Environmental Science

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Environmental Science

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Lecture 01
Scope and Importance of Environmental Studies

Environment is derived from the French word Environner, which mean encircle or surrounding. Environment is a complex of many variables, which surrounds man as well as the living organisms. Environmental studies describe the interrelationships among organisms, the environment and all the factors, which influence life on earth, including atmospheric conditions, food chains, the water cycle, etc. It is a basic science about our earth and its daily activities, and therefore, this science is important for one and all.

Scope of environmental studies

Environmental studies discipline has multiple and multilevel scopes. This study is important and necessary not only for children but also for everyone. The scopes are summarized as follows:

- The study creates awareness among the people to know about various renewable and nonrenewable resources of the region. The endowment or potential, patterns of utilization and the balance of various resources available for future use in the state of a country are analysed in the study.
- It provides the knowledge about ecological systems and cause and effect relationships.
- It provides necessary information about biodiversity richness and the potential dangers to the species of plants, animals and microorganisms in the environment.
- The study enables one to understand the causes and consequences due to natural and main induced disasters (flood, earthquake, landslide, cyclones etc.,) and pollutions and measures to minimize the effects.
- It enables one to evaluate alternative responses to environmental issues before deciding an alternative course of action.
- The study enables environmentally literate citizens (by knowing the environmental acts, rights, rules, legislations, etc.) to make appropriate judgments and decisions for the protection and improvement of the earth.
- The study exposes the problems of over population, health, hygiene, etc. and the role of arts, science and technology in eliminating/ minimizing the evils from the society.
- The study tries to identify and develop appropriate and indigenous eco-friendly skills and technologies to various environmental issues.
- It teaches the citizens the need for sustainable utilization of resources as these resources are inherited from our ancestors to the younger generating without deteriorating their quality.
- The study enables theoretical knowledge into practice and the multiple uses of environment.

Importance of environmental study

Environmental study is based upon a comprehensive view of various environmental systems. It aims to make the citizens competent to do scientific work and to find out practical solutions to current environmental problems. The citizens acquire the ability to analyze the environmental parameters like the aquatic, terrestrial and atmospheric systems and their interactions with the biosphere and anthrosphere.

Importance

- World population is increasing at an alarming rate especially in developing countries.
- The natural resources endowment in the earth is limited.
- The methods and techniques of exploiting natural resources are advanced.
- The resources are over-exploited and there is no foresight of leaving the resources to the future generations.
- The unplanned exploitation of natural resources lead to pollution of all types and at all levels.
- The pollution and degraded environment seriously affect the health of all living things on earth , including man.
- The people should take a combined responsibility for the deteriorating environment and begin to take appropriate actions to space the earth.
- Education and training are needed to save the biodiversity and species extinction.
- The urban area, coupled with industries, is major sources of pollution.
- The number and area extinct under protected area should be increased so that the wild life is protected at least in these sites.
- The study enables the people to understand the complexities of the environment and need for the people to adapt appropriate activities and pursue sustainable development, which are harmonious with the environment.
- The study motivates students to get involved in community action, and to participate in various environmental and management projects.
- It is a high time to reorient educational systems and curricula towards these needs.
- Environmental studies take a multidisciplinary approach to the study of human interactions with the natural environment. It integrates different approaches of the humanities , social sciences, biological sciences and physical sciences and applies these approaches to investigate environmental concerns.
- Environmental study is a key instrument for bringing about the changes in the knowledge, values, behaviors and lifestyles required to achieve sustainability and stability within and among countries.

Environmental studies deals with every issue that affects an organism. It is essentially a multidisciplinary approach that brings about an appreciation of our natural world and human impacts

on its integrity. It is an applied science as it seeks practical answers to making human civilization sustainable on the earth's finite resources. Its components include

- Biology
- Geology
- Chemistry
- Physics
- Engineering
- Sociology
- Health
- Anthropology
- Economics
- Statistics
- Philosophy

Major environmental issues

Man and nature have lived together and as long as man's wants were in conformity with nature, there was no problem. But unfortunately, man's ambition for limitless enjoyment and comfort has led him towards the exploitation of nature's wealth so indiscriminately as to reduce nature's capacity for self stabilization. The indiscriminate exploitation of nature over centuries has created numerous environmental problems. Man's voracious appetite for resources and his desire to conquer nature has put him on collision course with environment. The demands of his explosive technological society impose intense stress on the state of equilibrium with the environment. Major environmental issues threatening mankind are Global warming, water pollution, pesticide pollution, Hazardous waste, biomedical wastes, e waste, and loss of biodiversity

India today is one of the first ten industrialized countries of the world. Today we have a good industrial infrastructure in core industries like metals, chemicals, fertilizers, petroleum, food etc. What has come out of these?, Pesticides, detergents, plastics, solvents, paints, dyes, food additives etc. Due to progress in atomic energy, there are also been an increase in radioactivity in the biosphere. Besides these there are a number of industrial effluent and emissions particularly poisonous gases in the atmosphere. Mining activities also added to this problem particularly as solid waste.

Such activities of man had adverse effect on all forms of living organisms in the biosphere. The earth planet along with the atmosphere (air, land, water) that sustains life is called the Biosphere. Due to lack of development of a culture of pollution control, there has resulted a heavy backlog of gaseous, liquid and solid pollution in our country. The solid wastes which causes pollution are Hazardous waste, pesticides, medical waste etc. they are become the major environmental issues in addition to automobile pollution, climate change, water pollution, pesticide pollution and biodiversity loss in our country and worldwide.

Industrial / Vehicular pollution

The coolest culprits of environmental degradation in metropolitan cities are vehicular and industrial pollution. Since 1975 the Indian economy has grown 2.5 times, the industrial pollution load has grown 3.47 times and the vehicular pollution load 7.5 times, in Delhi, for example 70% of air pollution is caused by vehicular pollution. Thanks to the 3 million vehicles on its roads-while industries account for 17%. The pollutants emitted by the vehicles could produce inflammatory effects on the respiratory organs, could be toxic or even carcinogenic depending upon the fuel type, In India, vehicles primarily run on diesel or petrol.

Air pollutants from automobiles

Climate Change

The rising concentrations of greenhouse gases (GHGs) of anthropogenic origin in the atmosphere such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) have increased, since the late 19th century. According to the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change, because of the increase in concentration of greenhouse gases in the atmosphere (for e.g., CO2 by 29 per cent, CH4 by 150 per cent and N2O by 15 per cent) in the last 100 years, the mean surface temperature has risen by 0.4–0.8°C globally. The precipitation has become spatially variable and the intensity and frequency of extreme events has increased. The sea level also has risen at an average annual rate of 1–2 mm during this period. The continued increase in concentration of GHG in the atmosphere is likely to lead to climate change resulting in large changes in ecosystems, leading to possible catastrophic disruptions of livelihoods, economic activity, living conditions, and human health. The United Nations Framework Convention on Climate Change requires the parties to protect the climate system in accordance with their 'common but differentiated responsibilities' and respective capabilities. In the year 1990, the developed world (Australia, Canada, USA, Europe, former USSR and Japan) emitted around 66 per cent of the total global GHG emissions, which though has reduced to 54 per cent in 2000, mainly offset by the rise in Chinese emissions. The South Asian region, including three-fourths emission share of India, contributed only 3 per cent of the total global GHG emissions in 1990 and the share of emissions from South Asia has grown merely by 4 per cent in 2000.

Water pollution

India has 12 major rivers with a total catchments area of 252.8 million hectare. The Indian homes produce about 75 % of the wastewater, and sewage treatment facilities are inadequate in most cities and almost absent in rural India. According to the Central pollution Control Board, of the 8,432 large and medium industries in the country, only 4,989 had installed appropriate measures to treat wastewater before discharge. Of the over two million small scale industrial units, a number of which like tanneries are extremely polluting, very few have any treatment facilities whatsoever and their untreated wastes invariably find their way into country's water systems.

Polluted tank

Marine pollution

Industrial pollution

Poisoned by Pesticides

Poisoning from pesticides affects 68,000 farmers and workers every day; annually, an estimated 25 million workers suffer from pesticide poisoning throughout the world. Farmers and agricultural workers are exposed to pesticides directly when they are mixing and spraying these pesticides, especially so in developing countries such as Asia. Every year, about 3 million people are poisoned around the world and 200,000 die from pesticide use.

Beyond these reported acute cases of pesticide poisoning, evermore worrying are the chronic long-term effects such as cancers, adverse effects-not only on specific body organs and systems but also on the endocrine system which include reduction in male sperms count and undecided testes as well as increasing incidences of breast cancer. Communities and Consumers are insidiously exposed to pesticides through contamination of the soil, air and water. The chronic effects of pesticides are particularly alarming when new studies link certain pesticides to cancer, lowered fertility and disruption of the endocrine system and to the suppression of immune systems.

Important pesticide episodes are

- The struggles of common plantation workers in Malaysia against the impact of pesticides such as Parquet as their assertion of their rights as workers.
- The tale of ex-International Rice Research Institute (IRRI) workers in the Philippines poisoned by pesticides used in the IRRI test fields and unfairly healed by IRRI. There were also details about the fisher flock community in Kamukhaan, Philips, that been poisoned and their environment devastated by Pesticides used in the neighboring banana plantation.
- The communities living in Kasar code, Kerala who have been poisoned by Endosulfan, which was aerially sprayed by the plantation corporation of Kerala, India.
- Farming and Agricultural Worker communities in Warangal, Andhra Pradesh, who have been poisoned by Pesticides during spraying, Warangal is already in famous for the large number of cotton farmer suicide deaths, one the main reasons during the farmers to suicide in the resistance being developed by pests to pesticides.

Pesticides Action Network Asia and the Pacific (PANAD) first launched 'No Pesticide Use Day' in 1998 to protest the manufacture and use of pesticides worldwide. The day is held to commemorate the thousand who dies, and the tens of thousand who still suffer and continue to dies, as a result of the 1984 Bhopal Disaster. The tragedy of Bhopal is a powerful and poignant example of chemical pesticide contamination; the victims continue to suffer to this day.

Pescticides In Soft Drinks

Soft drinks are non-alcoholic water-based flavored drinks that are optionally sweetened, acidulated and carbonated. Some carbonated soft drinks also contain caffeine; mainly the brown-colored cola drinks. The two global majors PepsiCo and Coca-Cola dominate the soft drink market in India.

Coco cola brands -Thumps Up, Limca, sprite, Minute Maid, and Gold Spot from Parle Beverages and soft drink brands Crush, Canada Dry and Sport Cola from Cadbury

Pepsico brands - Pepsi-Cola Brands ,Frito-Lay Brands ,Tropicana Brands ,Quaker Brands ,Gatorade Brands

Sample Analysis

A laboratory report prepared by CSE in 2003 detailed some astonishing facts about the extent of pesticide contamination in soft drinks sold in India. CSE found high levels of toxic pesticides and insecticides, high enough to cause cancer, damage to the nervous and reproductive systems, birth defects and severe disruption of the immune system. Market leaders Coca-Cola and Pepsi had almost similar concentrations of pesticide residues. At the same time CSE also tested two soft drink brands sold in the US, to see if they contained pesticides. They didn't. This only goes to show the companies were following dual standards.

1. Among the total pesticide found in 18 cities in India, Kolkata is on the top and Guwahati is in the bottom of that list. Kolkata has pesticide content in cold drinks of about 51.7 ppb. The pesticides cause irreparable harm to the human body.
2. It has been shown time and again that these pesticides can be used to kill bacteria in bathrooms. The acidic content of these drinks are harmful to the human body.

Release of Hazardous waste from industries

Hazardous waste may be liquid, solid or gas and all have one thing in common are dangerous and can pose a substantial hazard to human health and environment when not managed properly. In India, generation of

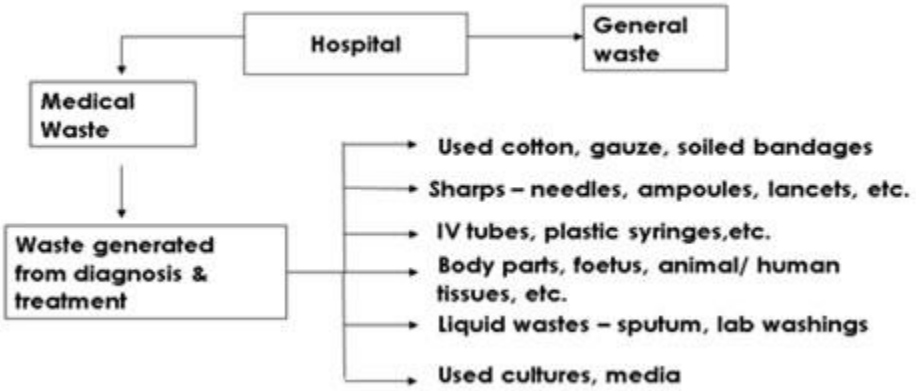
hazardous waste to the tune of 6-7 million tonnes per year and may vary depending on the nature and quantity of hazardous waste generated in India. The major hazardous waste in India is petrochemicals, pharmaceuticals, pesticides, paints, dyes, fertilizers, chlor-alkali and other different industries

The lack of a preventative approach to waste management has led to generation of more and more hazardous wastes and sadly, controlling hazardous waste has become a serious problem in India and no special care is taken in their management. Implementation of the ban on the ground is very negligent and hazardous waste is coming to our shores in regular phenomenon. Apart-from generating their own hazardous wastes, India invites import to such waste in the name of reuse and recycling, though there is lack of environmental friendly technology to reuse and recycle hazardous waste. Thus indiscriminate generations, improper handling, storage and disposal of hazardous waste are the main factors contributing to the environmental and human health impact. The pressing need is to rethink the present approach of pollution control and end-of-the-pipe approaches and focus on pollution prevention, waste minimization, cleaner production and toxics reduction.

Dumping of Tannery Sludge:

Biomedical Waste

Biomedical waste includes both organic and inorganic wastes generated from hospitals. On an average a hospital bed generates 1 kg of waste per day, out of which 10-15% is infectious, 5% is hazardous and rest us general waste. Every day, country's numerous hospitals and medical facilities churn out tonnes of waste. A WHO report documents that Hepatitis – B Virus can survive in a spring for 8 days.



The disposable syringe one uses with a sense of security may actually be giving a false sense of security. It may actually be a used syringe repacked by the mafia, which is involved in medical waste trafficking.

Unmediated and unhealed syringe in the municipal dump may come back in the hospitals and may then be used on a patient, who may get cross-infected.

The problem of Medical waste has acquired gargantuan proportions and complex dimensions. While the health care establishments are trying to provide better medicare facility of the citizens, the hospital waste disposal systems are undermining such efforts. The rules for management of this waste exist, what is urgently needed now is training of all the health care staff and setting up waste management system in the hospitals.

Plastics constitute a major chunk of medical waste. In fact, in India, the market for medical disposable has grown from US$2.350 million (1979) to 4,000 million (1986). The use of plastics in medical

equipment is now growing at the rate of 6% per annum. Even though plastics reduce the possibility of transmission of infection with in the hospital, there are many problems related to its use and disposal.

Mercury is more poisonous and Dangerous than Lead and Arsenic.

Cracking down on crackers

Over the years, Diwali has turned into a festival of pollution by noise, crackers, artificially coloured sweets and serious health hazards. On this day, cities turn into gas chambers increases toxic fumes and gases like CO2, SO2, NO2, as well as suspended particulate matter (SPM), in the air. The worst affected are children. Pregnant women and those suffering from respiratory problems. In addition, the factories making crackers float safety norms and exploit child labour. These children work for 16-18 hrs each day in unhygienic dingy, make-shift and suffocating factories-for only Rs.10-15 per day. They handle chemical that cause deadly diseases of the lungs, kidneys, skin and eyes.

E Waste

- People discard computers every two to four years on average.
- Cell phones have a life-cycle of less than two years in industrialized countries.
- Each computer screen contains about 20% lead by weight.
- A mobile phone, is 19 % copper and 8% iron.
- Informal name for electronic products nearing end of their "useful life".
- Large household appliances - Refrigerators Air conditioners, computers & Stereo systems, Mobile phones.
- Its volume increases by 3-5% per annum.
- Major pollutants are Heavy metals – Hg, Pb, Cd, Cr (VI) and Flame retardants – Polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDEs).

International Scenario

- 20-50 MT / yr of e waste are generated world-wide.
- USA accounts 1% to 3% of the total municipal waste generation.

- EU - 5 to 7 million tonnes per annum or about 14 to 15 kg per capita and is expected to grow at a rate of 3% to 5% per year.
- In developed countries, currently it equals 1% of total solid waste generation and is expected to grow to 2% by 2010.

Magnitude of the problem in India

- India – 1,46,000 tonnes to 4.7 lakh tonnes by 2011.
- India's e-waste generation is growing at the rate of 15per cent and is expected to cross 800,000 tonne by 2012.
- Sixty-five cities generate more than 60% of the total e-waste in India.
- Top cities (70%) – Mumbai, Delhi, Bangalore, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur.
- 50,000 MT / yr illegally imported.

Loss of Biodiversity

The continuous loss of biodiversity due to over exploitation, habitat degradation, deforestation and land pollution has posed serious threat to the very existence of the mankind. It has been calculated that if this trend of biodepletion continues, about 1/4th of the world species may be extinct by the year 2050. The rate of destruction which has been of the order of one species per year over the past 600 million years is today feared to be dozens of species a day. Hence, the conservation of biodiversity has become one of the most pressing environmental issues. The challenge is for nations, government agencies, organizations and individuals to protect and enhance biological diversity, while continuing to meet people's need for natural resources.

We are at a major turning point in human history and for the first time, we now have the resources, motivation, and knowledge to protect our environment and to build a sustainable future for ourselves and our children. Until recently, we didn't have these opportunities, or there was not enough clear evidence to inspire people to change their behavior and invest in environmental protection; now the need is obvious to nearly everyone. Unfortunately, this also may be the last opportunity to act before our problems become irreversible.

Lecture 02

Natural resources: Renewable and Non renewable resources. Land and Water

Natural Resources:

A resource is anything needed by an organism or group of organisms. The sum of all physical, chemical, biological and social factors, which compose the surroundings of man, is referred as environment and each element of these surroundings constitutes a resource on which man draws in order to develop a better life. Resources which are not reproducible and are obtained from the fenite non-living reserves are called non-renewable resources (eg.) Coal and metals.

Any material which can be transformed in a way that it becomes more valuable and useful can be termed as a resource. Thus, only part of our natural environment, such as land, water, air, minerals, forest, rangeland, wildlife, fish or even human population that man can utilize to promote his welfare may be regarded as a natural resource. In the case of humans, a resource is any form of energy of matter essential for the fulfillment of physiological, socio-economic and cultural needs, both at the individual level and that of the community.

The five basic ecological variables - energy, matter, space, time and diversity are sometimes combinedly called natural resources.

Classification of natural resources:

Based on quantity, mutability and reusability schematic representation of classification of natural resources:

Inexhaustible

- Unlimited or unending
- Both qualitative, and quantitative degradation

Exhaustible

- Limited.
- Quality may be degraded, not quantity

Renewable

- Perpetual harvest
- Ex. Human power, fertility of soil

Non-renewable

- No-replacement
- Ex. Species of wild life

Based on Continual Utility

- Renewable
- Non renewable
- Cyclic resource

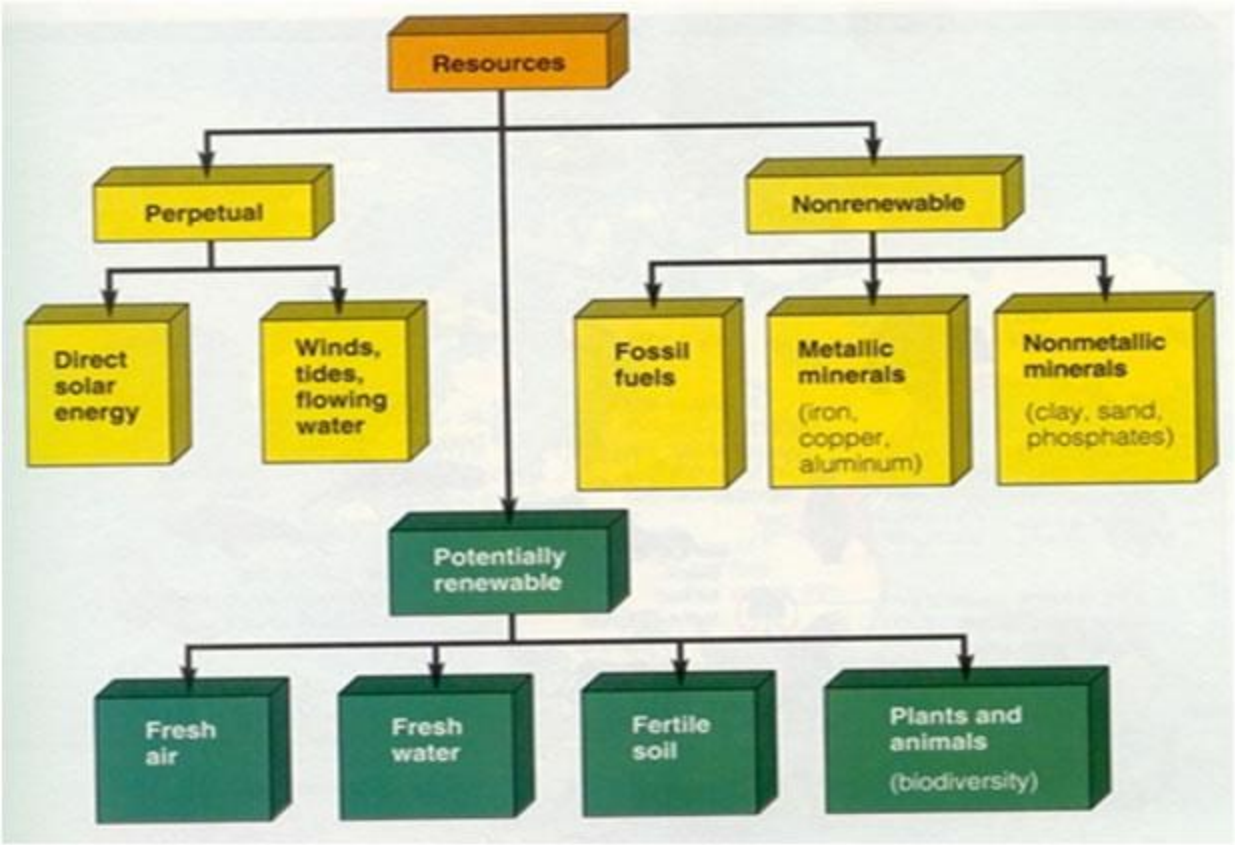
Based on origin

- Biotic and
- Abiotic

Based on Utility

- some as raw materials
- some as energy resources

Renewable resources are those which are reproducible and are obtained from the biomass of living organisms. (Eg.) Forests. Potentially renewable can become nonrenewable resources, if used for a prolonged time at a faster rate than it is renewed by natural processes.



Land

The land although appears to be available unlimited but, infact, its judicious use would limit the availability of this indispensable life support system. In rural land use planning, concentration is chiefly devoted to creating and developing more farmland by removing forests and natural grasslands, channeling streams for irrigation and so on. Unfortunately, no effort is made to save existing prime farmland from degradation by ill planned development.

A nation's well-being is inextricably linked with the fertility and abundance of soil resources. Productive land is since the source of human sustenance and security everywhere at all times, this resource because of mounting demands of swelling population and long mismanagement would put in jeopardy the very survival of man.

Deteriorating quality of urban and sub urban environment is to a great extent the result of injudicious land use and is a threat to the whole socio economic system. Major problems emerging out of abuse of land in cities include unsafe and unhygienic dwellings and those in rural areas are of erosion of soil and loss of fertility. While urban problems can be prevented and cured by proper town planning and municipal facilities, the problem relating to rural areas need long-term soil conservation programme.

Soil consists of mineral and organic matter, air and water. The proportions vary, but the major components remain the same. Minerals make up 50 per cent of an ideal soil while air and water make up 25 per cent each. Every soil occupies space. Soil extends down into the planet as well as over its surface. Soil has length, breadth, and depth. The concept that a soil occupies a segment of the earth is called the "soil body". a single soil in a soil body is referred to as a "pedon". The soil body is composed of many pedons and thus called a "polypedon".

Every soil has a profile or a succession of layers (horizons) in a vertical section down into the non-soil zone referred to as the parent material. Parent materials can be soft rock, glacial drift, wind blown sediments, or alluvial materials. The nature of the soil profile is important for determining a soil's potential for root growth, storage of water, and supply of plant nutrients.

Soil texture

Relative amounts of the different sizes and types of mineral particles

Soil porosity

A measure of the volume of pores or spaces per volume of soil and the average distances between these pores

Soil permeability

Rate at which water and air move from upper to lower soil layers

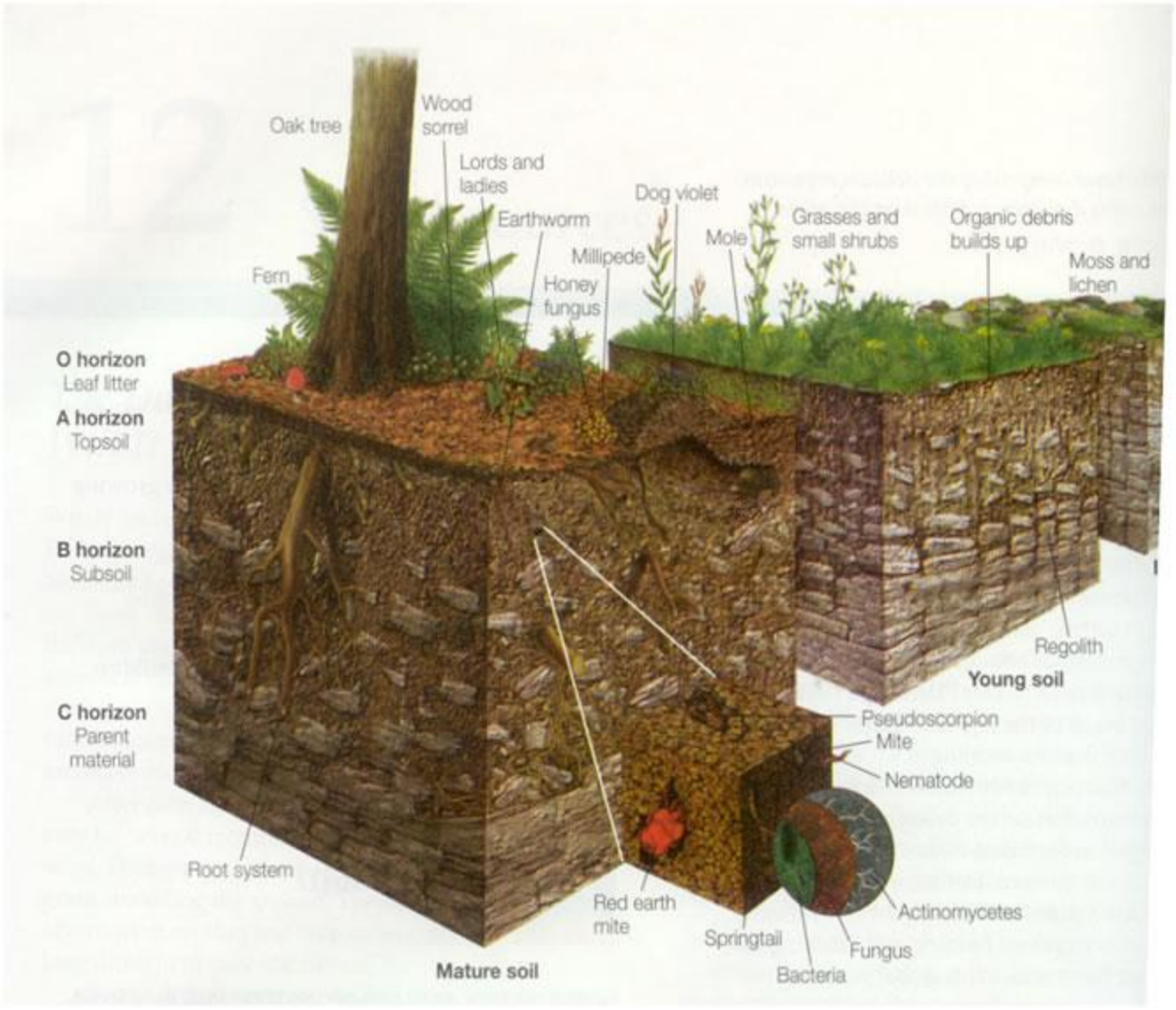
Processes of soil formation – 2 stages

1) Weathering

2) Soil development or pedogenesis

- Weathering

- Physical – Wetting- drying, Heating – cooling, Freezing, Glaciations, solution, sand blast
- Chemical - Hydration,Hydrolysis, O/R, Carbonation,Chelation



Soil development

1. Pedogenesis – lichens, bacteria, fungi, algae, microarthropods, mollusc – secretion of Organic acids, enzymes,CO2, addition of Organic Matter – leads to soil formation – soil Profile
2. Factors affecting soil formation
    1. Passive Factors – Parent material, topography, time
    2. Active Factors – Rainfall, Temp, humidity, Wind,
    3. Biosphere effect (Phytosphere, Zoosphere, MO)

Throughout history, the progress of civilizations has been marked by a trail of wind-blown or water-washed soils that resulted in barren lands. Continuing to use the soil without appropriate soil conservation management is very destructive to the environment. Protecting the quality of our nation's

topsoil is largely within human control. To many soil scientists, saving our soil is much more important than saving oil, coal, or natural gas resources.

Water Resources

Water is a vitally important substance in all parts of the environment. Water resources occupy a unique place among other natural sources. It is the most abundant and most widely distributed element in the world. It occupies about three fourths (70%) of the earth's surface. It occurs in all spheres of the environment – in the oceans as a vast reservoir of saltwater, on land as surface water in lakes and rivers, underground as groundwater in the atmosphere as water vapor, and in the polar icecaps as solid ice. This amounts to a staggering 1400 million cubic kilometer, which is enough to cover the earth with a layer 3000 meters deep. This apparent abundance is, however, misleading and hides an ironical fact which is not always fully appreciated, a mammoth 97.5% of the amount, contained in the world's oceans and seas, being saline, is unfit for human consumption. We, like many creatures, require fresh water to survive, and that constitute a miserly 2.5 % of the total amount. Of this, about 68.9% lies inaccessible in ice fields and glaciers and another 29.9% is present as groundwater. In effect, only one – hundredth of three per cent (0.03%) of the world's total supply amounting to some 14 billion cubic meters is considered easily available for human use on a regular basis. This water is found in decreasing order of abundance in saline and freshwater lakes and reservoirs; as soil moisture; as water held in living organisms, as vapor, droplets, and miniscule ice crystals in the atmosphere; in swamps and marshes; and in rivers and streams. The problem would not have been so acute had freshwater been evenly distributed around the globe, throughout the seasons or from year to year. It is not so. Two thirds of the world's population i.e around 4 billion people lives in areas receiving only one quarter of the world's annual rainfall.

Freshwater distribution

About three-quarters of annual rainfall come down in areas containing less than one-third of the world's population. As water –short societies have done for centuries, many countries attempt to move water from where it occurs on nature to where the people want it, and also to store water for future use. Worldwide, there are 40,000 dams higher than 15 mts, most of them built in the last 50 years. Although dams help ensure a steady water supply, they often endanger aquatic systems by blocking river channels, altering water flows of rivers, food plains, deltas, and other natural wetlands, as well as imperiling plant and animal life.

How water is used?

The amount of water that people in a country actually use depends not only on minimum needs and how much water is available for use but also on the level of economic development and the extent of urbanization. Globally, of the three categories of freshwater use- for agriculture, industry and domestic, agriculture dominates. On a worldwide basis, agriculture accounts for about 69% of the annual water withdrawals; industry, about 23% and domestic use, about 8%.

India's Water Resources Potential

India receives an annual precipitation of about 4000 cu.km. About 1869 cu.km occurs as natural run off in rivers. India has 12 major rivers with a total catchments area of 252.8 million hectare. Of these, the

Ganga-Brahmaputra-Meghana system is the biggest with a catchment area of about 110 m.ha. It also provides about 60% of the total amount of freshwater amongst other rivers. Others with catchment areas of more than 10 m.ha are Indus (32.1 m.ha), Godavari (31.3 m.ha.), Krishna (25.9 m.ha.) and Mahanadi (14.2 m.ha.) The national annual per capita availability of water in the country is about 2208 cu.m.

Groundwater

In India groundwater has been used for irrigation and domestic water supply since time immemorial. At present, more than 70% of the population uses groundwater for its domestic needs and more than half of the irrigation is provided from this source. The total replenishable ground water in India is estimated to be about 43.18850 million hectare meter per year. About 7.1 m ha m/yr is used for domestic and industrial use. It is estimated that about 32.47264 m ha m/yr is available for irrigation. About 32% of available groundwater resources have so far been used. There is increasing extraction of groundwater to meet the demands of the agriculture, especially for the cultivation of water intensive crops, like sugarcane. Some 90% of the groundwater extracted is used for irrigation. Today, more than 8.5 million electric and diesel pumps are used to withdraw groundwater leading to falling water tables in most states.

Water scarcity

Years of rapid population growth and increasing water consumption have strained the world's freshwater resources. In some areas the demand for water already exceeds nature's supply, and a growing number of countries are expected to face water shortages in the near future.The world's population, at 6.1 billion is growing by about 80 million people each year. This number implies an increased demand for freshwater of about 64 billion cubic meters a year. A country is said to experience water stress when annual water supplies drop below 1,700 cubic meters per person. Below 1,000 cubic meters per person, the country faces water scarcity. Once a country experiences water scarcity, it can expect chronic shortages of freshwater that threaten food production, hinder economic growth and development, and damage eco system.

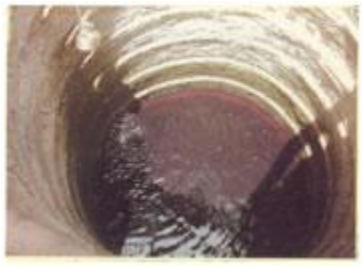
In 1995, 31 countries containing 458 million people faced either water stress or scarcity. By 2025, according to projections made by Population Action International, more than 2.8 billion people in 48 countries will be facing water stress or scarcity. By 2050, the number of water short countries soars to 54, affecting 4 billion people, or 40% of the projected global population. The worst hit areas are in the Middle East, North Africa and Sub-Saharan Africa. Over 200 million Sub Saharan Africans already live in water short countries. This figure balloons to 700 million by 2025, of whom over half will live in countries facing severe shortages for most of the year.

World Water Demand/Year	
1940	1000 km3
1990	4130 km3
2000	5000 km3
2002	6650 km3

Water scarcity is now the single biggest threat to food production, as falling groundwater levels and shrinking rivers make less water available for agriculture. According to UNEP, India will be water – stressed before 2025-with average annual water availability limited to between 1000 cubic meters to 1700 cu. m per person.

Depletion of water resources

- Shrinking of rivers, lakes & ponds
- Water pollution – 70% of surface water polluted
- Ground water depletion - >10 cm/yr & pollution- NO3
- Increase of sewage & industrial effluents
- India will be water stressed by 2025 (UNEP)
- Per capita water has decreased from 2208 to 1700cu.m in a decade

Management of water implies making the best use available water resources for human benefit while not only preventing and controlling its depletion and degradation but also developing it in view of the present and future needs. Floods, droughts, improper use, pollution, disease transmission are the important problems related to water. Pollution of a body of water is detrimental not only to the human

society but also to regional ecology and the ecology of very aquatic system. It is therefore, essential that the water should not be treated as a simple repository of waste disposal, and if inevitable, the water only after proper treatment should be released in it under strict ecological considerations.

Drought

Drought may be caused due to variability of rainfall, delay in onset or early withdrawal of monsoon, duration of break in the monsoon, area differences in persistence of monsoon and human activities. Based on the physical characteristics, drought may be of meteorological drought, hydrological drought, soil-moisture drought, agricultural drought, socio-economic drought, famine and ecological drought.

Combating drought

Planning for drought includes;

- Scientific use of rainfall, surface and underground water.
- Introduction of proper cropping pattern.
- Development of irrigation facilities.
- Development of existing irrigation potential.
- Lining of canals and distributaries to minimize water losses.
- Drip irrigation/Trickle irrigation mainly in saline areas.
- Expeditious completion of continuing projects should be given priority in planning.
- Construction of new irrigation projects.
- Desilting of irrigation tanks.
- Technology of dry farming.

Dams: Today there are more than 45,000 large dams around the world, which play an important role in communities that harness these water resources for their economic development. Current estimates suggest that about 30-40 % of the irrigated land worldwide relies on dams. The world's two most populous countries China and India – have built around 57% of the world's large dams. In India, of the 16-18 million people displaced by dams, 40-50% wee tribal people, who account only for 8% of our nations one billion people.

Problems caused by Dams:

- Fragmentation and physical transformation caused by dams
- Serious impact on riverine ecosystems
- Social consequences of large dams due to the displacement of people
- Dislodging animal populations, damaging their habitat and cutting off their migratory routes
- Disruption of fishing and waterway traffic
- The emission of green house gases from reservoirs due to rotting vegetation and carbon inflows from the catchment

Lecture 03
Natural resources: forest, wildlife, energy and food resources

3.1. Forest:

It is a natural ecosystem having multispecies and multiage trees as dominant community. Forest covers about 1/3rd of the earth's land surface of which about 50% is occupied by tropical forest. Thus forests are important in two ways ecologically and economically important.

Increased urbanization, industrialization and mining have entailed indiscriminate felling of trees and denudation of forests. The depleted forest wealth would simply deprive the man of economic and environmental values offered by forest Thus, forest ecology is a highly diverse and important branch of ecological study. The presence of trees makes forest ecosystems and their study unique.

Causes of Deforestation

Deforestation is a consequence of over-exploitation of our natural ecosystems for space, energy and materials. The basic reasons for such extensive deforestation are:

(1) Expansion of Agriculture:

Expanding agriculture is one of the most important causes of deforestation. As demands on agricultural products rise more and more land is brought under cultivation for which forests are cleared, grass-lands ploughed, uneven grounds leveled, marshes drained and even land under water is reclaimed. However, this expansion is usually marked with more ecological destruction than rationality. Governments often distribute land under forests to landless people, instead of redistributing already established farm-lands, howsoever, wasteful, unequal and unjust the distribution of ownership of land may be. During the process of clearing the land precious timber is simply burned. Ghana's 80% forests have disappeared but only 15% timber was harvested. Similarly in Brazil, little timber was extracted before the forests were burned for clearing the land.

(2) Extension of Cultivation on Hill Slopes:

Outside humid tropical zone, in most of the third world countries, major forests often occur on hill tops and slopes. Though agriculture has nearly always been concentrated on plains and floors of valleys, farming on narrow flat steps cut one after another across the slope or terrace farming is an age-old practice. It has never been extensive because of the gruelling labour and low productivity. However, the ever rising human numbers and their necessities have forced many to go up to mountain slopes for cultivation. More and more slopes are cleared of plants, steps carved out and against many odds cultivation is attempted. After a few crops the productivity declines and torrential sub-tropical rains carry down massive quantities of precious top soils to streams and rivers. While denuding hill slopes, the silt and sediments settle further down raising stream bottoms and river beds aggravating the flood situation.

(3) Shifting Cultivation:

Shifting cultivation or Jhum is often blamed for destruction of forests. In fact it is poor fertility of soil

which has given rise to such a pattern of farming. A small patch of tropical forest is cleared, vegetation slashed, destroyed and burned. Crops are grown as long as the soil is productive, after which the cultivation is abandoned and cultivators move on to fresh patch of land. The abandoned land was allowed to lay fallow for long periods during which regrowth of vegetation took place and natural ecosystem was restored. Shifting cultivators, therefore, worked in harmony with nature. However, the demands of growing population have shortened the fallow periods drastically. The soil is unable to regain its fertility before it is put to use again.

(4) Cattle Ranching:

Large areas of tropical forests in North Eastern States have been cleared for use as grazing land to raise cattle and agricultural purpose. The soil degenerates within a short span of time due to over-grazing and massive soil erosion occurs.

(5) Firewood Collection:

To majority of rural population and a large number of people living in small towns and cities of developing countries, the only fuel is wood which is burned to cook food and to provide heat in chilly winters. Firewood collection contributes much to the depletion of tree cover, especially in localities which are lightly wooded. Denser forests usually produce a lot of combustible material in the form of dead twigs, leaves etc. There is hardly any need of cutting down live trees in densely wooded localities. However, in the case of lightly wooded forests, where the pressure of demand is usually higher, a slow thinning of woodland occurs due to regular foraging of villagers. In Madhya Pradesh, India, a recent observation revealed that felling of small trees for use as firewood and timber exceeds fresh plant growth. In some places in the state, the Government! Allows people to collect head loads of dead wood from forests for personal use.

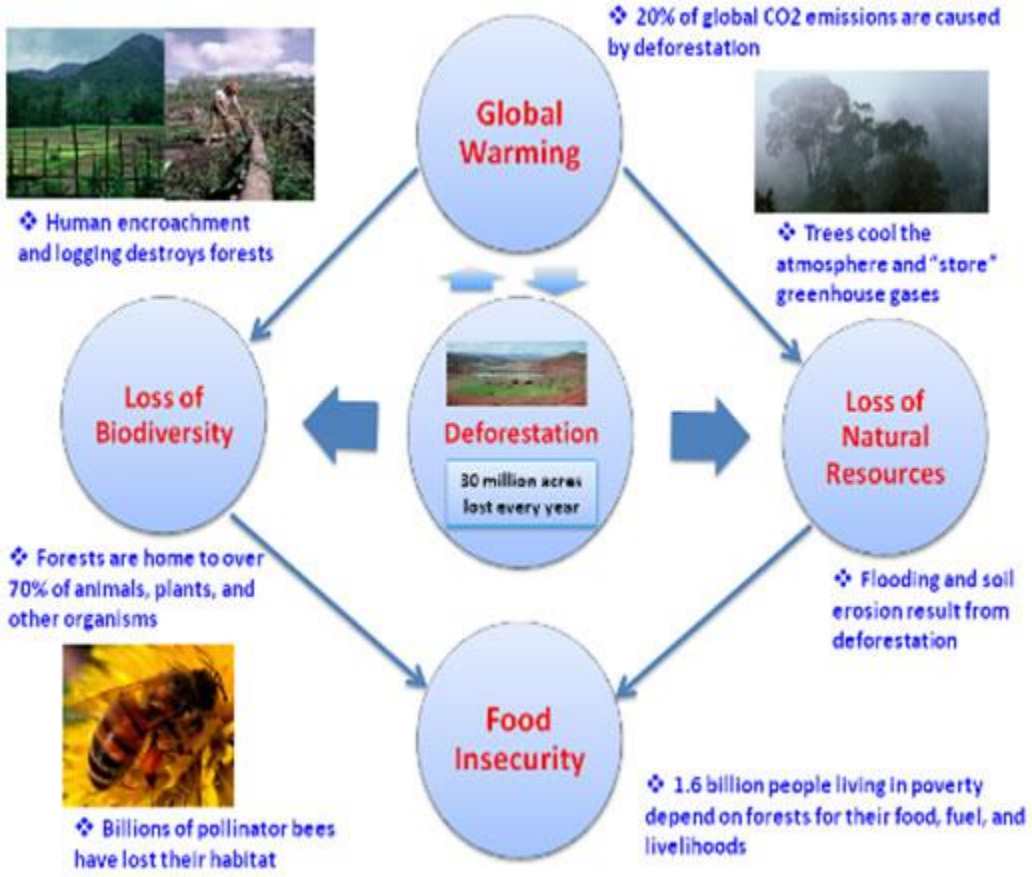
(6) Timber Harvesting:

Timber resource is an important asset for a country's prosperity. Commercial wood finds ready national as well as international markets. As a consequence of which natural forests are being mercilessly exploited. Logging or felling of forest trees for obtaining timber is an important cause of deforestation in third world countries. Live trees with thick and straight trunks are felled and transported to commercial establishments elsewhere, to consumers who are ready to pay. In the process large stretches of forests are damaged and the system which could have provided resources worth much more to the local people is disrupted. Ironically the profits from timber trade are enjoyed by Governments, large companies or affluent contractors. Local people get a tiny share in the benefits while axing their own resource base.

Commercial logging in tropical countries usually involves felling of trees of only selected species which fetch better prices. This process of creaming or removing a few selected trees amidst dense vegetation on rather a delicate soil causes much more destruction than the actual number of trees or the volume of timber taken out would suggest. The selective harvesting practiced by loggers leave many forests permanently deficient in valuable plant species. Much of the West Africa has become useless for commercial logging as important plant species required by the loggers are not available. In Philippines, the valuable groups of tall trees (Dipterocarpus sp.) have shrunk from original 16 million hectares in

1960, to about one million hectares left standing in remote regions.
The practice of cutting down larger trees, of the selected species, leaving behind younger ones which can grow into fresh stock to be harvested later may appear rational. In theory such patch should become ready for reharvesting within thirty to forty years. However, in practice none of the loggers leaves the required number of younger trees and the notion that the woodland shall be ready for another valuable timber harvest in forty years appears to be a wistful thinking at its best.

Consequences of Deforestation



Forest Management

Of various factors employed in forest management, restrained felling, block and selective cutting, reforestation and recycling of forest products are most important practices.

