



Study Material: **Environmental Studies {18CIV59}**

Department of Civil Engineering, **BMS Institute of Technology and Management**, Bengaluru 560064
For further materials: <https://www.youtube.com/channel/UCeJdH2Kc0IjqW2eluEPpp3w> (CV - Official YouTube Channel)

Study Materials
Environmental Studies
18CIV59
As per VTU syllabus
CBCS – OBE
2018 Scheme



Study Material Compiled by

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BMS INSTITUTE OF TECHNOLOGY AND MANAGEMENT

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Vision Statement: To be an Exemplary Centre, disseminating quality education and developing technically competent civil engineers with professional integrity for the betterment of society

Mission Statements

1. Impart technical proficiency through quality education.
2. Motivate entrepreneurship through enhanced industry -interaction and skill based training.
3. Inculcate human resource values through outreach activities.
- 4.

Program Educational Objectives (PEOs)

1. Lead a successful career by analyzing, designing and solving various problems in the field of Civil Engineering.
2. Execute projects through team building, communication and professionalism
3. Excel through higher education and research for endured learning.
4. Provide effective solution for sustainable environmental development.

Program Specific Outcomes (PSO)

1. Identify & address the challenges in transportation, sanitation, waste management, and urban flooding in metropolitan cities.
2. Provide solutions related to Civil Engineering built-environment through multidisciplinary approach.

DISCLAIMER

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This presentation is merely a conceptual compilation, with several edited intellectual inputs from varying relevant databases.

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B. E. Common to all Branches				
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)				
SEMESTER – V				
ENVIRONMENTAL STUDIES				
Course Code	18CIV59	CIE Marks	40	
Teaching Hours / Week (L:T:P)	(1:0:0)	SEE Marks	60	
Credits	01	Exam Hours	02	
Module - 1				
Ecosystems (Structure and Function): Forest, Desert, Wetlands, Riverine, Oceanic and Lake. Biodiversity: Types, Value; Hot-spots; Threats and Conservation of biodiversity, Forest Wealth, and Deforestation.				
Module - 2				
Advances in Energy Systems (Merits, Demerits, Global Status and Applications): Hydrogen, Solar, OTEC, Tidal and Wind. Natural Resource Management (Concept and case-studies): Disaster Management, Sustainable Mining, Cloud Seeding, and Carbon Trading.				
Module - 3				
Environmental Pollution (Sources, Impacts, Corrective and Preventive measures, Relevant Environmental Acts, Case-studies): Surface and Ground Water Pollution; Noise pollution; Soil Pollution and Air Pollution. Waste Management & Public Health Aspects: Bio-medical Wastes; Solid waste; Hazardous wastes; E-wastes; Industrial and Municipal Sludge.				
Module - 4				
Global Environmental Concerns (Concept, policies and case-studies):Ground water depletion/recharging, Climate Change; Acid Rain; Ozone Depletion; Radon and Fluoride problem in drinking water; Resettlement and rehabilitation of people, Environmental Toxicology.				
Module - 5				
Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): G.I.S. & Remote Sensing, Environment Impact Assessment, Environmental Management Systems, ISO14001; Environmental Stewardship- NGOs. Field work: Visit to an Environmental Engineering Laboratory or Green Building or Water Treatment Plant or Waste water treatment Plant; ought to be Followed by understanding of process and its brief documentation.				
Course outcomes: At the end of the course, students will be able to: <ul style="list-style-type: none"> • Understand the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale, • Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment. • Demonstrate ecology knowledge of a complex relationship between biotic and a biotic components. • Apply their ecological knowledge to illustrate and graph a problem and describe the realities that managers face when dealing with complex issues. 				
Question paper pattern: <ul style="list-style-type: none"> • The Question paper will have 100 objective questions. • Each question will be for 01 marks • Student will have to answer all the questions in an OMR Sheet. • The Duration of Exam will be 2 hours. 				
Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Environmental Studies	Benny Joseph	Tata McGraw – Hill.	2 nd Edition, 2012
2	Environmental Studies	S M Prakash	Pristine Publishing House, Mangalore	3 rd Edition' 2018
3	Environmental Studies – From Crisis to Cure	R Rajagopalan	Oxford Publisher	2005
Reference Books				
1	Principals of	Raman Sivakumar	Cengage learning,	2 nd Edition, 2005



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Preamble

"Environmental science" is the study of the interactions among the physical, chemical and biological components of the environment [French word – environ]; with a focus on pollution and degradation of the environment related to human activities; and the impact on biodiversity and sustainability from local and global development.

It is inherently an interdisciplinary field that draws upon not only its core scientific areas, but also applies knowledge from other non-scientific studies such as economics, law and social sciences. Environmental science encompasses issues such as climate change, conservation, biodiversity, groundwater and soil contamination, use of natural resources, waste management, sustainable development, air pollution and noise pollution.



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MODULE 1



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INTRODUCTION

The four major components of environment are Atmosphere, Lithosphere, Hydrosphere and Biosphere.

BIOSPHERE

The outer layer of the planet Earth can be divided into several compartments: the hydrosphere (or sphere of water), the lithosphere (or sphere of soils and rocks), and the atmosphere (or sphere of the air). The biosphere (or sphere of life), sometimes described as "the fourth envelope", is all living matter on the planet or that portion of the planet occupied by life. The biosphere is the part of the earth, including air, land, surface rocks, and water, within which life occurs, and which biotic processes in turn alter or transform.

Biosphere, a thin shell of organic matter on surface of earth comprising of all living things; is a subsystem responsible for recycling and occupies least volume of all 3 spheres. In hydrosphere oceans take responsibility of sinks while rivers play the role of conveyors. Atmosphere has the least storage capacity for matter while it supports transportation the most. Atmosphere in conjunction with hydrosphere form effective transporters of matter.

HYDROSPHERE

The Earth's hydrosphere consists of water in all forms: the ocean (which is the bulk of the hydrosphere), other surface waters including inland seas, lakes, and rivers; rain; underground water; ice (as in glaciers and snow); and atmospheric water vapor (as in clouds). The average depth of the oceans is 3,794 m (12,447 ft), more than five times the average height of the continents.

The abundance of water on Earth is a unique feature that distinguishes our "Blue Planet" from others in the solar system. Approximately 70.8 percent (97% of it being sea water and 3% fresh water) of the Earth is covered by water and only 29.2 percent is landmass.

The water cycle describes the methods of transport for water in the hydrosphere. This cycle includes water beneath the Earth's surface and in rocks (lithosphere), the water in plants and animals (biosphere), the water covering the surface of the planet in liquid and solid forms, and the water in the atmosphere in the form of water vapor, clouds, and precipitation.

The water in the oceans moves as it is of different temperature and salinity on different locations. Surface waters are also moved by winds, giving rise to surface ocean currents. Warm water is lighter or less dense than cold water which is more dense or heavier and salty water is also denser than fresh water. The combination of the water's temperature and salinity determines whether it rises to the surface, sinks to the bottom, or stays at some intermediate depth.



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ATMOSPHERE

The atmosphere is a complex, dynamic natural gaseous system that is essential to support life on planet Earth. The gases are attracted by the gravity of the body, and are retained for a longer duration if gravity is high.

The sky appears blue during daytime and blazing red-orange at sunset due to the phenomenon of scattering. Blue color has shorter wavelength and hence is scattered more than other colors during sunrise as sun is high on horizon and blue encounters very less molecules.

During sunset, sun is low on the horizon; sunlight passes through more of the atmosphere and hence encounters more molecules. This is because red has longer wavelength while blue scatters off our line of sight.

The pressure of an atmosphere decreases with altitude due to the diminishing mass of gas above each location. However, atmospheres are not uniform in temperature, so the exact determination of the atmospheric pressure at any particular altitude is more complex. Atmospheric gases scatter blue light more than other wavelengths, giving the Earth a blue halo when seen from space.

The Earth's atmosphere consists, from the ground up, of the troposphere as lowest layer, stratosphere, mesosphere, ionosphere (or thermosphere) and the exosphere.

The ozone layer, which absorbs ultraviolet energy from the Sun, is located primarily in the stratosphere, at altitudes of 15 to 35 km. The Kármán line, located within the thermosphere at an altitude of 100 km, is commonly used to define the boundary between the Earth's atmosphere and outer space.

Troposphere is the lowest layer of the atmosphere that begins at the surface and extends to between 7 km at the poles and 17 km at the equator. The troposphere has a great deal of vertical mixing due to solar heating at the surface. Hence most weather activities take place here. Stratosphere from the troposphere's 7-17 km range to about 30 km, here temperature increases with height. Global warming, ozone depletion originate here. Mesosphere starts about from 50 km to the range of 80-85 km, here temperature decreasing with height. Thermosphere starts from 80-85 km to 640+ km, temperature increasing with height. Ionosphere is the part of the atmosphere that is ionized by solar radiation. It plays an important part in atmospheric electricity and forms the inner edge of the magnetosphere. It has practical importance because, among other functions, it influences radio propagation to distant places on the Earth. It is located in the thermosphere.

Exosphere begins from 500-1000 km up to 10,000 km, free-moving particles that may migrate into and out of the magnetosphere or the solar wind. The boundaries between these regions are named the tropopause, stratopause, mesopause, thermopause and exobase.

Commercial airliners [subsonic] fly in lower stratosphere, jet airliners [supersonic] fly in the troposphere. Spy satellites orbit in exosphere at about 434 miles [700 km], where in while meteorites burn up in thermosphere.



COMPOSITION OF AIR [by volume]

75.523% nitrogen
23.133% oxygen
1.288% argon
0.035% carbon dioxide
0.001267% neon
0.00029% methane
0.00033% krypton
0.000724% helium
0.0000038 % hydrogen

LITHOSPHERE

The lithosphere is the solid outermost shell of a rocky planet. The lithosphere is about 100 km thick. If you could slice the Earth in half, you would see four layers: the crust, the mantle, the inner core, and the outer core. Each layer is made of different materials, has a different density, and has a different thickness.

The Crust

The crust is Earth's outermost layer. The crust varies from 5 to 70 kilometers in thickness. The crust includes rocks, minerals, and soil. There are two kinds of crust: continental and oceanic. Yes, there is even crust under the ocean! The crust is constantly moving, which is why continents move and earthquakes happen. The science that studies how the parts of the crust move is called "Plate Tectonics."

Earth's oceanic crust is a thin layer of dense rock about 5 kilometers thick. The continental crust is less dense, with lighter-colored rock that varies from 30 to 70 kilometers thick. The continental crust is older and thicker than the oceanic crust.

The crust is made of many types of rocks and hundreds of minerals. These rocks and minerals are made from just 8 elements: Oxygen (46.6%), Silicon (27.72%), Aluminum (8.13%), Iron (5.00%), Calcium (3.63%), Sodium (2.83%), Potassium (2.70%), and Magnesium (2.09%). The oceanic crust has more Silicon, Oxygen, and Magnesium. The continental crust has more Silicon and Aluminum.

The Mantle

Directly below the crust is the mantle. The mantle makes up the largest volume of the Earth's interior. It is almost 2900 kilometers thick and comprises about 83 % of the Earth's volume. It has two parts, an upper layer and a lower layer. The upper mantle is about 670 kilometers in depth. It is brittle and less dense. It is thought to be made of peridotite, a rock made from the minerals olivine and pyroxene. The rocks in the upper mantle are more rigid and brittle because of cooler temperatures and lower pressures. The Lower Mantle is much thicker and denser. It is 670 to 2900 kilometers below the Earth's surface. This layer is hot and plastic. The higher pressure in this layer causes the formation of minerals that are different from those of the upper mantle.



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The Outer and Inner Core

The region beneath the mantle is called the core, and is made of two parts, a liquid outer core that is about 2250 km thick and a solid inner core which is 1220 km thick. The core is mostly made of iron, with a little bit of nickel.

The outer core is at 1,800 - 3,200 miles (2,890-5,150 km) below the earth's surface. The temperature in the outer core is about 7200 - 9032 °F (4000-5000°C). The molten, liquid iron in the outer core is important because it helps create Earth's magnetic field.

The inner core is 3,200 - 3,960 miles (5,150-6,370 km) below the earth's surface and mainly consists of iron, nickel and some lighter elements (probably Sulphur, carbon, oxygen, silicon and potassium). The temperature in the inner core is about 9032 - 10832 °F (5000-6000 °C). Because of the high pressure, the inner core is solid.

Earthquake is an outcome of pressure buildup in lithospheric plates called tectonic plates that move about each other, generating friction and resulting in pressure built up. But when pressure exceeds sustenance, huge amount of force is released destroying tectonic plates resulting in phenomenon called earthquake.

ECOSYSTEM

An ecosystem can be defined as any situation where there is interaction between organisms and their environment. The ecosystem is composed of two entities, the entirety of life and the medium that life exists in. They can be classified as AQUATIC and TERRESTRIAL.

A **BALANCED ECOSYSTEM** is one in which there is a Population balance existing between Prey-Predators, Producers-Consumers relationship and as well its ensured that there is constant and optimum recycling of matter.

Plants constitute 99 percent of earths living species and the rest 1 per cent include animals and man who depend on the plant world for their food. If this ratio (99:1) is disturbed by elimination of plants (i.e., deforestation), then the natural balance will be lost and the entire living world will suffer most. The dynamic balance is among plants (producers), bacteria and micro-organisms (decomposers who decompose mineral salts in soil into elements which are cycled back into the plants) and animals plus man (consumers). Once this dynamic balance is upset, there would be ecological crisis and the entire biosphere would be in danger.

Soil (edaphic factors) includes soil texture, soil air, soil temperature, soil water, soil solution and pH, together with soil organisms and decaying matter.

Winds carry water vapor which may condense and fall in the form of rain, snow or hail. Wind plays a role in pollination and seed dispersal of some plants, as well as the dispersal of some animals, such as insects. Wind erosion can remove and redistribute topsoil, especially where vegetation has been reduced.



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Physiographic factors are those associated with the physical nature of the area, such as altitude, slope of land and the position of the area in relation to the sun or rain-bearing winds. Altitude plays a role in vegetations zones.

Slopes are important when considering the temperature of the soil surface on land with a northern slope, on level and on land with south facing slopes.

The most important gases used by plants and animals are oxygen, carbon dioxide and nitrogen. Oxygen is used by all living organisms during respiration. Carbon dioxide is used by green plants during photosynthesis. Nitrogen is made available to plants by certain bacteria and through the action of lightning.

Plant and animal habitats vary from entirely aquatic environments to very dry deserts. Water is essential for life and all organisms depend on it to survive in especially desert areas. Plants can be classified into 3 groups according to their water requirements. Hydrophytes are plants which grow in water e.g. water-lilies and rushes. Mesophytes are plants with average water requirements e.g. roses, sweet peas. Xerophytes are plants which grow in dry environments where they often experience a shortage of water e.g. cacti and often succulents.

The distribution of plants and animals is greatly influenced by extremes in temperature for instance the warm season. The occurrence or non-occurrence of frost is a particularly important determinant of plant distribution since many plants cannot prevent their tissues from freezing or survive the freezing and thawing processes.

Light energy (sunlight) is the primary source of energy in nearly all ecosystems. It is the energy that is used by green plants (which contain chlorophyll) during the process of photosynthesis; a process during which plants manufacture organic substances by combining inorganic substances. Visible light is of the greatest importance to plants because it is necessary for photosynthesis. Factors such as quality of light, intensity of light and the length of the light period (day length) play an important part in an ecosystem.

Macronutrients are those elements, which generally occur in 1000 ppm or higher in plants. They include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S), whereas the micronutrients are generally found in plants at levels of 500 ppm or less. Group of minerals that plants use in very small amounts are commonly referred as "trace or micro" nutrients and include iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), boron (B), chlorine (Cl) and nickel (Ni). The classical approach to assessing micronutrient limitations is based on the law of limiting factors, sometimes also referred to as Liebig's law of the minimum.

Biotic factors include INTRASPECIFIC AND INTERSPECIFIC relations.

Interspecific relations are interactions between different species, usually described according to their beneficial, detrimental or neutral effect. Intraspecific relations are those that are established between individuals of the same species, forming a population.



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Positive Interactions:

- [a] Mutualism: Populations help each other through mode of symbiosis.
[E.g. Pollination, lichens]
- [b] Commensalism: Only one species is benefited while neither is harmed or Benefited. [E.g. Epiphytes]
- [c] Proto-co-operation: Non-obligatory symbiotic relationship.
[E.g., Sea Anemone attached to molluscan shell harboring hermit crab].

Negative Interactions:

- [a] Competition:
 - [i] Resource competition: Battle for resources in scarcity
 - [ii] Interference competition: Battle for resources in non-scarcity
- [b] Parasitism: Receiving benefit at cost of other's survival or well-being.

The most significant relation is the relation of predation (to eat or to be eaten), which leads to the essential concepts in ecology of food chain.

HYDROLOGICAL CYCLE

The movement of water around, over and through the Earth is called the water cycle. The water cycle has no starting point. However, we'll begin in the oceans, since that is where most of Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapor into the air. Ice and snow can sublime directly into water vapor.

Organisms play an important role in the water cycle. As you know, most organisms contain a significant amount of water (up to 90% of their body weight). This water is not held for any length of time and moves out of the organism rather quickly in most cases. Animals and plants lose water through evaporation from the body surfaces and through evaporation from the gas exchange structures (such as lungs).

In plants, water is drawn in at the roots and moves to the gas exchange organs, the leaves, where it evaporates quickly. This special case is called transpiration because it is responsible for so much of the water that enters the atmosphere. Rising air currents take the vapor up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. Guttation is the process of loss of water form roots.

The vapor rises into the air where cooler temperatures cause it to condense into clouds. Air currents move clouds around the globe; cloud particles collide, grow and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years.

Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the



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landscape, with stream flow moving water towards the oceans. Runoff, and ground-water seepage, accumulate and are stored as freshwater in lakes.

Snowmelt refers to the runoff produced by melting snow. Runoff includes the variety of ways by which water moves across the land. This includes both surface runoff and channel runoff. As it flows, the water may infiltrate into the ground, evaporate into the air, become stored in lakes or reservoirs, or be extracted for agricultural or other human uses.

Once water condenses, gravity takes over and the water is pulled to the ground. Gravity continues to operate, either pulling the water underground (groundwater) or across the surface (runoff). In either event, gravity continues to pull water lower and lower until it reaches the oceans. Infiltration is the flow of water from the ground surface into the ground. Once infiltrated, the water becomes soil moisture or groundwater.

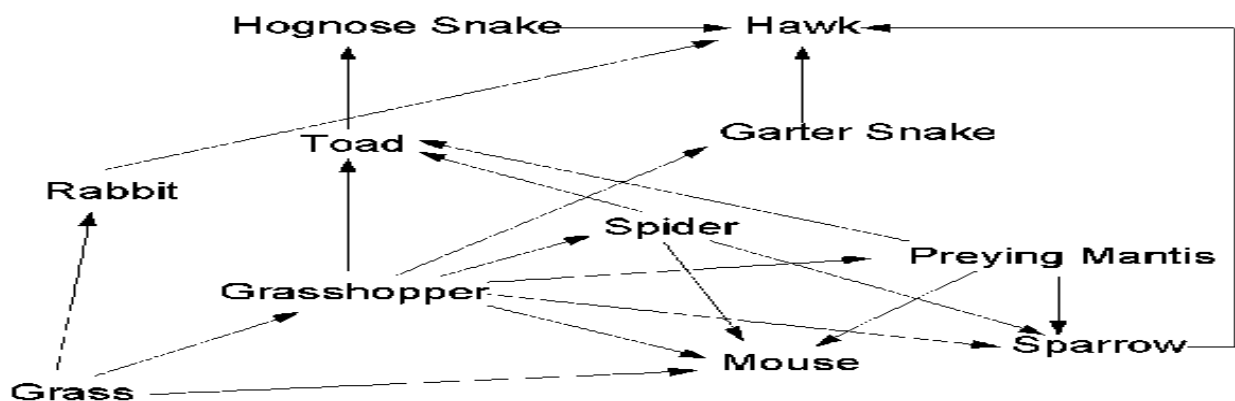
Not all runoff flows into rivers, though. Much of it soaks into the ground as infiltration. Some water infiltrates deep into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration finds openings in the land surface and emerges as freshwater springs. Subsurface Flow is the flow of water underground, in the vadose zone and aquifers. Subsurface water may return to the surface as a spring or by being pumped) or eventually seep into the oceans. Groundwater tends to move slowly, and is replenished slowly, so it can remain in aquifers for thousands of years.

FOOD CHAIN

A food chain is the flow of energy from one organism to the next. Organisms in a food chain are grouped into trophic levels. Trophic levels may consist of either a single species or a group of species that are presumed to share both predators and prey. They usually start with a primary producer and end with a carnivore. Below a food chain has been depicted beginning from grass extending to hawk in a single linear chain.

GRASS ---> GRASSHOPPER --> MOUSE ---> SNAKE ---> HAWK

FOOD WEB





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A food web extends from a food chain concept from a simple linear pathway to a complex network of interactions. Food chains, food webs graphically represent the transfer of material and energy from one species to another within an ecosystem. Below a food web has been depicted showing the complex nature of interactions between each trophic level influencing directly and indirectly.

ORGANISMS REPRESENTED IN FOOD CHAINS

Producers/Autotrophs -- An organism that produces complex organic compounds from simple inorganic molecules and an external source of energy, such as light or chemical reactions of inorganic compounds.

