea-life as they get stuck in the barrage or sucked through the tidal turbine blades.**

Nuclear Power Source

Nuclear energy is used to produce electricity. Heat generated from the splitting of uranium atoms in a process known as fission is used to produce steam. This steam in turn powers turbines, which are used to produce the electricity that supplies the surrounding community. Nuclear power stations are set up in a multiple-step process that has been designed to help contain the energy and many of its negative byproducts. This process alone is the base of several advantages and disadvantages for this energy source.

Nuclear Power Plant

Advantages of Nuclear Energy

Despite potential drawbacks and the controversy that surrounds it, nuclear energy does have a few advantages over some other methods of energy production.

Expense

Less uranium is needed to produce the same amount of energy as coal or oil, which lowers the cost of producing the same amount of energy. Uranium is also less expensive to procure and transport, which further lowers the cost.

Reliability

When a nuclear power plant is functioning properly, it can run uninterrupted for up to 540 days. This results in fewer brownouts or other power interruptions. The running of the plant is also not contingent of weather or foreign suppliers, which makes it more stable than other forms of energy.

No Greenhouse Gases

While nuclear energy does have some emissions, the plant itself does not give off greenhouse gasses. Studies have shown that what life-cycle emissions that the plants do give off are on par with renewable energy sources such as wind power. This lack of greenhouse gases can be very attractive to some consumers.

Disadvantages of Nuclear Energy

One of the reasons that nuclear energy falls under fire so frequently is due to the many disadvantages it brings.

Raw Material

Uranium is used in the process of fission because it's a naturally unstable element. This means that special precautions must be taken during the mining, transporting and storing of the uranium, as well as the storing of any waste product to prevent it from giving off harmful levels of radiation.

Water Pollutant

Nuclear fission chambers are cooled by water. This water is then turned into steam, which is used to power the turbines. When the water cools enough to change back into liquid form, it is pumped outside into nearby wetlands. While measures are taken to ensure that no radiation is being pumped into the environment, other heavy metals and pollutants can make their way out of the chamber. The immense heat given off by this water can also be damaging to eco systems located nearby the reactor.

Waste

When the uranium has finished splitting, the resulting radioactive byproducts need to be removed. While recycling efforts of this waste product have been undertaken in recent years, the storage of the by-product could lead to contamination through leaks or containment failures.

Shutdown Reactors

There have been several nuclear reactors that have failed and been shutdown that are still in existence. These abandoned reactors are taking up valuable land space, could be contaminating the areas surrounding them, and yet are often too unstable to be removed.

A non-renewable resource is a resource of economic value that cannot be readily replaced by natural means on a level equal to its consumption. Most fossil fuels, such as oil, natural gas and coal are considered nonrenewable resources in that their use is not sustainable because their formation takes billions of years.

Earth minerals and metal ores are examples of non-renewable resources. The metals themselves are present in vast amounts in Earth's crust, and their extraction by humans only occurs where they are concentrated by natural geological processes (such as heat, pressure, organic activity, weathering and other processes) enough to become economically viable to extract. These processes generally take from tens of thousands to millions of years, through plate tectonics, tectonic subsidence and crustal recycling.

Natural resources such as coal, petroleum (crude oil) and natural gas take thousands of years to form naturally and cannot be replaced as fast as they are being consumed. Eventually it is considered that fossil-based resources will become too costly to harvest and humanity will need to shift its reliance to other sources of energy such as solar or wind power, see renewable energy.

Energy sources that are almost always classified as non-renewable:

a. **Fossil fuels**
b. **Coal**
c. **Petroleum**
d. **Natural gas**
e. **Fossil fuel**

Fossil fuels are fuels formed by natural resources such as anaerobic decomposition of buried dead organisms. The age of the organisms and their resulting fossil fuels is typically millions of years and sometimes exceeds 650 million years. The fossil fuels, which contain high percentages of carbon, include coal, petroleum, and natural gas. Fossil fuels range from volatile materials with low carbon: hydrogen ratios like methane, to liquid petroleum to nonvolatile materials composed of almost pure carbon, like anthracite coal. Methane can be found in hydrocarbon fields, alone associated with oil, or in the form of methane catharses. It is generally accepted that they formed from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust over millions of years.

Coal: Coal is a combustible black or brownish-black sedimentary rock normally occurring in rock star forms, such as anthracite coal, can be regarded as metamorphic rock because of later exposure to elevated temperature and pressure. Coal is composed primarily of carbon along with variable quantities of other elements, chiefly sulfur, hydrogen, oxygen and nitrogen. Coal begins as layers of plant matter accumulate at the bottom of a body of water. For the process to continue the plant matter must be protected from biodegradation and oxidization, usually by mud or acidic water. The wide shallow seas of the Carboniferous period provided such conditions. This trapped atmospheric carbon in the ground in immense peat bogs that eventually were covered over and deeply buried by sediments under which they metamorphosed into coal. Over time, the chemical and physical properties of the plant remains (believed to mainly have been fern-like species antedating more modern plant and tree species) were changed by geological action to create a solid material.

Petroleum: Petroleum {L. petroleum, from Greek: petra (rock)+ Latin: oleum (oil)} or crude oil is a naturally occurring, flammable liquid consisting of a complex mixtureof

hydrocarbons of various molecular weights and other liquid organic compounds, that are found in geologic formations beneath the Earth's surface. Petroleum is recovered mostly through oil drilling. It is refined and separated, most easily by boiling point, into a large number of consumer products, from gasoline and kerosene to asphalt and chemical reagents used to make plastics and pharmaceuticals. The term petroleum was first used in the treatise De Natura Fossilium, published in 1546 by the German mineralogist Georg Bauer, also known as Georgius Agricola. In the 19th Century, the term petroleum was frequently used to refer to mineral oils produced by distillation from mined organic solids such as cannel coal (and later oil shale) and refined oils produced from them; in the United Kingdom storage (and later transport) of these oils were regulated by a series of Petroleum Acts, from the Petroleum Act 1862 c. 66 onward.

Natural gas: Natural gas is a gas consisting primarily of methane, typically with 0-20% higher hydrocarbons (primarily ethane). It is found associated with other fossil fuels, in coal beds, as methane clathrates, and is an important fuel source and a major feedstock for fertilizers. Most natural gas is created by two mechanisms: biogenic and thermo genic. Biogenic gas is created by methanogen organisms in marshes, bogs, landfills, and shallow sediments. Deeper in the earth, at greater temperature and pressure, thermo genic gas is created from buried organic material. Before natural gas can be used as a fuel, it must undergo processing to remove almost all materials other than methane. The by-products of that processing include ethane, propane, butanes, pentanes, and higher molecular weight hydrocarbons, elemental sulfur, carbon dioxide, water vapour and sometimes helium and nitrogen.

Indian Scenario

India is one of the countries where the present level of energy consumption, by world standards, is very low. The estimate of annual energy consumption in India is about 330 Million Tones Oil Equivalent (MTOE) for the year 2004. Accordingly, the per capita consumption of energy is about 305 Kilogram Oil Equivalent (KGOE). As compared to this, the energy consumption in some of the other countries is of the order of over 4050 for Japan, over 4275 for South Korea, about 1200 for China, about 7850 for USA, about 4670 for OECD countries and the world average is about 1690.

In so far as electricity consumption is concerned, India has reached a level of about 600-kilowatt hour (kwh) per head per year. The comparable figures for Japan are about 7,800, for South Korea about 7,000, for China about 1380, for USA about 13,000, for OECD countries about 8050 and world average are about 2430. Thus, both in terms of per capita energy consumption and in terms of per capita electricity consumption, India is far behind many countries, and as a matter of fact, behind even the world average. Therefore, to improve the standards of living of Indian people and to let them enjoy the benefit of economic development, it is imperative that both energy consumption and electricity consumption level is enhanced. India is targeting a growth rate of 9 – 10%, having already reached a level of almost 8%. To sustain the double-digit growth rate for next 10-15 years, it would be essential that the level of energy availability and consumption, and electricity consumption in particular, is enhanced substantially.In the profile of energy sources in India, coal has a dominant position. Coal constitutes about 51% of India‘s primary energy resources followed by Oil (36%), Natural Gas (9%), Nuclear (2%) and Hydro (2%). To address the issue concerning energy consumption, and more particularly, the need for enhancing the energy supply, India has accorded appropriate priority to both - supply side management and demand side management.

Non-Conventional Energy Sources

	Potential (MW)	Existing capacity (MW)
Wind	45,000	1,460

Indian Government has accorded very high priority to develop and expand installed capacity base through non-conventional sources of electricity generation. There is a separate Ministry in the Government of India to exclusively focus on this important area of power generation. National Electricity Policy notified in 2005 in pursuance of the Electricity Act, 2003, prescribes that State Electricity Regulatory Commissions should prescribe a proportion of power which should be produced and supplied to the grid through the non-conventional sources. Some of the Regulatory Commissions have come out with specific policy guidelines with a different approach on tariff for these plants in order to encourage these technologies and plants. National Electricity Tariff Policy mandates that State Commissions should fix such minimum percentage latest by April, 2006. India has very high potential for these capacities:

It may be seen from the above that India has achieved substantial success on wind turbine based power generation. Ministry of Non-conventional Energy Sources (MNES) has set a target of achieving at least 10,000 MW capacity through various non-conventional sources, by the year 2012.

Conventional Sources of Electricity Generation

Fossil fuel based thermal power, hydro-electric, and nuclear constitute the conventional sources of power. Non-conventional sources are less than 5% of total installed capacity in India. The present installed capacity (as in March 2006) is about 1,25,000 MW, consisting of coal based plants (56%), gas based plants (10%), hydro-electric (26%), nuclear (3%) non-conventional (5%).

Indian Power Sector was opened up for private power generation in 1991. In terms of ownership structure, the profile consists of Central Government owned companies (32%), State Government owned companies/Electricity Boards (57%) and Private Sector (11%). 100% FDI is permitted in all segments of electricity industry – viz. Generation, Transmission, Distribution, Trading.

In the last three years far-reaching structural changes have been introduced in the Indian Electricity Sector. Electricity Act 2003 is an historic legislative initiative with powerful potential to transform the power sector industry and market structure.

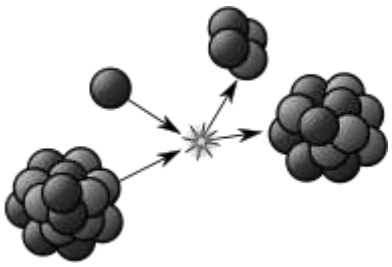
Most important features of the Electricity Act 2003 are as follows:

5. **The Act creates a liberal and transparent framework for power development**
6. **It facilitates investment by creating competitive environment and reforming distribution segment of power industry.**
7. **Entry Barriers have been removed/reduced in following areas:**
   - **e) Delicensed generation.**
   - **f) Freedom to captive generation including group captive**
   - **g) Recognizing trading as an independent activity**
   - **h) Open access in transmission facilitating multi buyer and seller model.**
   7. **Open access to consumers above 1 MW within five years commencing from 27th January, 2004 (date of enforcement of amendment to Electricity Act) Regulators have been mandated to ensure this.**
   8. **Multiple licenses in distribution in the same area of supply so that competition could yield better services to consumers.**
   9. **Regulatory Commissions – to develop market and to fix tariff.**

Nuclear energy: Nuclear power is the use of nuclear reactions that release nuclear energy to generate heat, which most frequently is then used in steam turbines to produce electricity in a nuclear power plant. The term includes nuclear fission, nuclear decay and nuclear fusion. Presently, the nuclear fission of elements in the actinide series of the periodic table produce the vast majority of nuclear energy in the direct service of humankind, with nuclear decay processes, primarily in the form of geothermal energy, and radioisotope thermoelectric generators, in niche uses making up the rest.

Nuclear Fusion is a reaction in which two or more atomic nuclei come close enough to form one or more different atomic nuclei and subatomic particles (neutrons or protons). The difference in mass between the products and reactants is manifested as the release of large amounts of energy. This difference in mass arises due to the difference in atomic "binding energy" between the atomic nuclei before and after the reaction. Fusion is the process that powers active or "main sequence" stars, or other high magnitude stars.

The fusion process that produces a nucleus lighter than iron-56 or nickel-62 will generally yield a net energy release. These elements have the smallest mass per nucleon and the largest binding energy per nucleon, respectively. Fusion of light elements toward these releases energy (an exothermic process), while a fusion producing nuclei heavier than these elements, will result in energy retained by the resulting nucleons, and the resulting reaction is endothermic. The opposite is true for the reverse process, nuclear fission. This means that the lighter elements, such as hydrogen and helium, are in general more fusible; while the heavier elements, such as uranium and plutonium, are more fissionable. The extreme astrophysical event of a supernova can produce enough energy to fuse nuclei into elements heavier than iron.



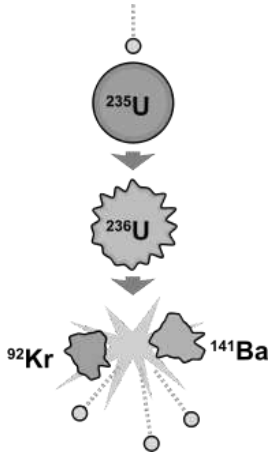
Process of Nuclear Fission

Nuclear Fission is either a nuclear reaction or a radioactive decay process in which the nucleus of an atom splits into smaller parts (lighter nuclei). The fission process often produces free neutrons and gamma photons, and releases a very large amount of energy even by the energetic standards of radioactive decay.

Nuclear fission of heavy elements was discovered on December 17, 1938 by German Otto Hahn and his assistant Fritz Stresemann, and explained theoretically in January 1939 by Lise Meitner and her nephew Otto Robert Frisch. Frisch named the process by analogy with biological fission of living cells. It is an exothermic reaction which can release large amounts of energy both as electromagnetic radiation and as kinetic energy of the fragments (heating the bulk material where fission takes place). In order for fission to produce energy, the total binding energy of the resulting elements must be less negative (higher energy) than that of the starting element.

Fission is a form of nuclear transmutation because the resulting fragments are not the same element as the original atom. The two nuclei produced are most often of comparable but slightly different sizes, typically with a mass ratio of products of about 3 to 2, for

common fissile isotopes. Most fissions are binary fissions (producing two charged fragments), but occasionally (2 to 4 times per 1000 events), three positively charged fragments are produced, in a ternary fission. The smallest of these fragments in ternary processes ranges in size from a proton to an argon nucleus.



Process of Nuclear Fusion

REACTORS

All nuclear reactors are devices designed to maintain a chain reaction producing a steady flow of neutrons generated by the fission of heavy nuclei. They are, however, differentiated either by their purpose or by their design features. In terms of purpose, they are either research reactors or power reactors.

TYPES OF REACTORS

including some where no nuclear power reactors are operated. These reactors generate neutrons for multiple purposes, including producing radiopharmaceuticals for medical diagnosis and therapy, testing materials and conducting basic research.

Power reactors are usually found in nuclear power plants. Dedicated to generating heat mainly for electricity production, they are operated in more than 30 countries (see Nuclear Power Reactors). Their lesser uses are drinking water or district water production. In the form of smaller units, they also power ships.

Differentiating nuclear reactors according to their design features is especially pertinent when referring to nuclear power reactors (see Types of Nuclear Power Reactors).

Nuclear Power Reactors

There are many different types of power reactors. What is common to them all is that they produce thermal energy that can be used for its own sake or converted into mechanical energy and ultimately, in the vast majority of cases, into electrical energy.

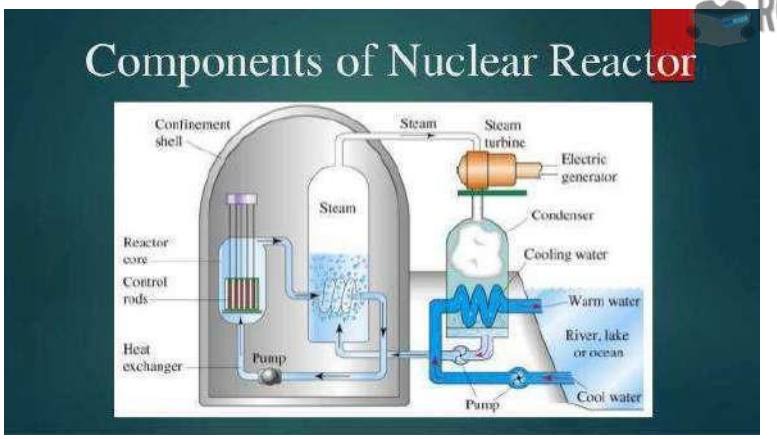
In these reactors, the fission of heavy atomic nuclei, the most common of which is uranium-235, produces heat that is transferred to a fluid which acts as a coolant. During the fission process, bond energy is released and this first becomes noticeable as the kinetic energy of the fission products generated and that of the neutrons being released. Since these particles undergo intense deceleration in the solid nuclear fuel, the kinetic energy turns into heat energy.

In the case of reactors designed to generate electricity, to which the explanations below will now be restricted, the heated fluid can be gas, water or a liquid metal. The heat stored by the fluid is then used either directly (in the case of gas) or indirectly (in the case of water and liquid metals) to generate steam. The heated gas or the steam is then fed into a turbine driving an alternator.

Components of a nuclear reactor

There are several components common to most types of reactors:

1. **Fuel. Uranium is the basic fuel. Usually pellets of uranium oxide (UO_2) are arranged in tubes to form fuel rods. The rods are arranged into fuel assemblies in the reactor core.* In a 1000 MWe class PWR there might be 51,000 fuel rods with over 18 million pellets.**
2. **Moderator. Material in the core which slows down the neutrons released from fission so that they cause more fission. It is usually water, but may be heavy water or graphite.**
3. **Control rods. These are made with neutron-absorbing material such as cadmium, hafnium or boron, and are inserted or withdrawn from the core to control the rate of reaction, or to halt it. In some PWR reactors, special control rods are used to enable the core to sustain a low level of power efficiently. (Secondary control systems involve other neutron absorbers, usually boron in the coolant – its concentration can be adjusted over time as the fuel burns up.) PWR control rods are inserted from the top, BWR cruciform blades from the bottom of the core.**
4. **Coolant. A fluid circulating through the core so as to transfer the heat from it. In light water reactors the water moderator functions also as primary coolant. Except in BWRs, there is secondary coolant circuit where the water becomes steam.**
5. **Pressure vessel or pressure tubes. Usually a robust steel vessel containing the reactor core and moderator/coolant, but it may be a series of tubes holding the fuel and conveying the coolant through the surrounding moderator.**
6. **Steam generator. Part of the cooling system of pressurised water reactors (PWR & PHWR) where the high-pressure primary coolant bringing heat from the reactor is used to make steam for the turbine, in a secondary circuit. Essentially a heat exchanger like a motor car radiator.* Reactors have up to six 'loops', each with a steam generator.**
7. **Containment. The structure around the reactor and associated steam generators which is designed to protect it from outside intrusion and to protect those outside from the effects of radiation in case of any serious malfunction inside. It is typically a metre-thick concrete and steel structure.**



Types of Nuclear Power Reactors

Nuclear power reactors can be classified according to the type of fuel they use to generate heat.

Uranium–fuelled Reactors

The only natural element currently used for nuclear fission in reactors is uranium. Natural uranium is a highly energetic substance: one kilogram of it can generate as much energy as 10 tonnes of oil. Naturally occurring uranium comprises, almost entirely, two isotopes: U238 (99.283%) and U235 (0.711%). The former is not fissionable while the latter can be fissioned by thermal (i.e. slow) neutrons. As the neutrons emitted in a fission reaction are fast, reactors using U235 as fuel must have a means of slowing down these neutrons before they escape from the fuel. This function is performed by what is called a moderator, which, in the case of certain reactors simultaneously acts as a coolant. It is common practice to classify power reactors according to the nature of the coolant and the moderator plus, as the need may arise, other design characteristics.

Reactor Type	Coolant	Moderator	Fuel	Comment
Pressurised water reactors (PWR, VVER)	Light water	Light water	Enriched uranium	Steam generated in secondary loop
Boiling water reactors (BWR)	Light water	Light water	Enriched uranium	Steam from boiling water fed to turbine
Pressurised heavy water reactor (PHWR)	Heavy water	Heavy water	Natural uranium	
Gas-cooled reactors (Magnox, AGR, UNGG)	CO2	Graphite	Natural or enriched uranium	
Light water graphite reactors (RBMK)	Press-urised boiling water	Graphite	Enriched uranium	Soviet design

PWRs and BWRs are the most commonly operated reactors in Organization for Economic Cooperation and Development (OECD) countries. VVERs, designed in the former Soviet Union, are based on the same principles as PWRs. They use "light water", i.e. regular water (H2O) as opposed to "heavy water" (deuterium oxide D2O). Moderation provided by light water is not sufficiently effective to permit the use of natural uranium. The fuel must be slightly enriched in U235 to make up for the losses of neutrons occurring during the chain reaction. On the other hand, heavy water is such an effective moderator that the chain reaction can be sustained without having to enrich the uranium. This combination of natural uranium and heavy water is used in PHWRs, which are found in a number of countries, including Canada, Korea, Romania and India.

Graphite-moderated, gas-cooled reactors, formerly operated in France and still operated in Great Britain, are not built any more in spite of some advantages.

RBMK-reactors (pressure-tube boiling-water reactors), which are cooled with light water and moderated with graphite, are now less commonly operated in some former Soviet Union bloc countries. Following the Chernobyl accident (26 April 1986) the construction of this reactor type ceased. The operating period of those units still in operation will be shortened.

Plutonium-fuelled Reactors

Plutonium (Pu) is an artificial element produced in uranium-fuelled reactors as a by-product of the chain reaction. It is one hundred times more energetic than natural uranium; one gram of Pu can generate as much energy as one tonne of oil. As it needs fast neutrons in order to fission, moderating materials must be avoided to sustain the chain reaction in the best conditions. The current Plutonium-fuelled reactors, also called "fast" reactors, use liquid sodium which displays excellent thermal properties without adversely affecting the chain reaction. These types of reactors are in operation in France, Japan and the Commonwealth of Independent States (CIS).

Light Water Reactors

The Light Water Reactors category comprises pressurised water reactors (PWR, VVER) and boiling water reactors (BWR). Both of these use light water and hence enriched uranium. The light water they use combines the functions of moderator and coolant. This water flows through the reactor core, a zone containing a large array of fuel rods where it picks up the heat generated by the fission of the U235 present in the fuel rods. After the coolant has transferred the heat it has collected to a steam turbine, it is sent back to the reactor core, thus flowing in a loop, also called a primary circuit.

In order to transfer high-quality thermal energy to the turbine, it is necessary to reach temperatures of about 300 °C. It is the pressure at which the coolant flows through the reactor core that makes the distinction between PWRs and BWRs.

In PWRs, the pressure imparted to the coolant is sufficiently high to prevent it from boiling. The heat drawn from the fuel is transferred to the water of a secondary circuit through heat exchangers. The water of the secondary circuit is transformed into steam, which is fed into a turbine.

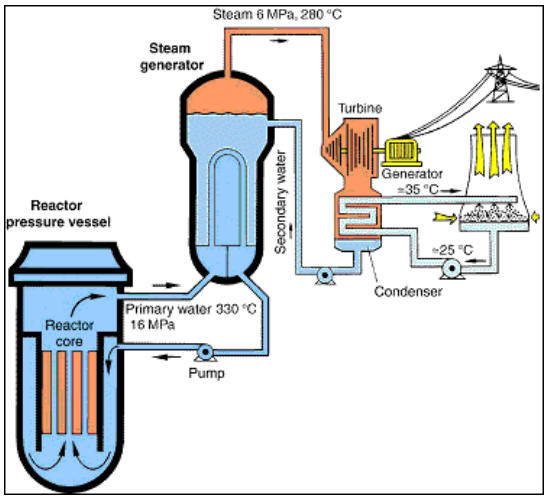
In BWRs, the pressure imparted to the coolant is sufficiently lower than in a PWR to allow it to boil. It is the steam resulting from this process that is fed into the turbine.

This basic difference between pressurised and boiling water dictates many of the design characteristics of the two types of light water reactors, as will be explained below.

Despite their differing designs, it must be noted that the two reactor types provide an equivalent level of safety.

Pressurised Water Reactors

The fission zone (fuel elements) is contained in a reactor pressure vessel under a pressure of 150 to 160 bar (15 to 16 MPa). The primary circuit connects the reactor pressure vessel to heat exchangers. The secondary side of these heat exchangers is at a pressure of about 60 bar (6 MPa) - low enough to allow the secondary water to boil. The heat exchangers are, therefore, actually steam generators. Via the secondary circuit, the steam is routed to a turbine driving an alternator. The steam coming out of the turbine is converted back into water by a condenser after having delivered a large amount of its energy to the turbine. It then returns to the steam generator. As the water driving the turbine (secondary circuit) is physically separated from the water used as reactor coolant (primary circuit), the turbine-alternator set can be housed in a turbine hall outside the reactor building.



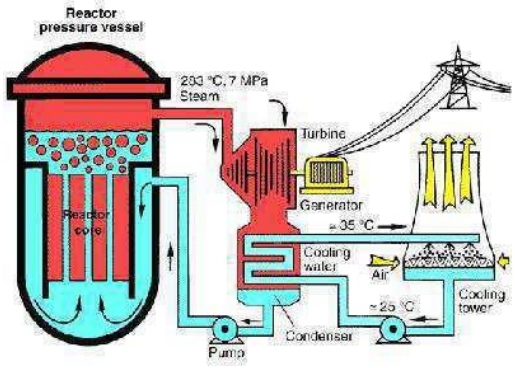
Nuclear power plant with pressurized water reactor

Boiling Water Reactors

The fission zone is contained in a reactor pressure vessel, at a pressure of about 70 bar (7 MPa). At the temperature reached (290 °C approximately), the water starts boiling and the resulting steam is produced directly in the reactor pressure vessel. After the separation of steam and water in the upper part of the reactor pressure vessel, the steam is routed directly to a turbine driving an alternator.

The steam coming out of the turbine is converted back into water by a condenser after having delivered a large amount of its energy to the turbine. It is then fed back into the primary cooling circuit where it absorbs new heat in the fission zone.

Since the steam produced in the fission zone is slightly radioactive, mainly due to short-lived activation products, the turbine is housed in the same reinforced building as the reactor.



Principle of a nuclear power plant with boiling water reactor

Advantages of nuclear power

The generation of electricity through nuclear energy reduces the amount of energy generated from fossil fuels (coal and oil). Less use of fossil fuels means lowering greenhouse gas emissions (CO^2 and others).

Currently, fossil fuels are consumed faster than they are produced, so in the next future these resources may be reduced or the price may increase becoming inaccessible for most of the population.

Another advantage is the required amount of fuel: less fuel offers more energy. It represents a significant save on raw materials but also in transport, handling and extraction of nuclear fuel. The cost of nuclear fuel (overall uranium) is 20% of the cost of energy generated.

The production of electric energy is continuous. A nuclear power plant is generating electricity for almost 90% of annual time. It reduces the price volatility of other fuels such as petrol.

This continuity benefits the electrical planning. Nuclear power does not depends on natural aspects. It's a solutions for the main disadvantage of renewable energy, like solar energy or eolic energy, because the hours of sun or wind does not always coincide with the hours with more energy demand.

It's an alternative to fossil fuels, so the consumption of fuels such as coal or oil is reduced. This reduction of coal and oil consumption benefits the situation of global warming and global climate change. By reducing the consumption of fossil fuels we also improve the quality of the air affecting the disease and quality of life.

Disadvantages of nuclear power

We've previously discussed the advantage of using nuclear energy to reduce fossil fuel consumption. Organizations often use this argument in favor of nuclear energy but it's a partial truth. Much of the consumption of fossil fuels is due to road transport, used in heat engines (cars, trucks, etc.). Savings in fossil fuel for power generation is fairly low.

Despite the high level of sophistication of the safety systems of nuclear power plants the human aspect has always an impact. Facing an unexpected event or managing a nuclear accident we don't have any guarantee that decisions we took are always the best. Two good examples are Chernobyl and Fukushima.

The Chernobyl nuclear accident is, by far, the worst nuclear accident in the history. Different wrong decisions during the management of the nuclear plant caused a big nuclear explosion.

Referring to the Fukushima nuclear accident, the operations done by the staff were highly questionable. Fukushima nuclear accident is the second worst accident in the history.

One of the main disadvantages is the difficulty in the management of nuclear waste. It takes many years to eliminate its radioactivity and risks.

The constructed nuclear reactors have an expiration date. Then, they've to be dismantled, so that main countries producing nuclear energy could maintain a regular number of operating reactors. They've to built about 80 new nuclear reactors during the next ten years.

Nuclear plants have a limited life. The investment for the construction of a nuclear plant is very high and must be recovered as soon as possible, so it raises the cost of electricity generated. In other words, the energy generated is cheap compared to the cost of fuel, but the recovery of its construction is much more expensive.

Nuclear power plants are objectives of terrorist organizations.

Nuclear power plants generate external dependence. Not many countries have uranium mines and not all the countries have nuclear technology, so they have to hire both things overseas.

Current nuclear reactors work by fission nuclear reactions. These chain reactions is generated in case control systems fail, generating continuous reactions causing a radioactive explosion that would be virtually impossible to contain.

Hydrogen energy

Hydrogen can be produced using a number of different processes. Thermochemical processes use heat and chemical reactions to release hydrogen from organic materials such as fossil fuels and biomass. Water (H_2O) can be split into hydrogen (H_2) and oxygen (O_2) using electrolysis or solar energy. Microorganisms such as bacteria and algae can produce hydrogen through biological processes.

THERMOCHEMICAL PROCESSES

Some thermal processes use the energy in various resources, such as natural gas, coal, or biomass, to release hydrogen from their molecular structure. In other processes, heat, in combination with closed-chemical cycles, produces hydrogen from feedstocks such as water. Learn more about the following thermochemical processes:

- Natural gas reforming (also called steam methane reforming or SMR)
- Coal gasification
- Biomass gasification
- Biomass-derived liquid reforming
- Solar thermochemical hydrogen (STCH).

ELECTROLYTIC PROCESSES

Electrolyzers use electricity to split water into hydrogen and oxygen. This technology is well developed and available commercially, and systems that can efficiently use intermittent renewable power are being developed. Learn more about electrolysis.

DIRECT SOLAR WATER SPLITTING PROCESSES

Direct solar water splitting, or photolytic, processes use light energy to split water into hydrogen and oxygen. These processes are currently in the very early stages of research but offer long-term potential for sustainable hydrogen production with low environmental impact. Learn more about the following solar water splitting processes:

- **Photoelectrochemical (PEC)**

In photoelectrochemical (PEC) water splitting, hydrogen is produced from water using sunlight and specialized semiconductors called photoelectrochemical materials, which use light energy to directly dissociate water molecules into hydrogen and oxygen. This is a long-term technology pathway, with the potential for low or no greenhouse gas emissions.

Prodcution

The PEC water splitting process uses semiconductor materials to convert solar energy directly to chemical energy in the form of hydrogen. The semiconductor materials used in the PEC process are similar to those used in photovoltaic solar electricity generation, but for PEC applications the semiconductor is immersed in a water-based electrolyte, where sunlight energizes the water-splitting process.

- **Photobiological**

The photobiological hydrogen production process uses microorganisms and sunlight to turn water, and sometimes organic matter, into hydrogen. This is a longer-term technology pathway in the early stages of research that has a long-term potential for sustainable hydrogen production with low environmental impact.

Prodcution

In photolytic biological systems, microorganisms—such as green microalgae or cyanobacteria—use sunlight to split water into oxygen and hydrogen ions. The hydrogen ions can be combined through direct or indirect routes and released as hydrogen gas. Challenges for this pathway include low rates of hydrogen production and the fact that splitting water also produces oxygen, which quickly inhibits the hydrogen production reaction and can be a safety issue when mixed with hydrogen in certain concentrations. Researchers are working to develop methods to allow the microbes to produce hydrogen for longer periods of time and to increase the rate of hydrogen production.

Some photosynthetic microbes use sunlight as the driver to break down organic matter, releasing hydrogen. This is known as photofermentative hydrogen production. Some of the major challenges of this pathway include a very low hydrogen production rate and low solar-to-hydrogen efficiency, making it a commercially unviable pathway for hydrogen production at this time.

Researchers are looking at ways to make the microbes better at collecting and using energy to make more available for hydrogen production, and to change their normal biological pathways to increase the rate of hydrogen production.

Microbes such as bacteria and microalgae can produce hydrogen through biological reactions, using sunlight or organic matter. These technology pathways are at an early stage of research, but in the long term have the potential for sustainable, low-carbon hydrogen production. Learn more about the following biological processes:

- **Microbial biomass conversion**

Microbial biomass conversion processes take advantage of the ability of microorganisms to consume and digest biomass and release hydrogen. Depending on the pathway, this research could result in commercial-scale systems in the mid- to long-term timeframe that could be suitable for distributed, semi-central, or central hydrogen production scales, depending on the feedstock used.

Prodcution

In fermentation-based systems, microorganisms, such as bacteria, break down organic matter to produce hydrogen. The organic matter can be refined sugars, raw biomass sources such as corn stover, and even wastewater. Because no light is required, these methods are sometimes called "dark fermentation" methods.

In direct hydrogen fermentation, the microbes produce the hydrogen themselves. These microbes can break down complex molecules through many different pathways, and the byproducts of some of the pathways can be combined by enzymes to produce hydrogen. Researchers are studying how to make fermentation systems produce hydrogen faster (improving the rate) and produce more hydrogen from the same amount of organic matter (increasing the yield).

Microbial electrolysis cells (MECs) are devices that harness the energy and protons produced by microbes breaking down organic matter, combined with an additional small electric current, to produce hydrogen. This technology is very new, and researchers are working on improving many aspects of the system, from finding lower-cost materials to identifying the most effective type of microbes to use.

- **Photobiological.**

The photobiological hydrogen production process uses microorganisms and sunlight to turn water, and sometimes organic matter, into hydrogen. This is a longer-term technology pathway in the early stages of research that has a long-term potential for sustainable hydrogen production with low environmental impact.

<u>Hydrogen energy</u>

Advantages of Hydrogen Energy

1. **It's a renewable energy source and bountiful in supply**

Hydrogen is a rich source of energy for many reasons; the main being that it's bountiful in supply. While it may take a lot of resources to harness it, no other energy source is infinite as hydrogen. That, essentially, means there is no possibility of it running out like other sources of energy.

2. **It practically a clean energy source**

When hydrogen is burnt to produce fuel, the byproducts are totally safe, which means, they have no known side effects. Aeronautical companies actually use hydrogen as a source of drinking water. After hydrogen is utilized, it is normally converted to drinking water for astronauts on ship or space stations.

3. **Hydrogen energy is non-toxic**

This means that it does not cause any harm or destruction to human health. This aspect makes it preferred compared to other sources of fuel like nuclear energy, natural gas, which are extremely hazardous or daunting to harness safely. It also allows hydrogen to be used in places where other forms of fuel may not be allowed.

4. **It's far more efficient than other sources of energy**

Hydrogen is solidly efficient energy type since it has the ability to convey a lot of energy for every pound of fuel. This categorically means that an automobile that utilizes hydrogen energy will travel more miles than one with an equal amount of gasoline.

5. **Used for powering space ships**

Hydrogen energy's efficiency and power makes it an ideal fuel source for spaceships. Its power is so high that it's able to quickly rocket spaceships to exploration missions. It's also the safest form of energy to perform such an energy-intensive task. Hydrogen energy is in fact 3 times more potent than gasoline and other fossil-based sources of fuel. This ideally means that you need less hydrogen to complete an enormous task.

It also offers motive power for airplanes, boats, cars, and both portable and stationary fuel cell applications. The downside to using hydrogen in cars is that it's practically difficult to store in cryogenic or high-pressure tanks.

Disadvantages of Hydrogen Energy

While hydrogen energy has a lot of admirable benefits, it's not really the outright preferable, clean and cheap energy source for most governments and companies. In gaseous state, it's quite volatile. While its volatility gives it an edge over energy sources in terms of accomplishing numerous tasks, it equally renders it risky to use and work around. Some of the disadvantages of hydrogen energy include:

1. **Hydrogen energy is expensive**

Electrolysis and steam reforming, the two main processes of hydrogen extraction are extremely expensive. This is the real reason it's not heavily used across the world. Today, hydrogen energy is chiefly used to power most hybrid vehicles. A lot of research and innovation is required to discover cheap and sustainable ways to harness this form of energy. Until then, hydrogen energy would remain exclusively for the rich.

2. **Storage complications**

One of hydrogen properties is that it has a lower density. In fact, it is a lot less denser than gasoline. This means that it has to be compressed to liquid state and stored the same way at lower temperatures to guarantee its effectiveness and efficiency as an energy source. This reason also explains why hydrogen must at all times be stored and transported under high pressure, which is why transportation and common use is far from feasible.

3. **It's not the safest source of energy**

The power of hydrogen should not be underestimated at all. Although gasoline is a little more dangerous than hydrogen, hydrogen is hugely flammable and frequently makes headlines for its potential dangers. Compared to gas, hydrogen lacks smell, which makes any leak detection almost impossible. To detect leaks, one must install sensors.

4. **Tricky to move around**

It's a daunting task to transport hydrogen brilliantly due to its lightness. Oil can be transported safely because it's mostly pushed through pipes. Coal can conveniently be transported in dump trucks. Hydrogen also presents challenges when considering moving it in large quantities, which is why it's mostly only transported in small batches.