3.2. Wild life

It was once customary to consider all undomesticated species of vertebrate animals as wildlife. Birds and mammals still receive the greatest public interest and concern, consistently higher than those expressed for reptiles and amphibians. Most concern over fishes results from interest in sport and commercial value. The tendency in recent years has been to include more life-forms under the category

of wildlife. Thus, mollusks, insects, and plants are all now represented on national and international lists of threatened and endangered species.

People find many reasons to value wildlife. Virtually everyone appreciates the aesthetic value of natural beauty or artistic appeal present in animal life. Giant pandas, bald eagles, and infant harp seals are familiar examples of wild-life with outstanding aesthetic value. Wild species offer recreational value, the most common examples of which are sport hunting and bird watching.

Less obvious, perhaps, is ecological value, resulting from the role an individual species plays within an ecosystem. Alligators, for example, create depressions in swamps and marshes. During periods of droughts, these "alligator holes" offer critical refuge to water-dependent life-forms. Educational and scientific values are those that serve in teaching and learning about biology and scientific principles. Wildlife also has utilitarian value which results from its practical uses. Examples of utilitarian value range from genetic reservoirs for crop and livestock improvement to diverse biomedical and pharmaceutical uses. A related category, commercial value, includes such familiar examples as the sale of furs and hunting leases.

To define as the uncultivated flora and the undomesticated fauna amongst the plants and animals or any form existing in natural surroundings, Provides aesthetic, recreations and economic benefits. For maintaining the balance of nature, wildlife plays an integral part. In biodiversity of life forms, India is the 2nd largest country in the world and Africa stands first.

Wildlife includes 350 spp of mammals, 1200 spp of birds and more than 20,000 spp insect and countless number of plant species. Today wildlife species are gradually disappearing and number is becoming reduced. Many species of wildlife have become the way of extinction.

Basic reasons for the extinction of wildlife:

i) Destruction of their natural habitat due to expanding agriculture, urbanization and industrialization.

ii) Overgrazing by domestic animals that convert the area into deserts.

iii) Hunting/poaching on a large scale for meat, fur, ivory etc-commercial exploitation.

iv) Export of some species.

v) An unbalanced sex ratio

vi) Some species are narrowly restricted to an area.

Vii) Natural processes are also cause a decline in the population. Low population may external and new population colonizes, when death exceeds birth rate.

Data regarding all endangered plant and animal species are recorded in red data book. According to RDB of IUCNNR (International Union for Conservation of Nature and Natural Resources) more than 1000 creatures are threatened with extinction. Among these, most immediate danger are all species of rhinoceros, Siberian tigers, Mexican gizzly bear, Red wolf, Mountain gorilla, Asiatic lion. In plants, more than 450 plant species are identified as endangered and threatened.

Wildlife Management and Conservation:

The conservation is the practice of preservation, maintenance, sustainable utilization, restoration and

enhancement of the natural environment. Conservation is judicious management of resources towards their optimum utilization. Wild life management includes maintenance of habits suitable to the different species. Both governmental and non-governmental and voluntary organizations at state and central levels have been set up to protect wildlife. Ministry of Environment and Forest has been entrusted with the task of environmental protection.

Wildlife Management:

- Protection of natural habitats through controlled, limited exploitation of species.
- Maintenance of the viable number of species in protected areas (National Park, Sanctuary, Biosphere reserve etc.)
- Establishment of Biosphere Reserves for plants and animal species
- Protection through legislation.
- Improving the existing protected areas.
- Imposing restrictions on export of rare plant and animal species and their products.
- Educating public for environmental protection at all levels of education.

Governmental Organizations:

- Indian Board of Wildlife (IBWC), 1952
- Madras Wild Elephant Preservation Act, 1873
- All-India Elephant Preservation Act, 1879
- The Wild Birds and Animals Protection Act, 1912
- Bengal Rhinoceros Preservation Act, 1932
- Assam Rhinoceros Preservation Act, 1954
- Wildlife (Protection) Act, 1972
- Becoming a Part to CITES,1976

9. Committee for Biosphere Reserve, 1972.
10. Projects to conserve endangered species

Project Tiger

The main objective of Project Tiger is to ensure a viable population of tiger in India for scientific , economic , aesthetic , cultural and ecological values and to preserve for all time, areas of biological importance as a natural heritage for the benefit, education and enjoyment of the people. Initially, the Project started with 9 tiger reserves, covering an area of 16,339 sq.km., with a population of 268 tigers. At present there are 27 tiger reserves covering an area of 37761 sq.km., with a population of 1498 tigers. This amounts to almost 1.14% of the total geographical area of the country. The selection of reserves was guided by representation of ecotypical wilderness areas across the biogeographic range of tiger distribution in the country. Project Tiger is undisputedly a custodian of major gene pool. It is also a repository of some of the most valuable ecosystem and habitats for wildlife.

Tiger Reserves are constituted on a 'core-buffer' strategy. The core area is kept free of biotic disturbances and forestry operations, where collection of minor forest produce, grazing, human disturbances are not allowed within. However, the buffer zone is managed as a 'multiple use area' with twin objectives of providing habitat supplement to the spillover population of wild animals from the core conservation unit, and to provide site specific ecodevelopmental inputs to surrounding villages for relieving their impact on the core. Project Tiger has put the tiger on an assured course of recovery from the brink of extinction, and has resurrected the floral and faunal genetic diversity in some of our unique and endangered wilderness ecosystem. The population of tigers in the country has increased significantly to about 4000 from less than 2000 at the time of launch of the project
The effective protection and concerted conservation measures inside the reserves have brought about considerable intangible achievements also, viz. arresting erosion, enrichment of water regime thereby improving the water table and overall habitat resurrection. Labour intensive activities in tiger reserves have helped in poverty alleviation amongst the most backward sections, and their dependence on forests has also reduced.

IX PLAN ACHIEVEMENT OF PROJECT TIGER DIVISION

- During the VIII plan period the budget outlay for Project Tiger Scheme was Rs. 40.00 Crores. During the IX plan the budget outlay was substantially increased to rs. 75.00 Crores.
- During the IX Plan, Project Allowance to an extant of Rs. 3.95 Crores to field level staff was funded under this scheme for the first time.
- During this Plan period funds to an extant of Rs. 2.49 Crores has been released for creation of Strike Force to combat the growing insurgency and extremist situations within the Tiger Reserves.
- During the Plan period four new Tiger Reserves were declared, namely

No.	Tiger Reserve	State	Year of Formation	Area(sq. Kms.)	Funds released
1	Bhadra	Karnataka	1998-99	492	318.459
2	Pench	Maharashtra	1998-99	257	223.421
3	Pakui-Nameri	Arunachal Pradesh / Assam	1999-2000	1206	93.100
4	Bori-Satpura Panchmarhi	Madhya Pradesh	1999-2000	1486	75.220
				3441	**710.200**

- The effective protection and concerted conservation measures inside the reserves have brought about considerable intangible achievements also viz. arresting erosion, enrichment of water

regime and thereby improving the water table and overall habitat resurrection. Labour intensive activities in tiger reserves have helped in poverty alleviation of the most backward sections and their dependence on forests has also reduced. The project has been instrumental in mustering local support for conservation programme in general.

- During the X Plan, it is envisaged to carry out on the Project with further impetus on people's support for conservation of nature and natural resources.

India has taken several steps in recent times to protect the tiger and other wildlife species :

- Setting up the Subramanium Committee to look into the issue of prevention of illegal trade in wildlife and wildlife products. The recommendations of this Committee are, however, yet to be enforced.
- Setting up the J.J.Dutta Committee to review the management of the tiger project and suggest the future course of action.
- Organising training of various enforcement agencies in the Wildlife Institute of India for species conservation.
- Organising an enforcement training workshop in New Delhi, with the help of the US Fish and Wildlife Service and CITES for the enforcement agencies like Customs, Revenue Intelligence, Indo-Tibetan Border Police, Coast Gaurds, Border Security Force, State Police, Deputy Directors of Wildlife Preservation and Scientific Organisation like BSI and ZSI.
- Setting up of a National Coordination Committee for the control of poaching and illegal trade in wildlife with enforcement agencies mentioned above as well as the Army, the Postal Department and so on.
- The eco-development programme has been taken up around the major protected areas for winning over the support of the fringe dwellers to the cause of wildlife conservation including tiger under national schemes.
- Initiating India's Eco-development Project under the Global Environment Facility (GEF) in seven protected areas which include seven prime tiger habitats (five tiger reserves).
- Launching of a public awareness programme to involve NGOs and others for supporting the government in its efforts at tiger conservation.
- Supporting programmes of some institutions and NGOs in exploring tiger trade routes and developing a forensic identification reference manual for tiger parts and products.
- Taking initiatives with the Government of Nepal and Government of China to evolve an effective strategy to control trafficking of tiger products across international borders.

Gir Lion Project
Asiatic Lion habitat, distribution and population

Asiatic Lion at Gir

The Asiatic Lions habitat is dry scrub land and open deciduous forest. These lions were once found across northern Africa, south west Asia and northern Greece. Now there are only around 411 left in the wild and all of them are in or around the Gir Forest National Park. The first modern day count of lions was done by Mark Alexander Wynter-Blyth, the Principal of Rajkumar College, Rajkot sometime between 1948 to 1963, probably early in his tenure as the Principal during that period. Even though the Gir Forest is well protected, there are instances of Asiatic Lions being poached. They have also been poisoned for attacking livestock. Some of the other threats include floods, fires and the possibility of epidemics and natural calamities. Gir nonetheless remains the most promising long term preserve for them.

The Lion Breeding Programme creates and maintains breeding centres. It also carries out studies of the behaviour of the Asiatic lions and also practices artificial insemination. One such centre has been established in the Sakkarbaug Zoo at the district headquarters of Junagadh, which has successfully bred about 180 lions. 126 pure Asiatic lions have been given to zoos in India and abroad.
The census of lions takes place every five years. Previously indirect methods like using pugmarks of the lion were adopted for the count. However, during the censusof April 2005 (which originally was scheduled for 2006, but was advanced following the reports and controversy over vanishing tigers in India), "Block-Direct-Total Count" method was employed with the help of around 1,000 forest officials, experts and volunteers. It means that only those lions were counted that were "spotted" visually. Use of "live bait" (a prey that is alive and used as a bait) for the exercise, though thought to be a traditional practice, was not used this time. The reason believed to be behind this is the Gujarat High Court ruling of 2000 against such a use of animals.
Gir National Park and Sanctuary does not have a designated area for tourists. However, to reduce the tourism hazard to the wildlife and to promote nature education, an Interpretation Zone has been created at Devalia within the sanctuary. Within its chained fences, it covers all habitat types and

wildlife of Gir with its feeding-cum-living cages for the carnivores and a double-gate entry system. The Government of India, with all its political will, is endeavouring to reinforce tiger conservation programmes in the country. The Ministry of Environment & Forests, has been convening regular meetings of the Steering Committee of Project Tiger and the Tiger Crisis Cell to introduce additional measures for the protection of the tiger and its habitat. The Union Home Minister has also issued a letter to all the Chief Ministers to take appropriate steps for conserving wildlife. Further, acknowledging the written request of the Ministry for according high priority to tiger conservation programmes in the wake of the renewed tiger crisis, the Prime Minister during the Indian Board of Wildlife meeting held in March, 1997 has assured full government support and also proposed to convene a meeting of chief ministers in the near future to discuss wildlife issues.
However, in order to resolve the present tiger crisis the following issues need special attention:-

1. Since more than half of the tiger population of the country is found outside the tiger reserves, there is an urgent need to introduce a special programme for protection: One of the measures to counter the threat is to include more new areas into the fold of Project Tiger.
2. To curb poaching in tiger reserves, it is necessary to create a "Strike Force" in every reserve.
3. At least five tiger reserves, i.e. Palamau and Valmiki in Bihar, Manas (Assam), Indravati (M.P.) and Nagarjunsagar (Andhra Pradesh) are facing serious problems due to the insurgents/criminals seeking refuge in them. To bring about normalcy, deployment of central armed forces is urgently needed.
4. In view of the large scale illegal trade of tiger parts in big cities, new strategies, based on identification of bottlenecks, need to be introduced. This would inevitably involve an in situ conservation mechanism, strengthening of Central Wildlife Enforcement Agencies and greater financial assistance to the states.
5. In order to address all these issues, a substantial increase in the Project Tiger budget would be essential during the Ninth Plan period. A proposal to this effect has already been sent by the Ministry to the Planning Commission for allocating Rs.90 crores under the Project Tiger Scheme for the current Plan.

Biosphere Reserves:
Biosphere reserves programme was launched by UNESCO with the following objectives:

- Conserve representative samples of ecosystems
- Provide long-term *in-situ* conservation of genetic diversity
- Promote and facilitate basic and applied research and monitoring
- Provide opportunities for education and training
- Promote appropriate sustainable management of living resource
- Disseminate the experience so as to promote sustainable development
- Promote international co-operation

- It includes conservation, research, education and local involvement.
- Participation of local people in the management
    - Research
    - Monitoring
    - Training and education through organizing environmental centers are among the important features of the programme.
- World: 234 BSR in 65 countries - covering 115 million ha.
- BSR - include natural, minimally disturbed, man modified and degraded ecosystem.
    - **India first Biosphere Reserve came into being in 1986 - Nilgiri BSR - covering 5520 km**
    - **Second: Nanda Devi Biosphere reserves - 1560 sq.m.**
    - **Third: Nokrek 1988 -** Great Nicobar in 1989
- Ecological development programmes in the areas surrounding biosphere reserves.

Location of biosphere reserve in the country:

Biosphere reserve	**States / U.T**
Namdapha	Arunachal Pradesh
Uttarakhand (Valley of flowers)	Uttar Pradesh
Gulf of Mannar	Tamil Nadu
Sunderbans	West Bengal
Thar Desert	Rajasthan
Manas	Assam
Little Rann of Kutch	Gujarat
North Islands of Andamans	Andaman and Nicobar
Nanda Devi	Uttar Pradesh
Kaziranga	Assam
Kanha	Madhya Pradesh
Nokrek (Tura Range)	Meghalaya
Nilgiris	Karnataka, Kerala and Tamil Nadu

For management of endangered species especially, medicinal plants, programmes on biology and tissue culture have to be initiated to conserve *in situ* and mass multiplication of species. The programme includes identification and enumeration of eco-system on regional basis, systematic studies on reproductive biology, gene pool conservation, artificial propagation in natural habitats, development of tissue culture techniques for mass multiplication and domestication and cultivation of selected threatened species.

Mangrove Forest

Mangroves (generally) are trees and shrubs that grow in saline (brackish) coastal habitats in the tropics and subtropics. The word is used in at least three senses: (1) refers to the habitat and entire plant assemblage or **mangal**, for which the terms **mangrove swamp** and **mangrove forest** are also used,

(2) refers to all trees and large shrubs in the mangal, and (3) refers to the mangrove *family* of plants, the Rhizophoraceae, or even more specifically just to mangrove trees of the genus*Rhizophora*. Mangals are found in depositional coastal environments where fine sediments, often with high organic content, collect in areas protected from high energy wave action.

Above and below water view at the edge of the mangal

About 110 species have been identified as belonging to the mangal. Each species has its own capabilities and solutions to these problems; this may be the primary reason why, on some shorelines, mangrove tree species show distinct zonation. Small environmental variations within a mangal may lead to greatly differing methods of coping with the environment. Therefore, the mix of species at any location within the intertidal zone is partly determined by the tolerances of individual species to physical conditions, like tidal inundation and salinity, but may also be influenced by other factors such as predation of plant seedlings by crabs.

A cluster of mangroves on the banks of the Vellikeel River in Kannur District of Kerala,

Once established, roots of mangrove plants provide a habitat for oysters and help to impede water flow, thereby enhancing the deposition of sediment in areas where it is already occurring. Usually, the fine, anoxic sediments under mangroves act as sinks for a variety of heavy (trace) metals which are scavenged from the overlying seawater by colloidal particles in the sediments. In areas of the world where mangroves have been removed for development purposes, the disturbance of these underlying sediments often creates problems of trace metal contamination of seawater and biota.

Mangroves protect the coast from erosion, surge storms (especially during hurricanes), and tsunamis. Their massive root system is efficient at dissipating wave energy. Likewise, they slow down tidal water enough that its sediment is deposited as the tide comes in and is not re-suspended when the tide leaves, except for fine particles. As a result, mangroves build their own environment. Because of the uniqueness of the mangrove ecosystems and their protection against erosion, they are often the object of conservation programs including national Biodiversity Action Plans.

Despite their benefits, the protective value of mangroves is sometimes overstated. Wave energy is typically low in areas where mangroves grow, so their effect on erosion can only be measured in the long-term. Their capacity to limit high-energy wave erosion is limited to events like storm surges and tsunamis. Erosion often still occurs on the outer sides of bends in river channels that wind through mangroves, just as new stands of mangroves are appearing on the inner sides where sediment is accreting.

Mangroves support unique ecosystems, especially on their intricate root systems. The mesh of mangrove roots produces a quiet marine region for many young organisms. In areas where roots are permanently submerged, they may host a wide variety of organisms, including algae, barnacles, oysters, sponges, andbryozoans, which all require a hard substratum for anchoring while they filter feed. In some cases, export of carbon fixed in mangroves is important in coastal food webs. The habitats also host several commercially important species of fish and crustaceans. Despite replanting programs, over half of the world's mangroves have been lost in recent times.

The Sundarbans is the largest mangrove forest in the world, located in the Ganges delta in Bangladesh and West Bengal, India. There are major mangals in theAndaman and Nicobar Islands and the Gulf of Kutch in Gujarat. Other significant mangals include the Bhitarkanika Mangroves and Godavari-Krishna mangroves. ThePichavaram Mangrove Forest near Chidambaram, South India is the second largest mangrove forest in the world. It is home to a large variety of birds—local resident, migratory resident and the pure migratory birds—and is separated from the Bay of Bengal by a lovely beach. It is one of those rare mangrove forests which has actually increased by 90% between 1986 and 2002.

3.3.Energy sources

Fossil fuels such as coal, gas or oil represent the principal source of energy and supply about eighty five per cent of the commercial energy requirement. Fossil fuels are types of sedimentary organic

materials, often loosely called bitumens, with asphalt, a solid, and petroleum, the liquid form. More correctly bitumens are sedimentary organic materials that are soluble in carbon disulfide.
Petroleum consists largely of paraffins or simple alkanes, with smaller aromatic compounds such as benzene present in most crude oils. Natural gas is an abundant fossil fuel that consists largely of methane and ethane, although traces of higher alkanes are present. Coal, unlike petroleum, contains only a little hydrogen. Fossil evidence shows that coal is mostly derived from the burial of terrestrial vegetation with high proportion of lignin and cellulose.
Nuclear power is an attractive alternative to fossil fuels and considered as "the clear energy alternative". Damming rivers to create hydroelectric power from spinning water turbines has the attraction of providing a low-cost, renewable, air pollution-free energy source.
There are several sustainable, environmentally benign energy sources that should be developed. Among these are wind power, biomass (burning renewable energy crops such as fast-growing trees or shrubs), small-scale hydropower (low head or run-of the river turbines), passive-solar space heating, active-solar water heaters, photovoltaic energy (direct conversion of sunlight to electricity), and ocean tidal or wave power. A big disadvantage is that most of these alternative energy sources are diffuse and not always available when or where we want to use energy.
Other possibilities include converting biomass into methane or methanol fuels or using electricity to generate hydrogen gas through electrolysis of water. These fuels would be easily storable, transportable, and used with current technology without great alterations of existing systems.

Conventional exhaustible energy sources:

a) Fire wood:

Man has been logging down the trees for various purposes including to get firewood as an important one. This lead to thinning of woodland that had serious consideration from both ecological and economic viewpoints. The only way out to the problem is making available to the village the cheaper non-conventional energy sources, such as biogas and solar energy in usable form.

b) Fossil fuel :

Are the most extensively used sources of energy today. Increase in population and percapital energy demand coupled with the industrialization at a faster rate are factors responsible for depletion of fossil fuel. Petroleum and natural gas to-day fulfill 60% of the world's total energy requirements. If the exploitation and consumption of these resources continues at the present incredible rate, there supply may lost only for a few more decades.

Non-conventional and in-exhaustible energy sources:

The rapid depletion of conventional energy sources has promoted governments and people to concentrate on finding and tapping some non-conventional energy sources that may last for long. The in-exhaustible energy sources like solar, hydal, tidal, wind and atomic power, can only bring hope for the sustained socio-economic development of humanity.

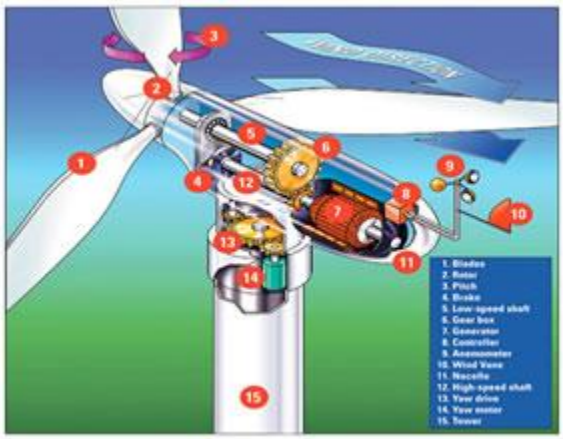
a) Solar energy:

Research and application in the field of solar energy have opened new vistas in the direction of fulfilling world's future energy requirements. It is especially drawn attention for its practically free

steady supply and pollution free use. This resource can especially be tapped more effectively in the regions where there are long run shine hours. Department of non-conventional energy sources of Government of India has prepared a prespective plan that envisages generation of energy through non-conventional sources. Chiefly solar, to the extent of 250 million tons of coal replacement per annum

b) Wind Power:

The power of wind is being used in running mills, irrigation of fields and carrying out other farm activities. According to DNES, Government of India, 20,000 MW electricity can be generated from the wind alone.



c) Hydro power:

It is considered to be the cheapest source of electricity. The Brahmaputra basin has the highest hydropower potential and nearly 30% of the country's production. Next to it rank the Indus, Godavari and Ganga basins respectively. Apart from economic consideration development of such projects is beneficial for irrigation and other purposes.

d) Atomic power:

Atomic power appears to be the only hope for large-scale energy requirements when fossil fuels are exhausted. Atomic energy has its application not only in generation of electricity but has successfully been used in chemical and food processing industry. The important constraints in atomic energy generation are cost of construction and maintenance of plants and also disposal of radioactive wastes.

e) Bio-energy:

Organic wastes provide an important renewable source of energy. It is considered to be advantageous in view of its relatively cheaper supply, and are of organic wastes in its generation reduces the impending threat of pollution due to their release in environment. As such, it serves two purposes; fuel production and waste disposal. It has more practical applicability in villages where organic waste, in the form of cattle dung, is available in plenty. Biogas so generated is thus economic and convenient to use as compared to conventional practice of burning of dry dung cakes.

Since the total natural resources available are limited, the way-out to the problem seems only through control of population and also the per capita consumption of resources. Because it is difficult to bring down per capita consumption, the recycling and stringent conservation can bring hope for sustained development without reducing per capita use of resources.

3.4. Food Resources

We have thousands of edible plants and animals over the world, out of which only about three dozen types constitute the major food of humans. The main food resource include wheat, rice, maize, potato, barely, oats, cassava, sugarcane, pulses, sorghum, millet, about 20 or 50 common fruits and vegetables, milk, meat, fish and sea food. 76% of world food is produced from croplands and most it produced grains. About 17% of world food is obtained from Rangeland (Meat etc). Seven % of world food supplied by oceanic fisheries. About 30,000 plant species are eatable. 2/3 of the people used traditional

grains (rice, wheat etc.,). People consume more beef, pork, chicken; egg etc., Fish and sea food are the important sources of food. Milk products are also widely used.

World Food Problems

- The world population increases and cultivable land area decreases.
- Due to the inadequate rainfall, the productivity of food is reduced by every year.
- Environmental degradation like soil erosion, water logging, water pollution, salinity, affects agricultural lands.
- Urbanization is another problem for the reduction of agricultural lands.

Indian Scenario

- India is the 3rd largest producer of crops, but 300 million Indians are still undernourished
- Land wise, India is only half as much of USA, but population wise three times higher.
- Food problem is directly related to population growth.

Under Nutrition and Malnutrition

To maintain good health and resistant disease, we need large amount of macronutrients such as carbohydrates, proteins, fats and smaller amount of micronutrients such as vitamins A,C and E and minerals such as iron, calcium and iodine.

a) Under nutrition

- The Food and Agriculture Organization (FAO) of United Nations estimated that on an average, minimum calorie intake on a global scale is 2,500 calories per day.
- Peoples receiving less than 90% of these minimum dietary calories are called under nourished.
- If it is less than 80% that are said to be seriously undernourished.
- People who cannot buy enough food to meet their basic energy needs (carbohydrates) suffer from under nutrition.

Effects

They are suffering from mental retardation and infectious diseases such as measles and diarrhea.

b) Malnutrition

- Besides, the minimum calorie intake, we also need proteins, minerals etc.,
- Deficiency or lack of nutrition often leads to malnutrition.

Effects of malnutrition

S.No	Deficiency of nutrient	Effects
1	Proteins	Growth
2	Iron	Aneamia
3	Iodine	Goitre, Cretinism
4	Vitamin A	Blindness

- Thus chronically under nourished and malnourished people are diseases prone

  and are too weak to work or think clearly.

- The world Food summit,1996 has set the target to reduce the number of under

nourished to just half by 2015 which still means 410 million undernourished people on the earth.

Food Distribution around the World and Their Problems

- During the last 50 years world grain production has increased almost three times. But, at the same time, population growth increased at such a rate in LDCs (Less Developed Countries).
- Every year 40 million people (50% of children (15 year) die on undernourishment and malnutrition. This means that every year our food problem is killing as many people were killed by the atomic bomb dropped on Hiroshima during World War II.
- In countries like North America and Europe the daily average calorie intake is about 3500 cals, which is nearly one-third more than that required for healthy living.

Indian Scenario

Although India is the third largest producer of stable crops, an estimated 300 million Indians are still undernourished. Indians has only half as much land as USA, but it has nearly three times population to feed. Our food problems are directly related to population. The world Food summit, 1996 has set the target to reduce number of under nourished to just half by 2015, which still means 410 million undernourished people on the earth.

Lecture 04

Ecosystems: Definition, concept, structure and functions

Ecology is the science that deals with the relationships between living organisms with their physical environment and with each other. Ecology can be approached from the viewpoints of (1) the environment and the demands it places on the organisms in it or (2) organisms and how they adapt to their environmental conditions. An ecosystem consists of an assembly of mutually interacting organisms and their environment in which materials are interchanged in a largely cyclical manner. An ecosystem has physical, chemical, and biological components along with energy sources and pathways of energy and materials interchange. The environment in which a particular organism lives is called its habitat. The role of an organism in a habitat is called its niche.

For the study of ecology it is often convenient to divide the environment into four broad categories.

- Terrestrial environment - The terrestrial environment is based on land and consists of biomes, such as grasslands, one of several kinds of forests, savannas, or deserts.
- Freshwater environment - The freshwater environment can be further subdivided between *standing-water habitats (*lakes, reservoirs) and *running-water habitats (*streams, rivers).
- Oceanic marine environment - The oceanic marine environment is characterized by saltwater and may be divided broadly into the shallow waters of the continental shelf composing the neritic zone
- Oceanic region - The deeper waters of the ocean that constitute the oceanic region.

Two major subdivisions of modern ecology are

- Ecosystem ecology - which views ecosystems as large units, and
- Population ecology - which attempts to explain ecosystem behavior from the properties of individual units.

In practice, the two approaches are usually merged. Descriptive ecology describes the types and nature of organisms and their environment, emphasizing structures of ecosystems and communities and dispersions and structures of populations. Functional ecology explains how things work in an ecosystem, including how populations respond to environmental alteration and how matter and energy move through ecosystems.

Ecosystems are broadly divided into natural and artificial. *Natural ecosystems* are those that are existing in nature; they are further classified into terrestrial and aquatic. Terrestrial includes hot desert, grass

land, tropical and temperate rainforest and *aquatic* includes ponds, river, streams, lakes, estuaries, oceans, mangroves, swamps and bays etc. However these two ecosystems are self regulating, open system with a free exchange of inputs and outputs with other systems. Artificial ecosystems are simple, human-made, unstable and subjected to human intervention and manipulation. Usually it is formed by clearing a part of the forest or grassland e.g. crop field, agricultural land.

Structure and Function of an ecosystem

An ecosystem has two components the biotic components consisting of living things, and the abiotic portion, consisting of elements that are not alive. The non living constituents are said to include the following category, habitat, gases, solar radiation, temperature, moisture and inorganic and organic nutrients. The living organisms may be sub divided into producers, consumers and decomposers. Abiotic Components include basic inorganic and organic components of the environment or habitat of the organism. The inorganic components of an ecosystem are carbon dioxide, water nitrogen, calcium phosphate all of which are involved in matter cycle (biogeochemical cycles). The organic components of an ecosystem are proteins, carbohydrates, lipids and amino acids, all of which are synthesized by the biota (flora and fauna) of an ecosystem and are reached to ecosystem as their wastes, dead remains etc. the climate 'microclimate' temperature, light soil etc. are abiotic components of the ecosystems.

Functions of an Ecosytem

Ecosystem function is the capacity of natural processes and components to provide goods and services that satisfy human needs, either directly or indirectly. Ecosystem functions are subset of ecological processes and ecosystem structures. Each function is the result of the natural processes of the total ecological sub-system of which it is a part. Natural processes, in turn, are the result of complex interactions between biotic (living organisms) and abiotic (chemical and physical) components of ecosystems through the universal driving forces of matter and energy. **There are four primary groups of ecosystem functions** (1) regulatory functions, (2) habitat functions, (3) production functions and (4) information functions. This grouping concerns all ecosystems, not only for forests.

General characterization of ecosystem functions are:

(1) Regulatory functions: this group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through bio-geochemical cycles and other biospheric processes. In addition to maintaining the ecosystem (and biosphere health), these regulatory functions provide many services that have direct and indirect benefits to humans (i.e., clean air, water and soil, and biological control services).

(2) Habitat functions: natural ecosystems provide refuge and a reproduction habitat to wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and the evolutionary process.

(3) Production functions: 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. This broad diversity in carbohydrate structures provides many ecosystem goods for human consumption, ranging from food and raw materials to energy resources and genetic material.

(4) Information functions: Since most of human evolution took place within the context of an undomesticated habitat, natural ecosystems contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience.

Components of an ecosystem: Complete ecosystem consists of four basic components such as producers, consumers, decomposers and abiotic components e.g. Pond. If anyone of these four components are lacking, then it is grouped under incomplete ecosystem e.g. Ocean depth or a cave.

Productivity in the Environment: The productivity of an ecosystem is the rate at which solar energy is fixed by the vegetation of the ecosystem; it is further classified into primary productivity, secondary productivity and net productivity.

Primary productivity refers to the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers; it is further distinguished as gross primary productivity (GPP) and net primary productivity (NPP). It is expressed in terms of weight (g/m2/yr) or energy (kcal/m2).

Secondary productivity refers to the rates of energy storage at consumer levels.

An understanding of ecology is essential in the management of modern industrialized societies in ways that are compatible with environmental preservation and enhancement. The branch of ecology that deals with predicting the impacts of technology and development and making recommendations such that these activities will have minimum adverse impacts, or even positive impacts, on ecosystems may be termed as Applied Ecology. It is a multidisciplinary approach .

Interactions among living organisms are grouped into two major groups *viz*.,

- Positive interactions
- Negative interactions

I. Positive interactions

Here the populations help one another, the interaction being either one way or reciprocal. These include (i) Commensalism, (ii) Proto co-operation and (iii) mutualism.

1. Commensalism

In this one species derives the benefits while the other is unaffected.

Eg. (i) Cellulolytic fungi produce a number of organic acids from cellulose which serve as carbon sources for non-cellulolytic bacteria and fungi.

(ii) Growth factors are synthesised by certain microorganisms and their excretion permits the proliferation of nutritionally complex soil inhabitants.

2. Proto-cooperation

It is also called as non-obligatory mutualism. It is an association of mutual benefit to the two species but without the co-operation being obligatory for their existence or for their performance of reactions.

Eg. N2 can be fixed by *Azotobacter* with cellulose as energy source provided that a cellulose decomposer is present to convert the cellulose to simple sugars or organic acids.

3. Mutualism

Mutually beneficial interspecific interactions are more common among organisms. Here both the species derive benefit. In such association there occurs a close and often permanent and obligatory contact more or less essential for survival of each.

Eg. (i) Pollination by animals. Bees, moths, butterflies etc. derive food from hectar, or other plant product and in turn bring about pollination.

(ii) Symbiotic nitrogen fixation:

Legume - *Rhizobium* symbiosis. Bacteria obtain food from legume and in turn fix gaseous nitrogen, making it available to plant.

II. Negative interactions

Member of one population may eat members of the other population, compete for foods, excrete harmful wastes or otherwise interfere with the other population. It includes (i) Competition, (ii) Predation, (iii) Parasitism and (iv) antibiosis.

(i) Competition

It is a condition in which there is a suppression of one organism as the two species struggle for limiting quantities of nutrients O2 space or other requirements.

Eg. Competition between *Fusarium oxysporum* and *Agrobacterium radiobacter*.

(ii) Predation

A predator is free living which catches and kills another species for food. Most of the predatory organisms are animals but there are some plants (carnivorous) also, especially fungi, which feed upon other animals.

Eg. (i) Grazing and browsing by animals on plants.

(ii) Carnivorous plants such as *Nepenthes, Darligtoria, Drosera* etc. consume insects and other small animals for food.

(iii) Protozoans feeding on bacteria.

(iii.) Parasitism

A parasite is the organism living on or in the body of another organisms and deriving its food more or less permanently from its tissues. A typical parasite lives in its host without killing it, whereas the predator kills its upon which it feeds.

Eg. Species of *Cuscuta* (total stem parasite) grow on other plants on which they depend for nourishment.

Parasitism may occur even with in the species. Hyperparasites which are chiefly fungi growing parasitically on other parasites, (ie) Parasite on a parasite.

Eg. *Cicinnobolus cesatii* is found as hyperparasite on a number of powdery mildew fungi.

(iv) Antibiosis

The phenomenon of the production of antibiotic is called as antibiosis. Antibiotic is an organic substance produced by one organism which in low concentration inhibits the growth of other organism.

Eg. Streptomycin - *S.griseus* , Penicillin - P. *notatum* , *Trichoderma harzianum* inhibits the growth of *Rhizoctonia* sp.

Matter and cycles of matter

Biogeochemical cycles describe the circulation of matter, particularly plant and animal nutrients, through ecosystems. These cycles are ultimately powered by solar energy, fine-tuned and directed by energy expended by organisms. In a sense, the solar-energy-powered hydrologic cycle acts as an endless conveyer belt to move materials essential for life through ecosystems.

Most biogeochemical cycles can be described as elemental cycles involving nutrient elements such as carbon, oxygen, nitrogen, sulfur and phosphorus. Many are gaseous cycles in which the element in question spends part of the cycle in the atmosphere – O2 for oxygen, N2 for nitrogen, CO2 for carbon. Others, notably the phosphorus cycle, do not have a gaseous component and are called sedimentary cycles. All sedimentary cycles involve salt solutions or soil solutions that contain dissolved substances leached from weathered minerals that may be deposited as mineral formations or they may be taken up by organisms as nutrients. The sulfur cycle, which may have H2S or SO2 in the gaseous phase or minerals (CaSO4 2H2O) in the solid phase, is a combination of gaseous and sedimentary cycles.

Carbon Cycle

Carbon, the basic building block of life molecules, is circulated through the carbon cycle. This cycle shows that carbon may be present as gaseous atmospheric CO2, dissolved in groundwater as HCO3 or molecular CO2 (aq), in underlying rock strata as limestone (CaCO3), and as organic matter, represented in a simplified manner as (CH2O). Photosynthesis fixes inorganic carbon as biological carbon, which is a constituent of all life molecules.

An important aspect of the carbon cycle is that it is the cycle by which energy is transferred to biological systems. Organic or biological carbon, (CH2O), is an energy-rich molecule that can react biochemically with molecular oxygen, O2, to regenerate carbon dioxide and produce energy. This can occur in an organism as shown by the "decay" reaction or it may take place as combustion, such as when wood is burned.

Oxygen Cycle

The oxygen cycle involves the interchange of oxygen between the elemental form of gaseous O2 in the atmosphere and chemically bound O in CO2, H2O, and organic matter. Elemental oxygen becomes chemically bound by various energy-yielding processes, particularly combustion and metabolic processes in organisms. It is released during photosynthesis.

Nitrogen Cycle

Nitrogen, though constituting much less of biomass than carbon or oxygen, is an essential constituent of proteins. The atmosphere is 78% by volume elemental nitrogen, N2 and constitutes an inexhaustible

reservoir of this essential element. The N2 molecule is very stable so that breaking it down to atoms that can be incorporated in inorganic and organic chemical forms of nitrogen is the limiting step in the nitrogen cycle. This does occur by highly energetic processes in lightning discharges such that nitrogen becomes chemically combined with hydrogen or oxygen as ammonia or nitrogen oxides. Elemental nitrogen is also incorporated into chemically bound forms or fixed by biochemical processes mediated by microorganisms. The biological nitrogen is returned to the inorganic form during the decay of biomass by a process called mineralization.

Phosphorus cycle

The phosphorus cycle is crucial because phosphorus is usually the limiting nutrient in ecosystems. There are no common stable gaseous forms of phosphorus, so the phosphorus cycle is strictly sedimentary. In the geosphere phosphorus is held largely in poorly soluble minerals, such as hydroxyapatite, a calcium salt. Soluble phosphorus from these minerals and other sources, such as fertilizers, is taken up by plants and incorporated into the nucleic acids of biomass. Mineralization of biomass by microbial decay returns phosphorus to the salt solution from which it may precipitate as mineral matter.

Phosphorus cycle

Sulfur cycle

The sulfur cycle is relatively complex. It involves several gaseous species, poorly soluble minerals, and several species in solution. It is involved with the oxygen cycle in that sulfur combines with oxygen to form gaseous sulfur di oxide (SO2) an atmospheric pollutant, and soluble sulfate ion, (SO42-). Among the significant species involved in the sulfur cycle are gaseous hydrogen sulfide, H2S; mineral sulfides, such as PbS; sulfuric acid, H2SO4, the main constituent of acid rain; and biologically bound sulfur in sulfur-containing proteins.

Sulfur cycle

It should be obvious that material cycles, often based on elemental cycles, are very important in the environment.

Energy and cycles of energy

Biogeochemical cycles and virtually all other processes on Earth are drive by energy from the sun. The sun acts as a blackbody radiator with an effective surface temperature of 5780 K (Celsius degrees above absolute zero). It transmits energy to earth as electromagnetic radiation. The maximum energy flux of the incoming solar energy is at a wavelength of about 500 nanometers, which is in the visible region of the spectrum. A 1 square meter area perpendicular to the line of solar flux at the top of the atmosphere receives energy at a rate of 1,340 watts, sufficient, for example, to power an electric iron. This is called solar flux.

Energy in natural systems is transferred by heat, which is the form of energy that flows between two

bodies as a result of their difference in temperature, or by work, which is transfer of energy that does not depend upon a temperature difference, as governed by the laws of thermodynamics. The first law of thermodynamics states that, although energy may be transferred or transformed, it is conserved and is not lost. Chemical energy in the food ingested by organisms is converted by metabolic processes to work or heat that can be utilized by the organisms, but there is no net gain or loss of energy overall. The second law of thermodynamics describes the tendency toward disorder in natural systems. It demonstrates that each time energy is transformed; some is lost in the sense that it cannot be utilized for work, so only a fraction of the energy that organisms derive from metabolizing food can be converted to work; the rest is dissipated as heat.

Energy Flow and Photosynthesis

Whereas materials are recycled through ecosystems, the flow of useful energy may be viewed as essentially a one-way process. Incoming solar energy can be regarded as high-grade energy because it can cause useful reactions to occur, the most important of which in living systems is photosynthesis. Solar energy captured by green plants energizes chlorophyll, which in turn powers metabolic processes that produce carbohydrates from water and carbon dioxide. These carbohydrates represent stored chemical energy that can be converted to heat and work by metabolic reactions with oxygen in organisms. Ultimately, most of the energy is converted to low-grade heat, which is eventually re-radiated away from Earth by infrared radiation.

Succession

Environment is always kept on changing over a period of time due to (1) variations in climatic and physiographic factors, (2) the activities of the species of the communities themselves. These influences bring about marked changes in the dominants of the existing community, which is thus sooner or later replaced by another community at the same place. This process continues and successive communities develop one after another over the same area until the terminal final community again becomes more or less stable for a period of time. It occurs in a relatively definite sequence. This orderly change in communities is referred as succession. Odum called this orderly process as ecosystem development/ecological succession.

Succession is an orderly process of community development that involves changes in species structure and community processes with time and it is reasonably directional and therefore predictable. Succession is community controlled even though the physical environment determines the pattern.

Causes of succession

Succession is a series of complex processes, caused by (I) Initial/initiating cause: Both climatic as well as biotic. (II) Ecesis/continuing process ecesis, aggregation, competition reaction etc. (III) Stabilizing cause: Cause the stabilization of the community. Climate is the chief cause of stabilization and other factors are of secondary value.

Types of succession

- Primary succession: Starts from the primitive substratum where there was no previously any sort of living matter. The first group of organisms establishing there are known as the pioneers, primary community/primary colonizers. Very slow is the series of community changes that takes place in disturbed areas that have not been totally stripped their soil and vegetation.
- Secondary succession: Starts from previously built up substrata with already existing living matter. Action of and external force, as a sudden change in climatic factors, biotic intervention, fire etc, causes the existing community to disappear. Thus area becomes devoid of living matter but its substratum, instead of primitive is built up. Such successions are comparatively more rapid.
- Autogenic succession: Community - result of its reaction with the environment, modified its own environment and thus causing its own replacement by new communities. This course of succession is autogenic succession.
- Allogenic succession: Replacement of the existing community is caused largely by any other external condition and not by the existing organisms.
- Autotrophic succession: Characterized by early and continued dominance of autotrophic organisms like green plants. Gradual increase in organic matter content supported by energy flow.
- Heterotrophic succession: Characterized by early dominance of heterotrophs, such as bacteria, actinomyces, fungi and animals. There is a progressive decline in the energy content.

General Process of succession

(i) Nudation: Development of barren area without any form of life. Cause of nudation: It may be (a) Topographic soil erosion by wind (b) Climatic - storm, frost etc. (c) Biotic - man, disease and epidemics. (ii) Invasion: Successful establishment of a species in a barren area. This species actually reaches this new site from any other area by (i) Migration, (ii) Ecesis and (iii) Aggregation.

Slow soil development by weathering, activities of tolerant species

Pioneer Species

Retrogressive succession:

Continuous biotic influences have some degenerating influence on the process. Due to destructive effects of organisms, the development of disturbed communities does not occur. Process of succession, instead of progressive, it becomes retrogressive. (Eg.) Forest may change to shrubby or grassland community.

Deflected succession:

Sometimes due to changes in local conditions as soil character or microclimate the process of succession becomes deflected in a different direction than that presumed under climatic conditions of the area. Thus the climax communities are likely to be different from the presumed climatic climax community. In India, with a monsoon type of climate, in some habitats like temporary ponds, Pools etc. It is common to observe each year, the development of different kinds of communities in different seasons

of the year - seasonal succession. But such changes are simply recurrent and not developmental and should not be designated as successful. Species do not remain unchanged indefinitely. In course of time many species become extinct and disappeared forever. Or a species may form one or more new species that differ from the original one. All these changes are result of evolution (ie) by the process of evolution organism arise by modification from ancestral forms of life.

Lecture 05

Producers, consumers and decomposers of an ecosystem. Energy flow in the ecosystem. Types of ecosystems

Our environment consisting of both living and non-living systems, influence each other in form, function and property which is necessary to maintain life. The composition of the living and the non-living systems are the building blocks of an ecosystem.

Producers

In an ecosystem, producers are those organisms that use photosynthesis to capture energy by using sunlight, water and carbon dioxide to create carbohydrates, and then use that energy to create more complex molecules like proteins, lipids and starches that are crucial to life processes. Producers, which are mostly green plants, are also called autotrophs.

Producers funnel into the ecosystem the energy needed for its biological processes. The carbohydrates and other organic chemicals formed by the producers are utilized by the heterotrophs, or consumers; first by the herbivores who eat the plants--the primary consumers--then by the predators who eat the herbivores--the secondary, tertiary, and so on consumers. But at each step, much energy is lost. Less than 10 percent of the energy stored in plants is converted to herbivore mass. The loss from herbivore to predator is similar. Thus energy needs to be added to the ecosystem continuously.

Producers: Organism which produces its own food by using energy from the sun

Consumers

Consumers are organisms (including humans) that get their energy from producers, regarding the flow of energy through an ecosystem. For example, producers, (such as plants), make their own food by the process of photosynthesis. An organism ate this plant, than it would be a primary consumer. The animal that eats *this* animal is known as the second order consumer. Scientifically, all consumers are either herbivores, carnivores, omnivores or detrivores (decomposers and other organism that break down organic matter). These 'orders' are known as trophic levels.