Autotrophs are considered producers in a food chain. Plants and other organisms that carry out photosynthesis are phototrophs (or photoautotrophs). Bacteria that utilize the oxidation of inorganic compounds such as hydrogen sulfide, ammonium or ferrous iron as an energy source are chemoautotrophs

They take energy from the environment (sunlight or inorganic sources) and use it to process carbon-based and other organic molecules that are used to carry out various biological functions such as cell growth. Other organisms, called heterotrophs, utilize autotrophs as food to carry out these same functions.

Consumers/Heterotrophs -- animals, which can be primary consumers (herbivorous), secondary or tertiary consumers (carnivorous) and Tertiary consumers (omnivores). There are some species of organisms that require organic compounds as a source of carbon, but are able to use light or inorganic compounds as a source of energy. Such organisms are not defined as autotrophic, but rather as heterotrophic. An organism that obtains carbon from organic compounds but obtains energy from light is called a photo heterotroph, while an organism that obtains carbon from organic compounds but obtains energy from the oxidation of inorganic compounds is termed a chemo heterotroph.

Decomposers --organisms that consume dead plants and animals, and, in doing so, carry out the natural process of decomposition. The primary decomposers are bacteria and fungi. When a plant or animal dies, it leaves behind nutrients and energy in the organic material that comprised its body. Scavenger and detritivores may feed on the carcasses or litter, but they will inevitably leave behind a considerable amount of unused energy and nutrients. Decomposers complete decomposition by breaking down this remaining organic matter. Although decomposers are generally located on the bottom of ecosystem diagrams such as food chains, food webs, and energy pyramids, decomposers in the biosphere are crucial to the environment.

ECOLOGICAL PYRAMIDS

Pyramid of Numbers: Developed by Charles Elton, it depicts the number of organisms at each trophic level. The general representation shows maximum numbers at the base [producers] and least at the top usually Homo sapiens.



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Pyramid of Biomass: The biomass of the members of the food chain present at any time forms the pyramid of bio-mass. The pyramid depicts decrease in bio-mass as one move from base to apex.

Pyramid of Energy: when production is considered in terms of energy that i.e., chemical energy, the scenario is same displaying energy losses as the movement is towards the apex

ENERGY FLOW

All ecosystems must have a source of energy (usually the sun) because all organism functions such as growth and reproduction require energy. Energy moves through the ecosystem by a series of events that link organism's together. Plants and photosynthetic microorganisms convert light into chemical energy by the process of photosynthesis, which creates glucose (a simple sugar) and releases free oxygen. Glucose; thus, becomes the secondary energy source which drives the ecosystem.

Photosynthesis

Carbon dioxide + Water + Sunlight (Energy) = Glucose + Oxygen

Some sugars produced during photosynthesis are broken down during respiration to release energy needed by the plant for growth and reproduction. Others are used to make "building blocks" that are combined to make plant cells, hence plant parts.

Respiration

Glucose + Oxygen = Carbon dioxide + Water + Energy (Heat)

Animals that eat plants (herbivores) use them to make animal parts or burn them to produce energy for their cell functions. Any compounds not used immediately are combined and stored as fats. Tissues of animals eaten by other animals (predators/carnivores) are broken down and re-combined into new parts for that animal and so on. Thus, all animals depend on plants for food. In any food network, the energy contained in the level of the producers is not completely transferred to the consumers, the higher one_[n] goes up the chain, the more energy and resources is lost and consumed. It is often the case that biomass of each trophic level decreases from the base of the chain to the top. This is because energy is lost to the environment with each transfer. On average, only 10% of the organism's energy is passed on to its predator. The other 90% is used for the organisms life processes or is lost as heat to the environment.

Anthroposystem

In an ecosystem most of the materials are transferred from the producers (plants) to the recyclers (bacteria), and only a small fraction is passed through the consumers to the recyclers. The decomposers (recyclers) return most of the materials to the producers from reuse. In the Anthroposystem the flow from the producers to the recyclers is small or even nonexistent since it would be pointless to produce (mobilize) materials and immediately recycle them without a consumer in the loop. In the Anthroposystem much of the mobilized materials are transferred to the rest of the material environment, to the producer and to the consumer. Hence, it is mostly an open system, where recycling accounts for only a small fraction of the mobilized matter.



In the Anthroposystem, there is usually a significant physical displacement between the producer and the consumer.

Balanced Ecosystem

A Balanced Ecosystem occurs when there is a Population balance existing between Prey-Predators and Producers-Consumers relationships. It ensures that there is constant and optimum recycling of matter. Plants constitute 99 percent of earth's living species and the rest one percent include animals and homo-sapiens. If this ratio (99:1) is disturbed by elimination of plants (i.e., deforestation), then the natural balance will be lost and the entire system will collapse. There is a dynamic balance among green plants (producers), bacteria and micro-organisms (i.e., decomposers who decompose mineral salts in soil into elements which are cycled back into the plants) and animals (consumers). Once this dynamic balance is upset, there would be ecological crisis and the entire biosphere would be in danger. To avoid this, there must exist equilibrium between the biotic (living) and abiotic (non-living). To overcome imbalances and for survival, organisms sometime undertake in Ecological succession, a process in which ecological communities respond to changes in their environment.

Classification of Ecosystem

Aquatic Ecosystems

Marine Ecosystems: These cover approximately 71% of the Earth's surface and form approximately 97% of the planet's water. Marine ecosystems generate 32% of the world's net primary production. They are distinguished from freshwater ecosystems by the presence of dissolved compounds, especially salts, in the water. Marine ecosystems can be divided into oceanic shelf, salt marshes, coral reefs and hydrothermal vents. Classes of organisms found in marine ecosystems include brown algae, dinoflagellates, corals, cephalopods, echinoderms, and sharks.

Freshwater Ecosystems: These cover 0.8% of the Earth's surface and contain 0.009% of its total water. They generate nearly 3% of its net primary production. There are 2 basic types of freshwater ecosystems.

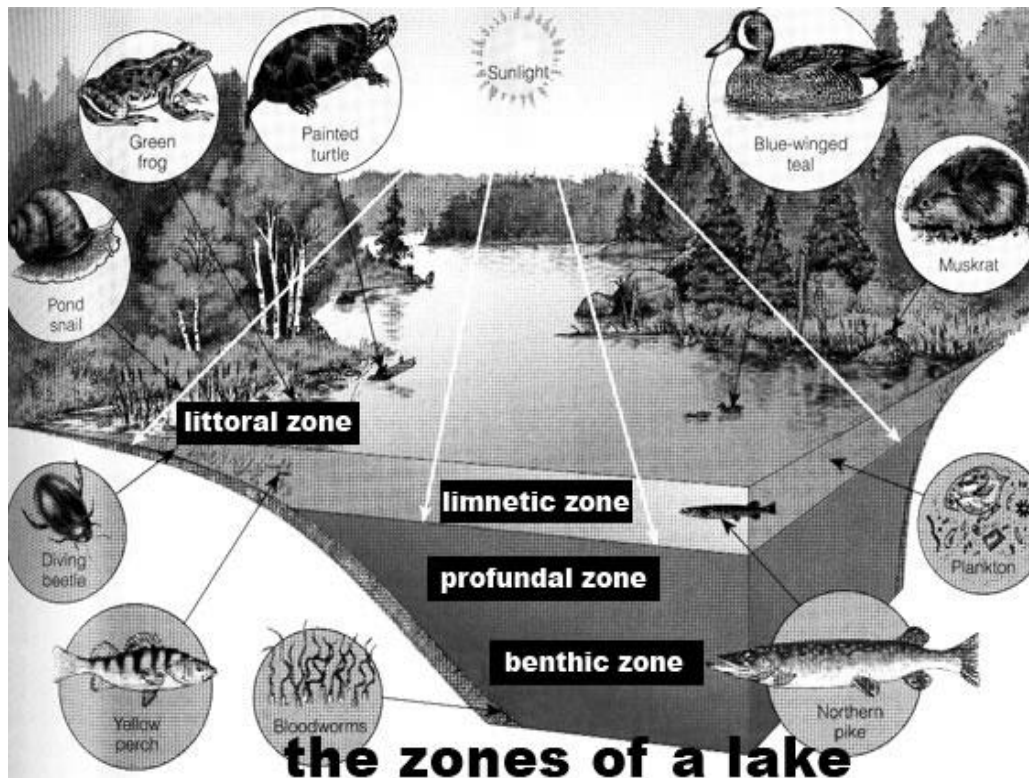
- ✓ Lentic: Slow-moving water, including pools, ponds, and lakes.
- ✓ Lotic: Rapidly-moving water, for example streams and rivers.

Organisms in marine ecosystems tolerate salinity, while many freshwater organisms are intolerant of salt. Estuaries are special ecosystems formed where sea water mixes with fresh water and nutrients from rivers, streams, and runoff. The pond is the simplest aquatic ecosystem. During rainy seasons, when a pond begins to fill, its life forms such as the algae and microscopic animals, aquatic insects, snails, and worms come out of the floor of the pond where they remained dormant in the dry phase. The vegetation in the pond consists of floating weeds and rooted vegetation on the periphery which grows on the muddy floor under water and emerges out of the surface of the water. As the pond fills during the monsoon, a large number of food chains are formed. Algae are eaten by microscopic animals, which are in turn eaten by small fish.

The temporary ponds dry after the rains and surrounding grasses and terrestrial plants spread into the exposed moist mud. Frogs, snails and worms remain dormant in the mud, anticipating next monsoon.

Lake Ecosystem

Lakes are large natural bodies of standing-water, which is formed when precipitation, runoff, or groundwater seepage fills depressions on the Earth's surface”.



The parts of a lake also can be classified by temperature:

- ❖ The epilimnion [the upper layer of warm water].
- ❖ The hypolimnion [the lower layer of colder, denser water].
- ❖ The thermocline [the area in between in which water temperature decreases rapidly with depth].

Lakes and ponds are divided into 4 different “zones” usually determined by depth and distance from the shoreline. The four zones of a lake from top to bottom are the littoral zone, the limnetic zone, the profundal zone and the bathyal zone.

- ❖ Littoral zone encompasses the area near the shore at the top of the lake that receives sunlight, extending down to the depth where rooted plants stop growing. This zone has high biodiversity. This zone is the warmest since it is shallow and can absorb more of the Sun's heat. It sustains a fairly diverse community, which can include several species of algae (like diatoms), rooted and floating aquatic plants, grazing snails, clams, insects, crustaceans, fishes, and amphibians. As further depth increases, dissolved oxygen levels



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decreases, so the epilimnion has the highest amount of oxygen and the hypolimnion the lowest amount.

- ❖ Limnetic zone the near-surface open water surrounded by the littoral zone. The limnetic zone is essentially the open area away from the shore. Most photosynthesis occurs in this part of the lake itself. The zone is well-lighted just like the littoral zone and is dominated by plankton, both phytoplankton and zooplankton.
- ❖ Profundal zone the deep open water where it is tough for photosynthesis to happen and the planktons here have short life spans. This zone is much colder and denser than the other 2 as little light penetrates. The fauna are heterotrophs, meaning that they eat dead organisms and use oxygen for cellular respiration.
- ❖ Benthic zone is the very bottommost layer of the lake. Organisms here tend to tolerate cooler temperatures much better. Low levels of photosynthesis result in low levels of DO in this level.

Terrestrial Ecosystems

Terrestrial ecosystems include Forests, Grasslands, Semi-arid areas and Deserts.

Forest Ecosystem

A forest is a highly complex, constantly changing environment encompassing variety of living and non-living things. The word forest is derived from the Latin word Foris. Forest cover approximately occupies 9.4% geographical portion of the earth. Forests Ecosystem sub-Classification includes Tropical Rainforests, Sub-Tropical Forests, Mediterranean Forests, Temperate Forests, Coniferous Forests, Montane Forests, Plantation Forests, Deciduous Forest and Evergreen Forest.

Functions of Forest Ecosystem

Regulatory functions

- ✓ It helps regulate water cycle.
- ✓ The ecological benefit apart from cleansing of air, water includes carbon sequestration, and reducing Global warming.
- ✓ It helps regular global ambient air temperature.
- ✓ It provides raw material for paper and pulp industries.

Habitat functions

- ✓ Provides a reproduction habitat to wild plants and animals
- ✓ Contributes to in-situ conservation of biological and genetic diversity and the evolutionary process.



Production functions

- ✓ Through the process of photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures which are then used by secondary producers to create an even larger variety of living biomass.

Information functions

- ✓ Provides an essential 'reference function'
- ✓ Contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience.
- ✓ Trees also help in absorbing noise and creating an aesthetic environment free of stress and peace.
- ✓ It serves for tourism attraction and provides recreational activities like hunting, camping, hiking, fishing, watching wildlife, off road biking, horseback riding and plant collecting.

Desert Ecosystem

Deserts are terrestrial ecosystems found around the tropic of Cancer and tropic of Capricorn in Northern and Southern Hemispheres. They have mega-thermal climate, as per Koppen climate classification. The desert is the hottest biome on Earth and occupies about one fifth of the Earth's land surface. Sahara Desert, Arabian Desert, Gobi Desert, Kalahari Desert and Thar Desert are few of famous deserts around the world.

Hot deserts

- ✓ Temperature is very warm entire year, with summers being extremely hot.
- ✓ More flora and fauna can be found here compared to cold desert.
- ✓ Water is very scarce.
- ✓ Temperature is very high during day and very low at night.
- ✓ Xerophytes have modifications like pulpy stem to store water and wax covered thorny leaves to reduce transpiration. The roots are very long to reach the water table.
- ✓ Animals such as reptiles, rodents, wolves display nocturnal behaviour.

Cold deserts

- ✓ This type of desert has short and warm summers, and Long, cold winters
- ✓ Found in places near the north and south poles
- ✓ Less flora and fauna can be found compared to hot desert.

Functions of Desert Ecosystem

- ✓ Deserts contain valuable mineral deposits like silica, gypsum, borates are found here.
- ✓ Due to consistent dryness, deserts are ideal places for natural preservation of artifacts and fossils.



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Structure of Desert Ecosystem

- ✓ The abiotic factors include sunlight, oxygen, carbon-di-oxide, ground water, temperature, humidity, p^H .
- ✓ The producers mainly include shrubs, bushes, some grasses and few trees

Abiotic Factors of Desert Ecosystem

- ✓ The thin soils frequently attacked by sand storm and wind with lack of humus makes them infertile.
- ✓ The moisture lost through evaporation is much greater than that gained during rainfall.
- ✓ The rainfall is extremely irregular.
- ✓ The drought period is usually longer than a year.

Biotic Factors of Desert Ecosystem – Fauna

- ✓ Hundreds of different animals thrive in deserts.
- ✓ Most of these are found only at dawn or dusk, when climate is much cooler.
- ✓ The fauna include snakes, owls, mice, armadillo lizards, fennec foxes, bats, vultures and camels.

Biotic Factors of Desert Ecosystem – Flora

- ✓ There are several varieties of plants that are able to survive in the desert.
- ✓ Most plants survive due to their tap roots that are able to reach underground water.
- ✓ The vegetation of the Desert Biome is mostly characterized by dominance of annual plants, often annual grasses.
- ✓ These plants have special parts and adaptations that help them save water.

BIODIVERSITY & ITS VALUES

Biodiversity can be defined as the richness of the diversification of all the species living in a particular area. The values of biodiversity are classified as Ecosystem service value, Ethical Values, Aesthetic Values, Ecosystem service value, Option value, Social value and Productive use values.

Ethical Value is also sometimes called as existence value. It incorporates the ethical issues that all life must be preserved. This is based on the concept of Live and Let Live. Biodiversity is valuable in all facets and If we want our human race to survive, then we must protect all biodiversity. The ethical aspect means that we may or may not use a species, but knowing the very fact that this species exists in nature gives us pleasure. We are not deriving anything directly animals from Kangaroo, Zebra or Giraffe, but the strong urge must be that these species should co-exist in nature. Hence it means, there is an ethical value or existence value attached to every species on earth.



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Option values include the potential of biodiversity that are presently unknown and needs to be explored from their realms for their true function. There is a hint that we might have potential cure for diseases such as AIDS or cancer existing within the depths of a marine ecosystem, or a tropical rainforest. Option value is hence knowing that there are biological resources existing on this biosphere that may one day prove to be an effective option for the future. The option value of biodiversity therefore suggests that any species may prove to be a useful someday. The biodiversity is a precious gift of nature and we should not commit the folly of losing these gifts even before unwrapping them.

Social values are associated with the social life, customs, religion and psycho-spiritual aspects of the humans. Many plants are considered holy and sacred in our country such as Tulsi, Peepal, Lotus, Bael. The leaves, fruits or flowers of these plants are used in worship of deities or the plant itself is sometimes worshipped. The tribal people are very closely linked with social values of the forests. The social life, songs, dances and customs of tribes are closely woven around the forest and its wildlife. Many animals like Cow, Snake, Bull, Peacock, Owl have significant place in our psycho-spiritual arena and hence gains social importance.

Ecosystem service values refers to the services provided by ecosystems in preventing soil erosion and floods, fixation of nitrogen, cycling of water, their role as carbon sinks, pollutant absorption and mitigating the threat of global warming. Ecosystem services those are often not readily visible. It plays a part in regulating the chemistry of our atmosphere. Biodiversity is directly involved in recycling nutrients and providing fertile soils. Experiments with controlled environments have revealed that humans cannot easily build ecosystems to support human needs. Example: Insect pollination cannot be mimicked by human-made construction.

Productive use values are the commercially viable values where the product is marketed and sold for profitable ventures. This includes lumber or wild gene resources that can be traded by scientists for introducing desirable traits in the crops and domesticated animals. This may include the animal products like silk from silk-worm, wool from sheep, fur of many animals, lac from lac insects. Many industries are dependent upon productive use values of biodiversity such as paper and pulp industry, plywood industry, Silk industry, textile industry. Developing nations of Asia, Africa and Latin America are the richest biodiversity centers.

Consumptive use value includes direct use values where the biodiversity product can be harvested and consumed directly.

Levels of Biodiversity

Biodiversity can be explained at three levels, namely **Genetic Diversity, Species Diversity and Ecosystem Diversity**.

- ✓ **Genetic biodiversity** reflects at the variation of genes within a species. Diversity of genes within a species increases its potential ability to adapt to disease, pollution and the other changes in habitat or environment. When a variety of particular specie is destroyed, the genetic diversity gets diminished; hence increase in genetic diversity is essential for a species to evolve.



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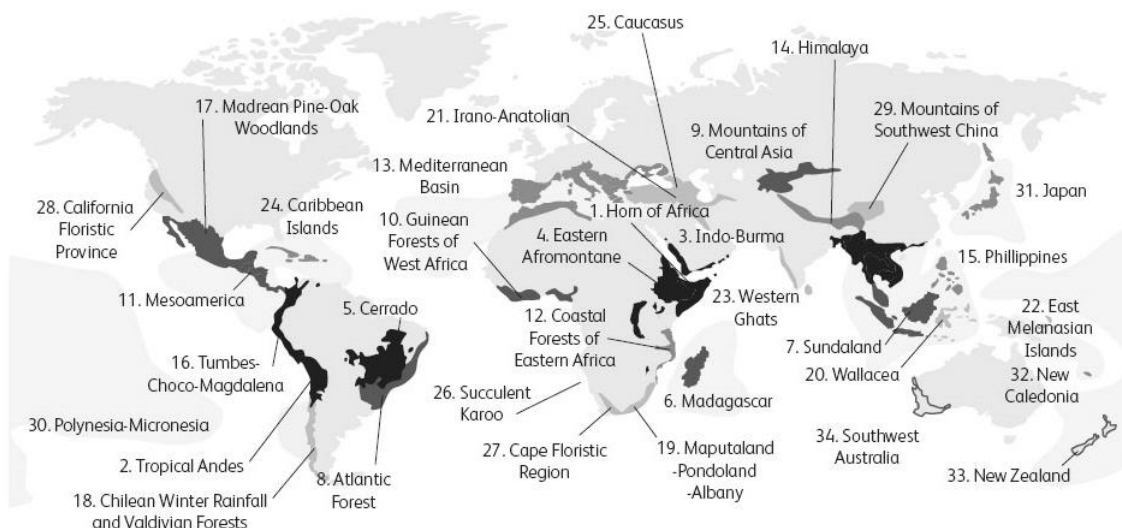
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- ✓ **Species Diversity** is portrayed as the variability found within the population of a species or between different species of a community. It indicates broadly the species richness and their abundance of community. Species biodiversity indicates variability of species within a region. Species diversity can be measured on the basis of species in a region. Greater species biodiversity reflects at more biological wealth.
- ✓ **Ecosystem diversity** is defined as ‘the aggregation of various habitats, community types and abiotic environments of a given area’. This is essentially the diversity of ecological complexity showing variations in ecological niches, trophic structure, food-webs and nutrient cycling. This diversity reflects on the variations with respect to physical parameters like moisture, temperature, altitude precipitation. The ecosystem diversity is of great value that must be kept intact as its destruction would disrupt the ecological balance. This diversity refers to diversity at habitat level. For example in a forest ecosystem, the ecosystem diversity is reflected by tropical rainforest, deciduous forest, temperate deciduous forest and boreal forest.

Human knowledge of the world’s biodiversity is still inadequate. There are three levels of biodiversity, global, national and local levels. All the three global, national and local levels are linked and constitute a gene pool.