5. **Hydrogen energy cannot sustain the population**

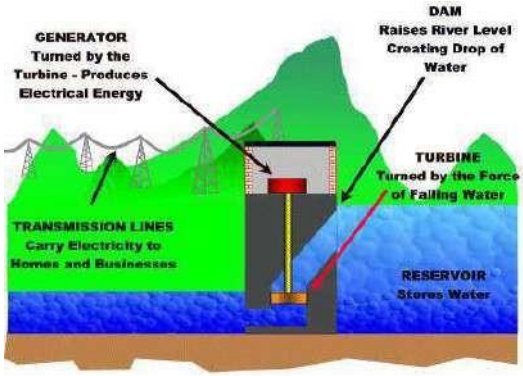
Despite the fact that hydrogen is bountiful in supply, the cost of harnessing it limits extensive utilization. As you realize, it's quite challenging to disrupt the status quo. Energy from fossil fuels still rule the world. There is also no framework put in place to ensure cheap and sustainable hydrogen energy for the normal car owner in the future. Even if hydrogen were to become cheap right now, it would take years to become the most used source of energy since vehicles themselves and service stations would need to be customized to conform to hydrogen requirements. This would require massive capital outlay.

It's a fact that hydrogen energy is a renewable resource because it's abundantly available and its impacts hugely neglected. However, hydrogen companies will, in real sense, need other forms of non-renewable energy such as fossil (coal, natural gas, and oil) to separate it from oxygen. We may be able to minimize over-reliance on fossils fuels when we embrace hydrogen energy, but it will be daunting to get rid of it from the system.

Hydro Power

HYDROPOWER

Hydropower transforms the potential energy of a mass of water flowing in a river or stream with a certain vertical fall (termed the "head") Hydroelectric power is the cheapest source of energy, renewable and environmentally benign during running. The potential annual power generation of a hydropower project is proportional to the head and flow of water.



Elements of hydropower plant

1) Dam

The dam is the most important component of hydroelectric power plant. The dam is built on a large river that has abundant quantity of water throughout the year. It should be built at a location where the height of the river is sufficient to get the maximum possible potential energy from water.

2) Water Reservoir

The water reservoir is the place behind the dam where water is stored. The water in the reservoir is located higher than the rest of the dam structure. The height of water in the reservoir decides how much potential energy the water possesses. The higher the height of water, the more its potential energy. The high position of water in the reservoir also enables it to move downwards effortlessly. The height of water in the reservoir is higher than the natural height of water flowing in the river, so it is considered to have an altered equilibrium.

This also helps to increase the overall potential energy of water, which helps ultimately produce more electricity in the power generation unit.

3) Intake or Control Gates

These are the gates built on the inside of the dam. The water from reservoir is released and controlled through these gates. These are called inlet gates because water enters the power generation unit through these gates. When the control gates are opened the water flows due to gravity through the penstock and towards the turbines. The water flowing through the gates possesses potential as well as kinetic energy.

4) The Penstock

The penstock is the long pipe or the shaft that carries the water flowing from the reservoir towards the power generation unit, comprised of the turbines and generator. The water in the penstock possesses kinetic energy due to its motion and potential energy due to its height. The total amount of power generated in the hydroelectric power plant depends on the height of the water reservoir and the amount of water flowing through the penstock. The amount of water flowing through the penstock is controlled by the control gates.

5) Water Turbines

Water flowing from the penstock is allowed to enter the power generation unit, which houses the turbine and the generator. When water falls on the blades of the turbine the kinetic and potential energy of water is converted into the rotational motion of the blades of the turbine. The rotating blades causes the shaft of the turbine to also rotate. The turbine shaft is enclosed inside the generator. In most hydroelectric power plants there is more than one power generation unit. There is large difference in height between the level of turbine and level of water in the reservoir. This difference in height, also known as the head of water, decides the total amount of power that can be generated in the hydroelectric power plant. There are various types of water turbines such as Kaplan turbine, Francis turbine, Pelton wheels etc. The type of turbine used in the hydroelectric power plant depends on the height of the reservoir, quantity of water and the total power generation capacity.

6) Draft tube:

The draft tube is a part of the reaction turbine. The draft tube is a diverging discharge passage connecting the running with tailrace. It is shaped to decelerate the flow with a minimum loss so that the remaining kinetic energy of the water coming out of the runner is efficiently regained by converting into suction head., thereby increasing the total pressure difference on the runner. This regain of kinetic energy of the water coming out from the reaction turbine is the primary function of the draft tube. The regain of static suction head in case where the runner is located above the tail water level is the secondary purpose of the draft tube.

7) Generators

It is in the generator where the electricity is produced. The shaft of the water turbine rotates in the generator, which produces alternating current in the coils of the generator. It is the rotation of the shaft inside the generator that produces magnetic field which is converted into electricity by electromagnetic field induction. Hence the rotation of the shaft of the turbine is crucial for the production of electricity and this is achieved by the kinetic and

potential energy of water. Thus in hydroelectricity power plants potential energy of water is converted into electricity.

Seafty services

9. **Spillway:**

The function of spillway is to provide safety of the dam. Spillway should have the capacity to discharge major floods without damage to the dam and at the same time keeps the reservoir levels below some predetermined maximum level.Trash Rack:

The water intake from the dam or from the forebay are provided with trash rack. The main function of trash rack is to prevent the entry of any debris which may damage the wicket gates and turbine runners or choke-up the nozzles of impulse turbine. During winter season when water forms ice, to prevent the ice from clinging to the trash racks, they are often heated electrically. Sometimes air bubbling system is provided in the vicinity of the trash racks which brings warmer water to the surface of the trash racks.

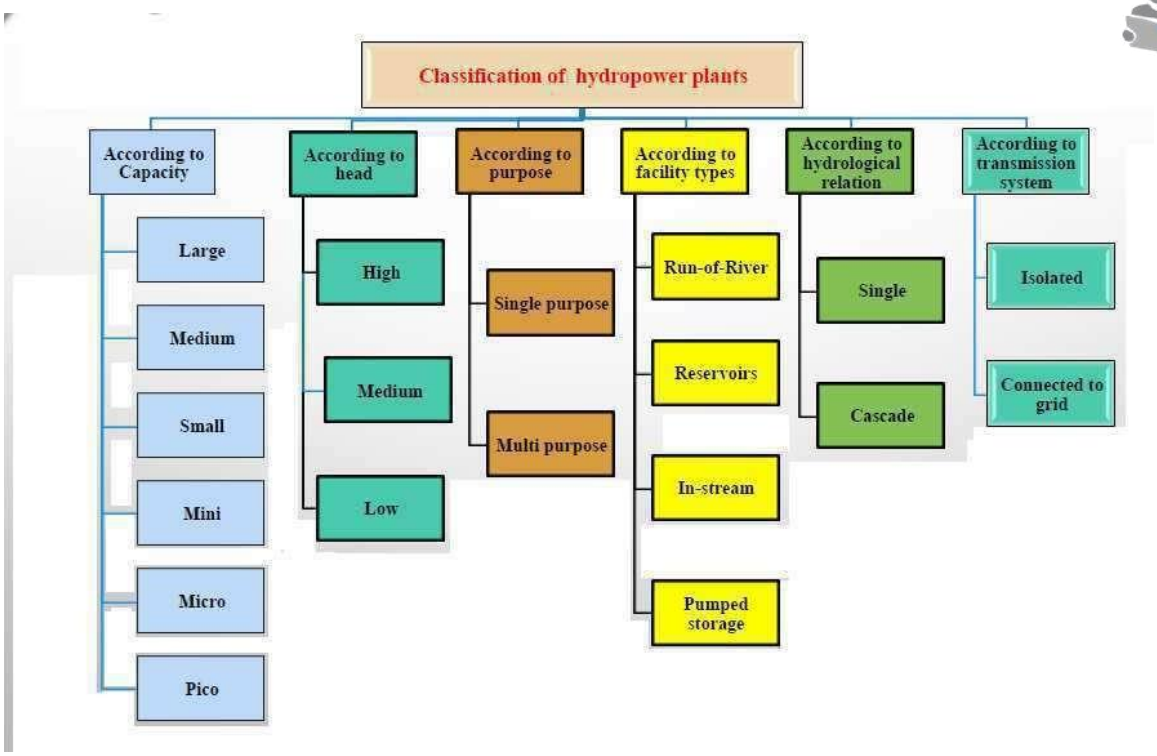
2. **Forebay:**

The function of forebay is to act as regulating reservoir temporarily storing water when the load on the plant is reduced and to provide water for initial increment of an increasing load while water in the canal is being accelerated. In many cases, the canal itself is large enough to absorb the flow variations. In short, forebay is naturally provided for storage of water to absorb any flow variations if exist. This can be considered as naturally provided surge tank as it does the function of the surge tank. The forebay is always provided with some type of outlet structure to direct water to penstock depending upon the local conditions.

3. **Surge Tank:**

The main function of surge tank is to reduce the water hammering effect. When there is a sudden increase of pressure in the penstock which can be due sudden decrease in the load demand on the generator. When there is sudden decrease in the load, the turbine gates admitting water to the turbine closes suddenly owing to the action of the governor. This sudden rise in the pressure in the penstock will cause the positive water hammering effect. This may lead to burst of the penstock because of high pressures. When there is sudden increase in the load, governor valves opens and accepts more water to the turbine. This results in creation of vacuum in the penstock resulting into the negative water hammering effect. Therefore the penstock should have to withstand both positive water hammering effect created due to close of governor valve and negative water hammering effect due to opening of governor valve.In order to protect the penstock from these water hammering effects, surge tank is used in hydroelectric power station. A surge tank is introduced in the system between dam and the power house nearest. Surge tank is a tank provided to absorb any water surges caused in the penstok due to sudden loading and unloading of the generator. When the velocity of the water in the penstock decreases due to closing of turbine valves, the water level in the surge tank increases and fluctuating up and down till its motion is damped out by the friction. Similarly when the water accelerates in the penstock, water is provided by the surge tank for acceleration. Surge tank water level falls down and fluctuates up and down absorbing the surges.

Classification Of Hydropower Plants



Classification according to capacity

LARGE: >100 MW

MEDIUM: 25 – 100 MW

SMALL: 1-25 MW

MINI: 100 KW - 1MW

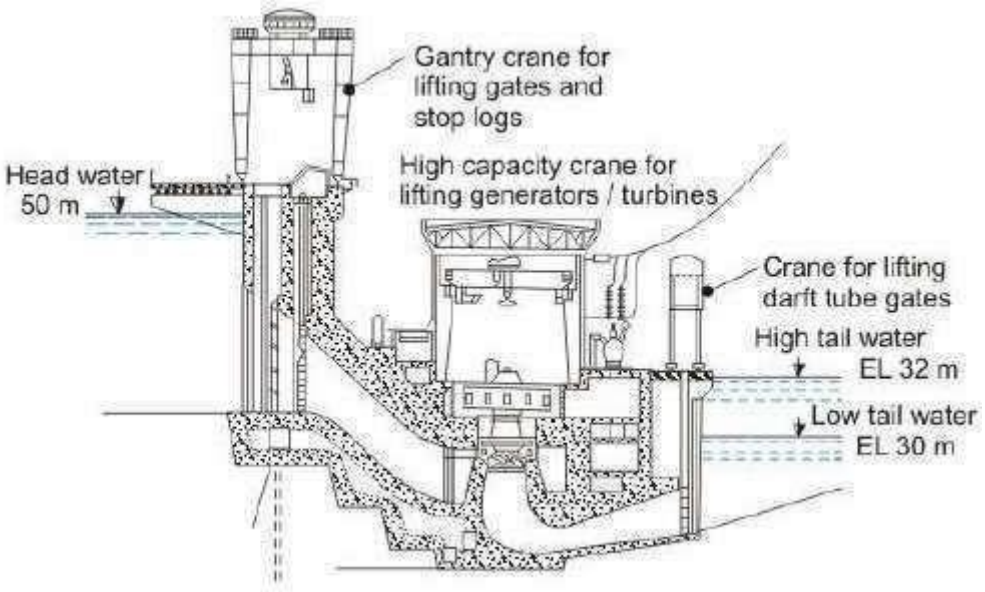
MICRO: 5 – 100 KW

PICO: < 5 KW

Classifcation According To Head

LOW HEAD:

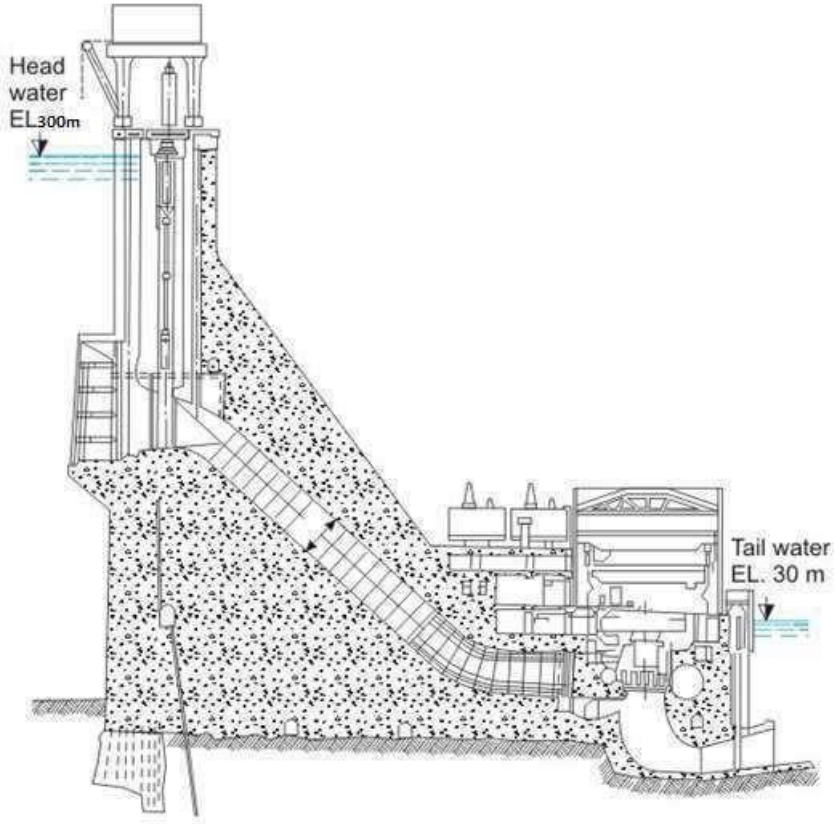
Low head hydro power applications use river current or tidal flows of 30 meters or less to produce energy. These applications do not need to dam or retain water to create hydraulic head, the head is only a few meters. Using the current of a river or the naturally occurring tidal flow to create electricity may provide a renewable energy source that will have a minimal impact on the environment.



Sectional View Of Low Head Hydropower Plant

MEDIUM HEAD:

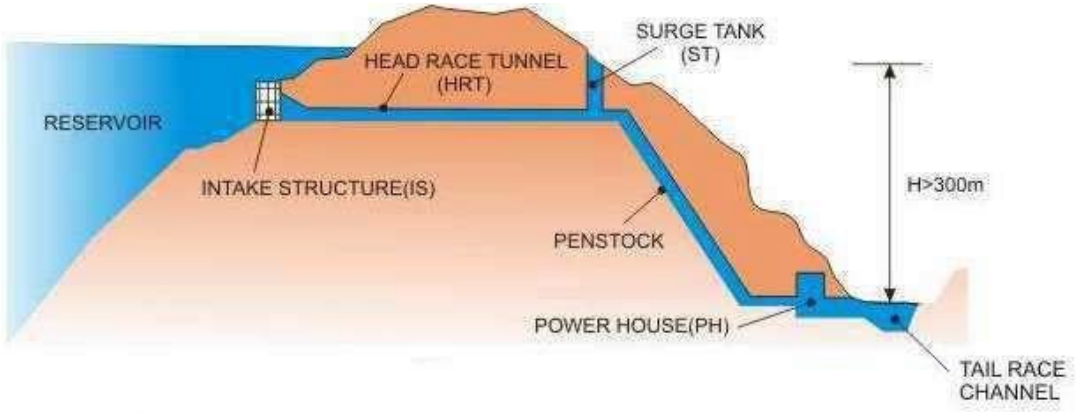
A power station operating under heads from 30m to 300m.



Sectional View Of Medium Head Hydropower Plant

HIGH HEAD:

A power station operating under heads above about 300m. A head of 200m/250m is considered as the limit between medium and high head power stations.

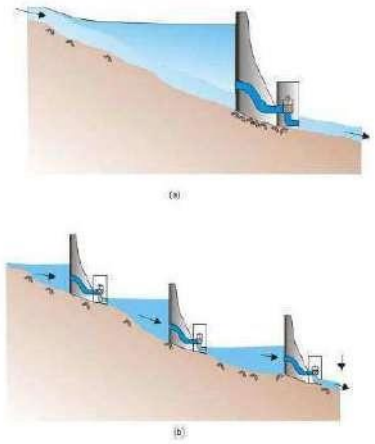


High Head Hydropower Plant

Classification according to hydrological relation

SINGLE STAGE- When the run off from a single hydropower plant is diverted back into river or for any other purpose other than power generation, the setup is known as Single Stage.

CASCADE SYSTEM- When two or more hydropower plants are used in series such that the runoff discharge of one hydro power plant is used as the is a intake discharge of the second hydro power plant such a system is known as CASCADE hydropower plant.



(a) single stage hydropower development scheme

(b) cascade or multistage hydropower system

Classification According To Purpose

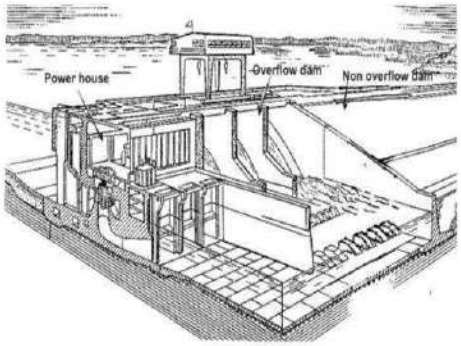
SINGLE PURPOSE: When the whole soul purpose of a project is to produce electricity then such a project is known as a Single Purpose Hydro Power Project.

MULTIPURPOSE : When the water used in hydropower project is to be used for other purposes like irrigation, flood control or fisheries then such a project is known as Multi Purpose Hydro Power Project.

According to facility types

RUN-OF-RIVER TYPE

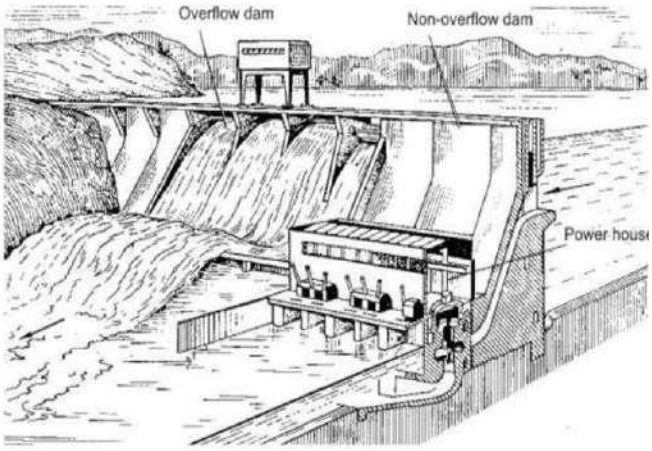
These are hydro power plants that utilize the stream flow as it comes , without any storage being provided.



STORAGE (RESERVOIR) TYPE

Hydropower plants with storage are supplied with water from large storage reservoir that have been developed by constructing dams across rivers.

Assured flow for hydro power generation is more certain for the storage schemes than the run-of-river schemes.

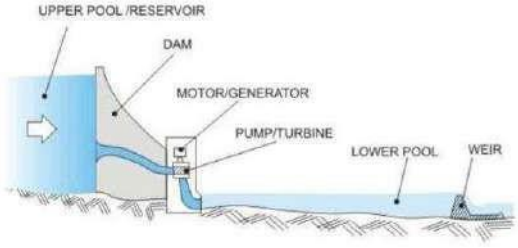


PUMPED STORAGE TYPE

Pumped storage type hydropower plants are those which utilize the flow of water from a reservoir at higher potential to

one at lower potential.

During off-peak hours, the reversible units are supplied with the excess electricity available in the power grid which then pumps part of the water of the tail-water pond back into the head-water pond.



IN-STREAM

When the velocity of water i.e kinetic energy flowing in the stream is used for conversion into electrical power, then the system is known as In- stream.

According to trasmission system

ISOLATED: Whenever a hydropower plant is set up in a remote area in order to meet the local demands then such a hydropower plant is known as Isolated System.

CONNECTED TO GRID: Whenever the hydropower plant is set up to meet the demands of areas which are at a fair distance from the plant, then the transmission of power takes through the grid system. Such a setup is referred to as Connected to grid.

Energy storage or regeneration

Pumped-storage hydroelectricity (PSH), or pumped hydroelectric energy storage (PHES), is a type of hydroelectricenergy storage used by electric power systems for load balancing. The method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation. Low-cost surplus off-peak electric power is typically used to run the pumps. During periods of high electrical demand, the stored water is released through turbines to produce electric power. Although the losses of the pumping process makes the plant a net consumer of energy overall, the system increases revenue by selling more electricity during periods of peak demand, when electricity prices are highest.

Pumped-storage hydroelectricity allows energy from intermittent sources (such as solar, wind) and other renewables, or excess electricity from continuous base-load sources

(such as coal or nuclear) to be saved for periods of higher demand.The reservoirs used with pumped storage are quite small when compared to conventional hydroelectric dams of similar power capacity, and generating periods are often less than half a day.

Pumped storage is the largest-capacity form of grid energy storage available, and, as of 2017, the United States Department of Energy Global Energy Storage Database reports that PSH accounts for over 96% of all active tracked storage installations worldwide, with a total installed nameplate capacity of over 168 GW.[3] The round-trip energy efficiency of PSH varies between 70%–80%, with some sources claiming up to 87%.[8] The main disadvantage of PSH is the specialist nature of the site required, needing both geographical height and water availability. Suitable sites are therefore likely to be in hilly or mountainous regions, and potentially in areas of outstanding natural beauty, and therefore there are also social and ecological issues to overcome. Many recently proposed projects, at least in the U.S., avoid highly sensitive or scenic areas, and some propose to take advantage of "brownfield" locations such as disused mines.

At times of low electrical demand, excess generation capacity is used to pump water into the upper reservoir. When there is higher demand, water is released back into the lower reservoir through a turbine, generating electricity. Reversible turbine/generator assemblies act as a combined pump and turbine generator unit (usually a Francis turbine design).

Types: natural or man-made reservoirs

In open-loop systems, pure pumped-storage plants store water in an upper reservoir with no natural inflows, while pump-back plants utilize a combination of pumped storage and conventional hydroelectric plants with an upper reservoir that is replenished in part by natural inflows from a stream or river. Plants that do not use pumped-storage are referred to as conventional hydroelectric plants; conventional hydroelectric plants that have significant storage capacity may be able to play a similar role in the electrical grid as pumped storage by deferring output until needed.

Economic efficiency

Taking into account evaporation losses from the exposed water surface and conversion losses, energy recovery of 70-80% or more can be regained.[10] This technique is currently the most cost-effective means of storing large amounts of electrical energy, but capital costs and the presence of appropriate geography are critical decision factors in selecting pumped-storage plant sites.

The relatively low energy density of pumped storage systems requires either large flows and/or large differences in height between reservoirs. The only way to store a significant amount of energy is by having a large body of water located relatively near, but as high above as possible, a second body of water. In some places this occurs naturally, in others one or both bodies of water were man-made. Projects in which both reservoirs are artificial and in which no natural inflows are involved with either reservoir are referred to as "closed loop" systems.

These systems may be economical because they flatten out load variations on the power grid, permitting thermal power stations such as coal-fired plants and nuclear power plantsthat provide base-load electricity to continue operating at peak efficiency, while reducing the need for "peaking" power plants that use the same fuels as many base-load thermal plants, gas and oil, but have been designed for flexibility rather than maximal efficiency. Hence pumped storage systems are crucial when coordinating large groups of heterogeneous generators. Capital costs for pumped-storage plants are relatively high, although this is

somewhat mitigated by their long service life of up to 75 years or more, which is three to five times longer than utility-scale batteries.

Station	Country	Location	Capacity (MW)	Refs
Bath County Pumped Storage Station	United States	38°12'32"N 79°48'00"W	3,003	[25]
Guangdong Pumped Storage Power Station	China	23°45'52"N 113°57'12"E	2,400	[26][27]
Huizhou Pumped Storage Power Station	China	23°16'07"N 114°18'50"E	2,400	[28][29][30][31]
Okutataragi Pumped Storage Power Station	Japan	35°14'13"N 134°49'55"E	1,932	[32]
Ludington Pumped Storage Power Plant	United States	43°53'37"N 86°26'43"W	1,872	[33][34]

Potential technologies

Seawater

Pumped storage plants can operate with seawater, although there are additional challenges compared to using fresh water. In 1999, the 30 MW Yanbaru project in Okinawa was the first demonstration of seawater pumped storage. It has since been decommissioned. A 300 MW seawater-based Lanai Pumped Storage Project was considered for Lanai, Hawaii, and seawater-based projects have been proposed in Ireland. A pair of proposed projects in the Atacama Desert in northern Chile would use 600 MW of photovoltaic solar (Skies of Tarapacá) together with 300 MW of pumped storage (Mirror of Tarapacá) raising seawater 600 metres (2,000 ft) up a coastal cliff.

Underground reservoirs

The use of underground reservoirs has been investigated. Recent examples include the proposed Summit project in Norton, Ohio, the proposed Maysville project in Kentucky(underground limestone mine), and the Mount Hope project in New Jersey, which was to have used a former iron mine as the lower reservoir. The proposed energy storage at the Callio site in Pyhäjärvi (Finland) would utilize the deepest base metal mine in Europe, with 1,450 metres (4,760 ft) elevation difference. Several new underground pumped storage projects have been proposed. Cost-per-kilowatt estimates for these projects can be lower than for surface projects if they use existing underground mine space. There are limited

opportunities involving suitable underground space, but the number of underground pumped storage opportunities may increase if abandoned coal mines prove suitable.

Decentralised systems

Small pumped-storage hydropower plants can be built on streams and within infrastructures, such as drinking water networks and artificial snow making infrastructures. Such plants provide distributed energy storage and distributed flexible electricity production and can contribute to the decentralized integration of intermittent renewable energy technologies, such as wind power and solar power. Reservoirs that can be used for small pumped-storage hydropower plants could include natural or artificial lakes, reservoirs within other structures such as irrigation, or unused portions of mines or underground military installations. In Switzerland one study suggested that the total installed capacity of small pumped-storage hydropower plants in 2011 could be increased by 3 to 9 times by providing adequate policy instruments.

Underwater reservoirs

In March 2017 the research project St. EnSea (Storing Energy at Sea) announced their successful completion of a four-week test of a pumped storage underwater reservoir. In this configuration a hollow sphere submerged and anchored at great depth acts as the lower reservoir, while the upper reservoir is the enclosing body of water. Electricity is created when water is let in via a reversible turbine integrated into the sphere. During off-peak hours the turbine changes direction and pumps the water out again, using "surplus" electricity from the grid. The quantity of power created when water is let in grows proportionally to the height of the column of water above the sphere, in other words: the deeper the sphere is located the more potential energy it can store, which can be transformed into electric power. On the other hand, pumping the water back out at greater depths also uses up more power, since the turbine-turned-pump must act on the same entire column of water.

As such the energy storage capacity of the submerged reservoir is not governed by the gravitational energy in the traditional sense, but rather by the vertical pressure variation.

While St EnSea's test took place at a depth of 100 m in the fresh water Lake Constance, the technology is foreseen to be used in salt water at greater depths. Since the submerged reservoir needs only a connecting electrical cable, the depth at which it can be employed is limited only by the depth at which the turbine can function, currently limited to 700 m. The challenge of designing salt water pumped storage in this underwater configuration brings a range of advantages:

- **No land area is required,**
- **No mechanical structure other than the electrical cable needs to span the distance of the potential energy difference,**
- **In the presence of sufficient seabed area multiple reservoirs can scale the storage capacity without limits,**
- **Should a reservoir collapse, the consequences would be limited apart from the loss of the reservoir itself,**
- **Evaporation from the upper reservoir has no effect on the energy conversion efficiency,**
- **Transmission of electricity between the reservoir and the grid can be established from a nearby offshore wind farm limiting transmission loss and obviating the need for onshore cabling permits.**

Superconducting Magnetic Energy Storage (SMES)

SMES systems store energy in the magnetic field created by the flow of direct current in a superconducting coil which has been cryogenically cooled to a temperature below its superconducting critical temperature.

A typical SMES system includes three parts: superconducting coil, power conditioning system and cryogenically cooled refrigerator. Once the superconducting coil is charged, the current will not decay and the magnetic energy can be stored indefinitely.

The stored energy can be released back to the network by discharging the coil. The power conditioning system uses an inverter/rectifier to transform alternating current (AC) power to direct current or convert DC back to AC power. The inverter/rectifier accounts for about 2–3% energy loss in each direction. SMES loses the least amount of electricity in the energy storage process compared to other methods of storing energy. SMES systems are highly efficient; the round-trip efficiency is greater than 95%.Due to the energy requirements of refrigeration and the high cost of superconducting wire, SMES is currently used for short duration energy storage. Therefore, SMES is most commonly devoted to improving power quality.

Current use

There are several small SMES units available for commercial use and several larger test bed projects. Several 1 MW·h units are used for power quality control in installations around the world, especially to provide power quality at manufacturing plants requiring ultra-clean power, such as microchip fabrication facilities.

These facilities have also been used to provide grid stability in distribution systems. SMES is also used in utility applications. In northern Wisconsin, a string of distributed SMES units were deployed to enhance stability of a transmission loop. The transmission line is subject to large, sudden load changes due to the operation of a paper mill, with the potential for uncontrolled fluctuations and voltage collapse.

The Engineering Test Model is a large SMES with a capacity of approximately 20 MW·h, capable of providing 40 MW of power for 30 minutes or 10 MW of power for 2 hours.

Calculation of stored energy

The magnetic energy stored by a coil carrying a current is given by one half of the inductance of the coil times the square of the current.

Where

E = energy measured in joules

L = inductance measured in henries

I = current measured in amperes

Now let's consider a cylindrical coil with conductors of a rectangular cross section. The mean radius of coil is R. a and b are width and depth of the conductor. f is called form function which is different for different shapes of coil. Ç (xi) and δ (delta) are two parameters to characterize the dimensions of the coil. We can therefore write the magnetic energy stored in such a cylindrical coil as shown below. This energy is a function of coil dimensions,number of turns and carrying current.

Where

E = energy measured in joules

I = current measured in amperes

f(Ç,δ) = form function, joules per ampere-meter

N = number of turns of coil

Solenoid vs Toroid

Besides the properties of the wire, the configuration of the coil itself is an important issue from a mechanical engineering aspect. There are three factors which affect the design and the shape of the coil - they are: Inferior strain tolerance, thermal contraction upon cooling and Lorentz forces in a charged coil. Among them, the strain tolerance is crucial not because of any electrical effect, but because it determines how much structural material is needed to keep the SMES from breaking. For small SMES systems, the optimistic value of 0.3% strain tolerance is selected. Toroidal geometry can help to lessen the external magnetic forces and therefore reduces the size of mechanical support needed. Also, due to the low external magnetic field, toroidal SMES can be located near a utility or customer load.

For small SMES, solenoids are usually used because they are easy to coil and no pre-compression is needed. In toroidal SMES, the coil is always under compression by the outer hoops and two disks, one of which is on the top and the other is on the bottom to avoid breakage. Currently, there is little need for toroidal geometry for small SMES, but as the size increases, mechanical forces become more important and the toroidal coil is needed.

The older large SMES concepts usually featured a low aspect ratio solenoid approximately 100 m in diameter buried in earth. At the low extreme of size is the concept of micro-SMES solenoids, for energy storage range near 1 MJ.

Low-temperature versus high-temperature superconductors

Under steady state conditions and in the superconducting state, the coil resistance is negligible. However, the refrigerator necessary to keep the superconductor cool requires electric power and this refrigeration energy must be considered when evaluating the efficiency of SMES as an energy storage device.

Although the high-temperature superconductor (HTSC) has higher critical temperature, flux lattice melting takes place in moderate magnetic fields around a temperature lower than this critical temperature. The heat loads that must be removed by the cooling system include conduction through the support system, radiation from warmer to colder surfaces, AC losses in the conductor (during charge and discharge), and losses from the cold–to-warm power leads that connect the cold coil to the power conditioning system. Conduction and radiation losses are minimized by proper design of thermal surfaces. Lead losses can be minimized by good design of the leads. AC losses depend on the design of the conductor, the duty cycle of the device and the power rating.

The refrigeration requirements for HTSC and low-temperature superconductor (LTSC) toroidal coils for the baseline temperatures of 77 K, 20 K, and 4.2 K, increases in that order. The refrigeration requirements here is defined as electrical power to operate the refrigeration system. As the stored energy increases by a factor of 100, refrigeration cost only goes up by a factor of 20. Also, the savings in refrigeration for an HTSC system is larger (by 60% to 70%) than for an LTSC systems.

Cost

Whether HTSC or LTSC systems are more economical depends because there are other major components determining the cost of SMES: Conductor consisting of superconductor and copper stabilizer and cold support are major costs in themselves. They must be judged with the overall efficiency and cost of the device. Other components, such as vacuum vessel insulation, has been shown to be a small part compared to the large coil cost. The combined costs of conductors, structure and refrigerator for toroidal coils are dominated by the cost of the superconductor. The same trend is true for solenoid coils. HTSC coils cost more

than LTSC coils by a factor of 2 to 4. We expect to see a cheaper cost for HTSC due to lower refrigeration requirements but this is not the case.

UNIT 2: Ecosystems

Concept of an ecosystem; Structure and function of an ecosystem; Producers, consumers and decomposers; Energy flow in the ecosystem; Ecological succession; Food chains, food webs and ecological pyramids; Introduction, types, characteristic features, structure and function of the following ecosystem (a.)Forest ecosystem (b) Grassland ecosystem (c) Desert ecosystem (d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Ecosystem

An ecosystem is a community of living organisms in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system. It refers to both biotic factors as well as abiotic factors. An ecosystem is self-supporting. These biotic and abiotic components are regarded as linked together through nutrient cycles and energy flows

The term 'environment 'originated from the French word environner or environment meaning 'to surround'. From this etymology, environment means the things or events that surround something else. In other words, environment means the area in which something exists or lives. Environment is defined as the social, cultural and physical conditions that surround, affect and influence the survival, growth and development of people, animals or plants. Environment includes everything around us. It encompasses both the living (biotic) and non-living (abiotic) components of the Earth.

Concept of an Ecosystem:

The term ecosystem was coined in 1935 by the Oxford ecologist Arthur Tansley to encompass the interactions among biotic and abiotic components of the environment at a given site. The living and non-living components of an ecosystem are known as biotic and abiotic components, respectively.

Ecosystem was defined in its presently accepted form by Eugene Odum as, "an unit that includes all the organisms, i.e., the community in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles, i.e., exchange of materials between living and non-living, within the system".

Smith (1966) has summarized common characteristics of most of the ecosystems as follows:

1. The ecosystem is a major structural and functional unit of ecology.

2. The structure of an ecosystem is related to its species diversity in the sense that complex ecosystem have high species diversity.

3. The function of ecosystem is related to energy flow and material cycles within and outside the system.

4. The relative amount of energy needed to maintain an ecosystem depends on its structure.

5. Young ecosystems develop and change from less complex to more complex ecosystems, through the process called succession.

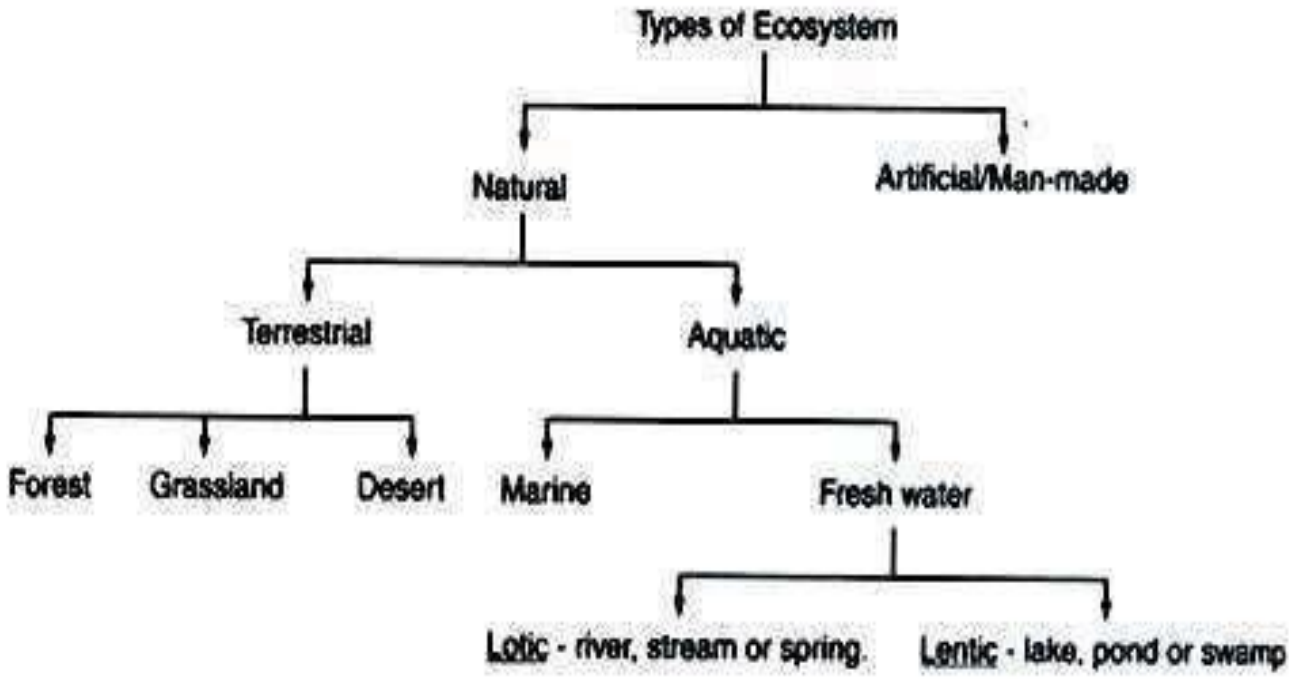
6. Each ecosystem has its own energy budget, which cannot be exceeded.