Consumers: Organism which doesn't make its own food, but gets it from eating plants or other animals

Decomposers

Decomposers eventually convert all organic matter into carbon dioxide (which they respire) and nutrients. This releases raw nutrients (such as nitrogen, phosphorus, and magnesium) in a a form usable to plants and algae, which incorporate the chemicals into their own cells. This process resupplies nutrients to the ecosystem, in turn allowing for greater primary production. 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. By breaking down dead

material, they provide the nutrients that other organisms need to survive. As decomposers feed on dead organisms, they leave behind nutrients. These nutrients become part of the soil. Therefore, more plants can grow and thrive.

Decomposer: Organism which digests or breaks down formerly living material

Ecological pyramids

The trophic structure and function at successive trophic levels, i.e. producers - herbivores - carnivores, may be shown graphically by means of ecological pyramids where the first or producer level constitutes the base of the pyramid and the successive levels, the tiers making the apex.

The graphic expression of the trophic structure and function at successive trophic level is referred as "Ecological Pyramids". Ecological Pyramids are of three types;

i) Pyramid of numbers refers to number of individual organisms at each level.

ii) Pyramid of biomass refers to total dry weight of total amount of living matter

- Pyramid of energy shows the rate of energy flow/productivity at successive energy level.

The pyramids of numbers and biomass may be upright or inverted depending upon the nature of the food chain in the particular ecosystem, whereas pyramids of energy are always upright.

Tertiary consumers (carnivores)
Secondary consumers
Primary consumers (herbivores)
Producers

Pyramid of numbers

It shows the relationship between producers, herbivores and carnivores at successive trophic level in terms of their numbers. In grassland ecosystem, producers are maximum in number. This number then shows a decrease towards apex as the primary consumer/herbivore are lesser in number than producers and tertiary consumers are least in number. So pyramid becomes upright. But in forest ecosystem, producers are lesser in number, which forms the base of pyramid. Herbivores - fruit/eating birds, elephants, deers etc. are more in number than producers.

In parasitic food chain, pyramids are always inverted. Number of organisms gradually shows an increase making the pyramid inverted.

Pyramids of Biomass

In grassland and forest ecosystems, the pyramid of biomass shows an upright position. But in ponds and other aquatic systems, producers are small organisms and biomass is also least. This value shows an increase towards the apex of the pyramid and making the pyramid inverted.

Pyramids of Energy

Of the three types of ecological pyramid, this energy of pyramid gives the best picture of overall nature of the system. It is a picture of the rates of passage of food mass through food chains. So it's shape is

always upright. Because there is always a gradual decrease in the energy content at successive trophic levels from the producers to various consumer.

Energy flow models

the behavior of energy in an ecosystem can be termed, as energy flow. It is always unidirectional. From energetics point of view it is essential to understand for an ecosystem (i) the efficiency of the producers in absorption and conversion of solar energy. (ii) the use of this converted chemical form of energy by the consumers. (iii) the total input of energy in form of food and its efficiency of assimilation. (iv) the loss through respiration heat, excretion etc., and (v) the gross net production.

There are two models to explain the flow of energy.

1. Single channel energy models (SCEM)
2. 'Y' shaped/2 channel energy flow models

Single channel energy model

This model explains the unidirectional flow of energy. Whatever the energy captured by the autotrophs does not revert back to solar input. As it moves progressively through the various trophic levels, it is no longer available to the previous level.

- the system would collapse if the primary source, the sun, were cut off.
- there is a progressive decrease in energy level at each trophic level.

So, shorter the food chain, greater would be the available food energy.

"Y" shaped energy flow model

It is applicable to both terrestrial and aquatic ecosystems. In this energy model, one arm represents herbivore food chain and the other arm represents the decomposer (detritus) food chain. The primary producers are entirely different for each arms. This model also indicates that two food chains are infact, under natural conditions, not completely isolated from one another.

- it confirms to the basic stratified structure of ecosystem.
- it separates the grazing and detritus food chains in both time and space, and
- micro consumers and macro consumers differ greatly in size and metabolic relations.

Universal model of energy flow

Proposed by Odum. It is applicable to any living component whether a plant, animal /microorganisms or individual/population or a trophic group. It may depict food chain as shown in single/Y shaped energy flow system or bioenergetics of entire system.

These models depict the basic pattern of energy flow in ecosystem. Under natural conditions, these organisms are inter related in a way that several food chains become interlocked this results into a complex food web. Complexity of food web depends on the length of the food chain. Thus in nature,

there operate multi channel energy flows. But in these the channels belong to either of the two basic food chains - Grazing or Detritus. Interlocking pattern of such several chains in food web of an ecosystem would lead to a multi channel flow of energy. Thus in practice, under food conditions, it is difficult to measure the energetics of the ecosystem.

Food Chain

A **food chain** shows how each living thing gets its food. Some animals eat plants and some animals eat other animals. For example, a simple food chain links the trees & shrubs, the giraffes (that eat trees & shrubs), and the lions (that eat the giraffes). Each link in this chain is food for the next link. A food chain always starts with plant life and ends with an animal.

1. Plants are called **producers** because they are able to use light energy from the Sun to produce food (sugar) from carbon dioxide and water.
2. Animals cannot make their own food so they must eat plants and/or other animals. They are called **consumers**. There are three groups of consumers.
    a. Animals that eat ONLY PLANTS are called **herbivores** (or primary consumers).
    b. Animals that eat OTHER ANIMALS are called **carnivores**.
        - carnivores that eat herbivores are called secondary consumers
        - carnivores that eat other carnivores are called tertiary consumers
          e.g., killer whales in an ocean food web ... phytoplankton → small fishes → seals → killer whales
3. Animals and people who eat BOTH animals and plants are called **omnivores**.
4. Then there are decomposers (bacteria and fungi) which feed on decaying matter. These decomposers speed up the decaying process that releases mineral salts back into the food chain for absorption by plants as nutrients.

The consumer organisms are heterotrophic. Unlike the autotrophic plants, which manufacture their own food from simple inorganic chemicals, the herbivores must utilize the energy-rich compounds synthesized by the plants. In turn, the carnivores obtain energy for their metabolism when they consume the herbivores.

Phytoplanktons → Zoos planktons → Fish → Grasses → Rabbit → fox → Grasses → grasshopper → Frog → Snake → Hawk → Small Bacteria → Bdellovibio → Protozoa → Phytoplanktons

Food Web

There cannot be too many links in a single food chain because the animals at the end of the chain would not get enough food (and hence energy) to stay alive. Most animals are part of more than one food chain and eat more than one kind of food in order to meet their food and energy requirements. These interconnected food chains form a **food web** ie. Interlocking pattern of food chain is called food web.

This interdependence of the populations within a food chain helps to maintain the balance of plant and animal populations within a community. For example, when there are too many zebras; there will be insufficient shrubs and grass for all of them to eat. Many zebras will starve and die. Fewer zebras means more time for the shrubs and grass to grow to maturity and multiply. Fewer zebras also mean less food is available for the lions to eat and some lions will starve to death. When there are fewer lions, the zebra population will increase.

Ecosystems

The first steps in the evolution of agriculture were the tending of particular plant species and the taming of useful animal species. The next steps were (a) domestication of these species so as to gain control of their reproduction thereby enabling selective breeding of more productive types and (b) creation of special environmental conditions which would enable these improved types to realize their higher production potential. These environmental modifications involve soil tillage, soil water management, weeding and pest control. The resulting combination of humans, domesticated plant and animal species and their modified environments is an *agro-ecosystem*, in contrast to natural ecosystems in which humans play no special role. In agro-ecosystems, the farmer is an essential ecological variable, influencing or determining the composition, functioning and stability of the system.

Agro-ecosystems may be viewed as food procurement systems in which the natural ecosystem has been modified to various degrees in order to increase output of food and other useful products of value to humans. The dominants in agro-ecosystems are selected plant and animal species which are tended and harvested by humans for particular purposes. According to the nature of the modifications, agro-ecosystems range from shifting agriculture, nomadic pastoralism, and non-industrial continuous agriculture to ranching, industrial agriculture and feedlot animal production. The first three systems are practiced primarily for subsistence, and may therefore be called **subsistence agro-ecosystems**, while the last three are **industrial agro-ecosystems** which are geared to a market economy. Agro-ecosystems which involved field crop husbandry *viz*., shifting agriculture, non-industrial continuous agriculture and industrial agriculture are also referred to as field crop ecosystems.

Intensive and extensive agro ecosystems

Agro-ecosystems are classifiable according to whether they are extensive or intensive. Extensive systems may be defined as those where the annual output of consumable nitrogen is less than 20 kg per ha. Outputs of crop or livestock products per unit area are low, and these outputs are dependent largely on natural soil nutrient reserves and management which conserves these reserves. Forms of subsistence agriculture such as nomadic pastoralism and shifting agriculture are widespread examples. In intensive agro-ecosystems, very high outputs are maintained by large inputs of nutrients. Both the volume and rate of nutrient cycling are much higher than in extensive systems, particularly in industrial agriculture. Since nutrient inputs are almost entirely in the form of inorganic fertilizers,

nitrogen fixation and soil organic matter are both depressed to very low levels. Losses of nutrients from the system through exports of produce are great, while considerable leaching losses, of both soil nutrient reserves and nutrient inputs occur particularly in wetter environments when land is bare during part of the growing season.

Agro-ecosystems which involve a significant livestock sub-system as well as a cropping sub-system are known as *mixed farming* systems. They are usually intermediate in intensity between extensive and intensive agro-ecosystems.

Shifting agriculture

Shifting agriculture is a very widespread agro-ecosystem in the tropics. It includes a wide range of different localized systems which have developed in response to local environmental and cultural conditions. The essential features of the agro-ecosystem are that fields are rotated rather than crops, and a fallow period restores soil fertility. Disturbance to the soil is also negligible since there is no soil tillage. The system is well suited to nutrient poor soils in areas of low population density. Provided the fallow period is long enough, relative to the cropping period, the agro-ecosystem is sustainable indefinitely. The cropping phase is just another human induced and managed disturbance in the natural, continuing pattern of gap creation and secondary succession in forest. The cleared area, during the period of cropping, is often referred to as a swidden.

Because of their great age and highly leached condition, most soils in the moist tropics are too poor to sustain high levels of crop production without fertilizer application. In shifting agriculture, the fertilizer requirement is provided in the form of ash by felling and burning the forest vegetation prior to cropping. When the land is abandoned after one to three years of cropping, soil regains its original fertility characteristics through forest regeneration, provided the fallow period is of sufficient duration.

Nomadic Pastoralism

Nomadic pastoralism is a subsistence agro-ecosystem which usually prevails in semi-arid or arid regions which are too dry to sustain rain fed, field crop ecosystems. Human densities associated with nomadic pastoralism are low, much lower than in shifting agriculture. This is largely due to two reasons *viz*., (a) low and unpredictable primary production caused by low and highly erratic rainfall and (b) dependence on secondary production by warm blooded herbivores. This result is only a small proportion of the energy fixed in primary production being available to humans, who are secondary consumers in this agro-ecosystem. Pastoralism however allows conversion of low quality, inedible plant biomass *viz*., grass, to high quality foods *viz*., meat and milk, in regions which would not support any people on the basis of crop production.

In range grazing, a high proportion of nutrients is recycled via plant residues since the proportion of available herbage consumed by livestock or other herbivores is low. The nutrient cycle is thus small in magnitude and highly dependent on release of nutrients by organic matter decomposition. The rate of this process is impeded by the lack of soil moisture over a large part of the year. The practice of burning speeds up nutrient turnover but it also increases losses of nitrogen. All nutrients are also subject to loss by runoff due to heavy rainfall intensities during the short wet season. Nitrification is also very slow. In nomadic pastoralism, manipulation of the environment is usually limited to selection

of grazing routes and watering sites. The environment is manipulated to a greater extent where wells are provided to improve water supplies for cattle and where fires are set off to improve the quality and quantity of natural grazing.

Non-industrial and semi-industrial continuous agriculture

Eco-systems created by humans and characterized by continuous field crop husbandry are often termed *field crop ecosystems*. They are cultivated plant communities which are managed to achieve goals such as the production of food and other useful agricultural commodities; financial gain; and personal satisfaction. Usually, they are managed to achieve a combination of these goals. Field crop ecosystems fall into two main categories *viz*., non-industrial agriculture and industrial agriculture. Those in the former category are largely self contained agro-ecosystems, while those in the latter category are part of, and dependent upon, other elements within larger agro-ecosystems. Field crop ecosystems differ from natural ecosystems in several plant and community characteristics as well as in their functioning. These differences are summarized below

Characteristics of field crop and natural ecosystems

Characteristic	Field crop system	Natural ecosystem
Goals	Purposeful	Not purposeful
Control	Largely human	Largely biological
Plant Characteristics		
Genetic Variability	Low	High
Life History Strategy	Opportunistic	Conservational
Life Cycles	Mostly annual	Perennial/Mixed
Energy in Reproduction	Large	Small
Community Characters		
Total Biomass	Low	High
Plant architecture	Simple	Complex
Species Diversity	Low	High
Food Chains	Simple, short	Complex, long
Population Levels	Fluctuating	Fairly Constant
Response Times	Fairly fast	Slow
Energetics		
NPP : Biomass Ratio	High	Low
Standing Biomass	Low	High
Nutrient Cycles	Open, leaky	Closed, tight

Field crop ecosystems may be categorized as monocultural systems when they are dominated by a single crop species and as multi-crop systems when no single crop species is dominant. There is a continuous gradient from high input monocultural systems at one end of the spectrum to low input multi-crop system at the other. Mixed farming systems, in which cropping and livestock subsystems are integrated within a single agro-ecosystem, constitute a special category of multi-cropping systems, in which one or more of the crops grown are grazed or used as fodder. Besides outputs in various forms such as meat and milk, the livestock subsystem also provides the cropping subsystem with (a) fertilizer in the form of manure and (b) a source of power for various operations such as soil tillage, weeding and irrigation of crops, and transport and processing of crop harvests. Energy use efficiency is however lowered where the agro-ecosystem includes a livestock subsystem.

Industrial Agriculture

Industrial agriculture is primarily distinguished by the substitution of fossil fuel energy for human labour and animal power. Two persons may be employed per ha in non-industrial continuous agriculture, whereas only 0.1 person may be needed per ha in industrial agriculture. The fossil fuel energy subsidy is used to produce agro-chemicals such as fertilizers, pesticides and herbicides; to manufacture farm machinery; to operate this machinery in the performance of work such as soil tillage, planting and harvesting of crops, and application of fertilizers or pesticides and for irrigation and transport.

Because of the massive amounts of energy required to produce chemical fertilizers, pesticides and weedicides on the one hand, and to manufacture and operate agricultural machinery on the other; industrial agriculture is highly intensive in its use of energy subsidies. The increased use of energy subsidies is associated with increase in energy output per unit area and per man-hour, but the ratio of energy output to energy input decreases. Efficiency of energy use in semi-industrial and industrial agriculture is therefore considerably lower than in non-industrial agriculture with efficiency decreasing sharply as the energy subsidy increases.

In industrial agriculture, a primary objective is to maximize yields, and this is achieved largely through increasing use of chemical fertilizers. A major disadvantage of reliance on chemical fertilizers, apart from their cost to subsistence farmers, is their role in further depleting the already low organic matter content of tropical soils. Control of pests and pathogens in industrial agriculture relies heavily on the use of chemical pesticides. Pesticide use has however created almost as many problems as it was designed to solve.

Industrial agriculture displays many of the characteristics of manufacturing industry such as high capital expenditure on buildings and machinery; specialization of production; and large outputs of wastes which are not recycled within the system. Wastes from industrial agriculture, such as chemicals leached in drainage, are significant pollutants of other ecosystems. The most harmful effects of industrial agriculture on the environment are however due to soil tillage and undue exposure of bare soil, resulting in accelerated soil erosion and consequent depletion of the soil resource base.

Lecture 06

Bio-diversity: Definition, classification, threats to biodiversity and its conservation

Variation is the law of nature. It occurs everywhere and every moment. The variations take place at micro levels. The variations may be linear or cyclic. The variety and variability of organisms and ecosystems is referred to as biological diversity. The world Commission on Environment and Development (WCED) constituted by the UN General Assembly published a report in 1987 which provided a boost and endorsement to the need for conserving the world's rich biodiversity. Despite conflicting views among nations, a broad consensus was reached after bitter negotiations, and 170 countries signed the Biodiversity Convention, which is now ratified by 104 countries.

Perhaps the greatest value of biodiversity is yet unknown. Scientists have discovered and named only 1.75 million species – less than 20 per cent of those estimated to exist. Of those identified, only a fraction has been examined for potential medicinal, agricultural or industrial value. Much of the earth's great biodiversity is rapidly disappearing, even before we know what is missing. Estimates vary, but the most widely accepted figure lies between 10 and 13 million species. Of these, biologists estimate that as many as 27,000 species are becoming extinct each year. This translates into an astounding 3 species every hour.

Types of Biodiversity (Diversity Indices):

Alpha (a) Diversity : Species diversity within a community or habitat, comprises two components i.e. species richness and evenness. Sometimes dominant of one vegetation stratum may affect the α diversity of the other strata.

Beta (β) Diversity : β diversity is the inter community diversity expressing the rate of species turnover per unit change in habitat.

Gamma (g) Diversity : Gamma diversity is the overall diversity at landscape level includes both α and β diversities. The relationship is as follows:

$\gamma = \mathbf{a} + \beta + Q$

where, Q = Total number of habitats or communities, **a** = Average value of α diversities

β = Average value of β diversities

Levels of Biodiversity

Theoretically there are three levels of biodiversity.

- **Genetic diversity**

It refers to the variation of genes within the species. This constitutes distinct population of the same species or genetic variation within population or varieties within a species.

- **Species diversity**

It refers to the variety of species within a region. Such diversity could be measured on the basis of number of species in a region.

- **Ecological diversity**

Ecological diversity is the intricate network of different species present in local ecosystem and the dynamic interplay between them. An ecosystem consists of organisms from many different species living together in a region that are connected by the flow of energy, nutrients, and matter that occurs as the organisms of different species interact with one another.

The Mega Diversity Regions

The World Conservation Monitoring Centre recognised 17 mega diverse countries in July 2000 including Australia, Brazil, China, Colombia, Democratic Republic of the Congo (DRC) (formerly Zaire), Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, the Philippines, South Africa, the United States of America (USA) and Venezuela. Together, these 17 countries harbour more than 70% of the earth's species. Some of the very valuable "gene pool" from these countries have been identified and they have been utilized for the built up of modern agriculture and allied business.

Hotspots of Biodiversity

The earth's biodiversity is located in specific ecological regions. There are over a thousand major 'ecoregions" in the world. Of these,200 are said to be richest, rarest and most distinctive natural areas. These areas are reffered to as the 'Global 200'.

It has been estimated that 50,000 endemic plants, which comprise 20% of global plant life, probably occur in only 18 'hot spots' in the world. Countries have a relatively large proportion of these biodiversity hotspots are referred as 'mega-diversity nations'.

Global Species Diversity

Group	Number of described species
Bacteria and blue-green algae	4,760
Fungi	46,983
Algae	26,900
Bryophytes(Mosses and Liverworts)	17,000
Gymnosperms(Conifers)	750
Angiosperms(Flowering plants)	250,000
Protozoans	30,800
Sponges	5,000
Corals and Jellyfish	9,000
Roundworms and earthworms	24,000
Crustaceans	38,000

Insects	751,000
Other arthropods and minor invertibrates	132,461
Molluscs	50,000
Starfish	6,100
Fishes(Teleosts)	19,056
Amphibians	4,184
Reptiles	6,300
Birds	9,198
Mammals	4,170
Total : **1,435,662 species**	

From: Conserving the world's Biological Diversity, WRI, IUCN, CI, WWF-YS, the World Bank.

India's biodiversity

India is exceptionally rich in biodiversity and is one of the twelve mega diversity centres of the world. With 10 biogeographic zones and 25 biotic provinces, all major ecosystems are represented. India is a land mass of nearly 33 lakh sq.km with a coastline of 7,616 km and 14 different types of climatic forests and the total forest coverage in India is about 6,50,000 sq.km. India is the home land of 13,000 species of flowering plants, 20,000 species of fungi, 50,000 species of insects, 65,000 species of fauna including 2000 species of birds, 350 mammals and 420 of reptiles. It covers nearly 7% of world's flora and 6.5% of world's fauna of which 33 % flora and 62% fauna are endemic. India has over 30 National parks that constitute about 1% of the landmass and 441 sanctuaries that constitute 3.5% of the area. India is a home of over 35,000 tigers and the umbrella of project tiger 23 specially demarcated project tiger reserves covering 33,000 sq.km representing different climatic forests are spread across the country. India has a rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats from tropical rainforests to alpine vegetation and from temperate forests to coastal wetlands. **India figured with two hotspots** - the Western Ghats and the Eastern Himalayas - in an identification of 18 biodiversity hotspots carried out in the eighties. Recently, Norman Myers and a team of scientists have brought out an **updated list of 25 hotspots**. In the revised classification, the 2 hotspots that extend into India are The Western Ghats/Sri Lanka and the Indo-Burma region (covering the Eastern Himalayas); and they are included amongst the top eight most important hotspots. In addition**, India has 26 recognized endemic centers** that are home to nearly a third of all the flowering plants identified and described to date.

Of the estimated 5–50 million species of the world's biota, only 1.7 million have been described to date, and the distribution is highly uneven. About seven per cent of the world's total land area is home to half of the world's species, with the tropics alone accounting for 5 million. India contributes significantly to this latitudinal biodiversity trend. With a mere 2.4% of the world's area, India accounts for 7.31% of the global faunal total with a faunal species count of 89,451 species. Some salient features of India's biodiversity have been mentioned below.

- India has two major realms called the Palaearctic and the Indo-Malayan, and three biomass, namely the tropical humid forests, the tropical dry/deciduous forests, and the warm desert/semi-deserts
- India has ten biogeographic regions including the Trans-Himalayan, the Himalayan, the Indian desert, the semi-arid zone(s), the Western Ghats, the Deccan Peninsula, the Gangetic Plain, North-East India, and the islands and coasts.
- As of date, there are 911 properties under the World Heritage List, which cover 711 cultural sites, 180 natural sites and 27 mixed properties encompassing 152 countries, including India. India is one of the 12 centres of origin of cultivated plants.
- India's first two sites inscribed on the list at the Seventh Session of the World Heritage held in 1983 were the Agra Fort and the Ajanta Caves. Over the years, 27 more sites have been inscribed, the latest site inscribed in 2012 being the Western Ghats. Of these 29 sites, 23 are cultural sites and the other six are natural sites. A tentative list of further sites/properties submitted by India for recognition includes 33 sites.
- India has 17 biosphere reserves, and 19 Ramsar wetlands. Amongst the protected areas, India has 102 national parks and 490 sanctuaries covering an area of 1.53 lakh sq. km.
- The wildlife sanctuaries in India are home to around two thousand different species of birds, 3500 species of mammals, nearly 30000 different kinds of insects and more than 15000 varieties of plants

The endemism of Indian biodiversity is high. About 33% of the country's recorded flora are endemic to the country and are concentrated mainly in the North-East, Western Ghats, North-West Himalaya and the Andaman and Nicobar islands. Of the 49,219 plant species, 5150 are endemic and distributed into 141 genera under 47 families corresponding to about 30% of the world's recorded flora, which means 30% of the world's recorded flora are endemic to India. Of these endemic species, 3,500 are found in the Himalayas and adjoining regions and 1600 in the Western Ghats alone. About 62% of the known amphibian species are endemic with the majority occurring in the Western Ghats. Nearly 50% of the lizards of India are endemic with a high degree of endemicity in the Western Ghats. India is a centre of crop diversity - the homeland of 167 cultivated species and 320 wild relatives of crop plants.
Corals reefs in Indian waters surround the Andaman and Nicobar Islands, the Lakshadweep Islands, and the Gulf areas of Gujarat and Tamil Nadu. They are nearly as rich in species as tropical evergreen forests. India's record in agro-biodiversity is equally impressive. There are 167 crop species and wild relatives. India is considered to be the centre of origin of 30,000-50,000 varieties of rice, pigeon-pea, mango, turmeric, ginger, sugarcane, gooseberries etc and ranks seventh in terms of contribution to world agriculture.

Endemic species of plants

Group	No. of species
Pteridophyta	200
Angiosperms	4950

Endemic species of animals

Group	No. of species	Group	No. of species
Mollusca		Amphibia	110
Land	878	Reptilia	214
Freshwater	89	Aves	69
Insecta	16,214	Mammalia	38

Loss of Biodiversity

With the current rate of development, population growth and migration communities are increasingly unable to meet their sustained needs. However, the present day drastic changes in the environment and habitat due to population explosion and unmanaged developmental activities are so unnatural that the species are not getting full liberty of time and space for their survival and adaptive radiation, therefore, resulting in loss of biodiversity, which is a global crisis. It is high time that our natural wealth be preserved from loss.

Threats to Biodiversity

The diversity in India i.e. forests, grass lands, wetlands, mountains, deserts and marine ecosystems face many pressures. One of the major causes for the loss of biological diversity in India has been the depletion of vegetative cover in order to expand agriculture. Since most of the biodiversity rich forests also contain the maximum mineral wealth and also the best sites for water impoundment, mining and development projects in such areas have often led to destruction of habitats. Poaching and illegal trade of wildlife products too have adversely affected biological diversity.

Causal factors of threat

Causal factors of threat may be natural or manmade. They are

1. **Development pressure**
    - Construction
    - Forest based industries
    - Hydel/ Irrigation projects
    - Mining
    - Oil drilling

- Pollution
- Resource extraction
- Road & Transport

2. **Encroachment**
    a. Agriculture
    b. Expansion of forest villages
    c. Fishery
    d. Grazing / increased domestic animals
    e. Habitat depletion / change
    f. New settlements
    g. Shifting cultivation
3. **Exploitation**

    a. Collection made by scientific/educational institutions
    b. Exploitation by local authorities as revenue resources
    c. Firewood collection
    d. Food gathering and hunting
    e. Poaching
4. **Human induced disasters**

    a. Floods
    b. Major oil spills/leakage
    c. Epidemics
    d. Forest fires
5. **Management of Natural resources**

    a. Genetic uniformity
    b. Inadequate water/ food for wildlife
    c. Increased competition
    d. Introduction of exotic species
    e. Predation
6. **Management of Human Resource**

    a. Change in people's lifestyle
    b. Increasing demands
    c. Dilution of traditional values
    d. Human harassment
    e. Inadequate trained human resources
    f. Lack of effective management

g. In appropriate land use

7. **Political and policy issues**

a. Change in use / legal status
b. Civil unrest
c. Intercommunity conflict
d. Military activities

Categories of threat

The following categories of threat have been recognized by IUCN (International Union for Conservation of Nature and Natural Resources)

1. Endangered

The taxa in danger of extinction and whose survival is unlikely, the causal factors continue operation. The taxa whose number have been reduced to a critical level or whose habitats have been so drastically reduced that they are seemed to be in immediate danger of extinction (eg) *Nepenthes sp., Vanda, Cycas beddomii*.

2. Vulnerable

Taxa likely to move into endangered category in near future, if the causal factors continue operating included taxa of which most or all the population are decreasing because of over exploitation, extensive destruction of habitats or other environmental disturbances. Eg. *Dioscoria deltoidea*

3. Rare

Taxa with small world population that are not at present endangered or vulnerable but are at risk. These taxa are usually localized within restricted geographical areas or habitat or are thinly scattered over more extensive range (eg) *Rauvolfia serpentina*

4. Threatened

The term threatened is used in the conservation for species which fall in one of the above three categories

Endangered plant and animal species

- 427 – endangered plant species (BSI) in **Red Data Book**
- Contributes to about 20% of India's floristic wealth of higher plants

Endangered plants

- *Acer laevigatum*
- *Phoenix rupicola*
- *Lactuca cooperi*
- *Carum villosum*
- *Amorphophalius bulbifeer*
- *Dioscorea laurifolia*

Endangered animals

Andaman wild pig, Bison, Black buck, Blue whale, Cheetah, crab eating macaque, two horned antelope, giant squirrels, Hyaena, Lion tailed Macaque, musk deer, Nilgiri tahr, Sambar, rhinoceros, Siberian White crane

Conservation of Biodiversity

The very existence of human being is threatened due to continuous loss of biodiversity. Tropical rain forests have been the focal point of the debates on biodiversity conservation. In fact, the rain forest covers only 7% of the earth's geographical area but supports more than half of the world's identified species. Of these, 15 rain forests have been identified as hot spots. Tropical deforestation will be the single greatest cause of species extinction in the next century.

Strategies of Conservation

Future strategy for Conservation has 4 goals

1. Maintenance of adequate resources
2. Conservation of resources through reduction in demand and achievement of greater end use
3. Maximum use of renewable resources
4. Reduction in dependency of non-renewable resources

***In situ* strategy**

This strategy emphasizes on the conservation work at original site of biodiversity i.e. in wild. Conservation of overall diversity of genes, populations, species, communities and the ecological processes comes under this strategy. There are 37,000 protected area in the world (World Conservation Monitoring Centre , WCMC). India has 17 biosphere reserves, and 19 Ramsar wetlands. Amongst the protected areas, India has 102 national parks and 490 sanctuaries covering an area of 1.53 lakh sq. km.

***Ex situ* Strategy**

This strategy says that conservation work should be done outside the natural habitat in form of botanical and zoological gardens, conservation stand, seed and seedling banks, pollen banks, germ plasm banks, tissue culture banks, gene and DNA banks etc. In India, conservation of genetic diversity of cultivated plants and their wild relatives is done by NBPGR (National Bureau of Plant Genetic Resources).

Reduction of Anthropogenic Pressure

Increasing population and it's demands pose remarkable threat to taxa important to human being. About 70% of identified medicinal plants of Indian Himalaya are exposed to destructive harvesting. Cultivation of such plants elsewhere would contribute to their conservation.

Restoration of endangered species

It is tough and difficult strategy. It requires specific knowledge about species and its surrounding. This strategy includes diagnosis of factors responsible for the decline of species, habitat conservation, captive breeding and restriction of harvesting etc. the strategy include:

- Reintroduction programmes in the original site of living
- Augmentation programmes to increase the existing population size and genetic diversity of a species
- Introduction programmes for a new area.

Endemic species

Endemic species are the plants, which are limited in their distribution i.e. they are restricted to a small area and are not found elsewhere in the world. Endemism of Indian biodiversity is significant. About 4,900 species of flowering plants and 33% of the recorded floras are endemic to the country. These are distributed over 141 genera belonging to 47 families. These are concentrated in the floristically rich areas of North East India, the western Ghats, North West Himalayas and the Andaman and Nicobar Islands. The Western Ghats and the Himalayas have two of the 18 hot spots identified in the world. It is estimated that 62% of the known amphibian species are endemic to India of which a majority occur in Western Ghats. Endemism may be due to:

- Poor adaptability of a species in a wide range of ecology
- Presence of some geographical barrier
- Failure of dispersal of reproductive organs
- The species might have comparatively been young and not have time to spread.

Biosphere Reserves

Biosphere reserve programme was launched by UNESCO in 1971 under its MAB (Man and Biosphere Programme). Biospheres are sites where protection is granted not only to the flora and fauna of the protected region, but also to the human communities who inhabit these regions, and their ways of life. Biosphere reserves are sites established by countries and recognized under UNESCO's Man and the Biosphere (MAB) Program to promote sustainable development based on local community efforts and sound science. Currently there are 580 sites across 114 countries. The Indian government has established 17 **Biosphere Reserves of India.**Seven of the seventeen biosphere reserves are a part of the World Network of Biosphere Reserves, based on the UNESCO Man and the Biosphere (MAB) Program list.

Biosphere reserves of India

S.No	Name of Biosphere Reserve	Location
1	Great Rann of Kutch	Gujarat
2	Nokrek	Meghalaya
3	Manas	Assam
4	Gulf of Mannar	Tamil Nadu
5	Sundarban	West Bengal
6	Nandadevi	Uttrakhand
7	Nilgiri	Tamil Nadu, Kerala and Karnataka
8	Dehang Debang	Assam
9	Panchmani	Madhya Pradesh
10	Amarkantak	Madhya Pradesh and Chattisgarh
11	Kanchenjunga	Sikkim
12	Agasthyamalai Biosphere Reserve	Kerala and Tamil Nadu
13	Great Nicobar Biosphere Reserve	Andaman and Nicobar
14	Dibru-Saikhowa	Assam
15	Cold Desert	Himachal Pradesh
16	Seshachalam Hills	Andhra Pradesh
17	Simplipal	Orissa

Important National parks and wild life sanctuaries in India

- Andhra Pradash – Pakhal, Povharam, kawal, kollaeru, pelicanary wild life sanctuaries
- Arunachal Pradesh – Namidapha Wild life sanctuary
- Assam – Kaziranga National Park, Manas Wild life sanctuaries
- Bihar – Hazaribagh National park
- Gujarat – Gir National Park
- Karnataka – Bandipur National park, Silent Valley National park
- Kerala – Periyar Wild life sanctuary, Wyanad Wild life sanctuaries
- Orissa – Chilka Lake Bird sanctuary
- Tamil Nadu – Mudumalai Wild life sanctuary, Vedanthangal Bird Sanctuary
- Uttar Pradah – Corbett National park
- West Bengal – Jaldapara Wild life sanctuary

Some of the policies, which can be taken into account for biodiversity conservation, are:

- Identifying and monitoring the important components of biological diversity that needs to be conserved and used sustainably.
- Establishing protected areas to conserve biological diversity while promoting environmentally sound development around these areas.
- Respecting, preserving and maintaining traditional knowledge of the sustainable use of biological diversity with the involvement of indigenous peoples and local communities.
- Educating people and raising awareness about the importance of biological diversity and the need to conserve it
- Promoting public participation, particularly when it comes to assessing the environmental impacts of development projects that threaten biological diversity and protecting the biodiversity hot spots from alien species.

Biodiversity conservation is an important step towards a successful disaster management and if policies are implemented to protect it, then we can get one step closer in making a Disaster Free World.

Lecture 07

Environmental pollution: Causes, effects and control of air

India today is one of the first ten industrialized countries of the world. Today we have a good industrial infrastructure in core industries like metals, chemicals, fertilizers, petroleum, food etc. what has come out of these? Pesticides, detergents, plastics, solvents, fuels, paints, dyes, food additives etc. are some examples. Due to progress in atomic energy, there has also been an increase in radioactivity in the biosphere. Besides these, there are a number of industrial effluents and emissions particularly poisonous gases in the atmosphere. Mining activities also added to this problem particularly as solid waste.

Thus, pollution is a necessary evil of all development. Due to lack of development of a culture of pollution control, there had resulted a heavy backlog of gaseous, liquid and solid pollution in our country. It is to be cleaned. Thus pollution control in our country is a recent environmental concern.

What is pollution? Pollution is an undesirable change in the physical, chemical or biological characteristics of air, water and soil that may harmfully affect the life or create a potential health hazard of any living organism. Pollution is thus direct or indirect changes in any component of the biosphere that is harmful to the living component(s), and in particular undesirable for man, affecting adversely the industrial progress, cultural and natural assets or general environment.

What are pollutants? Any substance which causes pollution is called a pollutant. A pollutant may thus include any chemical or geochemical (dust, sediment, grit etc.) substance, biotic component or its product, or physical factor (heat) that is released intentionally by man into the environment in such a concentration that may have adverse harmful or unpleasant effects.

Environmental Pollutants

The various principal pollutants which pollute our air, water, land are as follows :

- Deposited matter – soot, smoke, tar, dust, grit etc.
- Gases – Oxides of nitrogen (NO, NO2), sulphur (SO2), carbon monoxide, halogens, (chlorine, bromine, iodine),
- Acids droplets – sulphruric, acid nitric acid etc.
- Fluorides
- Metals – Mercury, lead, iron, zinc, nickel, tin, cadmium, chromium etc.
- Agrochemicals – Biocides (pesticides, herbicides, fungicides, nematicides, bactericides, weedicides etc), and fertilizers.
- Complex organic substances – Benzene, ether, acetic acid, benzopyrenes etc.
- Photochemical oxidants – Photochemical smog, ozone, peroxyacetyl nitrate (PAN), peroxybenzoil nitrate (PBzN), nitrogen oxides, aldehydes, ethylene etc.
- Solid wastes

- Radioactive waste
- Noise

Kinds of Pollution

Various types of pollutions are classified in different ways. On the basis of the type of environment being polluted, we may recognize air pollution, water pollution, land soil pollution, marine pollution etc. on the basis of the kind of pollutant involved, we may have sulphur dioxide pollution, fluoride pollution, carbon monoxide pollution, smoke pollution, lead pollution, mercury pollution, solid waste pollution, radioactive pollution, noise pollution etc. Of the variety of pollutants, we recognize the following two basic types of pollutants: non degradable and biodegradable.

(1) Nondegradable pollutants

These are the materials and poisonous substances like aluminium cans, mercuric salts, long-chain phenolics, DDT etc. that either do not degrade or degrade only very slowly in nature. They are not cycled in ecosystem naturally but by subsequent movement in food chains and biogeochemical cycles.

(2) Biodegradable pollutants

They are the domestic wastes that can be rapidly decomposed under natural condition. They may create problems when they accumulate (i.e. their input into the environment exceeds their decomposition).

Atmosphere

The earth's vertically extended atmosphere, an envelope of gases is divided into the following layers : (i) troposphere (up to 5 km) – the lowest atmosphere in which temperature decreases with height bounded by land or sea surface below and by tropopause above, (ii) stratosphere (5 to 45 km) - the region above the troposphere, in which temperature increases up to 900C with height. This is limited by stratopause, (iii) mesosphere (45 to 80 km) – the part between stratosphere and thermosphere (ionosphere). Temperature again decreases up to – 800C. (iv) thermosphere (ionosphere) – above 80 km, the upper part in which temperature increases with height. There is no boundary between the atmosphere and void of outer space. About 75% of the earth's atmosphere lies within 16 km. of the surface and 99% of the atmosphere lies below an altitude of 30 km.

The atmosphere is an insulating blanket around the earth. It is source of essential gases, maintains a narrow difference of day and night temperatures and provides a medium for long-distance radio communication. It also acts as shield around the earth against lethal UV radiations and meteors. Without atmosphere, there will be no lightening, no wind, no clouds, no rains, no snow and no fire.

Normal composition of clean air at or near sea (1990) is as follows:

Gases	**Percent (by Volume)**
Nitrogen	78.084
Oxygen	20.9476
Argon	0.934
Carbon dioxide	0.0314
Methane	0.0002

Hydrogen	0.00005
Other gases	minute

Air is necessary for the survival of all higher forms of life on Earth. On an average, a person needs at least 30 lb of air every day to live, but only about 3 lb of water and 1.5 lb of food. A person can live about 5 weeks without food and about 5 days without water, but only 5 minutes without air. Naturally, everyone likes to breathe fresh, clean air. But the atmosphere, that invisible yet essential Ocean of different gases called air, is as susceptible to pollution from human activities as are water and land environments.

Air Pollution

It is defined as the excessive concentration of foreign material in the atmosphere , which affects the health of individuals and also causes damage to the property.

Air pollution episodes

- ***London smog*** : SO2 à H2SO3 vapours in the atmosphere. When automobile exhausts are trapped by this smog and exposed to sunlight, it produces photochemical smog.
- ***Bhopal gas tragedy*** **:** The poisonous gas, methyl isocyanate (MTC) leakage in the pesticide manufacturing plant of Union Carbide of India Ltd., (UCIL), Bhopal, Madhya Pradesh on December 3, 1984. 46 tons of MIC was released spreading to 40 km. *Effects* : About 65,000 people suffered from various disorders in eyes, lungs, stomach, heart, etc. The immediate symptom is bronchospasm which causes coughing, chest pain and abdominal pain. Nearly 3000 people died within a short span of time, 1600 domestic animals died and crop yields were reduced .
- **Darkening effect of Taj Mahal**

Taj Mahal is a white marble stone mausoleum. Recently it was observed that the walls of Taj Mahal has become darkened and disfigured due to air pollution from nearby Mathura Oil refinery.

$H_2O + SO_2$ à H_2SO_3 , $SO_2 + O_2$ à SO_3; $SO_3 + H_2O$ à H_2SO_4.

The acid rain reacts with marble stone (CaCO3) to produce calcium sulphate, causing darkening and disfigurement.

Types, sources and effects of air pollution

Air pollution may be simply defined as the presence of certain substances in the air in high enough concentrations and for long enough duration to cause undesirable effects. "Certain substances" may be any gas, liquid or solid, although certain specific substances are considered significant pollutants because of very large emission rates are harmful and unwanted effects. "Long enough durations" can be anywhere from a few hours to several days or weeks; on a global scale, durations of months and years are of concern.

Sources

Air pollution results from gaseous emission from mainly industry, thermal power stations, automobiles, domestic combustion etc.

1. **Industrial chimney wastes**: There are a number of industries which are source of air pollution. Petroleum refineries are the major source of gaseous pollutants. The chief gases are SO2 and NOx. Cement factories emit plenty of dust, which is potential health hazard. Stone crushers and hot mix plants also create a menace. Food and fertilizers industries which emit gaseous pollutants. Chemical manufacturing industries which emit acid vapours in air.
2. **Thermal power stations:** There are a number of thermal power stations and super thermal power stations in the country. The National thermal power corporation (NTPC) is setting up four mammoth coal-powered power stations to augment the energy generation. These are at Singrauli in U.P., Korba in M.P., Ramagundam in Andhra Pradesh and Farakka in W. Bengal. The coal consumption of thermal plants is several million tones. The chief pollutants are fly ash, SO 2 and other gases and hydrocarbons.
3. **Automobiles**: The toxic vehicular exhausts are a source of considerable air pollution, next only to thermal power plants. The ever increasing vehicular traffic density posed continued threat to the ambient air quality. Chief sources of emission in automobiles are (i) exhaust system, (ii) fuel tank and carburettor and (iii) crankcase. The exhaust produces many air pollutants including unburnt hydrocarbons, CO, NOx and lead oxides. There are also traces of aldehydes, esters, ethers, peroxides and ketones which are chemically active and combine to form smog in presence of light. Evaporation from fuel tank goes on constantly due to volatile nature of petrol, causing emission of hydrocarbons. The evaporation through carburettor occurs when engine is stopped and heat builds up, and as much as 12 to 40 ml of fuel is lost during each long stop causing emission of hydrocarbons.

Criteria Air Pollutants

The five primary criteria pollutants include the gases- Carbon Monoxide (CO), nitrogen oxides (NOx) , sulfur dioxide (SO2), and solid or liquid particulates (smaller than 10 μm), and particulate lead.

a) Carbon Monoxide

- CO is a colorless, odourless and tasteless gas.
- It is produced when carbonaceous fuels are burned under less than ideal conditions.
- Incomplete combustion, yielding CO instead of CO2, results when any of the following variables are not kept sufficiently high:
- Oxygen supply
- flame temperature
- gas residence time at high temperature and
- combustion chamber turbulence.
- Most of the CO emissions are from the transportation sector. Hourly atmospheric concentrations of CO often reflect city driving patterns. Peaks occur on week days during the morning and late afternoon rush hours.

- The CO, at levels that occur in urban air has no detrimental effect on materials or plants; but adversely affects human health.
- CO interferes with the blood's ability to carry oxygen to the cells of the body. When inhaled, it readily binds to hemoglobin in the blood stream to form carboxyhemoglobin (COHb).
- Even small amounts of CO can seriously reduce the amount of oxygen conveyed throughout the body à brain function is affected and heart rate increased in an attempt to offset the oxygen deficit.

b). Oxides Of Nitrogen

- 7 oxides of nitrogen are known to occur – NO, NO2, NO3, N2O, N2O3, N2O4 and N2O5.
- Nitric oxide (NO) and Nitrogen dioxide (NO2) are important in air pollution study.
- There are two sources of nitrogen oxides (or NOx):
- *Thermal NOx* are created when nitrogen and oxygen in the combustion air are heated to a high enough temperature (> 1000 K) to oxidise nitrogen.
- *Fuel NOx* result from the oxidation of nitrogen compounds that are chemically bound in the fuel molecules themselves. Natural gas almost has no nitrogen in them and some coal can have 3% N by weight. Fuel NOx is often the dominant source of NOx.
- Almost all NOx emissions are in the form of NO, which has no adverse health effects.
- However, NO can oxidise to NO2, which in turn may react with hydrocarbons in the presence of sunlight to form photochemical smog, which is injurious.
- NO2 also reacts with hydroxyl radical (HO) in the atmosphere to form nitric acid (HNO3) and results in acid rain.
- NO2 is an acute irritant at higher concentrations. Prolonged exposure to relatively low concentrations is linked to increased bronchitis in children. It can also damage plants. When converted to nitric acid it causes corrosion of metal surfaces.
- NO is a colourless gas, but NO2 gives smog its reddish brown colour.
- Reductions in NOx emissions have been harder to achieve.
- When mobile source controls are introduced, modifications to the combustion process that improve emissions of CO tend to make the NOx problem worse and vice-versa. To control CO, it helps to increase the combustion air supply and to raise the temperature. To control NOx, the opposite is true.

The NO-NO2–O3 photochemical reaction sequence

- NO is formed during combustion

$$N_2 + O_2 \rightarrow 2\,NO$$

- The nitric oxide thus emitted, can oxidise to NO2.