India is a signatory to Convention on Biological Diversity by ratifying it in 1993. There are 34 world biodiversity hot spots. Overall 6% of the global species are found in India itself.

Biodiversity Hot-Spots



Threats to Biodiversity

As human population expands and natural habitats shrink, they constantly and increasingly come into conflict over living space and other resources. Humans unlike other animals prefer to change the environment around them instead of adjusting himself according to the environment.



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Animals often end crossing paths without humans for reasons such as loss of habitat, loss of food and natural pathway of migration and movement. Environmental pollution and global warming also causes certain animals especially those who cannot regulate body temperature and under stress to lock horns with humans. The other major threats are:

- ✓ Loss of habitat
- ✓ Poaching and Over hunting
- ✓ Man-wildlife conflicts
- ✓ Deforestation
- ✓ Dams
- ✓ Urbanisation
- ✓ Agriculture
- ✓ Deforestation
- ✓ Forest fires
- ✓ Introduction of new species
- ✓ Natural disasters
- ✓ Mining
- ✓ Desertification

Control measures to conserve and protect Biodiversity

- ✓ Proper Land-use planning
- ✓ Community Based Management
- ✓ Ensuring forests are free of human interference.
- ✓ Controlling rate of deforestation.
- ✓ Strict adherence to forest laws.
- ✓ Strict implementation of law, punishments and penalties for violators and poachers.
- ✓ Regular monitoring by foot patrol and GIS tracking.
- ✓ Strict control on the issuance of license of firearms around important protected areas.
- ✓ Spread awareness amidst general public about conservation and preservation of wildlife and their habitat.
- ✓ Protection of the habitats permanently through formation and conservation of national parks, nature reserves and wilderness areas will help preserve biodiversity.

In-situ & Ex-situ conservation of Biodiversity

The enormous value of biodiversity in the form of their genetic, commercial, medical, aesthetic and ecological importance emphasizes the need to conserve biodiversity.

There are two approaches to biodiversity conservation: **In-situ conservation** and **Ex-situ conservation**. In situ conservation (within habitat) is achieved by protection of wild flora and fauna by creating environment similar to nature such as national parks, forest reserves, and Sanctuaries. Ex-situ conservation (outside habitats) is done by establishing gene banks, seed banks, zoos, and botanical gardens. Genes are the basic units of hereditary information transmitted from one generation to the other. The genes found in organisms can form enormous combinations each of which gives rise to some variability. When the genes within the same species show different versions due to new combinations, it is called genetic variability.



NATURAL RESOURCES

Nature provides life support materials or resources for sustenance of life on earth for plants, animals and man. These are known as Natural Resources. Examples are water, air, soil, forests, minerals, crops etc.

There are 2 categories of natural resources:

1. Renewable resources: These can be recycled and regenerated within a given span of time. E.g., Forests, wind energy, solar energy, biomass energy, hydropower etc.
2. Non-Renewable Resources: These cannot be regenerated e.g., fossil fuels such as coal, petroleum, minerals etc.

The major natural resources are:

1. Forest resources
2. Water resources
3. Mineral resources
4. Food resources
5. Energy resources
6. Land resources

FOREST WEALTH

Forest resources play a vital role in the economy of India, the following section deal with the forest resources, its utility and emerging threats

COMPONENTS OF FOREST

A forest is a highly complex, constantly changing environment made up of a variety of living [wildlife, trees, shrubs, wildflowers, ferns, mosses, lichens, fungi and microscopic soil organism] and non-living [water, nutrients, rocks, sunlight and air] things. Trees are the most dominant component of this environment

BENEFITS OF FOREST

Forests cover much of the planets land area. They are extremely important to humans and the natural world. For humans, they have many aesthetic, recreational, economic, historical, cultural and religious values. Timber and other products of forests are important economically both locally and as exports.

Forest provides wood for fuel as a significant for those who harvest the wood or products of the living forest. Other non-wood products come in the form of medicinal compounds, dyes and fabrics. One-third of the world's population depends on wood for fuel as a significant energy source. Some indigenous people [tribal] depend completely on forest as their home and for many it's a source of their livelihood.



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Key benefits of forest are:

Provides clean water by intercepting water from rain and slowing it down and hence aids soil absorption for gradual release into streams at a slow and even rate. Cleansing action is done by root system.

Provides clean air by mode of photosynthesis wherein they release oxygen and take in carbon-dioxide. Trees filter air off harmful pollutants and moderate the air temperature.

Provides home/shelter to a wide array of species of flora and fauna. There is a possibility that many herbs of potential medical treatments, cures and vaccines may lie undiscovered within forests.

As source of economic growth by providing timber and playing important role in wood based industries and paper and pulp industries. Also it serves for tourism attraction And finally it also provide fruits, nuts, flowers and many other products of economic value.

Provides recreational activities like hunting, camping, hiking, fishing, watching wildlife, off road biking, horseback riding and plant collecting.

The ecological benefit apart from cleansing of air, water includes carbon sequestration i.e., taking carbon-di-oxide of out of the earth atmosphere to produce wood and leaf matter.

Trees as well help in absorbing noise, creating an aesthetic environment free of stress and peace. Trees protect topsoil from erosion and reduce risk of failure of slopes and hence prevent landslides and avalanches.

Water from roots is drawn up to the leaves where it evaporates. The conversion from water to gas absorbs huge amounts of heat cooling hot city air. Trees help to offset the heat island effect resulting from too much glass and concrete in city environments.

DEFORESTATION

It refers to the loss of forest cover; land that is permanently converted from forest to agricultural land, golf courses, cattle pastures, homes, lakes or desert. It is sometimes referred as change of forest with depletion of tree crown cover more than 90%.

UNCED 1992 defined deforestation as land degradation in arid, semi-arid and sub humid areas resulting from various factors including climatic variations and human activities.

Causes:

Agriculture – most of the forest clearing around the world is done for agricultural purposes [grazing cattle, planting crops etc.] poor farmers cut down small areas [few acres] and burn down the trees and proceed with agriculture. Intensive an extensive agriculture destroys forest on a larger scale.



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Commercial logging – cutting trees for timber or pulp. Logging can occur selectively [only the economically valuable species are cut] or by clear cutting [all trees are cut]. Commercial logging employs heavy machinery.

The cash crop economy – this is an integral part of the Third World Development and a major cause of deforestation. The best land is taken to earn export income, which is very often used to pay the foreign debt. Farmers are forced onto marginal land.

Mining and Dams – mining, hydro-electric schemes and industrial development are also significant causes of deforestation, both in terms of land they occupy and displacement of forest people.

Effects:

- Fewer trees result in insecure work for forest workers
- Heavy rainfall and high sunlight damage the topsoil in absence of trees.
- Erosion of soil, landslide frequented
- Loss of future markets for eco-tourism
- Indigenous people loss livelihood
- Loss of rare/endangered wildlife species
- Loss of habitat and migration of wild animals to rural and urban zones
- Cutting or burning of trees give a lot of carbon-di-oxide into atmosphere
- Reduction in rainfall
- Desertification
- No recycling of water
- Less carbon-di-oxide and nitrogen exchange
- Desiccation of soil

Remedies

- Reduce the consumption of forest and related products
- Avoid harmful products by consumer boycotts; such as tropical rainforest wood, old growth wood from the tropical rainforest.
- Boycott products of companies involved in deforestation
- Compel govt. and industries to make changes in forest policies
- Increase public awareness



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MODULE 2



ENERGY

Energy is the capacity to do work. A plenty of energy is needed to sustain industrial growth and agricultural production.

CLASSIFICATION OF ENERGY

1. Conventional energy: is in practice for long duration of time and well established technology is available to tap and use them. e.g. Coal, oil, natural gas, hydro power, nuclear power etc.
2. Non-conventional energy: source can be used with advantage for power generation as well as other applications in a large number of locations and situations. These energy sources cannot be easily stored and used conveniently. e.g. Solar, wind, tidal and geothermal etc.

Based upon nature, energy sources are classified as

1. Renewable energy sources are inexhaustible and are renewed by nature itself. Solar, wind, tidal, hydro and biomass are few examples.
2. Non-renewable energy sources are exhaustible within a definite period of time depending upon its usage. Fossil fuels (coal, oil, gas) and nuclear fuels are few examples.

Renewable

1. sun
2. water
3. wood
4. wind
5. biomass
6. geothermal
7. ocean tides

Nonrenewable

1. coal
2. natural gas
3. petroleum
4. nuclear fission

SOLAR ENERGY

The surface of the earth receives about 10^{14} kW from sun in the form of solar energy which is approximately five orders of magnitude greater than that currently being consumed from all resources. There are two obvious obstacles to harnessing solar energy. Firstly it is not constantly available on earth. Thus some form of storage is needed to sustain solar energy through the night and during rainy season. Secondly the solar energy is diffused. Although the total amount of energy is enormous, the collection and conservation of solar energy into useful forms must be carried out over a large area which entails large capital investments. By using solar radiation, water or any fluid can be heated by using a solar collector. Such systems can provide hot water for different applications in industries directly or as boiler feed and also in hostels, hotels and canteens. There are two types of solar collectors in use:



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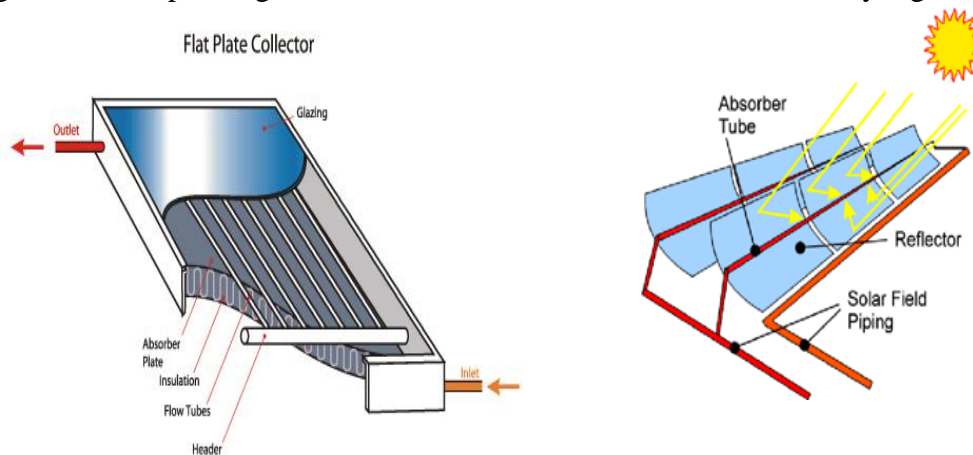
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Flat plate collector:

The absorber plate is metallic. It is usually coated black to absorb more heat energy. Tubes, passages or channels integral with the collector carry water or other working fluid. Insulation should be provided at the back and at the sides to minimize the heat losses. Usually glass wool is used as insulation material. A transparent cover (glass) will be provided at the top to permit the radiation from the sun to the metal plate.

Parabolic or concentrating collector

Highly polished metallic surfaces are used as the reflector. The reflector will have a parabolic shape so that the sun rays striking the profile will be reflected on its focal point. If a tube carrying a fluid is kept along the focal line, the fluid will be heated to a very high temperature.



Advantages

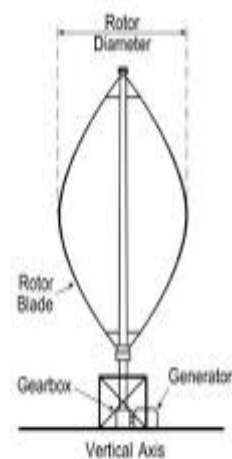
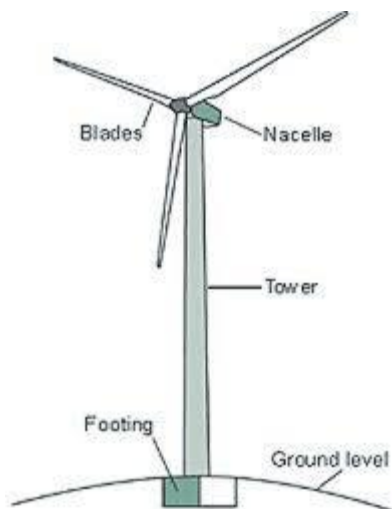
1. Renewable source of energy
2. Pollution free
3. After the capital cost, the cost of power generation is quite low
4. Wide range of applications, powering street lights to satellites

Disadvantages

1. Capital cost is very high
2. Large area of land is required
3. Large number of solar panels are required
4. Affected by seasons.



WIND ENERGY



The electrical energy can be generated by wind energy by utilizing the kinetic energy of wind. The wind energy which is an indirect source of energy can be used to run a wind mill which in turn drives a generator to produce electricity. Wind mills are classified into two types.

Horizontal Axis Wind Turbine

Horizontal axis wind turbines have the main rotor shaft running horizontally. Fig shows a schematic arrangement of a horizontal axis machine. This system consists of a tower mounted two bladed or multi bladed rotor facing the wind, rotating around a horizontal axis and turning an electrical generator. The Blades are generally made of composite material, usually fibre reinforced plastic (FRP) because of its high strength and light weight. Wind mills are manufactured with a capacity from a few kilowatts to several megawatts in Europe, the USA, and other parts of the world including India.

Vertical Axis Wind Turbine

Vertical axis wind turbines have the main rotor shaft running vertically. The tower construction is simple here because the generator and gear box can be placed at the bottom, near the ground.

Advantages

1. Wind is Renewable and free of cost
2. Pollution free
3. Can be installed in remote villages, thus reducing costly transmission lines

Disadvantages

1. Capital cost is very high
2. Large area of land is required
3. Maintenance cost is very high



TIDAL ENERGY

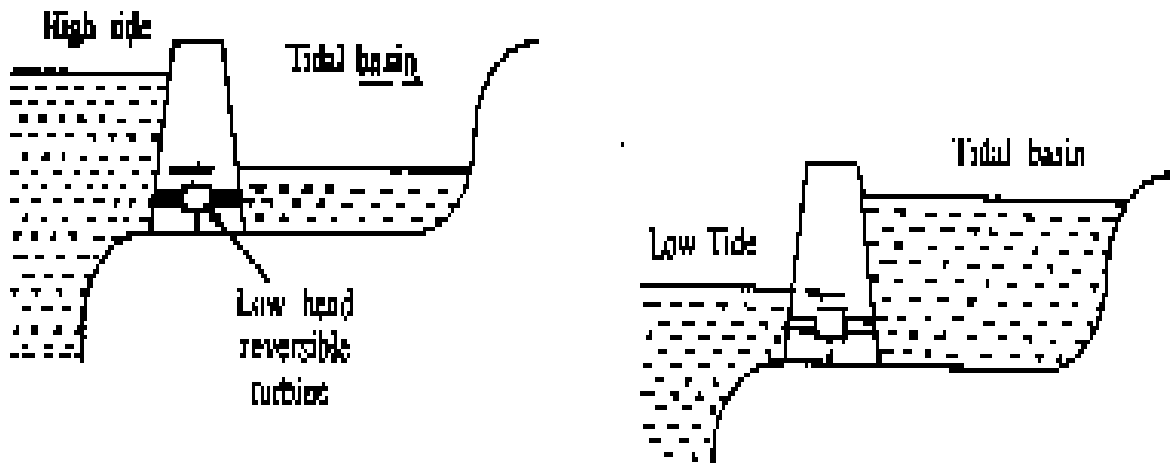
The periodic rise and fall of water level of sea which are carried by the action of the sun and moon on water of the earth is called “tide”. The large scale up and down movement of sea water represents an unlimited source of energy. The main feature of the tidal cycle is the difference in water surface elevations at the high tide and at the low tide. If the differential head could be utilized in operating a hydraulic turbine, the tidal energy could be converted into electrical energy by means of an attached generator.

Tidal Power Plant

A Tidal power plant mainly consists of the following:

1. A barrage with gates and sluices
2. One or more basins
3. A power house

A barrage is a barrier constructed across the sea to create a basin for storing water. The barrage has to withstand the pressure exerted by the water head and also should resist the shock of the waves. A basin is the area where water is retained by the barrage. Low head reversible water turbines are installed in the barrage separating the sea from the basin. During high tide, water will flow from sea to tidal basin through turbine, thus producing electricity. During low tide, water will flow from tidal basin to sea through turbine producing electricity.



Advantages

1. It is inexhaustible source of energy
2. No problem of pollution
3. The cost of power generation is quite low
4. High output can be obtained compared to solar or wind energy

Disadvantages



1. Capital cost is very high
2. As the head is not constant, variable output is obtained
3. As the head is low, large amount of water is necessary for the turbine
4. It will not operate when the available head is less than 0.5m

GEOHERMAL ENERGY

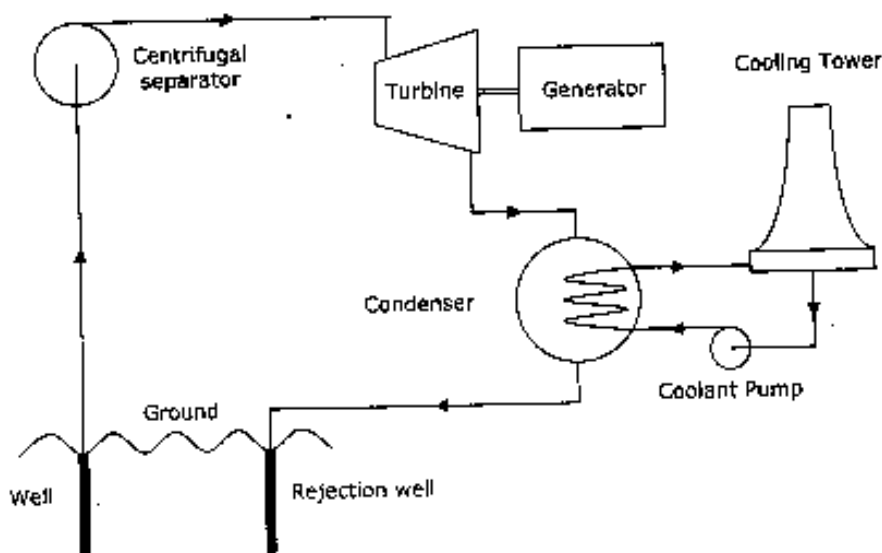
Geothermal power plants derive energy from the heat of the earth's interior. The average increase in temperature with depth of the earth is 1°C for every 30-40m. At a depth of 10-15km, the earth's interior is as hot as $1000-1200^{\circ}\text{C}$. In certain areas of our planet, the underground heat has raised the temperature of water to over 200°C which bursts out as hot steam through the cracks in the earth's crust. These are called thermal springs. This steam can be utilized for power production.

Geothermal Sources

1. Hydrothermal convective systems
 - (i) Vapor dominated or dry steam fields
 - (ii) Liquid dominated or wet steam fields
 - (iii) Hot water fields
2. Geo-pressure resources
3. Petrothermal or hot dry rocks
4. Magma resources
5. Volcanoes

Geothermal Power Plants

Geothermal wells are drilled at suitable locations. Water vaporized into steam comes out of the earth's surface in a dry condition at around 200°C and 8 bar. The moisture is removed by a centrifugal separator and this steam will run the turbine coupled with a generator. Steam is condensed in a condenser and re injected back into the ground by a rejection well.





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Advantages

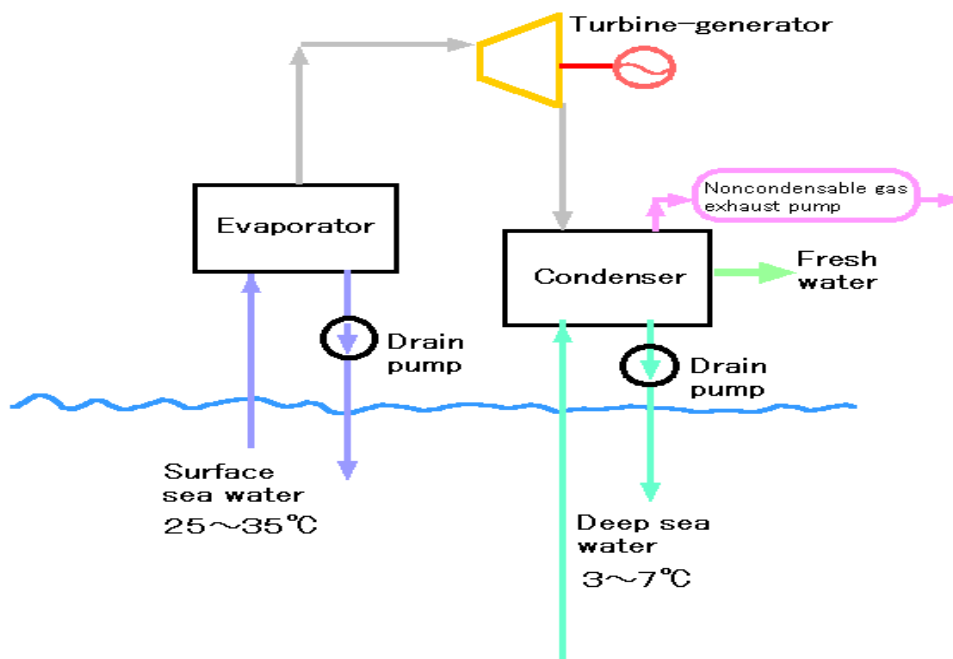
1. Geothermal energy is cheaper
2. Used as space heating for buildings
3. Used as industrial process heat
4. Geothermal energy is inexhaustible

Disadvantages

1. Low overall power production efficiency (about 15%)
2. Large areas are needed for exploitation of geothermal energy

OCEAN THERMAL ENERGY CONVERSION

OTEC uses the temperature difference of the sea water at different depths to generate electricity. OTEC utilizes the temperature difference that exists between the surface waters heated by the sun and the colder deep (up to 1000m) waters to run a heat engine. This source and sink provides a temperature difference of 20°C in ocean areas within 20° of the equator. These conditions exist in tropical coastal areas, roughly between the tropic of Capricorn and the tropic of cancer. Such a small temperature difference makes energy extraction difficult and expensive. Hence, typically OTEC systems have an overall efficiency of only 1 to 3%. The OTEC is shown in fig.