7. Adaptation to local environmental conditions is the important feature of the biotic components of an ecosystem, failing which they might perish.

8. The function of every ecosystem involves a series of cycles, e.g., water cycle, nitrogen cycle, oxygen cycle, etc. these cycles are driven by energy. A continuation or existence of ecosystem demands exchange of materials/nutrients to and from the different components.

<u>Types of Ecosystem:</u>

We can classify ecosystems as follows:



<u>Types of Ecosystem</u>

(a) Natural Ecosystems:

These ecosystems are capable of operating and maintaining themselves without any major interference by man.

A classification based on their habitat can further be made:

1. Terrestrial ecosystems: forest, grassland and desert.

2. Aquatic ecosystems: fresh water ecosystem, viz. pond, lake, river and marine ecosystems, viz. ocean, sea or estuary.

(b) Artificial Ecosystem:

These are maintained by man. These are manipulated by man for different purposes, e.g., croplands, artificial lakes and reservoirs, townships and cities.

Basic Structure of an Ecosystem:

Every ecosystem has a non-living (abiotic) and living (biotic) components.

Abiotic Components:

Basic inorganic compounds of an organism, habitat or an area like carbon dioxide, water, nitrogen, calcium, phosphorus, etc. that are involved in the material cycles are collectively called as abiotic component. The amount of these inorganic substances present at any given time, in an ecosystem is called as the standing state or standing quality of an ecosystem.

Whereas, organic components e.g., proteins, amino acids, carbohydrates and lipids that are synthesized by the biotic counterpart of an ecosystem make the biochemical structure of the ecosystem. The physical environment, viz. climatic and weather conditions are also included in the abiotic structure of the ecosystem.

Biotic Components:

From the trophic (nutritional) point of view, an ecosystem has autotrophic (self-nourishing) and a heterotrophic (other nourishing) components:

(a) Autotrophic component (Producers):

This component is mainly constituted by the green plants, algae and all photosynthetic organisms. Chemosynthetic bacteria, photosynthetic bacteria, algae, grasses, mosses, shrubs, herbs and trees manufacture food from simple inorganic substances by fixing energy and are therefore called as producers.

(b) Heterotrophic component (Consumers):

The members of this component cannot make their own food. They consume the matter built by the producers and are therefore called as consumers. They may be herbivores, carnivores or omnivores. Herbivores are called as primary consumers whereas carnivores and omnivores are called as secondary consumers. Collectively we can call them as macro-consumers.

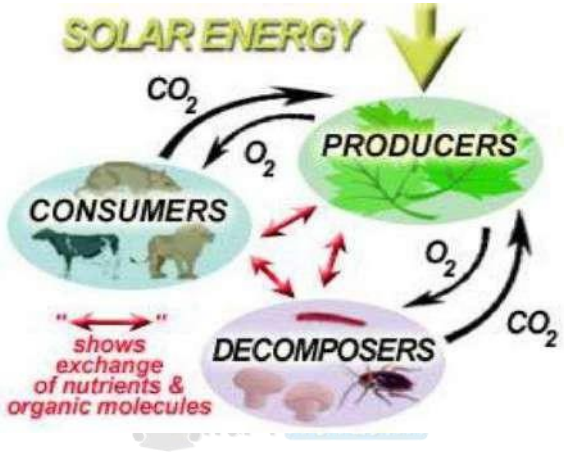
(c) Decomposers:

Heterotrophic organisms chiefly bacteria and fungi that breakdown the complex compounds of dead protoplasm, absorb some of the products and release simple substances usable by the producers are called as decomposers or reducers. Collectively we call them as micro consumers.

Energy flow in Ecosystem:

Organisms can be either producers or consumers in terms of energy flow through an ecosystem. Producers convert energy from the environment into carbon bonds, such as those found in the sugar glucose. Plants are the most obvious examples of producers; plants take energy from sunlight and use it to convert carbon dioxide into glucose (or other sugars). Algae and cyanobacteria are also photo- synthetic producers, like plants.

Other producers include bacteria living around deep-sea vents. These bacteria take energy from chemicals coming from the Earth's interior and use it to make sugars. Other bacteria living deep under-ground can also produce sugars from such inorganic sources. Another word for producers is autotrophs.



Routes of Usage:

Consumers get their energy from the carbon bonds made by the producers. Another word for a consumer is a heterotroph.

Based on what they eat, we can distinguish between 4 types of heterotrophs:

Routes of Usage

A trophic level refers to the organisms position in the food chain. Autotrophs are at the base. Organisms that eat autotrophs are called herbivores or primary consumers. An organism that eats herbivores is a carnivore and a secondary consumer. A carnivore which eats a carnivore which eats a herbivore is a terti-ary consumer, and so on.

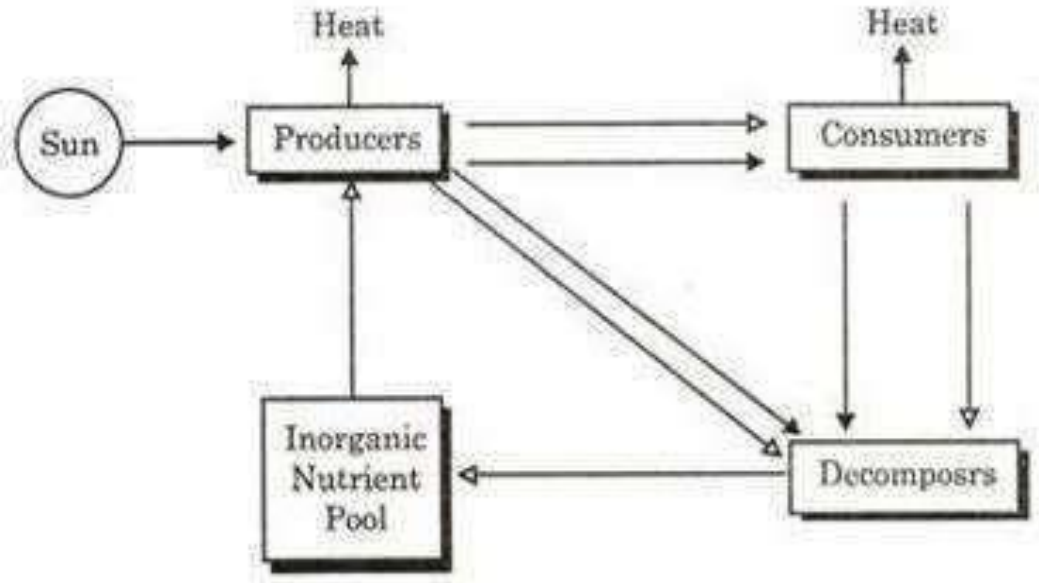
It is important to note that many animals do not specialize in their diets. Omnivores (such as humans) eat both animals and plants. Further, except for some specialists, most carnivores don't discriminate between herbivorous and carnivorous bugs in their diet. If it's the right size, and moving at the right distance, chances are the frog will eat it.

<u>Flow of Energy and its Utilisation:</u>

The diagram 3.5 shows how both energy and inorganic nutrients flow through the ecosystem. Energy "flows" through the ecosystem in the form of carbon- carbon bonds. When respiration occurs, the carbon-carbon bonds are broken and the carbon is combined with oxygen to form

This process releases the energy, which is either used by the organism (to move its muscles, digest food, excrete wastes, think, etc.) or the energy may be lost as heat. The dark arrows represent the movement of this energy. Note that all energy comes from the sun, and that the ultimate fate of all energy in ecosystems is to be lost as heat. Energy does not recycle.

The other component shown in the diagram is the inorganic nutrients. They are inorganic because they do not contain carbon-carbon bonds. These inorganic nutrients include the phosphorous in your teeth, bones, and cellular membranes the nitrogen in your amino acids (the building blocks of protein); and the iron in your blood (to name just a few of the inorganic nutrients).



Flow of Energy and its Utilisation

The movement of the inorganic nutrients is represented by the open arrows. Note that the autotrophs obtain these inorganic nutrients from the inorganic nutrient pool, which is usually the soil or water surrounding the plants or algae.

These inorganic nutrients are passed from organism to organism as one organ-ism is consumed by another. Ultimately, all organisms die and become detritus, food for the decomposers. At this stage, the last of the energy is extracted (and lost as heat) and the inorganic nutrients are returned to the soil or water to be taken up again. The inorganic nutrients are recycled, the energy is not.

<u>Ecological succession</u>

Ecological succession is the process of change in the species structure of an ecological community over time. The time scale can be decades (for example, after a wildfire), or even millions of years after a mass extinction.

The community begins with relatively few pioneering plants and animals and develops through increasing complexity until it becomes stable or self-perpetuating as a climax

community. The "engine" of succession, the cause of ecosystem change, is the impact of established species upon their own environments. A consequence of living is the sometimes subtle and sometimes overt alteration of one's own environment.

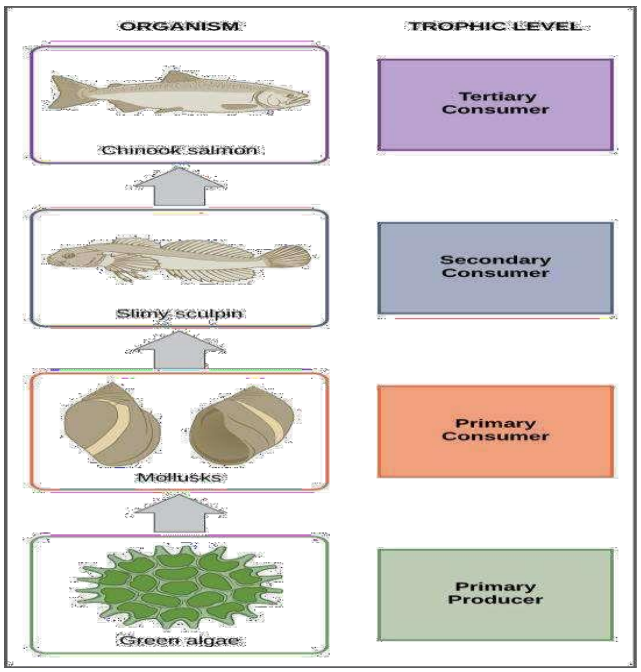
Food chain

A food chain is a linear sequence of organisms through which nutrients and energy pass as one organism eats another. In a food chain, each organism occupies a different trophic level, defined by how many energy transfers separate it from the basic input of the chain.

Parts of a typical food chain, starting from the bottom—the producers—and moving upward.

At the base of the food chain lie the primary producers. The primary producers are autotrophs and are most often photosynthetic organisms such as plants, algae, or cyanobacteria. The organisms that eat the primary producers are called primary consumers. Primary consumers are usually herbivores, plant-eaters, though they may be algae eaters or bacteria eaters. The organisms that eat the primary consumers are called secondary consumers. Secondary consumers are generally meat-eaters—carnivores. The organisms that eat the secondary consumers are called tertiary consumers. These are carnivore-eating carnivores, like eagles or big fish. Some food chains have additional levels, such as quaternary consumers—carnivores that eat tertiary consumers. Organisms at the very top of a food chain are called apex consumers.

We can see examples of these levels in the diagram below. The green algae are primary producers that get eaten by mollusks—the primary consumers. The mollusks then become lunch for the slimy sculpin fish, a secondary consumer, which is itself eaten by a larger fish, the Chinook salmon—a tertiary consumer.

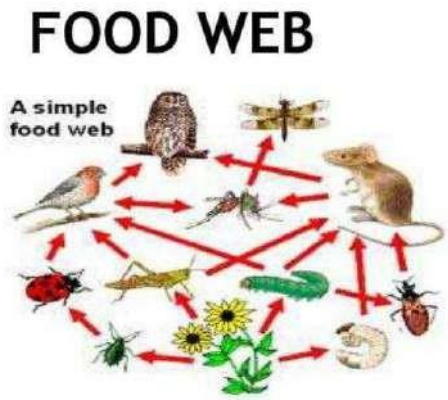


Food web

Food webs consist of many interconnected food chains and are more realistic representation of consumption relationships in ecosystems. Energy transfer between trophic levels is inefficient—with a typical efficiency around 10%. This inefficiency limits the length of food chains.

Or

Food web can be defined as, "a network of food chains which are interconnected at various tropic levels, so as to form a number of feeding connections amongst different organisms of a biotic community". It is also known as consumer-resource system. It is a graphical description of feeding relationships among species in an ecological community. It is also a mean of showing how energy and materials (e.g., carbon) flow through a community of species as a result of these feeding relationships.



Basics of food web

A node is one of the words/pictures that the arrows go toward or away from. A node may represent an individual species, or a group of related species or different stages of a single species (such as one node for adult frogs and a second for juvenile tadpoles). A link connects two nodes. Arrows represent links, and always go from prey to predator (as in food chain). The lowest trophic level are called basal species The highest trophic level are called top predators. Movement of nutrients is cyclic but of energy is unidirectional and non-cyclic.

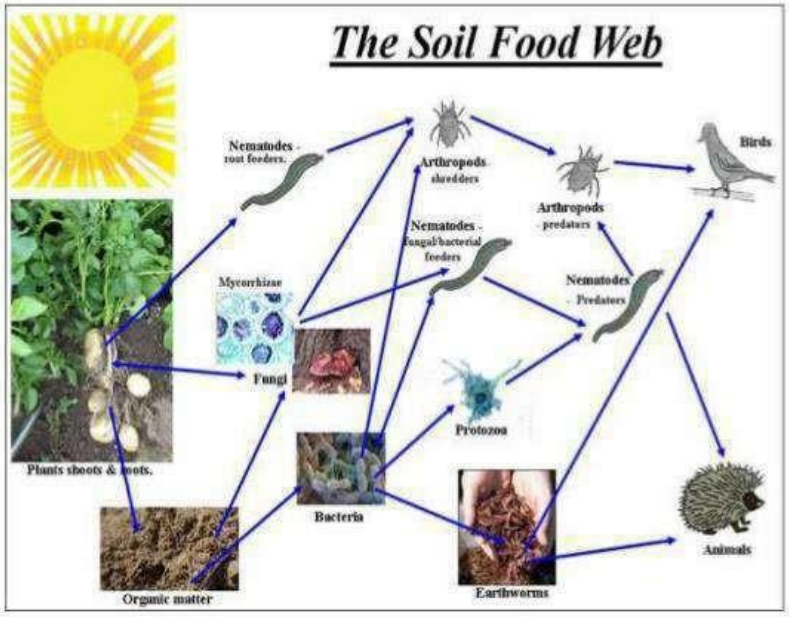
Types Of Food Web Represention

1. **Topological web :- Early food webs were topological. They simply indicate a feeding relationship.**
2. **Flow webs :- Bioenergetic webs, or flow webs, include information on the strength of the feeding interaction. This can be done in one of two ways: Vary the size of the arrow. Thicker arrows represent a larger percentage of the diet. (interactions where more prey are eaten or where more energy flows upward). The amount of energy moving between nodes next to the arrow.**

3. **Interaction webs :- An interaction web is similar to a topological web, but instead of showing the movement of energy or materials, the arrows show how one group influences another. In interaction food web models, every link has two direct effects. One of the resource on the consumer and one of the consumer on the resource. The effect of the resource on the consumer is positive, (the consumer gets to eat) and the effect on the resource by the consumer is negative (it is eaten).**

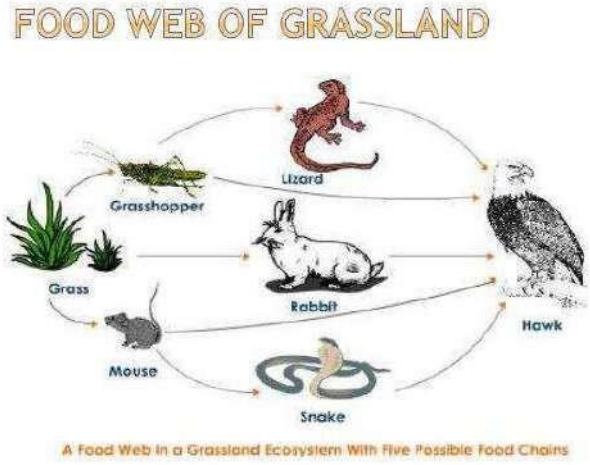
<u>Types of food webs</u>

1. **Soil food web:- The soil food web is the community of organisms living all or part of their lives in the soil. It describes a complex living system in the soil and how it interacts with the environment, plants, and animals.**



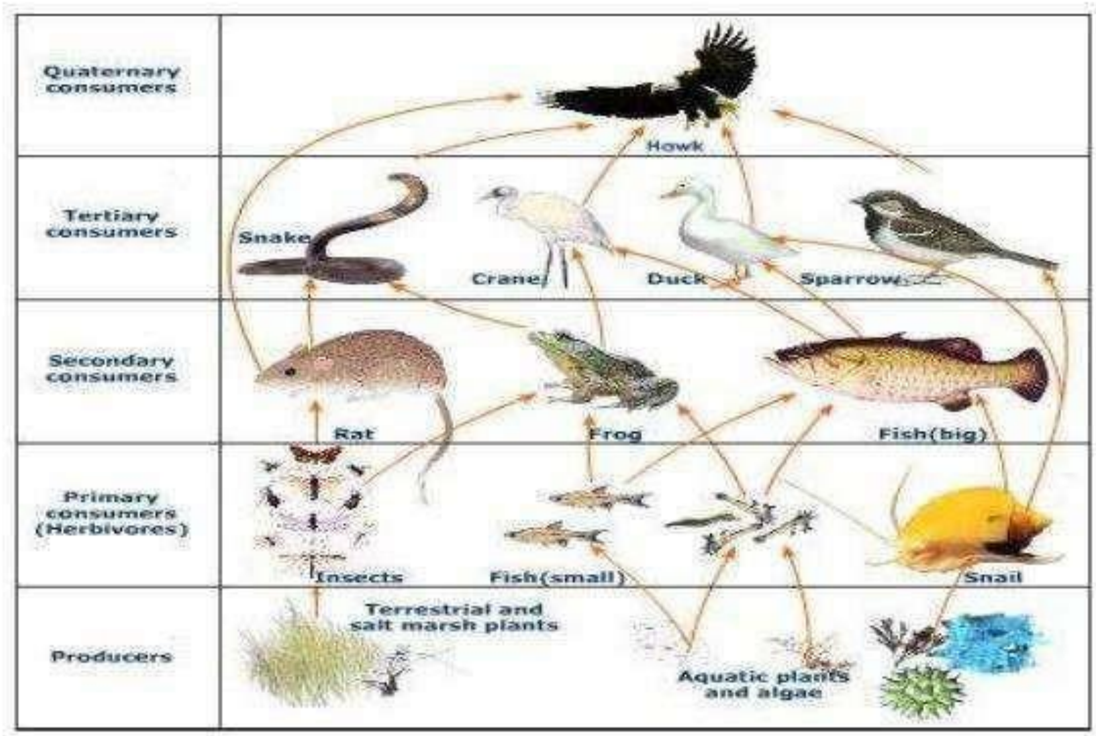
2. **Aquatic food web:- A balanced food web is essential to any marine or fresh water system, and can be an indicator of habitat quality. Planktonic algae are the foundation of aquatic food webs. The size and diversity of the planktonic algae community determines the diversity of the zooplankton community that can be supported as well as the small fish community.**
3. **Food web in forest:-**

4. Food web of grassland



5. Food web in terrestrial and aquatic ecosystem

FOOD WEB IN TERRESTRIAL AND AQUATIC ECOSYSTEM



Ecological Pyramid

An ecological pyramid is a graphical representation of the relationship between different organisms in an ecosystem. Each of the bars that make up the pyramid represents a different trophic level, and their order, which is based on who eats whom, represents the flow of energy. Energy moves up the pyramid, starting with the primary producers, or autotrophs, such as plants and algae at the very bottom, followed by the primary consumers, which feed on these plants, then secondary consumers, which feed on the primary consumers, and so on. The height of the bars should all be the same, but the width of each bar is based on the quantity of the aspect being measured.

Types of Ecological Pyramids

Pyramid of numbers

This shows the number of organisms in each trophic level without any consideration for their size. This type of pyramid can be convenient, as counting is often a simple task and can be done over the years to observe the changes in a particular ecosystem. However, some types of organisms are difficult to count, especially when it comes to some juvenile forms. Unit: number of organisms.

Pyramid of biomass

This indicates the total mass of organisms at each trophic level. Usually, this type of pyramid is largest at the bottom and gets smaller going up, but exceptions do exist. The biomass of

one trophic level is calculated by multiplying the number of individuals in the trophic level by the average mass of one individual in a particular area. This type of ecological pyramid solves some problems of the pyramid of numbers, as it shows a more accurate representation of the amount of energy contained in each trophic level, but it has its own limitations. For example, the time of year when the data are gathered is very important, since different species have different breeding seasons. Also, since it's usually impossible to measure the mass of every single organism, only a sample is taken, possibly leading to inaccuracies. Unit: g m-2 or Kg m2.

Pyramid of productivity

The pyramid of productivity looks at the total amount of energy present at each trophic level, as well as the loss of energy between trophic levels. Since this type of representation takes into account the fact that the majority of the energy present at one trophic level will not be available for the next one, it is more accurate than the other two pyramids. This idea is based on Lindeman's Ten Percent Law, which states that only about 10% of the energy in a trophic level will go towards creating biomass. In other words, only about 10% of the energy will go into making tissue, such as stems, leaves, muscles, etc. in the next trophic level. The rest is used in respiration, hunting, and other activities, or is lost to the surroundings as heat. What's interesting, however, is that toxins are passed up the pyramid very efficiently, which means that as we go up the ecological pyramid, the amount of harmful chemicals is more and more concentrated in the organisms' bodies. This is what we call biomagnification.

The pyramid of productivity is the most widely used type of ecological pyramid, and, unlike the two other types, can never be largest at the apex and smallest at the bottom. It's an important type of ecological pyramid because it examines the flow of energy in an ecosystem over time. Unit: J m-2 yr-1, where Joule is the unit for energy, which can be interchanged by other units of energy such as Kilojoule, Kilocalorie, and calorie.

While a productivity pyramid always takes an upright pyramid shape, number pyramids are sometimes inverted, or don't take the shape of an actual pyramid at all. To demonstrate, let's take an oak tree, which can feed millions of oakworms. If we consider this ecosystem as our focus, then the producers' level (one tree) will end up much smaller than the primary consumers' level (millions of insects). This is less likely to occur in biomass pyramids, but is not impossible. The pyramids below show the different types of pyramids and the shapes they can have in different ecosystems.

Ecological Pyramid Examples

The diagram below is an example of a productivity pyramid, otherwise called an energy pyramid. The sun has been included in this diagram, as it's the main source of all energy, as well the decomposers, like bacteria and fungi, which can acquire nutrients and energy from all trophic levels by breaking down dead or decaying organisms. As shown, the nutrients then go back into the soil and are taken up by plants.

The loss of energy to the surroundings is also shown in this diagram, and the total energy transfer has been calculated. We start off with the total amount of energy that the primary producers contain, which is indicated by 100%. As we go up one level, 90% of that energy is used in ways other than to create flesh. What the primary consumers end up with is just 10% of the starting energy, and, 10% of that 10% is lost in the transfer to the next level. That's 1%, and so on. The predators at the apex, then, will only receive 0.01% of the starting energy! This inefficiency in the system is the reason why productivity pyramids are always upright.

Function of Ecological Pyramid

An ecological pyramid not only shows us the feeding patterns of organisms in different ecosystems, but can also give us an insight into how inefficient energy transfer is, and show the influence that a change in numbers at one trophic level can have on the trophic levels above and below it. Also, when data are collected over the years, the effects of the changes that take place in the environment on the organisms can be studied by comparing the data. If an ecosystem's conditions are found to be worsening over the years because of pollution or overhunting by humans, action can be taken to prevent further damage and possibly reverse some of the present damage.

Related Biology Terms

Trophic level – The position that an organism occupies within a food chain or an ecological pyramid, such as a producer, or a primary consumer. Many animals feed at several different trophic levels.

Species – A group of organisms that exhibit common characteristics and can breed among themselves to produce fertile offspring.

Ecosystem – A community of interdependent living organisms in association with the nonliving elements surrounding them. The way the living organisms and the physical environment interact is by exchange of nutrients and energy.

Food web – A system of food chains that are interlocked with one another. Unlike in food chains, an organism in a food web can occupy several different trophic levels.

Or

Ecological Pyramid

An ecological pyramid (also trophic pyramid, energy pyramid, or sometimes food pyramid) is a graphical representation designed to show the biomass or bio productivity at each trophic level in a given ecosystem. Biomass is the amount of living or organic matter present in an organism. Biomass pyramids show how much biomass is present in the organisms at each trophic level, while productivity pyramids show the production or turnover in biomass.

Ecological pyramids begin with producers on the bottom (such as plants) and proceed

through the various trophic levels (such as herbivores that eat plants, then carnivores that eat herbivores, then carnivores that eat those carnivores, and so on). The highest level is the top of the chain. An ecological pyramid of biomass shows the relationship between biomass and trophic level by quantifying the biomass present at each trophic level of an ecological community at a particular time. It is a graphical representation of biomass (total amount of living or organic matter in an ecosystem) present in unit area in different tropic levels. Typical units are grams per meter2, or calories per meter2.

General concepts

Energy flows through the food chain in a predictable way, entering at the base of the food chain, by photosynthesis in primary producers, and then moving up the food chain to higher trophic levels. Because the transfer of energy from one trophic level to the next is inefficient, there is less energy entering higher trophic levels.

It may also be useful and productive to examine how the number and biomass of organisms vary across trophic levels. Both the number and biomass of organisms at each trophic level should be influenced by the amount of energy entering that trophic level. When there is a direct correlation between energy, numbers, and biomass then biomass pyramids and numbers pyramids will result. However, the relationship between energy, biomass, and number can be complicated by the growth form and size of organisms and ecological relationships occurring among trophic levels. Thus, it is possible, and common that biomass pyramids and numbers pyramids do not look like pyramids at all

<u>Types</u>

There are 3 types of ecological pyramids as described as follows:
Pyramid of Energy
Pyramid of numbers
Pyramid of biomass.

<u>Pyramid of Energy</u>
The pyramid of energy or the energy pyramid describes the overall nature of the ecosystem. During the flow of energy from organism to other, there is considerable loss of energy in the form of heat. The primary producers like the autotrophs there is more amount of energy available. The least energy is available in the tertiary consumers. Thus, shorter food chain has more amount of energy available even at the highest trophic level.

1. **The energy pyramid always upright and vertical.**
2. **This pyramid shows the flow of energy at different trophic levels. It depicts the energy is minimum as the highest trophic level and is maximum at the lowest trophic level.**
3. **At each trophic level, there is successive loss of energy in the form of heat and respiration, etc.**

Pyramid of Numbers

The pyramid of numbers depicts the relationship in terms of the number of producers, herbivores and the carnivores at their successive trophic levels. There is a decrease in the number of individuals from the lower to the higher trophic levels. The number pyramid varies from ecosystem to ecosystem.

There are three of pyramid of numbers:

1. **Upright pyramid of number**
2. **Partly upright pyramid of number and**
3. **Inverted pyramid of number.**

1. **Upright Pyramid of Number :- This type of pyramid number is found in the aquatic and grassland ecosystem, in these ecosystems there are numerous small autotrophs which support lesser herbivores which in turn support smaller number of carnivores and hence this pyramid is upright.**
2. **Partly Upright pyramid of Number :- It is seen in the forest ecosystem where the number of producers are lesser in number and support a greater number of herbivores and which in turn support a fewer number of carnivores.**
3. **Inverted Pyramid of Number :- This type of ecological pyramid is seen in parasitic food chain where one primary producer supports numerous parasites which support more hyperparasites.**

Pyramid of Biomass

The pyramid of biomass is more fundamental, they represent the quantitative relationships of the standing crops. In this pyramid there is a gradual decrease in the biomass from the producers to the higher trophic levels. The biomass here the net organisms collected from each feeding level and are then dried and weighed. This dry weight is the biomass and it represents the amount of energy available in the form of organic matter of the organisms. In this pyramid the net dry weight is plotted to that of the producers, herbivores, carnivores, etc.

There are two types of pyramid of biomass, they are:

1. **Upright pyramid of biomass and**
2. **Inverted pyramid of biomass.**

1. **Upright Pyramid of Biomass:- This occurs when the larger net biomass of producers support a smaller weight of consumers.**

   Example: Forest ecosystem.

2. **Inverted Pyramid of Biomass: - This happens when the smaller weight of producers support consumers of larger weight.**

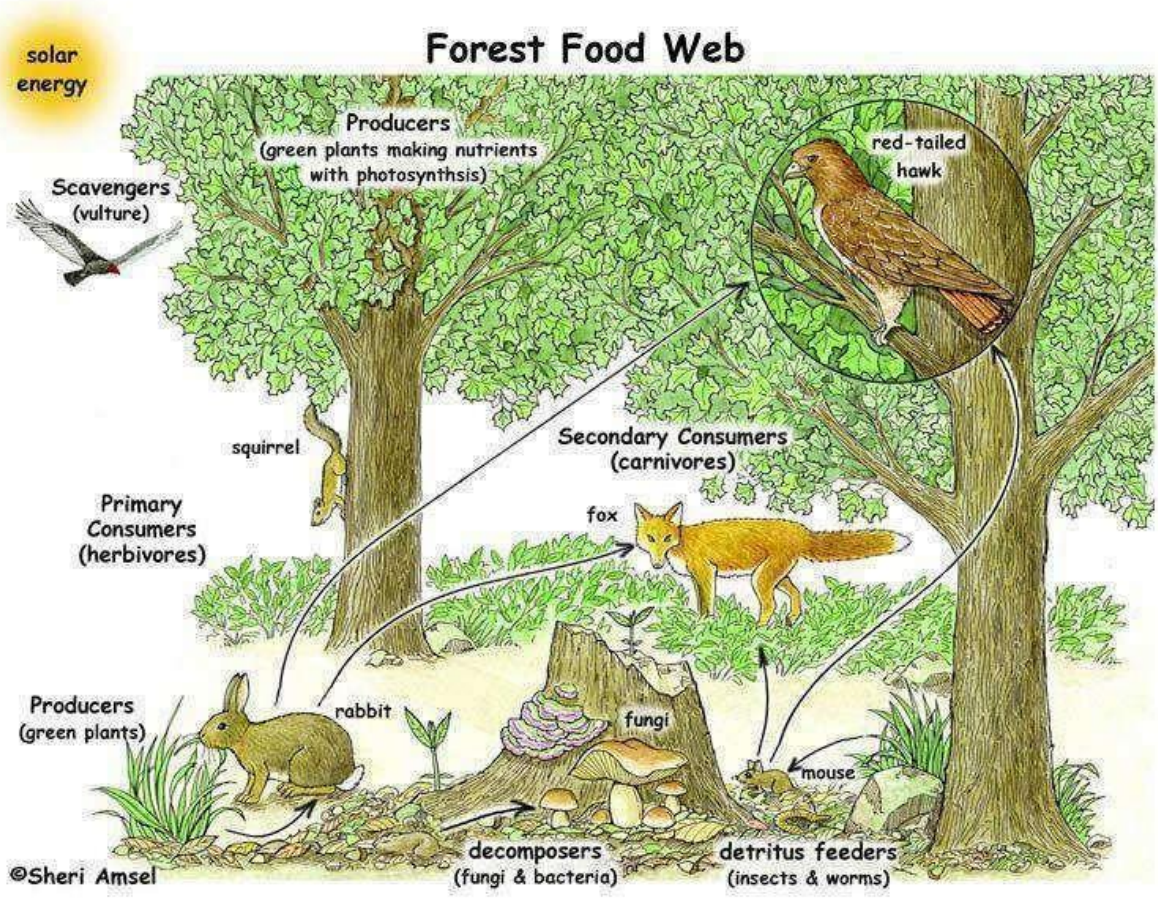
   Example: Aquatic ecosystem.

Types of Ecosystem

Forest Ecosystem

The word forest means a wooded area. This word comes from the Latin word forus which simply means outside (and it is where we get the English word foreign).

However, over the years, via the Latin phrase 'forestis silva' (which means a wood outside) the word forest came to mean a group of trees. An ecosystem is an ecological system: i.e. a group of organisms (this can include animals and plants as well as birds, bacteria and insects) that live together as a community.



An ecosystem is usually a distinct system with its own special characteristics. So, a forest ecosystem is:

There are many types of forests throughout the world. Below, you can find some of the main categories of forest ecosystem that are used by scientists. One thing to remember throughout this discussion is that trees in a forest can be either deciduous or evergreen. i.e. they can either shed their leave in autumn and grow them again in the spring or they will keep their flourishing leaves throughout the year.

Taiga: this thin, sparse forest exists at the extreme north of the world, in countries such as Canada and Finland and in the Arctic Circle. It is characterized by chilly conditions and the fact

that the animals and birds and other organisms that live there have adapted to the cold. The taiga is a very ancient forest.

Rain forests: rain forests are huge, humid highly bio-diverse swathes of forest that are usually found within the global South. Due to the thick canopy created by their leaves, rain forests usually create their own mini ecosystem that seals off heat and humidity.

Boreal forests: boreal forests exist in the sub Arctic zones of the world (i.e. less far north than the Taiga). Here, you can find a mix of deciduous and evergreen trees and plenty of different animals, insects, birds and so on.

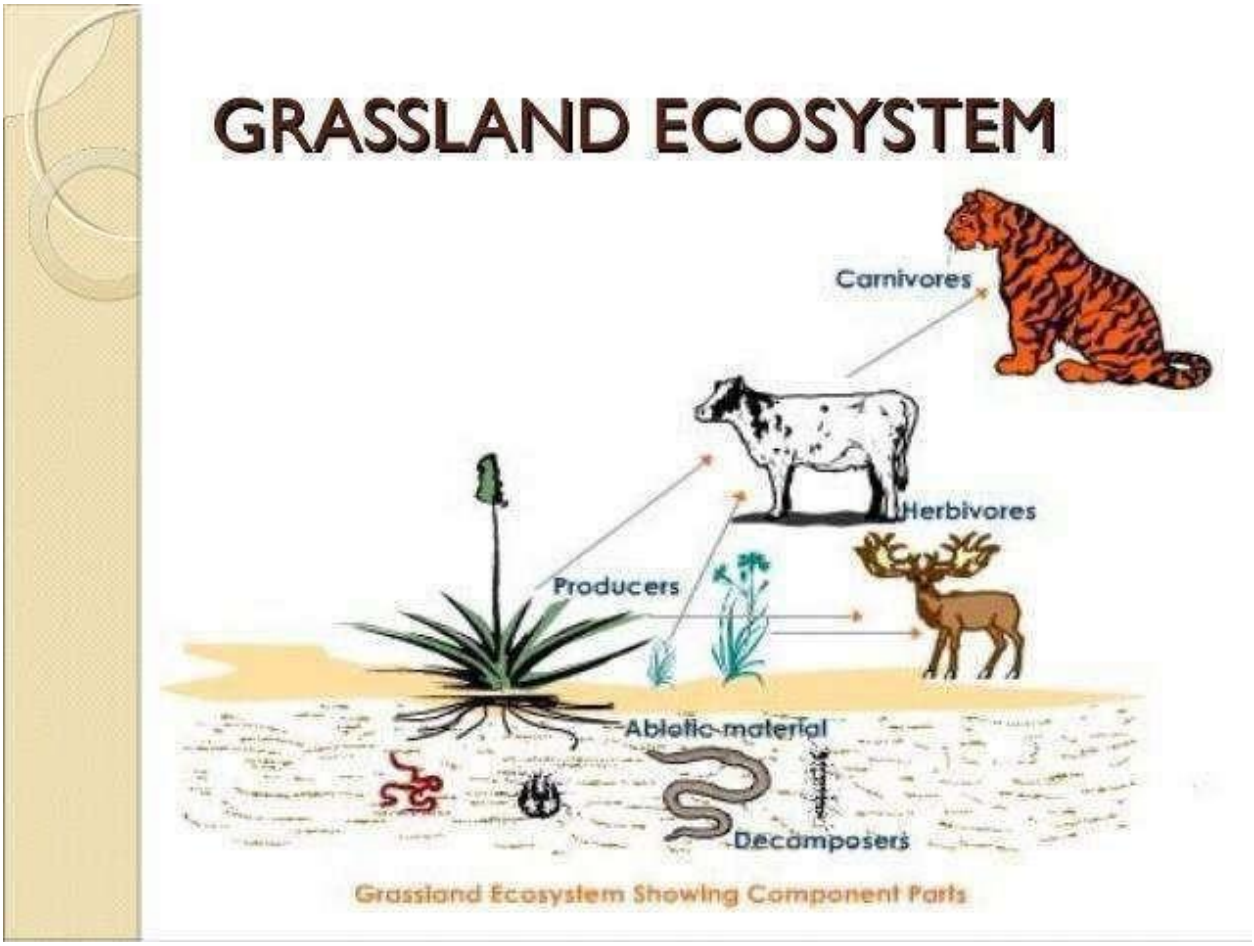
Forests of the temperate zone: located between the freezing cold of the polar zones and the scorching heat of the equator, the temperate zone is somewhere where forests can truly flourish. Some very ancient forests, such as the New Forest in Britain, are example of how in the temperate zone conditions are just right for huge amounts of biodiversity to occur. Again, in this zone, forests can be made of a mix of deciduous and evergreen trees – or of mainly one or mainly the other type of tree.