  2 NO + O2 à 2 NO2.

- If sunlight is available, NO2 can photolyse, and the freed atomic oxygen can then help to form ozone:

  NO2 + hvà NO + O

O + O2 + M à O3 + M

where hv represents a photon (l < 0.38 µm) and M represents a molecule (usually O2 or N2) whose presence is necessary to absorb excess energy from the reaction.

- Ozone can then convert NO back to NO2 :

  O3 + NO à NO2 + O2

- Thus, NO concentrations rise as early morning traffic emits its load of NO. Then as morning progresses, there is a drop in NO and a rise in NO2 as NO gets converted to NO2. As the sun's intensity increases toward noon, the rate of photolysis of NO2 increases; thus NO2 begins to drop while O3 rises. Ozone is so effective in its reaction with NO that as long as O3 is present, NO concentrations do not rise through the rest of the afternoon, even though there may be new emissions.

If only NO2 photolytic cycle is involved, O3 can not accumulate in sufficient quantity in photochemical smog to account for the actual measured data. The introduction of hydrocarbons upsets the balance in production and destruction of ozone, thus allowing more O3 to accumulate.

Photochemical smog and ozone

- When oxides of nitrogen, various hydrocarbons and sunlight come together, they initiate a complex set of reactions that produce a number of secondary pollutants known as photochemical oxidants.
- Ozone (O3) is the most abundant photochemical oxidant responsible for chest constriction and irritation of the mucous membrane in people, cracking of rubber products and damage to vegetation.
- Other components of the photochemical smog viz., formaldehyde, peroxy benzoyl nitrate (PBzN), peroxy acetyl nitrate (PAN) and acrolein cause eye irritation.
- The formation of photochemical smog can be expressed in the simples terms as : Hydrocarbons + NOx + sunlight à photochemical smog.

C). Oxides of sulfur

- Over 80% of anthropogenic sulfur oxide emissions are the result of fossil fuel combustion in stationary sources. Of that, almost 85% is released from electric utility power plants. Only about 2% comes from highway vehicles.
- The only significant non combustion sources of Sulfur emissions are associated with petroleum refining, copper smelting and cement manufacture.
- Oil and coal generally contain appreciable quantities of sulfur (0.5-6%), either in the form of inorganic sulfides or as organic sulfur. When these fuels are burned, the sulfur is released mostly as sulfur dioxide (SO2), but also with small amounts of sulfur trioxides (SO3).
- SO2, once released, can convert to SO3 in a series of reactions which, once again, involve a free radical such as OH.

$SO_2 + OH. \rightarrow HO SO_2.$

$HO SO_2. + O_2 \rightarrow SO_3 + HO_2.$

- The HO2 radical can then react with NO to return the initial OH. ($HO_2. + NO \rightarrow NO_2 + OH.$).
- Sulfur trioxide reacts very quickly with H2O to form sulfuric acid, which is the principal cause of acid rain.

$SO_3 + H_2O \rightarrow H_2SO_4$

- Sulfuric acid molecules rapidly become particles by either condensing on existing particles in the air or by merging with water vapour to from H2O – H2SO4 droplets.
- Often a significant fraction of particulate matter in the atmosphere consists of such sulfate (SO_4^{2-}) aerosols.
- The transformation from SO2 gas to sulfate particles is gradual, taking a matter of days. In either form, sulfur can be deposited during precipitation (wet deposition) or by slow continuous removal processes that occur without precipitation (dry deposition).
- Most sulfate particles in urban air have en effective size of less than 2 µm, with most of them being in the range of 0.2 µm. Their size allows deep penetration into the respiratory system.
- SO2 is highly water soluble (much more than any of the other criteria pollutants). As a result, when it is inhaled it is most likely to be absorbed in the most passages of the upper respiratory tract, the nose and upper air ways.
- However, when sulfur is entrained in an aerosol, the aerodynamic properties of the particles themselves affect the area of deposition and it is possible for sulfur oxides to reach far deeper into the lungs.
- The combination of particulate matter and sulfur oxides can than act synergistically, with the effects of both together being much more detrimental than either of them separately.

- Sulfur oxides can damage vegetation. Sulfur pollutants can discolour paint, corrode metals and cause organic fibres to weaken. Airborne sulfates significantly reduce visibility and discolour the atmosphere.
- Prolonged exposure to sulfates causes serious damage to building marble, lime stone (CaCO3) and mortar, as the carbonates in these materials are replaced by sulfates.

CaCO3 + H2SO4 ® CaSO4 + CO2 + H2O
The calcium sulfate (gypsum) produced by this reaction is water soluble and easily washes away, leaving a pitted, eroded surface.

d).Lead

- Most lead emissions in the past have been from motor vehicles burning gasoline containing the antiknock additive, tetraethyl lead, (C2 H5) 4 Pb.
- Lead is emitted to the atmosphere primarily in the form of inorganic particulates.
- Much of this is removed from the atmosphere by settling in the immediate vicinity of the source.
- Air borne lead may affect human populations by direct inhalation, in which case people living nearest to highways are at greatest risk, or it can be ingested after the lead is deposited onto food stuffs.
- Most of human exposure to airborne lead is the result of inhalation. It has been estimated that about one third of the lead particles inhaled are deposited in the respiratory system and that about half of those are absorbed by the blood stream.
- The NAAQS standard for lead – 1.5 µg/m3.
- Lead poisoning can cause aggressive, hostile and destructive behavioral changes as well as learning disabilities, seizures, severe and permanent brain damage and even death. Children and pregnant women are at greatest risk.
- Blood lead levels associated with neurobehavioral changes in children appear to begin at 50-60 µg per decilitre (µg/dL). Encephalopathy, with possible brain damage or death occurs at levels somewhat 80 µg / dL.
- Sources of lead exposure ® air emissions, drinking water (lead can be leached out of lead solder used in copper piping systems), ingestion of lead in food and leaded paint.

e).Particulate Matter
Atmospheric *particulate matter* is defined to be any dispersed matter, solid or liquid, in which the individual aggregates are larger than single small molecules (about 0.0002mm in diameter), but smaller than 500mm.

- Particulate matter is diverse and complex.

- The ability of the human respiratory system to defend itself against particulate matter is, to a large extent, determined by the size of the particles.

Particles larger than 10mm

- Large particles that enter respiratory system can be trapped by the hairs and lining of the nose. Once captured, they can be driven out by a cough or sneeze.
- Smaller particles that make it into the tracheobronchial system can be captured by mucus, worked back to the throat by tiny hair like cilia, and removed by swallowing or spitting.

Particles smaller than 10mm

- These particles may make it into the lungs, but depending on their size, they may or may not he deposited there.
- Some particles are so small that they tend to follow the air stream into the lungs and then right back out again.
- Particles roughly between 0.5 and 10mm may be large enough to be deposited in the lungs by sedimentation. Sedimentation is most effective for particles between 2 and 4mm.
- Particulates <10mm are most important from view of adverse health effects on humans.
- High particulate concentration in the atmosphere, especially in conjunction with oxides of sulfur® respiratory infection, cardiac disorders, bronchitis, asthma, pneumonia …
- Some particles are toxic. Many carbonaceous particles, especially those containing polycyclic aromatic hydrocarbons (PAHs) are suspected carcinogens.
- Particulate emissions have decreased substantially in the past few decades, due to tremendous reductions in combustion emissions (especially by electric utilities).

Indoor Air Quality

- People tend to spend more time indoors than out, and in many circumstances, the air we breathe indoors is even more polluted than outdoor air.

Sources of indoor air pollution

- Combustion (to heat water, cook and space heating) can produce elevated levels of CO and NOX.
- Certain photocopying machines emit ozone.
- Formaldehyde emissions from particle board, plywood, urea – formaldehyde foam insulation.
- Asbestos used for fireproofing and insulation.
- Various volatile organics emitted from household cleaning products.

- Many pollutants, such as cigarette smoke and radon when emitted indoors can be concentrated, leading to harmful exposure levels.
- Tobacco smoke contains numerous known or suspected carcinogens, including benzene, hydrazine, benzo - a-pyrene (BaP) and Nickel.
- Smoke particles are small, averaging about 0.2 μm, so they are easily carried into the deepest regions of the lungs.
- A single cigarette smoke gives off on the order of 1012 smoke particles, most of which are released while the cigarette is simply smoldering in the air (*sidestream smoke*) rather than when a smoker takes a puff (*mainstream smoke*).
- Hence non smokers are also exposed to significant amount of smoke particles.
- Other indoor air pollutants arising from tobacco smoke include carbon monoxide, nicotine, nitrosamines, acrolein and other aldehydes.
- Another potentially important source of indoor air pollution is caused by wood-burning stoves and fireplaces.
- Wood combustion produces CO, NOX, hydrocarbons and respirable particles and some emissions that are suspected carcinogens like benzo - a-pyrene.

Effects of air pollution

Air pollution is known to have many adverse effects, including those on human health, building facades and other exposed materials, vegetation, agricultural crops, animals, aquatic and terrestrial ecosystems, and the climate of earth as a whole.

a) Health affects

Perhaps the most important effect of air pollution is the harm it causes to human health. Generally, air pollution is most harmful to the very old and the very young. Many elderly people may already suffer from some form of heart or lung disease, and their weakened condition can make them very susceptible to additional harm from air pollution. The sensitive lungs of new born infants are also susceptible to harm from dirty air. But it is not just the elderly or the very young who suffer; healthy people of all ages can be adversely affected by high levels of air pollutants. Major health effects are categorized as being acute, chronic, or temporary.

There is much evidence linking lung cancer to air pollution, although the actual cause-and – effect relationship is still unknown. Typical effects of sulfur dioxide, oxides of nitrogen, and ozone include eye and throat irritation, coughing and chest pain. Nitrogen dioxide is known to cause pulmonary edema, an accumulation of excessive fluids in the lungs. Ozone, a highly irritating gas, produces pulmonary congestion; symptoms of ozone exposure may include dry throat, headache, disorientation, and altered breathing patterns.

B) Effect on Materials

Every year , air pollutants cause damage worth billions of rupees. Air pollutants breakdown the exterior paint in cars and houses. Air pollutants have discolored irreplaceable monuments, historic buildings, marble statues and other heritage and natural beauty sites.

c) Effect on plants.

Some gaseous pollutants enter leaf pores and damage the crop plants. Chronic exposure of leaves to air pollutants damages waxy coating, leads to damage from diseases, pests, drought and frost. Such exposure interferes with photosysthesis and plant growth, reduces nutrient uptake and causes leaves to turn yellow, brown or drop off. At higher concentrations of SO2 most of the flower buds become stiff and hard and fall off. Prolonged exposure to higher levels of air pollutants from Iron smelters, coal burning power plants and industries, vehicles can damage trees and plants.

d)on Stratosphere

Ozone is continuously being created in the stratosphere by the absorption of short-wavelength UV radiation, while at the same time it is continuously being removed by various chemical reactions that convert it back to molecular oxygen. The rates of creation and removal at any given time and location dictate the concentration of ozone present. The balance between creation and removal is being affected by increasing stratospheric concentrations of chlorine, nitrogen and bromine, which acts as catalysts, speeding up the removal process. CFCs are predominant.

Management of Air Pollution

For ages man has been dumping wastes into the atmosphere, and these pollutants have disappeared with the wind. We have seen that the main sources of air pollution are (i) motor vehicles, (ii) industries-particularly their chimney wastes, (iii) fossil-fuel (coal) based plants, as thermal power plants. Steps are to be taken to control pollution at source (prevention) as well as after the release so pollutants in the atmosphere. There is an urgent need to prevent the emissions from the above said major sources of air pollution. The control of emissions can be realized in number of ways

1. Source Correction: There are several approaches or strategies for air pollution control. The most effective control would be to prevent the pollution from occurring in the first place. Complete source shutdown would accomplish this, but shutdown is only practical under emergency conditions, and even then it causes economic loss. Nevertheless, state public health officials can force industries to stop operations and can curtain highway traffic if an air pollution episode is imminent or occurring.

An important approach for air pollution control is to encourage industries to make fuel substitutions or process changes. For example, making more use of solar, hydroelectric, and geothermal energy would eliminate much of the pollution caused by fossil fuel combustion at power generating plants. Nuclear power would do the same, but other problems related to high level radioactive waste disposal and safety remain to be solved. Fuel substitutions are also effective in reducing pollution from mobile sources. For example, the use of reformulated gasoline or alternative fuels such as liquefied petroleum gas, compressed natural gas, or methanol for highway vehicles would help to clear the air. The use of correct operation and maintenance practices is important for minimizing air pollution and should not be overlooked as an effective control strategy.

2. Collection of pollutants:

Often the most serious problem in air pollution control is the collection of the pollutants so as to provide treatment. Automobiles are most dangerous, but only because the emissions can not be readily

collected. If we could channel the exhausts from automobiles to some central facilities, their treatment would be much more reasonable than controlling each individual car. One success in collecting pollutants has been the recycling of blow by gases in the internal combustion engine. By reigniting these gases and emitting them through the car's exhaust system, the need of installing a separate treatment device for the car can be eliminated.

3. Cooling: The exhaust gases to be treated are sometimes too hot for the control equipment and the gases must first be cooled. This can be done in three general ways: dilution, quenching, or heat exchange coils. Dilution is acceptable only if the total amount of hot exhaust is small. Quenching has the additional advantage of scrubbing out some of these gases and particulates. The cooling coils are perhaps the most widely used, and are especially appropriate when heat can be conserved.

4. Treatment

The selection of the correct treatment device requires the matching of the characteristics of pollutant and features of the control device. It is important to realize that the sizes of air pollutants range many orders of magnitude, and it is therefore not reasonable to expect one device to be effective for all pollutants. Although, any new devices may appear any day in the market, the following are the most widely used:

- **Setting chambers** are nothing more than large places in the flues, similar to settling tanks in water treatment. These chambers remove only the large particulates.
- **Cyclones** are widely used for removing large particulars. The dirty air is blasted into a conical cylinder, but off the centerline. This creates violent swirl within the cone, and the heavy solids migrate to the wall of the cylinder where they slow down due to friction and exit at the bottom of the cone. The clean air is in the middle of the cylinder and exits out the top. Cyclones are widely used as pre-cleaners to remove the heavy material before further treatment.
- **Bag filters** operate like the common vacuum cleaner. Fabric bags are used to collect the dust which must be periodically shaken out of the bags. The fabric removes nearly all particulates. Bag filters are widely used in many industries, but are sensitive to high temperature and humidity.
- **Wet collectors** come in many shapes and styles. The simple spray tower is an effective method for removing large particulates. More efficient scrubbers promote the contact between air and water by violent action in a narrow throat section into which the water is introduced.
- **Electrostatic precipitators** are widely used in power plants. The particulate matter is removed by first being charged by electrons jumping from one high voltage electrode to the other, and then migrating to the positively charged electrode. The particulates will collect on the pipe and must be removed by banging the pipes with hammers. Electrostatic precipitators have no moving parts, require electricity, and are extremely effective in removing submicron particulates. They are expensive.
- **Gas scrubbers** are simply wet collectors as described above but are used for dissolving the gases.

- **Absorption** is the use of the material such as activated carbon to capture pollutants. Such adsorbers may be expensive to regenerate. Most of these work well for organics and have limited use for inorganic pollutants.
- **Incineration** is a method for removing gaseous pollutants by burning them to CO2, H2O and inerts. This works only for combustible vapours.
- **Catalytic combustion** involves the use of a catalyst to adsorb or chemically change the pollutants.

Cyclone separator
Bag Filter

5. Dispersion

The concentration of the pollutants at the recipient is affected by atmospheric dispersion, or how the pollutant is diluted with clean air. This dispersion takes place horizontally as well as vertically. Earth rotation presents new areas for the sun to shine upon and to warm air. Accordingly a pattern of winds is set up around the world, some seasonal (e.g. hurricanes) and some permanent.

Diffusion is the process of spreading out the emission over a large area and thus reducing the concentration of the specific pollutants. The plume spread or dispersion as told above is horizontal as well as vertical. We assume that the maximum concentration of pollutants is in the plume centerline, i.e. in the direction of the prevailing wind. As we move further from the centerline, the concentration becomes lower. If we assume that the spread of a plume in both directions is approximated by a Gaussian probability curve, we can calculate the concentration of a pollutant at any distance X downwind from the source.

Ambient Air quality Standards

Area	SPM (mg/m3)	SO2(mg/m3)	CO(mg/m3)	NOx(mg/m3)
Industrial and Mixed use	500	120	5000	120
Residential and Rural	200	80	2000	80
Sensitive	100	3	1000	30

Integrated approach for air pollution Control

- Putting greater emphasis on pollution prevention rather than Control
- Reducing the use of Fossil fuels
- Improving quality of vehicular fuel
- Increasing the use of renewable energy

Lecture 08
Global warming and climate change
(GHG emission, GH effect, impact on environment and agriculture – mitigation strategies, Ozone depletion and Acid Deposition)

Air pollution problems are not necessarily confined to a local or regional scale. Atmospheric circulation can transport certain pollutants far away from their point of origin, expanding air pollution to continental or global scales; it can truly be said that air quality problems know no international boundaries. Some air pollutants are known to be associated with changes in Earth's climate, requiring consideration of governmental actions to limit their impacts. Two important air pollution problems that are generally considered worldwide in scope are **global warming** and **depletion of stratospheric ozone.**

Greenhouse Gases

Since CO2 is confined exclusively to the troposphere, its higher concentration may act a serious pollutant. Under normal conditions (with normal CO2 Concentration) the temperature at the surface of the earth is maintained by the energy balance of the sun rays that strike the planet the planet and heat that is radiated back into space. However, when there is an increase in CO2 concentration, the thick layer of this gas prevents the heat from being re-radiated out. This thick CO2 layer thus functions like the glass panels of a greenhouse (or the glass windows of a motor car), allowing the sunlight to filter through but preventing the heat from being re-radiated in outer space. This is the so-called greenhouse effect. Nitrogen and oxygen, the main constituents of the atmosphere, play no part in the green house effect. But there are approximately 35 trace gases that scientists believe contribute to global warming. **Carbon dioxide (CO2)** is considered to be one of the most important of these greenhouse gases, absorbing most of the heat trapped by the atmosphere.

Other gases of special importance in global warming are **chlorofluorocarbons** (CFCs), **methane, nitrous oxide** and **ozone.** Although the average concentrations of these gases are much lower than that of carbon dioxide, they are much more efficient than carbon di oxide at soaking up long – wave radiation. Overall, carbon dioxide is estimated to cause almost 60 per cent of the warming effect and CFCs about 25 per cent, and the remainder is caused by methane, nitrous oxide, ozone, and other trace gases.

More than 80% of the mass of the atmosphere and virtually all of water vapour, clouds and precipitation occur in the troposphere. Earth's surface, it consists of*troposphere, stratosphere, mesosphere* and the *thermosphere.* Troposphere extends upto 10-12 km at mid latitudes (at equator – 18 km, at poles 5-6 km). In troposphere, temperatures typically decrease at 5-7°C per km (wet adiabatic lapse rate).

Above the troposphere is a stable layer of very dry air called stratosphere. Pollutants that find their

way into the stratosphere may remain there for many years, before they eventually drift back into the troposphere à removed by rainfall or settling. In the stratosphere, short wavelength UV energy is absorbed by ozone, causing the air to be heated. The resulting temperature inversion is what causes the stratosphere to be so stable. The troposphere and stratosphere combined account for 99.9% of the mass of the atmosphere. Together they extend to only about 50 km above the surface of the earth.

CARBON DIOXIDE

CO2 has been recognized for its importance as a greenhouse gas for almost a century. Arrhenius (1896) is usually credited with the first calculations on global temperature as a function of atmospheric CO2 content.

The carbon cycle

Carbon moves continually from the atmosphere into the food chain during photosynthesis and returns to the atmospheric during respiration.

- From the atmosphere it can be assimilated by plants on the land or in the oceans, or it can dissolve into the sea water.
- Respiration by living things, including decomposers that are feeding on dead organic matter, return CO2 either to the oceans or to the atmosphere.
- A very small portion of the dead organic matter each year ends up being buried in sediments. The slow, historical accumulation of buried organic matter is the source of our fossil fuels – oil, gas and coal.
- When these are burned, C in the form of CO2 is returned to the atmosphere. The rapid accumulation of CO2 in the atmosphere is attributed mainly to fossil fuel burning and deforestation.

Historical emissions of CO2

- The concentration of CO2 in the atmosphere at the beginning of the 19th century was around 280 ppm. By 1990 it was 355 ppm and was climbing at about 1.5 ppm per year
- CO2 concentrations in 1990 were more than 25 per cent higher than those just before the industrial revolution.
- 1 ppm rise in CO2 rise would add 2.12 Gt C into the atmosphere.
- However, some carbon added to the atmosphere will be absorbed by the oceans or taken up by the plants during photosynthesis, thus, not all emissions will result in increased CO2 concentrations.
- It is convenient to represent the fraction of emissions that remain in the atmosphere with a quantity called the *airborne fraction*.

Airborne fraction =
where (D c atmosphere) is the change in carbon content of the atmosphere and
(D c emissions) is the total amount of carbon added to the atmosphere.

- Values of airborne fraction has been estimated at anywhere from 0.4 to 0.7, with 0.5 being a commonly used ratio.

Equilibrium temperature increase caused by CO2

- Considerable effort has gone into attempting to quantify the relationship between expected global temperature change and CO2 concentration.
- Typical of current understanding is that a doubling of CO2 will likely result in an eventual global warming of approximately 1.5 –4.5°C.
- An increase of only 1.5°C over the pre industrial temperature would make the earth warmer than it has been in the last 10,000 years.
- In the past 100 years or so, an increase of 0.5°C has actually occurred in the global average surface temperature.
- Elevated temperatures increase evaporation, increasing the amount of water vapour in the air. Since water vapour is a green house gas, it might cause even more warming. On the other hand, increased cloudiness may increase the albedo. Increasing albedo would lead to global cooling.

CHLOROFLUOROCARBONS

- CFCs are mainly used as refrigerants, solvents, foaming agents in the production of rigid and flexible foams and as aerosol propellants for such products as deodorants, hairspray and spray paint.
- Chloroflurocarbons (CFCs) are molecules that contain chlorine, fluorine and carbon.
- As opposed to other greenhouse gases, CFCs do not occur naturally and their presence in the atmosphere is due entirely to human activities.
- CFCs absorb strongly in the atmospheric window (7-12 μm) and tend to have long atmospheric residence times. Hence they are potent greenhouse gases.
- The two CFCs that have received the most attention, in both ozone and climate change contexts are trichlorofluoromethane, CFCl3 (CFC-11), and dichlorofluoromethane, CF2Cl2 (CFC-12).
- CFC molecules are inert and non–water soluble, so they are not destroyed through chemical reactions or removed with precipitation.
- The only known removal mechanism is photolysis by short wavelength solar radiation, which occurs after the molecules drift into the stratosphere. The chlorine freed during this process can go on to destroy stratospheric ozone.

- CFCs are mainly used as refrigerants, solvents, foaming agents in the production of rigid and flexible foams and as aerosol propellants for such products as deodorants, hairspray and spray paint.
- Some of the CFCs are based on a one-carbon methane structure, such as trichlorofluromethane (CFCl3) and dichlorofluromethane (CF2Cl2), they were often referred as *chlorofluromethanes or CFMs*. The Duiont trade name freon has also been used.
- When molecules contain only fluorine, chlorine and carbon, they care called *fully halogenated CFCs*.
- Some CFCs contain hydrogen as well as chlorine, fluorine and carbon and they are called *hydrochlorofulorocarbons or HCFCs*.
- HCFCs have the environmental advantage that, due to the hydrogen bond, they are less stable in the atmosphere and hence, are less likely to reach the stratosphere to affect the ozone layer. The ozone depleting potential of HCFCs is only 2-5% compared most commonly used CFCs. The most widely used CFCs are CFC –11, CFC –12 and CFC –113.
- When no chlorine is present in the molecule, they are called *hydroflurocarbons or HFCs*. HFCs are important replacements for CFCs, since their lack of chlorine means they do not threaten the ozone layer.

OTHER GREENHOUSE GASES

- *Methane* is a naturally occurring gas that is increasing in concentration, as a result of human activities.
- It is produced by bacterial fermentation under anaerobic conditions, such as in swamps, marshes, rice paddies, as well as in the digestive systems of ruminants and termites.
- It is also released during the production, transportation and consumption of fossil fuels, as well as when biomass fuels are burned.
- After its release, methane is thought to have an atmospheric residence time of around 8-11 years. It is eventually removed through oxidation with various OH radicals.
- Methane concentrations have increased rapidly in the past 20 years and correlate quite well with human population size.
- *Nitrous oxide* is another naturally occurring greenhouse gas that has been increasing in concentration due to human activities.
- It is released into the atmosphere mostly during the nitrification portion of the nitrogen cycle

NH_4^+ à N_2 à N_2O à NO_2^- à NO_3^-

  - Combustion of fossil fuels and nitrogen fertilizer consumption are thought to be the two most important human activities leading to increases in nitrous oxide levels.

- It apparently has no significant tropospheric sinks and is only slowly degraded in the stratosphere by photolysis.
- The destruction process in the stratosphere involves a reaction with atomic oxygen leading to formation of nitric oxide, which in turn reacts catalytically with ozone.
- The desired removal of nitrous oxide, then, has the undesired effect of reducing stratospheric ozone.
- Nitrous oxide has an extremely long residence time of 150 years in the atmosphere. It has strong absorption bands at 4.5, 7.8 and 17 µm and it is thought to be about 230 times as potent as CO2 in causing global warming.
- *Ozone* plays an important role in both troposphere and stratosphere.
- About 90% of atmospheric ozone resides in the stratosphere and it protects life by absorbing short-wavelength ultraviolet radiation.
- Stratospheric ozone also affects climate, but in a very complex way. Incoming solar energy is absorbed, which heats the stratosphere. This, however, reduces the radiation arriving at the earth's surface, thereby cooling the surface.
- On the other hand, the warmed stratosphere radiates energy back to the earth's surface, thereby heating it. The net effect is uncertain.
- In the troposphere, ozone is a component of photochemical smog and it poses a serious health problem.
- Tropospheric ozone absorbs strongly at around 9.6 µm, right in the middle of the atmospheric window. Increasing concentrations could contribute to raising global temperatures.
- Ozone, however, has a rather short residence time in the troposphere, measured in days. It is irregularly distributed by time of day, geographic location, and altitude. So it has been difficult to assess its overall change with time, leaving us uncertain as to its impact on climate.

The Greenhouse effect

- Nearly all the incoming solar energy arrives extra terrestrially, with wavelength less than 4 µm (short wavelength radiation), while the outgoing energy radiated by the earth has essentially all of its energy in wavelength greater than 4 µm (long wavelength or thermal radiation)
- Essentially all the incoming solar radiation with wavelengths less than 0.3 µm (ultraviolet) is absorbed by oxygen and ozone in the stratosphere.
- Most of the long wave-length energy radiated by the earth is affected by a combination of radiatively active gases, most importantly water vapour (H2O), CO2, N2O and CH4.
- Radiatively active gases that absorb wavelengths longer than 4 µm are called *greenhouse gases*.

- These gases trap most of the outgoing thermal radiation attempting to leave the earth's surface. This absorption heats the atmosphere, which, in turn, radiates energy back to the earth as well as out to space.
- The greenhouse effect adds 33°C of warming to the surface of the earth, i.e., if there was no greenhouse effect, the earth would have an average temperature of –18°C or about 0°C.
- Distributed over the entire surface of the earth, the incoming solar radiation is equal to 343 W/m2.
- Since the albedo is 30% (103 W/m2), the amount of incoming radiation absorbed by the atmosphere and earth is 240 W/m2.
- Of that 240 W/m2, 86 W/m2 are absorbed by the atmosphere and the remaining 154 W/m2 are absorbed by the surface of the earth.

Global Warming and Climate Change

Carbon dioxide is a green house gas that is confined to the troposphere and its higher concentration may act as a serious pollutant. Under normal conditions the temperature at the surface of the earth is maintained by energy balance of the sun rays that strike the planet and heat that is reradiated back into space. However when there is an increase in CO2 concentration, the thick layer of the gas prevents the heat from being reradiated out. This thick CO2 layer functions like the glass panel of a green house, allowing the sun light to filter through but preventing the heat from being reradiated into outer space. Therefore, it is warmer inside the green house than outside. Similar condition is resulted in the troposphere of the earth and termed as **'Green house effect'**.

Carbon dioxide concentration of the troposphere has been increasing steadily due to industrial growth. Nearly hundred years ago the CO2 concentration was 275 ppm, today it is 350 ppm and by the year 2040 it is expected to reach 450 ppm. Certain gases in the atmosphere, known as 'green house' gases like CO, CO2, CH4 are able to absorb and emit heat. When sunlight strikes the earth's surface it warms up, emits heat, which radiates upwards into space. This heat warms up the green house gases so that they also emit heat, some into space and some back down to earth, which results in heating up of the earth atmosphere, also known as **Global warming.**

Average land surface temperatures are increasing worldwide. In fact, the decade of the 1990s was the warmest ever recorded, and the trend of gradually rising average temperatures seems to be continuing. By some estimates, global mean temperature has risen roughly 0.5oC (1°F) since the end of the 19th century. This may seem to be an insignificant rise, given the wide variation in temperatures that occur on a daily and annual basis at any given location, as well as the obvious difficulty in measuring, collecting, and interpreting world wide temperature records dating as far back as a century or more ago. But most atmospheric scientists think that even a small increase in average global temperature can have a noticeable impact on Earth's climate.

Potential impacts of global warming on Environment, Agriculture and Human Health

One of the methods that scientists used to estimate the impacts of global warming involves computer analysis of mathematical equations that model Earth's atmosphere. Typically, these sophisticated

computer programs are called General Circulation Models (GCMs). As a basis for predicting future global impacts, most models assume that the concentration of greenhouse gases will effectively double. On this basis, the GCMs generally predict an average global warming of up to 42oC (7.5oF) and an overall increase in precipitation of about 10 per cent by the year 2050. It is also expected that global warming will create a more active hydrologic cycle, increasing cloudiness as well as precipitation. Recent estimates suggest that global sea level has risen by about 0.15 m during the 20th century, with most of the rise occurring since 1930. Some scientists believe that, because of global warming, average sea levels may raise by at least 0.3 m and as much as 1.4 m by the year 2030. This is likely to cause extensive economic and social hardship in coastal areas all over the world. Temperature would increase by 1.5 to 4.5°C . The polar icecaps would melt. A rise of five degrees would raise the sea level by five meters within a few decades increase the evaporation of water, thus reducing grain yield. Potential impacts of global warming on ecosystems mainly include the effects on agriculture and forest growth. Plant growth and development will be influenced by an increase in carbon di oxide levels, which stimulates photosynthesis and decreases water losses from transpiration. In addition to affecting agriculture and forests, global warming is expected to have other impacts. For example, higher temperatures and humidity may increase the chances of disease in humans and animals in some parts of the world.

Ozone and Photochemical smog

Ozone (O3), a secondary air pollutant in the troposphere, is formed by a set of exceedingly complex chemical reactions between nitrogen dioxide (NO2) and volatile organic compounds (VOCs). VOCs are hydrocarbons that quickly evaporate under normal atmospheric conditions. The reactions are initiated by the ultraviolet energy in sunlight. Actually, a number of secondary pollutants (collectively termed photochemical oxidants) are formed in the reactions. Ozone, the most abundant of the oxidants, is the key component of photochemical smog. It is universally accepted that the ozone layer in the stratosphere protects us from the harmful UV radiations from sun. The depletion of this O3 layer by human activities may have serious implications and this has become a subject of much concern over the last few years. The ozone near the earth's surface in troposphere creates pollution problems. Ozone and other oxidants such as hydrogen peroxide are formed by light dependent reactions between NO2 and hydrocarbons. Ozone may also be formed by NO2 under UV-radiations effect. These pollutants cause photochemical smog.

A series of harmful effects are caused by an increase in UV radiation. Cancer is the best established threat to man. When the O3 layer becomes thinner or has holes, it causes cancers, especially relating to skin like melanoma. A 10% decrease in stratospheric ozone appears likely to lead a 20-30% increase in skin cancer. The other disorders are cataracts, destruction of aquatic life and vegetation and loss of immunity. Photochemical smog is highly oxidizing polluted atmosphere comprising largely of O3, NOx, H2O2, organic peroxides, PAN, and PBz N. This is produced as a result of photochemical reaction among NOz hydrocarbons and oxygen.

The word **smog** is coined by combining smoke and fog which characterized air pollution episode in London, Glasgow, Manchester and other cities of U.K. where sulphur-rich coal was used. The term

smog is said to have been coined in 1905 by H.A. Des Voeux. The U.K. smog was a mixture of reducing pollutants and has been called reducing smog, whereas Los angels smog, a mixture of oxidizing pollutants is called oxidizing smog or photochemical smog.

Greenhouse gas inventory estimation – Indian Scenario

Estimations of anthropogenic GHG emission inventories in India, began in a limited scale in 1991, which were enlarged and revised and the first definitive report for the base year 1990 was published4 in 1992. Since then, several papers and reports have been published which have upgraded the methodologies for estimation, included country-specific emission factors and activity data, accounted for new sources of emissions and new gases or pollutants. A comprehensive inventory of the Indian emissions from all energy, industrial processes, agriculture activities, land use, land use change and forestry and waste management practices has recently been reported in India's Initial National Communication to the UNFCCC for the base year 1994.

In 1994, 1228 million tonnes of CO2 equivalent emissions took place from all anthropogenic activities in India, accounting for 3 per cent of the total global emissions. About 794 million tonnes, i.e. about 63 per cent of the total CO2 equivalent emissions was emitted as CO2, while 33 per cent of the total emissions (18 million tonnes) was CH4, and the rest 4 per cent (178 thousand tonnes) was N2O. The CO2 emissions were dominated by emissions due to fuel combustion in the energy and transformation activities, road transport, cement and steel production. The CH4 emissions were dominated by emissions from enteric fermentation in ruminant livestock and rice cultivation. The major contribution to the total N2O emissions came from the agricultural soils due to fertilizer applications. At a sectoral level, the energy sector contributed 61 percent of the total CO2 equivalent emissions, with agriculture contributing about 28 per cent, the rest of the emissions were distributed amongst industrial processes, waste generation, and land use, land use change and forestry.

Comparative national emission trends

The compounded annual growth rate of CO2 equivalent emissions from India is between 1990 and 2000 showed an overall increase by 4.2 per cent per annum. On a sectoral basis, the maximum growth in emissions is from the industrial process sector (21.3 per cent per annum), followed by the emissions from the waste sector (7.3 per cent per annum). The energy sector emissions have only grown by 4.4 per cent per annum with almost no increase in emissions registered from the agriculture sector. Significant increase in emissions from the industrial process sector can be attributed to the growth in cement and steel production in India over the decade. Similarly, increase in emissions from the waste sector can be attributed to increase in quantity of waste generated due to the large influx of population from villages to cities in 2000 with respect to 1990, where because of systematic waste disposal practices; anaerobic conditions are created leading to CH4 emissions.

Data from some of the developed countries indicate that between 1990 and 2000, there has been a decline in the compounded annual growth rates of GHGs such as in the case of Russian federation, Germany and UK were the growth rates have decreased by –2.8, –2.0 and –1.4 per cent per annum respectively. In comparison, the emissions from Japan, USA and India have grown by 1.6, 2.0 and 4.2

per cent per annum respectively within the same period. Even the emissions from China and Brazil for the period 1990–1995 show a high compounded annual growth rate of 5 and 6 per cent respectively. Though the compounded annual growth rates of CO2 equivalent emissions from India are on a higher side (4.2 per cent per annum), the absolute value of these emissions is still 1/6th of that of USA. Also, the per capita GHG emissions from India are one of the lowest. In the year 2000, the US per capita CO2 equivalent emission was 15.3 times more than that of India. The German per capita emissions were 8.0 times higher. Similarly, the Japanese per capita CO2 equivalent emissions were 6.7 times higher than that of India. Even when compared with developing countries such as China and Brazil, the Indian per capita emissions were 2.2 and 1.3 times lower respectively.

For almost all the countries, the share of CO2 emissions is actually increasing continuously between the period 1990 and 2000 and it is the CH4 and N2O emissions which have decreased in this period, resulting in an overall decrease in the growth rates of the CO2 equivalent emissions. Exceptions are in the case of India, where the N2O emissions are also increasing, and in the case of UK and Germany, where all three emissions are declining. Further the decrease in emission trends in Germany and the UK, is due to the fact that the solid and liquid fuel use in these countries is on the decline and the natural gas consumption is increasing. Japan is the only country amongst all the countries considered, where the solid fuel use has increased between 1990 and 2000. In the USA, the fuel mix has remained same between 1990 and 2002, with maximum use of liquid fuel, followed by gaseous and solid fuel. In India too, the commercial fuel mix has remained almost the same between 1990 and 2002, wherein 10 per cent of the fuel used is solid fuel, 81 per cent is liquid fuel and the rest is gaseous fuel. Penetration of commercial biomass as a main fuel source is still very low.

Indian climate-friendly initiatives

The GHG intensity of the Indian economy in the year 2000, in terms of the purchasing power parity, is estimated to be little above 0.4 tonne CO2 equivalent per 1000 US dollars, which is lower than that of the USA and the global average. The Indian Government has targeted an 8% GDP growth rate per annum for 2002–07 to achieve its development priorities. In order to achieve these developmental aspirations, substantial additional energy consumption will be necessary and coal, being the abundant domestic energy resource, would continue to play a dominant role. Since GHGs emissions are directly linked to economic growth, India's economic activities will necessarily involve increase in GHGs emissions from the current levels. The CO2 equivalent emissions from India are set to increase up to 3000 million tonnes by 2020. Energy and power sector reforms, for instance, have helped to enhance the technical and economic efficiency of energy use. Policies adopted by India for a sustainable development, such as energy efficiency, improvement measures in various sectors, increasing penetration of cleaner fuels. And a thrust for renewable energy technologies have all contributed towards GHG emission reduction since the last decade. Past few years have also witnessed introduction of landmark environmental measures that have targeted cleansing of rivers, enhanced forestation, installed significant capacity of hydro and renewable energy technologies.The Indian government has simultaneously introduced clean coal technologies like coal washing and introduced

the use of cleaner and lesser carbon intensive fuel, like introducing auto LPG and setting up of Motor Spirit-Ethanol blending projects in selected states.

Climate Change Effects

Sea level and climate change

One quarter of the Indian population live along the country's coasts, and are largely dependent on coastal livelihoods. Climate change effects on sea level can impact coastal areas in two ways – through increase in mean sea level, and through increased frequency and intensity of coastal surges and storms. Climate change is of concern to India in view of the damages that occur along the east coast of India from the cyclones that form in the Bay of Bengal. Any increase in the frequency or intensity of tropical disturbances due to climate change in the future could cause increased damages to life and property in the coastal regions. The National Institute of Oceanography (NIO) and the Indian Agricultural Research Institute (IARI) conducted a study on the impacts of climate change on sea level to assess the degree to which mean sea level and the occurrence of extreme events may change.

The National Institute of Oceanography

The National Institute of Oceanography (NIO) is a research organization of the Council of Scientific and Industrial Research (CSIR), Government of India. NIO is a large oceanographic laboratory with a focus on the oceanography of the seas around India. Their core areas of study are ocean processes, coastal studies, resource surveys, conservation, and ocean engineering.

Predicted climate change impacts on sea level

As a result of the study, the following changes due to climate change were predicted for sea level:

Mean sea level: Mean sea level rise estimates (using past tide gauge data) were found to be slightly less than 1 mm/yr for most of the stations analyzed along the Indian coast. However, data on vertical land movements was not available, and will need to be incorporated in order to obtain net sea level rise estimates.

Storm surges: The study showed a greater number of high surges under climate change. In addition, the model showed an increased occurrence of cyclones in the Bay of Bengal, particularly in the post-monsoon period, along with increased maximum wind speeds associated with cyclones.

Agriculture and climate change

The agricultural sector represents 35% of India's Gross National Product (GNP) and as such plays a crucial role in the country's development. Food grain production quadrupled during the post-independence era; this growth is projected to continue. The impact of climate change on agriculture could result in problems with food security and may threaten the livelihood activities upon which much of the population depends. Climate change can affect crop yields (both positively and negatively), as well as the types of crops that can be grown in certain areas, by impacting agricultural inputs such as water for irrigation, amounts of solar radiation that affect plant growth, as well as the prevalence of pests. The Indian Agricultural Research Institute (IARI) examined the vulnerability of agricultural production to climate change, with the objective of determining differences in climate change impacts on agriculture by region and by crop.

Models used to predict climate change impacts on agriculture

The following models were developed to evaluate the impacts of changes in temperature and carbon dioxide on crops:

1. INFOCROP, a generic growth model for various crops, was developed by IARI for optimal resource and agronomic management options.

2. INFOCANE, a simple sugarcane growth model, was developed by IARI to measure effects on cane yield.

Human Health and climate change

Both climatologically and medical communities are increasingly concerned that climate change is likely to have wide-ranging impacts on health. The poor, as well as the elderly, children, and the disabled are likely to be most vulnerable to these changes, as they already face limited access to health facilities. Among vector-borne diseases in India, malaria is of considerable concern. Periodic epidemics of malaria occur every five to seven years, and the World Bank estimates that about 577,000 DALYs (disability-adjusted life years) were lost due to malaria in India in 1998. Climate change could increase the incidence of malaria in areas that are already malaria-prone, and also introduce malaria into new areas. The National Physical Laboratory (NPL), New Delhi undertook a study of the impacts of predicted climate change on human health in India, with a particular focus on malaria.

Health concerns and vulnerabilities due to climate changes change

1. **Temperature related morbidity**

• Heat and cold related illness
• Cardio vascular illnesses

2. **Vector borne diseases**

- Changed patterns of diseases by region and by climate parameter
- Malaria, Filaria, Kala-azar, Japanese Encephalitis, and Dengue caused by bacteria, viruses and other pathogens carried by mosquitoes, ticks, and other vectors.

3. **Health effects of extreme weather**

- Diarrhoea, Cholera and intoxication caused by biological and chemical contaminants in water.
- Damaged public health infrastructure due to cyclones / floods
- Injuries and illness
- Social and mental health stress due to disasters and displacement

4. **Health effects due to insecurity**

- Malnutrition, hunger, particularly in children in food production

Mitigation strategies

CARBON REDUCTION

India's Initiatives

India has undertaken numerous response measures that are contributing to the objectives of the United Nations Framework Convention on Climate Change (UNFCCC). India's development plans balance economic development and environmental concerns. The planning process is guided by the principles of sustainable development. Reforms in the energy and power sector have accelerated economic growth and enhance the efficiency of energy use. These have been complemented by notable initiatives taken by the private sector.

In the last few years several measures relating to environmental issues have been introduced. They have targeted increasing significantly, the capacity of renewable energy installations; improving the air quality in major cities (the world's largest fleet of vehicles fuelled by compressed natural gas has been introduced in New Delhi); and enhancing afforestation. Other similar measures have been implemented by committing additional resources and realigning new investments, thus putting economic development on a climate-friendly path.

Sectoral initiatives

Coal : Coal is and will remain the mainstay of commercial energy production. To ensure more efficient use of coal the following measures have been taken:

- Rationalization of coal use
- Participation of private sector encouraged
- Reforms in pricing
- Technology upgradation involving: coal-washing, improvements in combustion technology and the recovery of coal-bed methane.

Oil : To promote fuel efficiency and conservation, the following measures have been undertaken.

- Reduction of gas-flaring
- Installation of waste heat-recovery systems
- Energy audits
- Equipment upgradation
- Substitution of diesel with natural gas. Establishment of PCRA (Petroleum Conservation research Association) to increase awareness and develop fuel-efficient equipment.

Gas : This source of energy is the preferred substitute for coal and oil. In the residential sector, gas has replaced coal and kerosene. CNG has been introduced in the place of petrol and diesel in the transport sector. Major investments have been made in developing infrastructure for long distance and local distribution. Import options are under consideration. The share of gas in the power sector has increased from 2-8%.

Hydropower : The government's policy objective is to exploit the huge potential in India's northeast. At present, about 25% of the total installed capacity is accounted for by hydro.

Renewables : India has a very active programme to promote the use of renewable energy. Some salient features of the current renewables situation are given source-wise

Solar : Photovoltaic system based on solar energy have been put to a variety of uses in rural electrification, railway signalling, microwave repeaters, power to border outposts and TV transmission and reception. Grid-connected PV power plants with an aggregate capacity of 1900 kWp have been set up for demand-side management or tail-end voltage support. A 140 MW integrated solar combined cycle (ISCC) plant is being set up based on solar thermal technology and liquified natural gas. Solar lanterns, home- and street-lighting systems, stand-alone power plants, and pumping systems are being promoted. So far, 9,20,000 SPV systems with an aggregate capacity of 82 MWp have been installed in the country.

Wind Energy : India is among the five leading nations in wind power generation. The installed capacity is 1507 MW, and generators of capacity 250-600 kW are manufactured here. 95% of installed wind power capacity is in the private sector. State-of-the-art wind power systems are also being manufactured in the country. In fact, wind turbine equipment is also being exported to other developing and developed countries.