Advantages

OTEC uses clean, renewable, natural resources. Warm surface seawater and cold water from the ocean depths replace fossil fuels to produce electricity.

Suitably designed OTEC plants will produce little or no carbon dioxide or other polluting chemicals.



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There is enough solar energy received and stored in the warm tropical ocean surface layer to provide most, if not all, of present human energy needs.

The use of OTEC as a source of electricity will help reduce the state's almost complete dependence on imported fossil fuels.

Disadvantages

OTEC-produced electricity at present would cost more than electricity generated from fossil fuels at their current costs.

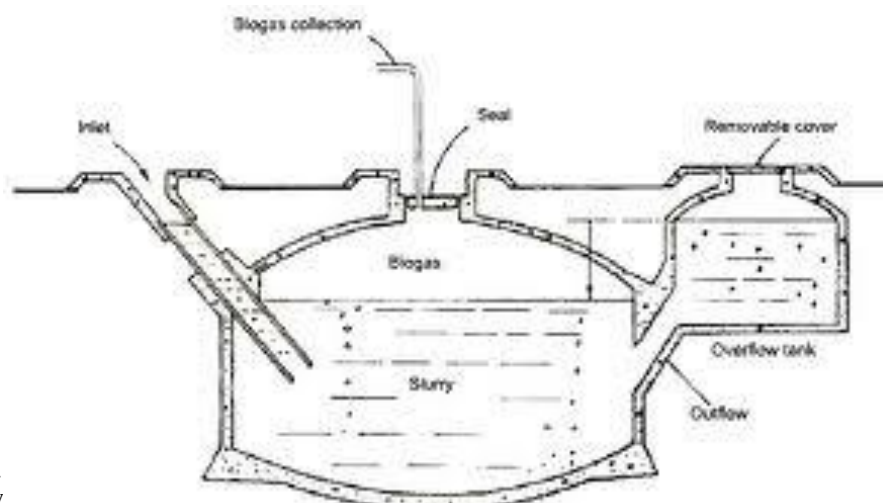
OTEC plants must be located where a difference of about 20° C occurs year round. Ocean depths must be available fairly close to shore-based facilities for economic operation. Floating plant ships could provide more flexibility.

Construction of OTEC plants and lying of pipes in coastal waters may cause localised damage to reefs and near-shore marine ecosystems.

BIOGAS

Biogas is generated when bacteria degrade biological material in the absence of oxygen, in a process known as anaerobic digestion. Since biogas is a mixture of methane (also known as marsh gas or natural gas, CH₄) and carbon dioxide (CO₂) it is a renewable fuel produced from waste treatment. Anaerobic digestion is basically a simple process carried out in a number of steps by many different bacteria that can use almost any organic material as a substrate .

Anaerobic digestion breaks down readily degradable organic matter in a series of steps, where the product of one step becomes the substrate for the next step. The initial step is usually considered to be “hydrolysis” – where extra cellular enzymes break complex organic molecules like fats and starches into simpler molecules like glucose. These simpler molecules are then utilised by “acetogenic” bacteria to produce acetic acid, with carbon dioxide as another product of the breakdown. “Methanogens” are then able to use the acetic acid and produce methane. There is also another group of “methanogens” that convert carbon dioxide to methane. As a result of these steps “biogas” is mainly methane (typically 60%, but less if the digester is not operating properly and sometimes up to about 80%) and carbon dioxide with traces of hydrogen sulphide, ammonia, water vapour, other organic volatiles and possibly some nitrogen gas.





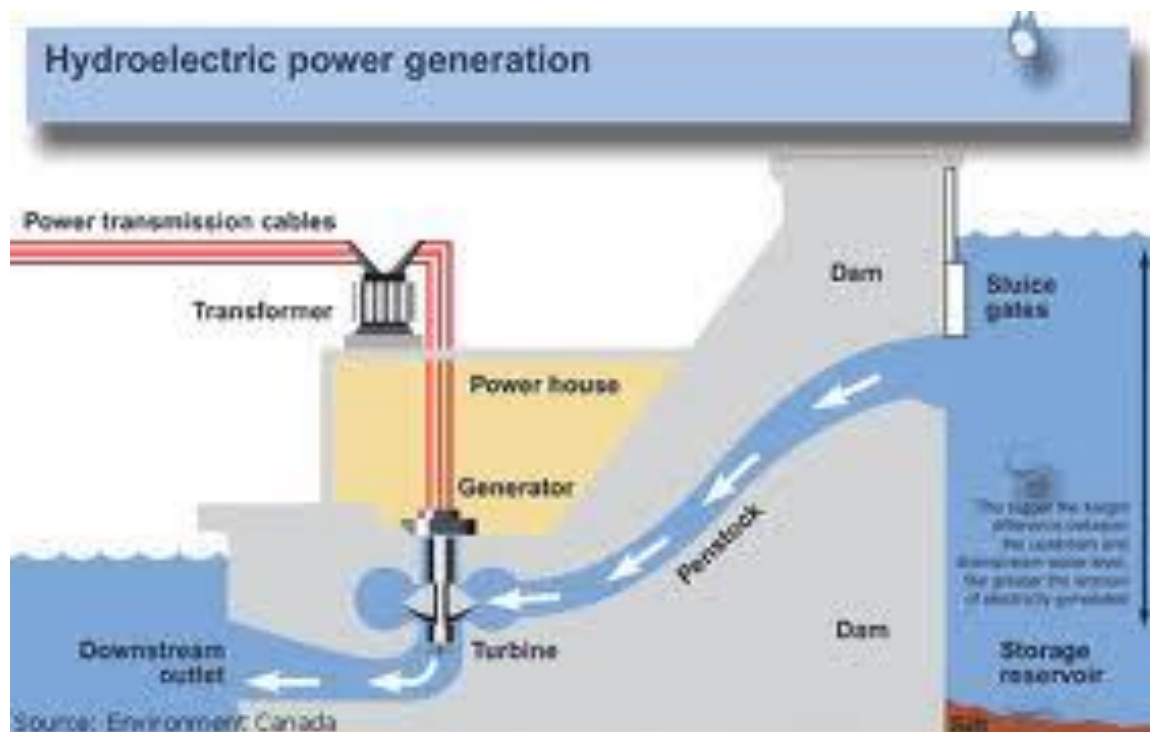
Advantages

Produces a renewable fuel that is flexible and can be used to produce heat, power, domestic gas use or as a vehicle fuel;
Generates methane that can be captured and used to produce energy that might otherwise leak into the atmosphere and increase the greenhouse effect;
The process fixes nitrogen in the digestate and reduces emissions of nitrous oxide (a strong greenhouse gas) compared to composting or landfill.

Disadvantages

Biogas contains contaminant gases which can be corrosive to gas engines and boilers;
Will only produce a limited quantity of energy demand and is dependent upon location in proximity to feedstock and energy users;
There is little or no control on the rate of gas production, although the gas can, to some extent be stored and used as required.

HYDRO ELECTRIC POWER



Advantages

1. Once a dam is constructed, electricity can be produced at a constant rate.
2. If electricity is not needed, the sluice gates can be shut, stopping electricity generation.
3. Dams are designed to last many decades and so can contribute to the generation of electricity.



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4. The lake that forms behind the dam can be used for water sports and leisure / pleasure activities.
5. The lake's water can be used for irrigation purposes.
6. The buildup of water in the lake means that energy can be stored until needed.
7. When in use, electricity produced by dam systems does not produce greenhouse gases.

Disadvantages

1. Dams are extremely expensive to build and must be built to a very high standard.
2. The high cost of dam construction means they must operate for many decades to become profitable.
3. The flooding of large areas of land means that the natural environment is destroyed.
4. People living in villages and towns that are in the valley to be flooded, must move out.
5. The building of large dams can cause serious geological damage.
6. Dams built blocking the progress of a river in one country.
7. Building a large dam alters the natural water table level.

MINING

Mining is the extraction of valuable minerals or other geological materials from the earth. Materials recovered by mining include bauxite, coal, copper, gold, silver, diamonds, iron, precious metals, lead, limestone, nickel, phosphate, oil shale, rock salt, tin, uranium, and molybdenum.

Any material that cannot be grown from agricultural processes, or created artificially in a laboratory or factory, is usually mined. Mining in a wider sense can also include extraction of petroleum, natural gas, and even water.

On an industrial scale can produce environmental damages resulting from exploration and development, even long after the mine is closed.

The exploratory phase generally causes the least impact, although drilling holes to determine the existence of deposits may involve transporting heavy equipment's and building roads. Environmental effects include erosion, formation of sinkholes, loss of stability, subsidence of land, weakening of lithospheric plates, dust generation, removal of green belt, desertification, loss of top soil, noise generation, loss of biodiversity, and contamination of groundwater and surface water by chemicals from the mining process and products.

Mining can have adverse effects on surrounding surface and ground water if protection measures are not exercised. The result can be unnaturally high concentrations of some chemical elements, notably arsenic and sulfuric acid, over a significantly large area of surface or subsurface. Old mines are often dangerous and can contain deadly gases, snakes, and other dangerous animals. The entrance to an old mine in particular can be very dangerous, as weather may have eroded the earth/rock surrounding the entrance. Old mine workings, caves, etc. are commonly hazardous simply due to the lack of oxygen in the air (a condition in mines known as blackdamp) and this is a deadly killer which provides no warning to those entering such an environment.



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Acid mine drainage (AMD), or acid rock drainage (ARD), refers to the outflow of acidic water from (usually) abandoned metal mines or coal mines. Open pit mining, generates enormous quantities of waste compared to any other natural resource extraction activity. Water interacts with these wastes to generate contaminated fluids that can pollute soils, rivers and ground water. These fluids can be highly acidic and metal laden or highly alkaline and they often contain various forms of cyanide and sulfides. $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$

CLOUD SEEDING

Cloud seeding is a type of weather modification that aims to change the amount or type of precipitation that falls from clouds by dispersing substances into the air that serve as cloud condensation or ice nuclei, which alter the microphysical processes within the cloud. The usual intent is to increase precipitation (rain or snow), but hail and fog suppression are also widely practiced in airports where harsh weather conditions are experienced. Cloud seeding also occurs due to ice nucleators in nature, most of which are bacterial in origin.

The most common chemicals used for cloud seeding include silver iodide, potassium iodide and dry ice (solid carbon dioxide). Liquid propane, which expands into a gas, has also been used. This can produce ice crystals at higher temperatures than silver iodide. After promising research, the use of hygroscopic materials, such as table salt, is becoming more popular. When cloud seeding, increased snowfall takes place when temperatures within the clouds are between -4 and 19 °F (-20 and -7 °C). Introduction of a substance such as silver iodide, which has a crystalline structure similar to that of ice, will induce freezing nucleation.

There are three cloud seeding methods: static, dynamic and hygroscopic.

Static cloud seeding involves spreading a chemical like silver iodide into clouds. The silver iodide provides a crystal around which moisture can condense. The moisture is already present in the clouds, but silver iodide essentially makes rain clouds more effective at dispensing their water.

Dynamic cloud seeding aims to boost vertical air currents, which encourages more water to pass through the clouds, translating into more rain. Up to 100 times more ice crystals are used in dynamic cloud seeding than in the static method. The process is considered more complex than static clouding seeding because it depends on a sequence of events working properly.

Hygroscopic cloud seeding disperses salts through flares or explosives in the lower portions of clouds. The salts grow in size as water joins with them.

With an NFPA 704 health hazard rating of 2, silver iodide can cause temporary incapacitation or possible residual injury to humans and other mammals with intense or chronic exposure. However, there have been several detailed ecological studies that showed negligible environmental and health impacts.



Carbon Trading

Carbon trading is an exchange of credits between nations designed to reduce emissions of carbon dioxide. It is also referred to as carbon emissions trading. Carbon emissions trading accounts for most emissions trading.

When countries use fossil fuels and produce carbon dioxide, they do not pay for the implications of burning those fossil fuels directly. There are some costs that they incur, like the price of the fuel itself, but there are other costs not included in the price of the fuel. These are known as externalities. In the case of fossil fuel usage, often these externalities are negative externalities, meaning that the consumption of the good has negative effects on third parties. These externalities include health costs, (like the contribution that burning fossil fuels makes to heart disease, cancer, stroke, and lung diseases) and environmental costs, (like environmental degradation, pollution, climate change, and global warming). Interestingly, research has found that, often, the burdens of climate change most directly affect countries with the lowest greenhouse emissions. So, if a country is going to burn fossil fuels, and produces these negative externalities, the thinking is that they should pay for them.

The carbon trade originated with the 1997 Kyoto Protocol, with the objective of reducing carbon emissions and mitigating climate change and future global warming. At the time, the measure devised was intended to reduce overall carbon dioxide emissions to roughly 5% below 1990 levels by between 2008 and 2012.

Basically, each country has a cap on the amount of carbon they are allowed to release. Carbon emissions trading then allow countries that have higher carbon emissions to purchase the right to release more carbon dioxide into the atmosphere from countries that have lower carbon emissions.

The carbon trade also refers to the ability of individual companies to trade polluting rights through a regulatory system known as cap and trade. Companies that pollute less can sell their unused pollution rights to companies that pollute more. The goal is to ensure that companies in the aggregate do not exceed a baseline level of pollution and to provide a financial incentive for companies to pollute less.



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MODULE 3



ENVIRONMENTAL POLLUTION

Pollution is the introduction of pollutants (chemical substances

noise, heat, light, energy and others) into the environment which results in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems, and impair or interfere with amenities and other legitimate uses of the environment.

Major forms of pollution

The major forms of pollution are listed below along with the particular pollutants relevant to each of them:

- Air pollution, the release of chemicals and particulates into the atmosphere. Common examples include carbon monoxide, sulfur dioxide, chlorofluorocarbons (CFCs), and nitrogen oxides produced by industry and motor vehicles. Photochemical ozone and smog are created as nitrogen oxides and hydrocarbons react to sunlight.
- Water pollution via surface runoff, leaching to groundwater, liquid spills, wastewater discharges, Eutrophication and littering.
- Soil contamination occurs when chemicals are released by spill or underground storage tank leakage. Among the most significant soil contaminants are hydrocarbons, heavy metals, herbicides, pesticides and chlorinated hydrocarbons.
- Radioactive contamination, added in the wake of 20th-century discoveries in atomic physics.
- Noise pollution, which encompasses roadway noise, aircraft noise, industrial noise as well as high-intensity sonar.
- Light pollution, includes light trespass, over-illumination and astronomical interference.
- Visual pollution, which can refer to the presence of overhead power lines, motorway billboards, scarred landforms (as from strip mining), open storage of trash or municipal solid waste.
- Thermal Pollution is a temperature change in natural water bodies caused by human influence.

AIR POLLUTION

Definition: the presence in the air of substances generally originating from manmade/natural activities in concentrations that interfere with the health, comfort, and safety of living beings. It can be indoor as well outdoor Air pollution. However our discussion will be restricted to Outdoors type.



CLASSIFICATION OF AIR POLLUTANTS

[a] Origin of pollutants

Primary pollutants: emitted directly from source, say, release of SO₂ from burning of coal.

Secondary Pollutants: Formed due to interaction of 2 or more primary and secondary pollutants, say for instance Acid rain, Ozone, PAN, Smog etc.

[b] States of Matter

Particulates: composed of solid-liquid --- inert/reactive particles sized 2×10^{-4} – 500 microns. e.g., dust/smoke

Gaseous: SO₂, CO, H₂S, CH₄, CO₂ and O₃

[c] Chemical composition

Organic: Aldehydes, Esters, ethers, and amines

Inorganic: NO_x, SO₂, NH₃, H₂S and O₃

[d] Characteristics

Physical: Dust, fly ash, spray, pollen, smoke, mist and fumes

Chemical: Organic – Inorganic

Biological: Protozoa, Bacteria, Fungi and Virus.

Chernobyl Nuclear disaster

April, 27, 1986, a major accident had occurred at an atomic reactor at Chernobyl in the Ukraine area of the erstwhile Soviet Union. This had resulted in clouds of radioactive smoke over a large area in Scandinavian countries about 2000 km away, and in the Russian region itself. 1st explosion occurred at reactor number 4 at the Chernobyl complex occurred on April 26, 1986 and resulted in a massive and uncontrollable fire.

The explosion was followed by a second explosion on May 5th. Majority of radiation [about 10.19 Bq. of radio nuclides] escaped was released in span of 10 days between 2 explosions. The explosion and fire was caused by failure of emergency cooling system in the light water graphite reactor, due to human error.



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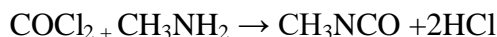
The explosion and subsequent hot fire (about 2500⁰C) blew large amounts of radionuclides high into the atmosphere. Four main radionuclides released include I-131 [half-life 8.5 years], Cesium-137 [half-life 30 years], C-14 [half-life 5730 years] and Sr-90 [half-life 28 years].

During the first 10 days over 400 million people were exposed to the radiation. In the immediate vicinity 30 soviet citizens died from radiation poisoning. Over 1,50,000 were evacuated from an area of radius 30km.

The chronic health impacts include blood abnormalities, hemorrhagic diseases, thyroid changes, mutagenic and somatic alterations, bone necrosis, skin cancer, failure of reproductive organs etc.

Bhopal Gas Tragedy

On the fateful night of December 02, 1984 and the early hours of December 03, 1984, more than one million residents of Bhopal, capital of Madhya Pradesh, India, reported irritation of eyes that quickly lead to macabre death dancing. A cloud of poisonous gas was released from the union carbide factory, a pesticide manufacturing plant owned by UNION CARBIDE INDIA Ltd., a subsidiary of union carbide, USA. The factory was licensed to produce Methyl Iso Cynate, CH₃NCO, an extremely hazardous chemical, which is used in the manufacture of several pesticides like Sevin Carbaryl and Temik 10-G. Carbon monoxide, obtained by partial oxidation of coal is combined with chlorine gas in presence of activated carbon to produce phosgene, COCl₂. Phosgene gas and methyl amine combine to form MIC. The product is stored in tanks for further production carbomite insecticides.



Bhopal gas tragedy was as well associated with thick winter fog and thermal inversion, which did not allow the pollutants to disperse and dilute. It was alleged that MIC is stored up to a purity of 99.5% and 0.1% phosgene is permitted as impurity.

MIC shall not be stored more than 1 month, but due to sheer negligence and ignorance, it was stored for more than 3 months, as a result of which there was pressure built-up, and the tank couldn't resist the extreme pressure generated and exploded releasing as into atmosphere.

About 40 tons of MIC AND 40 kg of phosgene was vaporized and released. In such a scenario, there is a provision of burning up the gas, by control equipment called flare tower, on whose failure the gas can be neutralized by caustic soda using vent scrubber. Unfortunately both control devices failed to work as they were maintained. This was sheer case of human negligence.

MIC is a toxic gas that is denser than air and even at low concentrations is fatal causing death due to anoxia. MIC is a very reactive chemical that can react with itself unless maintained at a specific temperature [15⁰C]. Liquid nitrogen was used to maintain this, but device circulating it had failed to operate and situation worsened.

The next day entire Bhopal railway station was filled with corpses of people who tried to fled the place, had it not been for presence of 2 lakes that came in way of escaping gas, the disaster would have been multifold.



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Impacts of Air Pollution

Health issues, Soiling of clothes, buildings and plants, Lack of appetite, rapid loss of weight, lameness, death and Masking of human performance. In plants causes collapse of tissues [necrosis], reduction in chlorophyll [chlorosis] and dropping of leaves [abscission].

CONTROL MEASURES AND PREVENTION MEANS

Control techniques:-

At Source: Modification of process / equipment / exhaust / products.

At Receiver: Proper zoning / planning of industrial area.

At Transmission: Operation/maintenance of vehicles / forest belt.

Alternative Fuel resources: bio fuel/ eco-friendly fuel/ low Sulphur % coals

Norms & Regulations: Emission tests, Penalties, Stringent enforcements & monitoring

Dilution of pollutants concentration at source by use of tall stacks and control equipment's.

Some of the control equipment's used are settling chamber, cyclonic separator, filter, electrostatic precipitator and wet collector, the choice depends on characteristics of air pollutant.

NOISE POLLUTION

Noise can be defined as the wrong sound at wrong place at wrong time. It is derived from the Latin word Nausea.

Noise is any sound independent of loudness producing undesirable effects on individual. Amplitude [loudness] and frequency [intensity] are its two properties.

Sources of noise

- ❖ Indoor – Outdoor
- ❖ Industrial - Residential/Traffic
- ❖ Natural - Manmade

- Indoor source: baby crying, door banging, audio systems
- Outdoor source: loud speakers, brawling
- Natural sources: birds, thunder, earthquake, volcanic eruptions
- Man-made sources: automobiles
- Industrial sources: drilling, rotary machinery, mining,
- Traffic: aircrafts, railways



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Time of exposure, Frequency, intensity are certain factors under which effect of noise is biased. Noise can affect auditory, circulatory and nervous system of human body.