- **A community of organisms living together in a forest.**
- **A distinct system, that can be defined as having certain distinctive characteristics.**
- **Variable depending on where the forest is located.**
- **Vulnerable to climate change and deforestation.**
- **Important to protect.**

Grassland Ecosystem

The word grassland is somewhat self explanatory. A grassland is a wide open grassy space. A grassland may also contain low shrubs and other plants, but its predominant feature is that it is a place where plenty of grass grows.

A grassland ecosystem is a community of creatures living together within a grassy space. These creatures can include various types of grasses, insects, and animals, etc.



The importance of grassland ecosystems.

Grassland ecosystems are very important for a wide variety of different reasons. Below, you will find some of the main ones.

1. Habitat. Grassland ecosystems are key habitats for huge numbers of different animals including zebras, bison, lions and elephants.

2. Soil quality. The delicate balance of plants and animals in grassland ecosystems maintains a high soil quality. When humans intervene in grasslands and use them for crop based agriculture they alter the mineral composition of the soil and its quality and hence fertility declines.

3. Beauty. Grassland ecosystems should be important to us, too, because they are quite simply very beautiful open spaces.

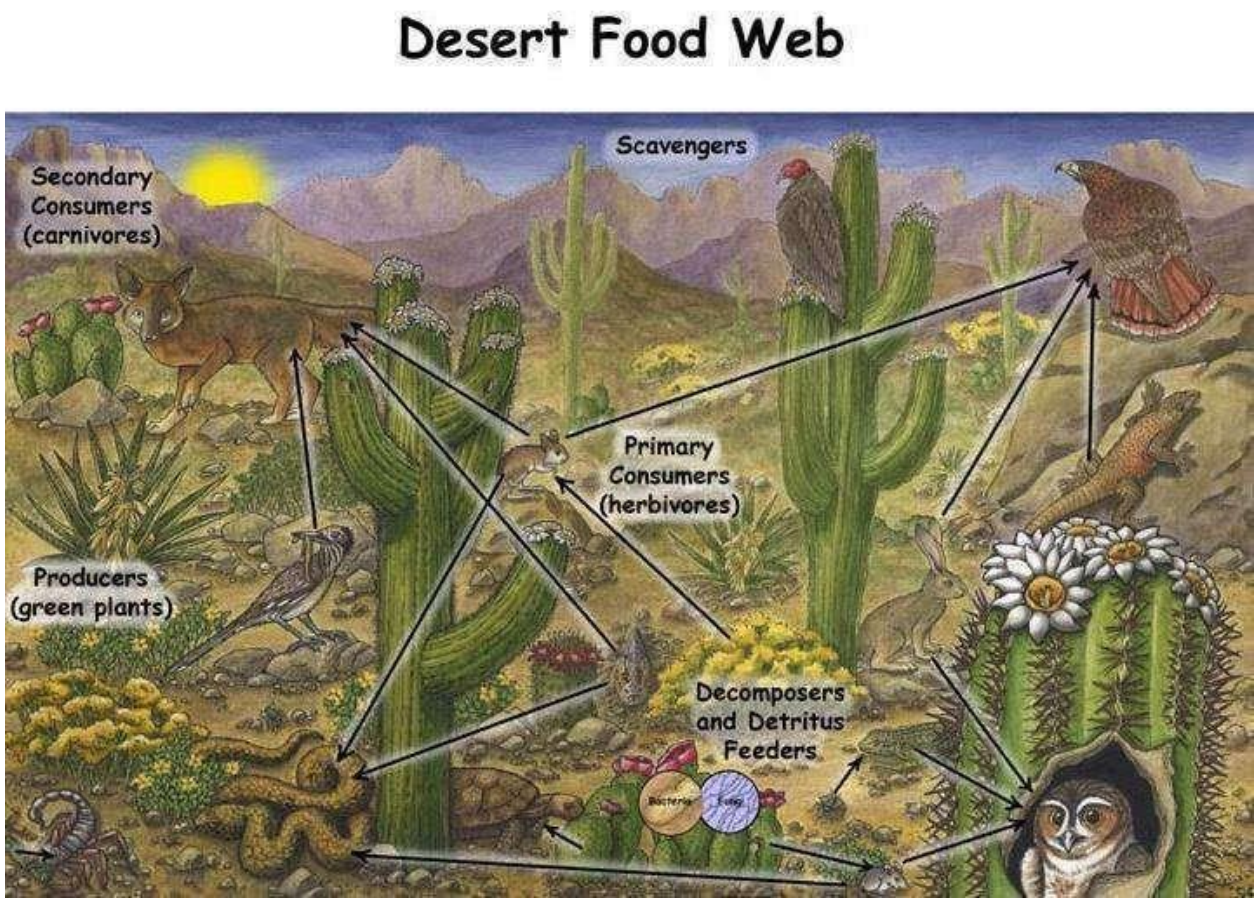
4. Large area. Around a quarter of the earth's total landmass is taken up by grassland ecosystems. That makes the grassland ecosystem one of the largest and most important types of ecosystem in the world.

5. Useful to humans. Grassland ecosystems are very useful to humans, particularly as pasture for cattle. The prairies of North America, for example, have traditionally been used as pasture grounds for many centuries.

Desert Ecosystem

The word desert comes from the Latin word 'desertus'. 'Desertus' means waste, or something that has been left. From this we get English words such as desert and deserted.

An ecosystem is a system of organisms that live together as a community. So, putting these words together, we can say that a desert ecosystem is a community of organisms that live together in an environment that seems to be deserted wasteland.



A desert is any place that is difficult to inhabit. Desert ecosystems can be hot (as in the sandy Sahara) or cold (as on the peaks of mountains where the high altitude makes conditions very harsh) but both hot and cold deserts have in common the fact that they are difficult for organisms to inhabit.

A desert ecosystem is generally witnesses little rainfall, resulting in less vegetation than in more humid areas of the globe. Look closely at any seemingly deserted piece of land and you will usually be able to see:

- **Numerous insects living in communities.**
- **An abundance of plant life.**
- **Mammals and birds.**
- **In addition, micro organisms such as bacteria will also be present in this ecosystem, though they are not visible to the naked human eye.**

In desert ecosystems, the plant and animal life that lives there will have evolved so that they can combat the harsh conditions (for example, they will have evolved to store water supplies in their bodies as water is very scarce in deserts).

There are so many different types of desert ecosystems. Let us look at each of them in turn.

Types of desert ecosystems.

When we hear the word desert, we usually think of a very hot, sandy environment. But, this is just one type of desert ecosystem. Read on to find out about this, and all the other key types of desert ecosystems.

1. Hot deserts.

Hot deserts can be found close to the equator. The Sahara is a good example of a hot desert. Hot deserts tend to feature scorching hot ground which many plants may struggle to grow on, little shade, and a shortage of water. The plants and animals that live here have evolved in order to adapt to these very hot conditions. For example, cacti have grown a tough outer skin and interiors which can store up any fluid that they absorb so that they can stay hydrated during droughts.

2. Cold deserts.

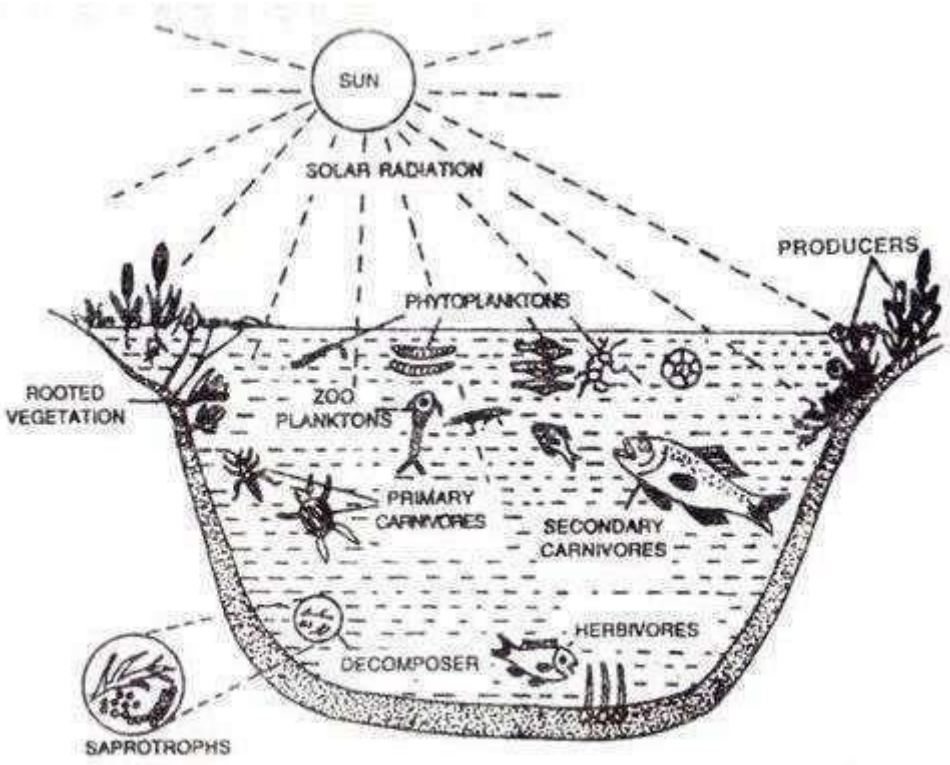
Hot deserts usually exist at low altitudes. Desertification can exist at high altitudes too, however – and when this happens, the desert will be cold. A good example is the deserted rocky peaks of a mountain. A cold desert may be sandy or rocky, but it will be a harsh environment where organisms have adapted in weird and wonderful ways so that they can survive.

3. Ice deserts.

Ice deserts are another type of cold desert. Here, instead of a sandy or rocky wasteland, we have a seemingly uninhabited region that is composed of ice. Ice deserts can be found towards the north and south poles of the planet, though they may also be located high up on mountain peaks.

Aquatic ecosystem

An aquatic ecosystem is an ecosystem that is water based. The word 'aquatic' comes from the Latin word for water. An ecosystem is a distinct community of organisms in a specific environment.



PONDS AS ECO-SYSTEM

So, we can say that an aquatic ecosystem is a community of organisms that live together, interact, and to an extent depend on each other in a water based environment.

There are various different types of aquatic ecosystem and this article explains all about four main types of aquatic habitats for animals. So, read on to find out all about them.

Characteristics of aquatic ecosystems.

Characteristics of aquatic ecosystems include:

1. **Being underwater, or**
2. **Being based around water.**
3. **Being a community of organisms.**
4. **Being a distinct community that is more or less self contained.**

Types of aquatic ecosystems.

It includes marine ecosystem and freshwater ecosystem – pond ecosystems, lake ecosystems and river ecosystems.

A. Marine ecosystems – salty water

Marine is a word that comes from the Latin word for sea – mar. So, a marine ecosystem is any ecosystem that exists within the sea. Our seas and oceans are vast bodies of salt water and so – while it may be argued that the whole ocean is one giant ecosystem – it may be also argued

that several different ecosystems can coexist within a single ocean. A whole host of different organisms live in marine ecosystems. When it comes to plant life, for example, we have seaweeds and marine algae. Invertebrates that live in the marine ecosystem include jellyfish and crustaceans. Meanwhile, there are fish such as sharks and eels, and mammals such as whales and seals. There are also various sea birds in all parts of the sea: they feed off the fish and other organisms that live there. Humans may also form part of the marine ecosystem if they fish in the sea for food.

B. Freshwater ecosystems

Contrary to the marine water ecosystem that contains salty water, freshwater ecosystem has little or no salt. The major types of freshwater ecosystem includes pond ecosystem, lake ecosystem and river ecosystem.

C. Pond ecosystems

A pond is discernibly a closed, self contained environment which houses a community of organisms. Ponds are usually freshwater ecosystems, however they can also be made up of brackish (salty or briny) water. Many different plants, fish and animals can live in these types of ecosystems. Frogs, newts, water weeds and water lilies are all examples of pond creatures. In addition, various types of fish can live in a pond. Ponds can be natural or human made ecosystems; if human made, it is not uncommon for goldfish or ornamental carp (such as koi carp) to live in a pond ecosystem. In addition, certain birds and insects may visit the pond ecosystem with regularity. For example, we might see dragonflies or herons around the pond. It may be up for debate whether these visitors are truly part of the ecosystem as they may also visit other ecosystems. But, it is certain that they have an impact on the ecosystem – and that it has an impact on them.

D. Lake ecosystems

Because they tend to be physically enclosed by the earth, rock or mountains around them, freshwater lakes are also identifiable as a distinct habitat that is inhabited by a distinct community of organisms. In a freshwater lake ecosystem, we can find all kinds of different organisms, including crustaceans (such as shrimp and crayfish), fish (like carp, trout and pike) and many birds, reptiles and amphibians. Freshwater lakes can be home to some beautiful plant life, such as tall purple irises, and the flora and fauna that abound within them may also change with the seasons. Some animals may only use lakes for looking after their offspring in, such as frogs that may leave frogspawn in a lake before leaving to inhabit other ecosystems.

E. Freshwater river ecosystems

River ecosystems are slightly different to ponds and lakes because whilst the latter two ecosystems offer stagnant (static) water, river water is always flowing. That means that these river ecosystems are the homes of animals and plants that are best adapted to living in flowing water. Salmon are a key example, as they use the flowing motion of a river to help them with their annual migration. And, in general, organisms that prefer to migrate – whether to seek food or to seek a partner – are often to be found in freshwater river

ecosystems because the motion of the river suits their style of life (whilst they, in their turn, have evolved to suit a flowing environment). Rivers tend to flow into the sea, and in this way river ecosystems and marine ecosystems meet each other. It may well, therefore, be up for debate to what extent river ecosystems are closed systems. But it is definitely clear that these are distinct types of fresh water ecosystems.

Importance of aquatic ecosystems.

The health of aquatic ecosystems is crucial to the health of the planet as a whole. Our earth is not called the blue planet for nothing: the seas with their fish, weeds, invertebrates and mammals and the rivers, lakes, streams, swamps and ponds of this world are all precious repositories of biodiversity. The seas help to regulate the world's temperature, too, and to lock carbon away from the atmosphere. Though we should all try and cut down on fish as a food source, there is no denying that fish and other aquatic organisms are irreplaceable links in the food chain for many terrestrial animals (i.e. animals that live on earth) as well.

Module 3: Biodiversity and its conservation • Introduction – Definition: genetic, species and ecosystem diversity; Biogeographically classification of India; Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values; Biodiversity at global, National and local levels; India as a mega-diversity nation; Hot-sports of biodiversity; Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts; Endangered and endemic species of India; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Biodiversity

The term biodiversity was coined as a contraction of biological diversity by E.O. Wilson in 1985. Biodiversity may be defined as the variety and variability of living organisms and the ecological complexes in which they exist. In other words, biodiversity is the occurrence of different types of ecosystems, different species of organisms with the whole range of their variants and genes adapted to different climates, environments along with their interactions and processes.

Biodiversity includes the genetic variability (for which different varieties of spices have appeared in the course of evolution) and diversity of life forms such as plants, animal microbes, etc. living in a wide range of ecosystems.

The diversity may be interspecific (within species) and interspecific (in between the species) but these are well supported by ecosystem. It is seen that the diverse living forms of the ecosystem are modulated with the global environmental changes.

Types of Biodiversity:

There are three interrelated hierarchical levels of biodiversity namely, genetic diversity, species diversity and community or ecosystem diversity.

1. Genetic diversity:

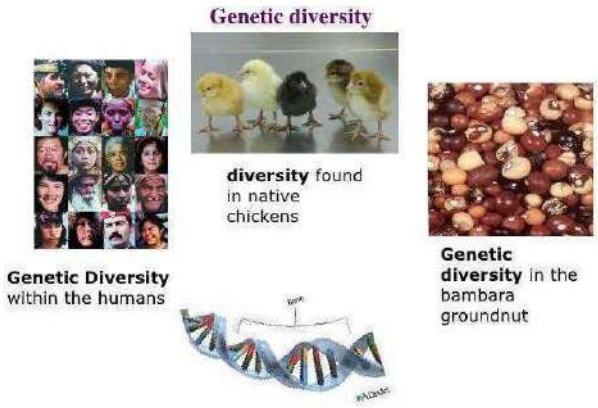
It describes the variation in the number and types of genes as well as chromosomes present in different species. The magnitude of variation in genes of a species increases with increase in size and environmental parameters of the habitat. The genetic variation arises by gene and chromosome mutation in individuals and in sexually reproducing organisms and it is spread in the population by recombination of genetic materials during cell division after sexual reproduction.

Genetic diversity has the following importance:

(i) It helps in speciation or evolution of new species;

(ii) It is useful in adaptation to changes in environmental conditions;

(iii) It is important for agricultural productivity and development.



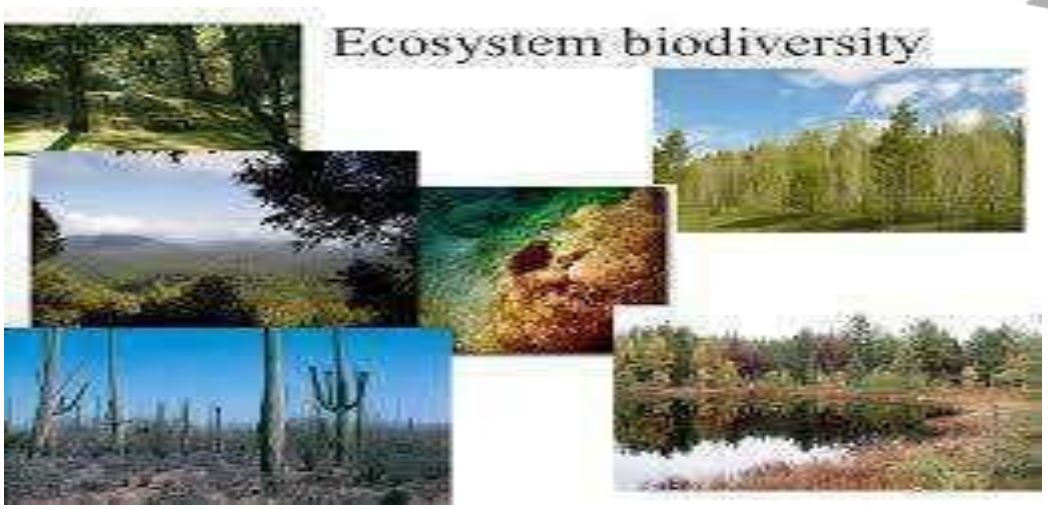
2. Species diversity:

It describes the variety in the number and richness of the spices with in a region. The species richness may be defined as the number of species per unit area. The richness of a species tells about the extent of biodiversity of a site and provides a means for comparing different sites. The species richness depends largely on climatic conditions. The number of individuals of different species with in a region represents species evenness or species equitability. The product species richness and species evenness give species diversity of a region. When a species is confined entirely to a particular area, it is termed as endemic species.

3. Ecosystem diversity:

It describes the assemblage and Interaction of spices living together and the physical environment a given area. It relates varieties of habitats, biotic communities ecological processes in biosphere. It also tells about the diversity within the ecosystem. It is referred as Land escape diversity because it includes placement and size of various ecosystems.

For example, the landscapes like grass lands, deserts, mountains etc. show ecosystem diversity. The ecosystem diversity is due to diversity of niches, trophic levels and ecological processes like nutrient cycling, food webs, energy flow, role of dominant species and various related biotic interactions. Such type of diversity can generate more productive and stable ecosystems or communities capable of tolerating various types of stresses e.g. drought, flood etc.



According to Whittaker (1965), the community diversities are of three types:

(i) α-Diversity:
It tells the species diversity in a given community. It depends upon species richness and evenness.

(ii) β-Diversity:
It describes a range of communities due to replacement of species which arises due to the presence of different microhabitats, niches and environmental conditions.

(iii) γ -Diversity:
It describes diversity of habitat over a total land escape or geographical area.

Biogeographically classification of India

Biogeographic classification of India is the division of India according to biogeography characteristics. Biogeography is the study of the distribution of species (biology), organisms, and ecosystems in geographic space and through geological time. There are ten biogeographic zones in India.

(i) Trans Himalayas,
(ii) Gangetic plain,
(iii) Desert,
(iv) Semiarid zone;
(v) Western Ghats;
(vi) Deccan peninsula,
(vii) North eastern zone,
(viii) Coastal lands
(ix) Himalayas,
(x) Islands.

Trans Himalayas

The Himalayan ranges immediately north of the Great Himalayan range are called the Trans-Himalayas. The Trans-Himalayan region with its sparse vegetation has the richest wild sheep

and goat community in the world. The snow leopard is found here, as is the migratory black-necked crane.

Himalayas

Bio-geographical representation of himalayas.

The Himalayas consist of the youngest and loftiest mountain chains in the world. The Himalayas have attained a unique personality owing to their high altitude, steep gradient and rich temperate flora.

The forests are very dense with extensive growth of grass and evergreen tall trees. Oak, chestnut, conifer, ash, pine, deodar are abundant in Himalayas. There is no vegetation above the snowline. Several interesting animals live in the Himalayan ranges. Chief species include wild sheep, mountain goats, ibex, shrew, and tapir. Panda and snow leopard are also found here.

Semi-Arid Areas

Adjoining the desert are the semi-arid areas, a transitional zone between the desert and the denser forests of the Western Ghats. The natural vegetation is thorn forest. This region is characterized by discontinuous vegetation cover with open areas of bare soil and soil-water deficit throughout the year.

Thorny shrubs, grasses and some bamboos are present in some regions. A few species of xerophytic herbs and some ephemeral herbs are found in this semi-arid tract. Birds, jackals, leopards, eagles, snakes, fox, buffaloes are found in this region.

Western Ghats

The mountains along the west coast of peninsular India are the Western Ghats, which constitute one of the unique biological regions of the world. The Western Ghats extend from the southern tip of the peninsula (8°N) northwards about 1600 km to the mouth of the river Tapti (21°N).

The mountains rise to average altitudes between 900 and 1500 m above sea level, intercepting monsoon winds from the southwest and creating a rain shadow in the region to their East.

The varied climate and diverse topography create a wide array of habitats that support unique sets of plant and animal species. Apart from biological diversity, the region boasts of high levels of cultural diversity, as many indigenous people inhabit its forests.

The Western Ghats are amongst the 25 biodiversity hot-spots recognized globally. These hills are known for their high levels of endemism expressed at both higher and lower taxonomic levels. Most of the Western Ghat endemic plants are associated with evergreen forests.

The region also shares several plant species with Sri Lanka. The higher altitude forests were, if at all, sparsely populated with tribal people. Rice cultivation in the fertile valley proceeded gardens of early commercial crops like areca nut and pepper. The original vegetation of the ill-drained valley bottoms with sluggish streams in elevations below 100m would be often a special formation, the Myristica swamp.

Expansion of traditional agriculture and the spread of particularly rubber, tea, coffee and forest tree plantations would have wiped out large pockets of primary forests in valleys. The Western Ghats are well known for harboring 14 endemic species of caecilians (i.e., legless amphibians) out of 15 recorded from the region so far.

North-West Desert Regions

This region consists of parts of Rajasthan, Kutch, Delhi and parts of Gujarat. The climate is characterised by very hot and dry summer and cold winter. Rainfall is less than 70 cm. The plants are mostly xerophytic. Babul, Kikar, wild palm grows in areas of moderate rainfall. Indian Bustard, a highly endangered bird is found here. Camels, wild asses, foxes, and snakes are found in hot and arid parts of the desert.

Deccan Plateau

Beyond the Ghats is Deccan Plateau, a semi-arid region lying in the rain shadow of the Western Ghats. This is the largest unit of the Peninsular Plateau of India. The highlands of the plateau are covered with different types of forests, which provide a large variety of forest products.the Deccan plateau includes the region lying south of the Satpura range.it extends up to the southern tip of peninsular India.Anai mudi is the highest peak of this region.The Deccan plateau is surrounded by the western and the eastern ghats.These ghats meet each other at the Nilgiri hills. The western ghats includes the Sahyadri, Nilgiris, Anamalai, and cardamom hills.many rivers such as Mahanadi, Godavari, krishna, and kaveri originates from western ghats and flow toward the east.The eastern ghats are broken into small hill rangesby river coming from the western ghats.Most of these rivers fall into the bay of bengal.The Godavari is the longest river in the Deccan plateau .the Narmada and the Tapi flow westwards and fall into the Arabian sea.

Gangetic Plain

In the North is the Gangetic plain extending up to the Himalayan foothills. This is the largest unit of the Great Plain of India. Ganga is the main river after whose name this plain is named. The aggradational Great Plains cover about 72.4mha area with the Ganga and the Brahmaputra forming the main drainage axes in the major portion.

The thickness in the alluvial sediments varies considerably with its maximum in the Ganga plains. The physiogeographic scenery varies greatly from arid and semi-arid landscapes of the Rajasthan Plains to the humid and per-humid landscapes of the Delta and Assam valley in the east.

Topographic uniformity, except in the arid Western Rajasthan is a common feature throughout these plains. The plain supports some of the highest population densities depending upon purely agro-based economy in some of these areas. The trees belonging to these forests are teak, sal, shisham, mahua, khair etc.

North-East India

North-east India is one of the richest flora regions in the country. It has several species of orchids, bamboos, ferns and other plants. Here the wild relatives of cultivated plants such as banana, mango, citrus and pepper can be grown

Islands

The two groups of islands, i.e., the Arabian Sea islands and Bay Islands differ significantly in origin and physical characteristics. The Arabian Sea Islands (Laccadive, Minicoy, etc.) are the foundered remnants of the old land mass and subsequent coral formations. On the other hand, the Bay Islands lay only about 220 km.

Away from the nearest point on the main land mass and extend about 590 km. With a maximum width of 58 km the island forests of Lakshadweep in the Arabian Sea have some of the best-preserved evergreen forests of India. Some of the islands are fringed with coral reefs. Many of them are covered with thick forests and some are highly dissected.

Coasts

India has a coastline extending over 7,516. 4 km. The Indian coasts vary in their characteristics and structures. The west coast is narrow except around the Gulf of Cambay and the Gulf of Kutch. In the extreme south, however, it is somewhat wider along the south Sahyadri.

The backwaters are the characteristic features of this coast. The east coast plains, in contrast are broader due to depositional activities of the east-flowing rivers owing to the change in their base levels.

Extensive deltas of the , Godavari, Krishna and Kaveri are the characteristic features of this coast. Mangrove vegetation is characteristic of estuarine tracts along the coast for instance, at Ratnagiri in Maharashtra.

Larger parts of the coastal plains are covered by fertile soils on which different crops are grown. Rice is the main crop of these areas. Coconut trees grow all along the coast.

Value of biodiversity

The living organisms on earth are of great diversity, living in diverse habitats and possessing diverse qualities and are vital to human existence providing food, shelter, clothing's, medicines etc.

Value of biodiversity

1. Productive values:

Biodiversity produces a number of products harvested from nature and sold in commercial markets. Indirectly it provides economic benefits to people which include water quality soil

protection, equalization of climate, environmental monitoring, scientific research, recreation etc.

2. Consumptive value:

The consumptive value can be assigned to goods such as fuel woods, leaves, forest products etc. which may be consumed locally and do not figure in national and international market.

3. Social value:

The loss of biodiversity directly influences the social life of the country possibly through influencing ecosystem functions (energy flow and biogeochemical cycle). This be easily understood by observing detrimental effects of global warming and acid rain which cause an unfavorable alteration in logical processes.

4. Aesthetic value:

Aesthetic values such as refreshing fragrance of the flowers, taste of berries, softness of mossed, melodious songs of birds, etc. compel the human beings to preserve them. The earth's natural beauty with its colour and hues, thick forest, and graceful beasts has inspired the human beings from their date of birth to take necessary steps for its maintenance. Similarly botanical and zoological gardens are the means of biodiversity conservation and are of aesthetic values.

5. Legal values:

Since earth is homeland of all living organisms, all have equal right to coexist on the surface of earth with all benefits. Unless some legal value is attached to biodiversity, it will not be possible to protect the rapid extinction of species.

6. Ethical value:

Biodiversity must be seen in the light of holding ethical value. Since man is the most intelligent amongst the living organisms, it should be prime responsibility and moral obligation of man to preserve and conserve other organisms which will directly or indirectly favour the existence of the man.

7. Ecological value:

Biodiversity holds great ecological value because it is indispensable to maintain the ecological balance. Any disturbance in the delicately fabricated ecological balance maintained by different organisms, will lead to severe problems, which may threaten the survival of human beings.

8. Economic value:

Biodiversity has great economic value because economic development depends upon efficient and economic management of biotic resources.

In the day to day life, human beings are maintaining their lifestyle at the sacrifice of surrounding species which come from diversity of plants and animals struggling for their existence.

So, it is highly essential for the human beings to take care of their surrounding species and make optimum use of their service, for better economic development. Thus, it is rightly told, survival of the man depends upon the survival of the biosphere.

Biodiversity at Global, National and Local Levels

Global Level: **Conservative estimates of the existing biodiversity is ten million species, but if estimates for insects are correct then it could be around 30 million species, we have till now enlisted about 1.4 million species.**

It includes among others about 98% birds, 95% reptiles and amphibians, 90% fish and about 85% higher plants known to exist on this Earth.

Table 4.1 Known and Estimated diversity of life on Earth

Form of Life	Known Species	Estimated Total Species
Insects and other arthropods	874,161	30 Million species, extrapolated from surveys in forest canopy in Panama, most believed to be unique to tropical forests.
Higher plants	248,400	Estimates range from 275,000 to 400,000 at least 10.15% species believed undiscovered.
Invertebrates (excludes arthropods)	116,873	True invertebrates may number millions of species. Nematodes, eelworms, and roundworms may each comprise more than one million species
Lower plants (fungi and algae)	73,900	Not available
Micro organisms	36,600	Not available
Fish	10,056	21,000 assuming that 10% fish remain undiscovered, the Amazon and Orinoco rivers alone may account for 2,000 additional species.
Birds	9,040	Known species probably account for over 98% of all birds.
Reptiles and Amphibians	8,962	Known species probably account for over 95% of all reptiles and amphibians.
Mammals	4,000	Known species probably account for over 95% of all mammals.
Total	1,390,992	10 million species considered a conservative estimate. If insect estimates are accurate, total exceeds 30 million.

National and Local Level:

India has over 108,276 species of bacteria, fungi, plants and animals already identified and described (Table 4.2). Out of these, 84 percent species constitute fungi (21.2 percent), flowering plants (13.9 percent), and insect (49.3 percent). In terms of the number of species, the insecta alone constitute nearly half of the biodiversity in India (Fig 4.1).

These species occur on land, fresh and marine waters, or occur as symbionts in mutualistic or parasitic state with other organisms. In the world as a whole, 16, 04,000 species of Monera, Protista, Fungi, Plantae and Animalia have been described so far. However, it is estimated that at least 179, 80,000 species exist in the world, but as a working figure 122, 50,000 species are considered to be near reality.

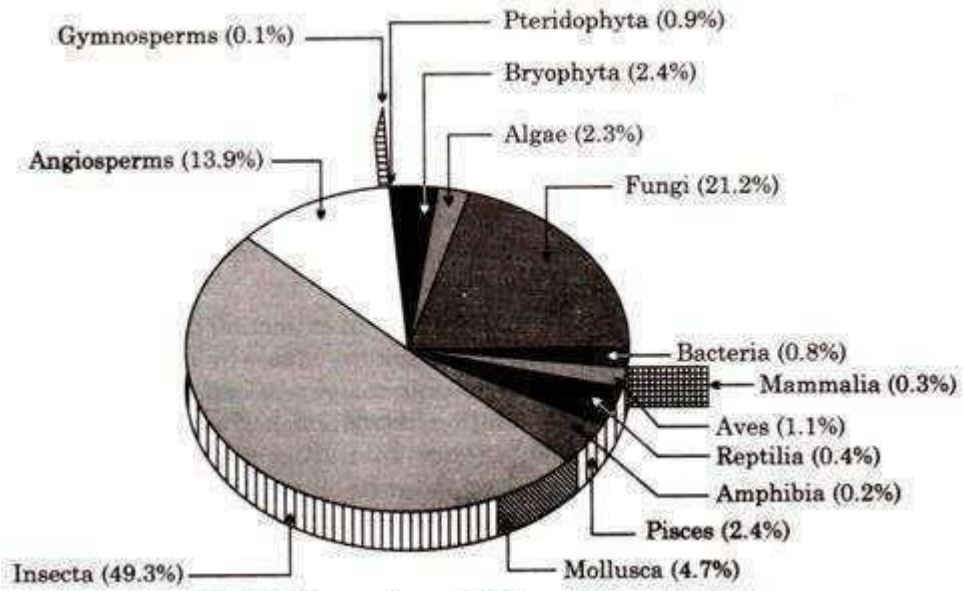


Fig. 4.1. Percentage of Different Biota in India.

Table 4.2 : Number of Species of Bacteria, Fungi, Plants and Animals

Taxon	Number of Species	Percentage
Bacteria	850	0.8
Fungi	23,000	21.2
Algae	2,500	2.3
Bryophyte	2,564	2.4
Pteridophyta	1,022	0.9
Gymnosperms	64	0.1
Angiosperms	15,000	13.9
Insecta	53,430	49.3
Mollusca	5,050	4.7
Pisces	2,546	2.4
Amphibian	204	0.2
Reptilia	446	0.4
Aves	1,228	1.1
Mammalian	372	0.3
Total	108,276	100.00

India is 10th among the plant rich countries of the world, fourth among the Asian countries, eleventh according to the number of endemic species of higher vertebrates (amphibia, birds and mammals), and tenth in the world as far as richness in mammals is concerned. Out of the 10 'Hot spots' identified in the world, India has four. These are Eastern Himalaya, North East India, Western Ghats and Andaman & Nicobar Islands.

The crops which first grew in India and spread throughout the world include rice, sugarcane, Asiatic vignas, jute, mango, citrus, and banana, several species of millets, spices, medicinal, aromatics and ornamentals. India ranks sixth among the centres of diversity and origin in terms of agro-biodiversity.

India as a mega-diversity nation

A mega-diverse country is one that harbors the majority of the Earth's species and is therefore considered extremely biodiverse. India is rich in biodiversity from north to south and from east to west. India contains many species that world's gone country have. It has 14 major basins through which drain numerous rivers. The annual rainfall varies from less than 37 cm in Rajasthan to 1500m in Cherapunji. The country experiences three different seasons – winter, summer, and monsoons. It has two global terrestrial biodiversity hot spots – the North-eastern States and the Western Ghats. The Western Ghats have moist deciduous forests and rainforests. The region shows high species diversity as well as high levels of endemism. Around 62% of reptile and 77% of amphibians are found in here. The North-eastern States depicts high altitudinal variations. This area has at least 163 globally threatened species like one-horned rhinoceros and the wild Asian water buffalo. The Relict Dragonfly, an endangered species found here. This zone houses the Himalayan Newt the only salamander species found within Indian limits.

1. **The great variety of ecological conditions prevailing in India, tropical location, climate and physical features all aid in supporting an enormous diversity of wildlife, including, hot desert forms, like wild ass and the cold desert forms, like the Tibetan antelope: animals of open scrubland, like the black buck and of grassy swamps, like the rhinoceros; animals of the deciduous forests like the wild gaur and of the tropical rainforests, like the lion-tailed macaque. India's bio-geographical composition is unique as it combines living forms from three major bio-geographical realms, namely – Eurasian, Agro-Tropical, and Indo-Malayan. India lies at the confluence of Ethiopian, Palaearctic, and Indo-Malayan faunas and possesses some interesting components. The chinkara, the hyena, and the rates represent the Ethiopian element; the lynx, wolf, hangul represent the Palaearctic; the Chinese by red panda and the musk-deer; the Indo-Malayan by the hoolock gibbon, the goat-antelope, and the mouse deer. The endemic varieties include sloth bear, antelope or black buck, four-horned antelope and Boselaphus or nilgai. 15,000 species of flowering plants, 53,430 species of insects; 5050 species of mollusks, 6,500 species of other invertebrates; 2,546 species of fishes; 1228 species of birds, 446 species of reptiles, 372 species of mammals and 204 species of amphibians have been identified. India's biodiversity is estimated to be over 45,000 plant species representing about 7% of the world's flora and India stands tenth in 25 most plant-rich countries of the world. Its variety of animal life represents 6.5 per cent of world's fauna.**
2. **It has great marine diversity due to its 7500km long coastline. The near shore coastal waters of India are extremely rich fishing grounds. The marine environment of India supports coral reefs in the Gulf of Kutch, off the southern mainland coast, and around some islands opposite Sri Lanka. Indian coral reefs' resources are of high commercial**

value. On the Gulf of Mannar and Gulf of Kutch reefs corals, coral debris and coral sands are widely exploited, and ornamental shells, sharks, and pearl oysters are the basis of an important reef industry in the south of India. Five species of marine turtle occur in Indian waters: Green turtle Chelonia mydas, Loggerhead Caretta caretta, Olive RidleyLepidochelys olive, Hawksbill Eretmochelys imbricate, and Leatherback Dermochelys coriacea. Seagrass beds are important feeding areas for the Dugong dugon, plus several species of marine turtle.