Biogas : Biomass power generation plants of a total capacity of about 358 MW have been installed and gasification systems of a total capacity of 42.8 MW have been set up for decentralized energy application. In rural areas, over 3.2 million biogas plants and 33 million improved stoves have been installed.

Agriculture : Some efforts to mitigate climate change in the agricultural sector have also been undertaken. They are:

- Standardization of fuel-efficient pump sets, rectification of existing pump sets.
- Rationalization of power tariffs.
- Better cultivar practices which will help in reducing N2O emissions.

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Residential: Fuel-efficient equipment/appliances such as kerosene and LPG stoves, compact fluorescent lamps, pump sets for lifting water in high-rise buildings are being promoted in the residential sector.

Afforestation and land restoration

The basic components of India's forest conservation efforts include protecting existing forests, putting a check on the diversion of forest land for non-forestry purposes, encouraging farm forestry/private area plantations, expanding the protected area network and controlling forest fires. Forests cover 19.4% of the country's landmass. Forests with a crown cover of more than 40% have been increasing. The National Forestry Action Programme has been formulated for sustainable forest development and to bring one-third of the country's geographical area under forest/ tree cover as mandated in the National

Forest Policy, 1988.

A major programme of afforestation is being implemented with the people's participation under the Joint Forest Management. The National Forest Policy envisages the participation of people in the development of degraded forests to meet their requirements of fuel wood, fodder and timber. Twelve biosphere reserves have been set up to protect representative ecosystems. Management plans are being implemented for 20 wetlands with coral reefs and mangroves being given a priority. The National Wasteland Development Board is responsible for regenerating private, non-forest and degraded land. The National Afforestation and Eco Development Board is responsible for regenerating degraded forest land, land adjoining forests and ecologically fragile areas.

Role of Methanotrophs and Methylotrophs

The atmospheric concentration of methane, a green house gas, has more than doubled during the past 200 years. Consequently, identifying the factors influencing the flux of methane into the atmosphere is becoming increasingly important. Methanotrophs, microaerophilic organisms widespread in aerobic soils and sediments, oxidize methane to derive energy and carbon for biomass hence, they play an important role in mitigating the flux of methane into the atmosphere. Several physico chemical factors influence rates of methane oxidation in soil including soil diffusivity, water potential and levels of oxygen, methane, ammonium, nitrate, nitrite and copper. Most of these factors exert their influence through interactions with methane monooxygenase (MMO), the enzyme that catalyzes the reaction converting methane to methanol, the first step in methane oxidation. Although biological factors such as competition and predation undoubtedly play a role in regulating the methanotroph population in soils, and thereby limit the amount of methane consumed by methanotrophs.

Methane, is second only to carbon dioxide in its importance as a green house gas. The ability of microorganisms to oxidize methane has been known since 1906, when **Sohngen** first isolated an organism capable of growing on methane as a carbon source and named it ***Bacillus methanicus***. Since that time, methane oxidizing microorganisms (methanotrophs) have been found in a variety of soil and aquatic environments. Oxidation of methane to carbon dioxide in soil occurs primarily as part of aerobic metabolism in methanotrophic bacteria. The net reaction of methane oxidation under aerobic conditions can be described as:

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Methane oxidation can also be linked to the reduction of sulphate in anaerobic metabolism. Anaerobic methane oxidation has not been detected in environments lacking sulphate and appears to be most prevalent in aquatic environments.

Methanotrophs, are a subset of the larger group of organisms that utilize one – carbon compounds, the methylotrophs. Classically, the methanotrophs have been divided into a few main genera: *Methylococcus*, *Methylomonas*, *Methylobacter*, *Methylosinus*, *Methylocystis, Methylobacterium* and *M ethylosporovibrio.*

From a functional standpoint, methanotrophs can be divided into three types based on their carbon – assimilation pathway or pathways, as well as intra cytoplasmic membrane arrangement, cell morphology and their guanine and cytosine content of their DNA. Type I methanotrophs possess the

ribulose monophosphate pathway, Type II the serine pathway, and Type X both the pathways.

CARBON SEQUESTRATION

Global warming is amongst the most dreaded problems of the new millennium. Carbon emission is supposedly the strongest causal factor for global warming. So, increasing carbon emission is one of today's major concerns, which is well addressed in Kyoto Protocol. Trees are amongst the most significant elements of any landscape, both due to biomass and diversity. Their key role in ecosystem dynamics is well known. However, it is paradoxical that the vegetation has undergone destruction and degradation in the modern times due to industrial and technological advancement achieved by human society. This advancement has resulted in emission of carbon in the ecosystem. Therefore, there is need to address environmental issues related to them. Trees are important sinks for atmospheric carbon i.e. carbon dioxide, since 50% of their standing biomass is carbon itself.

Nearly half the Indian population will soon be living in urban areas. And urbanization is vigorously promoted both politically and socially as a means to enhance average living standards. However, the ever-growing urbanization threatens escalating of carbon emission due to higher consumption of goods and services compared to the rural sector. Hence, it is crucial that the balance be maintained between the carbon emission and carbon sequestration to achieve sustainability.

Global Carbon Sinks

Global carbon is held in a variety of different stocks. Natural stocks include oceans, fossil fuel deposits, the terrestrial system and the atmosphere. In the terrestrial system carbon is sequestered in rocks and sediments, in swamps, wetlands and forests, and in the soils of forests, grasslands and agriculture. About two-thirds of the globe's terrestrial carbon, exclusive of that sequestered in rocks and sediments, is sequestered in the standing forests, forest under-storey plants, leaf and forest debris, and in forest soils. In addition, there are some non-natural stocks. For example, long-lived wood products and waste dumps constitute a separate human-created carbon stock. A stock that is taking-up carbon is called a "sink" and one that is releasing carbon is called a "source." Shifts or flows of carbon over time from one stock to another, for example, from the atmosphere to the forest, are viewed as carbon "fluxes." Over time, carbon may be transferred from one stock to another.

How Forest Ecosystems Act as Sinks: A sink is defined as a process or an activity that removes greenhouse gases from the atmosphere. Carbon sequestration is the extraction of the atmospheric carbon dioxide and its storage in terrestrial ecosystems for a very long period of time - many thousands of years. Forests offer some potential to be managed as a sink, that is, to promote net carbon sequestration.

Carbon Reduction Credits:

The cost aspect of forest based carbon sequestration, as an offset mechanism is particularly important. It determines how carbon sequestration compares with other potential carbon offset mechanisms in the broader scheme of greenhouse gas reduction policies. According to the protocol, each country will be given carbon credits based on the carbon emission and sequestration scenario. If developing countries like India has to improve on the issue of carbon credits, then role of vegetation patches in carbon

sequestered should be considered.

Indian Scene

According to Ravindranath *et al.* (1997) the standing biomass (as above and below ground biomass) in India is estimated to be 8,375 million tons for the year 1986, of which the carbon storage would be 4,178 million tones. The total carbon stored in forests, including soil is estimated to be 9578 m t. On the other hand, carbon emissions from fossil based energy production and consumption activities in India have been estimated at 152-205 m t per year. The corresponding estimate from agriculture activities including fuel burning ranges from 43 m t to as high as 115 m t. The current rate of carbon emission from agricultural and forestry sectors are just about being balanced by the current rate of reforestation.

Plant roots and carbon sequestration

Carbon management is a serious concern confronting the world today. A number of summits have been organized on this subject ranging from the Stockholm to Kyoto protocol. The current level of carbon in the atmosphere is about 375 ppm. It is estimated that if the carbon increases in the atmosphere at the present rate and no positive efforts are pursued, the level of carbon in the atmosphere would go up to 800–1000 ppm by the end of current century, which may create havoc for all living creatures on earth. Soil may be an important sink for the carbon storage in the form of soil organic carbon. This form of carbon is also a matter of serious concern for agricultural scientists across the globe because various researches reveal that the soil under intensive cultivation results in the increase.

Since the beginning of the industrial revolution, carbon dioxide concentration in the atmosphere has been rising alarmingly. Plant roots have ability to synthesize, accumulate and secrete a diverse array of compounds. More than 200 carbon compounds released from plant roots in the form of exudates are reported, which is termed as rhizodeposition. These exudates contain simple water-soluble compounds such as amino acids, organic acids, sugar and various plant secondary metabolites to complex polymeric compounds such as polysaccharides, polypeptides and enzymes.

Soil carbon sequestration

Soils are the largest carbon reservoirs of the terrestrial carbon cycle. Soils contain about three times more C than vegetation and twice as much as that present in the atmosphere. Soils contain much more C (1500 Pg of C to 1 m depth and 2500 Pg of C to 2 m; 1 Pg = 1 ´ 1015 g) than is contained in vegetation (650 Pg of C) and twice as much C as the atmosphere (750 Pg of C). Carbon in the form of organic matter is a key element to healthy soil. It is estimated that each tonne of soil organic matter releases 3.667 tonnes of CO2, which is lost into the atmosphere. Similarly, the build-up of each tonne of soil organic matter removes 3.667 tonnes of CO2 from the atmosphere. The conversion of natural habitats to cropland and pasture, and unsustainable land practices such as excessive tillage frees carbon from organic matter, releasing it to the atmosphere as CO2. Depletion of organic carbon, soils develop a carbon deficit. Soils can regain lost carbon by reabsorbing it from the atmosphere. This process is called carbon sequestration.

Agricultural practices for carbon sequestration

The carbon content of most agricultural soils is now about one-third less than that in its native

condition as either forest or grassland. Fortunately, modern agriculture has stopped this net loss to the atmosphere. This has come about through higher levels of biomass production, the return of greater proportions of crop residue to the land, use of cover crops and conservation tillage such as reduced and no till. Simultaneously, better fertility management through soil testing, precision farming and proper nutrient application can also lead to lowering of greenhouse gas emissions. Irrigation waters trap some CO2 because irrigated soils produce high crop residues which sequester carbon at a rate of 0.16 to 0.27 Pg per year.

Carbon and soil organic matter

Carbon is a key ingredient in soil organic matter (57% by weight). Plants produce organic compounds by using sunlight energy and combining carbon dioxide from the atmosphere with water from the soil. Soil organic matter is created by the cycling of these organic compounds in plants, animals, and microorganisms into the soil. Well decomposed organic matter forms humus, a dark brown, porous, spongy material that provides a carbon and energy source for soil microbes and plants. When soil is tilled, organic matter previously protected from microbial action is decomposed rapidly because of changes in water, air, and temperature conditions, and the breakdown of soil aggregate accelerates erosion.

What still needs to be known?

Improvement in monitoring and verification protocols for carbon sequestration in soil plant ecosystems is needed for quantitative economic and policy analyses. Such protocols must be acceptable, both domestically and internationally, to scientists, policy makers, landowners, and business groups. These protocols must be suitable for use by employees of government agencies and licensed professionals. Practical techniques to quantify the overall net beneficial impact of agricultural and silvicultural practices on all greenhouse gases, including methane (CH4) and nitrous oxide (N2O) are needed. Other beneficial services derived from improved land practices, such as changes in soil quality, productivity, water and air quality, and erosion must also be recognized and evaluated. Recommended carbon sequestration practices must show benefit for the total environment from a whole ecosystem accounting perspective. Long term studies are needed to insure that current effective carbon sequestration practices result in stable carbon forms for the long term (at least 20-50 years).

Acid deposition/Acid rain

The presence of excessive acid in rain water is called Acid rain. It is a mixture of nitric acid , sulphuric acid and carbonic acid. Since the early 1970s, problems associated with acidic precipitation have gained worldwide attention. Acid rain have damaged or destroyed fish and plant life in thousands of lakes throughout central and northern Europe (especially in Scandinavia), the north east United States, south east Canada, and parts of China. Many species of trees in forests throughout these regions have been in decline, largely due to soil acidification. Acid rain also causes pitting and corrosion of metals and the deterioration of painted surfaces, concrete, limestone, and marble in buildings, monuments, works of art, and other exposed objects.

Acid rain is caused by the emission of sulfur and nitrogen oxides into the atmosphere, mostly from the burning of fossil fuels for electric power. Other sources from human activities include certain

industrial processes and the gasoline powered automobile. Sulfur dioxide reacts with water vapor in the air to form sulfuric acid; nitrogen dioxide reacts with water vapor to form nitric acid. It has been found that the contribution of sulfur dioxide to acid rainfall is more than twice that from nitrogen oxides. Contribution of these gases from natural sources, such as from swamps and volcanoes, are small in comparison to human sources.
A major environmental impact of acid deposition is the lowering of pH in lakes and rivers. Most aquatic life is disrupted as the pH drops. Phytoplankton populations are reduced, and many common water – dwelling invertebrates, such as may flies and stone flies, cannot survive when the pH falls below about 6.0. Some sensitive species of fish, including trout and salmon, are harmed when pH levels fall below 5.5. Acidity has a deleterious effect on the reproductive cycle of fish; when the pH is less than 4.9, reproduction of most fish species is unlikely. Acid dead lakes have pH below about 3.5

Changes In Stratospheric Ozone

Ozone is continuously being created in the stratosphere by the absorption of short-wavelength UV radiation, while at the same time it is continuously being removed by various chemical reactions that convert it back to molecular oxygen. The rates of creation and removal at any given time and location dictate the concentration of ozone present. The balance between creation and removal is being affected by increasing stratospheric concentrations of chlorine, nitrogen and bromine, which acts as catalysts, speeding up the removal process. CFCs are predominant.

The Ozone layer as a protective shield

- Ozone formation in the stratosphere can be described by the following pair of reactions.
- In the first, atomic oxygen (O) is formed by the photolytic decomposition of molecular oxygen (O2)

$$O_2 + h\nu \rightarrow O + O,$$

where UV radiation in this case has wavelength <242 nanometers (nm)

- The atomic oxygen, in turn, reacts rapidly with molecular oxygen to form ozone.

$$O + O_2 + M \rightarrow O_3 + M,$$

where M represents a third body (N2 or O2) necessary to carry away the energy released in the reaction.

- Opposing the above formation process is ozone removal by photodissociation

$$O_3 + h\nu \rightarrow O_2 + O,$$

where in ozone absorbs UV radiation in the 200 – 320 nm wavelength region.

- The above combination of reactions form a long chain, in which oxygen atoms are constantly being shuttled back and forth between the various molecular forms.
- The net effect of the above reactions is the creation of a layer of ozone in the stratosphere that absorbs biologically damaging UV radiation.
- In addition, the heating that results from this UV adsorption is what creates the temperature inversion in the stratosphere, which produces stable conditions that lead to long residence times for stratospheric pollutants.
- As can be seen, the radiation reaching the earth's surface is rapidly reduced for wavelengths less than about 320 nm.
- The UV wavelength have been divided into two bands designated as UV-A and UV-B, where UV-A corresponds to wavelengths less than 320 nm.
- The UV-A portion of the spectrum is not carcinogenic at usual exposure levels on the earth's surface. The crucial role played by ozone in reducing UV-B is apparent.
- CFCs are very stable compounds in the troposphere. When they drift to the stratosphere, CFC molecule can be broken by UV radiation, freeing the chlorine, that is then available to destroy ozone.
- The reaction involving CFC-12 for example is CCl2F2 + hn Cl + CClF2, where hn represents solar radiation.
- The chlorine freed acts as a catalyst in the ozone removal process i.e. it contributes to the reaction, but is unaffected by it.
- A single chlorine atom may break down 1, 00,000 ozone molecules, before it returns to the troposphere, where it is rained out as hydrochloric acid.
- Concern over possible destruction of stratospheric ozone first expressed in the early 1970's (Molina and Rowland, 1974), but it was not until 1985, with the dramatic announcement of the discovery of a 'hole' the ozone layer over Antarctica, the size of the continental US, that the world began to acknowledge the seriousness of the problem.

The following set of reactions has been proposed to describe the role of chlorine and CFCs in the creation of the Antarctic ozone hole.

Cl + O3 ClO + O2, which reacts with nitrogen dioxide (NO2), to form a relatively inert molecule of chlorine nitrate (ClONO2) :

ClO + NO2 ClONO2

- All this point, the chlorine is effectively stored in an inactive form, unable to destroy more ozone.
- In the Antarctic winter, however, a unique atmospheric condition known as the *polar vortex* traps air above the pole and creates conditions that eventually allow the chlorine to be released.

- The polar vortex blocks warmer mid-latitude air from mixing with the air above the pole, creating extremely cold polar air temperature.
- Stratospheric temperatures may fall below – 90°C, which is cold enough to form polar stratospheric clouds even though the air is very dry.
- The ice crystals that make up polar clouds play a key role in the Antarctic phemomenon.
- By providing reaction surfaces, these ice crytals allow chlorine nitrate to react with water to form hypochorous acid (HOCL)

$H_2O + ClONO_2 \rightarrow HOCl + HNO_3$

- As soon as the Sun rises in Antarctic in August, the chlorine stored in HOCl is freed dry photolysis

HOCl + H u → Cl + OH

- As number of possible catalytic reactions have been proposed, whereby the freed chlorine can proceed to destroy ozone.
- As described by Rowland (1989), the chlorine formed can destroy an ozone molecule, creating chlorine monoxide.

$Cl + O_3 \rightarrow ClO + O_2$

and the OH radical can destroy another ozone

$OH + O_3 \rightarrow HO_2 + O_2$

- The ClO and H2O formed thus, can react with each other to form HOCl.

$ClO + HO_2 \rightarrow HOCl + O_2$

Which ca be photolysed, releasing chlorine once again

$HOCl + h\upsilon \rightarrow 3O_2$

- The destruction of ozone, as the sun first appears in the Antarctic spring, proceeds as described until the nitric acid formed ($H_2O + ClO_2 \rightarrow HOCl + HNO_3$) photolyses, creating NO_2 that ties up chlorine. ($ClO + NO_2 \rightarrow ClONO_2$), stopping the ozone destruction.

Since ozone absorbs biologically damaging UV radiation before it can reach the earth's surface, ozone destruction increase the risks associated with UV exposure. UV radiation is linked with human skin cancer, cataracts and suppression of immune system response. Moreover, many plants and aquatic organisms have been shown to be adversely affected by increases in UV exposure. And finally, increases in terrestrial UV flux could increase urban air pollution through the photolysis of formaldehyde, a common component of photochemical smog. Sunburn, Cataract, aging of the skin and

skin cancer are caused by increased UV radiation. It weakens the immune system by suppressing the body's resistance to certain infections like measles, chicken pox and other viral diseases that elicit rash and parasitic diseases such as Malaria introduced through skin. It affects the ability of plants to capture light energy during the process of photosynthesis. This reduces the nutrient content and the growth of plants. This is especially seen in legumes and cabbage. Zooplanktons and phytoplanktons are damaged by UV. UV exposure shortens the breeding period of Zooplanktons. As planktons from the basis of the marine food chain, any change will influence the fish and shellfish production.

Lecture 09

Causes, effects and control of water and marine pollution

Water is one of the most important commodities which Man has exploited than any other resource for sustenance of his life. Most of the water in this planet is stored in oceans and ice caps which is difficult to be recovered for our diverse needs. It can be said that no water is pure or clean owing to the presence of some quantities of gases, minerals and life. Pure water is considered to be that which has low dissolved and suspended solids and obnoxious gases as well as low biological life. Water can be regarded polluted when it changes its quality or composition either naturally or as a result of human activities, thus becoming less suitable for drinking, domestic, agricultural, industrial, recreational, wildlife and other uses.

Some pollutants can be formed by way of concentrations and transformations of naturally occurring compounds during their domestic, agricultural or industrial use. The generation of sewage and the waste waters containing agrochemicals, certain pesticides and surfactants, petrochemicals, hydrocarbons, heavy metals and radionuclides are some important examples of pollutants originated in this way.

Sources of Water Pollutants

To understand the effects of water pollution and the technology applied in its control, it is useful to classify pollutants into various groups or categories. Water pollutant can be classified according to the nature of its origin as either a **point source** or a **dispersed source pollutant**.

A **point source** pollutant is one that reaches the water from a pipe, channel or any other confined and localized source. The most common example of a point source of pollutants is a pipe that discharges sewage into a stream or river. Most of these discharges are treatment plant effluents.

A **dispersed or non point source** is a broad, unconfined area from which pollutants enter a body of water. Surface runoff from agricultural areas carries silt, fertilizers, pesticides, and animal wastes into streams, but not at only one particular point. These materials can enter the water all along a stream as it flows through the area. Acidic runoff from mining areas is a dispersed pollutant. Storm water drainage systems in towns and cities are also considered to be dispersed sources of many pollutants, because, even though the pollutants are often conveyed into streams or lakes in drainage pipes or storm sewers, there are usually many of these discharges scattered over a large area.

Point source pollutants are easier to deal with, while pollutants from dispersed sources are much more difficult to control. Many people think that sewage is the primary culprit in water pollution problems, but dispersed sources cause a significant fraction of the water pollution. The most effective way to control the dispersed sources is to set appropriate restrictions on land use.

Oxygen – Demanding Wastes

One of the most important water quality parameters is the dissolved oxygen (DO) present. Oxygen – demanding wastes are substances that oxidize in the receiving body of water, reducing the

amount of DO available. As DO drops, fish and other aquatic life are threatened and, in the extreme case, killed. In addition, as dissolved oxygen levels fall, undesirable odors, tastes, and colors reduce the acceptability of the water as a domestic supply and reduce its attractiveness for recreational uses. Oxygen-demanding wastes are usually biodegradable organic substances contained in municipal wastewaters or in effluents from certain industries, such as food processing and paper production. In addition, the oxidation of certain inorganic compounds may also contribute to the oxygen demand. Even naturally occurring organic matter, such as leaves and animal droppings, that find their way into surface water add to the DO depletion. Minimum amounts required for a healthy fish population may be as high as 5-8 mg/L for active species, such as trout, or as low as 3 mg/L for less desirable species, such as carp.

There are several measures of oxygen demand commonly used. The chemical oxygen demand, or COD, is the amount of oxygen needed to chemically oxidize the wastes, while the biochemical oxygen demand, or BOD, is the amount of oxygen required by microorganisms to biologically degrade the wastes. BOD has traditionally been the most important measure of the strength of organic pollution, and the amount of BOD reduction in a wastewater treatment plant is a key indicator of process performance.

Pathogens

It has long been known that contaminated water is responsible for the spread of many contagious diseases. Pathogens are disease-producing organisms that grow and multiply within the host. Examples of pathogens associated with water include bacteria responsible for cholera, bacillary dysentery, typhoid, and paratyphoid fever; viruses responsible for infectious hepatitis and poliomyelitis; protozoa, which cause amoebic dysentery and giardiasis; and helminthes, or parasitic worms, which cause diseases such as schistosomiasis and dracontiasis (guinea worm). The intestinal discharges of an infected individual, a carrier, may contain billions of these pathogens, which, if allowed to enter the water supply, can cause epidemics of immense proportions. Carriers may not even necessarily exhibit symptoms of their disease, which makes it even more important to carefully protect all water supplies from any human waste contamination.

Nutrients

Nutrients are chemicals, such as nitrogen, phosphorus, carbon, sulfur, calcium, potassium, iron, manganese, boron, and cobalt, that are essential to the growth of living things. In terms of water quality, nutrients can be considered as pollutant when their concentrations are sufficient to allow excessive growth of aquatic plants, particularly algae. When nutrients stimulate the growth of algae, the attractiveness of the body of water for recreational uses, as a drinking water supply, and as a viable habitat for other living things can be adversely affected. Nutrient enrichment can lead to blooms of algae which eventually die and decompose. Their decomposition removes oxygen from the water, potentially leading to levels of DO that are insufficient to sustain normal life forms.

Major sources of both nitrogen and phosphorus include municipal wastewater discharges, runoff from animal feedlots, and chemical fertilizers. In addition, certain bacteria and blue-green algae can obtain nitrogen directly from the atmosphere. These life forms are usually abundant in lakes that have high rates of biological productivity, making the control of nitrogen in such lakes extremely difficult. Certain forms of acid rain can also contribute nitrogen to lakes. While there are several special sources of nitrogen, the only unusual source of phosphorus is from detergents. When phosphorus is the limiting nutrient in a lake that is experiencing an algal problem, it is especially important to limit the nearby use of phosphate in detergents.

Not only is nitrogen capable of contributing to eutrophication problems, but when found in drinking water a particular form of it can pose a serious public health threat. Nitrogen in water is commonly found in the form of nitrate (NO3), which is itself not particularly dangerous. However, certain bacteria commonly found in the intestinal tract of infants can convert nitrates to highly toxic nitrites (NO2). Nitrites have a greater affinity for hemoglobin in the bloodstream than does oxygen, and when they replace that needed oxygen a condition known as methemoglobinemia results. The resulting oxygen starvation causes a bluish discoloration of the infant; hence, it is commonly referred to as the "blue baby" syndrome. In extreme cases the victim may die from suffocation.

Salts

Water naturally accumulates a variety of dissolved solids, or salts, as it passes through soils and rocks on its way to the sea. These salts typically include such cations as sodium, calcium, magnesium, and potassium, and anions such as chloride, sulfate, and bicarbonate. Commonly used measure of salinity is the concentration of total dissolved solids (TDS). As a rough approximation, fresh water can be considered to be water with less than 1500 mg/L TDS; brackish waters may have TDS values up to 5000 mg/L; and, saline waters are those with concentrations above 5000 mg/L. Seawater contains 30 000 – 34 000 mg/L TDS.

The concentration of dissolved solids is an important indicator of the usefulness of water for various applications. Drinking water, for example, has a recommended maximum contaminant level for TDS of 500 mg/L. Livestock can tolerate higher concentrations. Of greater importance, however, is the salt tolerance of crops. As the concentration of salts in irrigation water increases above 500mg/L, the need for careful water management to maintain crop yields becomes increasingly important. With sufficient drainage to keep salts from accumulating in the soil, up to 1500 mg/L TDS can be tolerated by most crops with little loss of yield but at concentrations above 2100 mg/L, water is generally unsuitable for irrigation except for the most salt tolerant of crops.

Thermal Pollution

A large steam-electric power plant requires an enormous amount of cooling water. A typical nuclear plant, for example, warms about 40m3/s of cooling water by 100C as it passes through the plant's condenser. If that heat is released into a local river or lake, the resulting rise in temperature can dramatically affect life in the vicinity of the thermal plume.

As water temperature increases, two factors combine to make it more difficult for aquatic life to get

sufficient oxygen to meet its needs. The first results from the fact that metabolic rates tend to increase with temperature, generally by about a factor of 2 for each 100C rise in temperature. This causes an increase in the amount of oxygen required by organisms. At the same time, the available supplies of dissolved oxygen are reduced both because waste assimilation is quicker, drawing down DO at a faster rate, and because the amount of DO that the water can hold decreases with temperature. Thus, as temperatures increases, the demand for oxygen goes up while the amount of DO available goes down.

Heavy Metals

In chemical terms heavy metal refer to metals with specific gravity greater than about 4 or 5, but more often, the term is simply used to denote metals that are toxic. The list of toxic metals includes aluminum, arsenic, beryllium, bismuth, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, strontium, thallium, tin, titanium, and zinc. Some of these metals, such as chromium and iron, are essential nutrients in our diets, but in higher doses are extremely toxic.

The most important route for the elimination of metals is via the kidneys. In fact, kidney can be considered to be complex filters whose primary purpose is to eliminate toxic substances from the body. The kidneys contain millions of excretory units called nephrons, and chemicals that are toxic to the kidneys are called nephrotoxins. Cadmium, lead, and mercury are examples of nephrotoxic metals. Metals have a range of adverse impacts on the body, including nervous system and kidney damage, creation of mutations, and induction of tumors.

Pesticides

The term pesticide is used to cover a range of chemicals that kill organisms that humans consider undesirable and includes the more specific categories of insecticides, herbicides, rodenticides, and fungicides. There are three main groups of synthetic organic insecticides: *organochlorines* (also known as *chlorinated hydrocarbons), organophosphates,* and *carbamates*. In addition, a number of herbicides, including the chlorophenoxy compounds 2,4,5-T (which contains the impurity dioxin, which is one of the most potent toxins known) and 2,4-D are common water pollutants.

The most well-known organ chlorine pesticide is DDT (dichlorodiphenyltrichloroethane) which has been widely used to control insects that carry diseases such as malaria, typhus, and plague. By contributing to the control of these diseases, DDT is credited with saving literally millions of lives worldwide. In spite of its more recent reputation as a dangerous pesticide, in terms of human toxicity DDT is considered to be relatively safe. It was its impact on food chains, rather than human toxicity that led to its ban. Organo chlorine pesticides, such as DDT, have two properties that cause them to be particularly disruptive to food chains. They are very *persistent,*which means they last a long time in the environment before being broken down into other substances, and they are quite *soluble* in lipids, which means they easily accumulate in fatty tissue. This phenomenon in which the concentration of a chemical increases at higher levels in the food chain is known as *biomagnification* or*bioconcentration.*

Other widely used organochlorines included methoxychlor, chlordane, heptachlor, aldrin, dieldrin, endrin, endosulfan, and kepone. Animal studies have shown dieldrin, heptachlor, and chlordane produce liver cancers, and aldrin, dieldrin, and endrin have been shown to cause birth defects in mice and hamsters. Given the ecosystem disruption, the toxicity, and the biological resistance to these

pesticides that many insect species have developed, organochlorines have largely been replaced with organophosphates and carbamates.

The organophosphates, such as parathion, malathion, diazinon, TEPP (tetraethyl pyrophosphate), and dimethoate, are effective against a wide range of insects and they are not persistent. However, they are much more toxic than the organochlorines that they have replaced. They are rapidly absorbed through the skin, lungs, and gastrointestinal tract and hence, unless proper precautions are taken, they are very hazardous to those who use them. Humans exposed to excessive amounts have shown a range of symptoms including tremor, confusion, slurred speech, muscle twitching, and convulsions. Popular carbamate pesticides include propoxur, carbaryl, and aldicarb. Acute human exposure to carbamates has led to a range of symptoms, such as nausea, vomiting, blurred vision, and in extreme cases, convulsions.

Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are among the most commonly found contaminants in groundwater. They are often used as solvents in industrial processes and a number of them are known or suspected carcinogens or mutagens. Their volatility means they are not often found in concentrations above a few micrograms per liter in surface waters, but in groundwater their concentrations can be hundreds or thousands of times higher. Their volatility also suggests the most common method of treatment, which is to aerate the water to encourage them to vaporize. *Vinyl chloride* (chloroethylene), *Tetrachloroethylene* (TCE), *Trichloroethylene 1,2-Dichloroethane, Carbon tetrachloride* are some of important VOCs found in groundwater.

Effects of Water Pollution

1. Physicochemical effects

A large number of pollutants can impart colour, tastes and odours to the receiving waters, thus making them unaesthetic and even unfit for domestic consumption. The changes in oxygen, temperature and pH affect the chemistry of waters often triggers chemical reactions resulting in the formation of unwanted products. The addition of organic matter results in depletion of oxygen with concomitant increase in carbon dioxide owing to bacterial degradation.

2. Biological effects

The addition of pollutants leads to the shift in flora and fauna due to homeostatic factors operating in the aquatic systems. Most of the freshwater algae are highly sensitive to pollutants and their elimination modifies the prey-predatory relationships by breaking down the food chains. This results in the change of the whole plant and animal communities. The diversity of organism decrease due to the presence of only a few tolerant forms in the polluted conditions.

The first response to the added nutrients is increased algal growth which is often composed of obnoxious bloom forming blue-green or green chlorophycean algal forms. Many of the blue-greens are not consumed by predators and some even produce toxic secretions causing allelopathic effects (e.g., *Microcystis* spp.)

3. Toxic effects

These are caused by pollutants such as heavy metals, biocides, cyanide and other organic and inorganic

compounds which are detrimental to the other organisms. These substances usually have very low permissible limits in water and their presence beyond limits can render the water unfit for aquatic biota and even for human use

These chemicals are toxic to aquatic organisms, and many of them especially those non-biodegradable, accumulate in the body of the organisms and biomagnify along the tropic levels causing long term effects.

4. Pathogenic effects

Besides the chemical substances, a few wastes like sewage, also contain several pathogenic and nonpathogenic microorganism and viruses. The *Clostridium perfringens* and *Streptococcus faecalis* cause various types of food poisoning. Apart from this, many water borne diseases like cholera, typhoid, paratyphoid, colitis, and infective hepatitis (jaundice) are spread by consumption of sewage contaminated waters.

5. Eutrophication

One of the most severe and commonest water pollution problems is due to enrichment of waters by plant nutrients that increases the biological growth and renders the water bodies unfit for diverse uses. The process of increase in the nutrients of waters and resultant spurt in algal productivity is called ***eutrophication*.**

The term eutrophication has been derived from a Greek word **eutrophos** meaning corpulent or rich. The first use of this term in ecology was made in connection with the remnants of the extinct lakes rather than with live lakes. Weber (1907), while studying the evolution of North German peat bogs, found that the upper layers have more nutrients in comparison to the lower ones as the original lakes received much higher nutrient supply prior to their transformation into bogs. He used the terms**eutrophic** (rich in nutrients) and **oligotrophic** (poor in nutrients) to distinguish between these two layers. The use of these terms in limnology was made for the first time by Naumann (1919), in order to denote nutrient poor (oligotrophic) and nutrient rich (eutrophic) conditions in relation to the development of different algal associations.

The Process Of Eutrophication

The eutrophication is basically a natural phenomenon which gets accelerated by increased nutrient supply through human activities. The process of eutrophication starts as soon as the lakes are formed because of the entry of nutrients by natural means, but the rate of eutrophication remains quite low under natural conditions. The process of eutrophication can be discussed under two heads of natural and accelerated processes, though its basic features remain essentially the same.

1. Natural eutrophication

The lakes generally originate as oligotrophic and have only limited quantities of nutrients depending upon the mode of their formation and composition of original sediments. These nutrients are insufficient to produce any significant algal growth. At this stage the lakes have only autochthonous nutrients (indigenous nutrients cycling therein), which usually recycle completely in the absence of any outside supply. All the biological production is completely decomposed after death. As

the**allochthonous** nutrients (nutrients from outside) start entering the lake, the process of eutrophication sets in. The principal natural sources of nutrients are the natural run-off, fall of leaves and twigs from the surrounding vegetation, periodical submergence of the nearby terrestrial vegetation, rain fall and bird droppings etc.
The build-up of nutrients through this slow mode of entry gradually starts increasing the growth of algae. When the algae die and decompose, the locked nutrients are again made available to the fresh algal growth. The tropical or hot climate usually supports a higher rate of eutrophication as it favours higher nutrients utilization and algal growth in comparison to cold and temperate climates.

2. Accelerated Eutrophication

The process of eutrophication is greatly augmented by the increased supply of nutrients through various human activities such as discharge of domestic sewage, industrial wasters, agricultural and urban run-off. Increased levels of air pollution also make the water bodies rich in nutrients through their transport with rains or by dry fallout. This increased supply of nutrients triggers the algal growth at much faster rate, thus increasing the speed of eutrophication, which otherwise would have been a slow natural phenomenon. The process of eutrophication is, therefore, sometimes referred to as ***ageing of lakes***.

Sources of nutrients

Water bodies may be enriched with nutrients through both natural and man made sources, nevertheless, their quantities may greatly differ from source to source. The man-made sources are much more significant contributors of nutrients than the natural sources.

- **Rainfall and Atmospheric Deposition**

Rain water may contain varying amounts of nutrients depending upon the local atmospheric pollution. Experimental data indicate that rain water, on an average, contains 0.16 to 1.06 mg L-1 of nitrate nitrogen, 0.04 to 1.7 mg L-1 of ammonia nitrogen and from traces to 0.1 mg L-1 of phosphorus.

- **Urban and Rural Run-Off**

The run-off water adds significant quantities of nutrients and organic matter from the soil and other surfaces. Urban run-off contains storm water drainage with organic and inorganic debris from various surfaces both paved and grassed, and fertilizers from gardens and lawns. Rural run-off originates from sparsely populated areas with little or no land devoted to agriculture.

- **Agricultural Run-off**

The enrichment material in the agricultural run-off is derived from fertilizer applied to the crops, and from farm animal houses. Nitrogen used as fertilizers may get converted into nitric acid in soil, solubilizing calcium, potassium and other ions which become highly liable to leaching.

- **Domestic Sewage**

Sewage is the commonest source of nutrients and organic matter, and undoubtedly the greatest contributor to the eutrophication of lakes. Large quantities of nitrogen and phosphorus are excreted by humans and animals which get their way into sewage. According to an estimate, an average of 2 g of PO4-P per day is released through urine and faces by an average person, Phosphatic detergents in sewage are also important contributor of phosphorus.

- **Industrial Wastes**

The nutrients in industrial effluents are variable in quality and quantity depending upon the processes and type of industry. The wastes from certain industries, particularly fertilizers, chemicals and food, are rich in nitrogen and phosphorus.

- **Water Fowl**

The droppings of water fowl is a source of nutrients which may cause the local problems of eutrophication, especially in small bodies of water. The overall effect of this source on the whole water body may be negligible. It is estimated that wild ducks contribute 5.8 kg of nitrogen/acre/year and 2.55 kg of total phosphorus/acre/year to the lakes.

- **Ground Water**

Ground water in some cases may act as a source of nitrogen to the surface waters. It is, however, not a recognized source at all places, but may be an important factor in certain areas. It has been estimated that about 42% of nitrogen in Wisconsin surface waters comes from ground water.

Effects Of Eutrophication

a. Physico – chemical Effects

Pollution can be considered as a departure from the balance between photosynthesis and respiration. At equilibrium (P = R), the chemical and biological composition of water remains unchanged, a stage that mostly occurs only in non-polluted waters with no external supply of nutrients. An eutrophic water body is one where photosynthesis exceeds the respiration activity. It is characterized by a progressive accumulation of algae which ultimately leads to an organic overloading. When respiration exceeds photosynthesis, dissolved oxygen gets rapidly exhausted forcing reduction of several oxidized chemical species like NO3, SO4-2 and CO2 into N2, NH4+, H2S and CH4 which are harmful to several aquatic species and produce typical odours.

b. Biological Effects

Many desirable species including fish are replaced by undesirable ones. There is an algal succession resulting in the dominance of blue green algae which have very low nutrition value in the food chains, and many of them produce the blooms. Some important bloom forming blue green algal genera

include *Microcystis, Anabaena, Oscillatoria and Aphanizomenon.* Filamentous green algae, such as *Spirogyra, Cladophora, and Zygnema* form a dense floating mat or "blanket" on the surface when the density of the bloom becomes sufficient to reduce the intensity of solar light below the surface. Nutrient enrichment has very limited direct effect on zooplankton communities, but indirect effect may be significant. The diversity of zooplankton remains high if the diversity of phytoplankton is also high as often found in case of oligotrophic or moderately enriched waters. As the changes occur in the water due to eutrophication, the characteristics of sediments also change. There is an accumulation of organic matter which affect the benthic communities.

Eutrophication of moderate level may be beneficial to fish production as it increases the food supply for fish in the form of algae. With the increase in the level of eutrophication, dominance of algal groups is taken over by blue greens making the edible or game fish to be replaced by hardy species of very little economic value. The algal blooms cause discolouration of water and attract water fowl which further contribute to the pollution of water. The overall effects make the waters much less suitable for recreation, fish production and domestic uses. The cost of water treatment is also escalated.

Control of Eutrophication

The first step in any control programme should be a regular monitoring of certain parameters *(e.g.,* nutrients, algal species, productivity, *etc.)* in the water body to evaluate the level of eutrophication and its trends. The next step would be to prepare an inventory of inflows, especially to know the sourcewise contribution of nutrients. The reduction of nutrient supply to a water body can be brought about by a number of methods involving either prevention of the entry of nutrients or by some*in situ* water treatment procedures to curtail the nutrient availability to algae.

a. Diversion of Nutrients from a Lake

The diversion of nutrient-bearing flows away from lakes can keep them free from nutrients. This can be achieved when the nutrients enter the lake mainly through point sources such as domestic sewage and industrial wastes. The wastes can be diverted directly to somewhere else like in downstream, estuary or oceans which have comparatively greater self-purification capacities than stagnant waters.

b. Removal of Nutrients from Waste Waters

Any degree of treatment to remove the nutrients and organic matter can be given to wastes depending upon the process selected. Secondary treatment usually removes only organic matter-and is not effective in controlling eutrophication. Though tertiary treatment methods are fairly well known to remove practically all nutrients, interest often lies in the removal of only phosphorus for control of eutrophication.

c. Flushing Out of Polluted Water by Nutrient Poor Water

The technique is useful for relatively small and highly polluted waters where the existing water can be removed to a convenient place and a supply of high quality water is readily available. Two approaches are usually followed for this; in one, the incoming water shall displace an equivalent amount of polluted water and in the other, a quantity of polluted water is removed first to be replaced later by the water of low nutrient content.

d. Removal of Locked-up Nutrients

Nutrients in aquatic ecosystems are locked-up in the tissues of fish, other animals, vegetation (macrophytes) and, of course, in the algae besides being in the water and sediments. Periodical removal of macrophytes and fish, especially when the water level is low, would help in removing a quantity of nutrients from water. The further entry of the nutrients should be checked, since their build up in water can start again after recovery.

e. Dredging of Sediments

A large proportion of nutrients can also be removed by dredging the sediments out of the lake. Dredging may be feasible where simultaneous deepening of the lake is also desired.

f. Covering of Sediments

The nutrients and organic matter present in upper sediments of a lake, under proper conditions, can be re solubilized by microbial action or by change in chemical conditions. The retardation of release of these nutrients shall check the internal fertilization. This can be performed by covering the sediments with some suitable material such as rubber or polythene sheets or some other inert material like clay or fly–ash.

g. Oxygenation and Mixing

Mixing of water column de stratifies the lakes and eliminates the anaerobic reducing conditions in hypolimnetic waters, promoting the development of uniform profiles of dissolved oxygen, temperature, phosphorus and other such parameter. The release of nutrients from the sediments is about10 times more in anaerobic conditions than that in aerobic conditions. Oxygenation by way of mixing eliminates anaerobic conditions and lowers the nutrient release from sediments. A proper mixing and aeration in water column can be carried out by using compressed air pump.

h. Nutrient Inactivation

The technique involves eliminating the nutrients from their natural cycles in the water bodies by various chemical means, in order to make them unavailable for the growth of algae. Phosphorus is the most important nutrient controlled in this manner. The use of calcium hydroxide or aluminium sulphate coprecipitates phosphorus with them which settles at the bottom.

i. Zoning and Watershed Management

Many of the water pollution problems arise due to lack of proper management of watershed areas leading to excessive erosion and entrainment of nutrients and organic matter in run-off. The land use pattern in the watershed or catchment's area will determine the nature of drainage. A check on deforestation and erosion will help reducing the nutrient load of the water resources. Selection of suitable sites for industries, agriculture, urban development and so on will also help in controlling the water quality.

6.Biological Magnification

When a living organism cannot metabolize or excrete ingested substance that substance gradually accumulates in the organisms. This phenomenon, called biological accumulation (or bioaccumulation), refers to the process by which a substance first enters in to a food chain. The extent to which bioaccumulation will occur depends on an organism's metabolism and on the solubility of the

substance first enters a food chain. If the substance is soluble in fat, it will typically accumulate in the fatty tissues of the organism. Bioaccumulation is of particular concern when the substance being concentrated is a toxic environmental pollutant and the organism is of a relatively low trophic level in a food chain.

When many contaminated organisms are consumed by second organism that can neither metabolize nor excrete the substance, the concentration of the substance will build to even higher levels in the second organism. This effect is magnified at each successive trophic level, and the process is called **biological magnification** (or biomagnification). In other words, biomagnification is the increasing concentration of a substance as it moves from one level of a food chain to the next (for example, from plankton to fish to birds or to humans). Biomagnification is of particular importance when chemicals are concentrated to harmful levels in organisms higher up in the food chain. Even very low concentrations of environmental pollutants can eventually find their way into organisms in high enough doses to cause serious problems.

Biomagnification occurs only when the pollutants are environmentally persistent (last a long time before breaking down into simpler compounds), mobile, and soluble in fats.

Biomagnification can't occur

- if they are not persistent, they will not last long enough in the environment to be concentrated in the food chain. (persistent substances are generally not biodegradable).
- If they are not mobile, that is, not easily transported or moved from place to place in the environment, they are not likely to be consumed by many organisms.
- if they are soluble in water rather than fatty tissue, they are much more likely to be excreted by the organism before building up to dangerous levels.

Impact of DDT

The incidence of mercury poisoning in people who consumed contaminated fish in the Minamata Bay region of Japan in 1950s is just one example of the detrimental effects of biomagnification. Another classic example involves DDT,an abbreviation for the organic chemical dichlorodiphenyltrichloroethane. It is a type of chemical known as chlorinated hydrocarbon,and it takes a long time to break down in the environment. With a "half-life" of 15 years, if 10 kg of DDT were released into the environment in the year 2000, 5 kg would still persist in the year 2015, about 2.5 kg would remain in 2030, and even after 100 years had elapsed, in the year 2100, more than 100 g of the substance would still be detected in the environment. Of course, long before that time span elapsed, some of the DDT could be inadvertently consumed by living organisms as they forage for food, and thereby enter a food chain.