Speech interference, masking, effect on human performance acoustic trauma [sudden permanent aural damage due to short exposure], temporary and permanent threshold shift are effects on auditory system observed in humans. Human hearing mechanism comprise ear drum, cochlea and hair cells.

Shrinking of blood vessels, low blood flow to organs, blood pressure, cardio-vascular death, heart attack and digestive spasms are effects on circulatory system while ear drum rupture, aggressiveness, fatigue, insanity are symptoms of effects on nervous system.

Noises can seriously damage and effect physiological and psychological health. Noise also make species communicate louder (which is called Lombard Vocal Response).

Noise Standards

CLASS	ZONE	7 AM - 10 PM	10 PM - 7AM
A	INDUSTRIAL	75	70
B	COMMERCIAL	65	55
C	RESIDENTIAL	55	45
D	SILENT	50	40

Noise pollution limits at residential area 55 dB, Industrial area 65 dB, Commercial area 60 dB and Silent zone is 45 dB. Tolerant noise level in city levels is 65 dB, while normal permissible is 45 dB.

Control of noise is to be achieved not only at the source but also at receiver end, via transmission route, via application of rules and regulations, maintenance of vehicular condition, utilization of silencers, ban on shrill horns, eco-friendly zoning, green belt development and proper town planning.

WATER POLLUTION

UTILISATION OF WATER

Precipitation is the primary resource of irrigation water, in the form of rainfall and snow. These give rise to secondary sources of irrigation broadly classified as;

1. Surface Water
2. Ground Water
3. Auxiliary Water



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Storage Component	Total water (%)
Oceans	97.6
Ice caps & Glaciers	1.9
Ground water & soil moisture	0.5
Fresh water lakes	0.009
Saline lakes	0.008
Rivers	0.0001
Atmosphere	0.001
TOTAL	100.00

Figure: Total available water in world

Distribution	%
Evaporation loss	18
Surface run of	29
Soil infiltration	53

Figure: Distribution of precipitation

About 97% of earth's water supply is in the oceans which is unfit for human consumption and the other uses due to salinity. Of the remaining, 2.3% is locked in the polar ice caps and hence out of bounds. The balance 0.7% is available as fresh water but the bulk of it 0.67 exist as ground water, and the rest 0.03% is available to us as fresh water, rivers, lakes and streams. The breakup of this 0.03% freshwater is 0.01% as lakes & rivers, 0.01 as water vapor, 0.0003 as streams and the remaining 0.0187 confined in plants and animal tissues. Mass balance of annual rainfall shows about 70 % loss by evapo-transpiration, while reminder is stream flow.

USES OF WATER

Productive use: water is primarily used for irrigation of food crops, fodder crops, medicinal herbs, etc.

Consumptive use: water is consumed in exhaustive quantities for domestic purposes such as drinking, cooking, washing etc. water find its application in almost all the processes in industries, starting from the manufacturing processes to housekeeping activities.

Commercial use: Water consumed for carrying out commercial and recreational activities.

Many uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. The framework for allocating water resources to water users (where such a framework exists) is known as water rights.

Agricultural



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It is estimated that 69% of world-wide water use is for irrigation. In some areas of the world irrigation is necessary to grow any crop at all, in other areas it permits more profitable crops to be grown or enhances crop yield.

Industrial

It is estimated that 15% of world-wide water use is industrial. Major industrial users include power plants, which use water for cooling or as a power source (i.e. hydroelectric plants), ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. The portion of industrial water usage that is consumptive varies widely, but as a whole is lower than agricultural use.

Household Drinking water

It is estimated that 15% of world-wide water use is for household purposes. These include drinking water, bathing, cooking, sanitation, and gardening. Basic household water requirements have been estimated at around 50 liters per person per day, excluding water for gardens.

Recreation

Recreational water use is usually a very small but growing percentage of total water use. Recreational water use is mostly tied to reservoirs. If a reservoir is kept fuller than it would otherwise be for recreation, then the water retained could be categorized as recreational usage. Other examples are anglers, water skiers, nature enthusiasts and swimmers.

WATER BORNE DISEASES

Waterborne diseases are caused by pathogenic microorganisms which are directly transmitted when contaminated drinking water is consumed.

Contaminated drinking water used in the preparation of food can be the source of food borne disease through consumption of the same microorganisms.

Waterborne disease can be caused by protozoa, viruses, bacteria, and intestinal parasites.

Bacterial Infections

Cholera - *Vibrio cholerae* bacteria - gastro-intestinal often waterborne

Diarrhoeal diseases - caused by the water contamination of *Cryptosporidium parvum* [*E.Coli*].

Dysentery - *Shigella/Salmonella* bacteria - gastro-intestinal food/water

Typhoid - *Salmonella typhi* bacteria - gastro-intestinal water/food borne

Viral Infections

Adenovirus infection - its serotypes are typically waterborne.



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Hepatitis A - Hepatitis A virus - gastro-intestinal water/food borne

Polio - polioviruses - gastro-intestinal exposure to untreated

WATER INDUCED DISEASES

On the other hand Water Induced Diseases are those which are not transmitted directly by water but facilitate its propagation such as Malaria that for instance support as breeding grounds for mosquitoes. Vivax & Plasmodium Falciparum are the 2 major strains of the 4 which affect humans globally, carried by female anopheles mosquitoes. Incidentally Malaria means Bad Air in Italy [Mal-aria], Salaria means healthy air.

WATER QUALITY STANDARDS

BIS: Bureau of Indian Standards IS 10500-2003 [for drinking water]

Turbidity 5 NTU [Nephelo Turbidity Units]

p^H 6.5-8.5 [U S studs 6-9]

Total hardness 300 ppm as CaCO₃

Iron 0.3 ppm

Lead 0.05 ppm

Fluoride 1.0 ppm

Arsenic 0.05 ppm

Nitrates 45 ppm

Pesticides NIL

Total Coliform 1 MPN/100 ml [Most probable number]

Hexavalent Chromium 0.05 ppm

Trivalent chromium 0.1 ppm

Water pollution is the introduction into fresh or ocean waters of chemical, physical, or biological material that degrades the quality of the water and affects the organisms living in it. This process ranges from simple addition of dissolved or suspended solids to discharge of the most insidious and persistent toxic pollutants (such as pesticides, heavy metals, and non-degradable, bio accumulative, chemical compounds).



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Ground water pollution i.e., highly prolific arsenic contamination is widely due to leaching of minerals below the earth surface. This happens as a result of excessive pumping of ground water by shallow tube wells. In this process air [Oxygen] is injected into ground water bed which leaches the overlying mineral, iron pyrites [Fe, As etc.,] oxidizes it and releases arsenic into ground water.

Sources of water pollution

- Geology of aquifers from which groundwater is abstracted
- Industrial discharge of chemical wastes and byproducts
- Discharge of poorly-treated or untreated sewage
- Surface runoff containing pesticides or fertilizers
- Slash and burn farming practice, which is often an element within shifting cultivation agricultural systems
- Surface runoff containing spilled petroleum products
- Surface runoff from construction sites, farms, or paved and other impervious surfaces e.g. silt
- Discharge of contaminated and/or heated water used for industrial processes
- Acid rain caused by industrial discharge of Sulphur dioxide (by burning high-Sulphur fossil fuels)
- Excess nutrients are added (Eutrophication) by runoff containing detergents or fertilizers
- Underground storage tank leakage, leading to soil contamination, and hence aquifer contamination
- Inappropriate disposal of various solid wastes and, on a localized scale, littering

Types of pollutants

- 1] Physical : turbidity, color, odor [Fe]
- 2] Chemical:
 - 2.1] Organic pollutants: domestic sewage, pesticides, and plant nutrients.
 - 2.2] Inorganic pollutants: mineral acids, detergents, and trace element.
 - 2.3] Radioactive materials: mineral wastes, debris of medicinal R&D, industrial facilities.
- 3] Thermal/heat; thermal pollution from coal fired/nuclear fuel fired thermal power plants.
- 4] Sediments/suspended matter: soil erosion, runoff.
- 5] Disease causative agents: Pathogens, total coliform group.

Contaminants may include organic and inorganic substances

Some organic water pollutants are:

1. Insecticides and herbicides, a huge range of organ halide and other chemicals
 2. Bacteria, often is from sewage or livestock operations; Food processing waste, including pathogens
- Tree and brush debris from logging operations
 - VOCs (Volatile organic compounds), such as industrial solvents, from improper storage

Some inorganic water pollutants include:



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- Heavy metals including acid mine drainage
- Acidity caused by industrial discharges (especially sulfur dioxide from power plants)
- Chemical waste as industrial by products
- Fertilizers, in runoff from agriculture including nitrates and phosphates
- Silt in surface runoff from construction sites, logging, slash and burn practices or land clearing sites

Sources of water pollution

- 1] industrial effluent
- 2] domestic sewage
- 3] fertilizers/pesticides from agricultural land as runoff
- 4] leachate from solid waste disposal sites.

Water pollution caused by domestic sewage amounts to 84% while industrial sewage contributes 16%. The previous exerts oxygen demand while latter is toxic and hazardous despite that the load is less. Industrial effluents contribute color [textile firms], heavy metals [electroplating], microbes [pharmacy-distillery] and organic load [paper and pulp industry].

Types of sources

- 1] Point sources: sources, which discharge pollutants at specific locations through pipelines, sewers into water bodies. E.g., factory outlets, STP [sewage treatment plant] because they are at specific places hence they are fairly easy to identify, monitor and regulate.
- 2] Non-point sources: sources, which include run off from urban, sub urban , agricultural farms, livestock, animal husbandry, crop lands etc. Difficulty is in controlling non-point source as it is almost impossible in identifying and controlling discharges from so many diffuse sources.

Basic Terminologies

- 1] Sewer: pipeline/conduit carrying sewage.
- 2] Sewage: the wastewater flowing in sewers, comprises > 99% water, < 1% solids. Generally referred as domestic sewage when water arises from both kitchen & toilets.
- 3] Sullage: wastewater arising only from kitchen areas.
- 4] Storm drainage; water entering a sewer due to rainfall. This increases load on treatment plant as well dilutes the waste quality.
- 5] Sewerage: art of collection, treatment and disposal of sewage.
- 6] Dry weather flow: in summer season, quantity of sewage in sewers is less as due to scanty rainfall.

Types of treatment offered

- 1] separate treatment: here individual and specific treatment is followed for industrial and domestic sewage separately. This treatment saves space and is process specific w.r.t. pollutant removal.



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2] Joint treatment: here domestic sewage is mixed with industrial sewage. This helps in diluting the toxicity of industrial wastes but also increases the load on STP.

3] Partial treatment: only a portion of domestic sewage is mixed with industrial waste. This is design specific based on characteristic of wastewaters.

Characteristic of Sewage

DO [dissolved oxygen] is the amount of free oxygen available to aquatic species necessary for their existence.

Situations can arise where in presence of organic matter in waters body necessitates situations where in presence of organic matter utilizes DO as oxidizing element. Organic matter is food for microbes.

Fresh sewage is grey in color, as time progresses DO depletes, and color turns black, and its termed Septic.

COD i.e., chemical oxygen demand can be defined as the amount of dissolved oxygen required by chemical compounds for oxidation process.

Effects of Water Pollution

Eutrophication, destruction of aquatic species, threats to coral reefs and endangered species, depletion of dissolved oxygen, spread of water borne, carrying diseases, ecological imbalance, recreational and tourism impacts, loss of water bodies

LAND POLLUTION

Land pollution is the degradation of the Earth's land surface through misuse of the soil by poor agricultural practices, mineral exploitation, industrial waste dumping, and indiscriminate disposal of urban wastes. It includes visible waste and litter as well as pollution of the soil itself. Land pollution is often a consequence of increasing urbanization and industrialization. Man's increasing demands on the environment and the resources it holds are putting countries under pressure.

Soil Pollution is mainly due to chemicals in herbicides (weed killers) and pesticides (poisons which kill insects and other invertebrate pests). Litter is waste material dumped in public places such as streets, parks, and picnic areas, at bus stops and near shops.

Waste Disposal: The accumulation of waste threatens the health of people in residential areas. Waste decays, encourages household pests and turns urban areas into unsightly, dirty and unhealthy places to live in.

Some of the more common soil contaminants are chlorinated hydrocarbons (CFH), heavy metals (such as chromium, cadmium--found in rechargeable batteries, and lead--found in lead paint, aviation fuel and still in some countries, gasoline), MTBE, zinc, arsenic and benzene.



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Ordinary municipal landfills are the source of many chemical substances entering the soil environment (and often groundwater), emanating from the wide variety of refuse accepted, especially substances illegally discarded there.

Soil pollution due to solid waste disposal was brought to the forefront of public attention by the notorious "Love Canal" case in 1978. Toxic chemicals were leached from oozing storage drums into the soil underneath causing an unusually large number of birth defects, cancers and respiratory, nervous and kidney diseases.

Control Measures

- Anti-litter campaigns can educate people against littering;
- Organic waste can be dumped in places far from residential areas;
- Inorganic materials such as metals, glass and plastic, but also paper, can be reclaimed and recycled.
- In – situ - Bioremediation, phyto remediation, bio-augmentation etc.

LANDFILL

Sanitary landfill is the cheapest satisfactory means of disposal, but only if suitable land is within economic range of the source of the wastes; typically, collection and transportation account for 75 percent of the total cost of solid waste management. In a modern landfill, refuse is spread in thin layers, each of which is compacted by a bulldozer before the next is spread. When about 3 m (about 10 ft) of refuse has been laid down, it is covered by a thin layer of clean earth, which also is compacted. Gases are generated in landfills through anaerobic decomposition of organic solid waste. If a significant amount of methane is present, it may be explosive; proper venting eliminates this problem.

INCINERATION

Incineration is a waste treatment technology that involves the combustion of organic materials and/or substances. Incineration and other high temperature waste treatment systems are described as "thermal treatment". Incineration of waste materials converts the waste into heat, which can be used to generate electricity, gases, particulates of combustion and ash.

Incineration has particularly strong benefits for the treatment of certain waste types in niche areas such as clinical wastes and certain hazardous wastes where pathogens and toxins must be destroyed by high temperatures. There are various types of incinerator plant design such as Simple, Fixed or moving grate combustion, Rotary-kiln, Multiple/stepped hearth and Fluidized bed

AUTOMOBILE POLLUTION

The addition of chemicals released from automobile emissions constituting NO_x , HC's, CO, SPM, SO_2 , Pb resulting in deterioration of ambient air is termed as automobile pollution. Automobile pollution also depends on several other factors such as age of the vehicle, type of fuel used, condition of engine, type of engine, maintenance and operation mode of vehicle etc.



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PETROL ENGINE vs. DIESEL ENGINE

Petrol engine	Diesel engine
High CO, HC's concentration in emissions	Lesser HC's concentration i.e., 1/10 CO that of petrol
Less smoke	Major problem odor and smoke, at least 80% SPM than in petrol exhaust
Less SO ₂ , NO _x , PM	More NO _x , SO ₂ , PM/SPM

Inference, why ? Diesel engines have higher compression ratio than petrol. First air is compressed, then fuel injected, then ignition but in petrol, air fuel mixed first, compressed and then ignited. HC's concentration is less, because blowby is negligible as only air is present in compression stroke & evaporative emissions. Hydrocarbons are as well low because diesel uses a closed injection fuel system.

SMOKE

When compared to diesel emissions, petrol emission is more toxic w.r.t. human; while diesel emissions contribute towards environmental impacts. yet smoke emission from diesel cannot be ignored.

Maximum smoke is produced when vehicle runs at 60% of total power. It is measured in Ringelmann's Scale.

Effects of smoke: Irritation of eye membrane, ear membrane and respiratory tract, soiling of clothes, disfiguring of buildings.

Control means: High A/F ratio, Smokeless fuel – Vehicle maintenance - Lean mixture.

2 STROKE ENGINE vs. 4 STROKE ENGINE

When compared to 4 stroke, 2 stroke engine produces more pollution [HC's, CO, SPM, Smoke] as it burns an oil gasoline mixture, but 2 stroke engine is more powerful, lighter, less expensive. On the contrary, 4 stroke engine gives more mileage, produces less HC's and VOC's [volatile organic carbon] as there is no short circuit of raw fuel.

Types of emissions

1. Tailpipe emissions: This is what most people think of when they think of vehicle air pollution; the products of burning fuel in the vehicle's engine, emitted from the vehicle's exhaust system. The major pollutants emitted include:

Hydrocarbons: This class is made up of unburned or partially burned fuel, and is a major contributor to urban smog, as well as being toxic. They can cause liver damage and even cancer.



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Nitrogen oxides (NO_x): These are generated when nitrogen in the air reacts with oxygen under the high temperature and pressure conditions inside the engine. NO_x emissions contribute to both smog and acid rain.

Carbon monoxide (CO): A product of incomplete combustion, carbon monoxide reduces the blood's ability to carry oxygen and is dangerous to people with heart disease.

Carbon dioxide (CO₂): Emissions of carbon dioxide are considered to pollute because it is a significant greenhouse gas and increasing its levels in the atmosphere contributes to global climate change.

Exhaust emissions: 100% CO, 100% NO_x, 100% Pb, 60% HC's

2. **Blowby/Crankcase emissions:** 20% HC's .mainly due to leakage of oil vapor around worn-out piston rings.

3. **Evaporative emissions:** These are produced from the evaporation of fuel, and are a large contributor to urban smog, since these heavier molecules stay closer to ground level. Fuel tends to evaporate in these ways:

Gas tank venting: the heating of the vehicle as the temperature rises from the night-time temperature to the hottest temperatures of the day mean that gasoline in the tank evaporates, increasing the pressure inside the tank above atmospheric pressure. This pressure must be relieved, and before emissions control it was simply vented into the atmosphere.

Running losses: the escape of gasoline vapors from the hot engine.

Refueling losses: these can cause a lot of hydrocarbon vapor emission. The empty space inside a vehicle's tank is filled with hydrocarbon gases, and as the tank is filled, these gases are forced out into the atmosphere. In addition, there is loss from further evaporation and fuel spillage.

Bird view of emission of net pollution

65 % from Exhaust + 15 % from Blowby + 20 % Evaporative = 100%

Bird view of Hydrocarbon emissions [mainly as Benzo pyrene]

60 % from Exhaust + 20 % from Blowby + 20 % Evaporative = 100%

Evaporative emissions: 20% HC'S via gas tank venting, refueling & running losses.

4. **Life Cycle Emission:**

These are produced in activities associated with the manufacturing, maintenance, and disposal of the automobile and include such items as:

Manufacturing plant power requirements

Volatile solvents utilized in the manufacturing process (auto paint finishes, etc.)

Out gassing of synthetic materials utilized to reduce weight and simplify manufacturing



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Maintenance requirements such as oil and filter changes, battery replacement, etc.

Disposal requirements including contaminated lubricants, tires, heavy metals, and landfill

Operation w.r.t Emissions

Mode of Operation	Unburnt HC's [ppm]	CO [% by volume]	NO _x [ppm]	A/F RATIO
IDLE	750	5.2	30	11:1-12:1
CRUISING	300	0.8	1500	11:1-13:1
ACCELERATION	400	5.2	3000	13:1-15:1
DECELERATION	4000	4.2	60	11:1-12.5:1

Comparative study

When A/F ratio is high, then less CO, HC's but high NO_x

When Vehicle decelerates high HC's [hydrocarbon]

When vehicle is idle [not switched off during signals] high CO, low NO_x, moderate HC's.

When vehicle accelerates low HC'S , high CO, high CO, and high NO_x

When vehicle cruises high NO_x, low CO, moderate HC's and high CO₂.

Drawbacks

Pb is released from exhaust as lead halides which are a cumulative toxin, a chief environmental pollutant capable of affecting neural development resulting in lower IQ.

Also lead acts as poison for catalytic converter. This resulted in advent of unleaded petrol. The alternative used was MTBE. But it has been found to be non-bio-degradable and possible ground contamination. This resulted in the use of ethanol as anti-knocking agent to boost octane rating. But ethanol causes fuel to absorb moisture from air, over long time it leads to rusting, corrosion in fuel line. Also it is poorly soluble and enhances possibility of bacterial contamination.

TEL now banned in road sector continues to be used in aviation fuel as additive called as AVGAS. The catch is despite using unleaded petrol; the emissions consist of benzene which causes cancer, anemia and blood cancer. The other option w.r.t knocking phenomenon is utilize branched chain alkanes, which results pre ignition, loss of power, lower octane rating.



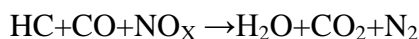
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Catalytic converters

The air fuel ratio must be so high that all CO formed is converted to CO₂, but if ratio is less [lack of O₂], it facilitates formation of CO, Unburnt HC's, NO_x. Also due to higher temperature [2000-2500 °C], high pressure formation of Nitric oxide takes place.

If a car burns fuel with perfect efficiency, its only exhaust products would be CO₂ and H₂O. Unfortunately not every molecule burns to completion. Catalytic converter consists of an array of tubes, each coated with porous ceramics. Embedded in this coating are tiny particles of platinum and rhodium which serve as catalyst. Previously V₂O₅, Vanadium Pentoxide served the purpose.