3. To preserve the rich biodiversity, nine biosphere reserves have been set up in specific biogeographic" zones: the biggest being in the Deccan Peninsula in the Nilgiris covering Tamil Nadu, Andhra Pradesh, and Karnataka. Others include the Nanda Devi in Uttarakhand in the Western Himalayas, the Nokrek in Meghalaya, Manas, and Dibru Saikhowa in Assam, the Sunderbans in the Gangetic plain in West Bengal, Similar in Orissa, the Great Nicobar and the Gulf of Mannar in Tamil Nadu. As per satellite imaging, about 19 percent of the land area of the country comprise of forests. It has 80 national parks at present, which houses the largest number of tigers and one-horned rhinos found in the world, Asiatic lions and a large percent of elephants. Six significant wetland areas of India have been declared as "'amsar Sites" under the Ramsar Convention. Under the World Heritage Convention, five natural sites have been declared as "World Heritage Sites."
4. There is a vital, but often neglected factor when we focus on biodiversity. It may be a matter of surprise to understand that the tribal people who officially constitute 7.5 percent of India's population have preserved around 90 percent of the country's biocultural diversity. To a large extent, the survival of our biodiversity depends on how best the tribal are looked after.
5. India accredited the International Convention on Biodiversity (CBD) on 18 February 1994 and became Party to the Convention in May 1994. The CBD is an international legal instrument for fostering conservation and sustainable use of biological diversity and the fair and equitable sharing of the benefits arising from commercial and other utilization of genetic resources. It is the responsibility of The Ministry of Environment and Forest in India to oversee environmental policy and procedures and the administration of the national parks of the country as well. India has worked on creating 'landscape conversion' that include wildlife reserves, communal forest, and some private lands.

India is one of the twelve mega diversity nations of the world due to the following reasons:

(i) It has 7.3% of the global fauna and 10.88% of global flora as per the data collected by Ministry of Environment and forest.

(ii) It has 350 different mammals, 1200 species of birds- 453 different reptiles, 182 amphibians and 45,000 plants spices.

(iii) It has 50,000 known species of insects which include 13,000 butterflies and moths.

(iv) It has 10 different biogeographical regions and 25 biotic provinces having varieties of lands and species.

(v) In addition to geographical distribution, geological events in the land mass provide high level of biological diversity.

(vi) Several crops arose in the country and spread throughout the world.

(vii) There is wide variety of domestic animals like cows, buffaloes, goats, sheep, pigs, horses etc.

(viii) The marine biota includes sea weeds, fishes, crustaceans, molluses, corals, reptiles etc.

(ix) There are a number of hot spots (namely Eastern Ghats, Western Ghats, North Eastern hills etc.).

Hot-spots of biodiversity

Hot spots are the areas with high density of biodiversity or mega diversity which are most threatened at present. There are 16 hot spots in world, out of which two are located in India namely North-East Himalayas and Western Ghats.

The hot spots are determined considering four factors:

(i) Degrees of endemism;

(ii) Degree of expectation

(iii) Degrees of threat to habitat due to its degradation and fragmentation and

(iv) Number of Species diversity.

The British biologist Norman Myers coined the term "biodiversity hotspot" in 1988 as a biogeographic region characterized both by exceptional levels of plant endemism and by serious levels of habitat loss. In 1990 Myers added a further eight hotspots, including four Mediterranean-type ecosystems. Conservation International (CI) adopted Myers' hotspots as its institutional blueprint in 1989, and in 1996, the organization made the decision to undertake a reassessment of the hotspots concept. Three years later an extensive global review was undertaken, which introduced quantitative thresholds for the designation of biodiversity hotspots.

According to CI, to qualify as a hotspot a region must meet two strict criteria: it must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics, and it has to have lost at least 70% of its original habitat. In 1999, CI identified 25 biodiversity hotspots in the book "Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions".

Collectively, these areas held as endemics about 44% of the world's plants and 35% of terrestrial vertebrates in an area that formerly covered only 11.8% of the planet's land surface. The habitat extent of this land area had been reduced by 87.8% of its original extent, such that this wealth of biodiversity was restricted to only 1.4% of Earth's land surface. In 2005 CI published an updated titled "Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions".

GLOBAL BIODIVERSITY HOTSPOTS: WORLD

1. **AFRICA**

A total of 8 Hotspots in African continent hold a diversity of plant and animal life, many of which are found nowhere else on Earth.

2. **ASIA-PACIFIC**

Composed of large land areas as well as islands dotting the Pacific seas, these 14 Hotspots represent important biodiversity.

3. **EUROPE AND CENTRAL ASIA**

From the Mediterranean Basin to the Mountains of Central Asia, these four Hotspots are unique in their diversity.

4. NORTH AND CENTRAL AMERICA

North and Central America play host to thousands of acres of important habitat.

5. SOUTH AMERICA

From Brazil's Cerrado to the Tropical Andes, South America has some of the richest and most diverse life on Earth.

Life on Earth faces a crisis of historical and planetary proportions. Unsustainable consumption in many northern countries and crushing poverty in the tropics are destroying wild nature. Biodiversity is besieged. Extinction is the gravest aspect of the biodiversity crisis: it is irreversible. While extinction is a natural process, human impacts have elevated the rate of extinction by at least a thousand, possibly several thousand, times the natural rate. Mass extinctions of this magnitude have only occurred five times in the history of our planet; the last brought the end of the dinosaur age. In a world where conservation budgets are insufficient given the number of species threatened with extinction, identifying conservation priorities is crucial.

The biodiversity hotspots hold especially high numbers of endemic species, yet their combined area of remaining habitat covers only 2.3% of the Earth's land surface. Each hotspot faces extreme threats and has already lost at least 70% of its original natural vegetation. Over 50% of the world's plant species and 42% of all terrestrial vertebrate species are endemic to the 35 biodiversity hotspots.

World's 35 Biodiversity Hotspots

I. Africa	**III. Europe and Central Asia**
Cape Floristic Region	**3. Caucasus**
Coastal Forests of Eastern Africa	**4. Irano-Anatolian**
Eastern Afromontane	**5. Mediterranean Basin**
Guinean Forests of West Africa	**6. Mountains of Central Asia**
Horn of Africa	
Madagascar and the Indian Ocean Islands	**IV. North and Central America**
Maputaland-Pondoland-Albany	
Succulent Karoo	**7. California Floristic Province**
	8. Caribbean Islands
II. Asia-Pacific	**9. Madrean Pine-Oak Woodlands**
	0. Mesoamerica
East Melanesian Islands	
0. Himalaya	**V. South America**
1. Indo-Burma	
2. Japan	**1. Atlantic Forest**
3. Mountains of Southwest China	**2. Cerrado**
4. New Caledonia	**3. Chilean Winter Rainfall-Valdivian Forests**
5. New Zealand	**4. Tumbes-Chocó-Magdalena**
6. Philippines	**5. Tropical Andes**
7. Polynesia-Micronesia	
8. Southwest Australia	

9. Forests of Eastern Australia (new) 10. Sundaland 11. Wallacea 12. Western Ghats and Sri Lanka	

GLOBAL BIODIVERSITY HOTSPOTS: ASIA-PACIFIC

1. East Melanesian Islands

Once largely intact, the 1,600 East Melanesian Islands are now a hotspot due, sadly, to accelerating levels of habitat loss.

2. Himalaya

The Himalaya Hotspot is home to the world's highest mountains, including Mt. Everest.

3. Indo-Burma

Encompassing more than 2 million km² of tropical Asia, Indo-Burma is still revealing its biological treasures.

4. Japan

The islands that make up the Japanese Archipelago stretch from the humid subtropics in the south to the boreal zone in the north, resulting in a wide variety of climates and ecosystems.

5. Mountains of Southwest China

With dramatic variations in climate and topography, the Mountains of Southwest China support a wide array of habitats including the most endemic-rich temperate flora in the world.

6. New Caledonia

An island the size of New Jersey in the South Pacific Ocean, New Caledonia is the home of no less than five endemic plant families.

7. New Zealand

A mountainous archipelago once dominated by temperate rainforests, New Zealand harbors extraordinary levels of endemic species.

8. Philippines

More than 7,100 islands fall within the borders of the Philippines hotspot, identified as one of the world's biologically richest countries.

9. Polynesia-Micronesia

Comprising 4,500 islands stretched across the southern Pacific Ocean, the Polynesia-Micronesia hotspot is the epicenter of the current global extinction crisis.

10. Southwest Australia

The forest, woodlands, shrublands, and heath of Southwest Australia are characterized by high endemism among plants and reptiles.

11. Forests of Eastern Australia

Forests of East Australia Hotspot consists of a discontinuous coastal stretch along the Australian states of Queensland and New South Wales, extending inland and further west, although it includes the New England Tablelands and the Great Dividing Range. This region contains more than 1500 endemic vascular plants.

12. Sundaland

The spectacular flora and fauna of the Sundaland Hotspot are succumbing to the explosive growth of industrial forestry in these islands.

13. Wallacea

The flora and fauna of Wallacea are so varied that every island in this hotspot needs secure protected areas to preserve the region's biodiversity.

14. Western Ghats and Sri Lanka

Faced with tremendous population pressure, the forests of the Western Ghats and Sri Lanka have been dramatically impacted by the demands for timber and agricultural land.

BIODIVERSITY HOTSPOTS IN INDIA

1. **Himalaya: Includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar)**
2. **Indo-Burma: Includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China)**
3. **Sundalands: Includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines)**
4. **Western Ghats and Sri Lanka: Includes entire Western Ghats (and Sri Lanka)**

Threats to biodiversity

Biodiversity is considered as a reservoir of resources to be used for the manufacture of food, medicine, industrial products, etc. But with an increased demand of rapid population growth, biodiversity is gradually depleting. A number of plants" and animal species have already become extinct and many are endangered.

The different factors responsible for causing threat to biodiversity are as follows:

1. Habitat destruction:

The primary cause of loss of biodiversity is habitat loss or destruction which is resulted due to the large industrial and commercial activities associated with agriculture, irrigation, construction of dams, mining, fishing etc.

2. Habitat fragmentation:

With increased population, the habitats are fragmented into pieces by roads, fields, canals, power lines, towns etc. The isolated fragment of habitats restricts the potential of species for dispersal and colonization. In addition, the habitat fragmentation also brings about microclimatic changes in light, temperature, wind etc.

3. Pollution:

The most dreaded factor inducing loss of biodiversity is environmental pollution which include air pollution, Water pollution, industrial pollution, pollution due to chemical Pastes, pesticides radioactive materials etc.

4. Over exploitation:

The natural resources are over exploited to meet growing rural poverty, intensive technological growth and globalization of economy. All these factors together may be responsible for the extinction of a number of species.

5. Introduction of exotic species:

The introduction of exotic species are due to:

(i) horticulture

(ii) agriculture;

(iii) European colonisation and

(iv) accidental transport.

It is seen that some exotic species may kill or eat the native species thereby causing its extinction.

6. Diseases:

Since the animals are more vulnerable to infection, the anthropological activities may increase the incidence of diseases in wild species, leading to their extinction.

7. Shifting or Jhum cultivation:

The shifting or Jhum cultivation by poor tribal people greatly affects the forest structure which is a store house of biodiversity.

8. Poaching of wild life:

A number of wildlife species are becoming extinct due to poaching and hunting.

<u>Conservation of biodiversity</u>

Biodiversity is being depleted by the loss of habitat, fragmentation of habitat, over exploitation of resources, human sponsored ecosystems, climatic changes, pollution invasive exotic spices, diseases, shifting cultivation, poaching of wild life etc. Since the human beings are enjoying all the benefits from biodiversity, they should take proper care for the preservation of biodiversity in all its form and good health for the future generation i.e., the human being should prevent the degradation and destruction of the habitats thereby maintaining the biodiversity at its optimum level. Conservation of biodiversity is protection, up lift- ment and scientific management of biodiversity so as to maintain it at its threshold

level and derive sustainable benefits for the present and future generation. In other words, conservation of bio-diversity is the proper management of the biosphere by human beings in such a way that it gives maximum benefits for the present generation and also develops its potential so as to meet the needs of the future generations.

Mainly the conservation of biodiversity has three basic objectives:

(a) To maintain essential ecological processes and life supporting systems.

(b) To preserve the diversity of species.

(c) To make sustainable utilisation of species and ecosystems.

Strategies for Conservation of Biodiversity:

The following strategies should be undertaken in order to conserve biodiversity:

(1) All the possible varieties (old or new) of food, forage and timber plants, live stock, agriculture animals and microbes should be conserved.

(2) All the economically important organisms in protected areas should be identified and conserved.

(3) Critical habitats for each species should be identified and safeguarded.

(4) Priority should be given to preserve unique ecosystems.

(5) There should be sustainable utilisation of resources.

(6) International trade in wild life should be highly regulated.

(7) The poaching and hunting of wildlife should be prevented as far as practicable.

(8) Care should be taken for the development of reserves and protected areas.

(9) Efforts should be made to reduce the level of pollutants in the environment.

(10) Public awareness should be created regarding biodiversity and its importance for the living organisms.

(11) Priority should be given in wildlife conservation programme to endangered species over vulnerable species and to vulnerable species over rare species.

(12) The habitats of migratory birds should be protected by bilateral and multilateral agreement.

(13) The over exploitation of useful products of wild life should be prevented.

(14) The useful animals, plants and their wild relatives should be protected both in their natural habitat (in-situ) and in zoological botanical gardens (ex-situ)

(15) Efforts should be made for setting up of National parks and wild life sanctuaries to safeguard the genetic diversity and their continuing evolution.

(16) Environmental laws should be strictly followed.

<u>Conservation Methods:</u>

There are two types of conservation methods namely in-situ and ex-situ conservations. Let us discuss the different conservation methods along with their importance.

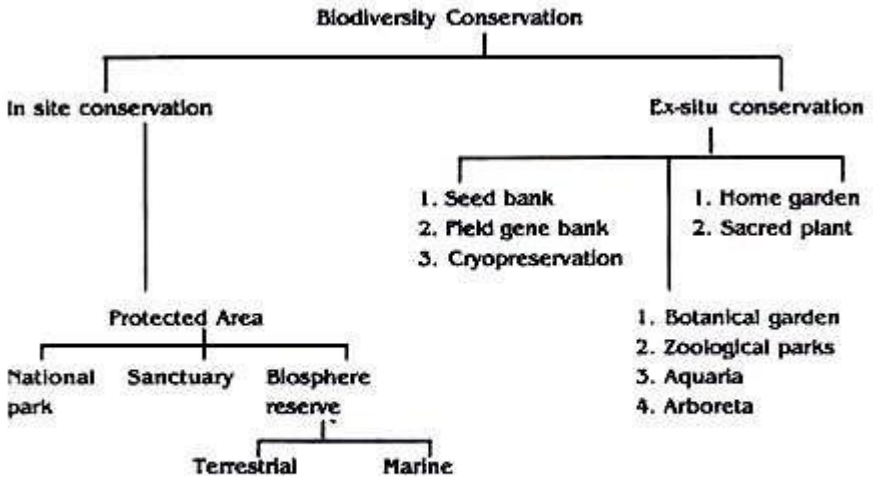


FIG. 5.1 : SCHEME SHOWING BIODIVERSITY CONSERVATION MANAGEMENT SYSTEMS.

(a) In situ conservation:

The conservation of species in their natural habitat or natural ecosystem is known as in situ conservation. In the process, the natural surrounding or ecosystem is protected and maintained so that all the constituent species (known or unknown) are conserved and benefited. The factors which are detrimental to the existence of species concerned are eliminated by suitable mechanism.

The different advantages of in situ conservation are as follows:

(a) If is a cheap and convenient way of conserving biological diversity.

(b) It offers a way to preserve a large number of organisms simultaneously, known or unknown to us.

(c) The existence in natural ecosystem provides opportunity to the living organisms to adjust to differed' environmental conditions and to evolve in to a better life form.

The only disadvantage of in situ conservation is that it requires large space of earth which is often difficult because of growing demand for space. The protection and management of biodiversity through in situ conservation involve certain specific areas known as protected areas which include national parks, Sanctuaries and Biosphere reserves.

1. Protected areas:

The protected areas are biogeographical areas where biological diversity along with natural and cultural resources are protected, maintained and managed through legal and administrative measures. The demarcation of biodiversity in each area is determined on the basis of climatic and physiological conditions.

In these areas, hunting, firewood collection, timber harvesting etc. are prohibited so that the wild plants and animals can grow and multiply freely without any hindrance. Some protected areas are: Cold desert (Ladakh and Spiti), Hot desert (Thar), Saline Swampy area (Sunderban and Rann of Kutch), Tropical moist deciduous forest (Western Ghats and north East) etc.

protected areas throughout the world. As per World Conservation Monitoring Centre, India has 581 protected areas, national parks and sanctuaries.

2. National parks:

These are the small reserves meant for the protection of wild life and their natural habitats. These are maintained by government. The area of national parks ranges between 0.04 to 3162 km. The boundaries are well demarcated and circumscribed. The activities like grazing forestry, cultivation and habitat manipulation are not permitted in these areas. There are about 89 national parks in India.

Some important national Parks of India are:

(i) Biological Park, Nandankanan, Orissa,

(ii) Corbett national Park Nainital, U.P. (First national Park)

(iii) Koziranga national Park, Jorhat, Assam

(iv) Tudula national Park, Maharashtra

(v) Hazaribagh national Park, Hazaribagh, Bihar

(vi) Band havgarh national park, M.P.

(vii) Bandipur national park, Karnataka.

(viii) Kanha National Park, M.P.

(ix) Reibul Lamjao National Park, Manipur

(x) Nawgaon National Park, Maharashtra

3. Sanctuaries:

These are the areas where only wild animals (fauna) are present. The activities like harvesting of timbers, collection of forest products, cultivation of lands etc. are permitted as long as these do not interfere with the project. That is, controlled biotic interference is permitted in sanctuaries, which allows visiting of tourists for recreation. The area under a sanctuary remains in between 0.61 to 7818 km.

Some important sanctuaries of Orissa are as follows:

(i) Nandankanan Zoological Park

(ii) Chandaka Elephant reserve

(iii) Simlipal Tiger Reserve

(iv) Bhitarkanika Wild life Sanctuary

(v) Gharial project at Tikarpada

(vi) Chilika (Nalaban) Sanctuary

4. Biosphere reserves:

Biosphere reserves or natural reserves are multipurpose protected areas with boundaries circumscribed by legislation. The main aim of biosphere reserve is to preserve genetic diversity in representative ecosystems by protecting wild animals, traditional life style of inhabitant and domesticated plant/ animal genetic resources. These are scientifically managed allowing only the tourists to visit.

Some importance of biosphere reserves are as follows:

(a) These help in the restoration of degraded ecosystem.

(b) The main role of these reserves is to preserve genetic resources, species, ecosystems, and habitats without disturbing the habitants.

(c) These maintain cultural, social and ecologically sustainable economic developments.

(d) These support education and research in various ecological aspects,

Some important biosphere reserves are:

Simlipal, (Orissa), Sunderban (West Bengal), Kanha (M.P Kaziranga (Assam) etc. The biosphere reserve net work was introduced by UNESCO 1971.

TABLE 5.2 : BIOSPHERE RESERVES OF INDIA

S. No.	Date notified	Name of the site	Area in sq.km.	Location (state)
1.	0.1.08.86	Nilgiri	5,520	Parts of Wynad, Nagarhole, bandipur and Mudumalai, Nilambur, Silent Valeey, and the Siruvani Hills (Tamil Nadu, Kerala and Karnataka)
2.	18.01.88	Nanda Devi	5,860.69	Parts o the Chamoli, Pithoragarh, and Almorae dis tricts Utaranchal)
3.	01.09.88	Nokrerk	820	Part of Gora Hills (Meghalaya)
4.	14.03.89	Manas	2,837	Parts of the Kokrajhar, Bongaigaon, Parpeta, Nalbari, Kamprup, and Daarang districts (Assam)
5.	29.03.89	Sunderbans	9,630	Parts of the Brahamaputra and Ganga deltas (West Bengal)
6.	18.02.89	Gulf of Mannar	10,500	Indian part of Gulf of Mannar between India and Sri Lanka (Tamil Nadu)
7.	06.01.89	Great Nicobar	885	Southernmost islands of the Andaman and Nicobar islands.
8.	21.06.94	Similpal	4,374	Partof Mayurbhanj district (Orissa)
9.	29.07.97	Dibru-Saikhowa	765	Parts of the Dibrugarh and Tinsukia districts (Assam)
10.	02.09.98	Dehang Debang	5,112	Parts of Siang and Debang Valley (Arunachal Pradesh).
11.	03.03.99	Pachmarhi	4,926.28	Part of the Betul, Hoshangabad, and Chindwara dis tricts (Madhya Pradesh)
12.	07.02.00	Kanchanjanga	2,619.92	Part of Kanchanjanga Hills (Sikkim)

(b) Ex-situ conservation:

Ex-situ conservation involves maintenance and breeding of endangered plants and animals under partially or wholly controlled conditions in specific areas like zoo, gardens, nurseries etc. That is, the conservation of selected plants and animals in selected areas outside their natural habitat is known as ex-situ conservation.

The stresses on living organisms due to competition for food, water, space etc. can be avoided by ex-situ conservation there by providing conditions necessary for a secure life and breeding.

Some important areas under these conservation are:

(i) Seed gene bank,

(ii) Field gene bank;

(iii) Botanical gardens;

(iv) Zoos.

The strategies for ex-situ conservations are:

(i) Identification of species to be conserved.

(ii) Adoption of Different ex-situ methods of conservation.

(i) Long-term captive breeding and propagation for the species which have lost their habitats permanently.

(ii) Short-term propagation and release of the animals in their natural habitat

(iii) Animal translocation

(iv) Animal reintroduction

(v) Advanced technology in the service of endangered species.

The different advantages of ex-situ conservation are:

(a) It gives longer life time and breeding activity to animals.

(b) Genetic techniques can be utilised in the process.

(c) Captivity breed species can again be reintroduced in the wild.

Some disadvantages of this method are:

(a) The favourable conditions may not be maintained always.

(b) Mew life forms cannot evolve.

(c) This technique involves only few species.

Endangered and Endemic species of India

1. **Endangered species of India**

A plant, animal or microorganism that is in immediate risk of biological extinction is called endangered species or threatened species. In India, 450 plant species have been identified as endangered species. 100 mammals and 150 birds are estimated to be endangered. India's biodiversity is threatened primarily due to:

1. **Habitat destruction**
2. **Degradation and**
3. **Over exploitation of resources**

The RED-data book contains a list of endangered species of plants and animals. It contains a list of species of that are endangered but might become extinct in the near future if not protected.

Some of the rarest animals found in India are:

1. **Asiatic cheetah**
2. **Asiatic Lion**
3. **Asiatic Wild Ass**
4. **Bengal Fox**
5. **Gaur**
6. **Indian Elephant**
7. **Indian Rhinocerous**
8. **Marbled Cat**
9. **Markhor**

Extinct species is no longer found in the world. Endangered or threatened species is one whose number has been reduced to a critical number. Unless it is protected and conserved, it is in immediate danger of extinction. Vulnerable species is one whose population is facing continuous decline due to habitat destruction or over exploitation. However, it is still abundant. Rare species is localized within a restricted area or is thinly scattered over an

extensive area. Such species are not endangered or vulnerable. A few endangered pecies in the world are listed below:

1. **West Virginia Spring Salamander (U.S.A)**
2. **Giant Panda (China)**
3. **Golden Lion Tamarin (Brazil)**
4. **Siberian Tiger (Siberia)**
5. **Mountain Gorilla (Africa)**
6. **Pine Barrens Tree Frog (Male)**
7. **Arabian Oryx (Middle East)**
8. **African Elephant (Africa)**

Other important endangered species are:

1. **Tortoise, Green sea Turtle , Gharial, Python (Reptiles)**
2. **Peacock, Siberian White Crane, Pelican, Indian Bustard (Birds)**
3. **Hoolock gibbin, Lion-tailed Macaque, Capped mokey, Golden monkey (Primates)**
4. **Rauvol fia serpentina (medicinal plant), Sandal wood tree, etc**

FACTORS AFFECTING ENDANGERED SPECIES

1. **Human beings dispose wastes indiscriminately in nature thereby polluting the air, land and water. These pollutants enter the food chain and accumulate in living creatures resulting in death.**
2. **Over-exploitation of natural resources and poaching of wild animals also leads to their extinction.**
3. **Climate change brought about by accumulation of green houses gases in the atmosphere. Climate change threatens organisms and ecosystems and they cannot adjust to the changing environmental conditions leading to their death and extinction.**

An international treaty to help protect endangered wildlife is, "Convention on International Trade in Endangered Species 1975" (CITES). This treaty is now signed by 160 countries.

1. **CITES lists 900 species that cannot be commercially traded as live specimens or wildlife products as they are in danger of extinction.**
2.
3. **CITES restricts trade of 2900 other species as they are endangered.**

DRAWBACKS OF CITES

1. **This treaty is limited as enforcement is difficult and convicted violators get away by paying only a small fine.**
2. **Member countries can exempt themselves from protecting any listed species.**

Endemic species of India

Species that are found only in a particular region are known as endemic species. Almost 60% the endemic species in India are found in Himalayas and the Western Ghats. Endemic species are mainly concentrated in:

1. **North-East India**
2. **North-West Himalayas**
3. **Western Ghats and**

4. **Andaman & Nicobar Islands.**

Examples of endemic Flora species are

1. **Sapria Himalayana**
2. **Ovaria Lurida**
3. **Nepenthis khasiana etc**

Endemic fauna of significance in the western ghats are:

1. **Lion tailed macaque**
2. **Nilgiri langur**
3. **Brown palm civet and**
4. **Nilgiri tahr**

<u>Factors affecting endemic species:</u>

1. **Habitat loss and fragmentation due to draining and filling of inland wetlands.**
2. **Pollution also plays an important role.**

Ex:

1. **Frog eggs, tadpoles and adults are extremely sensitive to pollutants especially pesticides.**
2. **Over-hunting and**
3. **Populations can be adversely affected by introduction of non active predators and competitors. Disease producing organisms also play an important adversary in reducing populations of endemic species.**

Module 4: Environmental Pollution Definition, Cause, effects and control measures of Air pollution, Water pollution,• Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards; Solid waste Management: Causes, effects and control measures of urban and industrial wastes; Role of an individual in prevention of pollution; Pollution case studies; Disaster management: floods, earthquake, cyclone and landslides.

Pollution

Pollution is the introduction of contaminants into the natural environment that causes adverse change. Pollution can take the form of chemical substances or energy, such as noise, heat or light.

Air pollution

Air pollution included harmful gases, dust particles, smoke fumes well as biological molecules present in the earth atmosphere which creates harmful effect on human health as well as environment comes in the categories of Air pollutions. Normally pollution can be natural origin or man mad.

Smoke from industries and automobiles, domestic and commercial sewage, radioactive substances from nuclear plants and discarded household articles (tins, bottles, broken crockery etc.) come under the category of pollutants.

Classification of pollutants

Depending on the existence of the nature we can broadly classify pollutant in two categories.

1. Quantitative pollutant: The quantitative pollutant is those pollutant whose concentration level is high due to manmade uncontrolled activity comes in this category. For example, carbon dioxide, if present in the atmosphere in concentration greater than normal due to automobiles and industries, causes measurable effects on humans, animals, plants or property, then it is classified as a quantitative pollutant

2. Qualitative pollutant: These are those substances which do not normally occur in nature but are added by man, for example, insecticides. Depending upon the form in which they persist after being released into the environment, the pollutants are categorized into two types, namely primary and secondary pollutants.

Primary Pollutants:

(a) These are those which are emitted directly from the source and persist in the form in which they were added to the environment. Typical examples of pollutants included under this category are ash, smoke, fumes, dust, nitric oxide, sulphur dioxide, hydrocarbons etc.

(b) Secondary Pollutants: These are those which are formed from the primary pollutants by chemical interaction with some constituent present in the atmosphere. Examples are: Sulphur trioxide, nitrogen dioxide, aldehydes, ketones, ozone etc.

Nitrogen oxides and hydrocarbons are two primary pollutants released from automobiles but in the presence of sunlight, they react to form peroxyacyl nitrate (PAN) and ozone, two secondary pollutants which are far more toxic than the primary pollutants from which they are derived.

This phenomenon of increased toxicity by chemical interaction among the pollutants is known as Synergism.

Secondary air pollution: Secondary air pollutant generally produced when in the air when two or more primary air pollutant interacts with each other with normal atmospheric constituent.

Example of some secondary air pollutant is ozone, formaldehyde, PAN (proxy acetyl nitrate), Smog, acid and mist etc.

S.No.	Primary Pollutants	Secondary Pollutants
1.	Carbon monoxide (CO)	Ozone (O3)
2.	Nitrogen Oxide (NOx)	Peroxyactyl nitrate (PAN)
3.	Sulphur Oxide (SOx)	Aldehydes
4.	Hydrocarbon (HC)	Ketones
5.	Particulates	Sulphur trioxide

Harmful effects

CO can cause oxygen deprivation (hypoxia), displacing oxygen in bonding with haemoglobin, causing cardiovascular and coronary problems, increasing risk of stroke, and impairing learning ability, dexterity and sleep. CO is mostly hazardous in relatively confined areas such as tunnels under bridges and overpasses, and in dense urban settings. In unconfined areas or away from population centres, it will stabilize into CO2 before damage to human health is likely.

It circulates directly into blood through lungs. Carbon monoxide binds to haemoglobin (Hb) in red blood cells, reducing their ability to transport and release oxygen throughout the body because of Carboxyl haemoglobin (CO Hb). The affinity of Carboxylhaemoglobin is 210 times greater to that of oxygen. Low exposures can aggravate cardiac ailments, while high exposures cause central nervous system impairment or death. It also plays a role in the generation of ground-level ozone.

Causes of Air pollution

1. Burning of Fossil Fuels: Sulfur dioxide emitted from the combustion of fossil fuelslike coal, petroleum and other factory combustibles is one the major cause of air pollution. Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause immense amount of pollution. We rely on them to fulfill our daily basic needs of transportation. But, there overuse is killing our environment as dangerous gases are polluting the environment. Carbon Monooxide caused by improper or incomplete combustion and generally emitted from vehicles is another major pollutant along with Nitrogen Oxides, that is produced from both natural and man made processes.

2. Agricultural activities: Ammonia is a very common by product from agriculture related activities and is one of the most hazardous gases in the atmosphere. Use of insecticides, pesticides and fertilizers in agricultural activities has grown quite a lot. They emit harmful chemicals into the air and can also cause water pollution.

3. Exhaust from factories and industries: Manufacturing industries release large amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air thereby depleting the quality of air. Manufacturing industries can be found at every corner of the

earth and there is no area that has not been affected by it. Petroleum refineries also release hydrocarbons and various other chemicals that pollute the air and also cause land pollution.

4. Mining operations: Mining is a process wherein minerals below the earth are extracted using large equipments. During the process dust and chemicals are released in the air causing massive air pollution. This is one of the reason which is responsible for the deteriorating health conditions of workers and nearby residents.

5. Indoor air pollution: Household cleaning products, painting supplies emit toxic chemicals in the air and cause air pollution. Have you ever noticed that once you paint walls of your house, it creates some sort of smell which makes it literally impossible for you to breathe.

Suspended particulate matter popular by its acronym SPM, is another cause of pollution. Referring to the particles afloat in the air, SPM is usually caused by dust, combustion etc.

Effects of Air pollution

1. Respiratory and heart problems: The effects of Air pollution are alarming. They are known to create several respiratory and heart conditions along with Cancer, among other threats to the body. Several millions are known to have died due to direct or indirect effects of Air pollution. Children in areas exposed to air pollutants are said to commonly suffer from pneumonia and asthma.

2. Global warming: Another direct effect is the immediate alterations that the world is witnessing due to Global warming. With increased temperatures world wide, increase in sea levels and melting of ice from colder regions and icebergs, displacement and loss of habitat have already signaled an impending disaster if actions for preservation and normalization aren't undertaken soon.

3. Acid Rain: Harmful gases like nitrogen oxides and sulfur oxides are released into the atmosphere during the burning of fossil fuels. When it rains, the water droplets combines with these air pollutants, becomes acidic and then falls on the ground in the form of acid rain. Acid rain can cause great damage to human, animals and crops.

4. Eutrophication: Eutrophication is a condition where high amount of nitrogen present in some pollutants gets developed on sea's surface and turns itself into algae and and adversely affect fish, plants and animal species. The green colored algae that is present on lakes and ponds is due to presence of this chemical only.

5. Effect on Wildlife: Just like humans, animals also face some devastating affects of air pollution. Toxic chemicals present in the air can force wildlife species to move to new place and change their habitat. The toxic pollutants deposit over the surface of the water and can also affect sea animals.

<u>CONTROL MEASURES</u>

The atmosphere has several built-in self cleaning processes such as dispersion, gravitational settling, flocculation, absorption, rain-washout, etc to cleanse the atmosphere. However, control of contaminants at their source level is a desirable and effective method through preventive or control technologies.

Source control: Some measures that can be adopted in this direction are:

1. **Using unleaded petrol**

2. **Using fuels with low sulphur and ash content**
3. **Encouraging people to use public transport, walk or use a cycle as opposed to private vehicles**
4. **Ensure that houses, schools, restaurants and playgrounds are not located on busy streets**
5. **Plant trees along busy streets as they remove particulates, carbon dioxide and absorb noise**
6. **Industries and waste disposal sites should be situated outsdide the city preferably on the downwind of the city.**
7. **Catalytic converters should be used to help control emissions of carbon monoxide and hydrocarbons**

<u>Control measures in industrial centers</u>

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

<u>EQUIPMENT USED TO CONTROL AIR POLLUTION</u>

The following equipment is used to control air pollution:

1. **<u>Control of SPM by gravitation</u>**

   Gravitational Settling Chamber A typical gravitational chamber is shown below.

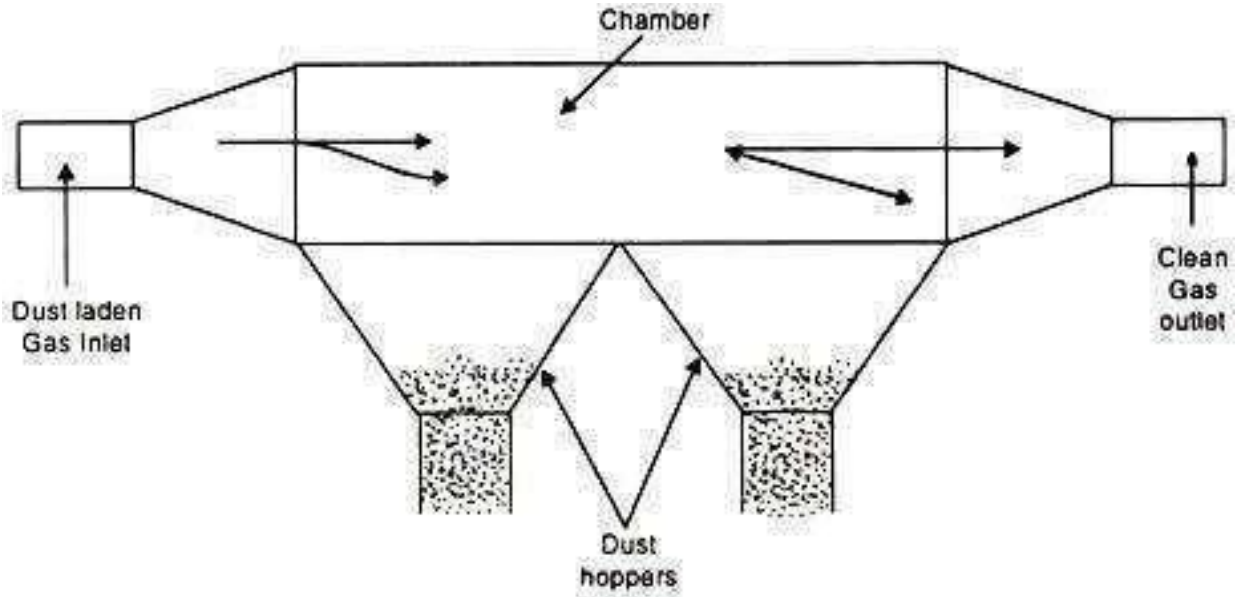


Fig. 6.4. Horizontal Flow Settling Chamber.