DDT is toxic to insects, but not very toxic to humans. It was much used in World War II to protect U.S. troops from tropical mosquito – borne malaria as well as to prevent the spread of lice and lice-borne disease among civilian populations in Europe. After the war, DDT was used to protect food crops from insects as well as to protect people from insect-borne disease. As one of the first of the modern

pesticides, it was overused, and by the 1960s, the problems related to biomagnificantion of DDT became very apparent.

Many other substances in addition to mercury and DDT exhibit bioaccumulation and biomagnification in an ecosystem. These include copper, cadmium, lead, and other heavy metals, pesticides other than DDT, and cyanide, selenium and PCBs.

Control of Water pollution

Raw or untreated sewage comprises about 99.9 per cent water and only about 0.1 per cent impurities. In contrast to this, sea water is only about 96.5 per cent pure water; it contains about 35,000 mg/L, or 3.5 per cent dissolved impurities. Although sea water contains more impurities than does sanitary sewage, we do not ordinarily consider seawater to be polluted. The important distinction is not the total concentration, but the type of impurities. The impurities in seawater are mostly inorganic salts, but sewage contains biodegradable organic material, and it is very likely to contain pathogenic microorganisms as well.

Actually, sewage contain so many different substances, both suspended and dissolved, that it is impractical to attempt to identify each specific substance or microorganisms. The total amount of organic materials is related to the strength of the sewage. This is measured by the biochemical oxygen demand, or BOD. Another important measure or parameter related to the strength of the sewage is the total amount of suspended solids, or TSS. On the average, untreated domestic sanitary sewage has a BOD of about 200 mg/L and a TSS of about 240 mg/L. Industrial wastewater may have BOD and TSS values much higher than those for sanitary sewage; its composition is source dependent.

Another group of impurities that is typically of major significance in waste water is the plant nutrients. Specifically, these are compounds of nitrogen and phosphorous. On the average, raw sanitary sewage contains about 35 mg/ L of N and 10 mg / L of P. Finally, the amount of pathogens in the waste water is expected to be proportional to the concentration of fecal coli form bacteria. The coli form concentration in raw sanitary sewage is roughly 1 billion per liter. Coli form concentration, as well as BOD, TSS, and concentrations of N and P, are parameters of water quality.

Before discharging wastewater back into the environment and the natural hydrologic cycle, it is necessary to provide some degree of treatment in order to protect public health and environmental quality. The basic purposes of sewage treatment are to destroy pathogenic microorganisms and to remove most suspended and dissolved biodegradable organic materials. Sometimes it is also necessary to remove the plant nutrients – nitrogen and phosphorous. Disinfection, usually with chlorine, serves to destroy most pathogens and helps to prevent the transmission of communicable disease. The removal of organics (BOD) and nutrients helps to protect the quality of aquatic eco-systems.

Waste water treatment

These treatment methods are grouped into three general categories: **primary** treatment, **secondary or biological** treatment and **tertiary or advanced** treatment.

Primary Treatment

Untreated or raw wastewater usually flows by gravity from an interceptor or trunk sewer into the head works of a treatment facility; sometimes wastewater may be pumped to the treatment plant in a force.

The head works of a treatment plant include a flow measurement device and mechanical systems that provide preliminary treatment. Preliminary treatment systems typically include screens, comminutors, and grit chambers.

The first treatment process for raw wastewater is coarse screening. Bar screens (or racks), as they are called, are made of long, narrow metal bars spaced about 25 mm (1 in.) apart. They retain floating debris, such as wood rags, or other bulky objects, that could clog pipes or damage mechanical equipment in the rest of the plant.

In some treatment plants, a mechanical cutting or shredding device, called a comminutor, is installed just after the coarse screens. The comminutor shreds and chops solids or rags that passed through the bar screen. The shredded material is removed from the waste water by sedimentation or flotation later in the treatment plant.

Grit removal

A portion of the suspended solids in raw sewage consists of gritty material, such as sand, coffee grounds, eggshells, and other relatively inert material. In cities with combined sewer systems, sand and silt may be carried in the sewage. Suspended grit can cause excessive wear and tear on pumps and other equipment in the plant. Most of it is non biodegradable and will accumulate in treatment tanks. For these reasons, a grit removal process is usually used after screening and / or comminuting.

Primary sedimentation (Settling)

After preliminary treatment by screening, comminuting, and grit removal, the wastewater still contains suspended organic solids that can be removed by plain sedimentation. Settling tanks that receive sewage after grit removal are called primary clarifiers. The combination of preliminary screening and gravity settling is called primary treatment. Chemicals may sometimes be added to the primary clarifiers to promote the removal of very small (or colloidal) particles. Primary treatment usually can remove up to 60 per cent of the suspended solids and about 35 per cent of the BOD from wastewater, but this relatively low level of treatment is no longer adequate. In almost all cases, primary treatment must be followed by secondary treatment processes; tertiary treatment may also be required to protect sensitive bodies of water that receive the treated effluent.

Secondary (Biological) Treatment

Primary treatment processes remove only those pollutants that will either float or settle out by gravity, but about half of the raw pollutant load still remains in the primary effluent. The purpose of secondary treatment is to remove the suspended solids that did not settle out in the primary tanks and the dissolved BOD that is unaffected by physical treatment. Secondary treatment is generally considered to meet 85 per cent BOD and TSS removal efficiency and represents the minimum degree of treatment required in most cases.

Biological treatment of sewage involves the use of microorganisms. The microbes, including bacteria and protozoa, consume the organic pollutants as food. They metabolize the biodegradable organics, converting them into carbon dioxide, water and energy for their growth and reproduction. A biological sewage treatment system must provide the microorganisms with a comfortable home. In effect, the treatment plant allows the microbes to stabilize the organic pollutants in a controlled, artificial

environment of steel and concrete, rather than in a stream or lake. This helps to protect the dissolved oxygen balance of the natural aquatic environment.

To keep the microbes happy and productive in their task of wastewater treatment, they must be provided with enough oxygen, adequate contact with the organic material in the sewage, suitable temperatures, and other favourable conditions. The design and operation of a secondary treatment plant is accomplished with these factors in mind.

Two of the most common biological treatment systems are the **trickling filter** and the **activated sludge** process. The trickling filter is a type of fixed growth system. The microbes remain fixed or attached to a surface while the wastewater flows over that surface to provide contact with the organics. Activated sludge is characterized as a suspended – growth system, because the microbes are thoroughly mixed and suspended in the waste water rather than attached to a particular surface.

Aerobic waste water treatment method

Trickling filters

A trickling filter consists basically of a layer or bed of crushed rock about 2m (6ft) deep. It is usually circular in shape and may be built as large as 60 m (200 ft) in diameter. Trickling filters are always preceded by primary treatment to remove coarse and settleable solids. The primary effluent is sprayed over the surface of the crushed stone bed and trickles downward through the bed to an under drain system.

A rotary distributor arm with nozzles located along its length is usually used to spray the sewage, although sometimes fixed nozzles are used. The rotary distributor arm is mounted on a center column in the trickling filter; it is driven around by the reaction force or jet action of the waste water that flows through the nozzles.

The under drain system serves to collect and carry away the wastewater from the bottom of the bed and to permit air circulation upward through the stones. As long as topography permits, the sewage flows from the primary tank to the trickling filter by the force of gravity, rather than by pumping. As the primary effluent trickles downward through the bed of stones, a biological slime of microbes develops on the surfaces of the rocks. The continuing flow of the wastewater over these fixed biological growths provides the needed contact between the microbes and the organics. The microbes in the thin slime layer absorb the dissolved organics, thus removing oxygen – demanding substances from the waste – water. Air circulating through the void spaces in the bed of stones provides the needed oxygen for stabilization of the organics by the microbes.

The stones are usually about 75 mm (3 in.) in size, much too large to filter out suspended solids. The stones in a trickling filter only serve to provide a large amount of surface area for the biological growths, and the large voids allow ample air circulation. The trickling filter effluent is collected in the under drain system and then conveyed to a sedimentation tank called a **secondary clarifier**. The secondary clarifier, or final clarifier as it is sometimes called, is similar in most respects to the primary clarifier, although there are differences in detention time, over flow rate, and other details.

To maintain a relatively uniform flow rate thorough the trickling filter and to keep the distributor arm rotating even during periods of low sewage flow, some of the waste water may be recirculated. In

other words, a portion of the effluent is pumped back to the trickling filter inlet so that it will pass through the bed of stones more than once. Recirculation can also serve to improve the pollutant removal efficiency; it allows the microbes to remove organics that flowed by them during the previous pass through the bed.

Activated sludge treatment

The basic components of an activated sludge sewage treatment system include an aeration tank a secondary settling basin or clarifier. Primary effluent is mixed with settled solids that are recycled from the secondary clarifier and then introduced into the aeration tank. Compressed air is injected continuously into the mixture through porous diffusers located at the bottom of the tank along one side.

In the aeration tank, microorganisms consume the dissolved organic pollutants as food. The microbes absorb and aerobically decompose the organics, using oxygen provided in the compressed air; water, carbon dioxide and other stable compounds are formed. In addition to providing oxygen, the compressed air thoroughly mixes the microbes and wastewater together as it rapidly bubbles up to the surface from the diffusers. Sometimes mechanical propeller like mixers, located at the liquid surface, are used instead of compressed air and diffusers. The churning action of the propeller blades mixes air with the wastewater and keeps the contents of the tank in a uniform suspension.

The aerobic microorganisms in the tank grow and multiply, forming an active suspension of biological solids called **activated sludge**. The combination of the activated sludge and waste water in the aeration tank is called the mixed liquor. In the basic or conventional activated sludge treatment system, a tank detention time of about 6h is required for thorough stabilization of most of the organics in the mixed liquor.

After about 6h of aeration, the mixed liquor flows to the secondary or final clarifier, in which the activated sludge solids settle out by gravity. The clarified water near the surface, called the supernatant, is discharged over an effluent weir; the settled sludge is pumped out from a sludge hopper at the bottom of the tank. Recycling a portion of the sludge back to the inlet of the aeration tank is an essential characteristic of this treatment process. The settled sludge is in an active state. In other words, the microbes are well acclimated to the wastewater and, given the opportunity, will readily absorb and decompose more organics by their metabolism.

By pumping about 30 per cent of the wastewater flow from the bottom of the clarifier back to the head of the aeration tank, the activated sludge process can be maintained continuously. When mixed with the primary effluent, the hungry microbes quickly begin to absorb and metabolize the fresh food in the form of BOD causing organics. Since the microbes multiply and increase greatly in numbers, it is not possible to recycle or return all the sludge to the aeration tank. The excess sludge, called waste activated sludge, must eventually be treated and disposed of (along with sludge from the primary tanks).

Tertiary (Advanced) Treatment

Secondary treatment can remove between 85 and 95 per cent of the BOD and TSS in raw sanitary sewage. Generally, this leaves 30 mg / L or less of BOD and TSS in the secondary effluent. But sometimes this level of sewage treatment is not sufficient to protect the aquatic environment. Another limitation of secondary treatment is that it does not significantly reduce the effluent concentrations of nitrogen and phosphorous in the sewage. Nitrogen and phosphorous are important plant nutrients. If they are discharged into a lake, algal blooms and accelerated lake aging or cultural eutrophication may be the result. Also, the nitrogen in the sewage effluent may be present mostly in the form of ammonia compounds. These compounds are toxic to fish if the concentrations are high enough. Yet another problem with the ammonia is that it exerts a nitrogenous oxygen demand in the receiving water as it is converted to nitrates. This process is called nitrification.

When pollutant removal greater than that provided by secondary treatment is required, either to further reduce the BOD or TSS concentrations in the effluent or to remove plant nutrients, additional or advanced treatment steps are required. This is also called **tertiary treatment**, because many of the additional processes follow the primary and secondary processes in sequence.

Tertiary treatment of sewage can remove more than 99 per cent of the pollutants from raw sewage and can produce an effluent of almost drinking water quality.

Effluent polishing

The removal of additional BOD and TSS from secondary effluents is sometimes referred to as effluent polishing. It is most often accomplished using a granular media filter much like the filters used to purify drinking water. Since the suspended solids consist mostly of organic compounds, filtration removes BOD as well as TSS.

Phosphorus Removal

When stream or effluent standards require lower phosphorous concentrations, a tertiary treatment process must be added to the treatment plant. This usually involves chemical precipitation of the phosphate ions and coagulation. The organic phosphorous compounds are entrapped in the coagulant flocs that are formed and settle out in a clarifier.

One chemical frequently used in this process is aluminium sulfate (Al2SO4). This is called **alum**, the same coagulant chemical used to purify drinking water. The aluminium ions in the alum react with the phosphate ions in the sewage to form the insoluble precipitate called aluminium phosphate. Other coagulant chemicals that may be used to precipitate the phosphorous include ferric chloride (FeCl3), and lime(CaO).

Nitrogen Removal

One of the methods used to remove nitrogen is called biological nitrification – denitrification. It consists of two basic steps. First, the secondary effluent is introduced into another aeration tank, trickling filter, or biodisc. Since most of the carbonaceous BOD has already been removed, the microorganisms that will now thrive in this tertiary step are the nitrifying bacteria, *Nitrosomonas* and *Nitrobacter*. In this first step, called **nitrification**, the ammonia nitrogen is converted to nitrate nitrogen, producing a nitrified effluent. At this point, the nitrogen has not actually been removed but only converted to a form that is

not toxic to fish and that does not cause an additional oxygen demand.
A second biological treatment step is necessary to actually remove the nitrogen from the wastewater. This is called **de nitrification**. It is anaerobic process in which the organic chemical methanol is added to the nitrified effluent to serve as a source of carbon. The denitrifying bacteria *Pseudomonas* and other groups use the carbon from the methanol and the oxygen from the nitrates in their metabolic processes. One product of this biochemical reaction is molecular nitrogen (N2), which escapes into the atmosphere as a gas.

Bioreactors

Certain organic hazardous wastes can be treated in slurry form in an open lagoon or in a closed vessel called a **bioreactor**. A bioreactor may have fine bubble diffusers to provide oxygen and a mixing device to keep the slurry solids in suspension.

b. Anaerobic wastewater treatment methods

The generation and disposal of large quantities of biodegradable waste without adequate treatment result in widespread environmental pollution. Some waste streams can be treated by conventional methods like aeration. Compared to the aerobic method, anaerobic digestion proves to be more advantageous in terms of efficiency of treatment as well as potential energy savings. Biomethanation is the process of conversion of organic matter in the waste (liquid or solid) to biogas and manure by microbial action in the absence of air. Methane produced by methanogenic bacteria is also another potential energy source. Methane is used for generation of mechanical, heat and electrical energy. Anaerobic decomposition of waste materials produces large amounts of methane. Many sewage treatment plants produce this fuel. Efficient generation of methane can be achieved by using algal biomass grown in pond cultures, sewage sludge, municipal refuse, plant residue and animal waste. Methanogens (Archaebacteria) are obligate anaerobes and produce CH4 by reducing acetate and/or CO2. **Biogas**, a mixture of different gases is produced by anaerobic microbes using domestic and agricultural wastes. Bulk (about 50 – 70%) of biogas is **methane** (CH4) and other gases are in low proportions. These include CO2 (25 – 35%), H2 (1 – 5%), N2 (2 – 7%) and O2 (0 – 0.1%). In India a large number of **gobar gas plants** are already in operation in rural areas. Left overs of these plants are good fertilizers also. Animal waste is first hydrolyzed by hydrolytic bacteria. It is followed by acid formation by a group of acetogenic bacteria, which convert monomers into simple compounds like NH3, CO2 and H2. Finally methanogens reduce acetate and/or CO2 to CH4. In India, cattle dung is the chief source of biogas.

Biomethanation requires adequate infrastructural facilities. The first and the foremost among them is the bioreactor in which the treatment is to be carried out, since extremely large volumes of effluents are encountered for treatment. Thus, an optimally designed bioreactor can decrease the treatment time and increase the treatment efficiency leading to an overall lowering of the treatment cost. Selection and design of bioreactors are dictated by process kinetics. Conventional digesters such as sludge digesters and anaerobic CSTR (Continuous Stirred Tank Reactor) have been used for many decades in sewage treatment plants for stabilizing the activated sludge and sewage solids. Interest in biomethanation as an energy-saving waste treatment has led to the development of a range of anaerobic reactor designs.

These high-rate digesters are also known as retained biomass reactors since they are based on the concept of retaining viable biomass by sludge immobilization.

Anaerobic reactors for liquid waste

- Upflow anaerobic sludge blanket
- Anaerobic fluidized bed
- Anaerobic filter
- Expanded granular sludge bed reactor

Upflow Anaerobic Sludge Blanket Reactor

Developed at Wageningen Agricultural University, Netherlands (Lettinga, 1978), the UASB reactor employs anaerobic bacteria especially methanogens, which have a propensity to form self-immobilized granular structures with good settling properties inside the reactor. These anaerobic bacteria granules make a "blanket" through which the effluent flows up the reactor. The substrate present in the effluent diffuses into the sludge granules, where it is degraded by the anaerobic route. Thus, these reactors due to their high biomass concentrations can achieve conversions several folds higher than that possible by conventional anaerobic processes and tolerate fluctuations in influent feed, temperature and pH. Moreover, since no support medium is required for attachment of the biomass it decreases the capital cost and minimizes the possibility of plugging. The energy requirement is also small because there is no mechanical mixing within the reactor, no recirculation of sludge, and no high recirculation of effluent.

Anaerobic Fluidized Bed (AFB) Reactors

In these reactors mixed culture bacteria are made to grow as a film on the surface of some inert carrier particle. These particles are then maintained inside in a "fluidized" state using the energy of the incoming effluent stream. The linear velocity of the effluent is kept above the minimum fluidization velocity so that the film-covered particles are always in motion and the bed appears to be boiling. The substrate present in the liquid phase diffuses into the biofilm and gets converted to VFAs and ultimately to methane. These products then diffuse out through the biofilm into the bulk liquid. The mixing and mass transfer achieved in these reactors is excellent and the resulting conversions are comparable or even superior to those obtained for UASB reactors. These reactors have typical loading rates of 25 KgCOD/m3 days. However, as the biofilm grows, the film-covered particles increase in size, which is accompanied by a decrease in their composite density. This causes the particle to move up in the bed ultimately resulting in its leaving the reactor, thereby leading to a reduction in the carrier particle concentration inside the reactor. This problem can be overcome by removing the biofilm from the carrier particle which has exited the reactor and then recycling the carrier particle (minus the biofilm) to the reactor. However, it is observed that the transport of solid particles as a rule creates too many operational problems let alone maintain strict anaerobic conditions within the reactor. Another drawback of AFB reactors is the high energy requirement due to the large recycle rates employed in these systems.

Many improved reactor designs for high rate biomethanation are being tried out in this context. In spite of several bottlenecks in the smooth and efficient operation of both UASB and AFB systems, there is hope that these systems have the potential to offer an extremely high rate of waste stabilization accompanied by methane production.

Expanded Granular Sludge Bed Reactor (EGSB)

- Faster rate of upward-flow velocity
- Increased flux permits partial expansion (fluidization) of the granular sludge bed, improving wastewater-sludge contact as well as enhancing segregation of small inactive suspended particle from the sludge bed
- Increased flow velocity is either accomplished by utilizing tall reactors, or by incorporating an effluent recycle (or both)
- EGSB design is appropriate for low strength soluble wastewaters (less than 1 to 2 g soluble COD/l)
- For wastewaters that contain inert or poorly biodegradable suspended particles which should not be allowed to accumulate in the sludge bed

Membrane Bio reactor (MBRs) brings a new age of biological waste water treatment. With pure oxygen the benefits of MBRs are enhanced resulting in even higher rate biological treatment systems which provide the control of COD, microorganisms and VOCs in waste water. Oxy-Dependent MBR can use high biomass concentrations, which for air-based systems cause oxygen transfer limitations. High purity oxygen resolves this, as well as the foaming and VOC issues associated with air-based systems.

Phytoremediation

Plants show several response patterns to the presence of potentially toxic concentrations of heavy metal ions. Most are sensitive even to very low concentrations, others have developed resistance and a reduced number behave as hyperaccumulators of toxic metals . This particular capacity to accumulate and tolerate large metal concentrations has opened up the possibility to use phytoextraction for remediation of polluted soils and waters Plants with metal resistance mechanisms based on exclusion can be efficient for phytostabilization technologies. Hyperaccumulator plants, in contrast, may become useful for extracting toxic elements and thus decontaminate and restore fertility in polluted areas.

1. Phytoextraction: This technique reduces metal concentrations by cultivating plants with a high capacity for metal accumulation in shoots. Plants used for this purpose should ideally combine high metal accumulation in shoots and high biomass production. Many hyperaccumulator species fulfill the first. but not the second condition. Therefore, species that accumulate lower metal concentrations but are high biomass producers may also be useful.
2. Rhizofiltration: This technique is used for cleaning contaminated surface waters or wastewaters

by adsorption or precipitation of metals onto roots or absorption by roots or other submerged organs of metal-tolerant aquatic plants. For this purpose, plants must not only be metal-resistant but also have a high adsorption surface and must tolerate hypoxia.

3. Phytostabilization: Plants are used for immobilizing contaminant metals by root uptake, adsorption onto roots or precipitation in the rhizosphere. By decreasing metal mobility, these processes prevent leaching and groundwater pollution. Bioavailability is reduced and fewer metals enter the trophic web.

4. Phytodegradation: Elimination of organic pollutants by decomposition through plant enzymes or products.

5. Rhizodegradation: Decomposition of organic pollutants by means of rhizosphere microorganisms

.6. Phytovolatilization: Organic pollutants absorbed by plants are released into the atmosphere by transpiration, either in their original form or after metabolic modification. In addition, certain metals can be absorbed and volatilized by certain organisms.

Mercury Pollution

Mercury enters water naturally as well as through industrial effluents. It is a potent hazardous substance. Both, inorganic and organic forms are highly poisonous. Methyl mercury gives off vapors. Mercury was responsible for the **Minamata** epidemic that caused several deaths, in Japan and Sweden. The tragedy had occurred due to consumption of heavily mercury-contaminated fish (27 to 102 ppm, average 50 ppm) by the villagers. Chloralkali plants seem to be the chief source of mercury containing effluents.

Effluents of industries making switches, batteries, thermometers, fluorescent light tubes and high intensity street lamps also contain mercury. From the effluents mercury compounds enter the water body and at their bottom these are metabolically converted into methyl mercury compounds by anaerobic microbes. Methyl mercury is highly persistent and thus accumulates in food chain. Methyl mercury is soluble in lipids and thus after being taken by animals it accumulates in fatty tissues. The symptoms of Minamata include malaise, numbness, visual disturbance, dysphasia, ataxia, mental deterioration, convulsions and final death. Mercury readily penetrated the central nervous system of children born in Minamata causing teratogenic effects.

Lead Pollution

Lead poisoning is common in adults. The chief source of lead to water is the effluents of lead and lead processing industries. Lead toys may be chewed by children. Painters also have a risk of lead consumption. In some plastic pipes lead is used as stabilizer. The water may become contaminated in these pipes. Lead is also used in insecticides, food, beverages, ointments and medicinal concoctions for flavouring and sweetening.

Lead pollution causes damage to liver and kidney, reduction in hemoglobin formation, mental retardation and abnormalities in fertility and pregnancy, chronic lead poisoning may cause three general disease syndromes (i) gastrointestinal disorders (ii) neuromuscular effects – weakness, fatigue muscular atrophy, and (iii) central nervous system effects or CNS syndrome – that may

result to coma and death. Lead poisoning also causes constipation, abdominal pain etc.

Fluoride Pollution

Fluorine is also regularly present in water and soil besides air. In nature it is found as fluoride. The crop plants grown in high-fluoride soils in agricultural, non-industrial areas had a fluoride content as high as 300 ppm. In Haryana and Punjab, consumption of fluoride-rich water from well caused endemic fluorosis. In Andhra Pradesh also high fluoride content water caused dental fluorosis. On an average, about 20-25 million Indian are affected with fluorosis. In our country this problem has become more severe in Rajasthan.

Fluoride is not absorbed in the blood stream. It has an affinity with calcium and thus gets accumulated in bones, resulting in the mottling of teeth, pain in the bones and joint and outward bending of legs from the knees knock knee syndrome. Fluoride levels more than 0.5 ppm over over a period of 5-10 years results in fluorosis terminating in crippling or paralysis. In water of most villages of Rajasthan fluoride level is higher than permissible limit of 1 mg/litre of water. The toxic effects are staining, mottling and abrasion of teeth, high fluoride levels in bone and urine, decreased milk production, and lameness, Animal becomes lethargic.

B. Marine Pollution

The marine water represents a different kind of habitat for microorganisms. The very vastness of the oceans and the variety of microbial life present in these make the study of these a special branch of microbiology called marine microbiology. The marine water contains algae, protozoa, yeasts, moulds, bacteria and viruses. The microorganism which are free - floating are collectively known as the plankton and may consist of algae (phytoplankton) and protozoa and minute animals (zooplankton). Bacteria and fungi may also form part of the plankton. The algae are the primary producers as they can photosynthesize while others are consumers at various levels of the food - chain. The microorganisms found at the bottom of the ocean are called the benthos or benthic microorganisms. A variety of microorganisms are found in the benthic region but the bacteria predominate.

In polluted areas of estuarine regions rich in organic nutrients, organisms such as *Beggiatoa, Thiothrix, Thiovolum* and various species of *Thiobacillu*s may be predominant. The transient bacteria may include species of *Bacillus, Corynebacterium, Sarcina,* Actinomyces and Gram - negative v*ibrio* - like organisms. A terminally bispored species of *Clostridium* which is unique to the ocean is named *Clostridium oceanicum*. Photosynthetic purple sulphur bacteria usually occur below algal mats in anaerobic environs, as most of the light and oxygen is absorbed by algae.

In polluted waters, there are large amounts of organic matter from sewage, feces and industrial complex. The microbes are usually heterotrophic. The digestion of organic matter by these organisms is incomplete, due to which there accumulate acids, bases, alcohols and various gases. The major types of bacteria are coliform bacteria, the Gram-negative nonspore forming bacilli usually found in the intestine. This group includes *E. coli* and species of *Enterobacter*. They ferment lactose to acid and gas. Noncoliform bacteria-*Streptococcus, Proteus* and *Pseudomonas* are also present.

Under some conditions, the polluting organisms multiply rapidly and consume most of the available oxygen. For instance, nutrients enter the river from sources like sewage treatment plants or urban/suburban runoff. Thus river suddenly develops a high nutrient content. Under these conditions algae may bloom rapidly. This leads to depletion of oxygen in water. There is very little oxygen available to the protozoa, small animals, fish and plants. Due to this non-availability of oxygen, a layer of dead organisms, mud and silt accumulate at the bottom and anaerobic species of *Clostridium, Desulfovibrio* etc. will flourish and they produce gases. One gas, H2S combines with lead or iron to give a precipitate which makes the mud black and the water poisonous. Due to complete depletion of oxygen, the suspended bacteria die in their own waste products. There is hardly any life in water at this stage. The gas bubbles from the anaerobes in the mud break the surface and such processes lead to death of a river.

All that what is carried by rivers ultimately ends up in the seas. On their way, rivers receive huge amounts of sewage, garbage, agricultural discharge, biocides, including heavy metals. These all are added to sea. Besides these discharge of oils and petroleum products and dumping of radionuclides waste into sea also cause marine pollution. Huge quantity of plastic is being added to sea and oceans. Over 50 million Ib plastic packing material is being dumped in sea of commercial fleets.

The pollutants in sea may become dispersed by turbulence and ocean currents or concentrated in the food chain. They may sediment at the bottom by processes like adsorption, precipitation and accumulation. Bioaccumulation in food chain may result into loss of species diversity.

Marine pollution

It is defined as the discharge of waste substances into the sea, posing threat to living sources, hazard to human health, hindrance to fishery and impairment of quality of sea water. Marine pollution is associated with the change in physical, chemical and biological conditions of the sea water. Nearly 71% of Earth surfaces is covered with Oceans, which comprise a total of approximately 1.37 x 1039 litres. Ocean is an ideal place to dump all the man wastes.

Marine pollutants in the sea.

- Pathogens
- Sediments
- Solid wastes
- Heat
- Freshwater
- Brine
- Toxic Inorganics
- Toxic Orgnics
- Pertoleum and oil
- Nutrients
- Radioactive materials

- Oxygen demanding materials
- Acids and Bases

These pollutants come from various sources. The Marine pollution may also off natural origin.

Sources of pollutants

- Marine commerce
- Industry
- Electircal Power generation
- Sewage treatment
- Other Non Industrial Wastes
- Recreation
- Construction

Oil Spills – Oil pollution of the sea normally attracts the greatest attention because of its visibility.

Behavior of Oil in Sea

Fate of Oil

Weathering

- Modifying physical and chemical properties
- Oil floating- spreading to a wide spectrum of the area
- Crude oil forms sticky layers-prevents free diffusion of gases, decreases the photosynthesis
- Volatile components-evaporate, heavy tar ball- assimilated by bottom organisms

Evaporation

- Series of chemical and physical changes that cause spilled oil to break down and become heavier than water
- Winds, waves, and currents may result in natural *dispersion*, breaking a slick into droplets
- These droplets may also result in the creation of a secondary slick or thin film on the surface of the water

Oxidation

- Occurs when the lighter substances within the oil mixture become vapors
- Leaves heavier components of the oil, which may sink to the ocean floor spills kerosene and gasoline contain a high proportion of flammable components (evaporate completely within a few hours)

- Reducing the toxic effects to the environment.
- Heavier oils leave a thicker, more viscous residue, which may have serious physical and chemical impacts on the environment
- Wind, waves, and currents increase both evaporation and natural dispersion

Biodegradation

- Occurs when microorganisms feed on oil
- To sustain biodegradation, nitrogen and phosphorus are added to encourage the microorganisms to grow and reproduce
- Biodegradation tends to work best in warm water environments

Emulsions

- Emulsions consisting of a mixture of small droplets of oil and water
- Emulsions are formed by wave action, and greatly hamper weathering and cleanup processes
- Two types of emulsions exist: water-in-oil and oil-in-water
- Water-in-oil emulsions are frequently called "chocolate mousse," - formed strong currents or wave action makes water trapped inside the viscous oil
- Oil and water emulsions cause oil to sink

Spreading

- Initially as a single slick depends upon the viscosity of the oil
- Fluid, low viscosity oils spread more quickly than those with a high viscosity
- Slicks quickly spread to cover extensive areas of the sea surface
- Spreading is rarely uniform and large variations in the thickness of the oil

Dispersion

- Waves and turbulence at the sea surface cause all or part of a slick to break up into fragments and droplets of varying sizes
- Oil that remains suspended in the water has a greater surface area than before dispersion occurred
- Encourages other natural processes (dissolution, biodegradation and sedimentation to occur
- Speed of oil disperses is largely dependent upon the nature of the oil and the sea state
- Quick if the oil is light and of low viscosity and if the sea is very rough.

Sedimentation/Sinking

- Heavy refined products have densities greater than one , so sink in fresh or brackish water
- Sea water has a density of approximately 1.025 and very few crudes are dense enough or weather sufficiently
- Sinking usually occurs due to the adhesion of particles of sediment or organic matter to the oil
- Oil stranded on sandy shorelines often becomes mixed with sand and other sediments

There are several sources though which the oil can reach the sea.

- Natural release
- Oil tanker and other ship accidents – Largest Oil Spills (World-Level)
    - Gulf War oil spill, Persian Gulf, January 23 1991
    - Ixtoc I oil well, S Gulf of Mexico, June 3, 1979
    - Nowruz oil field, Persian Gulf, February, 1983
    - Castillo de Bellver, off Cape Town, South Africa, August 6, 1983
    - Amoco Cadiz (BP/Amoco, USA) - Britanny, France, March 16 1978
    - Torrey Canyon, South England, March 18 1967
    - Sea Star,Gulf of Oman, December 19, 1972
    - Urquiola, La Coruna, Spain, May 12, 1976
    - Hawaiian Patriot, N Pacific February 26, 1977
    - Othello, Tralhavet Bay, Sweden, March 20, 1970
- Operation of ships other than tankers
- Offshore oil drilling and production plat forms
- Ship shore oil terminal operation
- Refinery operation

Tanker operations

Half the world production of crude oil , which is closed to three billion tones per year, is transported by sea. After a tanker has unloaded its cargo of oil, it has to take on sea water as ballast for the return journey. This ballast water is stored in the cargo compartments that previously contained the oil. During the unloading f the cargo certain amount oil remains clinging to the walls of the container and this may amount to 800 tonnes in a 2 lakh s container. The ballast water thus becomes contaminated with this oil. When a fresh cargo of oil is to be loaded, these compartments are cleaned with water, which discharges the dirty ballast along with the oil into the sea.

Two techniques have substantially reduced the oil pollution. In the load- on- top system, the compartments are cleaned by high pressure jets of water. The oily water is retained in the compartment until the oil floats to the top. The water underneath that contains only a little oil is then discharged into the sea and the oil is transferred tot a slope tank. At the loading terminal, fresh oil is loaded on top of

the oil in the tank and hence the name of the technique. In the second method, called crude oil washing, the cling age is removed by jets of crude oil by the cargo is being unloaded. Some Modern Tankers have segregated ballast, where the ballast water does not come in contact with this oil. Thus with the introduction of these new methods of the ballast, the amount t of oil entering the sea has been considerable reduced.

Dry Docking

All ships need periodic dry docking for servicing repairs, cleaning the hull etc. During this period when the cargo compartments are to be completely emptied, residual oil finds its way into the sea.

Bilge and fuel oils

As ballast tanks take up valuable space, additional ballast is sometimes carried in empty fuel tnaks. While being pumped overboard it carries into the sea. Individually, the quantity of oil released may be small, but it sometimes becomes a considerable amount when all the shipping operations are taken into consideration.

Tanker accidents

A large number of oil tanker accidents happen every year. Sometimes this can result in major disasters , such as that of Exxon Valdez on marine environment.

Offshore Oil Pollution

The oil that has extracted from the sea bed contains some water. even after it is passed through oil separators the water that is discharges contains some oil, which adds to marine pollution. Drilling mud, which are pumped down oil wells when they are being drilled, normally contain 70 to 80 % of oil. They are dumped on the sea bed beneath the drilling platform, thus heavily contaminating the water. In addition, the controlled release of oil from the wells can be catastrophic events resulting in oil pollution

Oil spill- India - In 1994, June14Indian authorities began siphoning off 700 tons of oil from the Sea Transporter, a 6,000-ton Greek cargo ship which had been anchored off Aguada after it ran aground following a cyclone on June 5. In March 25, 2005, 110 tonnes oil spilled in Goa port.

Control of Oil Pollution

Physical methods

Skimming: The oil could be removed from the surface

Oil can be removed by suitable absorbents Eg.Saw Dust, Polyurethane foam

Chemical Methods

- Evaporation, Emulsification, Absorbents, burning of oil are effective methods
- Super bug has been proved to be effective to clean up the oil pollution
- Oleophilic fertilizers enrich the soil eating microbes like pseudomonas sp and hence they could be used.

- To reduce the thermal pollution due to industrial effluents, high efficient heat exchangers should be used.
- Each industry should have a separate treatment plant to meet the standards which are given by central and state pollution control Boards.

General awareness must be created among the common people regarding the disposal of various wastes

Oil Degradation by superbug

Although many microorganisms can metabolize petroleum hydrocarbon no single microbe possesses the enzymatic capability to degrade all, or even most of the compounds in a petroleum mixture. Recombinant DNA technology has created a **'superbug'** that is able to degrade many hydrocarbon structures, that is potentially useful in oil pollution abatement programmes. This hydrocarbon-degrading microbe, *Pseudomonas putida* is the first organism for which a patent has been granted in the U.S.A.

Different strains of this bacterium contain a plasmid, which has genes for enzymes that digest a single family of hydrocarbon. These plasmids are designated based on the hydrocarbon they metabolize. Plasmid *CAM* digests camphor, *XYL*- xylene and toluene, *NAH*- naphthalene and *OCT*- octane. By crossing various strains of this bacterium a super bug was created. It carries the plasmids *XYL*, *NAH* and a hybrid plasmid having *CAM* and *OCT* genes. This multi plasmid bacterium can grow on a diet of crude oil. It has a potential of cleaning up of oil spills as it degrade all the four families of hydrocarbons.

Water quality standards

In the urbanized and industrialized world of today, it is necessary to have a legal basis for protecting water quality. It takes human effort, energy and money to keep water clean enough for the many different uses for which society requires it. Without a legal frame work to allow the enforcement of water quality standards, environmental quality and public health would be in constant jeopardy. Water quality standards are limits on the amount of physical, chemical, or microbiological impurities allowed in water that is intended for a particular use. These are legally enforceable by governmental agencies and include rules and regulations for sampling, testing and reporting procedures.

S. No.	Characteristics	Inland surface waters	Public sewers	Irrigation
1.	TSS (mg/l) max.	100	600	200
2.	DS (inorganics) (mg/l)	2100	2100	2100
3.	PH	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
4.	Oil and Grease (mg/l)	10	20	10
5.	Total Residual chlorine (mg/l)	1	-	-
6.	Ammoniacal nitrogen (as N) mg/l	50	50	-
7.	BOD5 (mg/l)	30	350	100
8.	COD (mg/l)	250	-	-

9.	Arsenic (as As) (mg/l)	0.2	0.2	0.2
10.	Mercury (as Hg) (mg/l)	0.01	0.01	-
11.	Lead (as Pb) (mg/l)	0.1	1	1
12.	Cadmium (as Cd) (mg/l)	2.0	1	1
13.	Hexavalent chromium (as Cr) (mg/l)	0.1	2	-

Lecture 10
Causes, effects and control of soil pollution

Soil Pollution

Soil is the loose and unconsolidated outer layer of earth's crust that is powdery in nature and made up of small particles of different sizes. Soil ecosystem includes inorganic and organic constituents, and the microbial groups. Soil microorganisms are the active agents in the decomposition of plant and animal solid wastes and said to be nature's garbage disposal system. The soil microbes keep our planet earth free of unwanted waste materials and recycle the elements (C, N, and P) through mineralization. Soil microbes decompose a variety of compounds, cellulose, lignin, hemi cellulose, proteins, lipids, hydrocarbons etc. The soil microbial community has little or no action on many man made synthetic polymers. The persistent molecules that fail to be metabolized or mineralized have been termed as recalcitrants.

Soil pollutants

Pesticide pollution

In modern agriculture the use of various agrochemicals is a common practice. These include pesticides, herbicides, insecticides, fungicides and others. Pesticides applied on seed or foliage ultimately reach the soil. Accumulation of pesticide residues in the biosphere creates ecological stress causing contamination of soil, water, and food. Persisting chemicals may also be hazardous to human health and should be eliminated. Persistent pesticides may accumulate in the bodies of animals and over a period of time increase in concentration if the animal is unable to flush leading to bioaccumulation. When an affected animal is eaten by a carnivore, the pesticide is further concentrated in the carnivore. This phenomenon ie. Increasing in the concentration of a nondegradable substance along the food chain is called Biomagnification.

Another problem associated with insecticides is the ability of insects become resistant. Most pesticides kill beneficial predators and parasites. The short term and long term health effects to the persons using the pesticides and public that consumes the food are the major concerns. Exposure to small quantities for longer time causes mutations leads to cancer. Pesticides or their metabolites affect many soil microbes and their activities. Seed treatment with mercuric fungicides are found to be inhibitory to *Rhizobium* (nodulation and nitrogen fixation), *Nitrosomonas and Nitrobacter* (nitrification).

Fertilizer pollution

The agricultural production depends on chemical fertilizer application, as most of our high yielding varieties are fertilizer responsive. Continuous application of chemical fertilizers alone lead to deterioration of soil properties and cultivated soils loose their natural characteristics. Fertilizers like ammonium sulphate, ammonium chloride and urea reduce the soil pH. Many crops, like potato, grapes, citrus, beans are sensitive to chloride toxicity. In integrated nutrient management, to sustain the

productivity of our soils, organic manures and bio fertilizers are recommended as supplements to chemical fertilizers.

Nitrate pollution

Nitrogen occurs in many forms in the environment and takes part in many biochemical reactions. The four forms of nitrogen that are of particular significance in environmental technology are organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. In water contaminated with sewage, most of the nitrogen is originally present in the form of complex organic molecules (protein) and ammonia (NH3). These substances are eventually broken down by microbes to form nitrites and nitrates.

Nitrogen, particularly in the nitrate form, is a basic nutrient that is essential to the growth of plants. Excessive nitrate concentrations in surface waters encourage the rapid growth of microscopic plants called algae andexcessive growth of algae degrades water quality.

Nitrates can enter the ground water from chemical fertilizers used in agricultural areas. Excessive nitrate concentrations in drinking water pose an immediate and serious health threat to infants under 3 months of age. The nitrate ions react with blood hemoglobin, reducing the blood's ability to carry oxygen and this produces a disease called ***blue baby***or *methemoglobinemia.*

- An illness that arises when an infant's blood is unable to carry enough oxygen to body cells and tissue
- An infant with moderate to serious "blue baby syndrome" may have a brownish-blue skin tone due to lack of oxygen
- Child may be fussy, tired, have diarrhea or vomiting
- Severe cases can cause death

Excess Salts and Water

Irrigation water helps to produce more yield than rain fed land. Irrigation water contains dissolved salts and in dry season, water is in the form of saline solution evaporates leaving its salts such as NaCl in the top soil. This saline soil causes stunted plant growth, lower yield. Flushing out salts reduces the salinity but makes downstream irrigation water, saltier. Another problem is water logging.

Heavy metal pollution

Heavy metals include all metals with atomic numbers greater than 23 (with few exceptions) or more than 5 gm per ml. (eg. Hg, 70 gm ml-1). Heavy metals are hazardous, not acceptable to biological system. They are toxic to man and other life forms. Most of them are slow poisons as they accumulate in the body and cause serious disorders. Mercury, lead, arsenic, chromium and cadmium are the five most common toxic heavy metals and they have serious effects on human health.

Effect of heavy metals on human health

S.No.	Heavy metal (forms)	Source	Effect
1.	Mercury: Hg++ (Mercuric) C6H5Hg CH3COO	Methyl mercury fungicides, electrical and electronic industries, PVC, plastics, paints.	Irreversible neurological damage in man, Minamoto disease
2.	Lead Pb2+, Pb4+	Automobile exhaust of leaded petrol (50%), Batteries, Pipes, Soldiering.	Cause mutation in algae and bacteria, blackening in fish, gradual paralysis in man.
3.	Arsenic As+++ Arsenic trioxide, Sodium arsenate	Herbicide, fungicide, wood preservative – Agro chemicals (70%), industrial chemicals – paints, bullets (20%), glass and glass wares (5%).	Accumulate in hair, nail, skin lesions, act as oxidative uncoupler, cause damage to kidney, respiratory tract and nervous disorders.
4.	Chromium Cr+6 CrO3	Tanneries, electroplating and metal finishing processes, Khaki dyeing in textiles.	Toxic to aquatic organisms, absorbed through intestinal tract in man.
5.	Cadmium (Cd)	Pigment and stabilizer for PVC, plastics, tires, rechargeable cells, electroplating, coal, oil and phosphate rocks.	Bones become brittle – Itai itai disease in Japan, gastro enteric distress and pain.

The unique physical, chemical and toxic properties of heavy metals have promoted their wide use in industrial processes and as biocides (fungicide and herbicide). As a result, higher concentration of these heavy metals accumulates in the environment, causing public health hazards and ecological problems. Removal of these metals is therefore a challenge to environmental management. The metals are generally removed by ion exchange and sorption to resins and precipitation as metal sulphides. Biodegradation of metals is not possible, because unlike organic pollutants, metals as elements cannot be mineralized to non-toxic compounds such as H2O and CO2. However, biomobilization is a valid concept in the management of metal pollution. Eukaryotic organisms detoxify heavy metals by binding to polythiols and bacteria have developed different and efficient mechanisms for tolerating heavy metals. They carry the genes controlling metal resistance on chromosome and plasmids, plasmids often contain genes resistance to several metals (Hg, Pb, As, Cr, Cd, Mo, U). As a result of biological action, metals undergo changes in valency and or conversion into organo metallic compounds.

Industrial Wastes: Indiscriminate dumping of untreated or inadequately treated domestic, mining and industrial wastes on and is an important source of soil pollution. Fall out of gaseous and particulate air pollutants from mining and smelting operations, smoke stacks etc. are the major source of soil pollutants in nearby areas.

Neyveli Lignite Corporation Limited (**NLC**) is a government-owned lignite mining and power generating company in India. NLC operates the largest open-pit lignite mines in India, presently mining 24 MT of lignite per year and has an installed capacity of 2740 MW of electricity and generates 2490 MW of power per year from three stations It operates three mines near the South Indian city of Chennai.

The power goes to the South Indian states of Andhra Pradesh, Karnataka, Kerela, Tamil Nadu, and Pondicherry. The company also provides consulting services in mine planning and construction and the renovation and life extension of old power stations. It also supplies a large quantity of sweet water to Chennai from the artesian aquifers in the lignite mines.
Open pit Coal mining at Garzweller, Germany

Urban Wastes : Millions of tones of urban waste are produced every year from polluted cities. The inadequately treated or untreated sewage sludge not only poses serious health hazards but also pollutes soil and decreases its fertility and productivity. Other waste materials such as rubbish, used plastic bag, garbage sludge, dead animals, hospital wastes, skins, tyres shoes etc. cause land and soil pollution. Suspended matter present in sewage can act as a blanket on the soil and interfere with its productivity.