Nowadays Rhodium, Platinum, Palladium serve the role as 3-way catalyst, once the exhaust heats the converter above 300°C, unwanted molecules bind temporarily to catalyst and are converted. 95% of HC's, CO, NO_x is removed by converter but the presence of Pb in fuel as lead Halide gets coated over surface inactivating them. Catalytic converters have no moving parts, but its limitations include poisoning by lead, deterioration with time and pressure loss.

Control measures

Car pool system, proper operation and maintenance of vehicles, clean fuel technology, eco-friendly fuels, hybrid vehicles, use of bio fuels, use of alternate energy such as solar driven, use of unleaded petrol, complying to rules and regulation, frequent periodical emission testing, stringent norms and enforcement on violation, walk shorter distances, ban shrill horns, utilize silencers, use of catalytic converters etc.

Use catalytic converter for HC's, CO, NO_x, C₆H₆
Increase air-fuel ratio for HC's, CO and Benzene
Recycle exhaust gas for NO_x, [15-25%]

In case of SPM, ensure proper maintenance and operation process, such as change air filter regularly, change engine oil as per manufacturer's specification, use moderate acceleration and avoid slowing of engine at top gear.

Pollution Control Acts in India

Wildlife protection act, 1972
Water act, 1974
Forest conservation act, 1980
Air act, 1981
Environmental protection act [EPA], 1986
Hazardous wastes rules, 1989
Public liability insurance act, 1991
Bio-medical waste rules, 1998
Noise pollution rules, 2000



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Central pollution control board, CPCB, a statutory organization was constituted in Sept., 1974 under the water act.

In the wake of Bhopal gas tragedy, Govt. of India enacted the EPA, 1986 under article 253 of the constitution.

Functions of CPCB at the national level include:

1. Advise the central govt. on any matter concerning prevention and control of water and air pollution and improvement of the quality of air.
2. Co-ordinate the activities of the state boards and resolve dispute among them.
3. Provide technical assistance and guidance to the state boards, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement of water and air pollution.
4. Organize through mass media, a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution.
5. Collect, compile and publish technical and statistical data relating to water and air pollution.
6. Planning and execution of a nation-wide programme for the prevention, control and abatement of environmental pollution;
7. Laying down standards for the quality of environment in its various aspects;
8. Laying down standards for emission or discharge of environmental pollutants from various sources whatsoever;
9. Restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards;
10. Laying down procedures and safeguards for the prevention of accidents which may cause environmental pollution and remedial measures for such accidents;
11. Laying down procedures and safeguards for the handling of hazardous substances;
12. Examination of such manufacturing processes, materials and substances as are likely to cause environmental pollution;
13. Carrying out and sponsoring investigations and research relating to problems of environmental pollution;
14. Inspection of any premises, plant, equipment, machinery, manufacturing or other processes, materials or substances and giving, by order, of such directions to such authorities, officers or persons as it may consider necessary to take steps for the prevention, control and abatement of environmental pollution;
15. Collection and dissemination of information in respect of matters relating to environmental pollution;
16. Preparation of manuals, codes or guides relating to the prevention, control and abatement of environmental pollution;
17. Such other matters as the Central Government deems necessary or expedient for the purpose of securing the effective implementation of the provisions of this Act.

THE WILDLIFE PROTECTION ACT, 1972

It extends to the whole of India, except the State of Jammu and Kashmir.



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It shall come into force in a State or Union Territory to which it extends, on such date as the Central Government may, by notification, appoint, and different dates may be appointed for different provision of this Act or for different States or Union Territories.

The Act provides for the protection of Wild animals, birds and plants and for matters connected therewith or ancillary or incidental thereto. It extends to the whole of India, except the State of Jammu and Kashmir

"Animal" includes amphibians, birds, mammals, and reptiles, and their young, and also includes, in the cases of birds and reptiles, their eggs,

"hunting", includes, Capturing, killing, poisoning, snaring, and trapping or any wild animal and every attempt to do so, Driving any wild animal for any of purposes specified in sub clause, Injuring or destroying or taking any part of the body of any such animal, or in the case of wild birds or reptiles, damaging the eggs of such birds or reptiles, or disturbing the eggs or nests of such birds or reptiles;

"Trophy" means the whole or any part of any captive animal or wild animal, other than vermin, which has been kept or preserved by any means, whether artificial or natural, and includes, rugs, skins, and specimens of such animals mounted in whole or in part through a process of taxidermy, and antler, horn, rhinoceros horn, feather, nail, tooth, musk, eggs, and nests;

"Wildlife" includes any animal, bees butterflies, crustacean, fish and moths; and aquatic or land vegetation which forms part of any habitat;

FOREST (CONSERVATION) ACT, 1980 WITH AMENDMENTS MADE IN 1988

It extends to the whole of India except the State of Jammu and Kashmir.

It shall be deemed to have come into force on the 25th day of October, 1980.

Notwithstanding anything contained in any other law for the time being in force in a State, no State Government or other authority shall make, except with the prior approval of the Central Government, any order directing-

(i) That any reserved forest (within the meaning of the expression "reserved forest" in any law for the time being in force in that State) or any portion thereof, shall cease to be reserved;

(ii) That any forest land or any portion thereof may be used for any non-forest purpose;

(iii) that any forest land or any portion thereof may be assigned by way of lease or otherwise to any private person or to any authority, corporation, agency or any other organization not owned, managed or controlled by Government;

(iv) that any forest land or any portion thereof may be cleared of trees which have grown naturally in that land or portion, for the purpose of using it for reforestation.



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For the purpose of this section, "non-forest purpose" means the breaking up or clearing of any forest land or portion thereof for-

- (a) The cultivation of tea, coffee, spices, rubber, palms, oil-bearing plants, horticultural crops or medicinal plants;
- (b) Any purpose other than re-afforestation;

It also defines the procedure to be followed for declaring an area to be a Reserved Forest, a Protected Forest or a Village Forest.

It defines what is a forest offence, what are the acts prohibited inside a Reserved Forest, and penalties leviable on violation of the provisions of the Act.

Reserved Forest is an area or mass of land duly notified under section 20 of the Indian Forest Act, 1927 [Act 16 of 1927] or under the reservation provisions of the Forest acts of the State Governments of the Indian Union. The manner in which a Reserved Forest, shortly written as RF, has to be constituted is described in section 3 to 20 of the Act. It is within power of a State Government to issue a preliminary notification under section 4 of the Act declaring that it has been decided to constitute such land, as specified in a Schedule with details of its location, area and boundary description, into a Reserved Forest.

Protected Forest is an area or mass of land, which is not a reserved forest, and over which the Government has property rights, declared to be so by a State Government under the provisions of the section 29 of the Indian Forest Act, 1927. It does not require the long and tedious process of settlement, as in case of declaration of a reserved forest... Further, in a protected forest, the Government may issue notifications declaring certain trees to be reserved, or suspend private rights, if any, for a period not exceeding 30 years, or prohibit quarrying, removal of any forest produce, or breaking of land etc.

Village Forest is constituted under section 28 of the Indian Forest Act, 1927. The Government may assign to any village community the rights over a land which may be a part of a reserved forest for use of the community. Usually, forested community lands are constituted into Village Grazing Reserve.

THE WATER (PREVENTION AND CONTROL OF POLLUTION) ACT, 1974

Definitions.-In this Act, unless the context otherwise requires. -

"outlet" includes any conduit pipe or channel, open or closed, carrying sewage or trade effluent or any other holding arrangement which causes, or is likely to cause, pollution;

"pollution" means such contamination of water or such alteration of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may or is likely to, create a nuisance or render such water harmful or injurious to public health or safety, or to



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domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms;

"sewage effluent" means effluent from any sewerage system or sewage disposal works and includes sullage from open drains;

"sewer" means any conduit pipe or channel, open or closed, carrying sewage or trade effluent;

"stream" includes - (i) river; (ii) water course (whether flowing or for the time being dry); (iii) inland water (whether natural or artificial); (iv) sub-terranean waters; (v) sea or tidal waters to such extent or, as the case may be, to such point as the State Government may, by notification in the Official Gazette, specify in this behalf;

"trade effluent" includes any liquid, gaseous or solid substance which is discharged from any premises used for carrying on any industry; operation or process or treatment and disposal system other than domestic sewage.

Prohibition on use of stream or well for disposal of polluting matter. -

no person shall knowingly cause or permit any poisonous, noxious or polluting matter determined in accordance with such standards as may be laid down by the State Board to enter (whether directly or indirectly) into any stream or well or sewer or on land; or

no person shall knowingly cause or permit to enter into any stream any other matter which may tend, either directly or in combination with similar matters, to impede the proper flow of the water of the stream in a manner leading or likely to lead to a substantial aggravation of pollution due to other causes or of its consequence.

A person shall not be guilty of an offence under sub-section (1), by reason only of having done or caused to be done any of the following acts, namely :-

(a) constructing, improving or maintaining in or across or on the bank or bed of any stream any building, bridge, weir, dam, sluice, dock, pier, drain or sewer or other permanent works which he has a right to construct, improve or maintain;

(b) depositing any materials on the bank or in the bed of any stream for the purpose of reclaiming land or for supporting, repairing or protecting the bank or bed of such stream provided such materials are not capable of polluting such stream;

Restrictions on new outlets and new discharges.

Subject to the provisions of this section, no person shall, without the previous consent of the State Board, -

establish or take any steps to establish any industry, operation or process, or any treatment and disposal system or any extension or addition thereto, which is likely to discharge sewage or trade effluent into a stream or well or sewer or on land (such discharge being hereafter in this section referred to as discharge of sewage); or



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- (b) bring into use any new or altered outlet for the discharge of sewage; or
- (c) being to make any new discharge of sewage.

THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

It extends to the whole of India.

It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint.

Definitions. In this Act, unless the context otherwise requires,-

"air pollutant" means any solid, liquid or gaseous substance 2[(including noise)] present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment;

"Air pollution" means the presence in the atmosphere of any air

"Approved fuel" means any fuel approved by the State Board for the purposes of this Act;

"Automobile" means any vehicle powered either by internal combustion engine or by any method of generating power to drive such vehicle by burning fuel;

"Central Board- means the 3[Central Board for the Prevention and Control of Water Pollution] constituted under section 3 of the Water (Prevention and Control of Pollution) Act, 1974;

"Chimney" includes any structure with an opening or outlet from or through which any air pollutant may be emitted,

"Control equipment" means any apparatus, device, equipment or system to control the quality and manner of emission of any air pollutant and includes any device used for securing the efficient operation of any industrial plant;

"Emission" means any solid or liquid or gaseous substance coming out of any chimney, duct or flue or any other outlet;

"Industrial plant" means any plant used for any industrial or trade purposes and emitting any air pollutant into the atmosphere;

"Occupier", in relation to any factory or premises, means the person who has control over the affairs of the factory or the premises, and includes, in relation to any substance, the person in possession of the substance;]

INDIA – ENVIRONMENTAL (PROTECTION) ACT, 1986

It extends to the whole of India.



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It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint and different dates may be appointed for different provisions of this Act and for different areas.

In this Act, unless the context otherwise requires,--

- (a) "environment" includes water, air and land and the inter-relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property;
- (b) "Environmental pollutant" means any solid, liquid or gaseous substance present in such concentration as may be, or tend to be, injurious to environment;
- (c) "Environmental pollution" means the presence in the environment of any environmental pollutant;
- (d) "handling", in relation to any substance, means the manufacture, processing, treatment, package, storage, transportation, use, collection, destruction, conversion, offering for sale, transfer or the like of such substance;
- (e) "hazardous substance" means any substance or preparation which, by reason of its chemical or physico-chemical properties or handling, is liable to cause harm to human beings, other living creatures, plant, micro-organism, property or the environment;

Municipal Solid Wastes

Source	Typical waste generators	Types of Solid Waste
Residential	Single and Multi-family dwellings	Food waste, paper, cardboard, plastics, textiles, leather, wood, glass, metals, ashes, consumer electronics, batteries, oil, housekeeping waste etc.
Industrial	Light and heavy manufacturing fabrication, construction sites, power and chemical plants.	Construction and demolition materials, hazardous wastes, ashes, special waste etc.
Commercial	Stores, hotels, markets, office building etc.	Paper, cardboard, plastic, wood, food waste, glass, metals, special waste and hazardous waste etc.
Institutional	Schools, hospitals, prisons, government centre's etc.	Paper, cardboard, plastic, wood, food waste, glass, metals, special waste and hazardous waste etc.
Construction Demolition	New construction sites, road repair, renovation sites, demolition of buildings etc.	Wood, steel, concrete etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and waste water treatment plants etc.	Street sweeping, landscape and tree trimming, general wastes from parks, beaches and other recreational areas, municipal sludge etc.
Agriculture	Crops, orchards, Vineyards, dairies, farms etc.	Spoiled food wastes, agricultural wastes, hazardous waste (e.g. pesticides) etc.



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Solid waste means any garbage, refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations. Solid waste is the unwanted or useless solid material generated from combined residential, industrial and commercial activities. These due to reckless open dumping or unethical practices present bad aesthetics to an area. Solid waste may be categorized according to its Origin (domestic, industrial, commercial, construction or institutional); Contents (organic material, glass, metal, plastic, paper etc.) and Hazard potential (toxic, non-toxic, flammable, radioactive, infectious etc.)

Impacts of Solid Wastes and its ill-management

- ❖ Unattended waste lying around attracts flies, rats, and other creatures that in turn spread disease.
- ❖ Other high-risk group includes increased risk of injury and infection to populations living close to a waste dump and those, whose water supply has become contaminated either due to waste dumping or leakage from landfill sites.
- ❖ In particular, Uncollected organic domestic waste poses a serious threat, since they ferment, creating conditions favorable to the survival and growth of microbial pathogens.
- ❖ Direct handling of solid waste can result in various types of infectious and chronic diseases with the waste workers, the rag pickers being the most vulnerable.
- ❖ Epidemics,
- ❖ Unaesthetic Issues,
- ❖ Land Pollution,
- ❖ Contamination Of Ground Water,
- ❖ Pollution Of Waterbodies
- ❖ Air Pollution
- ❖ Bad Odour Issues.

Control Measures of Municipal Solid Wastes

The most effective way to solve the solid waste problem is by reducing waste in the first place, i.e. before it is generated. A sanitary landfill is a solid waste management facility that utilizes an engineered method of land disposal, primarily for municipal solid wastes. To ensure a safe disposal of the Municipal Solid Waste, Composting process is proposed in two ways , aerobically and anaerobically. Bioremediation deals with the methods of solving the solid waste problems, by making use of microorganisms and fungi.

Waste or Source reduction, is the elimination or reduction of waste before it is created. This involves the design, manufacture, purchase or use of materials and products to reduce the amount or toxicity of what is thrown away. The need for waste reduction arises due to the Shortage of suitable landfill space, for in many areas, no suitable land is available for landfills development. The need also arises from the fact that the development of new landfill site is expensive and



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New landfills are often resisted due to public concerns over groundwater contamination, odors, and truck traffic.

Waste or Source reduction can be brought about by Buying Less, purchasing long-lasting goods, Seeking products and packaging that are as free of toxics as possible, Redesigning products to use less raw material in production have a longer life, or be used again after its original use, and Reusing items is another way to stop waste at the source.

Resource recovery can contribute to the wise and efficient use of materials, to conserving energy, to preserving the environment, and to improving the balance of trade by reducing our dependence on imported natural resources. By using materials more than once, unexploited resources can be conserved for ourselves and for future generations. Two major methods are there for recovering energy and materials for recycling from municipal solid waste, namely source separation and centralized resource recovery. Source separation consists of programs to separate recyclable materials at the waste source and then collect them through methods as curbside collection, community recycling centers, industry-sponsored recycling programs, and commercial and industrial methods of source separation.

Incineration is the process of burning putrescible solid waste in a controlled condition, as the most common thermal treatment process in the presence of oxygen. After incineration, the wastes are converted to carbon dioxide, water vapour and ash, and may be used as a means of recovering energy to be used in heating or the supply of electricity. The amount and volume of the MSW can be reduced up to 90% by volume and 75% by weight. However, incinerators may cause potential air pollution and health risks via Release of toxic chemicals into the atmosphere. Another demerit of Incineration is that it destroys potentially useful recyclable or compostable material by turning it into toxic ash. Disposal of the ash is another concern and the residual ash must itself be disposed of, usually in a special-purpose landfill called a monofill. Landfills are designed to greatly reduce or eliminate the risks that waste disposal may pose to the public health and environmental quality. These are usually placed in areas where land features act as natural buffers between the landfill and the environment. The bottom and sides of landfills are lined with layers of clay or plastic to prevent leachate, from escaping into the soil. The leachate is collected and pumped to the surface for further treatment. Boreholes or monitoring wells are dug in the vicinity of the landfill to monitor the groundwater quality.

A landfill is divided into a series of individual cells and only a few cells of the site are filled with waste at any one time. When the landfill has reached its capacity it is sealed and capped with an impermeable seal which is typically composed of clay soil.

Integrated Solid Waste Management must take an overall approach to creating sustainable systems that are economically affordable, socially acceptable and environmentally effective. An integrated solid waste management system must involve the use of a range of different treatment methods, and key to the functioning of such a system is the collection and sorting of the waste.

It is important to understand that no one single treatment method can manage all the waste materials in an environmentally effective way. Therefore all the available treatment and disposal options must be evaluated equally and the best combination of the available options suited to the particular community chosen. Effective management schemes therefore need to operate in ways which best meet current social, economic, and environmental conditions of the municipality.



E-Waste Management

E-waste (electrical and electronic waste) is the term used to describe old or discarded appliances that includes computers, consumer electronic goods etc. It also refers to electronic products nearing the end of their useful life. Roughly 40 million metric tonnes of e-waste is produced globally each year, and only about 13% of that weight is recycled (that too mostly in developing countries).



Figure: E-wastes

Characteristics of E-Wastes

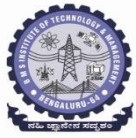
- ❖ Precious metals: Gold, Silver, Palladium and less quantities of platinum.
- ❖ Base metals: Copper, aluminum, nickel, tin, zinc, iron etc.
- ❖ Special metals: Indium, Bismuth, antimony, Selenium etc.
- ❖ Hazardous metals: Mercury, Beryllium, lead, cadmium, Arsenic etc.

Disposal methods

It is a fact that e-waste comprises of hazardous elements which offer the potential of increasing the intensity of their discharge in environment.

Based on composition following methods are suggested.

- ❖ **Land-filling:** It is not possible to quantify environmental impacts from e-waste in landfills. They contain mixtures of various waste streams, and Emission of pollutants from landfills can be delayed for several years. As a consequence of the complex material mixture in e-waste, it is not possible to exclude environmental (long-term) risks even in secured land filling.
- ❖ **Incineration:** Advantage of incineration of e-waste is the reduction of waste volume and the utilization of the energy of the combustible materials. By incineration some



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environmentally hazardous organic substances are converted into less hazardous compounds. A disadvantage of this also includes the emission of poisonous gases and residues into the atmosphere.

Impacts of E-Wastes and its ill-management

- ❖ The informal sector's recycling practices magnify health risks.
- ❖ Primary and secondary exposure to toxic metals (such as lead), results from open-air burning used to retrieve valuable components (such as gold).
- ❖ Combustion from burning e-waste creates fine particulate matter which is linked to pulmonary and cardiovascular disease.
- ❖ Guiyu in China is one of the largest e-waste recycling site in the world. It exhibits substantial digestive, neurological, respiratory and bone problems among workers.



Figure: E-wastes Dumpsites

Biomedical Waste Management

Biomedical waste is the discarded biological material from teaching, clinical and research laboratories and operations. Biomedical waste is a type of waste that is either putrescible (liable to decay) or potentially infectious. It may also include waste associated with the generation of biomedical waste that visually appears to be of medical or laboratory origin, as well research laboratory waste. In healthcare facilities, waste with these characteristics may alternatively be called medical or clinical waste.

Characteristics of Biomedical Wastes

- ❖ Infectious waste like human anatomical and surgical waste, animal waste, pathological waste, used syringes, I V tubes, blood bugs, items such as plasters and bandages when contaminated by blood and pus waste from isolation wards. These amounts to about 25 percent of the total waste generated from a health care unit.
- ❖ Non-infectious waste: It broadly comprises of kitchen waste and office waste. It is similar to household waste. Non-infectious wastes constitute nearly 75% of the total wastes generated from a health care unit.



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Disposal methods

Biomedical waste is distinct from normal trash or general waste, and differs from other types of hazardous waste, such as chemical, radioactive, universal or industrial waste. Medical facilities generate waste hazardous chemicals and radioactive materials. While such wastes are normally not infectious, they require proper disposal (Table 5.5). Some wastes are considered multi-hazardous, such as tissue samples preserved in formalin.

Disposal options for untreated biomedical waste

Type of waste	Landfill	Sanitary sewer	Incinerator	New Technology
Human Anatomical waste	NO	NO	YES	ENR/Municipal approval required
Microbiological waste	NO	NO	YES	--DO--
Microbiological lab waste	NO	YES	YES	--DO--
Human blood and body fluids	NO	YES	YES	--DO--
Waste sharps	NO	NO	YES	Isolyser sharps system approved (landfill)
Cyto toxic waste	NO	NO	YES	ENR/Municipal approval required



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MODULE 4



ACID RAIN

Definition

Rain water p^H is around 5.7 due to certain concentration of CO_2 dissolved as rainwater trickles down atmosphere, i.e. $CO_2 + H_2O \rightarrow HCO_3^- + H^+$

Acid rain is defined as any type of precipitation with a p^H that is unusually low. Dissolved carbon dioxide dissociates to form weak carbonic acid giving a p^H of approximately 5.6 at typical atmospheric concentrations of CO_2 . Therefore a p^H of less than 5.6 has sometimes been used as a definition of acid rain.