The dust laden gas enters at the inlet and due to the sudden increase in cross-section the

particulate matter settles at the bottom and can be removed from the dust hoppers as shown The clean gas free from particulate matter exits from the outlet

IMPORTANT FACTS:-

1. **Simple to construct and maintain**
2. **Efficient to remove particles of diameter greater than 50 mm from gas streams**
3. **They are used as pre-cleaners before passing gases through high efficiency collection devices**
4. **They rely on gravitational settling and are the simplest and oldest mechanical collectors for removal of particulates from gas streams Flow within the chamber must be uniform without macroscopic mixing**
5. **Dust removal system must be sealed to prevent production of turbulence due to air from leaking into chamber**
6. **Efficiency of the equipment increases with increased residence time of the waste gas. Hence, the equipment is operated at lowest possible gas velocity**
7. **The size of the unit depends on: gas velocity which should preferably be less than 0.3 m/s**

1. **ADVANTAGES**
    1. **Low capital and energy cost**
    2. **Low maintenance and operating costs**
    3. **Low pressure drop**
    4. **Reliable and Pollutants are collected in dry state**
    5. **Equipment is not subjected to abrasion due to low gas velocity**
    6. **Equipment provides incidental cooling of gas stream**
    7. **Temperature and pressure limitations depend on material of construction**

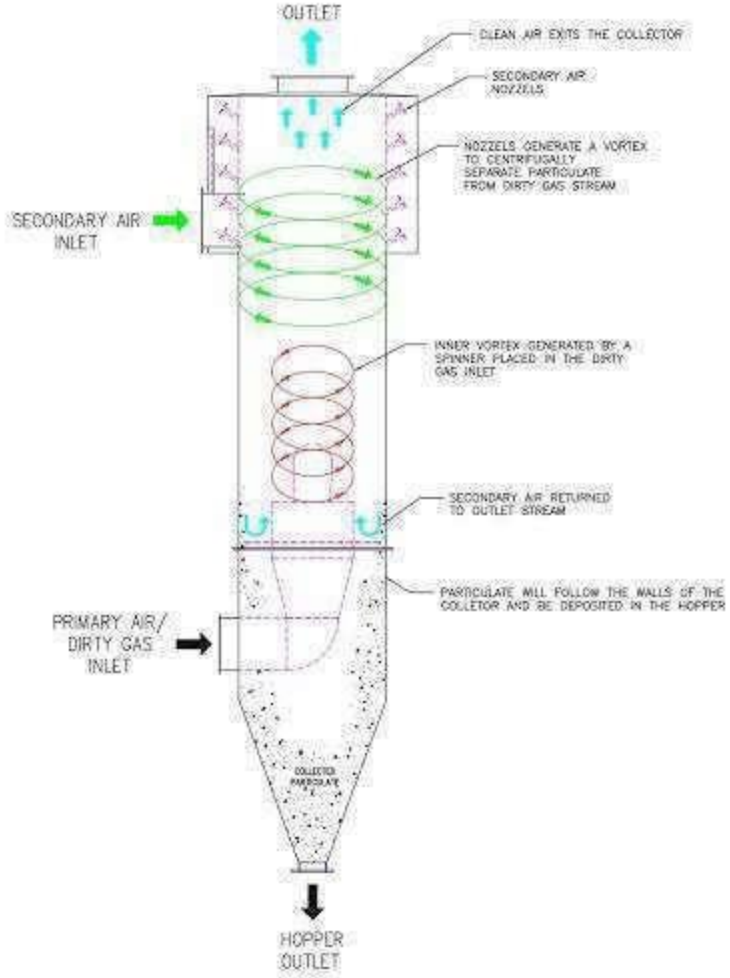
DISADVANTAGES

1. **Low particulate matter collection efficiency**
2. **Unable to handle sticky materials, Large size**
3. **Trays in multiple tray settling chamber may warp under high temperatures.**

2. <u>Control of SPM by centrifugation</u>

Equipment used: Cyclonic separator:-

Centrifugation is a process that involves the use of centrifugal force for sedimentation of a heterogeneous mixture with a centrifuge. It involves removal of particulates from air, gas or a liquid stream without use of filters with a vortex separation. When removing particulates from a gaseous stream, a gas cyclone is used while a hydro cyclone is used to remove particulates from a liquid stream. This method can also be used to separate fine droplets of liquid from a gaseous stream. A high speed rotating air flow is formed in a cylindrical or conical container called a cyclone. Air flows in a helical pattern from the top to a narrow bottom as show,



Cyclones use the principle of inertia to remove particulate matter from a gas stream. Several cyclones operating in parallel is known as multicyclone. In a cyclone separator, dirty gas is fed into a chamber where a spiral vortex exists. The large particles hit the inside walls of the container and drop down into the collection hooper. The clean flue gas escapes from the top of the chamber. Cyclones can be used efficiently to remove particles of size 10 microns or more. High efficiency cyclones can remove particles of dimeter as small as 2.5 microns. They are the least expensive of all particulate collection devices. They are used as rough separators before the gas is passed through fine filtration systems. Their efficiency is between 50-99%. Cyclone separators work best on flue gases that contain large amount of big particulate matter.

ADVANTAGES:

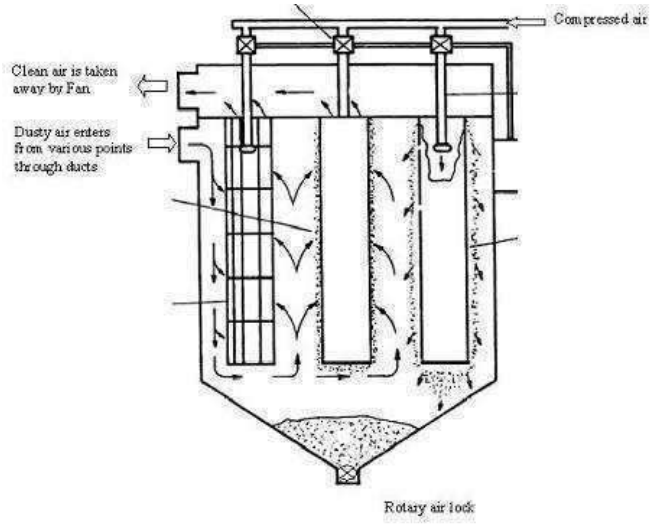
1. Cyclones are less expensive to install or maintain as they do not contain any moving parts

2. It is easy to dispose particulate matter as it is collected in the dry state
3. Space requirement is very less

DISADVANTAGES:
1. **They are not efficient in collecting particulate matter smaller than 10 microns**
2. **They cannot handle sticky material**

3. Control of SPM by filtration

In a fabric filter system, a stream of the polluted gas is made to pass through a fabric that filters out the particulate pollutant and allows the clear gas to pass through. The particulate matter is left in the form of a thin dust mat on the insides of the bag. This dust mat acts as a filtering medium for further removal of particulates increasing the efficiency of the filter bag to sieve more sub micron particles (0.5 μm).
A typical filter is a tubular bag which is closed at the upper end and has a hopper attached at the lower end to collect the particles when they are dislodged from the fabric. Many such bags are hung in a baghouse. For efficient filtration and a longer life the filter bags must be cleaned occasionally by a mechanical shaker to prevent too many particulate layers from building up on the inside surfaces of the bag. A typical bag house filter is shown in the figure below.



ADVANTAGES:
Bag filter is a high quality performance instrument to effectively control particulate emissions and its efficiency is as high as 99%
Collection efficiency is not affected by sulphur content in fuel
It is not sensitive to particle size distribution
It does not require high voltage
It can be used to collect flammable dust
Special fiber or filter aids can be used to sub-micron level smoke and fumes

DISADVANTAGES:

Fabric life is reduced due to presence of highly acidic or alkaline atmospheres, especially at high temperatures

Maximum operating temperature is 500 F

Collection of hygroscopic materials or condensation of moisture can lead to fabric plugging, loss of cleaning efficiency and large pressure losses.

Certain dusts may require special fabric treatments to aid in reducing leakage or to help in cake removal

Fabric bags are prone to burning or melting at extreme temperatures.

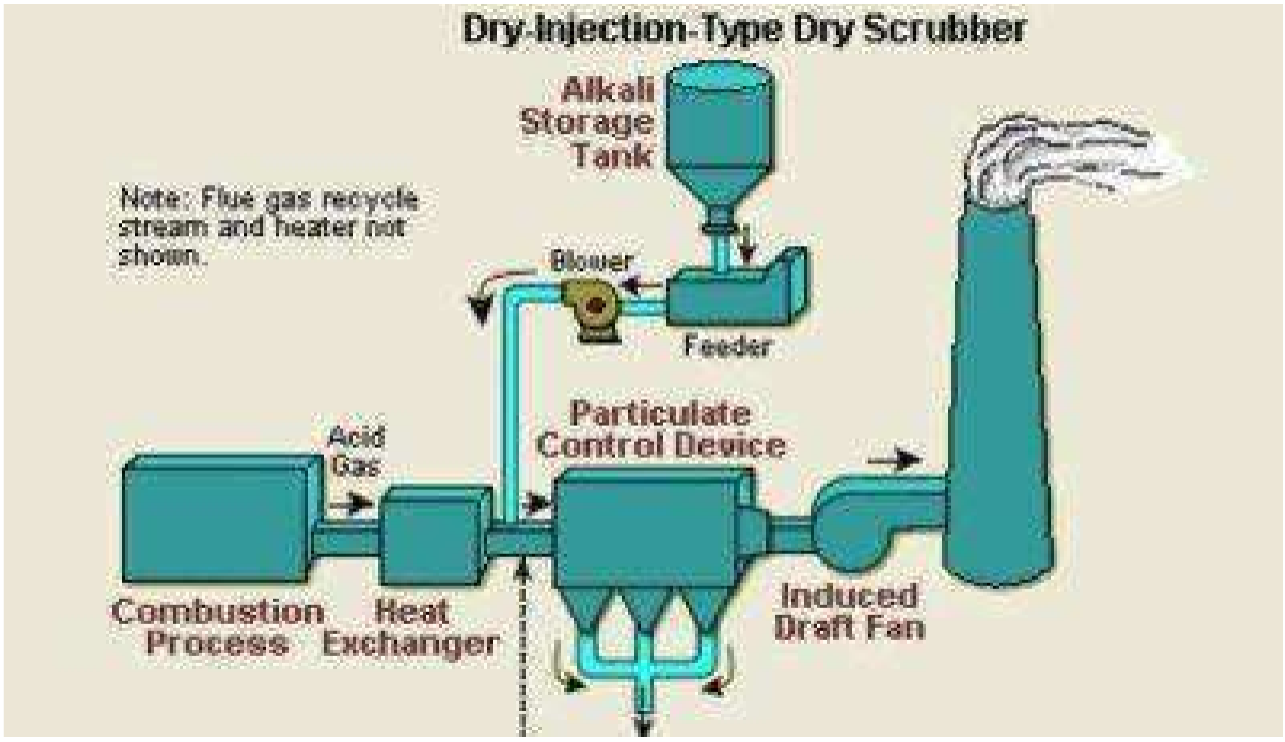
4. Control of SPM by scrubbing

A scrubber is a system used to remove harmful materials from industrial exhaust gases before they are released into the environment. The two main ways to scrub pollutants out of exhaust are:

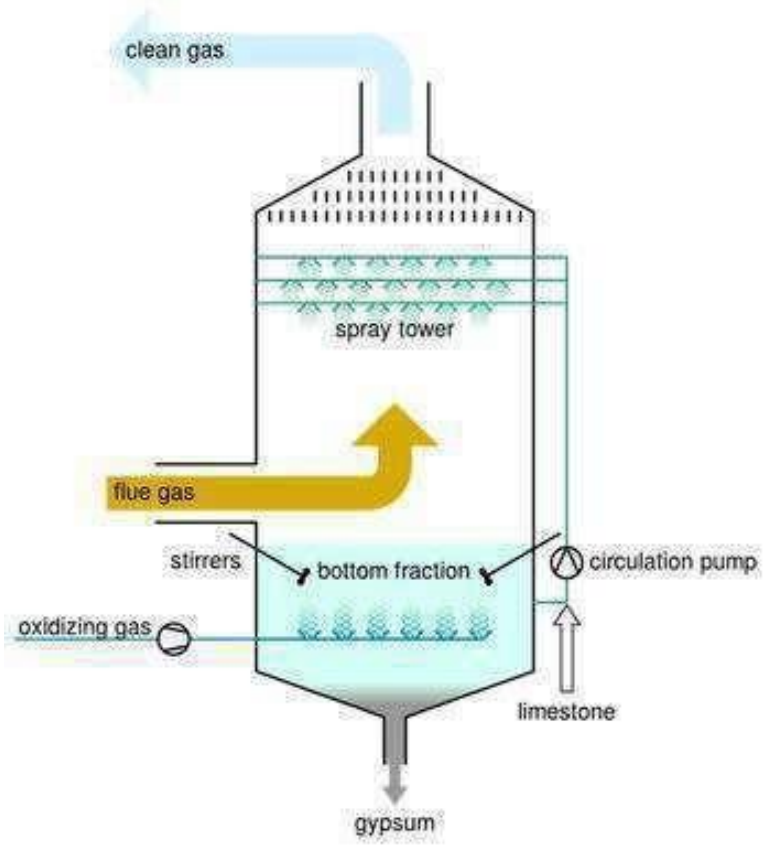
1. Dry scrubbing and

2. Wet scrubbing

In dry scrubbing, harmful components of exhausted flue gas are removed by introducing a solid substance (usually in the powdered form) in the gas stream.



Wet scrubbing involves removal of harmful components from exhaust by spraying a liquid substance through the gas.



Both methods work similarly and perform the same process of removing pollutants. The difference lies in the materials they use to remove the pollutant from the gas stream. By removing acidic gases from the exhaust before it is released into the atmosphere, scrubbers help in the prevent the formation of acid rain. Scrubbing is sometimes referred to as flue gas desulfurization.

Scrubbing is the most effective technique for the removal of oxides of sulphur and is widely used. Scrubbers remove sulphur oxides from flue gases by passing the gases through a spray of water in a wet scrubber that contains many chemicals, mainly calcium carbonate. If a dry scrubber is used, the flue gas comes in contact with pulverised limestone. The chemical reaction between suphur dioxide and calcium carbonate yields calcium sulphite. The calcium sulphite either falls out of the gas stream or is removed with other particulates. Scrubbers are highly efficient and remove almost 98% of sulphur from flue gases. However, they are expensive to maintain and install. They are also energy intensive as the flue gas must be reheated after coming into contact with water vapour in the wet scrubber to make the gas buoyant to exit the smoke stacks.

5. Control of SPM by Electrostatic precipitator

An Electrostatic precipitator is mainly used to control particulate matter. An Electrostatic precipitator uses electrostatic forces to separate dust particles from exhaust gases. A number of high-voltage, direct-current discharge electrodes are placed between grounded collecting

electrodes. The contaminated gases flow through the passage formed by the discharge and collecting electrodes as shown in the figure below.

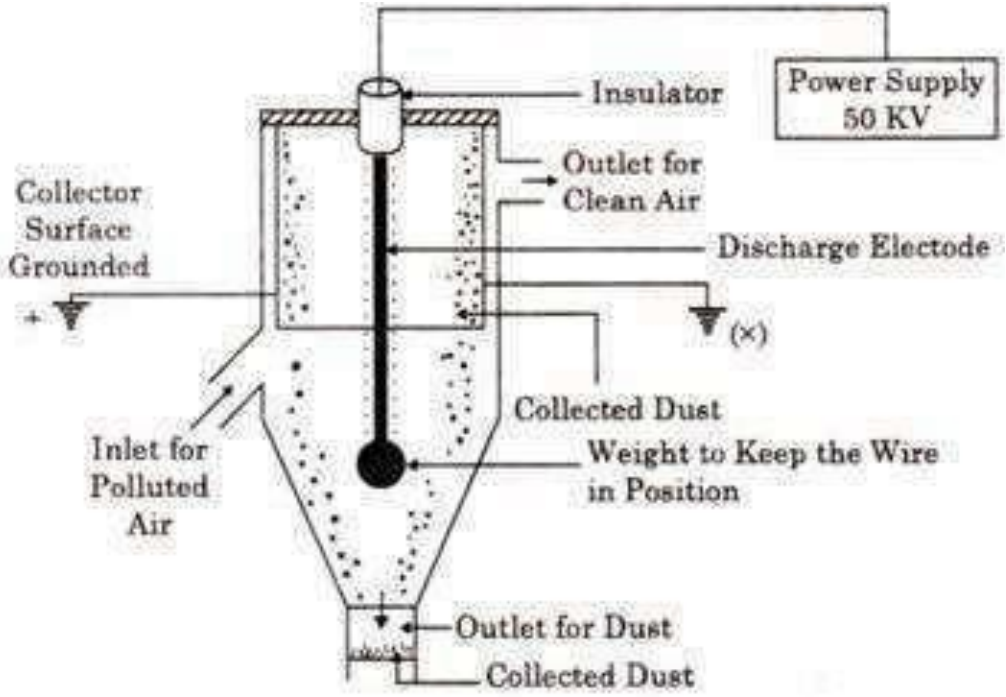


Fig. 5.4 Electrostatic Precipitator

Air borne particles receive a negative charge as they pass through the ionized field between the electrodes. These charged particles are then attracted to the oppositely charged electrode and stick to it. The collected material is then removed by rapping or vibrating the electrodes. Cleaning the electrodes is done without interrupting the air flow. The main components of all electrostatic precipitators are:

- **a power supply unit to supply high voltage DC power**
- **ionizing section to impart a charge to the particulates in the gas stream**
- **an attachment to remove the collected particulates**
- **a housing to enclose the precipitator zone**

The following factors influence the collection efficiency of electrostatic precipitators:

- **Larger collection surface areas and lower gas flow rates increase efficiency of electrostatic precipitators due to increased time for the electrical activity to collect the dust particles**
- **The dust particle migration velocity to the collecting electrodes can be increased by:**
- **Decreasing gas velocity**
- **Increasing gas temperature and**
- **Increasing the voltage field**

There are two types of precipitators:

1. **Single-stage precipitators that combine an ionization and collection step also known as cottrell precipitators. It is mainly used in mineral processing operations.**
2. **Low voltage, two stage precipitators that use a similar principle, but in this case, the ionization section is followed by collection plates. It is mainly used for filtration in air-conditioning systems.**

Electrostatic precipitators may be:
Plate precipitators in which particles are collected on flat parallel surfaces about 20 to 30 cm apart with a series of discharge electrodes spaced along the centerline of two adjacent plates. The contaminated particles pass through the passage between the plates and the particles get charged and adhere to the collection plates. The particles are eventually removed by rapping the plates and the dust is collected in the hoppers or bins placed at the base of the precipitator.
Tubular precipitators consist of cylindrical collection electrodes with discharge electrodes located on the axis of the cylinder. The contaminated gases flow around the discharge electrode and through the inside of the cylinders. The charged particles are collected on the grounded walls of the cylinder. The collected dust is removed from the bottom of the cylinder. They are generally used for collection of mist or fog or for adhesive, sticky, radioactive or extremely toxic materials.
Air pollution can be reduced by adopting the following approaches.

1. **Ensuring sufficient supply of oxygen to the combustion chamber and adequate temperature so that the combustion is complete thereby eliminating much of the smoke consisting of partly burnt ashes and dust.**
2. **To use mechanical devices such as scrubbers, cyclones, bag houses and electro-static precipitators in manufacturing processes. The equipment used to remove particulates from the exhaust gases of electric power and industrial plants are shown below. All methods retain hazardous materials that must be disposed safely. Wet scrubber can additionally reduce sulphur dioxide emissions.**
3. **The air pollutants collected must be carefully disposed. The factory fumes are dealt with chemical treatment.**

<u>Water Pollution</u>
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."

Types of Water Pollution
Surface Water Pollution
When hazardous substances come in contact with different sources of water, it leads to surface water pollution. The harmful contaminants from different sources mix or physically dissolve with lakes, lagoons, oceans and lead to surface water pollution.
Ground Water Pollution
Pesticides and chemicals applied on crops and soil are washed deep into the ground when it rains. The pesticides mix with underground water and lead to ground water pollution.

Suspended Matter Pollution

In this type of pollution, the pollutants enter into water and don't mix with the water molecules. The suspended particles in water form a silt on the waterbed that remove the nutrients from water and make it polluted.

Microbial Pollution

A natural form of water pollution, microorganisms cause this type of water pollution. Most of the microorganisms. Though most of the microorganisms are harmless, however some bacteria and viruses may cause serious health problems.

Chemical Water Pollution

Many industries and farmers use chemicals when working which end up polluting water that we use. Pollutants used to control weeds, insects and pests leech into water and lead to pollution. In addition, metals and solvents from industries also lead to water pollution.

Sewage

Disposing sewage in water is one of the major reasons of water pollution. Sewage disposed into the sea from households as well as factories can cause water pollution. Sewage disposal lead to a number of water-related illnesses such as diarrhea which is a leading cause of death among children.

Industrial Waste

Many factories and manufacturers pour industrial waste such as toxic chemicals into the water bodies before treatment which leads to water pollution. As a result of dumping toxic chemicals, the oxygen levels in water decreases leading to pollution.

Dumping of Solid Waste

Another major reason of water pollution is littering by humans. Dumping solid waste such as plastics, cardboards, Styrofoam contaminate water and make water unsuitable for consumption. Mass dumping of solid waste clog the water bodies and lead to water pollution.

Radioactive Wastes

Discharging of radioactive wastes (waste fuel that comes from nuclear power plants) into the sea is also one of the water pollution causes. High concentrations of radioactive wastes can lead to a number of health problems such as cancer and other serious illnesses.

Those were only some of the causes of water pollution. In addition to the sources mentioned above, there are many other reasons that contaminate water and lead to a number of health problems. Now, that we have understood about the causes, let us study about the effects of water pollution as well. This will help you comprehend, the consequences of water contamination.

Effects of Water Pollution

Groundwater contamination

Pesticides and fertilizers used for the cultivation of crops and vegetables contaminate the groundwater, which damages the ecosystem. This can also pollute the nearby lands and water when it rains, as rain water washes these chemicals which is soaked by groundwater or

takes them to marine areas. If this groundwater is supplied to your home through bore-wells or tube-wells, it can lead to a number of health problems.

Affects Aquatic Life

Solid wastes that we throw in the river/lakes or in sea can have an impact on the aquatic animals. This not only disrupts the eco-system as many species of aquatic animals are in danger of extinction. People who consume sea food are also at a risk of facing health issues when they consume the contaminated food items.

High TDS in water

Water is a best solvent which easily dissolves a variety of substances. The amount of dissolved solids present in water determine whether water is suitable for consumption. The TDS level in water needs to be less than 500 mg/litre to make it suitable for consumption. Presence of high amount of TDS can lead to a number of health problems in human beings.

Pollutants include:

1. **Sewage**
2. **Industrial effluents and chemicals**
3. **Oil and other wastes**

Chemicals in air dissolve in rain water, fertilizers, pesticides and herbicides leached from land pollute water.

<u>TYPES, EFFECTS AND SOURCES OF WATER POLLUTION</u> 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.

Infectious agents
Ex: Bacteria, Viruses, Protozoa, and parasitic worms.

Human sources
Human and animal wastes

Effects: Variety of diseases.

<u>Oxygen demanding wastes</u> (Dissolved oxygen): 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 to 15 mg/L Ex: Organic wastes such as animal manure and plant debris that can be decomposed by aerobic (oxygen-requiring) bacteria.

Human sources: 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.

Inorganic chemicals

Ex: Water soluble inorganic chemicals:

1. **Acids**
2. **Compounds of toxic metals such as lead (Pb), arsenic (As) and selenium (Se)**
3. **Salts such as NaCl in oceans and fluoride (F^-) found in some soils**

Human sources: Surface runoff, industrial effluents and household cleansers Effects:Inorganic chemicals can:

1. **Make freshwater unusable for drinking and irrigation**
2. **Cause skin cancer and neck damage**
3. **Damage nervous system, liver and kidneys**
4. **Harm fish and other aquatic life**
5. **Lower crop yields**
6. **Accelerate corrosion of metals exposed to such water**

Organic chemicals

Ex: Oil, Gasoline, Plastics, Pesticides, Cleaning solvents and Detergents.
Human Sources: Industrial effluents, household cleansers and surface runoff from farms.

Effects:

1. **Can threaten human health by causing nervous system damage and some cancers.**
2. **Harm fish and wildlife.**

Plant nutrients

Ex: Water soluble compounds containing nitrate, Phosphate and Ammonium ions.
Human sources: Sewage, manure and runoff of agricultural and urban fertilizers.

Effects:

1. **Can cause excessive growth of algae and other aquatic plants, which die, decay, deplete dissolved oxygen in water thereby killing fish**
2. **Drinking water with excessive levels of nitrates lower the oxygen carrying capacity of the blood and can kill urban children and infants.**

Sediment

Ex: Soil, silt, etc.

Human Sources: Land erosion

Effects:

1. **Causes cloudy water thereby reducing photosynthetic activity**
2. **Disruption of aquatic food chain**
3. **Carries pesticides, bacteria and other harmful substances**
4. **Settles and destroys feeding and spawning grounds of fish**
5. **Clogs and fills lakes, artificial reservoirs, stream channels and harbours.**

Radioactive materials:

Ex: Radioactive isotopes of:

1. **Iodine**
2. **Radon**
3. **Uranium**
4. **Cesium and**
5. **Thorium**

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

Effects: Genetic mutations, birth defects and certain cancers.

Heat (Thermal pollution)

Ex: Excessive heat

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

Effects

1. **Low dissolved oxygen levels thereby making aquatic organisms more vulnerable to disease, parasites and toxic chemicals.**
2. **When a power plant starts or shuts down for repair, fish and other organisms adapted to a particular temperature range, can be killed by an abrupt temperature change known as thermal shock.**

Point and non-point sources of water pollution:

Point sources These are pollutants that are discharged at specific locations through pipes, ditches or sewers into bodies of surface waters.

1. **Ex: Factories, sewage treatment plants, abandoned underground mines and oil tankers.**
2. **<u>Non point sources</u> These pollutants cannot be traced to a single point of discharge. They are large land areas or air-sheds that pollute water by runoff, subsurface flow or deposition from the atmosphere.**

Ex: Acid deposition, runoff of chemicals into surface water from croplands, livestock feedlots, logged forests, urban streets, lawns, golf courses and parking lots.

Control measures of water pollution

1. **Administration of water pollution control should be in the hands of state or central government**
2. **Scientific techniques should be adopted for environmental control of catchment areas of rivers, ponds or streams**
3. **Industrial plants should be based on recycling operations as it helps prevent disposal of wastes into natural waters but also extraction of products from waste.**
4. **Plants, trees and forests control pollution as they act as natural air conditioners.**
5. **Trees are capable of reducing sulphur dioxide and nitric oxide pollutants and hence more trees should be planted.**
6. **No type of waste (treated, partially treated or untreated) should be discharged into any natural water body. Industries should develop closed loop water supply schemes and domestic sewage must be used for irrigation.**
7. **Qualified and experienced people must be consulted from time to time for effective control of water pollution.**
8. **Public awareness must be initiated regarding adverse effects of water pollution using the media.**
9. **Laws, standards and practices should be established to prevent water pollution and these laws should be modified from time to time based on current requirements and technological advancements.**
10. **Basic and applied research in public health engineering should be encouraged.**

Following are the control measures of water pollution:

1. Stabilisation of ecosystem:

It involves following practices:

(a) Reduction of waste at source

(b) Harvesting and removal of biomass

(c) Trapping of the nutrients.

(d) Fish management.

2. Using water hyacinth to remove water pollutants:

Water hyacinth is extremely efficient in absorbing and concentrating dissolved nutrients from water in which it lives.

3. Using chemical methods:

Several chemical methods have been devised for the treatment of industrial effluents before discharging them in water bodies, like

(a) Ion Exchange:

It is a reversible reaction where in an iron from solution is exchanged for a similar charged ion attached to an immobile solid particle which is either naturally occurring inorganic zeolite or synthetically produced organic resins.

(b) Reverse Osmosis:

It involves the purification of water with the semipermeable membrane. When used as pre-treatment steps for deionization systems, reverse osmosis will remove feed water bacteria, organics and silica and reduce the dissolved salt content by greater than 95% only.

(c) Precipitation:

This process transform dissolved contaminants into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration.

(d) Coagulation:

Chemical coagulation enhances the removal of colloidal particles by destabilising and chemically precipitating them and accumulating the precipitated material into larger floe particles which can either removed by gravity setting or filtration.

4. Cooling methods:

For preventing thermal pollution such methods are used like cooling waste water effluent, evaporation tower, cooling ponds, dry cooling towers, wet cooling towers etc.

5. Recycling, Renovation, Recharge and Reuse (4R concept) of waste water:

The waste water consisting of domestic sewage industrial effluents, thermal and radioactive pollutants receive some sort of treatment before mixing into water bodies. Urban sewage and sludge etc may be recycled and reused to generate cheaper fuel, gas and electricity.

Soil pollution

Soil pollution

Soil pollution is defined as, "contamination of soil by human and natural activities which may cause harmful effect on living organisms".

Or

Soil pollution is the addition of chemicals to the soil in quantities that are toxic to the environment and its residents. This addition is mostly by human activities such as mining, modern practices in agriculture, deforestation, indiscriminate dumping of human generated trash and unregulated disposal of untreated wastes of various industries

Pollution by agricultural practises has come up ever since the demand for food has increased, proportional to the increase in population. To increase the yield of farms and fields the farmers have had to resort to additional chemical fertilizers, pesticides, weedicides, hormonal treatments for the animals, nutrient laden feed and many such practices which changed the way farming was done traditionally.

Composition of soil is listed below:

COMPONENT	%
Organic mineral matter	45

Organic	**matter**	**05**
Soil	**water**	**25**
Soil	**air**	**25**

TYPES, EFFECTS AND SOURCES OF SOIL POLLUTION

Soil pollution mainly occurs due to the following:

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

Industrial wastes – Disposal of Industrial wastes is the major problem for soil pollution
Sources: Industrial pollutants are mainly discharged from various origins such as pulp and paper mills, chemical fertilizers, 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, disturb the biochemical process and finally lead to serious effects on living organisms.

Urban wastes – Urban wastes comprise of both commercial and domestic wastes consisting of dried sludge and sewage. All the urban solid wastes are commonly referred to as refuse.
Constituents of urban refuse: This refuse consists of 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 industrial wastes, can still be dangerous. This happens because they are not easily degraded.

Agricultural practices – Modern agricultural practices pollute the soil to a large extent. With the advancing agro-technology, huge quantities of fertilizers, pesticides, herbicides and 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

Radioactive pollutants/ - Radioactive substances resulting from explosions of nuclear testing laboratories and industries giving rise to nuclear dust radioactive wastes, penetrate the soil

and accumulate giving rise to land/soil pollution.
Ex:

1. **Radio nuclides of Radium, Thorium, Uranium, isotopes of Potassium (K-40) and Carbon (C-14) are commonly found in soil, rock, water and air.**
2. **Explosion of hydrogen weapons and cosmic radiations include neutron, proton reactions by which Nitrogen (N-15) produces C-14. This C-14 participates in Carbon metabolism of plants which is then into animals and human beings.**
3. **Radioactive waste contains several radio nuclides such as Strontium90, Iodine-129, Cesium-137 and isotopes of Iron which are most injurious. Strontium get deposited in bones and tissues instead of calcium.**
4. **Nuclear reactors produce waste containing Ruthenium-106, Iodine-131, Barium-140, Cesium-144 and Lanthanum-140 along with primary nuclides Sr-90 with a half life 28 years and Cs-137 with a half life 30 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 the radio nuclides deposited on the soil emit gamma radiations.**
5. **Biological agents – Soil gets a large amount of human, animal and bird excreta which constitute a major source of land pollution by biological agents.**

Ex: 1. Heavy application of manures and digested sludge can cause serious damage to plants within a few years

Control measures of soil pollution:

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

Ex: Planting trees on barren slopes

Contour cultivation and strip cropping may be practiced instead of shifting cultivation

Terracing and building diversion channels may be undertaken.

Reducing deforestation and substituting chemical manures by animal wastes also helps arrest soil erosion in the long term.

2. **Proper dumping of unwanted materials: Excess wastes by man and animals pose a disposal problem. Open dumping is the most commonly practiced technique. Nowadays, controlled tipping is followed for solid waste disposal. The surface so obtained is used for housing or sports field.**
3. **Production of natural fertilizers: Bio-pesticides should be used in place of toxic chemical pesticides. Organic fertilizers should be used in place of synthesized chemical fertilizers. Ex: Organic wastes in animal dung may be used to prepare compost manure instead of throwing them wastefully and polluting the soil.**

4. **Proper hygienic condition: People should be trained regarding sanitary habits.**

Ex: 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 education.**

Ex: 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.**

Ex: Industrial wastes should be properly treated at source. Integrated waste treatment methods 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 improper disposal of radioactive wastes should be banned.**

Causes of Soil Pollution

- **Indiscriminate Use of Chemical fertilizers**

These are mostly nitrogen and phosphorus based chemicals like ammonia and nitrates that are most often than not, used in larger than required quantities and tend to accumulate in the soil.

- **Chemical pesticides**

Controlling pests are a farmer's need if a good crop is to be reaped. Pesticides and insecticides like organochlorines, organophosphates and carbonates are used regularly. These also contaminate the ground not only in the fields, but also in the places of manufacture, storage and disposal. They also tend to bio accumulate i.e. they collect in the body of the insects and then enter the food chain and lead to chronic poisoning of the higher level animals. Some pesticides also are absorbed naturally by the plants themselves and stored their different parts.

- **Heavy metals**

Cadmium, fluoride, radioactive elements like uranium are regularly found in the parent minerals from which the fertilisers are obtained. Dangerous metals such as Mercury, Lead, Arsenic, Chromium, and Nickel are seen in traces in Zinc rich wastes from the steel industries which are used as fertilizers. These are often not removed from the because of the high cost involved.

- **Excessive tillage of the land**

Overturning, digging or stirring leads to release of greenhouse gases produced in the ground such as nitrous oxide

- **Soil erosion**

Loss of soil material due to poor management causes soil to become infertile. Soil erosion is followed by deforestation, storm water runoff, overgrazing and excess of agriculture practices, constructions, mining. The soil sediments settling elsewhere on land or in water cause differences to occur in the environments there. In water it causes murkiness reducing visibility for fish and other animals sourcing their food. It leads to reduced penetration of sunlight and affects the process of photosynthesis causing reduction in oxygen levels of the water. Heavy pollutants and nutrients are bound to the sediment particles and carried into the water contaminating it. Faster rate of soil erosion changes the topography of a place.

- **Animal management**

The disposal of manure and other associated waste material from animal farms are also a reason for soil pollution. They cause pollution of the air as well as the water. 18 per cent of Greenhouse gases are said to be generated by farm animals. The large amounts of manure created, carry pathogens that are harmful for humans too.

- **Landfills and other waste dumping issues.**

Human generated sewage is a major cause for soil pollution. At the same time waste products such as plastics, glass, metals, Batteries, paper, fibres and rubber etc. add to the contamination as most of these are non-biodegradable. Much of the trash can be recycled such as paper, metal and glass, etc. Leaching of toxic materials occur at landfills. The more dangerous substances found in landfills are oils, battery metals, heavy metals from smelting industries and organic solvents.

- **Acid rain**

Air pollutants, sulphur dioxides, nitrous oxide and others combine with rain water, form acids and reach the soil. This is called acid rain. It reduces the pH of the soil ie it makes it acidic. It changes the nutrient content of the soil. These changes have adverse effects on the plants growing here, the insects and the other animal's dependant on the land.

Mechanisms (Types of Soil pollution)

Leaching and Ground Water Poisoning

When chemicals accumulate in the soil, depending on its water solubility and soil structure it percolates through reaching the ground water, causing its contamination. This also depends on the rainfall. For example after applying pesticides on crops in sandy areas, if excessive irrigation is done , the pesticide chemicals leach into ground. Leaching occurs not only in the fields, but also at the manufacturing, mixing and disposal sites.

Water runoff

Only a fraction of fertilisers and other chemical additives are utilised on the fields. The major bulk mixes in the runoff water and flows into the nearby watercourses. This is mainly in the form of nitrates and phosphates.

Barrenness of the ground

Many times the ground becomes barren and cannot support any flora or fauna on it. Use of excessive fertilizer progressively reduces the nutrient content of the foods such as proteins and vitamins in grains and vegetables.

Prevention of soil pollution

- **Managing and regulating the chemical waste disposal by industries is vital to soil health. Treatment of the wastes before disposal to remove chemicals and heavy metals at any cost must be done**
- **Prevention can never be a solo effort. The state governments, farmers' organisations, collectives and cooperatives, educational institutions and conservation groups need to work together for regulating and reducing farming related soil pollution.**
- **Planning the application of fertilizer at the right time, in the right quantity with the correct methods can reduce the accumulation of chemicals.**
- **Planting certain grasses and clovers that can absorb and recycle the additional nutrients and prevent soil erosion. Planting rows of trees and shrubs around fields and along the borders of the stream or lake also help in the same way.**
- **Over tilling of the soil must be avoided to prevent soil erosion and soil compaction.**
- **Managing the correct disposal of human and animal wastes and treating the sewage before release makes a big difference in the magnitude of soil and water pollution**
- **Composting, solid liquid separation, anaerobic digestion and lagoons are different ways of managing animal manure. Of these anaerobic digestion is the most effective. It involves the use of anaerobic bacteria and heat. The products of this process are nutrient rich liquid used as fertiliser and methane gas that can be burned to produce electricity and heat. Anaerobic digestion is a best method for controlling odour associated with manure management.**
- **Afforestation or planting of more trees is always good for binding the soil.**

Effects of soil pollution

Since soil pollution is not a lone standing entity, its effects are carried over as water pollution and air pollution. It affects every aspect of the environment and every organism from the earthworm to humans. Some of the adverse effects are as follows:

Human health

Since we are dependent on the land for our food, pollution from the soil is transferred to us in this manner. Bio accumulation of toxins occurs in our bodies, causing chronic poisoning, and leading to various diseases. Reproductive health, birth and developmental defects, neurologic effects, malnutrition, and mutations in the cells of the body leading to cancers; all these are on the increase today.

Growth of plants

Plants will not be able to adapt to sudden changes occurring in the soil. Fungi and bacteria found in the soils cannot bind the soil due to chemical changes and this causes soil erosion.

Large tracts of land become barren; unable to support any life on it. Even the plants that do grow on these lands will absorb the toxins and transfer to the food chain.

Air pollution

Toxic dust rises from landfills along with foul odour, pollutes the air and causes adverse effects to the people who live near them.