Plastics

Plastics form a major part of global domestic and industrial waste. Not being biodegradable, waste plastic accumulates, adding to pollution. Using photodegradable plastic or biodegradable plastic can solve plastic pollution problem. Photodegradable plastic contains an element sensitive to UV rays. Under the effect of solar rays the element is activated and breaks the polymeric chain of the photodegradable plastic. It results in small fragments that are easily digested by microbes.

Control of Soil Pollution

Soil may be polluted and converted into acidic soil or alkaline soil. It should be corrected by suitable technology, before cultivation.

Methods of Soil treatment

Air sparging is an *in situ* remedial technology that reduces concentrations of volatile constituents in petroleum products that are adsorbed to soils and dissolved in groundwater. This technology, which is also known as "*in situ* air stripping" and "*in situ* volatilization," involves the injection of contaminant-free air into the subsurface saturated zone, enabling a phase transfer of hydrocarbons from a dissolved state to a vapor phase. The air is then vented through the unsaturated zone. Air sparging is most often used together with soil vapor extraction (SVE), but it can also be used with other remedial technologies.

Soil washing is a water-based process for scrubbing soils ex situ to remove contaminants. The process removes contaminants from soils in one of the following two ways:

- By dissolving or suspending them in the wash solution (which can be sustained by chemical manipulation of pH for a period of time); or
- By concentrating them into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing (similar to those techniques used in sand and gravel operations).

The concept of reducing soil contamination through the use of particle size separation is based on the finding that most organic and inorganic contaminants tend to bind, either chemically or physically, to clay, silt, and organic soil particles. The silt and clay, in turn, are attached to sand and gravel particles by physical processes, primarily compaction and adhesion. Washing processes that separate the fine (small) clay and silt particles from the coarser sand and gravel soil particles effectively separate and concentrate the contaminants into a smaller volume of soil that can be further treated or disposed of. Gravity separation is effective for removing high or low specific gravity particles such as heavy metal-containing compounds (lead, radium oxide, etc.). Attrition scrubbing removes adherent contaminant films from coarser particles. However, attrition washing can increase the fines in soils processed. The clean, larger fraction can be returned to the site for continued use. Soil washing is generally considered a media transfer technology. The contaminated water generated from soil washing are treated with the technology(s) suitable for the contaminants. The duration of soil washing is typically short- to medium-term.

Biopile treatment is a technology in which excavated soils are mixed with soil amendments and placed on a treatment area that includes leachate collection systems and some form of aeration. It is used to reduce concentrations of petroleum constituents in excavated soils through the use of biodegradation. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation.

The treatment area will generally be covered or contained with an impermeable liner to minimize the risk of contaminants leaching into uncontaminated soil. The drainage itself may be treated in a bioreactor before recycling. Vendors have developed proprietary nutrient and additive formulations and methods for incorporating the formulation into the soil to stimulate biodegradation. The formulations are usually modified for site-specific conditions.

Soil piles and cells commonly have an air distribution system buried under the soil to pass air through the soil either by vacuum or by positive pressure. The soil piles in this case can be up to 20 feet high (generally not recommended, 2-3 meters maximum). Soil piles may be covered with plastic to control runoff, evaporation, and volatilization and to promote solar heating. If there are VOCs in the soil that will volatilize into the air stream, the air leaving the soil may be treated to remove or destroy the VOCs

before they are discharged to the atmosphere. It is a short-term technology. Duration of operation and maintenance may last a few weeks to several months.

Land Farming is a bioremediation treatment process that is performed in the upper soil zone or in biotreatment cells. Contaminated soils, sediments, or sludges are incorporated into the soil surface and periodically turned over (tilled) to aerate the mixture. This technique has been successfully used for years in the management and disposal of oily sludge and other petroleum refinery wastes. In situ systems have been used to treat near surface soil contamination for hydrocarbons andpesticides. The equipment employed in land farming is typical of that used in agricultural operations. These land farming activities cultivate and enhance microbialdegradation of hazardous compounds.

Soil conservation

Soil conservation is the protection of soil against excessive loss of fertility by natural, chemical, or artificial means. It encompasses all management and land-use methods protecting soil against degradation, focusing on damage by erosion and chemicals. Soil conservation techniques can be achieved through crop selection and rotation, fertilizer and lime application, tilth, residue management, contouring and strip cropping, and mechanical methods (e.g., terracing).

- **Biological methods**
- Agronomic practices Contour farming

Mulching

crop rotation
Strip cropping
2. Dry farming
3. Agrostological methods

Lay farming
Retiring of land to grass

- **Mechanical methods**
- Basin listing
- Contour terracing
- **Other methods**
- Gully control
- Afforestation

Terracing – increases the amount of land used for cultivation on steep slope and mountains and reduces erosion

Soil Amelioration

- **Soil Amelioration**

Amelioration of Acidic Soil: Soil acidity is due to the accumulation of H+ ions over OH- ions. Limiting material – are neutralization of H+ ions such as

- *Quicklime*- oxide of lime is usually known as burned lime or quicklime.
- *Slaked lime*-can be obtained by adding water to quick lime.
- *Blast furnace slag*- a byproduct during the manufacturer of pig iron viz, calcium silicate.
- *Basic Slag*- is a byproduct of the basic open heart method of producing steel from pig iron,
- *Electric furnace slag*- is produced from the electic furnace reduction of phosphate rock during preparation of phosphorous. The product is manly the calcium silicate.

The other methods which could result in amelioration of acidic soil are:

- Use of basic fertiizers such as sodium nitrate reduces the soil acidity.
- Proper soil and water management.
- Usage of corall shell, chalk, woodash, press mud, byproduct material of paper mills, sugar factories, fly ash and sludge etc.

Amelioration of Saline and Alkali Soil

Saline soil- they contain an excess of soluble salts. *Saline soil reclamation can be achieved by:*

- Providing proper drainage
- Using salt free irrigation water
- Use of acidic fertilizers-such as ammonium sulphate
- Use of organic fertilizers
- Use of organic manures.

Alkaline soil-they contain appreciable amounts of soluble salts. *Alkali soil reclamation* may be achieved by the following practices:

  - Application of gypsum
  - Use of sulphur
  - Addition of organic matter
  - Addition of molasses.

2. *Prevention of solid waste dumping*

Open dumping of solid waste should be segregated and recyclable materials could be recycled. Other

garbage can be conveted into organic manure by suitable technology.

3. **Usage of bio-fertilizers and bio-pesticides.**
4. **Following the concept of Integrated Plant Nutrient System (IPNS).**

Organic / Sustainable Agriculture

Organic farming is a holistic approach which aims for the production of quality and safe agriculture products for consumption. This system requires less financial and external inputs and provides sustainable income to the farming community. Organic farming aims at production of quality and safe agricultural products which contain no chemical residues due to the adoption of eco-friendly production methods and farming systems that restore and maintains soil fertility.

Organic farming is a production method which does not pollute the soil and ground water with chemical residues and provides safe and quality food for consumption. It also increases the biological diversity of plants and animals that helps to maintain the natural eco balance. This approach also aims to recycle only the natural resources and restricts the use of external inputs which indirectly helps to reduce the energy consumption in the farming system considerably.

The vision of organic farming in India has necessitated the government to launch the National programme for organic production (NPOP) during 2000. By National accreditation policy and programme, the government has also implemented the National standards for various organic farming activities. Hence organic farming has to be promoted in a big way to provide quality and safe food to the growing population and also to protect the environmental degradation.

Concepts of Organic Farming

Organic farming aspires to a complex mix of agronomic, environmental, agricultural and processing and are based on a number of principles. They are:

- To produce food of high quality and safety
- To interact in a constructive and life-enhancing way with natural systems and cycles
- To consider the wider social and ecological impact of the organic production and processing system
- To encourage and enhance biological cycles within the farming systems, involving microorganisms, soil flora and fauna, plants and animals
- To develop a valuable and sustainable aquatic ecosystem
- To maintain and increase the long term fertility of soils
- To promote the healthy use and proper care of water, water resources, and all life therein
- To use, as far as possible, renewable resources in locally organized production systems
- To create a harmonious balance between crop production and animal husbandry
- To minimize all forms of pollution
- To process organic products using renewable resources
- To produce fully biodegradable organic products.

These principles are given equal importance as that of other economically viable production technologies.

Organic Farming Requirements

Achieving the above mentioned principles of organic farming needs a holistic farming system with integrated approach in all aspects. The basic principle of organic farming in enhancing the soil fertility can be achieved through proper recycling of organic wastes, versatile crop rotation and cropping systems, a wide range of biological methods for control of pests, diseases and weeds and to avoid the use of synthetic fertilizers, chemical pesticides and herbicides. Habitat development is the key factor in restoring the natural eco-system which in turn facilitates the symbiotic co-existence of fauna and flora apart from promoting natural predators, parasites etc.

a. **Maintaining soil fertility**

Depletion of soil organic matter under intensive cropping system is the key factor in altering biological equilibrium of the soil ecosystem. It is essential to maintain the soil food web, where all the soil organisms viz, bacteria, fungi, actinomycetes, protozoa, earthworms etc, and they flourish in population in the presence of sufficient amount of soil organic matter. In order to maintain the soil fertility, the following farming practices are recommended.

- Increased use of organic manures, green manures
- Enriched vermicompost and bio composts
- Use of bio fertilisers
- Crop rotation with high and low biomass crops
- Avoiding the use of chemical fertilizers

b. **Plant Protection methods**

Indiscriminate use of chemical pesticides and herbicides leads to soil and ground water contamination which causes health problems in living systems. The accumulation of toxic residues in the food products has created considerable awareness among the producers and consumers. The reports on the pesticides residue in food products revealed that, most of the food products from conventional agriculture contain more than 70 per cent residues. In addition, it also impairs the soil microflora that is essential to maintain soil fertility. These problems can be solved by adopting organic farming practices which uses only the natural bio pesticides for plant protection. Generally bio pesticides, bio control agents, plant extracts etc are used for controlling the pest and disease problems.

c. Animal husbandry

The basis for including animal husbandry in the system is to respect the physiological and ecological needs of animals. This is achieved by providing sufficient quantities of good quality organic fodder, Shelters according to their behavioral needs and also by proper veterinary treatment. Animals are an important part of organic system because they act as the agents for recycling of byproducts with value

addition. Further contribute to complete the nutrient cycle and maintaining soil fertility. They also contribute draught energy for agricultural operations and provide essential manure for soil nutrition and urine for pesticides.

- **Processing of organic products**

The basis of processing organic products is that as far as possible the vital qualities of the products are maintained throughout each step of the process. This is achieved by choosing and developing methods which are adequate to the specifications of the ingredients and by developing standards which emphasize careful processing methods, limited refining, energy saving technologies, minimal use of additives and processing aids etc. The production and handling of organic products in a safe way can be achieved by adopting existing standards or by developing new standards, which define the safe methods of waste management in the form of products besides packing systems and energy saving systems in processing and transport.

The Indian domestic market being quite large, there is ample opportunity for marketing the products especially the organic products in the country. Greater opportunities are also available for exporting certified organic products to counties like USA, Japan and European Union. Although some farmers are practicing organic agriculture, their awareness on certification is limited and they are yet to recognize the importance of certification.

Lecture 11
Causes, effects and control of noise and thermal pollution

Noise pollution

Noise is perhaps one of the most undesirable by products of modern mechanized lifestyle. It may not seem as insidious or harmful as the contamination of drinking water supplies from hazardous chemicals, but it is a problem that affects human health and well-being and that can also contribute to the general deterioration of environmental quality. It can affect people at home, in their community, or at their place of work.

Sound waves cause eardrums to vibrate, activating middle and inner organs and sending bioelectrical signals to the brain. The human ear can detect sounds in the frequency range of about 20 to 20,000 Hz, but for most people hearing is best in the range of 200 to 10,000 Hz. A sound of 50 Hz frequency, for example, is perceived to be very low-pitched, and a 15,000 - Hz sound is very high pitched.

Simply defined, noise is undesirable and unwanted sound. It takes energy to produce sound, so, in a manner of speaking, noise is a form of waste energy. It is not a substance that can accumulate in the environment, like most other pollutants, but it can be diluted with distance from a source. All sounds come from a sound source, whether it be a radio, a machine, a human voice, an airplane, or a musical instrument. Not all sound is noise. What may be considered music to one person may be nothing but noise to another. To a extent, noise pollution is a matter of opinion. Noise is measured in terms of Decibel units.

Sources of noise

Based on the type of noise include

a) Industrial Noise

b) Transport Noise

C) Neighbourhood Noise

Industrial Noise

It is caused by machines used for the technological advancement. There exist a long list of sources of noise pollution including different machines of numerous factories, industries and mills.

Transport Noise:

Main source is transport. In addition to adversely impacting urban air quality, heavy automobile traffic creates seemingly unbearable noise pollution. Ever since industrial revolution doubling of noise for every 10 years

Pointed nose that angles downward during takeoff, the Anglo-French Concorde flies at more than twice the speed of sound. Supersonic plane is very noisy, and some believe its sonic booms harm the environment.

Animals such as whales use water to communicate with one another over great distances. Human-generated noises in the ocean, such as engine noises by boats, may interfere with animal communication.

Measurement of noise

The noise is usually measured either by i) Sound Pressure or ii) Sound Intensity. The Sound intensity is measured in Decibel (dB), which is tenth part of the longest unit "Bel" named after Alexander Graham Bell. Decibel (dB) is a ratio expressed as the logarithmic scale relative to a reference sound pressure level. The db is thus expressed as

$$\text{Sound Intensity Level} = 10 \log \frac{\text{Intensity Measured (I)}}{\text{Reference intensity (I0)}}$$

or $dB = 10 \log I / I0$

Intensity of Noise sources

Sources	Intensity(dB)
Breathing	10
Trickling clock	20-30
Normal conversation	35-60
Office noise	60 - 80
Traffic	50-90
Motor cycle	105
Jet fly	100 - 110

Effects of Noise Pollution

Auditory effects

- Auditory fatigue -- Whistling & buzzing in ears(noise level - 90dB)
- Deafness -- Permanent hearing loss (noise level- 100dB)

Tinnitus

- Persistent sound in one or both ears.
- Tinnitus is often experienced as a high-pitched hiss, ring, buzz, or roar.
- It is usually continuous, but it may pulsate, and the beats may coincide with the heartbeat.

Non auditory effects

- Interference with speech communication - 50dB

- Annoyance, ill temper, bickering
- loss in working efficiency - tiredness, deterioration or complete loss of ability to work

Physiological disorders

Neurosis, anxiety, hypertension, increased sweating, giddiness, nausea, fatigue, visual disturbance, reduces depth and quality of sleep , peptic ulcers, Increases cholesterol level resulting in constriction of blood vessel , Low weight children to mothers

Noise intensity	Health hazards
80	Annoyance
90	Hearing damage
95	Very annoying
110	Stimulation of reception in skin
120	Pain threshold
130	Nausea, vomiting
140	Pain in ear
150	Burning of skin
160	Rupture of tymphonic membrane
180	Permanent damage

Even the nonliving things such as buildings undergo physical damage by cracks, breakage of windows, doors, and glasses etc. by sudden and explosive sounds.

Control of Noise Pollution

Noise definitely affects the quality of life. It is therefore important to ensure the mitigation or control of noise pollution**.** Noise pollution can be controlled

Control of Noise Pollution

Noise definitely affects the quality of life. It is therefore important to ensure the mitigation or control of noise pollution. Noise pollution can be controlled

- At source level – Can be done by i) Designing and fabricating silencing devices in air craft engines, automobiles industrial machines and home appliances, ii) By segregating the noisy machines

- During Transmission – can be achieved by adding insulation and sound-proofing to doors, walls, and ceilings; covering the room walls with sound absorbers as acoustic tiles and construction of enclosures around industrial machinery. Zoning urban areas to maintain a separation between residential areas and zones of excessive noise. Sound absorbents can be used for the reduction of noise.

a) Acoustillite : made up of Compressed wood pulp, wood fibers and is available in the form of tiles

b) Acoustical blanket : Prepared from mineral wool or glass fibres

c) Hair Felt: Consists of wool fibres, Coarse Cotton Fibres.

d) Fibre Glass

e) Cork Carpet: Prepared out of pieces of corks treated with linseed oil and is used for covering floors.

f) Acoustic Plaster: Mainly consists of gypsum in the form of plaster.

- Protecting the exposed person
- By creating vegetation cover – Plants absorb and dissipate sound energy and thus act as Buffer Zone. Trees should be planted along highways, schools and other places.

Planting vegetation to absorb and screen out noise pollution – Trees can act as a noise barrier

1. Through law
2. Silence Zones must be created near Schools, hospitals
3. Indiscriminate use of loudspeakers at public places should be banned/restricted by laws
4. Restriction on unnecessary us e of horns and vehicles plying without silencers
5. Restrictions on aircraft flight at midnight

Permissible Ambient Noise Level in Different areas

Area	Code category	Noise level (dB)	
		Day Time (6 to 9 Am)	Night Time (9 to 6 PM)
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

1. The Air (prevention and control of pollution) Act, 1981
2. The Motor Vehicles Act,1988
3. Indian Penal Code – Sections 268 & 290
    1. Through education - We Indians are Noisy people. Every occasion, it may be religious or family functions or elections; we used to celebrate with noise. Educating the people that noise is a pollutant, not a part of our routine life.

Thermal Pollution

The term thermal pollution has traditionally been used more often to refer to the heating of lakes, river, streams, and other water bodies usually by electric power generating plants or by factories

1. The combustion of fossil fuels always produces heat, sometimes as a primary desired product, and sometimes as a secondary, less desired by-product i.e. noise
2. Heat is also produced when fossil fuels are burned to generate electricity. In this case, heat is a by-product, not the main reason that fuels are burned.
3. Electricity is also generated in nuclear power plants, when no combustion occurs.
4. The decay of organic matter in landfills also releases heat to the atmosphere.

It is clear, therefore, that a vast array of human activities result in the release of heat to the environment. As those activities increase in number and extent, so does the amount of heat released. In many cases, heat added to the environment begins to cause problems for plants, humans, or other animals. This effect is then known as*thermal pollution*.

Sources of Thermal pollution

1. Coal fired power plant effluents
2. Domestic sewage
3. Hydroelectric power effluent
4. Industrial effluents
5. Nuclear power plants

Effects of thermal Pollution

A one megawatt nuclear power plant may require 1.3 billion gallons (five million m3) of cooling water each day. The water used in such a plant has its temperature increased by about 63oF (17oC) during the cooling process. For this reason, such plants are usually built very close to an abundant water supply such as a lake, a large river, or the ocean.

When thermal pollution drives water temperatures up, most aquatic and marine wildlife cannot survive. Immobile organisms, such as plants and shellfish, simply die. One inevitable result of thermal pollution is a reduction in the amount dissolved oxygen in water. The amount of any gas that can be dissolved in water varies inversely with the temperature. As water is warmed, therefore, it is capable of dissolving less and less oxygen. Organisms that need oxygen to survive will, in such cases, cant be able to survive.

When heated water is released from a plant or factory, it does not readily mix with the cooler water around it. Instead, it forms a stream-like mass known as a thermal plume that spreads out from the outflow pipes. It is in this thermal plume that the most severe effects of thermal pollution are likely to occur. Only over an extended period of time does the plume gradually mix with surrounding water,

producing a mass of homogenous temperature

Invasion of Destructive Organism

Water temperatures can have other, less expected effects also. As an example, trout can swim less rapidly in water above 66oF (19°C) making them less efficient predators. Organisms may become more subject to disease in warmer water too. The bacterium *Chondrococcus columnaris* is harmless to fish at temperatures of less than 50oF (10°C). Between temperatures of 50 - 70°F (10 - 21°C), however, it is able to invade through wounds in a fish's body and at temperatures above 70°F (21°C) it can even attack healthy tissue.

Urban Heat dome

Another example of thermal pollution is the development of urban heat islands. An urban heat island consists of a dome of warm air over an urban area caused by the release of heat in the region. Since more human activity occurs in an urban area than in the surrounding rural areas, the atmosphere over the urban area becomes warmer than it is over the rural areas.

It is not uncommon for urban heat islands to produce measurable climate changes. For example, the levels of pollutants trapped in an urban heat island can reach 5 to 25 percent greater than the levels over rural areas. Fog and clouds may reach twice the level of comparable rural areas, wind speeds may be produced by up to 30 per cent, and temperatures may be 32.9 - 35.6°F (0.5 - 2°C) higher than in surrounding rural areas. Such differences may cause both personal discomfort and, in some cases, actual health problems for those living within an urban heat island.

Undesirable changes in Algal population: Excess Nutrients from the washout water from farm lands combined with thermal pollution cause an excessive algal growth with consequent changes. High Temperature promotes blue green algal blooms which disrupts the aquatic food chain.

Control of Thermal pollution

The water heated by thermal pollution also has a number of potential useful applications. For example, it may be possible to establish aquatic farms where commercially desirable fish and shellfish can be raised. The Japanese have been especially successful in pursuing this option. Some experts have also suggested using this water to heat buildings, to remove snow, to fill swimming pools, to use for irrigation, to de-ice canals, and to operate industrial processes that have modest heat requirements. Hot water is pumped into one end of the pond and cooler water is removed from the other end. The heat gets dissipated from the pond into the atmosphere. The main disadvantage is large amounts of water are lost due to evaporation

Here at Westport, Kentucky the Ohio River provides the large amount of water required by this coal-fired power plant. Thermal pollution is abated by the use of the large cooling tower which emits only steam into the atmosphere. The emission of the smokestack is largely steam but still contains pollutants.

Lecture 12

Causes, effects and management of nuclear hazards and industrial wastes

The spontaneous emission of particles and rays by an unstable nucleus is called Radioactivity and such substances are called Radioactive Substances eg. Radium, Uranium, Thorium. Radioactive pollution can be defined as the release of radioactive substances or high-energy particles into the air water, or earth as a result of human activity, either by accident or by design. Sometimes natural sources of radioactivity, such as radon gas emitted from beneath the ground, are considered pollutants when they become a threat to human health. The sources of Radioactive wastes are

- Natural sources: Solar radiation, Radionuclides in the earth Crust, Human Internal radiation, environmental Radiations.
- Anthropogenic Sources: The sources of such waste include : 1) nuclear weapon testing or detonation; 2) the *nuclear fuel cycle,* including the mining, separation, and production of nuclear materials for use in nuclear power plants or nuclear bombs; (3) accidental release of radioactive material from nuclear power plants..

Since even a small amount of radiation exposure can have serious (and cumulative) biological consequences, and since many radioactive wastes remain toxic for centuries, radioactive pollution in a serious environmental concern even though natural sources of radioactivity far exceed artificial ones are present. The faster a radioisotope is decaying, the more radioactive it will be. Another factor in deciding how dangerous a pure radioactive substance will be is the energy of the radiation. Some decays yield more energy than others. This is further complicated by the fact that few radioisotopes decay immediately to a stable state, but rather to a radioactive decay product leading to decay chains. Radioactive pollution that is spread through the earth's atmosphere is termed *fallout*. Such pollution was most common in the two decades following World War II, when the United States, the Soviet Union, and Great Britain conducted hundreds of nuclear weapons tests in the atmosphere. France and China did not begin testing nuclear weapons until the 1960s and continued atmospheric testing even after other nations had agreed to move their tests underground.

Three types of fallout result from nuclear detonations: local, tropospheric and stratospheric.

- Local fallout is quite intense but short-lived.
- Tropospheric fallout (in the lower atmosphere) is deposited at a later time and covers a larger area, depending on meteorological conditions.
- Stratospheric fallout, which release extremely fine particles into the upper atmosphere, may continue for years after an explosion and attain a worldwide distribution.

Types of radioactive waste:

Low level Waste (LLW) is generated from hospitals and industry, as well as the nuclear fuel cycle. It comprises paper, rags, tools, clothing, filters etc which contain small amounts of mostly short-lived radioactivity. It does not require shielding during handling and transport and is suitable for shallow land burial. To reduce its volume, it is often compacted or incinerated before disposal.

Intermediate level Waste (ILW) contains higher amounts of radioactivity and some requires shielding. It typically comprises resins, chemical sludges and metal fuel cladding, as well as contaminated materials from reactor decommissioning. It may be solidified in concrete or bitumen for disposal. Generally short lived waste (mainly from reactors) is buried in a shallow repository, while long lived waste (from fuel reprocessing) will be disposed of deep underground.

Transuranic Waste arises mainly from weapons production, and consists of clothing, tools, rags, residues, debris and other such items contaminated with small amounts of radioactive elements -- mostly plutonium. These elements have an atomic number greater than uranium -- thus transuranic (beyond uranium). Because of the long half-lives of these elements, this waste is not disposed of as either low level or intermediate level waste. It does not have the very high radioactivity of high level waste, nor its high heat generation. The United States currently permanently disposes of transuranic waste at the Waste Isolation Pilot Plant.

High level Waste (HLW) arises from the use of uranium fuel in a nuclear reactor and nuclear weapons processing. It contains the fission products and transuranic elements generated in the reactor core. It is highly radioactive and hot. It can be considered the "ash" from "burning" uranium. HLW accounts for over 95% of the total radioactivity produced in the process of nuclear electricity generation.

Waste Stored Safely Now

- After it is removed from the reactor, used fuel is stored at nuclear plant sites in steel-lined, concrete vaults filled with water.
- The water cools the used fuel and acts as a shield, to protect workers from radiation.
- This used fuel looks just like it did when it was placed in the reactor.
- The radioactive waste remains locked inside the uranium pellets, which are still encased in the metal fuel rods.

This used fuel has been stored safely at nuclear plant sites ever since the late 1950s, when the first nuclear power plants began making electricity. What is needed is a permanent repository for existing and future high-level waste. Initially, it was thought that spent fuel rods could be reprocessed and only to provide new fuel but also to reduce the amount of nuclear waste. However the cost of producing fuel rods by reprocessing was found to be greater than the cost of producing fuel rods from ore. Presently, India does operate reprocessing plants to reprocess spent fuel as an alternative to storing them as nuclear waste. At each step in the cycle, there is a danger of exposure to harmful radiation to possess several health and environmental concerns.

Effect of Radioactive wastes

Radioactive waste causes

- Soil pollution
- Water pollution

In these two pollutions, pollution hazards finally enter into the food chain the human who is the final victim of radioactive pollution as he is at the end of all reactions and interactions.

Effects of radioactive pollution:

The effect of radioactive pollution depends upon

- Half –life
- Energy releasing capacity
- Rate of diffusion
- Rate of deposition of the contaminant.
- Various atmospheric and climatic conditions such as wind, temperature, rainfall also determine their effects.

The possible general effects of radioactive wastes are categorised into

- Somatic Effect
- Genetic Effect
- Biomagnifications

Somatic effect: Affects somatic cells. It appears within individual and disappears with the death of the individual.

Immediate effects : Anemia, Reduced immune response, Haemorrhage , skin burn, mouth ulcers , CNS Damage

Delayed effects : Eye cataract, Leukemia, Cardiovascular disease, Premature ageing ,Reduced life span , reduction of fertility

Genetic Effects: The radiation affects the genes of the gamete cells. The changes are not apparent in the individual. The effects are exhibited by offspring and in the subsequent generations. They affect the DNA, RNA replication and chromosome. It causes

- Mutation
- Chromosomal aberration
- Chromosomal fragmentation
- Inhibition of RNA,DNA synthesis

Radioactive Pollution Incidents:

The two best known examples illustrating the effect of fallout contamination are the bombing of Hiroshima and Nagasaki, Japan in 1945, and the Chernobyl Nuclear Power Station disaster in April 1986. Within five years of the American bombing of Japan, as many as 225,000 people had died as a result of long-term exposure to radiation from the bomb blast, chiefly in the form of fallout.

The disaster at the Chernobyl Nuclear Power Station in Ukraine on April 26, 1986 produced a staggering release of radioactivity. In ten days at least 36 million curies spewed across the world. The fallout contaminated approximately 1,000 square mites (2,590 sq. km) of farmland and villages in the Soviet Union. In addition to the hundreds killed at the time of the explosion, scientists predict the eventual Soviet death toll from the Chernobyl accident is around 200,000; the estimated mortality in western Europe may be around 40,000.

Control of Radioactive pollution

The main objective in managing and disposing of radioactive (or other) waste is to protect people and the environment. This means isolating or diluting the waste so that the rate or concentration of any radionuclides returned to the biosphere is harmless. To achieve this for the more dangerous wastes, the preferred technology to date has been deep and secure burial. Transmutation, long-term retrievable storage, and removal to space have also been suggested.

- Nuclear devices should never be exploded in air. If these activities are extremely necessary they should be exploded underground.
- In nuclear reactions, closed-cycle coolant system with gaseous coolants of very high purity may be used to prevent extraneous activation products.
- In nuclear and chemical industries, the use of radio-isotopes may be carried under a set of soil or water instead of power or gaseous forms.
- In Nuclear mines, wet drilling may be employed along the underground drainage.
- Nuclear reactors must be enclosed in broad concrete walls to prevent the radiations that emerge out.
- Workers should wear protective garments and glass spectacles should be screened from radiation.
- Extreme care should be exercised in the disposal of industrial waste contaminated with radionuclides. The spend rods are very radioactive containing about 1% U 235 and 1% plutonim.

Deep Underground Disposal

Geologic repositories deep underground have been endorsed by independent scientific organizations around the world including

- The National Academy of Sciences,
- The National Research Council,

- The Congressional Office of Technology Assessment.

Nearly every other country with a nuclear energy program, including Germany, France, Japan and Sweden, has determined that Deep Geologic Disposal is the safest system of permanent nuclear waste management.

Effects of industrial effluents

Industries need a wide variety of raw materials and chemicals which are later discharged as effluents. Acids, alkalis, toxic metals, pesticides and other poisonous substances such as cyanide, dyes, oils, detergents, resins, rubbers are a few to mention. Heated effluents that impart thermal loading on receiving waters and effluents containing radioactive materials are also of prime concern. Some of the effluents such as from tanning and meat packing may also contain pathogenic bacteria. The nature and extent of pollution depends on the materials present in the effluent and on the quantity discharged.

Effects on water courses

Color : The effluents contain dyes in higher concentrations which impart color to the receiving streams and they persist for longer distances. Photosynthesis of phytoplankton is affected by these colors.

pH value : The extreme alkalinity makes the receiving water unfit for any purpose. Further, it is deleterious to most of the aquatic life.

Suspended impurities : The colloidal and suspended impurities produce turbidity in the receiving waters. The turbidity and color along with the oil and scum create an unsightly appearance.

Depletion of oxygen : Natural substances such as starch and dextrin and inorganic substances such as sulfide and nitrite present in the effluent exert an immediate oxygen demand. The stream will then be devoid of oxygen and the aquatic life are affected adversely.

Toxic substances : Chromium, sulfide, chlorine and aniline dyes present in these wastes are directly toxic to fish and microbial organisms which carryout purification. Thus the self purification of the water body is affected.

Oils : Various oils (mineral) in the effluent interfere with the oxygenation of stream as they form a blanket on the surface and prevents the entry of oxygen at air/water interface.

Dissolved minerals: The mineral materials, mostly sodium salts increase the salinity of the water and consequently it becomes unfit for irrigation.

Effects on land

1. The excess content of sodium (60%) and boron (2 mg/l) are deleterious to crops.
2. The high sodium alkalinity combined with salinity impairs the growth of plants.
3. Texture of the soil is affected by sodium and penetration of roots is prevented.
4. Soil permeability is also affected by sodium and ultimately the soil will lose its productivity.
5. Suspended and colloidal impurities clog the pores and form a mat on the surface of soil preventing the passage of air, water etc.

EFFECTS OF WATER POLLUTION

Pollution	Effects
Domestic waste	Water borne diseases like cholera (Vibrio cholera) typhoid, dysentery and various health problems, depletion of dissolved oxygen, objectionable odour.
Industrial effluents	It causes deleterious effects on living things and may bring death or sub lethal pathology of kidneys, liver, lungs, brain and reproductive system.
Agricultural waste	Excessive fertilizer leads to accumulation of nitrates in children called methemoglobinaemia. Richness of nutrients results in eutrophication.
Eutrophification	During eutrophification, algal bloom release toxic chemicals into the aquatic system. Algal Bloom leads to oxygen depletion and an increase in CO2 level. Thus aquatic organisms begin to die which leads to succession.
Bioaccumulation (or) Biological magnification	Aquatic plants and animals can accumulate certain pesticides in their body tissues in greater concentration than in water. This phenomenon is commonly referred to as biological magnification or biological amplification eg.,DDT. It is more threatening as its concentration continuosly increases in successive trophic levels in a food chain which results in many health hazards. DDT absorbed by fish eating birds 25 ppm ↑ DDT in large fish 2 ppm ↑ DDT in small fish 0.5 ppm ↑ DDT in zooplankton 0.003 ppm ↑ DDT in water 0.000003 ppm or 0.003 ppb
Lead (pb)	Anaemia, vomiting, damage of liver, brain and kidney
Arsenic(A)	Mental disturbance, lung cancer, ulcer, kidney damage
Mercury(Hg)	Abdominal pain, headache, diarrhea, chest pain
Cadmium(Cd)	Growth retardation, diarrhea, bone deformation, kidney damage, anemia, damage to lever
Barium(Ba)	Excessive salvation, diarrhea, paralysis
Chromium(Cr)	Gastro intestinal ulceration, diseases of central nervous system, cancer, nephritis
Zinc(Zn)	Vomiting, renal damage
Copper(Cu)	Hypertension, uremia, coma
Temperature:	Reduction of dissolved oxygen , Increase in Biological Oxygen Demand Early hatching of fish eggs and fish mortality, Mitigation of aquatic biota
Radioactivity	Serious skin cancer, carcinoma, melanoma, breast cancer, leukemia, DNA breakage and cataract
Siltation	Reduced visibility, Reduction in direct light penetration, Decrease in photosynthetic rate, Chances of anaerobic digestion in the benthos zone.
Oil	Reduction of dissolved oxygen in the water, Reduction in the light penetration, Direct oil coating makes the fishes unable to respire and clog their gill slits, hydrocarbons cause necrosis, paraffins like methane and ethane are asphyxiants.
Synthetic detergent	Complex formation between DNA and mercury or cadmium results in birth defects. Although detergents are not highly toxic to fishes they do cause damage to gills and remove the protective mucus from skin and the intestine.

Effect of Solid waste

Any material that is thrown away or discarded as useless and unwanted is considered as solid waste. At first glance, the disposal of solid waste may appear to be a very simple and mundane problem. In this age of lasers, microcomputers, and space flight, it hardly seems possible that garbage disposal should present any great challenge. But many factors make solid waste disposal a complex problem of huge proportions for a modern industrial society.

Classification of solid wastes

Domestic and municipal wastes: These include garbage and rubbish, like waste paper, plastic, cloth from households, office, hostel and market.

Industrial wastes: The two general categories are process and non-process wastes. The non-process wastes are common to all industries such as packaging, office and cafeteria wastes. Process wastes are more complex and specific to the industrial plants. Their composition depends on type of products produced.

Agricultural wastes: These include cereal and millet straw, paddy husk, sugarcane trash and other crop residues.

Special wastes: The waste materials which endanger public health and welfare and seriously affect environment are: a) Radioactive wastes from atomic power stations, labs and hospitals b) Toxic wastes such as pesticides, heavy metals, pharmaceuticals c) Biological products such as antibiotics, enzymes, and pathogens.

Auxiliary operations necessary for solid waste treatment

i) Transport and handling
ii) Pulverization
iii) Compaction

Transport and handling

Solid wastes are collected from source, transported in trucks with hydraulic and pneumatic system to a central place and to compact the waste to a high density, for disposal.

Pulverization

Pulverization of solid wastes is carried out prior to loading, land filling, compacting or incineration to facilitate these processes. Taw roll, impact and gyratory crushers and hammer mills are used for pulverization. It makes the solid waste homogenous and helps in greater initial settlement. The land can be more easily reclaimed and built on.

Compaction

Compaction and balling of solid wastes using hydraulic or pneumatic processes lead to reduction in refuse volume, reduction in collection and transport time and cost, lesser storage area and safety hazards and cleaner storage area.

The most effective way to ameliorate the solid waste disposal problem is to reduce the generation and toxicity of waste. But, as people search for better life and higher standard of living they tend to

consume more goods and generate more wastes. Consequently society is searching for improved methods of waste management and ways to reduce the amount of waste management system. This consists of reducing the amount of toxicity of the wastes at the source, recycling, reusing or composting as much of the waste as is economically reasonable. Burning the waste that cannot be economically recycled to generate heat reduces the need for fossils and nuclear fuels.

Recycling and waste reduction play an important part in any waste management strategy. But engineering analysis clearly shows that these options alone cannot solve the solid waste problem. At the same time, according to best estimates, it may be possible to reach recycling technologies that must be developed, additional markets must be found, and industry must produce more products that are easy to recycle. All the same, even if all of these steps are successfully taken more than 160 million tons of solid waste still have to be treated by other means, such as waste – to – energy combustion and land filling.

Technologies in solid waste management

Solid waste management is a difficult process because it involves many disciplines. These include, technologies associated with the control of generation, storage, collection, transfer and transportation, processing, marketing, incineration and disposal of solid wastes. All of these processes have to be carried out within existing legal and social guidelines that protect the public health and environment and are aesthetically acceptable. They must be responsive to public attitudes and the disciplines included in the disposal process include administrative, financial, legal, architectural, planning and engineering functions. For successful integrated solid waste management plant, it is necessary that all these disciplines communicate and interact with each other in a positive interdisciplinary relationship .The various techniques employed in solid waste management include,

1) Composting
2) Sanitary land filling (Controlled tipping)
3) Thermal process (Incineration and pyrolysis)
4) Recycling and reuse

COMPOSTING

It is being increasingly realized that composting is an environment friendly process to convert wide variety of wastes into valuable agricultural inputs. This process minimizes the environmental problems. Composts are excellent source of humus and plant nutrients, the application of which improves soil biophysical properties and organic matter status of the soil. Composting can be defined as the biological conversion of organic wastes into an amorphous dark brown to black colloidal humus like substance under conditions of optimum temperature, moisture and aeration. Nutrient content of compost depends largely on the nutrient content of the wastes. Composting is a process in which the organic portion of solid waste is allowed to decompose under carefully controlled conditions. It is a biological rather than a chemical or mechanical process; decomposition and transformation of the waste material are accomplished by the action of bacteria, fungi, and other microorganisms.

With proper control of moisture, temperature, and aeration, a composting plant can reduce the volume of raw organic material by as much as 50 per cent. In addition, composting can stabilize the waste and

produce an end product that may be recycled for beneficial use. The end product is called **compost** or **humus**. It resembles potting soil in texture and earthy odor, and it may be used as a soil conditioner or mulch.

A complete municipal solid waste (MSW) composting operation includes sorting and separating, shredding and pulverizing, digestion, product upgrading, and finally marketing. Sorting and separation operations are required to isolate organic, decomposable waste materials from the plastic, glass, metal, and other non biodegradable substances. Solid waste sorting and separation methods are a key part of MSW recycling operations.

Shredding and pulverizing serve to reduce the size of the individual pieces of the organic waste, resulting in a relatively uniform mass of material. This facilitates handling, moisture control, and aeration of the decomposing waste. Size reduction also helps optimize bacterial activity and increases the rate of decomposition. After size reduction, the wastes are ready for the actual composting or digestion step. Digestion may take place in open windrow or in an enclosed mechanical facility.

A windrow is a long, low pile of the prepared organic waste, usually about 3m (10 ft) wide at the base and about 2 m (6 ft) high. Most windrows are conical in cross section and about 50 m (150 ft) in length. The composting waste is aerated by periodically turning each windrow. Turning frequency varies with moisture content and other factors. When moisture content is maintained at about 50 per cent, windrows are turned two or three times a week and in some cases daily.

Generally, open – field windrow composting takes about 5 weeks for digestion or stabilization of the waste material. An additional 3 weeks may sometimes be required to ensure complete stabilization. Temperatures in an aerobic compost windrow may reach 65oC (150oF) because of the natural metabolic action of thermophilic microbes that thrive at such elevated temperatures. The relatively high temperatures destroy most of the pathogenic or disease-causing organisms that may be present in the waste.

Open-field windrow composting requires relatively large land areas. To reduce land requirements, various types of enclosed mechanical systems can be used in lieu of the open-field method. A variety of mechanical type compost systems are available. Oxygen is supplied to the waste material by forced aeration, stirring, or tumbling. In addition to reducing land requirements, enclosed mechanical compost facilities can reduce the time required for stabilization from about 5 weeks to about 1 week.

Composting is the aerobic, thermophilic degradation of organic matter present in the refuse by microbes, predominantly by fungi and actinomycetes, which are favoured by semi moist condition that prevail in the process. The control parameters for optimum composting include, temperature (40oC), moisture (40.7%), pH (4.5 – 9.5), nutrients (C:N ratio 40:1); C:P ratio (100:1), air (0.5 – 0.8 m / d / kg volatile solid) and particle size (6-25 mm).

The digestion of the waste is carried out naturally in an outside decomposition area in windrows (for five weeks) or in mechanized composting plants (for 4 to 6 days). In natural system, the garbage is mixed with nutrient source (sewage sludge / animal manure) and a filler (wood chips) to provide entry of air. The mixture is turned over twice a week and the process is completed in 4-6 weeks. The darkening of refuse, fall in temperature and a musty odour indicate completion of the process.

Before the stabilized compost or humus can be sold for use as a mulch or soil conditioner, it must be processed further to upgrade or improve its quality and appearance. This includes drying, screening, and granulating or pelletizing. Sometimes, the compost is placed in bags, although bulk sale is more efficient and economical. Compost can increase the organic and nutrient content of soil and improve its texture and ability to retain moisture.

Co-Composting

An interesting example of integrated waste management is co-composting of municipal solid waste and sewage sludge. Sewage sludge adds nitrogen, phosphorous, and other elements that enrich the solid waste and help the composting process. The sludge is first dewatered so that it does not add too much moisture to the compost pile. The dewatered sludge and organic portion of MSW must be thoroughly mixed. At a time when ocean disposal of sludge has been banned and sludge incinerators meet with much public opposition, co-composting may offer an increasingly viable technique for processing both sludge and MSW organics prior to final disposal.

Vermicomposting

The key role of earthworms in improving the soil fertility is well known for a longer period. Earthworms feed on any organic wastes, consume three to five times their body weight and after using 5 to 10 per cent of the organic wastes for their growth, excrete the mucus coated undigested matter as worm casts. Worm casts consist of organic matter that has undergone physical and chemical breakdown through the activity of the muscular gizzard, that grinds the material to a particle size of 1-2 micron. The nutrients present in the worm casts are readily soluble in water for the uptake of plants. Vermicastings are rich sources of macro and micronutrients, vitamins, enzymes, antibiotics, growth hormones and immobilized micro flora.

Vermicompost refers to organic manure produced by earthworms. It is a mixture of worm castings, including humus, live earthworms, their cocoons and other micro organisms. Vermicomposting is an appropriate method for disposal of non-toxic solid and liquid organic wastes. It helps in cost effective and efficient recycling of animal wastes (Poultry droppings, horse, piggery excreta and cattle dung), agricultural residues and industrial wastes using low energy.

Types of earthworms

Several types of earthworms are found in our soils. Earthworms can be divided into the following two categories:

1. Epigeic – the surface living worms
2. Endogeic – the burrowing worms

Epigeic: These worms are found on the surface and are reddish brown in colour. They do not process the soil but are efficient in composting of organic wastes. They enhance the rate of organic manure production through biodegradation or mineralization.

eg. *Lampito mauritii, Octochaetona serrata, Perionyx excavatus*

Endogeic: These species burrow and mix the soil, from different horizons in the profile. They ingest organic and mineral fraction of soil, thus promoting the formation of organo mineral complexes. Organo – mineral crumbs are brought from deeper parts of the soil profile to the surface. Different species of earthworms show specificity to soil types, moisture content and temperature. Method of vermicomposting

- Selection of earthworm: Earthworm that is native to the local soil may be used
- Size of pit: Any convenient dimension such as 2m x 1m x 1m may be prepared
- Preparation of vermibed: A layer, 15-20 cm thick of good loamy soil above a thin layer of (5 cms) broken bricks and sand should be made.
- Inoculation of earthworms: About one hundred earthworms are introduced as an optimum inoculating density into a compost pit of about 2m x 1m x 1m, provided with vermibed
- Organic layering: It is done on the vermibed with fresh cattle dung. The compost pit is then layered to about 5 cm with dry leaves or hay or organic wastes. Moisture content of the pit is maintained by the addition of water.
- Wet organic layering: It is done after four weeks with moist green organic waste, which can be spread over it to a thickness of 5 cm. This practice can be repeated every 4 days. Mixing of wastes periodically without disturbing the vermibed ensures proper vermicomposting. Wet layering with organic wastes can be repeated till the compost pit is nearly full.

Harvesting of compost: At maturation (after 120 days), the moisture content is brought down, by stopping the addition of water. This ensures drying of compost and migration of worms in to the vermibed. The mature compost, a fine loose granular mass (about 1500 kg), is removed from the pit, sieved, dried and packed. Matured vermicompost is rich in nutrients and recommended @ 50 t ha-1.