Acid rain was first found in Manchester, England. In 1852, Robert Angus Smith found the relationship between acid rain and atmospheric pollution. Though acid rain was discovered in 1852, it wasn't until the late 1960s that scientists began widely observing and studying the phenomenon.

Causes

The principal natural phenomena that contribute acid-producing gases to the atmosphere are emissions from volcanoes and those from biological processes that occur on the land, in wetlands, and in the oceans. The major biological source of sulfur containing compounds is dimethyl sulfide.

The principal cause of acid rain is sulfuric and nitrogen compounds from human sources, such as electricity generation, factories and motor vehicles. Coal power plants are one of the most polluting. The gases can be carried hundreds of kilometres in the atmosphere before they are converted to acids and deposited. Factories used to have short funnels to let out smoke, but this caused many problems, so now, factories have longer smoke funnels. The problem with this is those pollutants get carried far off, where it creates more destruction.

Sulfur dioxide contributes to about seventy percent of acid rain while nitrogen oxides provide the remaining thirty percent. The sources of sulfur in the atmosphere include coal combustion, smelting, organic decay, and ocean spray. Approximately ninety percent of atmospheric sulfur results from human activities.

In the atmosphere, sulfur dioxide combines with water vapor to form hydrogen sulfite gas: $SO_2 + H_2O + 1/2O_2 \rightarrow H_2SO_4$

Next, hydrogen sulfite reacts with oxygen to form sulfuric acid, a major component of acid rain: $H_2SO_3 + 1/2O_2 \rightarrow H_2SO_4$

The sources of nitrogen oxides include the combustion of oil, coal and natural gas, forest fires, bacterial action in soil, volcanic gases, and lightning-induced atmospheric reactions.

In the atmosphere, nitrogen monoxide reacts with oxygen gas to form nitrogen dioxide gas: $NO + 1/2O_2 \rightarrow NO_2$



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Then, nitrogen dioxide reacts with water vapor in the atmosphere to form hydrogen nitrite and hydrogen nitrate: $2\text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{HNO}_2 + \text{HNO}_3$

Henceforth, acid rain is a mixture of HNO_3 , $\text{H}_2\text{SO}_4 + \text{HCl}$. however conditions needed to favor formation of these are sunlight, temperature, humidity, hydrocarbons, NO_x , SO_2 .

Effects

Both the lower p^{H} and higher aluminum concentrations in surface water that occur as a result of acid rain can cause damage to fish and other aquatic animals. At p^{H} lower than 5 most fish eggs will not hatch and lower p^{H} can kill adult fish. As lakes become more acidic biodiversity is reduced. Soil biology can be seriously damaged by acid rain. Some tropical microbes can quickly consume acids but other microbes are unable to tolerate low p^{H} and are killed.

Acid rain can slow the growth of forests, cause leaves and needles to turn brown and fall off and die. In extreme cases trees or whole areas of forest can die. The death of trees is not usually a direct result of acid rain; often it weakens trees and makes them more susceptible to other threats.

Some scientists have suggested direct links to human health, but none have been proven. However, fine particles, a large fraction of which are formed from the same gases as acid rain (sulfur dioxide and nitrogen dioxide), have been shown to cause illness and premature deaths such as cancer and other deadly diseases

Toxic metals released into the environment by acid rain may enter water supplies or accumulate in fish and crops. Acid deposition also destroys statues, headstones, buildings, and fountains. Limestone structures are especially susceptible because they dissolve easily in acidic solutions.

Acid rain can also cause damage to certain building materials and historical monuments. Acid rain can cause weathering on ancient and valuable statues and has caused considerable damage. This is because the sulfuric acid in the rain chemically reacts with the calcium compounds in the stones (limestone, sandstone, marble and granite) to create gypsum, which then flakes off. Acid rain also causes an increased rate of oxidation for iron.

Control Measures

- Design more efficient automobile engines in order to reduce nitrogen oxide emissions.
- Increase efficiency of power plants that burn coal in order to reduce waste that contains sulfur dioxide and nitrogen oxide.
- Increase penalties on industries that do not meet air pollution guidelines.
- Increase tax incentives to industries that do meet guidelines.
- Use alternative energy sources, Increase funding for alternative energy sources; for example, give tax incentives to buyers of hybrid cars.
- Provide tax incentives to companies that use alternative energy sources.
- Add CaCO_3 (calcium carbonate) to lakes suffering from acid deposition; calcium carbonate acts as a buffer, resisting a change in p^{H} and lessening the negative effects of acid rain.



OZONE DEPLETION

Definition

Ozone layer is an umbrella 24 km [15 miles] from earth surface, an essential component of the stratosphere that absorbs short wavelength ultraviolet radiation from the sun, heating the gases of the stratosphere in the process. This is the reason temperatures rise with increasing altitude in the stratosphere, and also the reason life was able to move out of the oceans and on to the land, evolving into the diverse biosphere we know today.

World ozone day is celebrated on Sept, 16 of every year. Stratospheric ozone is measured in Dobson units [DU] named after G.M.B Dobson who pioneered the study; [1 Dobson unit = 0.01 mm thickness of stratospheric ozone], Average ozone thickness in stratosphere is 300 DU, & when it falls below 200 DU, it's considered as Ozone hole. It is thinnest around equator and thickest near poles.

Stratospheric ozone depletion is the term applied to the loss of stratospheric ozone molecules (O_3) and the disruption of Oxygen-Ozone concentration equilibrium in stratosphere [i.e., when chlorine atoms upset the natural O_2/O_3 equilibrium in the stratosphere]. Oxygen molecules interact with the intense solar radiation present at this elevation to form oxygen atoms. The oxygen atoms thus generated react with other oxygen molecules to form ozone (O_3).

Causes

Ozone depletion is caused by the release of chlorofluorocarbons (CFC's) and other ozone-depleting substances (ODS), which were used widely as refrigerants, insulating foams, and solvents. The discussion below focuses on CFCs, but is relevant to all ODS [NO, NO_2 (aircraft exhaust), Br \cdot , UV rays, [O] Atomic oxygen etc.].

Although CFCs are heavier than air, they are eventually carried into the stratosphere in a process that can take as long as 2 to 5 years. It can be recalled that commercial airliners [sub-sonic] fly in lower stratosphere, jet airliners [super-sonic] fly in the troposphere

When CFCs reach the stratosphere, the ultraviolet radiation from the sun causes them to break apart and release chlorine atoms which react with ozone, starting chemical cycles of ozone destruction that deplete the ozone layer. One chlorine atom can break apart more than 100,000 ozone molecules.

Other chemicals that damage the ozone layer include methyl bromide (used as a pesticide), halons (used in fire extinguishers), and methyl chloroform (used as a solvent in industrial processes). As methyl bromide and halons are broken apart, they release bromine atoms, which are 40 times more destructive to ozone molecules than chlorine atoms.

While it is true that volcanoes and oceans release large amounts of chlorine, the chlorine from these sources is easily dissolved in water and washes out of the atmosphere in rain. In contrast, CFCs are not broken down in the lower atmosphere and do not dissolve in water.



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The chlorine in these human-made molecules does reach the stratosphere. Measurements show that the increase in stratospheric chlorine since 1985 matches the amount released from CFCs and other ozone-depleting substances produced and released by human activities.

The Chapman Cycle

Chlorofluorocarbons, or CFC's, are inert molecules that are not removed in the troposphere. They have residence times of over a hundred years and ultimately diffuse through the troposphere to the stratosphere. In the stratosphere CFC's are exposed to the intense solar radiation that cannot penetrate the ozone layer, and the CFC's become photo chemically active. The result is the production of chlorine atoms and chlorine oxide molecules, two substances that behave very much like nitrogen oxide in the unperturbed atmosphere.

Ozone Depletion by CFC's



All above reactions occur in the presence of UV rays, while the 2nd set of reactions governs the oxygen-ozone equilibrium due to its spontaneity.

Effects

Effect of ozone hole include cataract, genetic mutation, constriction of blood vessels, reduced crop yield, leukemia, breast cancer, damage to crop, aqua culture, etc.,

The higher energy UV radiation absorbed by ozone is generally accepted to be a contributory factor to **skin cancer**. In addition, increased surface UV leads to increased tropospheric ozone, which is a health risk to humans. The increased surface UV also represents an increase in the **vitamin D** synthetic capacity of the sunlight.

It should be deduced that the above impacts are not due to exposure of Ozone but due to the UV rays that have reached the earth surface through the ozone holes. One important health hazard is Snow Blindness [photo keratosis], i.e., inflammation of cornea (outer coating of eyeball).

The most common forms of skin cancer in humans, basal and squamous cell carcinomas have been strongly linked to UVB exposure. Another form of skin cancer, malignant melanoma, is much less common but far more dangerous, being lethal in about 15% - 20% of the cases diagnosed.



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Presence of ozone causes plants to close their stomata, a defence mechanism that blocks out CO₂ as well inhibiting photosynthesis and respiration. Gross productivity to conduct photosynthesis will decrease at least by 14-23% due to this. In India there is no standard for Ozone. However WHO standard is 100 ppm for 8 hrs – avg.

Control Measures

The results of 18-year study of the ozone column over Antarctica [1st spotted, 1979] showing that the ozone column had decreased from 1957 to 1985, a 35% decrease.

This report led through several regulatory steps to the Montreal Protocol, an international agreement signed by 139 nations, banning the production of CFCs by the year 2000.

In 1978, the use of CFC propellants in spray cans was banned in the U.S. In the 1980s, the Antarctic "ozone hole" appeared and an international science assessment more strongly linked the release of CFCs and ozone depletion. It became evident that a stronger worldwide response was needed.

In 1987, the Montreal Protocol was signed and the signatory nations committed themselves to a reduction in the use of CFCs and other ozone-depleting substances. Since that time, the treaty has been amended to ban CFC production after 1995 in the developed countries, and later in developing. Today, over 160 countries have signed the treaty.

We can't make enough ozone to replace what's been destroyed, but provided that we stop producing ozone-depleting substances, natural ozone production reactions should return the ozone layer to normal levels by about 2050.

It is very important that the world comply with the Montreal Protocol; delays in ending production could result in additional damage and prolong the ozone layer's recovery.

Control mechanism stresses on replacement of the banned chemical by ammonia, steam, helium etc.

GREEN HOUSE EFFECT

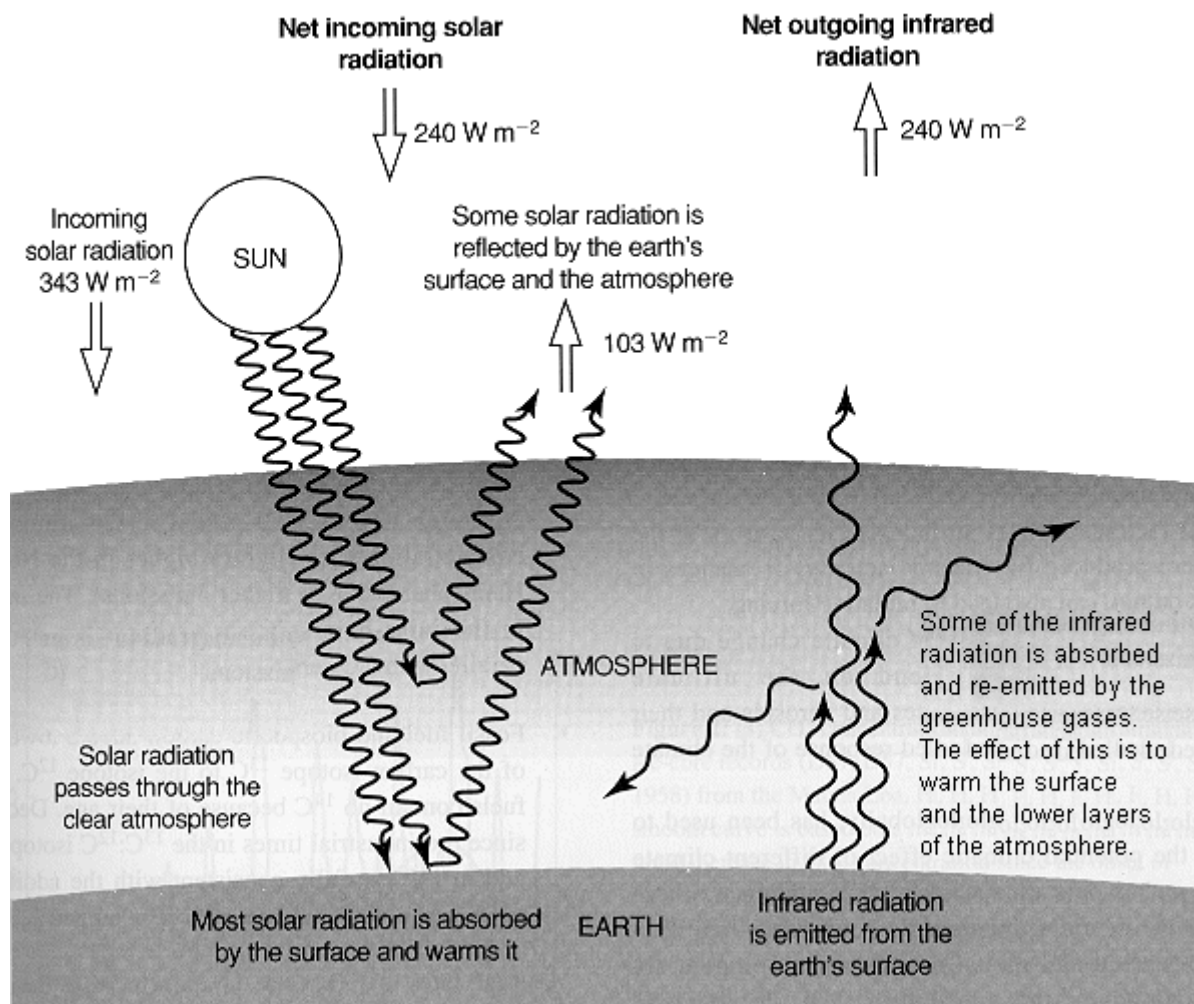
Objects that absorb all radiation upon them are called "blackbody" absorbers. The earth is close to being a black body absorber. Gases, on the other hand, are selective in their absorption characteristics.

While many gases do not absorb radiation at all some selectively absorb only at certain wavelengths. Those gases that are "selective absorbers" of solar energy are the gases we know as "Greenhouse Gases." The greenhouse effect is a phenomenon that ought to create a condition in the upper atmosphere, causing a trapping of excess heat and leading to increased surface temperatures.



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The Earth receives energy from the Sun in the form of radiation. The Earth reflects about 30% of the incident solar flux; the remaining 70% is absorbed, warming the land, atmosphere and oceans.

The visible solar radiation heats the surface, not the atmosphere, whereas most of the infrared radiation escaping to space is emitted from the upper atmosphere, not the surface.

The infrared photons emitted by the surface are mostly absorbed by the atmosphere and do not escape directly to space. Hence earth's greenhouse effect is a natural phenomenon that helps regulates the temperature of our planet. Simply put, the sun heats the earth and some of this heat, rather than escaping back to space, is trapped in the atmosphere by clouds and greenhouse gases, such as water vapor and carbon di oxide. If all these greenhouse gases were to suddenly disappear, our planet would be 60° F colder and uninhabitable.

The steady state condition of earth is disrupted by the presence of the excess greenhouse gasses. The solar radiations strike as ultra violet with long wavelength but on reflection they pare infrared with shorter wavelengths.



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On Earth, the major natural greenhouse gases are water vapor, which causes about 36–70% of the greenhouse effect (not including clouds); carbon dioxide (CO₂), which causes 9–26%; methane (CH₄), which causes 4–9%; and ozone, which causes 3–7%. The greenhouse gases [carbon-di-oxide, methane etc.,] traps these radiations preventing their reflection or escape back to atmosphere and this results in warming of land surface. Hence it's a natural phenomenon.

Hence excessive concentration of these gases resulting from natural or man-made activities building up in drastic proportions leads to greenhouse effect.

Carbon Dioxide

Sources: Released by the combustion of fossil fuels (oil, coal, and natural gas), flaring of natural gas, changes in land use (deforestation, burning and clearing land for agricultural purposes), and manufacturing of cement.

Sinks: Photosynthesis and deposition to the ocean.

Significance: Accounts for about half of all warming potential caused by human activity.

Methane

Sources: Landfills, wetlands and bogs, domestic livestock, coal mining, wet rice growing, natural gas pipeline leaks, biomass burning, and termites.

Sinks: Chemical reactions in the atmosphere.

Significance: Molecule for molecule, methane traps heat 20-30 times more efficiently than CO₂. Within 50 years it could become the most significant greenhouse gas.

Nitrous Oxide [296 times potential than CO₂]

Sources: Burning of coal and wood, as well as soil microbes' digestion.

Sinks: Chemical reactions in the atmosphere.

Significance: Long-lasting gas that eventually reaches the stratosphere where it participates in ozone destruction.

Ozone

Sources: Not emitted directly, ozone is formed in the atmosphere through photochemical reactions involving nitrogen oxides and hydrocarbons in the presence of sunlight.

Sinks: Deposition to the surface, chemical reactions in the atmosphere.

Significance: In the troposphere ozone is a pollutant. In the stratosphere it absorbs hazardous ultraviolet radiation.

Chlorofluorocarbons (CFCs)

Sources: Used for many years in refrigerators, automobile air conditioners, solvents, aerosol propellants and insulation.



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Sinks: Degradation occurs in the upper atmosphere at the expenses of the ozone layer. One CFC molecule can initiate the destruction of as many as 100,000 ozone molecules.
Significance: The most powerful of greenhouse gases — in the atmosphere one molecule of CFC has about 20,000 times the heat trapping power on a molecule of CO₂.

Another important feedback process is ICE-ALBEDO FEEDBACK. The increased CO₂ in the atmosphere warms the Earth's surface and leads to melting of ice near the poles. As the ice melts, land or open water takes its place. Both land and open water are on average less reflective than ice, and thus absorb more solar radiation. This causes more warming, which in turn causes more melting, and this cycle continues. This enhances sea level rise, coastal zone submergence, and malaria outbreaks and of course ice cap melting. Control measures include planting more trees, reducing vehicular emission and thermal stacks, and elimination of volatile organic compounds.

CLIMATE CHANGE

Global warming is the increase in the average temperature of the Earth's near-surface air and oceans in recent decades and its projected continuation. Global average air temperature near the Earth's surface rose to 0.74 ± 0.18 °C (1.3 ± 0.32 °F) during the past century.

In the Arctic, average temperatures have risen almost twice as fast as in the rest of the world and climate changes are particularly intense.

Other consequences may include changes in agricultural yields, glacier retreat, reduced summer stream flows, species extinctions and increases in the ranges of disease vectors.

The melting of Arctic ice and increased regional precipitation can add freshwater to the oceans, and potentially affect ocean currents in the North Atlantic.

Melt of glaciers can contribute to sea level rise: By 2100, melting of Arctic glaciers alone will have contributed to a sea level rise of roughly 5 cm out of the projected 10-90 cm total rise for this century.

Forest fires could become more frequent, Due to the warming; insect outbreaks will increasingly disturb large areas of forest. Most scenarios project more forest fires in all ecosystems.

Polar Bears depend on sea ice for their survival: Many Arctic animals, such as polar bears, seals, walrus, and seabirds, rely on the sea's biological productivity and on the presence of sea ice, both of which are highly dependent on climatic conditions.

Changes in sea surface temperatures or currents could have a strong effect on Arctic marine fish stocks, which are an important food source for the world and play a vital role in the region's economy.

Rising temperatures are modifying the Arctic coastline and are expected to change it even more in the future. Sea level rise is likely to cause flooding of marshes and coastal plains and accelerate beach erosion. Some towns and industrial facilities are already suffering severe damage as a result of erosion, and are now facing the prospect of relocation.



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More specifically, eleven of the last twelve years (1995-2006) rank among the 12 warmest years ever recorded since global surface temperatures are measured (1850). Over the last 100 years (1906–2005), global temperature has increased by 0.74°C. Bangalore faced the wettest March in 133 years

Other projected changes include acidification of the oceans, reduced snow cover and sea ice, more frequent heat waves and heavy precipitation, more intense tropical cyclones, and slower oceanic currents.

Warming and sea level rise caused by human activities will continue for centuries, even if greenhouse gas concentrations were to be stabilized. If warming persists over many centuries, it could lead to a complete melting of the Greenland Ice sheet, increasing global sea levels by about 7m.

Additional anticipated effects include 18% to 35% of a sample of 1,103 animal and plant species to be extinct by 2050, based on future climate projections.

The world's primary international agreement on combating global warming is the Kyoto Protocol, an amendment to the United Nations Framework Convention on Climate Change (UNFCCC), negotiated in 1997. The Protocol now covers more than 160 countries globally and over 55% of global greenhouse gas (GHG) emissions.