Marine pollution

Marine pollution refers to the contamination or presence of pollutants in oceans and seas. The word 'marine' comes from the Latin word for 'sea' and it is related to similar words, such as 'mariner'. Ocean pollution is become ever more of a problem in the present day.

Marine pollution can be defined as anything that contaminates the sea. Common marine pollutants include chemicals, small plastic beads in exfoliants and also toxic bio-matter (such as sewage). But, noise – due to excessive traffic around the ocean – can also be defined as pollution if it disrupts marine life.

Pollution can vary depending on the context and the purpose for which seawater is being used. For example, normal seawater has some small particles of plants or sand in, and when the sea is considered as the habitat of marine animals, one would not think of these particles as pollutants – whereas one would definitely define toxic chemicals as pollutants. However if somebody wanted to use this brine for cooking in, they might see the sand and plants as polluting our cooking water.

Causes/Sources of Marine Pollution

1. Toxic chemicals in water.

Chemical runoff from industry can really endanger marine life. Industrial waste pumped into the sea, household cleaners poured down the sink, and even chemicals in the atmosphere (for instance due to the discharge of industrial wastes through factory chimneys) that dissolve into the sea can pollute our oceans significantly.

2. Oil spillages.

This is usually an accidental form of industrial dumping, whereby leaks in oil tankers cause vast quantities of oil to pour into the ocean. Accidental oil spills can devastate marine life.

3. Small particles.

The tiny plastic beads in exfoliating creams and other small particles that we pour down the drain without thinking wind up polluting the ocean.

4. Plastic, Litter, and human waste.

Plastic bags, aluminum cans, trash and other human waste constitute a major pollutant of the world's oceans. A huge 'island' of trash roughly the size of Texas was recently found in the Pacific ocean for instance, demonstrating the vast scale of this problem.

5. Sewage.

Whether or not it is treated with toxic chemicals, sewage pollutes the clear, clean water of the oceans. This is another type of industrial dumping. Sometimes, sewage is not pumped directly into the sea but into rivers, and then the untreated water of rivers carries it into the sea.

6. The shipping industry.

Gases (which dissolve in the sea), chemicals and sewage from container ships are major pollutants.

7. Dissolved greenhouse gases.

Greenhouse gases from human fossil fuel consumption are making the sea more acidic.

Effects of Marine Pollution

1. Oxygen depletion.

Seawater is full of dissolved oxygen, however decomposing sewage and other biomatter in oceans can result in a condition known as 'hypoxia' or oxygen depletion. This makes it hard for oxygen loving marine life – plants, fish and animals – to survive in the oceans.

2. Higher acidity.

Toxic chemicals make our oceans more acidic. Again, this makes them poisonous to marine life and causes harm to fish and marine mammals as well as marine plants and corals.

3. Choking marine life.

Small pieces of plastic and other litter are increasingly being found in the stomach of fish, turtles and other marine animals. These pieces of trash choke marine animals and hamper their digestion, with an often fatal result.

4. Spoiling birds' feathers.

Oil spills coat the feathers of marine birds and strip them of the natural oils that birds use to keep their feathers waterproof and to maintain their own body temperatures. As a result, marine birds can overheat or get too cold, and they find it hard to stay afloat as their feathers get soggy. They will also find it difficult to fly when their feathers are clogged with oil.

5. Blocking out the sunlight.

Pollutants such as oil or litter can block out the sunlight from sea plants which need sunlight for photosynthesis.

6. Dangers to human health.

Human swimmers and water sports lovers can become endangered by swimming in a polluted sea.

Control Measures/ Solutions for Marine Pollution

1. Be careful with our chemicals.

Climate change and marine pollution are both results of excess human interference in the natural world. If we choose eco-friendly household cleaners and take measures to reduce the fumes we release into the air (for instance, by choosing public transport over cars) we can reduce the impact of our lives on the oceans.

Further, careful site monitoring to prevent or stop any chemical or oil spills at all times will reduce the instances of oil spills.

2. Don't flush or rinse away harmful particles.

If we do not flush plastics down the toilet, and if we do not pour oils and exfoliating beads down the faucet, we prevent these particles from reaching our oceans. Switch to exfoliants that use natural materials like seeds, sugar or sand instead – and recycle all plastics!

3. Campaign.

Influence the decisions of policymakers and factory bosses to make them more eco-friendly by lobbying, writing letters, spreading the word on social media and campaigning. Motivating

the shipping companies to use safe and environmentally friendly vessels are among the key measures that can be taken here.

4. Volunteer at an oil spill site.

Volunteers are always needed at oil spill sites to save the lives of marine birds by washing the oil from their feathers and caring for them until they are ready to fly, swim and dive under water again. Intervention is always needed as soon as possible to ensure that these birds do not suffer any ill effects to their health.

5. Volunteer at a beach cleanup – or organize one yourself.

Rid your local beach of litter by getting together with the rest of the community to pick up the trash left behind by careless picnickers, boat crews and more. Joining together as a community to care for the natural world is a wonderful way to remind everyone how intimately we are connected to nature, and how much we depend on it. Working together with other people also helps to keep us motivated and reminds us that we are not alone in our quest to care for the environment.

6. Ensuring no debris is released into the ocean.

Recycling our plastics and other recyclable, and disposing of our waste responsibly is key here.

Noise pollution

Noise is defined as, "the unwanted, unpleasant or disagreeable sound that causes discomfort to all living beings". Sound intensity is measured in decibels (dB), that is the tenth part of the longest unit Bel. One dB is the faintest sound that a human ear can hear.

TYPES OF NOISE: Environmental noise has been doubling every ten years. Noise is classified as:

1. **Industrial Noise**
2. **Transport Noise and**
3. **Neighbourhood noise**

Industrial Noise: It is sound with a high intensity sound caused by industry machines. Sources of such noise pollution is caused by machines from machines in various factories, industries and mills. Noise from mechanical saws and pneumatic drills is unbearable and a nuisance to the public.

The Indian Institute of Oto-Rino Laryngology, Chennai reported that increasing industrial pollution damages the hearing ability by atleast 20%.

Workers in steel industry, who work close to heavy industrial blowers are exposed to 112dB for eight hours suffer from occupational pollution.

Transport Noise: Transport noise mainly consists of traffic noise from road, rail and aircraft. The number of automobiles on roads like motors, scooters, cars, motor cycles, buses, trucks and diesel engine vehicles have increased enormously in the recent past further aggravating the problem of transport noise.

Noise levels in most residential areas in metropolitan cities is hovering around the border line due to increased vehicular noise pollution. This high level of noise pollution leads to deafening in the elderly.

Neighbourhood noise: This type of noise includes disturbance from household gadgets and community. Common sources being musical instruments, TV, VCR, Radios, Transistors, Telephones, and loudspeakers etc. Statistically, ever since the industrial revolution, noise in the environment has been doubling every ten years.

Causes of Noise pollution

Noise pollution can be caused by several phenomenon including industrial activity, and social activity (such as explosion of fire crackers, loud parties), and surface travel. The many causes of noise pollution are discussed below:

1. Fire crackers: Fire crackers are exploded to make huge sound during celebrations and festive occasions. It is common sight to witness the firing of crackers at live concerts. These high levels of sound is extremely problematic for people, especially elderly and sick people.

2. Transportation vehicles: Noise pollution is severest in the cities. All forms of machine powered vehicles cause noise pollution. The different modes of transportation (land, air and water), produces enough sound and collectively causes massive disturbance to the human mind and body. During the last few decades, the world is moving at unprecedented speed. People use surface transportation vehicles such as cars, vans, buses, trams, bullet trains. There are metro rails in major cities. Long distances are very often covered in an airplane or a bullet train. Airports and railway stations are busy throughout day and night. Far away places can be reached in hours. People take the water route to travel via motor shops, boats, yacht, and helicopters. Many people even own private air-crafts. The ever-increasing usage of various modes of transport is the major cause for noise pollution.

3. Microphones and Loud Speakers: Loud speakers and microphones are used during social, political and other special events. Large public gatherings are held. To make sure that the announcements and speeches are audible a large audience, microphones and loud speakers ate used. Though these public gatherings are generally held for welfare and entertainment of the public, the nearby residents suffer from loud noise.

4. Factories and industries: In large cities, there are large number of factories, mills and industries. Industries such as steel industry, shipping industry, aircraft, wires, switch gears and automobiles cause industrial noise. These industrial sites produce immense environmental noise to disturb the habitats of nearby residential areas. Large scale industries are often sites as a major cause of NIHL – Noise Induced Hearing Loss (read more about NIHL in Wikipedia). The workers and employees working in factories suffer from occupational noise (read more about occupational noise in Wikipedia). They are constantly exposed to noise of the working machinery. Their auditory system is at risk. Long-term exposure to industrial noise may lead to hearing disability.

5. Domestic household appliances: A majority of domestic household appliances that we use in everyday life causes noise pollution. Home theaters and televisions are played non-stop. The air cooler is supported by a large and powerful fan. The mixer grinders are used in grinding food materials. The juicer extracts juices from the fruits. The air purifier is used to purify the air. Washing machines are used for washing clothes. Loud music are played on advanced music systems. The smart phone keeps ringing.

6. Building and construction sites near residential areas: The building and construction activity involves use of sound producing equipment such as cement-mixer, road-roller, crane, etc. Cement mixers uses a revolving drum to mix cement, sand, small stones and water to create concrete. The sound of cement mixers are annoying.

7. Office Equipment: In offices, a wide variety of equipment is used. Many of the office equipment make noise. Paper shredders are used to cut papers. Printers are widely used for printing texts and pictures. A manual type writer, is used for typing. Fax machines are used to send or receive scanned texts or images through telecommunication lines. Phones keep ringing. And people keep talking to business partners, and clients over phone. When doors are opened and shut hard, it makes noise.

All the above activities produce enough noise to disturb the health and mind of human-beings and other living bodies.

Effects of Noise pollution

1. **Noise pollution affects both human and animal health. It leads to:**
    1. **contraction of blood vessels**
    2. **making skin pale**
    3. **excessive adrenalin in the blood stream which is responsible for high blood pressure.**
    4. **Blaring sounds are known to cause mental distress**
    5. **Heart attacks, neurological problems, birth defects and abortion**
2. **Muscle contraction leading to nervous breakdown, tension, etc**
3. **The adverse reactions are coupled with a change in hormone content of blood, which in-turn increases heart beat, constriction of blood vessels, digestive spams and dilation of the pupil of the eye.**
4. **Adverse affects health, work efficiency and behaviour. Noise pollution may cause damage to the heart, brain, kidneys, liver and may produce emotional disturbance.**
5. **The most immediate and acute effect of noise is impairment of hearing that diminishes some part of the auditory system. Prolonged exposure to noise of certain frequency pattern leads to chronic damage to the inner ear.**
6. **Impulsive noise may cause psychological and pathological disorders**
7. **Ultrasonic sound can affect the digestive, respiratory, cardiovascular system and semicircular canals of the internal ear.**
8. **The brain is adversely affected by loud and sudden noise by jets and airplanes. People are subjected to psychiatric illness.**
9. **Recent reports suggest that blood is thickened by excessive noise.**
10. **The optical system of human beings is also affected by noise pollution. Severe noise pollution causes:**
    1. **Pupullary dilation**
    2. **Impairment of night vision and**
    3. **Decrease in rate of colour perception**

Or

Effect on Human beings: Noise pollution affects the human mind and body negatively. The ill-effects of noise pollution are many. It is the major cause for several ailments. The quality of human life gets disrupted. The lives of the children, the aged or the ailing people become miserable.

1. **Loss of hearing and deafness: Noise above the tolerable threshold is the leading cause for loss of hearing and deafness.**
2. **Cardiac disturbance: Noise increase the risk of cardiac disturbance including coronary artery disease or ischemic heart disease (IHD).**
3. **Sleeplessness: Noise may make people restless and tired. It may cause disrupted sleeping pattern or may keep people away from sound sleep. In the long-term, due to tiredness and lack of sleep, the immune system may get compromised.**
4. **Headache: Human mind can tolerate sound only to a limited extent. Excess noise causes headache.**
5. **Stress, tension and aggressiveness: Loud noises can be very stressful. Constant exposure to irritating sound may cause stress and tension. The behavior of people often becomes aggressive. Other than psychological imbalance, is causes physical illness such as increased blood pressure, cardiac disturbance and insomnia.**
6. **Irregular blood pressure: For good health, it is very important to maintain normal pressure in the arteries both during the heartbeat and between the heartbeat. Noise may contribute to fluctuations in the levels of blood pressure.**
7. **Mental imbalance and nervous debility: Mental illness is among the worst negative effects of noise pollution. People may find it difficult to cope with their normal routine life. Human mind cannot accept sound beyond a certain level. Excess sound may lead to mental imbalance and nervous disability.**
8. **Psychological imbalance: It may also cause psychological imbalance.**
9. **Difficulty in talking: Due to excessive noise, it becomes very difficult to talk on roads or inside malls**

Effect on Animals: Noise pollution is hazardous for animals, both wild and domestic. It impairs hearing. Sometimes, it changes the reproductive behavior of the animals. Noise disrupts the communication among animals. Some animals cannot live in noisy atmosphere resulting in loss of habitat. In the presence of noise, some animals raise the level of their voice. For example, many marine animals raises their voice when large ships passes near them. The increased voice further adds to the noise already present. Marine animals are sensitive to noise.

Control measures:

1. **SOURCE CONTROL: This includes source modification such as acoustic treatment to machine surface, design changes, limiting operational timings, etc**

2. **TRANSMISSION PATH INTERVENTION:** This includes containing the source inside a sound insulating enclosure, constructing 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 noise from the machine.

Preventive measures:

1. Prescribing noise limits for vehicular traffic
2. Ban on honking (usage of horns) in certain areas
3. Creation of silence zones near schools and hospitals
4. Redesigning buildings to make them noise proof
5. Reduction of traffic density in residential areas
6. Giving preference to mass public transport system.

Some effective measures should be taken to solve the problem. The following measures can be taken to prevent noise pollution:

- Better town planning and ensuring that residential towns are set up at places away from heavy industrial units can help in combating the problem of noise pollution.
- Significant control over noise pollution caused by transportation vehicles can be controlled by making smooth roads, and by disallowing heavy carriage vehicles on roads near residential units.
- To prevent and control noise pollution it is necessary to create public awareness. Only law is not sufficient. People must be made aware of the harmful consequences and irreversible injuries caused of noise pollution such as deafness, mental illness, etc.
- There should be minimum use of sound producing instruments. There should be proper regulationsfor the use of loudspeakers, microphones, and other devices that produce noise beyond that are beyond the toleration limits of human-beings.
- The Pollution Control Board and the High Court have already taken effective measures to bring sound pollution under control. Adequate measures should be taken to ensure that noise related restrictionsare not violated.
- Anti-pollution laws should be enacted and enforced.
- Ban on fire crackers should be imposed and electric horns should be replaced by bulb horns. Further, use of horns in residential areas should be monitored and regulated.
- Usage of quieter machinery should be encouraged.

Thermal pollution

Thermal pollution can be simply explained as the addition of surplus heat to water and ejecting it back to the water bodies. So how does it happen? Well, numerous industries take

water from natural water resources for their industrial purposes. Maximum of this water is used as coolant as it is used to cool down the machines of any factory or plant.

Afterwards, this used water with altered and much high temperature is ejected back to the natural resources including lakes, ponds, seas, etc. This causes sudden increase in temperature of natural water bodies too. The altered water also creates disturbance in the oxygen level of water bodies. This in turn, harms the marine life and local ecosystems. Therefore, thermal pollution caused in water by spilling back the industrial waste and used water in it, causing adverse effects, is known as thermal pollution.

Thermal pollution is not only caused by the hot water but also by the cold water that is discharged by various industries into the rivers or seas containing warm water.

Or

An increase in the optimum water temperature by industrial process (steel factories, electric power houses and atomic power plants) may be called as "Thermal Pollution." Many industries generate their own power and use water to cool their generator.

Or

Thermal pollution is defined as the addition of excess of undesirable heat to water thereby making it harmful to man, animal or aquatic life. Thermal pollution may also cause significant departures from nor activities of aquatic communities.

Sources of Thermal Pollution:

The following sources contribute to thermal pollution.

1. **Nuclear power plants**
2. **Coal fired plants**
3. **Industrial effluents**
4. **Domestic sewage**
5. **Hydro-electric power**

1. **Nuclear power plants: Nuclear power plants including drainage from hospitals, research institutions, nuclear experiments and explosions, discharge a lot of heat that is not utilized along with traces of toxic radio nuclides into nearby water streams. Emissions from nuclear reactors and processing installations are also responsible for increasing the temperatures of water bodies. The operations of power reactors and nuclear fuel processing units constitutes the major contributor of heat in the aquatic environment. Heated effluents from power plants are discharged at 10 C higher than the receiving waters that affects the aquatic flora and fauna.**

2. **Coal-fired power plants: Coal fired power plants constitute a major source of thermal pollution. The condenser coils in such plants are cooled with water from nearby lakes or rivers. The resulting heated water is discharged into streams thereby raising the water temperature by 15C. Heated effluent decreases the dissolved content of water resulting in death of fish and other aquatic organisms. The sudden fluctuation of temperature also leads to "thermal shock" killing aquatic life that have become acclimatized to living in a steady temperature.**

3. **Industrial effluents: Industries like textile, paper, pulp and sugar manufacturing release huge amounts of cooling water along with effluents into nearby natural water**

bodies. The waters polluted by sudden and heavy organic loads result in severe drop in levels of dissolved oxygen leading to death of several aquatic organisms.

4. Domestic Sewage: Domestic sewage is discharged into rivers, lakes, canals or streams with minimal treatment or without any treatment. These wastes have a higher organic temperature and organic load. This leads to decrease in dissolved oxygen content in the receiving waters resulting in the set-up of anaerobic conditions causing release of foul and offensive gases in water. Eventually, this leads to development of anoxic conditions resulting in rapid death of aquatic organisms.

5. Hydro-electric power: Generation of hydroelectric power sometimes leads to negative thermal loading in water systems. Apart from electric power industries, various factories with cooling requirement contribute to thermal loading.

Thermal pollution in streams by human activities

1. **Industries and power plants use water to cool machinery and discharge the warm water into a stream**
2. **Stream temperature rises when trees and tall vegetation providing shade are cut.**
3. **Soil erosion caused due to construction also leads to thermal pollution**
4. **Removal of stream side vegetation**
5. **Poor farming Practices also lead to thermal polloution**

Causes of Thermal Pollution

1. **Water used as coolant & ejected back into water bodies – Mainly, the water that is used as coolant and transferred back to natural water bodies is the chief reason for thermal pollution. This kind of activity is mostly done by production; manufacturing and power plants. These plants use water to cool down their machines and eject back the hot water into water bodies. Thus, the natural water goes through a sudden rise in temperature.**

2. Release of cold water – Just as we mentioned before, many industries liberate very cool water from their reservoirs. This water when mixed up with warm water rivers, lakes or ponds creates a disbalance in the flora and fauna of affected water bodies.

3. Growing industrial activities – It gives a repenting feeling to know that thermal pollutants are increasing day by day because of the growing industrial activities. Therefore, thermal pollution is also growing each day.

4. Chemical pollutants discharged into water – There are copious factories that discharge their chemical waste directly into natural water bodies. This does not only causes thermal pollution but also makes the water poisonous.

5. Livestock waste mixed into water – This is another major cause of thermal pollution. Many industries dispose their livestock waste into water without analyzing upon the hazardous consequences of this act.

6. Water discharged from urban areas – Many urban areas like parking places, roads, etc., deposit rain water and discharge the heated water back into water bodies. The heated water disturbs the normal temperature of natural water bodies.

7. Human waste, household & personal care products – These products go into sewage water which pollutes the water in ponds, seas and other water bodies.

8. Deforestation & soil erosion – Soil erosion makes natural water bodies to rise beyond their normal level. Thus, they get more exposed to sunlight. Hence, the temperature of water rises. Forests absorb much of sun rays and save water bodies from getting too much heat. However, deforestation disturbs this cycle and provides augmented temperature of water.

9. Natural Geo-thermal activities – Natural geothermal activities can stimulate lava and can cause a rise in water temperature, making way for thermal pollution.

10. Unawareness among people – Growing thermal pollution is also the result of unawareness among people. Even after knowing the hazardous effects of thermal pollution on environment, there are abundant industries which are continuously using ways that encourage this pollution.

Effects of Thermal Pollution

1. **Thermal shock resulting in rise in temperature of water bodies – When industries and factories dispose the water, used as coolant, back into water bodies the temperature suddenly raises to an abnormal level. The sudden and abnormal temperature level acts as a thermal shock for aquatic life, which is adapted to living in a specific temperature and cannot, handle the abrupt change in water temperature.**

2. Depleted level of oxygen in natural water – When warm water discharged by industries enters the natural water bodies, they get heated up. The warm water causes an unusual growth of plants and expansion of algae. The algae expansion in water reduces the level of oxygen in water.

3. Contamination of water – Thermal pollution also results in contamination of water because various chemicals and other wastes get mixed up with the water that is disposed off back to rivers, ponds, lakes, etc., by various factories. If this contamination of water keeps on increasing, humans can suffer from shortage of water.

4. Reduced solubility of oxygen – Reduced solubility of oxygen in water bodies is another disappointing effect of thermal pollution. This less solubility of oxygen in water mainly affects the metabolism of water animal.

5. Adverse effect on water plants – Change in temperature levels is extremely harmful for the aquatic plants. These plants cannot cope up with the sudden alteration in water temperature. Hence, more and more aquatic plants are depleting each day because of thermal pollution

6. Adverse effects on water animals – The whole marine life gets disturbed because of thermal pollution. The contaminated water makes the natural water poisonous and has an adverse effect on animals living in it. Also, the reduced level of oxygen makes it difficult for water animals to survive.

7. Effect on population of water animals – When the temperature in natural water bodies gets disturbed because of thermal pollution, the cycle of animal population gets disturbed too. For example, sometimes the fish start laying eggs too soon and sometime they do it too late. The whole productivity of river gets disturbed too.

8. Disturbance in biological activities of water animals – Thermal pollution leads to a disturbance in quality and temperature of water in various water bodies. This altered quality and temperature directly affect all the biological activities of animals, thus disturbing the cycle of nature.

9. Unfavorable Effect on Water Biodiversity – Thermal pollution largely affects the water bio diversity. The rise in temperature of water results in increased metabolic activity of some water animals. Hence, they start consuming more food in short time. This also leads to shortage of certain water resources. Some animals which are unable to stand the raised temperature start moving to other regions. Therefore, the whole natural system of water bio diversity gets disturbed.

10. Unexpected Migration of Water Animals – When water animals find it difficult to survive in the changed water because of thermal pollution, they start for an unexpected migration, making way for a disturbed ecosystem.

Control Measures for Thermal Pollution

After reading about so many harmful effects of thermal pollution, and the disturbance that it causes in nature's cycle, you must definitely be wondering that whether there is any solution for the same. The good point is that of course, there is a solution for thermal pollution. As man has created the problem of thermal pollution, he should be the one to work out for its solution too!

The best part about the solution for thermal pollution problem is that we can definitely make a huge and positive difference if we start following just few steps. Without discussing these solutions, we cannot reach a positive conclusion.

So let us glance through some effective ways that can help reduce thermal pollution at a significant extent:

1. **Use less electricity – All of us know that power plants are the main reasons behind growing thermal pollution. This is so because power plants use water as a cooling agent for cooling down their machines. This used water, which is much higher in temperature, is discharged back into the rivers, seas or lakes. We can make a significant contribution in controlling thermal pollution by consuming less electricity,. The use of less electricity will lead to less workload on power plants and these plants will not have to use their machines too much, meaning controlled use of water as coolant. Hence, switch off fans when you are not sitting in that room, switch off unnecessary lights, use solar products and techniques. All such steps will help us use lesser electricity.**

2. Use of Better Technologies – Science has gifted us with plentiful inventions, discoveries, techniques and knowledge. Incorporating good techniques ensure a good lifestyle for human race. Use of better technologies is strongly recommended for solving the problem of thermal pollution. There are technologies available which help in the cooling down of machines. If machines will be cooled down with the help of technologies, the use of water as coolant will come to a much reduced level. Various industries and power plants should look out for appropriate technologies that serve the purpose without encouraging the steady problem of thermal pollution.

3. Holding back the water for good – If factories or plants cannot stop using water as a coolant, there is another option available for them. After using the water as coolant, they should store that water somewhere else for a temporary period. Instead of discharging back the heated water into water bodies, the temporarily collected heated water can be used for various other purposes too. Storing the heated water for a particular time will help in bringing back the high temperature of water to a normal level.

3. Plantation of more trees upon the banks of rivers, seas & other water bodies – This is also a good way to control thermal pollution. The trees around sources of water help in absorbing the harsh sun rays and prevent them from falling directly upon the water. This helps in prevention of heating of water bodies. Planting more trees also helps in controlling the problem of soil erosion because the strong roots of trees hold the soil firmly and stop it from erosion. Trees do not only help in controlling thermal pollution but also aid in a better environment including fresh air and peaceful scenic views. We should also encourage our coming generations to plant more and more trees.

5. Artificial Lakes – Industries, factories or plants which are serious about storing and reusing the heated water, used as coolant, can work out on artificial lakes. These are artificial lakes where the heated water can be stored easily. These lakes are very helpful for normalizing the temperature of hot water. This way, the hot water will not be disposed back to the lakes, rivers, etc., and will be used in other suitable tasks. Actually, the artificial lakes or ponds use evaporation or convection technique for cooling down the water. These artificial lakes or ponds generally contain two ends. From one end, the hot water is transferred into the lake; it is processed through evaporation or other

technique and finally, when it cools down, it is taken out from the other end. The evaporated heat dissolves in the air.

5. Recycling used water – Smart people always find intelligent solutions for even the most difficult of problems. If people start working upon the ideas of recycling the used water in plants and factories, the problem of thermal pollution will definitely be lessened to a significant extent. Every plant or industry should make it a rule that water used as coolant will not be spilled back into water bodies. Rather, it will be recycled for further tasks. In today's era, we often hear news about the shortage of water and thousands of people dying because of the same. Just ask yourself that isn't it our duty to save water and use it for good?

7. Spreading awareness among people – Environment can be made better with a united effort. Making more and more people aware about the problem of thermal pollution will be very beneficial in the long run. Groups of people can initiate a discussion with different plants and industries. These groups can discuss the harmful effects of thermal pollution on aquatic life and our environment. We can also aware others about the consistent problem of thermal pollution by gaining the right knowledge about thermal pollution.

8. Suitable arrangements in urban places – Places like parking spaces, drainage pipes, sewerage tanks, etc., should have proper arrangements so that the water does not get collected at those spaces. When the water is accumulated at these spaces, it gets heated up and gets mixed with seas, ponds, lakes, etc., thus making way for thermal pollution. Hence, by making appropriate arrangements at such places, we can stop water from getting accumulated.

9. Co-generation – Co-generation is also a wonderful idea to combat thermal pollution. In the process of co-generation, the useless heat from hot water can be recycled and used smartly in many tasks by industries.

10. Cooling towers – Cooling towers is also a good idea when talking about the solutions for thermal pollution. The purpose of using cooling towers is the same as artificial lakes. The cooling towers also use the hot water of industries, process it by transferring its heat and transform hot water into cold water. This cool water can be recycles and used again for different industrial purposes.

Generally, the cooling towers are of two types. This includes the wet cooling tower and the dry cooling tower. In wet cooling tower, the heated water gets spread upon the flow-directing panels. Afterwards, the high-speed cold air is passed upon it. Henceforth, the hot water gets cooled down.

In dry cooling towers, the heated water is made to flow in circular elongated pipes. Again, the cold air blows are passed upon these pipes that help in bringing down the temperature of hot water.

NUCLEAR POLLUTION

Nuclear radiation has catastrophic effects on the health of humans such as foetus damage, leukemia, permanent physical deformation, skin burns and even death in case if the person comes in contact with severe radiations. It also releases toxic minerals in the environment causing pollution

CAUSES OF NUCLEAR POLLUTION

- **Nuclear weapons testing-**

Beginning with the Second World War when Japan was subdued after the use of the nuclear bombs on the cities of Hiroshima and Nagasaki, countries have been in the race to develop their own nuclear arms, in the name of defence, but more to threaten rival nations. These were led by US, Russia, Britain, France and China. Nowadays N. Korea, Iran and many of the developing countries are equipped to build these weapons as well.

Testing the weapons involves explosions is the atmospheric layer called stratosphere. The exploded debris emitting radiation then falls back to the earth. Some of the radiation is absorbed by our atmosphere. But some of it reaches the earth falling on areas that are far away from the site where the weapon was released initially. This is called Fallout. When these particles settle on the vegetation and are consumed by animals they enter into the food chain. When fallout settles over the sea, the ecosystem of the sea gets affected and again entering the food chain.

- **Nuclear Power Plants**

Intense Nuclear energy from radioactive fuel is used to heat water to steam. The steam is then used to turn the turbines that in turn work the generators to produce electricity. Small amounts of radiation are released during this process into the water which may then dispose off indiscriminately causing nuclear pollution.

- **Improper disposal of spent nuclear fuel.**

Spent nuclear fuel contains very active radioactive atoms that remain so sometimes almost for 600yrs or more. These must be disposed of in a very careful manner, with strict regulations in well designated spaces. But the fact is many governments tend to approve of dumping nuclear fuel as far from their country as possible. The favourite dumping ground of many countries was the Pacific Ocean. Greenpeace an organisation dedicated to preserving the environment and saving the earth from pollution has brought attention to this activity and opposes it with fervour.

Some plants store spent fuel in underground water pools as these release a high amount of heat and need to be cooled down. There is always the danger of seepage into the land nearby, contaminating ground water and surrounding lands.

- **Accident/Damage to Nuclear power plants**

This most famous of these was the Chernobyl Nuclear Disaster in Russia in 1986. The fallout of this accident was felt over three countries- Russia, Ukraine and Belarus. The area surrounding the reactor is still polluted and not suitable for inhabitation or farming.

The other more recent accident was the Fukushima Daichii nuclear disaster on March 11th, 2011. An earthquake followed by a tsunami caused the main reactors and supplementary generators severe damage. Inadequate preparation to deal with an incident of this scale was also a factor that leads to hydrogen explosions and the seepage of radioactive material in the ground water.

Effects of Nuclear Pollution

The effect of nuclear pollution is seen on every organism in the environment from the bacteria to plants to human beings. Nothing is spared.

- **The immediate and closest to the source, experience Radiation Sickness. In small doses of 75-200 rems. One experiences vomiting, fatigue and loss of appetite. At higher exposures of 300 rem and more changes in the blood cells and bleeding occurs. Above 600 rems there is loss of hair, loss of immunity usually resulting in death in a few days to weeks. Radiation causes changes in the cell and gene structure of rapidly multiplying cells of the body, such as bone marrow, skin, intestines, lymphoid tissue and embryo.**
- **Those exposed from a distance may not show any immediate symptom. But the tendency to develop various forms of cancersand have a shortened life span is seen. Radiation also causes cell mutations which can be transferred to the next generation.**
- **Foetuses are affected with birth defects and cancers. They may also have a shorter life span.**
- **Plants die and some show genetic changes and stunted growth. Animals are also affected and do not survive for too long.**
- **The radiation in the atmosphere will not dissipate quickly. Every water source will also be affected. In fact it may take years or centuries to reach a point where such a space may become habitable.**
- **An average person will be exposed to about 180 milli rem of radiation in a year from exposure to natural radiation, medical and dental X rays, Colour TVs, airport baggage X rays etc.**

Prevention of Nuclear pollution

- **Whilst undergoing procedures for X rays or radiation therapy, correct protection gear such as lead aprons must be worn. This includes pregnant women. Using lead sheathed walls in imaging facilities is also mandatory.**
- **As a lay person one must be aware of the dangers of nuclear pollution. If living in the vicinity of a nuclear plant or hearing of one being planned, one should use one's right to make sure the governing bodies are planning thoroughly on the building, implementing and disposal of the wastes. Make certain that the authorities are prepared in case of a disaster, to handle all the situations such as containing the contamination to arranging an evacuation.**

- **While working at a radiation facility or in nuclear plant workers are always monitored for the amount of radiation they have been exposed to.**
- **Radioactive wastes are actually recyclable to a good extent because usable fuel is still being created in the wasted material which can then be reprocessed.**
- **Governments are authorising research on developing better means for disposal of radioactive wastes. The most feasible method now appears to be deep underground storage of wastes.**
- **Power plants must ensure that the radioactive fuel and wastes are being transported and disposed of in safe containers which are long lasting and unbreakable.**
- **Governing agencies need to make sure that radioactive material does not fall into wrong hands that will, for a profit sell these to people who are in the business of war mongering.**

Nuclear energy is a clean source of energy, inexpensive and extensive too. With a small amount of fuel a large amount of energy can be generated. Though there have been mishaps in the past and wrongful use of this energy, there is still great potential for it. Any well intentioned effort must be backed by good research, a well-designed plan and proper back up plans for any setbacks. The safety of the environment and the people must always come first.

<u>Solid waste management</u>

Rapid population growth and urbanization in developing countries has led to people generating enormous quantities of solid waste and consequent environmental degradation. The waste is normally disposed in open dumps creating nuisance and environmental degradation. Solid wastes cause a major risk to public health and the environment. Management of solid wastes is important in order to minimize the adverse effects posed by their indiscriminate disposal.

Types of solid wastes: Depending on the nature of origin, solid wastes are classified into

1. **URBAN OR MUNICIPAL WASTES**
2. **INDUSTRIAL WASTES and**
3. **HAZARDOUS WASTES**

<u>SOURCES OF URBAN WASTES</u>

Urban wastes include the following wastes:
Domestic wastes containing a variety of materials thrown out from homes
Ex: Food waste, Cloth, Waste paper, Glass bottles, Polythene bags, Waste metals, etc.
Commercial wastes: It includes wastes coming out from shops, markets, hotels, offices, institutions, etc.
Ex: Waste paper, packaging material, cans, bottle, polythene bags, etc.
Construction wastes: It includes wastes of construction materials.
Ex: Wood, Concrete, Debris, etc.
Biomedical wastes: It includes mostly waste organic materials

Ex: Anatomical wastes, Infectious wastes, etc.

Classification of urban wastes
Urban wastes are classified into:
Bio-degradable wastes - Those wastes that can be degraded by micro organisms are called bio-degradable wastes
Ex: Food, vegetables, tea leaves, dry leaves, etc.
Non-biodegradable wastes: Urban solid waste materials that cannot be degraded by micro organisms are called non-biodegradable wastes.
Ex: Polythene bags, scrap materials, glass bottles, etc.

SOURCES OF INDUSTRIAL WASTES

The main source of industrial wastes are chemical industries, metal and mineral processing industries.
Ex:
Nuclear plants: It generated radioactive wastes
Thermal power plants: It produces fly ash in large quantities
Chemical Industries: It produces large quantities of hazardous and toxic materials.
Other industries: Other industries produce packing materials, rubbish, organic wastes, acid, alkali, scrap metals, rubber, plastic, paper, glass, wood, oils, paints, dyes, etc.

EFFECT OF IMPROPER SOLID WASTE MANAGEMENT

1. **Due to improper disposal of municipal solid waste on the roads and immediate surroundings, biodegradable materials undergo decomposition producing foul smell and become a breeding ground for disease vectors.**
2. **Industrial solid wastes are the source for toxic metals and hazardous wastes that affect soil characteristics and productivity of soils when they are dumped on the soil**
3. **Toxic substances may percolate into the ground and contaminate the groundwater.**
4. **Burning of industrial or domestic wastes (cans, pesticides, plastics, radioactive materials and batteries) produce furans, dioxins and polychlorinated biphenyls that are harmful to human beings.**

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

STEPS INVOLVED IN SOLID WASTE MANAGEMENT:

Two important steps involved in solid waste management are:
Reduce, Reuse and Recycle of Raw Materials
Discarding wastes

Reduce - If usage of raw materials is reduced, the generation of waste also gets reduced

Reuse - Refillable containers that are discarded after use can be reused

Rubber rings can be made from discarded cucle tubes and this reduces waste generation during manufacture of rubber bands.

Recycle- Recycling is the reprocessing of discarded materials into new useful products

Ex: Old aluminium cans and glass bottles are melted and recast into new cans and bottles

Preparation of cellulose insulation from paper

Preparation of automobile body and construction material from steel cans

This method (Reduce, Reuse & Recycle), i.e, 3R's help save money, energy, raw materials and reduces pollution.

DISCARDING WASTES:

The following methods are adopted for discarding wastes:

1. **Landfill**
2. **Incineration and**
3. **Composting**

LANDFILL: Solid wastes are placed in a sanitary landfill in which alternate layers of 80 cm thick refuse is covered with selected earth-fill of 20 cm thickness. After 2-3 years solid waste volume shrinks by 25-30% and land is used for parks, roads and small buildings. This is the most common and cheapest cheapest method of waste disposal and is mostly employed in Indian cities.

Advantages:

It is simple and economical
Segregation of wastes is not required
Landfilled areas can be reclaimed and used for other purposes
Converts low-lying, marshy waste-land into useful areas.
Natural resourcesare returned to soil and recycled.

Disadvantages:

Large area is required
Land availability is away from the town, tansportation costs are high
Leads to bad odour if landfill is not properly managed.
Land filled areas will be sources of mosquitoes and flies requiring application of insecticides and pesticides at regular intervals.
Causes fire hazard due to formation of methane in wet weather.

INCINERATION:

It is a hygenic way of disposing solid waste. It is suitable if waste contains more hazardous material and organic content. It is a thermal process and very effective for detoxification of all combustible pathogens. It is expensive when compared to composting or land-filling. In this method municipal solid wastes are burnt in a furnace called incinerator. Combustibe substances such as rubbish, garbage, dead organisms and non-combustibe matter such as glass, porcelain and metals are separated before feeding to incinerators. The non-combustible materials can be left out for recycling and reuse. The leftover ashes and clinkers

may account for about 10 to 20% which need further disposal by sanitary landfill or some other means.

The heat produced in the incinerator during burning of refuse is used in the form of steam power for generation of electricity through turbines. Municipal solid waste is generally wet and has a high calorific value. Therefore, it has to be dried first before burning. Waste is dried in a preheater from where it is taken to a large incinerating furnace called "destructor" which can incinerate about 100 to 150 tonnes per hour. Temperature normally maintained in a combustion chamber is about 700 C which may be increased to 1000 C when electricity is to be generated.

ADVANTAGES

Residue is only 20-25% of the original and can be used as clinker after treatment
Requires very little space
Cost of transportation is not high if the incinerator is located within city limits
Safest from hygenic point of view
An incinerator plant of 3000 tonnes per day capacity can generate 3MW of power.

DISADVANTAGES

Its capital and operating cost is high
Operation needs skilled personnel
Formation of smoke, dust and ashes needs further disposal and that may cause air pollution.

<u>COMPOSTING</u>

It is another popular method practiced in many cities in our country. In this method, bulk organic waste is converted into fertilizer by biological action. Separated compostible waste is dumped in underground trenches in layers of 1.5m and finally covered with earth of 20cm and left for decomposition. Sometimes, actinomycetes are introduced for active decomposition. Within 2 to 3 days biological action starts. Organic matter is destroyed by actinomycetes and lot of heat is liberated increasing the temperature of compost by 75C and the refuse is finally converted into powdery brown coloured odourless mass called humus that has a fertilizing value and can be used in agriculture. Humus contains lot of Nitrogen essential for plant growth apart from phosphates and other minerals.
ADVANTAGES

Manure added to soil increases water retention and ion-exchange capacity of soil.
This method can be used to treat several industrial solid wastes.
Manure can be sold thereby reducing cost of disposing wastes
Recycling can be done
DISADVANTAGES

Non-consumables have to be disposed separately
The technology has not caught-up with the farmers and hence does not have an assured market.

Role of an Individual in Prevention of Pollution!

Over population and pollution are potent ecological forces impinging upon man by affecting the quality of the environment. All efforts aimed at bringing more and more people above the poverty line actually increase the pressure on natural resources.

Careless management of natural resources is disrupting the ecological processes so much so that earth's life supporting capacity is being substantially threatened.

Unmindful exploitation of the finite resources of the biosphere has a severe ecological backlash because no development is sustainable unless it is environmentally compatible. Environmental compatibility demands that the economic and social development should be linked with environmental management.

(a) Control of environmental pollution
(b) Conservation of natural resources
(c) Land management
(d) Development of non polluting sources of energy
(e) Environmental education
(f) Environmental laws.

Pollution is the burning issue of the day at the global level. A combined effort to control pollution has to be made by all government agencies, technologists, industrialists, agriculturists and last but not the least the common man.

5. **An international conference on "Human Environments" was held in Stockholm in 1971, to emphasise the need to control pollution.**

Efforts are required to be made by each individual to control pollution. These efforts include:

6. **(a) Installation of proper sewage disposal methods.**
7. **(b) Dumping of non biodegradable wastes in low lying areas.**
8. **(c) Installation of gobar gas plants in areas of high availability of cow dung.**
9. **(d) Reduction of smoke emission and treatment of chimney smoke to remove solid carbon particles.**
10. **(e) Judicious use of fertilisers, pesticides and detergents (Detergents of low- level phosphate content are less harmful).**
11. **(f) Growing plants like Pyrus (apple), Pinus (chir) and Vitis (grapes) is advocated because of their capability of metabolizing gaseous nitrogenous pollutants like nitrogen dioxide etc. and plants like coleus, ficus (banyan) can fix Carbon monoxide.**
12. **Skilled personnel with know-how to tackle the problems arising from pollution and for devising environmental pollution control measures are working in many institutions in India. Important ones amongst them are:**
13. **(a) National Environmental Engineering Research Institute (NEERI), Nagpur.**
14. **(b) Bhaba Atomic Research Centre (BARC), Mumbai**
15. **(c) National Committee of Environmental Planning and Co-ordination (NCEPC), New Delhi.**
16. **(d) Central Drug Research Institute (CDRI), Lucknow.**
17. **(e) Councils of Scientific and Industrial Research (CSIR).**
18. **(f) Central Public Health Engineering Research Institute (CPHERI), Nagpur.**

19. **Scientists have rightly said that, 'in the course of our progress from one age to another, we have simply passed from a say-age to sew-age.**

Disaster management

Disaster is a natural or human , caused phenomenon, which causes serious disruption of the functioning of a community or a society causing widespread human, material, economic and environmental losses which elicited the ability of the affected community, society to cope using its resources.

FLOODS ARE NATURAL PHENOMENA. FLOODS ARE WATER RELATED DISASTER

A flood occurs when the Geomorphic Equilibrium in the river system is disturbed because of intrinsic or extrinsic factors or when a system crosses the geomorphic threshold. (a) Flooding in a river due to aggradations of river bed (intrinsic threshold); (b) Flooding in a river due to heavy rainfall (extrinsic threshold)

Floods in major cities especially during rainy season are proving to disastrous not only to the environment but also have serious implications for human life and property.

Types of floods

- **Flash floods**
- **River floods**
- **Coastal Floods**
- **Urban Flood**

According to their duration flood can be divided into different categories: •Slow-Onset Floods: Slow Onset Floods usually last for a relatively longer period, it may last for one or more peeks, or even months. •Rapid-Onset Floods: Rapid1Onset Floods last for a relatively shorter period, they usually last for one or two days only. •Flash Floods: Flash Floods may occur within minutes or fe1w hours after heavy rainfall, tropical storm, failure of dams or levees or releases of ice dams. And it causes the greatest damages to society.

FLOODS IMPACTS

- **Human Loss**
- **Property Loss**
- **Affects the Major Roads**
- **Disruption of Air / Train / Bus services**
- **Spread of Water-borne Communicable Diseases**
- **Communication Breakdown**
- **Electricity Supply Cut off**
- **Economic and Social Disruption**
- **Increase in Air / Water Pollution 6/11/2013 Floods- Disaster Managme**

Flood forecasting

- **Anticipating floods before they occur allows for precautions to be taken and people to be warned so that they can be prepared in advance for flooding conditions.**
- **For example, – Farmers can remove animals from low-lying areas and utility services can put in place emergency provisions to re-route services if needed. Emergency services can also**

make provisions to have enough resources available ahead of time to respond to emergencies as they occur.

• In order to make the most accurate flood forecasts for waterways, it is best to have a long time-series of historical data that relates stream flows to measured past rainfall events

• Radar estimates of rainfall and general weather forecasting techniques are also important components of good flood forecasting. Flood Control

• In many countries around the world, waterways prone to floods are often carefully managed. Defences such as levees, bunds, reservoirs, and weirs are used to prevent waterways from overflowing their banks.

• In the riparian zone near rivers and streams, erosion control measures can be taken to try and slow down or reverse the natural forces that cause many waterways to meander over long periods of time.

• Flood controls, such as dams, can be built and maintained over time to try and reduce the occurrence and severity of floods as well. Flood benefits

• Floods (in particular more frequent or smaller floods) can also bring many benefits, such as – Recharging ground water, – Making soil more fertile and increasing nutrients in some soils.

• Flood waters provide much needed water resources in arid and semi-arid regions where precipitation can be very unevenly distributed throughout the year.

• Freshwater floods particularly play an important role in maintaining ecosystems in river corridors and are a key factor in maintaining floodplain biodiversity.

• Flooding can spread nutrients to lakes and rivers, which can lead to increased biomass and improved fisheries for a few years.

• For some fish species, an inundated floodplain may form a highly suitable location for spawning with few predators and enhanced levels of nutrients or food.

• Fish, such as the weather fish, make use of floods in order to reach new habitats. Bird populations may also profit from the boost in food production caused by flooding

Earthquake

Earthquake is a natural disaster that can be broadly defined as a series of vibrations that are induced from the earth's crust. A sudden movement of the earth's crust, sudden release of extreme energy, shaking or trembling of the crust of the earth due to shifting of rocks under the earth's surface or underground volcanic forces can be called as earthquakes. This is often accompanied by terrible noise. These waves can sometimes traverse half a hemisphere destroying the cities completely. The location where earthquake starts is called hypocenter or focus. The location just above the hypocenter is called epicenter. The main earthquake is called main shock. There are many aftershocks that occur after the mainshock. The amount of energy released during earthquake is called magnitude.

CAUSES OF EARTHQUAKES

Most of the scientists believe that earthquakes are formed due to the movement of the earth's plates. It is a very natural phenomenon and a theory commonly known as plate tectonics. As, we all know earth is divided into 3 layers namely – Crust, Mantle and Core. The

outermost layer of earth is known as the crust which is made up of granite and basalt. About 70% of the crust is ocean. The crust has several continental plates which drift every year. The second layer is called mantle. 80% of the earth is mantle. The mantle consists of lithosphere which is the upper mantle and asthenosphere which is the lower mantle. The core is the innermost layer of the earth. One third of the mass of the earth is core. The core has a liquid outer core made up of iron and it is very dense. It also has a solid inner core made of nickel and iron. The magnetic field of the earth is created when the liquid outer layer spins. So, as discussed above, the earth's crust is made up of several large and hard plates. These plates move slowly and continuously above the mantle. So collision and stress is caused among the plates. The stress among the plates can also occur when one plate goes over the other or when the sides if the plates collide. As the stress increases, the crust breaks and the energy is released. This released energy moves to and fro in the form of waves called seismic waves. Thus these naturally created waves shake the earth forming earthquakes.

MEASUREMENT OF EARTHQUAKES

The first widely used gadget for measuring earthquakes were the Richter scale which was developed by a Charles Richter in the year 1934. According to this scale, the largest wave was recorded in a seismometer and then the distance between the earthquake and the seismometer was measured. But unfortunately, the measurements in this Richter scale were not accurate. Main 2 devices are used by seismologist to measure earthquakes. They are: seismograph and seismoscope. Seismograph is an instrument to measure seismic waves of the earthquakes. Seismoscope is an instrument to measure the time or occurrence of earthquakes. Nowadays earthquakes are calculated by its magnitude and intensity. Logarithmic scale is the base for calculating magnitudes. This means that the higher the whole number on the magnitude, the motion recorded by the seismograph goes up ten times. This scale has no upper limit. Thus, magnitude is the amount of seismic energy at the hypocenter of the earthquakes. Intensity on the other hand is observed by the ground shaking of the people and buildings. This varies from place to place. According to the U.S geological center, the earthquakes are assigned to a class as per their magnitude. The classes are as under-

- **Great : magnitude is 8.0 or above- tremendous damage**
- **Major : magnitude 7.0 – 7.9- heavy damage**
- **Strong : magnitude 6.0 – 6.9- severe damage**
- **Moderate : magnitude 5.0 – 5.9- considerable damage**
- **Light : magnitude 4.0 – 4.9- moderate damage**
- **Minor : magnitude 3.0 – 3.9- light damage**
- **Micro : magnitude less than 3.0- slight treble.**

TYPES OF EARTHQUAKES

There are many classifications for earthquakes. Some of the classifications are as under:

- **On the basis of origin**

- **On the basis of dept of focus**
- **On the basis of magnitude and intensity**

Origin:

On the basis of origin, earthquakes are divided into tectnotic and non tectnotic earthquakes. Tectnotic earthquakes occur when the earth's plates shift due to some geographical force. Non tectnotic earthquakes occur due to the surfaces and collapse of the cavity roofs.

Dept of focus:

Here the depth of the focus is measured and further analyzed by seismograph. Here the further sub divisions are:

- **Surface earthquakes : these earthquakes have depth of focus of less than 10,000 meters and are called surface earthquakes.**
- **Normal earthquakes : these earthquakes have depth of focus between 10-50 kilometers and are called normal earthquakes.**
- **Intermediate earthquakes : these earthquakes have depth of focus between 50-300 kilometers and are called intermediate earthquakes.**
- **Deep earthquakes : these earthquakes have depth of focus between 500-700 kilometers and are called deep earthquakes.**

Magnitude and intensity :

Sometimes earthquakes are measured on the basis of magnitude i.e. the amount of seismic energy at the epicenter and intensity i.e. the total damage and destruction caused due to earthquakes.

Earthquakes can be again classified into:

- **Shallow fault earthquakes : When the rock breaks under the feet it is called a fault. So earthquakes occur within and through these faults. These faults are close to the surface of the earth, a small quake can cause a lot of damage.**
- **Subduction zone earthquakes : These earthquakes happen in the Subduction area of the earth along the Subduction zone. Huge shift in land level happens during this earthquake. The waves that occur are tremendously high and spread over a larger area.**
- **Deep earthquakes : These earthquakes occur in the deep ocean slabs beneath the continental crust of the earth.**

EFFECTS OF EARTHQUAKES

1. **Causes widespread damage and loss of human life.**
2. **Causes ground displacement along the fault.**
3. **The shaking of the ground causes landslides and avalanches.**
4. **Causes rupturing of dams and can cause floods and tsunami.**
5. **The broken electric lines and gas lines due to the earthquakes can cause fire.**
6. **Kills and injures hundreds.**
7. **The entire city can be devastated.**

8. **Liquefaction of the soil takes place**

To conclude, earthquakes are the most powerful and destructive natural force which is hazardous to mankind. Earthquakes are unpredictable disasters that arise with no warning and have plagued humans throughout history. The energy released earthquakes fracture the surface of the earth. Forecasting earthquakes are a bit difficult but earthquake warning systems have been developed. Earthquake engineering and earthquake insurance have to be developed in a larger angle so as to prepare for the aftereffects. But not all earthquakes are bad. Sometimes when earthquakes are created, it has even created notable landmarks in the world. So the place of occurrence is very important before stamping it as good or bad.

Land slides

A landslide is defined as the movement of a mass of rock, debris, or earth down a slope. Landslides are a type of "mass wasting," which denotes any down-slope movement of soil and rock under the direct influence of gravity. The term "landslide" encompasses five modes of slope movement: falls, topples, slides, spreads, and flows. These are further subdivided by the type of geologic material (bedrock, debris, or earth). Debris flows (commonly referred to as mudflows or mudslides) and rock falls are examples of common landslide types.

<u>Causes of Landslides</u>

<u>Natural Causes of Landslides</u>

Climate

Long-term climatic changes can significantly impact soil stability. A general reduction in precipitation leads to lowering of water table and reduction in overall weight of soil mass, reduced solution of materials and less powerful freeze-thaw activity.

Earthquakes

eismic activities have, for a long time, contributed to landslides across the globe. Any moment tectonic plates move, the soil covering them also moves along.

3. **Weathering**

Weathering is the natural procedure of rock deterioration that leads to weak, landslide-susceptive materials. Weathering is brought about by the chemical action of water, air, plants and bacteria.

4. **Erosion**

Erosion caused by sporadic running water such as streams, rivers, wind, currents, ice and waves wipes out latent and lateral slope support enabling landslides to occur easily.

5. **Volcanoes**

Volcanic eruptions can trigger landslides. If an eruption occurs in a wet condition, the soil will start to move downhill instigating a landslide. Stratovolcano is a typical example of volcano responsible for most landslides across the globe.

6. **Forest fires**

Forest fires instigate soil erosion and bring about floods, which might lead to landslides

7. **Gravity**

Steeper slopes coupled with gravitational force can trigger a massive landslide.

Human causes of landslides

1. **Mining**

Mining activities that utilize blasting techniques contribute mightily to landslides. Vibrations emanating from the blasts can weaken soils in other areas susceptible to landslides. The weakening of soil means a landslide can occur anytime.

2. **Clear cutting**

Clear cutting is a technique of timber harvesting that eliminates all old trees from the area. This technique is dangerous since it decimates the existing mechanical root structure of the area.

Effects of Landslides

1. **Lead to economic decline**

Landslides have been verified to result in destruction of property. If the landslide is significant, it could drain the economy of the region or country. After a landslide, the area affected normally undergoes rehabilitation. This rehabilitation involves massive capital outlay. For example, the 1983 landslide at Utah in the United States resulted in rehabilitation cost of about $500 million. The annual loss as a result of landslides in U.S. stands at an estimated $1.5 billion.

2. **Decimation of infrastructure**

The force flow of mud, debris, and rocks as a result of a landslide can cause serious damage to property. Infrastructure such as roads, railways, leisure destinations, buildings and communication systems can be decimated by a single landslide.

3. **Loss of life**

Communities living at the foot of hills and mountains are at a greater risk of death by landslides. A substantial landslide carries along huge rocks, heavy debris and heavy soil with it.

4. **Affects beauty of landscapes**

The erosion left behind by landslides leaves behind rugged landscapes that are unsightly. The pile of soil, rock and debris downhill can cover land utilized by the community for agricultural or social purposes.

5. **Impacts river ecosystems**

The soil, debris, and rock sliding downhill can find way into rivers and block their natural flow. Many river habitats like fish can die due to interference of natural flow of water. Communities depending on the river water for household activities and irrigation will suffer if flow of water is blocked.

Types of Landslides

- **Falls**

Falls are sudden movements of loads of soil, debris, and rock that break away from slopes and cliffs. Falls landslides occur as a result of mechanical weathering, earthquakes, and force of gravity.

- **Slides**

This is a kind of mass movement whereby the sliding material breakaways from underlying stable material. The kinds of slides experienced during this type of landslide include rotational and transitional. Rotational slides are sometimes known as slumps since they move with rotation.

Transitional slides consist of a planer or 2 dimensional surface of rupture. They involve landslide mass movement following a roughly planar surface with reduced rotation or backward slanting. Slides occur when the toe of the slope is undercut. They move moderately, and the consistency of material is maintained.

- **Topples**

Topple landslides occur when the topple fails. Topple failure encompasses the forward spinning and movement of huge masses of rock, debris, and earth from a slope. This type of slope failure takes place around an axis near or at the bottom of the block of rock. A topple landslide mostly lead to formation of a debris cone below the slope. This pile of debris is known as a Talus cone.

- **Spreads**

They are commonly known as lateral spreads and takes place on gentle terrains via lateral extension followed by tensile fractures.

- **Flows**

This type of landslide is categorized into five; earth flows, debris avalanche, debris flow, mudflows, and creep, which include seasonal, continuous and progressive.

Flows are further subcategorized depending upon the geological material, for example, earth, debris, and bedrock. The most prevalent occurring landslides are rock falls and debris flow.

Energy and Environment Engineering – Notes

Subject name-: EEE **Subject code ES-301**

Module 5: Social Issues and the Environment

• From Unsustainable to Sustainable development; urban problems related toenergy; Water conservation, rain water harvesting, watershed management;Resettlement and rehabilitation of people; its problems and concerns. CaseStudiesEnvironmental ethics: Issues and possible solutions. Climate change, globalwarming, acid rain, ozone layer depletion, nuclear accidents and holocaust. CaseStudies Wasteland reclamation; Consumerism and waste products; EnvironmentProtection Act; Air (Prevention and Control of Pollution) Act; Water(Prevention and control of Pollution) Act; Wildlife Protection Act; ForestConservation Act; Issues involved in enforcement of environmental legislation;Public awareness.

Introduction

The activities of human are continuously laid low with our values. Though the environmental crisis has beenledtobytheactivitiesofhumanitisinfactacrisisofvalues.It'sregardingtheconceptofrealizingthe values of the surroundings and accepting it. Humans produce cultural values supported nature (i.e. natural values).However,peopleusedtobelievethatsolelyhumanshadvalueswhereastheatmospheredidn't.We recognized solely cultural values, however not environmental values. Moreover, we often realized cultural values by damaging environmental values. Those behaviors have caused the loss of environmental values and harm to the natural basis on that humans produce cultural values that has light - emitting diode to the matter of non-sustainability. It is under such circumstances that the problem of environmental values has arisen.

Human values for environment

Environmental ethics is that the philosophical discipline that considers the ethical and moral relationship of folks to the surroundings. Environmental ethics helps outline man's ethical and moral obligations toward thesurroundings.howeverhumanvaluesbecomeanelementonceobservingenvironmentalethics.Human values area unit the items thatarea unit vital to people that they then use to gauge actions or events. Inalternativewords, humans assign worth to bound thingssouse this assignedworthto form selections regarding whether one thing is correct or wrong. Human values area unit distinctive every to every} individual because of not everybody places a similarimportance on each component oflife.

Impact of west on society:

Modernization and progress has had its share of disadvantages and one in every of the most aspects of concern is that the pollution it's inflicting to the world – be it land, air, and water. With increase within the international population and the rising demand for food and alternative necessities, there has been an increasewithinthequantityofwastebeinggenerateddailybyeverymenace.Thiswasteisultimatelythrown into municipal waste assortment centers from wherever it's collected by the world municipalities to be any thrown into the landfills and dumps. However, either attributable to resource crunch or inefficient infrastructure, not all this waste gets collected and transported to the ultimate dumpsites. If at this stage the management and disposal is wrongly done, it will cause serious impacts on health.

Waste that's not properly managed, particularly waste product and alternative liquid and solid waste from households and the community, square measure a significant jeopardy and cause the unfold of infectious diseases. Unattended waste lyingaroundattracts flies, rats,and alternative creatures that successively unfold malady. Commonly it's the wet waste that decomposes and releases a nasty odor. Thisendsupin insanitaryconditionsandtherebytoanincreasewithinthehealthissues.Theplaguenatural event in Surat could be an ideal of a town suffering attributable to the callous perspective of the native body in maintaining cleanliness within the town. Plasticwasteisanothercausefor pathologicalstate. Therefore, excessive solid

waste that's generated ought to be controlled by taking bound preventive measures.

Impact on Health:

Modernizationandprogresshashaditsshareofdisadvantagesandoneamongthemostaspectsofconcern is that the pollution it's inflicting to the world – be it land, air, and water. With increase within the world populationandthereforetherisingdemandforfoodandalternativenecessities,therehasbeenanincrease within the quantity of waste being generated daily by every house. This waste is ultimately thrownintomunicipal waste assortment centers from wherever it's collected by the world municipalities to be any thrown into the landfills and dumps. Impacts of solid waste on health.

The cluster in danger from the unscientific disposal of solid waste embrace – the population in areas wherever there's no correct waste disposal methodology, particularly the pre-school children; waste employees; and workers in facilities manufacturing noxious and infectious material. Alternative unsound cluster embrace population living near a waste dump and people, whose water system has become contaminated either thanks to waste merchandising or outflow from lowland sites. Uncollected solid waste additionally will increase risk of injury, and infection.

Inexplicit,organicdomesticwasteposesaheavythreat,sincetheyferment,makingconditionsfavorableto thesurvivalandgrowthofmicroorganismpathogens.Directhandlingofsolidwastemayresultinnumerous forms of infectious and chronic diseases with the waste employees and therefore the rag pickers being the foremost vulnerable. Exposure to unsafe waste will influence human health, kids being a lot of prone to these pollutants. In fact, direct exposure will cause diseases through chemical exposure because the unharnessed of chemical waste into the surroundings results in chemical poisoning. several studies are dispensed in numerous components of theglobe.

Solid waste management

Rapid increment and urbanization in developing countries has light-emittingdiode to folks generating monumental quantities of solid waste and sequent environmental degradation. The waste is often disposed in open dumps creating nuisance and environmental degradation. Solid wastes cause a significant risk to public health and therefore the surroundings. Management of solid wastes is vital to attenuate the adverse effects exhibit by their indiscriminatedisposal.

Types of solid wastes: counting on the character of origin, solid wastes are classified
into Urban or Municipal Wastes
Industrial Wastes
Hazardous Wastes

SOURCES OF URBAN WASTES

Urban wastes embody the subsequent wastes: Domestic wastes containing a spread of materials thrown out from homesick: waste matter, Cloth, paper, Glass bottles, synthetic resin baggage, Waste metals, etc.
Commercial wastes: It includes wastes starting up from outlets, markets, hotels, offices, establishments.
Ex: paper, packaging material, cans, bottle, synthetic resin baggage, .

Classification of urban wastes

Urban wastes are classified into:
Bio-degradable wastes - Those wastes that may be degraded by small organisms are referred to as bio- degradable wastesEx: Food, vegetables, tea leaves, dry leaves, etc.
Non-biodegradable wastes: Urban solid waste materials that can't be degraded by small organisms are referred to non-biodegradable wastes.

Ex: synthetic resin baggage, scrap materials, glass bottles, etc.

Source of commercial waste:
The main supply of commercial wastes are chemical industries, metal and extraction industries. Uninuclear plants: It generated radioactive wastes, Thermal power plants: It produces ash in giant quantities.
Chemical Industries: It produces giant quantities of dangerous and cyan genetic materials.
Other industries: alternative industries manufacture packing materials, rubbish, organic wastes, acid, alkali, scrap metals, rubber, plastic, paper, glass, wood, oils, paints, dyes, etc.

STEPS concerned IN SOLID WASTE MANAGEMENT:
Two vital steps concerned in solid waste management
are: Reduce, utilize and Recycle of Raw Materials
Discarding wastes

Reduce - If usage of raw materials is reduced, the generation of waste additionally gets reduced Reuse - Refillable containers that are discarded once use may be reused
Rubber rings may be made of discarded cycle tubes and this reduces
waste generation throughout manufacture of rubber bands.
Recycle- usage is that the reprocessing of discarded materials into new helpful merchandise
Ex: previous atomic number 13 cans and glass bottles are liquid and recast into new cans and bottles Preparation of polysaccharide insulation from paper
Preparation of automobile body and construction material from steel cans
This technique (Reduce, utilize & Recycle), i.e., 3R's facilitate economize, energy, raw materials and reduces pollution.

INCINERATION:
It is a hygienic manner of disposing solid waste. it's appropriate if waste contains a lotof dangerous material and organic content. it's a thermal method and effective for detoxification of all flammable pathogens. it's costly in comparison to composting or land-filling.In this technique municipal solid wastes are burnt in an exceedingly chamber referred to as furnace.Combustible substances like rubbish, garbage, dead organisms and non-combustiblematter like glass, ceramic ware and metal a separated before feeding to incinerators. The non-combustible materials may be omitted for usage and utilize. The leftover ashes and clinkers might accountfor concerning ten to twenty which require any disposal by landfill or another suggests that.

The heat made within the furnace throughout burning of refuse is employed within the style of steam power for generation of electricity through turbines. Municipal solid waste is mostly wet and incorporates a high hot price. Therefore, it's to be dried initial before burning. Waste is dried in anexceedingly preheated from wherever it's taken to an oversized incinerating chamber referred to as "destructor" which might incinerate concerning a hundred to a hundred and fifty tones perhour.Temperature commonly maintained in an exceedingly combustion chamber is concerning 700 C which can be hyperbolic to one thousand C once electricity is to be generated.

ADVANTAGES
Residue is barely 20-25% of the first and may be used as clinker once treatment requires little or no house
Cost of transportation isn't high if the furnace is found at intervals town limits Safest from hygienic

purpose of read. A furnace plant of 3000 tons per day capability will generate 3MW of power.

DISADVANTAGES

Its capital and overhead are high Operation wants experienced personnelFormation of smoke, mud and ashes wants any disposal which might cause pollution.

Examples of moral things

A patient has kidneys that square measure failing and desires chemical analysis (a medical treatment to get rid of waste merchandise from blood) to survive. The patient is refusing chemical analysis.

His spouse cares that her husband doesn't notice the results of his call. ought to chemical analysis be given?

A patient recently old a systole (heart stopped beating). though his heart was restarted, he suffered brain injury that's probably permanent. he's within the medical aid unit connected to a ventilator. The patient has antecedently expressed that he wouldn't wish to measure connected to machines. ought to the machine be disconnected?

A loved one observes a staffer treating another patient in what seems to be a disrespectful manner. What ought to happen next?

A patient has been diagnosed with a terminal unhealthiness. Her family doesn't wish her au courant of the identification. Ought to the patient be informed?

Preliminary studies regarding Environmental Protection Acts

CHAPTER I - PRELIMINARY

1. Short title, extent and commencement- (1) This Act could also be referred to as the surroundings (Protection) Act, 1986.

(2) It extends to the full of Asiannation.

(3) It shall get force on such date because the Central Government might, by notification within the Official Gazette, appoint and totally different dates could also be appointed for various provisions of thisActand for various areas**.**

Definitions - during this Act, unless the context otherwise requires-

(a) "environment" includes water, air and land and also the inter-relationship that exists among and between water, air and land, and mortals, alternative living creatures, plants, micro-organism and property;

(b) "environmental pollutant" suggests that any solid, liquid or vaporized substance gift in such concentration as could also be, or tend to be, injurious toenvironment;

(c) "environmental pollution" suggests that the presence within the surroundings of any environmental pollutant;

(d) "handling", about any substance, suggests that the manufacture, processing, treatment, package, storage, transportation, use, collection, destruction, conversion, providing purchasable, transfer or variety of suchsubstance;

(e) "hazardous substance" suggests that any substance or preparation that, because of its chemical or physic-chemical properties or handling, is prone to cause damage to mortals, alternative living creatures, plant, micro-organism, property or theenvironment;

(f) "occupier", about any works or premises, suggests that an individualUNagency has management over the affairs of the works or the premises and includes about any substance, the person in possession of the substance;

(g) "prescribed" suggests that prescribed by rules created beneath thisAct.

Top 6 environment Act in India

Environmental Act # one. life (Protection) Act, 1972:

Wildlife Act, a landmark within the history, was enacted for providing protection to wild animals and birds. Wildlife was transferred from State list to synchronal list in 1976, therefore giving powers to the Central government to enact legislation.The Act additionally provides the constitution of Indian Board of life (IBWL), that actively took up the task of putting in place life National parks and sanctuaries.

Objectives of the Act:

1. Restriction and prohibition on searching and trappingslife.
2. Rehabilitation of vulnerable and vulnerablespecies.
3. Preservation of biological diversity by establishing sanctuaries, national parks and regionreserves.
4. Grant of a special allow to hunt a life for research, scientific management and assortment of specimens for zoological gardens, museumsetc.
5. Regulation of exchange life and national conservationstrategy.
6. Collaboration with voluntary bodies andNGO's.

Environmental Act # two pair of. Forests (Conservation) Act, 1980:

The Act covers every kind of forests together with reserve forests, protected forests orany wooded land no matter its possession. The Act has created ample provisions to see deforestation and encourage conversion of non-forest areas.The National Forest Policy (1980) prohibits State governments for declaring any portion of forests as non- reserved while not approval of Central government. The policy additionally prohibits authorities for allotting any forest land for non-forest functions.The amended Act (1988) prohibits lease of forest land to anybody apart from the govt. It enhances conservation, plantation and increase of forest cowl to a median of half-hour.

Environmental Act # three. Water (Prevention and management of Pollution) Act, 1974:

The Act outlined terms like pollution, sewerage effluent, trade effluent, stream and boards. The salient options and provisions of the Act area unit summed up as follows:

1. The Act provides for maintenance and restoration of quality of every kind of surface and wellwater.
2. It provides for the institution of Central and State Boards for pollutionmanagement.
3. The Act assigns powers and functions to those Boards to regulatepollution.
4. The Central and State Pollution Management Boards area unit given comprehensive powers to advise, coordinate and supply technical help for hindrance and management ofpollution.
5. The Act has provisions for funds, budgets, accounts and audit of the Central and State Pollution ManagementBoards.
6. The Act prohibits disposal of any toxic, harmful or polluting touch the flow of water in an exceedingly stream. However, selling of any material into a stream for the aim of reclamation of land isn't thought of anoffence.
7. The Act provides for severe and deterrent punishments for violation of the Act which has fine and imprisonment.

The main regulative bodies area unit the Pollution Management Boards, that are bestowed the subsequent functions and powers.

Environmental Act # four. The Water (Prevention and management of Pollution) Act, 1977:

1. This Act empowers the Central Water Board to gather access on water consumed by persons carrying on sure regular industries and by native Authorities liable for supplywater.
2. The access and therefore the consent fees from the foremost sources of revenue to run the Central and State WaterBoards.
3. The Act has been amended in 1991 with a read to enhance the resources of the Boards by removing the lacunae within the Act and to supply rebate to the industries for obliging with the consumption and effluent qualitycustomary.

Environmental Act # five. Air (Prevention and management of Pollution) Act, 1981:

The Air Act was passed below Article 253 of the Constitution of India and in pursuance of selections of national capital Conference.

1. the target of this Act is to supply means that for the interference, management and abatement of pollution to preserve the standard ofair.
2. The Act defines relevant terms like pollution, air pollutants, transport exhausts and industrial

plants. 3.The Act additionally includes vehicles, diesel vehicles, transport, railways and domesticfuels.
4. The Act provides, as per Section nineteen, the declaration of bound heavily impurespaces as pollution management area and no works shall be operated in these areas while not previous consent of the State Pollution control panel.
5. The Central and State Water Boards are entrusted with the task of dominantand preventing pollution and consequently they need been redesigned as Central Pollution control panel and State Pollution control panel severally.

Environmental Act # half-dozen. setting Protection Act, 1986:

The setting Protection Act, Gregorian calendar month nineteen, 1986 was enacted as per the spirit ofthe national capital Conference command in June 1972 to require acceptable steps for the protection and improvement of the surroundings and to stop hazards to persons, living creatures and property. The Act consists of twenty-six Sections distributed among four chapters and extends to the complete country.

1. commonplace of quality of air, water and soil for varied areas and for variedfunctions.
2. most permissible limits of concentration for varied environmental pollutants (including noise) for variousareas.
3. Procedures and safeguards for handling of venturesomesubstances.
4. Prohibition and restrictions on the placement of industries and concludingoperations.
5. Procedures and safeguards for hindrance of accidents which can cause environmental pollution and 6. Providing for remedial measures just in case ofaccidents.

Environmental Education

Environmental education brings the important world into the language schoolroom, empowering learners to create positive changes within their native communities and in the world.Language academics UN agency introduce environmental topics like rain forest destructionand vulnerable animal species into their lessons realize that student's area unit fascinated by problems these issues gift. Besides serving as a fashionable and stimulating supply of real-world content, environmental education:

- provides an efficient framework for desegregation language skills;
- bridges the gap between English and different faculty subjects;
- develops important and artistic thinking skills;
- fosters the event of problem-solving skills;
- provides opportunities for exploring society attitudes and values;
- engages multiple intelligences;
- encourages student interaction.

Another reason, and therefore the most vital, for conveyance environmental problems into the language schoolroom is that the urgency of the environmental scenario itself. If student's area unit to participate absolutely in resolution the environmental issues of these days and therefore the future, environmental education is important. issues like plant and animal extinction area unit pressing. All educators have associate moral and private responsibility to contribute to students' awareness of environmental problems and to foster in their students the event of skills thatpromote property development.

A Global Approach

besides providing follow on specific language skills like speaking or reading, every of activities bestowed during this volume incorporates one or a lot of thesubsequent international objectives associated with the environment:

- Awareness: Promoting awareness of a specific environmental drawback and what people will do

to assist solve the matter.

- Concern: Encouraging students to explore their own values and feelings of concern regarding the surroundings.
- Skills: serving to students to amass and develop the required skills to unravel environmental issues.
- Action: Providing opportunities for college students to induce actively concerned in doing one thing to remedy environmental issues.

Self-exploration

The world's forests are being consumed speedily. Trees ar bog down for paper and wood product, for preparation fuel, to clear land for development, and to expand farming areas. The land left behind is stripped not solely of its trees, however the plants, animals, and insects that lived in this scheme further. With no plant roots to carry it in situ, valuable soil washes away with each precipitation and lands up within the rivers and streams upon which individuals rely for his or her water. In extreme cases, a whole bunch or thousands of individuals lose their homes or change state in landslides once deforested slopes become unstable.

Forests conjointly play a very important half in regulation world climate. Trees take away dioxide, a significant greenhouse emission, from the atmosphere, whereas athletics atomic number 8 into it. Once trees are bog down, however, the dioxide is free once more. It's calculable that up to twenty fifth of the full quantity of dioxide going into the atmosphere each year is free from trees being cut and burned. It's clear that protective the world's forests is a very important a part of determination the worldwide global climate change drawback.

Explanation about SWASTHYA

If we tend to choose the literal that means of swasthya, then it means that health. however, our health itself contains plenty of things, like our thoughts, wellbeing of our physical state, moreover as mental one, etc. we tend to ne'er notice the manner we tend to breathe, inhale, however would our lungs bebehaving throughout this? what all should be going within our body. What happens to the food once it goes down the esophagus? there are bound queries however we tend to ne'er care to seem or feel them. just because we all know ton overabundant} concerning digestion n have seen lot several things. however, is so?? my purpose here is that's it extremely all through? are not we tend to totally different fromthe represented representation.As said earlier SWASTHYA conjointly deals with our condition and its wellbeing. what wepredict, however we predict and why we predict area unit the queries that area unit answered by the individual on his or her own. all has their own perceptions relating to their thinking method. as it's their own and that we might need our own opinion concerning that isn't accepted by the thinker.

Explanation about SANYAMA

Sanyama deals with self-control, it's essentially the soul half. Our soul is that the in-built god precocious energy that provide the primary and therefore the basic most construct of our existence. Except for the superficial thoughts that soul is that this –that and bound different taboos, it's a glorious proven fact that soul is main interface between the heavenly energy and organic structure.