How to Prevent Global Warming

Use Compact Fluorescent Bulbs

Change Your Air Filter

Use Recycled Paper

Check Your Water Heater

Use Solar-heated Water

Change the AC Filter

Take Shorter Showers
Showerhead

Install a Low-Flow

Buy Products Locally
Goods

Buy Minimally Packaged

Buy a Hybrid Car, Bio-fuel driven

Buy a Fuel Efficient Car,

Carpool When You Can

Reduce Garbage

Plant a Tree

Buy Organic Food

Replace Old Appliances

Use a Push Mower

Unplug Un-Used Electronics

Air Dry Your Clothes



Insulate Your Home

Switch to Double Pane Windows

Bring Cloth Bags to the Market & Turn off Your Computer Whenever Possible

FLUORIDE PROBLEM IN DRINKING WATER [MPL = 1.0 ppm]

Fluorine, one of the most active halogens/elements is not used in its elemental form in environmental engineering, principle forms in which fluorine are added to public water supply include NaF, CaF₂, HF, Na₂SiF₆, H₂SiF₆ & (NH₄)₂SiF₆. All compounds containing fluorine disassociate to form fluoride ions. F⁻.

Determination of fluoride concentration is carried out by ion chromatography, electrode, colorimetric & SPADNS method.

Environmental engineer has a dual interest in F⁻ concentration in water supply schemes...

1. Design, operate units for removal of excessive concentration.
2. Ensure the minimum / optimum concentration to be present (1ppm).

Sources of F⁻ contamination include Alumunium Processing Plants. In aluminum units, cryolite [Na₃AlF₆] used as solvent for Al₂O₃ in electrolytic method of aluminum. At operating temperature, cryolite is molten hence F⁻ escapes to atmosphere as vapor.

Excess F⁻ Removal techniques i.e., Defluoridation involves passing water through Defluoridation media like activated alumina, bone char by combination of processes of sorption and ion exchange.

Extreme limits of F⁻ > 4ppm causes crippling skeletal fluorosis, 4 < x < 2 ppm causes dental fluorosis, while < 1 ppm causes dental carries. Fluoride does not concentrate in any tissues but only in bones and teeth.

Dental carries is a medical condition in which a human or any organism lacks necessary compounds containing F⁻ to keep bones and teeth healthy. Symptoms include yellow coloring of teeth, white flecks, small pits in enamel of teeth, severe case also displays brown stains.

The most widely accepted adverse effect of low concentration fluoridation at this time is fluorosis. It is a condition caused by 'excessive' intake of fluorine compounds over an extended period of time, and can cause yellowing of teeth. The definition of 'excessive' in the context of fluorosis falls on the order of parts per million and is generally accepted to mean significantly higher than the 0.7 to 1.2 ppm amounts recommended for fluoridated water. Excessive fluoride has been scientifically linked to liver damage, kidney function, and fluorosis in children.

Although it is usually the permanent teeth which are affected, occasionally the primary teeth may be involved. In mild cases, there may be a few white flecks or small pits on the enamel of the teeth. In more severe cases, there may be brown stains.



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Fluoride ions replace hydroxide ions in calcium hydroxyapatite, $\text{Ca}_5[(\text{PO}_4)_3\text{OH}]$, in teeth, forming calcium fluoroapatite, $\text{Ca}_5[(\text{PO}_4)_3\text{F}]$, which is more chemically stable and dissolves at a pH of 4.5, compared to 5.5 pH for calcium hydroxyapatite. This is generally believed to lead to fewer cavities, since stronger acids are needed to attack the tooth enamel.

RESETTLEMENT AND REHABILITATION OF PEOPLE

Major projects such as dams, mining or the notification of a National Park disrupt the lives of the people who live there and may also require their moving permanently to an alternative site. None would like to give up the home they grow up in. Uprooting people is a serious issue. When dams are constructed in populated areas, many tribal are compelled by government and forced to relocate without adequate or no compensation. The Government's promises to find 'good' arable land to resettle displaced persons and provide them with an adequate rehabilitation package to recover from the disruption has rarely occurred to the satisfaction of the project affected individuals.

Resettlement and Rehabilitation of People reduces the ability of residents to subsist on their traditional natural resource base and also creates great psychological pressures. Tribal whose lives are woven closely around their own natural resources, cannot adapt to a new way of life in a new place. Established communities get dispersed and are often destroyed. The communities that are forced to absorb the influx of displaced tribal are as well strained to their maximum capacity. The cost of moving often leaves the tribal poorer than before. Due to space and resource constraints, tribal are often forced to move long distances from their original homes. This, coupled with the hard transition into urban areas, often destroys traditional cultures. The Projects severely affected people's economic security as many receive little or no compensation for their land lost, and no compensation was given for other resources destroyed by the project. For those who are supposed to be covered under the resettlement and rehabilitation program, they are prone to many forms of economic victimization. In India several lakhs of people have been unfairly displaced by dam projects created since independence. The dams have been built virtually at the cost of the poor local people who have been powerless to resist the Government.

The Government's promises to find 'good' arable land to resettle displaced persons and provide them with an adequate rehabilitation package to recover from the disruption has rarely occurred to the satisfaction of the project affected individuals. Resettlement requires alternate land to be provided to the people. In our overpopulated country as there is no arable high quality land available, most times project affected persons are given unusable wasteland. There is also emotional and psychological trauma caused by forcibly removing people from their homeland where their families have lived for centuries. There are also situations when communities request for shifting to a new site. This is often observed when people live inside or on the periphery of a National Park or Wildlife Sanctuary. The Tehri Dam project in the outer Himalayas in Uttar Pradesh, when finished will submerge Tehri town and nearly another 100 villages. Little has been done to ensure proper rehabilitation and compensation for nearly a lakh of people who will be uprooted from their homes as a result of this dam, with little hope of rehabilitation, as no alternative land is available.



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Figure: Public Protest due to inadequate Resettlement and Rehabilitation.



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MODULE 5



Introduction to G.I.S. & Remote Sensing

G.I.S. or Geographical Information System (GIS) basically deals with information pertaining to spatial objects or features which can be referred or related to a specific location on the Earth's surface. While the objects may be natural or manmade; information deals with large volume of data relative to it on the earth's surface, and comprises of its qualitative and quantitative aspects. G.I.S. hence can be defined as a system which provides a computerized mechanism for integrating various geo-information datasets and analyzing them in order to generate information relevant to planning needs. Keeping long tradition of map-making as background, G.I.S. has been developed during mid-20th century with the development of Computer Science. The first time operational G.I.S. was developed by Dr. Roger Tomilson of Canada in 1964, who is also known as 'Father of GIS'. To achieve G.I.S., Remote Sensing can be adequately thought of as a tool.

Remote sensing means obtaining information of an object, area or phenomenon without coming in direct contact with it. The development of remote sensing over a time can be broadly divided into the following six phases. Initial phase (upto 1920), Development of platforms and sensors (1920-1945), Development of Teaching and Training (1945-1950), development of instruments for interpretation (1950-60), Significant phase (1960-85) and Recent development phase (1985 onwards). There are two types of remote sensing instruments, Passive and Active. Passive instruments detect natural energy that is reflected or emitted from the observed scene. Passive instruments sense only radiation emitted by the object being viewed or reflected by the object from a source other than the instrument. Reflected sunlight is the most common external source of radiation sensed by passive instruments. Scientists use a variety of passive remote sensors. This system employs Radiometer, Imaging Radiometer, Spectrometer and Spectroradiometer. On the other hand, Active instruments provide their own energy (electromagnetic radiation) to illuminate the object or scene they observe. They send a pulse of energy from the sensor to the object and then receive the radiation that is reflected or backscattered from that object. Scientists use many different types of active remote sensors. This system employs Radar (Radio Detection and Ranging), Scatterometer, Lidar (Light Detection and Ranging) and Laser Altimeter.

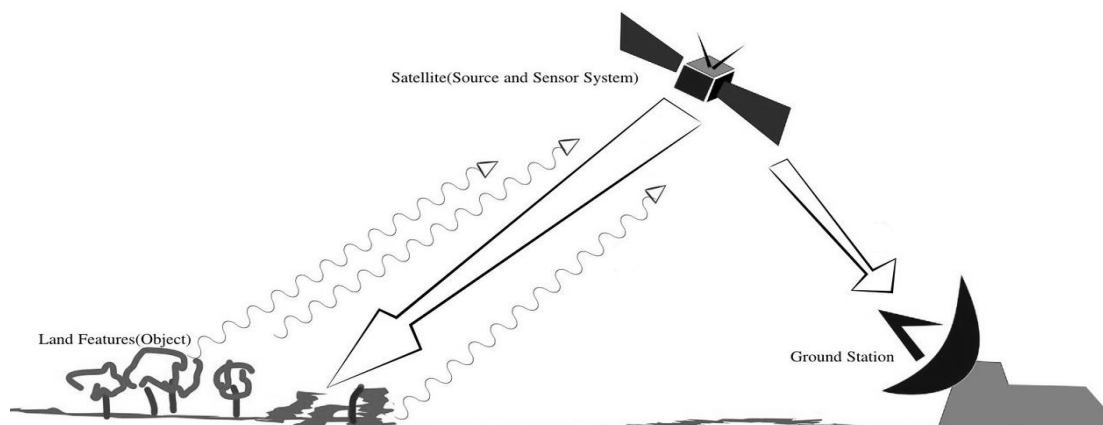


Figure: Basic Principle of G.I.S. and Remote Sensing.



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Applications of G.I.S. & Remote Sensing in Environmental Engineering Practices

Remote sensing and G.I.S. is the only technique that can provide holistic approach to the study of total environment. However, more advanced spatial and modeling techniques are required to support the decisions of managers and policy maker.

Environmental Monitoring

It is important to monitor the quantity, health and diversity of the forests, and further related aspects such as Deforestation (Rainforest, mangrove colonies), Species inventory, Watershed protection, Coastal protection etc.

Geological Application

It is a fact that Geology helps in the study of landforms, structures and the subsurface. So as to understand the various physical processes creating and modifying the earth's crust.

Remote sensing is used as a tool to extract information regarding the land structure composition or subsurface. In this arena, its applications encompass Surface deposit/bedrock mapping, lithological mapping, structural mapping, sand and gravel exploration, mineral exploration, hydrocarbon exploration, environmental geology, geo-botany, sediment mapping and monitoring, event mapping and monitoring, geo-hazard mapping and planetary mapping.

Urban mapping applications

While majority of remote sensing work has been focused on natural environments over the past decades, applying remote sensing to urban areas is relatively a newer application. Most urban sensing technology is relatively driven by technology advances and societal needs. The applications are as follows:

E-Hydrological Applications

Water Pollution Control

Soil Water and Drought Monitoring for early Warning Applications

Application of Remote Sensing in Coastal Ecosystem

NGO's

The term, "non-governmental organization" or NGO, came into currency in 1945 because of the need for the UN to differentiate in its Charter between participation rights for intergovernmental specialized agencies and those for international private organizations. They only have to be independent from government control, not seeking to challenge governments either as a political party or by a narrow focus on human rights, non-profit-making and non-criminal.



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The structures of NGOs vary considerably. They can be global hierarchies, with either a relatively strong central authority or a more loose federal arrangement. With the improvement in communications, more locally-based groups, referred to as grass-roots organizations or community based organizations, have become active at the national or even the global level.

At times NGOs are contrasted with social movements. Much as proponents of social movements may wish to see movements as being more progressive and more dynamic than NGOs, this is a false dichotomy. NGOs are components of social movements.

Operational NGOs have to mobilize resources, in the form of financial donations, materials or volunteer labor, in order to sustain their projects and programs. This process may require quite complex organization. Charity shops, staffed by volunteers, in premises provided at nominal rents and selling donated goods, end up providing finance to the national headquarters.

Fund-raising is still necessary, but on a smaller scale and it can serve the symbolic function of strengthening the donors' identification with the cause. Persuading people to donate their time is necessary, but, in addition to a small number of people giving a great deal of time, it is also necessary to be able to mobilize large numbers for brief periods. External donors may not impose onerous administrative burdens, but supporters still have to be supplied with information on an efficient regular basis.

Narmada Bachao Andolan, Chipko movement, Green Peace, WWF are few acclaimed NGO's.

ENVIRONMENTAL IMPACT ASSESSMENT [E.I.A.]

EIA is a tool used for decision-making regarding developmental projects and programs and it may be defined as a formal process used to predict the environmental consequences of any developmental project.

EIA thus ensures that the potential problems are foreseen and addressed at an early stage in the project planning and design.

EIA is intended to identify the environmental, social and economic impacts of a proposed development prior to decision-making.

Objectives

Identify, predict, and evaluate potential environmental, social, economic impacts.

Best practicable environmental options
Utilise alternative strategies

To analyze adverse effects due to all project activities on the total environment in a systematic manner



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To modify the project activities or to implement waste management programs to minimize pollution levels before disposal

To select best alternatives with minimum adverse effects

Resource conservation/waste minimization/recovery of by products

Benefits:

Reduced cost and time of project implementation

Cost saving modifications in project design

Increased project acceptance

Avoiding impacts and violations of laws and regulations

Avoiding impacts and violations of laws and regulations

Improved project performance

Avoiding waste treatment/cleanup expenses

Decreased resource use

Maintenance of biodiversity

Fewer conflicts over natural resource

Increased community skills.

Improved human health

EIA process can be CEIA [COMPREHENSIVE] and/or REIA [RAPID].

The 2 distinct stages in EIA are

[1] Preliminary Assessment (carried out in the early stages of planning)

[2] Detailed assessment (carried out during project planning until the project plan is completed and is reported formally as an environmental impact statement.

Public hearing is a key facet of any EIA project depending on its magnitude where in area inhabitants to be impacted are informed of the developmental process in presence of Govt and Project Employees.

The key elements are:

SCOPING - identifying key issues and concerns of interested parties

SCREENING – deciding whether an EIA is required based on information collected.

Identifying and evaluating ALTERNATIVES: listing alternative sites and techniques and the impact of each.

MITIGATION measures – dealing with uncertainty; reviewing proposed action to prevent or minimize the potential adverse effects of the project.

Issuing environmental STATEMENTS; reporting the finding of EIA.



ENVIRONMENTAL MANAGEMENT SYSTEMS

[E.M.S.]

An Environmental Management System (“EMS”) is a tool that is continuously growing in importance for companies. Most companies need to manage their products/services, employee safety, public opinion, environmental impact and other related opportunities. An EMS encompasses the methods and means to manage all of these aspects within your organization and helps you run and document its programs for environment-related management. If you want to become certified to ISO 14001:2015 we offer an all-in one certification package.

This can and does include comprehensive and systematic planning and commitment of key resources for developing, implementing and maintaining procedures for the preservation of the environmental systems of the planet. Basically, an EMS allows an organization to continuously monitor and improve all of their processes and impacts as it relates to the environmental system that they have created as part of their ongoing operations.

ISO 14001:2015 specifies the requirements for an environmental management system that an organization can use to enhance its environmental performance. ISO 14001:2015 is intended for use by an organization seeking to manage its environmental responsibilities in a systematic manner that contributes to the environmental pillar of sustainability.

ISO 14001:2015 helps an organization achieve the intended outcomes of its environmental management system, which provide value for the environment, the organization itself and interested parties. Consistent with the organization's environmental policy, the intended outcomes of an environmental management system include:

- enhancement of environmental performance;
- fulfilment of compliance obligations;
- achievement of environmental objectives.

ISO 14001:2015 is applicable to any organization, regardless of size, type and nature, and applies to the environmental aspects of its activities, products and services that the organization determines it can either control or influence considering a life cycle perspective. ISO 14001:2015 does not state specific environmental performance criteria.

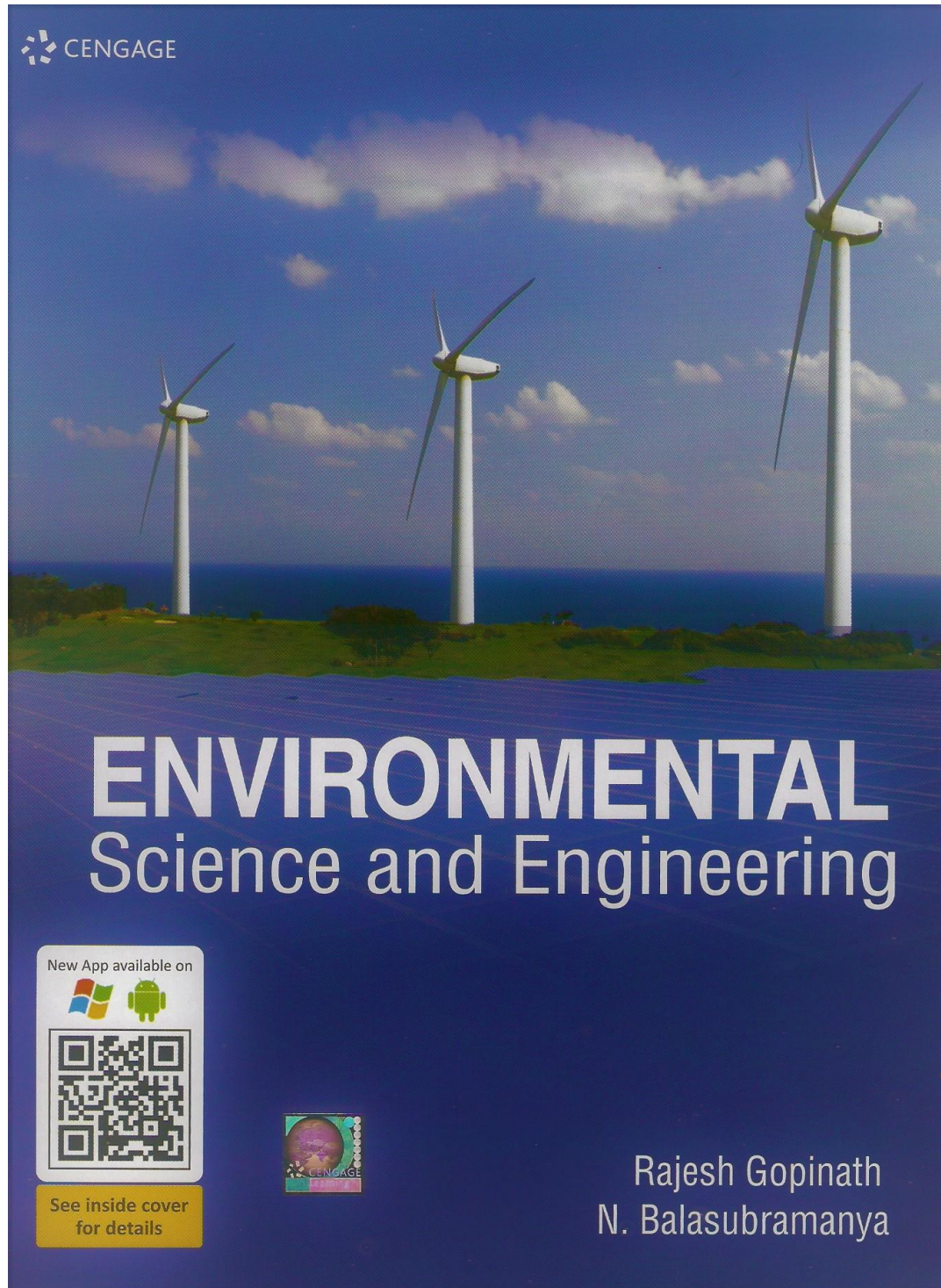
ISO 14001:2015 can be used in whole or in part to systematically improve environmental management. Claims of conformity to ISO 14001:2015, however, are not acceptable unless all its requirements are incorporated into an organization's environmental management system and fulfilled without exclusion.



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For Additional Reading





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ENVIRONMENTAL Science and Engineering

Environmental science is the study of the interactions among the physical, chemical, and biological components of the environment; with a focus on pollution, impact on biodiversity, and sustainability. This knowledge repository, therefore, encompasses issues such as climate change, conservation, biodiversity, ground water & soil contamination, natural resources, waste management, sustainable development, air and noise pollution, etc.

This textbook has been prepared in a manner to cater to the syllabus and schemes for degree courses in most of the Indian universities offering environmental studies/science in their curriculum; to name a few, Anna University, VTU, University of Kashmir, Jammu University, Nagaland University, Calcutta University, Cotton College State University, University of Burdwan, University of Delhi, Bharathidasan University, JNVU Jodhpur, and Dibrugarh University.

Key Features

- Simple and lucid language
- Caters to the degree programmes of most Indian Universities
- Contains more than 500 solved multiple-choice questions

About the Authors

Rajesh Gopinath holds master's degree in Environmental Engineering from VTU. His doctoral research on Urban Climatology and Town Planning from JNTUA was bestowed the 'Most Contributing Research Outcome Award' by Hillgrove Research Pvt. Ltd in 2017. He was honoured with the 'Young Scientist Award—Environmental Engineering' at the International Conference on Biodiversity, Climate Change, & Environmental Sciences in 2017. He also holds an MBA in HRM, Postgraduate Diploma in Environmental Law from National Law School of India University, and certificate course in Strategic Management from IISc. Dr Gopinath has a teaching experience of more than 10 years. He has published 15 articles in journals in USA, Morocco, and Russia. He has published a textbook *Environmental Studies*, as per latest VTU module-based system (CBCS), and a field guide *CCCV and Counting—A Handbook on Urban Flora and Fauna of AIT, Bangalore*, released by MoEF&CC on the occasion of World Earth day 2016.

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