Characteristics of vermicompost

pH	7.00
EC dsm-1	1.20
Organic carbon%	30.50
Macronutrients	
Total nitrogen %	0.66
Total P2O5%	1.93
Total K2O%	0.42
Micro nutrients	
Fe (ppm)	19.8
Zn (ppm)	0.90
Mn (ppm)	16.50
Cu (ppm)	2.30

Sanitary land filling (Controlled tripping)

Land filling is the most common and economic method of solid waste disposal. The indiscriminate land filling of solid waste in open dumps without adequate control and consideration of sanitation and public health as generally followed in India is dangerous. It results in water pollution, bad odour, fire and breeding of flies and rats.

It should be replaced by sanitary land filling or controlled tipping. The construction of sanitary land filling includes:

1) Deposition of solid waste in such a way to have a working force of minimum area.
2) Spreading and compaction of waste in thin layers
3) Covering of the waste with a layer of compacted cover soil daily.
4) Final cover of the entire construction with compacted earth layer of 1.0 m thick.

The solid wastes in sanitary land fill are degraded by soil microbes. In comparison with other biological treatment systems such as activated sludge and anaerobic digestion, the microbial degradation of solid waste proceeds at a slow rate.

Thermal process

Incineration

Incineration is a process of destruction of waste at high temperature. The combustible wastes are converted through controlled combustion to a residue, which contain no combustible matter. If land suitable for solid waste (SW) land filling operations is not available within economic haul distances, then incineration is necessary. The solid waste is reduced in volume (80% - 90%) and height (98-99%). Incinerator can accept toxic and industrial wastes of any size in solid or powdery form. The other special wastes include hospital wastes, putrifiable organic solids from slaughter houses.

Pyrolysis (Destructive distillation)

Pyrolysis is the process of conversion of biomass into solid, liquid and gaseous energy. Pyrolysis results in the chemical breakdown of organic carbon material into three basic components: 1) gas phase containing mainly hydrogen, CO2, CO and CH4 2) tar or oil phase containing simple organic acids, methanol and acetone and 3) char phase made up of pure carbon and inert material. Pyrolysis does not cause pollution of the atmosphere and large quantities of potentially hazardous plastics could be treated.

There is no single prescription for an integrated waste management program that successfully works in every instance. Each situation must be analyzed on its own merit, an appropriate integrated waste management plan must be developed from hard data, and social attitudes and the legal frame work must be taken into account. The waste management disposal field is in a constant state of flux and appropriate solutions should be innovative, as well as technically and economically sound.

Sludge management

Suspended solids removed from wastewater during sedimentation and then concentrated for further treatment and disposal are called **sludge** or **biosolids**. Even in fully aerobic waste treatment processes in which sludge is repeatedly recycled, most of the sludge must eventually be removed from the system. The task of treating and disposing of this material is called **sludge management**.

Sludge characteristics

The composition and characteristics of sewage sludge vary widely. Since no two wastewaters are alike, the sludges produced will differ. Furthermore, sludge characteristics change considerably with time. Wastewater sludge typically contains organics (proteins, carbohydrates, fats oils), microbes (bacteria, viruses, protozoa), nutrients (phosphates and nitrates), and a variety of household and industrial chemicals. The higher the level of heavy metals and toxic compounds, the greater is the risk to humans and the environment. A key physical characteristic is the solids concentration, because this defines the volume of sludge that must be handled.

Sludge is treated prior to ultimate disposal for two basic reasons: **volume reduction** and **stabilization of organics**. Stabilized sludge does not have an offensive odor and can be handled without causing a nuisance or health hazard. A reduced sludge volume minimizes pumping and storage requirements and lowers overall sludge-handling costs. Several processes are available for accomplishing these two basic objectives. They include sludge thickening, digestion, dewatering, and co-composting. Incineration is considered as a final disposal option.

Sludge disposal

Widely employed methods for final disposal of waste water sludge have included ocean dumping, land filling, incineration, land application, and sale as fertilizer.

Effect of hazardous wastes

The World Health Organization (WHO) considers waste causing short term hazards such as acute toxicity by ingestion, inhalation or skin absorption , corrosivity or other skin or eye contact hazards or risk or fire and explosion and wastes causing long term hazards including chronic toxicity upon repeated exposure, carcinogenecity, resistant to detoxification process such as biodegradation, the potential to pollute underground or surface water or aesthetically objectionable properties such as offensive smell as “hazardous wastes”.

The major hazardous wastes include,

1. Radionuclides
2. Xenobiotics
3. Heavy metals

Industrial growth, economic development, consumerisation indicate a country’s progress and life standard of individuals. Industrial growth has brought along with new problems, too. Water pollution, air pollution, land pollution, noise pollution, radioactive pollution, solid wastes, depletion of resources, scarcity of good quality water, spreading health hazards, are all the consequences of stupendous industrial activities with less attention to its negative impacts on man and his environment (Ramana, 1999). Nature’s built in mechanisms and self regulation ability has been thrown out of gear by the quantity and complexity of wastes generated by the modern society. As technological progress has followed the industrial revolution, environmental problem solving must follow technological progress.

Industrial processes and products thereof both must become environmentally friendly and least damaging.

Hazardous waste management is the most challenging task before the different technologies. Although efforts are continuously on to improve upon the raw material usage, processes and search for alternative eco friendly products, the generation of hazardous wastes and their quantitative contribution requires to be tackled.

Treatment technologies for hazardous wastes

Physical : Soil washing, Air \stream stripping, Vitrification, Solidification, Carbon adsorption, Ion exchange.

Thermal : Incineration

Chemical : Solvent extraction, oxidation, ozonolysis, Electro kinetic removal.

Biological : Land farming, composting, bio reactor processes, bio- enrichment, bio augmentation and landfill.

Principles of Biological Treatment methods

"***Biostimulation***" and "***bioaugmentation***" are the two main ways of initiating biological treatment, particularly in land treatment for hazardous wastes. Biostimulation makes use of existing microorganisms and makes conditions favourable for their action by adjustment of nutrients, pH, temperature, growth factors etc. Bioaugmentation involves externally introduced cultures pure or mixed with specific degradation capacities. Bioaugmentation if done for biodegradation, introduced microorganisms should able to remain viable, should compete with the existing microorganisms.

Genetic, biochemical and ecological ability of microorganisms used plays important role in biodegradation. Although a faster kinetic rate will mean a less expensive system, biomass with a slow specific growth rate responds more favourably to shock loadings. Reactors are to be designed so that microbiological systems are properly controlled under various operating conditions to give effluents of acceptable quality.

Treatment systems

Suspended growth and fixed film are the two main categories of treatment systems although combinations of them are widely used. Immobilised systems are less sensitive to toxicity and have higher efficiency in degradation of hazardous wastes. Fixed film systems are more stable due to a higher biomass concentration and resistance to mass transfer. In fixed films, no wash out of organisms occurs even if the growth rate of the organisms is greatly reduced. Land treatment is the most widely used option to treat toxic wastes .

Microbial Cultures for biodegradation

Biological detoxification may be carried out using pure cultures or mixed cultures. Mixed cultures have a potential advantage over pure cultures in the degradation of toxic compounds in hazardous wastes. Mixed cultures are particularly useful when complete degradation of toxic organics to CO2, CH4, H2S, N2 etc. Enrichment and selection procedures are useful in selecting mixed cultures carrying out degradation.

Biotechnological process for treating liquid waste containing toxic metals

1. Adsorption
2. Extra cellular precipitation
3. Uptake by purified bio polymer

Adsorption of heavy metals to living or dead cells, extra cellular polysaccharide , capsules and slime layer all referred as biosorption. Cell walls and envelops of bacteria, yeast, algae are very efficient in bio sorption due to the charged group present in them. Metals may deposit around cells in the form of phosphates, sulfates or oxides.

Advantages of Biological Treatment methods

1. These methods have economic advantages over other methods.
2. Diversity of degradation action is possible by biological treatment.
3. These methods are robust and have a large capacity for degrading toxic

And hazardous materials.

Disadvantages of Biological treatment

i. Difference in wastes

Microbial enzymes responsible for degradation are specific for individual compounds , no single organism destroy all wastes.

ii. Concentration of waste chemicals

Higher concentration of toxic chemicals inhibit the survival of key members.

iii. Inhibitory mixtures

Industrial wastes / contaminated sites contain not only the toxic chemicals but also the other chemicals that incompatible with the catabolism of target compounds.

iv. Rate of degradation

Because of the above problems the degradation / treatment process is very slow and hence, development of improved strains essential.

Cloning vector for environmental applications

The environmental applications of genetically engineered organisms requires the use of cloning vector that function under environmental conditions are stably maintained , non transmissible , cost effective , environmentally friendly Modern molecular biological techniques, in particular rapid sequencing, the polymerase chain reaction, and site-directed mutagenesis, allow selective alteration of nearly any protein and provide an avenue into rational protein design to improve catabolic activities protein engineering may improve enzyme stability ,substrate specificity, and kinetic properties.

Construction of bacteria with multiple pathways

Genetic engineering permits the combination of several degradative activities within a single host organism. For eg: Bio remediation efforts are sometimes limited by the survival and or *in situ* performance of an added bio catalyst because of ecological factors that are not easily predicted from laboratory studies. Moreover , the combination of multiple activities in host that is easily and inexpensively cultured to high cell densities would certainly reduce fermentation costs.

Advantages of *in situ* application:

1. It allows destruction of contaminants *in situ*
2. Minimum risk, and environmental impact
3. Minimum cost for removing, treating, and disposing

Engineering stress resistance

Microorganisms used to remediate hazardous wastes are likely to be exposed to a wide variety of environmental stresses . Stress factor can range from high concentration of contaminants, toxic metals, or solvents; through extremes in pH , oxygen tension , temperature , ionic strength, and nutrient concentrations; to conditions of extremely low carbon and nutrient availability. Microorganisms must adapt to these conditions to be able to effect remediation. In some cases genetic engineering may be helpful in augmenting resistance to such stresses, there by facilitating good performance of the degradative organism under adverse conditions.

The following is the list of *in situ* options with order of preference for hazardous waste management.

1. Eliminate hazardous waste generation at production process stage
2. Do recovery of constituents of hazardous waste
3. See if landfill is suitable and economical
4. Decompose the waste by physical / chemical/biological means
5. Immobilise the waste by solidification or encapsulation so that landfill becomes acceptable.

Improper disposal of hazardous and toxic waste can cause serious damages to health and environment. Recalcitrant, man made compounds and their products are of major concern in this regard. Bioremediation, is one of the most effective innovative technologies to come along in this century to treat these hazardous wastes. They offer complete destruction of contaminants and can often be applied at a lower total cost, at a faster rate. With the advancement of bioreactor designs, the use of genetically engineered microbes, biodegradation technology has been successful in making its impact felt on pollution abatement efforts.

Lecture 13

Disaster management, Floods, earthquakes, cyclones and land slides

Disaster is a sudden, calamitous event bringing great damage, loss, destruction and devastation to life and property. The damage caused by disaster is immeasurable and varies with the geographical location, climate and the type of the earth surface. This influences the mental, socio-economic, political and cultural state of the affected area. Generally, disaster has the following effects in the concerned areas,

1. It completely disrupts the normal day to day life
2. It negatively influences the emergency systems
3. Normal needs and processes like food, shelter, health, etc. are affected and deteriorate depending on the intensity and severity of the disaster.

It may also be termed as "a serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of the affected society to cope using its own resources."

Types of Disaster

Generally, disasters are of two types – **Natural** and **Manmade**. Based on the devastation, these are further classified into major/minor natural disaster and major/minor manmade disasters. Some of the disasters are listed below,

Major natural disasters:

- Flood
- Cyclone
- Drought
- Earthquake

Minor natural disasters:

- Cold wave
- Thunderstorms
- Heat waves
- Mud slides
- Storm

Major manmade disaster:

- Setting of fires
- Epidemic
- Deforestation
- Pollution due to prawn cultivation
- Chemical pollution.
- Wars

Minor manmade disaster:

- Road / train accidents, riots
- Food poisoning
- Industrial disaster/ crisis
- Environmental pollution

Disaster Management

There are no standardized rules defining the different phases of the disaster management cycle. Different agencies use different cycles depending upon their objectives. However, while approaches vary, it is agreed that disaster management activities should be carried out in a cycle. The following figures illustrates the phases of the disaster management cycle, which are described as follows:

Disaster prevention, mitigation and preparedness
the first important steps towards reducing disaster impact are to correctly analyse the potential risk and identify measures that can prevent, mitigate or prepare for emergencies. Information and Communication Technology can play a significant role in highlighting risk areas, vulnerabilities and potentially affected populations by producing geographically referenced analysis through, for example, a geographic information system (GIS). The importance of timely disaster warning in mitigating negative impacts can never be underestimated. For example, although damage to property cannot be avoided, developed countries have been able to reduce loss of life due to disasters much more effectively than their counterparts in the developing world. A key reason for this is the implementation of effective disaster warning systems and evacuation procedures used by the developed countries, and the absence of such measures in the developing world.
Comparison of Damage Caused by Three Recent Disasters

All the figures reported in the above table are rough estimates as it is impossible to have exact figures in such situations. However, it clearly shows that in the case of Hurricane, Katrina, although the economic loss and damage to property were much higher, the number of deaths was remarkably less than that resulting from the Indian Ocean tsunami in Sri Lanka and the Pakistan earthquake. This is

largely because in Sri Lanka and Pakistan, the victims were mainly communities living below the poverty line – a factor that significantly contributed to their vulnerability – and because effective disaster warning systems were not in place. In New Orleans, official warnings were dispatched in advance and many in the affected areas were evacuated in time. In addition, the disaster management process was much better than what it had been in Sri Lanka and Pakistan, despite the heavy criticism it received.

A warning can be defined as the communication of information about a hazard or threat to a population at risk, in order for them to take appropriate actions to mitigate any potentially negative impacts on themselves, those in their care and their property.

The occurrence of a hazard does not necessarily result in a disaster. While hazards cannot be avoided, their negative impacts can be mitigated. The goal of early public warning is to ensure to the greatest extent possible that the hazard does not become a disaster. Such warnings must be unambiguous, communicate the risks succinctly and provide necessary guidance.

The success of a warning can be measured by the actions that it causes people to take, such as evacuation or avoiding at-risk areas. In a disaster situation, there is no doubt that timely warnings allow people to take actions that saves lives, reduce damage to property and minimize human suffering. To facilitate an effective warning system, there is a major need for better coordination among the early warning providers as well as those handling logistics and raising awareness about disaster preparedness and management.

While disaster warnings are meant to be a public good, they are often most effectively delivered through privately-owned communication networks and devices. There are many new communication technologies that allow warning providers not only to reach the people at risk but also to personalize their warning message to a particular situation. Opportunities are available right now to significantly reduce loss of life and potential economic hardship if disaster warning systems can be improved.

It is important to note that disaster warning is indeed a system, not a singular technology, constituting the identification, detection and risk assessment of the hazard, the accurate identification of the vulnerability of a population at risk, and finally, the communication of information about the threat to the vulnerable population in sufficient time and clarity so that they can take action to avert negative consequences. This final component underscores the importance of education and creating awareness in the population so that they may respond with the appropriate actions.

Disaster Warning

Disaster Reduction identifies several key parties that play major roles in the disaster management process, especially in disaster warning.

Communities, particularly those most vulnerable, are vital to people-centred early warning systems. Their input into system design and their ability to respond ultimately determine the extent of risk associated with natural hazards. Communities should be aware of hazards and potential negative impacts to which they are exposed and be able to take specific actions to minimize the threat of loss or damage. As such, the geographic location of a community is an essential determinant in the selection of

disasters on which the system should focus their community education. For example, coastal communities need to be educated and prepared for the possibility of a tsunami, while a mountain community can be educated to respond to an early warning system for landslides.

Local governments should have considerable knowledge of the hazards to which their communities are exposed. They must be actively involved in the design and maintenance of early warning systems, and understand information received to be able to advise, instruct or engage the local population in a manner that increases their safety and reduces the potential loss of resources on which the community depends.

National governments are responsible for policies and frameworks that facilitate early warning, in addition to the technical systems necessary for the preparation and issuance of timely and effective hazard warnings for their respective countries. They should ensure that warnings and related responses are directed towards the most vulnerable populations through the design of holistic disaster response and early warning frameworks that address the specific needs of the related micro- and macro-level actors. The provision of support to local communities and local governments to develop operational capabilities is an essential function to translate early warning knowledge into risk reduction practices.

Regional institutions and organizations should provide specialized knowledge and advice in support of national efforts to develop or sustain the operational capabilities of countries that share a common geographical environment. Regional organizations are crucial to linking international capabilities to the particular needs of individual countries and in facilitating effective early warning practices among adjacent countries.

International bodies should provide support for national early warning activities and foster the exchange of data and knowledge between individual countries. Support may include the provision of advisory information, technical assistance, and policy and organizational support necessary to ensure the development and operational capabilities of national authorities or agencies responsible for early warning practice.

Non-governmental organizations (NGOs) play a critical role in raising awareness among individuals and organizations involved in early warning and in the implementation of early warning systems, particularly at the community level. In addition, they play an important advocacy role to help ensure that early warning stays on the agenda of government policy makers.

The private sector has a diverse role to play in early warning, including developing early warning capabilities in their own organizations. The private sector is also essential as they are usually better equipped to implement Information and Communication Technology-based solutions. The private sector has a large untapped potential to help provide skilled services in the form of technical manpower, know-how, or donations of goods or services (in-kind and cash), especially for the communication, dissemination and response elements of early warning.

The media plays an important role in improving the disaster consciousness of the general population and in disseminating early warnings. The media can be the critical link between the agency providing the warning and the general public.

The scientific community has a critical role in providing specialized scientific and technical input to assist governments and communities in developing early warning systems. Their expertise is critical to analysing the risks communities face from natural hazards, supporting the design of scientific and systematic monitoring and warning services, fostering data exchange, translating scientific or technical information into comprehensible messages, and disseminating understandable warnings to those at risk.

Channels Used for Disaster Warning

Radio and Television

Considered the most traditional electronic media used for disaster warning, radio and television have a valid use. The effectiveness of these two media is high because even in developing countries and rural environments where the tele-density is relatively low, they can be used to spread a warning quickly to a broad population. The only possible drawback of these two media is that their effectiveness is significantly reduced at night, when they are normally switched off.

After the Indian Ocean tsunami of 2004, many radio manufacturers considered introducing new digital radio alert systems that react even if the set is switched off. In order to trigger this alarm, a special flag integrated into the received signal from a terrestrial transmitter or a satellite would be used and the set would automatically tune to the emergency broadcast channel. The only disadvantage of this system is that to introduce a new generation of receivers in analogue environment generally takes 5 to 10 years. With digital receivers, this would be somewhat easier (Dunnette, 2006).

Telephone (Fixed and Mobile)

Telephones can play an important role in warning communities about the impending danger of a disaster.

Short Message Service

Short message service (SMS) is a service available on most digital mobile phones that permits the sending of short messages (also known as 'text messages', 'SMSes', 'texts' or 'txts') between mobile phones, other handheld devices and even landline telephones.

Satellite Radio

A satellite radio or subscription radio is a digital radio that receives signals broadcast by communications satellite, which covers a much wider geographical range than terrestrial radio signals. Satellite radio functions anywhere there is line of sight between the antenna and the satellite, given there are no major obstructions such as tunnels or buildings. Satellite radio audiences can follow a single channel regardless of location within a given range.Satellite radio can play a key role during both disaster warning and disaster recovery phases. Its key advantage is the ability to work even outside of areas not covered by normal radio channels. Satellite radios can also be of help when the transmission towers of the normal radio station are damaged in a disaster.

Internet/Email

The role Internet, email and instant messages can play in disaster warning entirely depends on their penetration within a community and usage by professionals such as first responders, coordinating

bodies, etc. While these media can play a prominent role in a developed country, where nearly half of all homes and almost all offices have Internet connections, this is not the case in the developing world. In many developing countries, less than 5 percent of the population uses the Internet and even those who are users do not use it on a regular basis. In such a situation, it is difficult to expect Internet and email to play any critical role.

GIS and Remote Sensing in Disaster Management

GIS can be loosely defined as a system of hardware and software used for storage, retrieval, mapping and analysis of geographic data. Spatial features are stored in a coordinate system (latitude, longitude, state, plane, etc.) that references a particular place on the earth. Descriptive attributes in tabular form are associated with spatial features. Spatial data and associated attributes in the same coordinate system can then be layered together for mapping and analysis. GIS can be used for scientific investigations, resource management and development planning.

Remote sensing is the measurement or acquisition of information about an object or phenomenon by a recording device that is not in physical or intimate contact with the object. In practice, remote sensing is the remote utilization (as from aircraft, spacecraft, satellite or ship) of any device for gathering information about the environment. Thus, an aircraft taking photographs, earth observation and weather satellites, monitoring of a foetus in the womb via ultrasound, and space probes are all examples of remote sensing. In modern usage, the term generally refers to techniques involving the use of instruments aboard aircraft and spacecraft.

As disaster management work usually involves a large number of different agencies working in different areas, the need for detailed geographical information in order to make critical decisions is high. By utilizing a GIS, agencies involved in the response can share information through databases on computer-generated maps in one location. Without this capability, disaster management workers have to access a number of department managers, their unique maps and their unique data. Most disasters do not allow time to gather these resources. GIS thus provides a mechanism to centralize and visually display critical information during an emergency.

There is an obvious advantage to using a map with remote sensing or GIS inputs instead of a static geographical map. A static map is mostly analogous and is not interactive. On the other hand, a vulnerability map with GIS input provides dynamic information with cause and effect relationship. As shown in Figure , the visualization effect is much more effective in the latter case.

Difference Between an Ordinary (2D) Map and a Map with GIS Input

The use of GIS in different phases

Planning

Locating and identifying potential problems is a core requirement in disaster management. GIS can be used effectively to achieve this objective. Using a GIS, it is possible to pinpoint hazard trends and start to evaluate the consequences of potential emergencies or disasters. When hazards are viewed with

other map data, such as buildings, residential areas, rivers and waterways, streets, pipelines, power lines, storage facilities, forests, etc., disaster management officials can formulate mitigation, preparedness, response and possible recovery needs.

Mitigation

After potential emergency situations are identified, mitigation needs can be addressed. This process involves analysing the developments in the immediate aftermath of a disaster, evaluating the damage and determining what facilities are required to be reinforced for construction or relocation purposes. Mitigation may also include implementing legislation that prevents building structures in areas prone to earthquake, flood or tsunami. Other mitigation approaches may target fire-safe roofing materials in wildfire hazard areas. Utilizing existing databases linked to geographic features in GIS makes the task of monitoring these possible.

Preparedness

During the preparedness and response phases, GIS can accurately support better response planning in areas such as determining evacuation routes or locating vulnerable infrastructure and vital lifelines, etc. It also supports logistical planning to be able to provide relief supplies by displaying previously available information on roads, bridges, airports, railway and port conditions and limitations. Apart from this, activities such as evacuee camp planning can also be done using GIS.

Disaster response

The most difficult period of a disaster is the immediate aftermath. This period calls for prompt action within an exceptionally short period of time. In the aftermath of any disaster, a significant number of individuals will be injured and/or displaced. Many of them may still be living with the trauma they have encountered, including loss of loved ones. Affected individuals may also be without food or other essential items. They might be waiting in temporary shelters, with no idea what to do next. Some might need immediate medical attention, while the disaster aftermath environment also creates ideal breeding grounds for possible epidemics.

- Tracing Missing Persons
- Coordinating Donor Groups
- Recording the Locations of Temporary Camps and Shelters

Disaster recovery

Disaster reconstruction has to start as soon as the initial disaster cleanup has taken place. This is a very complex endeavour, requiring a huge array of skill sets and a thorough knowledge of an ever-increasing variety of techniques and equipment. A range of software tools are being used for these purposes. Thus, while the role of Information and Communication Technology in the long-term disaster recovery process is not as apparent as it is in disaster warning, there is no doubt that Information and Communication Technology is being used widely to expedite these activities.

Specific Disaster Management Software

Different types of software tools are being used to gather, store and analyse data related to disasters,

not only in post-disaster conditions, but also as a long-term measure to mitigate the risk of the disasters. One such approach is known as DesInventar.
DesInventar is a methodical way to gather and store information about characteristics and effects of different types of disasters, particularly the ones not visible from global or national scales. This allows for the observation and analysis of accumulated data regarding these 'invisible' disasters at a global or national scale.
Despite the fact that disaster preparedness has not been identified as one of the Millennium Development Goals, it is apparent that proper mechanisms for disaster awareness and means of disaster recovery are essential to achieving the Millennium Development Goals. In particular, the Millennium Development Goal targets such as integrating the principles of sustainable development into country policies and programmes, and reversing the loss of environmental resources can never be achieved without giving due emphasis to effective disaster management strategies.

Disaster management in India

The **National Disaster Management Authority** (NDMA), headed by the Prime Minister of India, is the Apex Body for Disaster Management in India. The setting up of the NDMA and the creation of an enabling environment for institutional mechanisms at the State and District levels is mandated by the Disaster Management Act, 2005.

Evolution of NDMA

Emergence of an organization is always an evolutionary process. Establishment of NDMA has also gone through the same processes. Towards this aim, theGovernment of India (GOI), in recognition of the importance of Disaster Management as a national priority, has set up a High-Powered Committee (HPC) in August 1999 and also a nation committee after the 2001 Gujarat earthquake, for making recommendations on the preparation of Disaster Management plans and suggestion effective mitigation mechanisms. The Tenth Five-Year Plan Document also had, for the first time, a detailed chapter on Disaster Management. Similarly, the Twelfth Finance Commission of India was also mandated to review the financial arrangements for Disaster Management. On 23 December 2005, the Government of India enacted the Disaster Management Act, which envisaged the creation of the National Disaster Management Authority (NDMA), headed by the Prime Minister of India, and State Disaster Management Authorities (SDMAs) headed by respective Chief Ministers of the States, to spearhead and implement a holistic and integrated approach to Disaster Management in India.

Floods

A flood is an expance of water submerging land. A flood is caused by excess water in a location, usually due to rain from a storm or thunderstorm or the rapid melting of snow. A flood happens when an area of land, usually low-lying, is covered with water. The worst floods usually occur when a river overflows its banks. The flood is constituted not only of the overflowing water but also of all other

waters that are unable to drainoff into water channels.

Causes of floods

- When snow on a mountain melts or when a river or a lake of some sort overflows
- Flooding from water displacement, such as in a landslide,
- The failure of a dam,
- An earthquake induced tsunami,
- A hurricane's storm surge or melt water from volcanic activity.
- Flooding of Coastal areas by high tides or by tsunami waves caused by undersea earthquakes.
- A flood that rises and falls rapidly with little or no advance warning is called a flash flood. Flash floods usually result from intence rainfall over a relatively small area.

Elements at risk

- Buildings built of earth (mud),weak foundation and water soluble material.
- Basement of buildings.
- Utilities such as sewerage, water supply.
- Agricultural equipment and crops, vehicles, fishing boats etc.

Effects of flood

- Physical damage- structures such as buildings get damaged due to flood water. Landslides can also take place. Top soil gets washed away
- Causalities - people and livestock die due to drowning. It can also lead to epidemics and diseases.
- Water supplies- Contamination of water. Clean drinking water becomes scarce.
- Crops and food supplies- shortage of food crops can be caused due to loss of entire harvest.

Flood management

Flood management involves the following activities:

- **Mapping**- of the flood prone area.
- **Land use control**- no major development should be permitted in the areas subjected to flooding.
- **Construction of engineered structures**- strong structures to withstand flood forces. Moreover the buildings should be constructed on an elevated area and if necessary should be build on stits.
- **Flood control**- it aims to reduce flood damage. It includes:
- Flood reduction
- Flood diversion
- Flood proofing

For example,

- London is protected from flooding by a huge mechanical barrier across the river Thames, which is raised when the water level reaches a certain point.

Notable floods

- Jakarta on January 2007 till now is having a 1.5 M flood.whole city is affected. 80 people killed.
- The floods in peninsular Malaysia, Sabha and Sumithra in December 2006 and January 2007 is considered to be the worst in 100 years, resulting in evaluation of over 100,000 people in the worst-hit state of Johor at its peak.
- Ethiopia saw one of its worst floods in August 2006.

Cyclone

The name cyclone was first coined by Captain Henry Piddington, Chairman of Marine Court, Calcutta in 1848. It is derived from Greek word means coil of a snake. Cyclone is an meteorological phenomena in which an area of low pressure characterized by inward spiraling winds that rotate counter clockwise in the northern hemisphere and clockwise in the southern hemisphere of the earth. Near the places of their origin they are only 80 Km in diameter, but well developed cyclones have their diameter ranging from 300 to 1500 km. They move at faster rate over the oceans than over the land because the irregularities of the land surface retard their speed. The six main types of cyclones are polar cyclone, polar low, extra tropical, subtropical, tropical and mesoscale.

Polar cyclone

Polar or arctic cyclones are vast areas of low pressure. A polar cyclone is a low pressure weather system usually spanning 1,000-2000 kilometers per hour, in which the air circulates in a counterclockwise fashion in the northern hemisphere.

Polar low

A polar low is a small-scale, short-lived atmosphere system (depression) that is found over the ocean areas in both the Northern and southern hemispheres. They are part of the larger class of meso scale weather systems. Polar lows can be difficult to detect using conventional weather reports and are a hazard to high latitude operations, such as shipping and gas and oil platforms. Polar lows have been referred to by many other terms, such as comma cloud, mesocyclone, polar meso scale vortex, Arctic hurricane, Arctic low and depression.

Extra-tropical

An extra tropical cyclone sometimes inaccurately called a cyclone is a synoptic scale low pressure weather system that has neither tropical nor polar characteristics. The “extra-tropical” refers to the fact that this type of cyclone generally occurs outside of the tropics, in the middle latitudes of the planet. These systems may also be described as “mid-latitude cyclones” or “post-tropical cyclones.

Sub-tropical

A sub-tropical cyclone is a weather system that has some characteristics of an extra-tropical cyclone. It can in a wide band of latitude, from the equator to 50°C. ZIYAD is a very dangerous cyclone now affecting Mauritius.

Tropical

A tropical cyclone is a low-pressure cyclonic storm system. It is caused by evaporated water which comes off the ocean and becomes a storm. Typical cyclones are the worst natural hazards in the tropics. They are large revolving vortices in the atmosphere extending horizontally from 150-1000 km and vertically from the surface from 12-14 km. Strong winds spiraling anti-clockwise in the Northern Hemisphere blow around the cyclone center at the low level. At the higher levels, the sense of rotation is just opposite to that at the lower level. They generally move 300-5000 km per day over the ocean. While moving over the ocean, they pick up energy from the warm water of the ocean and some of them grow into a devastating intensity. On an average, about 5-6 tropical cyclones form in the Bay of Bengal and the Arabian sea every year, out of which 2-3 may be severe.

Depending on their location and strength, there are various terms by which tropical cyclones are known, such as hurricane, typhoon, tropical storm, cyclonic storm and tropical depression. They are all cyclonic storm systems that form over the oceans. Tropical cyclones can produce extremely strong winds, tornadoes, torrential rain, high waves, and storm surges. The heavy rains and storm surges can produce extensive flooding. Although one cannot control cyclones, the effects of cyclones can be mitigated through effective mitigation policies and strategies.

- Installation Of Earth Warning Systems **:** Such systems fitted along the coastlines can greatly assist forecasting techniques, thus helping in early evacuation of people in the storm surge areas.
- Developing communication infrastructure Amateur Radio has today emerged as second line unconventional communications systems and is an important tool for disaster mitigation.
- Developing shelter belts: Shelter belts with plantations of trees can act as effective wind-and tide-breakers. Apart from acting as effective windbreakers and protecting soil crops from being damaged, they also prevent soil erosion.
- Developing community cyclone shelters: Cyclone shelters at strategic locations can help in minimizing the loss of human life. In the normal course of life, these shelters can be used as public utility buildings.
- Construction of permanent houses: There is a need to build appropriately-designed concrete houses that can withstand high winds and tidal waves.
- Training and education: Public awareness programs that inform the population about their response to cyclone warnings and preparedness can go a long way in reducing causalities.
- Land use control and settlement planning: Ideally, no residential and industrial units should be permitted in the coastal belt of 5 km from the sea, as it is the most vulnerable belt. No further

growth of settlements in this region should be permitted. Major settlements and other important establishments should be located beyond 10 km from the sea.

Earthquakes and Mitigation Measures

Earthquake is those movements of the earth crust which make the ground vibrate and shake backward and forward. The shaking of earth crust proceeds in the form of waves from the centre of disturbance. Longitudinal waves, transverse waves and surface waves are the 3 types of waves. Earthquake may be caused by two types of forces.

1) Techtonic occurrence: techtonic occurrence like faulting, breaking of rocks, raising or sinking of layers of the earth, folding of the strata or vapour seeking to escape from the earth.

2) volcanic activity: violent eruptions and intrusion of igneous magma from below the earth.

Types of earthquake:

Volcanic earthquake: are associated with the flow of hot magma interrupting volcanoes. These happen to be localized and seldom cause any extensive damage.

Techtonic earthquake: are those which result from structural and justments inside the earth.

Plutonic earthquake: are those which have their origin at greater depths. They may also be generated in the same manner as the techtonic earthquake far belw the surface of the earth.

Effects of earthquake:

- Collapse of manmade structure like building, bridges, towers etc.
- Roads get affected due to subsidence of the ground and enormous fissures appear on land.
- Extensive landslides in hilly regions and rocky depris come down to block the path of streams.
- When earthquake are accompanied by volcanic activity, the destruction is very enormous**.**

Mitigation measures:

- Damage to structure can be avoided by prohibiting restriction on such earthquake prone zones.
- Power lines and pipelines can be built with extra slack where they cross such earthquake prone zones.
- New buildings should be constructed with proper earthquake resistant measures. They require secure anchoring and tight bonding of foundations, frame, outer and inner walls, floors and roofs.

- Vulnerable older building located in high risk areas might be rebuilt to withstand anticipated earth quake.

Indian Scenario

It has been several years since the earthquakes struck Gujarat on January 26, 2001, rehabitation has been done on a massive scale. Gujarat's experience has taught that building shelters with less vulnerability to earthquakes should also take into consideration of the specific needs of the victims instead of being a top-down approach. The role of NGO's in this is very important. Their strength lies in their manpower, informality in operations and valuable human resources. Their ability to reach out to the community and sensitivity to local traditions is an asset in such situations.

The initiatives of the International Fund for Agricultural Development in supporting the self-employed Woman association(SEWA) and the Government's initiative in community-based livelihood security for earthquakes and drought victims have the potential to shape future disaster response and development projects in Gujarat, the Gujarat Woman's Economic Development Corporation (GWEDC) initiative in reviving woman's businesses after the calamity also provides many practical lessons in regenerating local economies and artisan markets.

The coordination between Government, local NGO's and local community initiatives, both for rescue as well as rehabilitation, needs to be strengthened as this can cause delays, overlaps and waste of relief material and efforts.

Land Slides and Mitigation Measures

In the recent years, intensive construction activity and the destabilizing forces of nature have aggravated the land Slide problem. Landslides refer to the downward sliding of huge quantities of land masses. Sliding occurs along steep slopes of hills of mountains. The rate of movement of such a mass is never constant. Landslides occur as a result of changes on a slope, sudden or gradual, either in its composition, structure, hydrology or vegetation. The changes can be due to geology, climate, weathering, changing land use and earthquakes.

The causes of landslides may be grouped into two types:

- Inherent or internal causes.
- Immediate causes.

Effect of landslides:

Landslides are not only destructive to the man but also to the structures. One of the most disastrous landslides occurred in Switzerland in 1806, when great masses of loose rock and soil suddenly slide down into the valley form the mountainside. It resulted in killing of 800 persons. Initially the Vajont Dam, was the highest arch failed due to landslide on October 9, 1963, when a rock mass of about 600 million tons slide down into the lake.

- A significant reduction in hazards caused by landslides can be achieved by prevention of the exposure of population and facilitates by physically controlling the landslides.
- Development programs that involve modification of the topography, exploitation of natural resources and change in the balance load on the ground should not be permitted.
- Some critical measures that could be undertaken to prevent further landslides are drainage measures, erosion control measures such bamboo check-dams, terracing, jute and coir netting and rock control measures such as grass plantation, vegetated dry masonry walls, retaining walls and, most importantly, preventing deforestation and improving afforestation.
- Disasters cannot be totally prevented. However, early warning systems, careful planning and preparedness on part of the vulnerable community would help in minimizing the loss of life and property due to these disasters.

Lecture 14

Social issues and the environment, unsustainable to sustainable development

Sustainable Development

Human beings interact both with the social world and nature. Both, economic development and stable environment are required for the continual improvement of lifestyle and living standards. But until now, the development was human oriented and limited to rich nations. The development was achieved by damaging the environment and over exploitation of natural resources which were non renewable. That caused instability of environment and crossed the threshold limit of environmental damage.

Sustainable development can be defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." It is effective use of resources for economic development while preserving the environment and ecosystem so that not only the needs of presents are fulfilled but also for the future generations. Sustainable development also interlinks the development and carrying capacity of environment and ecosystem.

Causes for Unsustainable Development.

- Some people argue that developing countries responsible for the degradation. Others hold Developing Countries are responsible for them.
- The important issues is not rate of increase of National Pollution, it is the rate of increase of Total Pollution. In this regard developed countries contribute much more than developing countries.
- Some people argue that raising population in the third world countries to be the crucial pollutant and it is essential to control it by all means.
- People should look at environment as not only reserve of man but of all living organism. So development has to sustain not only for man but also for all living organisms.

True sustainable development

It aims at optimum use of natural resources with high degree of sustainity, minimum wastage, least generation of toxic byproducts and maximum productivity.

- **Inter generational equity**

We should minimize any adverse impacts on resources and environment for future generation.

- **Intra generational equity**

Technological development of rich countries should support economic growth of poor countries and lead to sustainability.

- Don't use high quality energy to do a job that can be done with low quality energy.

Electricity, very high temp(>2500C),nuclear fission, fusion, high velocity wind	Very high	To run electrical devices
High temp heat (1000 – 2500C), H2 gas, coal, gasoline, food	high	To move vehicles, industrial processes
Normal sunlight, wood, crop wastes	moderate	Cooking, hot water, 100 – 1000C
Low temperature heat (below 100C)	Low	Low temperature for space heating

- Place more emphasis on pollution prevention and waste reduction.
- Recycle and reuse as many of our waste products and resources possible.
- Make more goods that last longer and easy to use, recycle and repair.
- Depend on renewable source of energy, sun wind, biomass, flowing water, geo thermal and tidal.
- Sustain Earths Biodiversity with emphasis on protecting vital habitats of the wild species.
- Use potentially renewable resources such as wastes soil, plants, animals no faster than they are renewed.
- Increase the usage of non renewable resources to minimize the resource depletion at a faster rate.
- Earth Degrading activities should be discouraged
- Reduce poverty and rate of population growth

Measures for sustainable Development:

- **Using appropriate technology**

It is one which is locally adaptable, eco friendly efficient and culturally suitable. It involves local labors, less resources and produces minimum waste. the Concept is **''Design with Nature''.**

- **3-R Approach**

Reduce,Reuse and Recycle approach.
Reduce the usage and also reduce the wastage of resource by making things that last longer and are easier to recycle, reuse and repair.

- **Promoting environmental education awareness**

Environmental education will help in changing the thinking and attitude of people towards environment.

- **Population stabilization**

We can achieve sustainable development by controlling population.

- **Conservation of nonrenewable resources**

It should be conserved by recycling and reusing.

- **Usage of renewable resources**

Usage of renewable resources should not be faster than their regeneration capacity.

Sustainable development also looks at the equity between countries and continents, races and classes, gender and ages. It includes social development and economic opportunity on one hand and the requirements of environment on the other. It is based on improving the quality of life for all, especially the poor and deprived within the carrying capacity of the supporting ecosystems. It is a process which leads to a better quality of life while reducing the impact on the environment. Its strength is that it acknowledges the interdependence of human needs and environmental ...
To ensure sustainable development, any activity that is expected to bring about economic growth must also consider its environmental impacts so that it is more consistent with long term growth and development. Many 'development projects', such as dams, mines, roads, industries and tourism development, have severe environmental consequences that must be studied before they are even begun. Thus for every project, in a strategy that looks at sustainable development, there must be a scientifically and honestly done EIA, without which the project must not be cleared. Large dams, major highways, mining, industry, etc. can seriously damage ecosystems that support the ecological health of a region.
Forests are essential for maintaining renewable resources, reducing carbon dioxide levels and maintaining oxygen levels in the earth's atmosphere. Their loss impairs future human development. Loss of forests depletes biodiversity which has to be preserved to maintain life on earth. Major heavy industries if not planned carefully lead to environmental degradation due to air and water pollution and generate enormous quantities of waste that lead to long term environmental hazards. Toxic and Nuclear wastes can become serious economic problems as getting rid of them is extremely costly.

In order to safeguard the existence of life and future of humanity, we have to change our approach from unsustainable to sustainable development. A judicious balance between developmental activities

and environmental protection should be assured. It is possible only trough sustainable development.

Social issues and Environment.

- **Urban problems related to energy**
- **Water conservation -**
- Rain water harvesting and water shed management,
- Recycling of industrial wastes,
- Construction of Storage reservoirs
- Better Agricultural Practices.

Rain water harvesting

The activity of collecting rain water direct ly recharging it into the ground to improve the ground water storage in the aquifer is called Rain Water harvesting. This may increase the level of ground water, reduce the ground water table depletion and arrest the sea water intrusion

- Traditional methods - Temple tanks of India, Ponds
- Modern methods - Absorption pit method, Absorption well method, Well cum Bore

method, Group Houses – Terrace water saving method

Water shed management

Principles factors influencing watershed operations

a. Physiography,
b. Soil and Geology,
c. Land Use,
d. Climitological and meteorological information,
e. Design peak runoff rate,
f. Socio-economic factors.

Restoration and rehabilitation Techniques

The survival of human has now become an important issue to be concentrated, as human faces many threats for his survival too. He is disturbed to a maximum and at times, he needs resettlement too. Based on the causes, resettlement activities can be broadly grouped into 2 categories.

1. *Voluntary Rehabilitation:* Due to natural calamities such as Political, racial, religious disturbance, floods, cyclones, famines, earthquakes etc.,
2. *Involuntary Rehabilitation*: Due to construction of various types of developmental projects.

Environmental ethics

'If there is to be a war, let it be against environmental contamination, nuclear contamination, chemical contamination of soil and water systems'. The four basic tents of biocentrism are:

- Humans are members of Earth's living community in the same way and on the same terms as all other living things,
- Humans and other species are inter-dependent,
- Each organism is a unique individual pursuing its own way, and
- Humans beings are not inherently superior to other living things.

Three principles of ethical conduct are**:**

- We should not harm any natural entity that has an intrinsic worth.
- We should not try to manipulate, control, modify, manage or interfere with the normal functioning of natural ecosystems, biotic communities or individual wild organisms, and
- We should not try to deceive or mislead any animal capable of being deceived or misled.

Some issues of concern:

- Waste land reclamation
- Greenhouse effect
- Acid rain
- El Nino
- Ozone depletion – Ozone friendly chemicals are HFC 1349 and HCFC 22
- Other than these issues, biodiversity loss, over all pollution of water , air, noise are all typical examples for over ruling the environmental ethics.

How to achieve sustainable development?
The following four rules can be defined as the key mantras of sustainability. These four rules are

- Reduce our dependency on heavy metals and fossil fuels such as coal, oil and natural gas.
- Reduce our dependency on synthetic chemicals.
- Reduce our destruction of nature which includes clearing of forest and natural habitats for human needs.
- The fourth principal is to ensure that we don't stop people from meeting their needs in order to achieve environmental sustainability. We must maintain a balance between environmental and economic sustainability.

Lecture 15
The Environment Protection Act, the Air Act, the water Act, the Wildlife Protection Act and Forest Conservation Act

The Environment Protection Act, 1986

The Environment Protection Act, 1986 was constituted on 19 Nov, 1986, to provide protection and improvement of environment and for matters connected with environment. The sprit of the proclamation adopted by the United Nations Conference on Human Environment, held in Stockholm in June 1972, was implemented by the Government of India by creating this act.

There are four main chapters and different clauses under various chapters which lay down the standards, policies and act of environmental degradations and policies for improvement of environment and prevention of human beings from environmental hazards.

Chapter I - describes the definitions of various entities that are related to environment.

Chapter II - describes the role of central government to take measures for environment protection and its improvement along with the economic development. It includes the appointment of officers, power to give directions, rules to regulate environmental pollution, laying down procedures and standards for industrial waste, emissions, hazardous waste etc.

Chapter III - Deals with the prevention, control and abatement of environmental pollution. As per the guidelines, a person running an industry or operation cannot emit or discharge environmental pollutants in excess of the permissible limit. Central government or its officers may take samples of air, water, soil or other substance from any factory for the purpose of analysis and upon failure to satisfy the norms, shall liable to be proceeded against and punished accordingly. Penalty- Imprisonment of five years with a fine upto one lakh rupees or it extend to Rs 5000 every day.

Chapter IV - lists miscellaneous clauses which are not pertaining to environment but are guidelines for functioning and conduct of officers and government representatives and these guidelines must be laid before parliament for its validity.

The Air (Prevention And Control of pollution) Act,1981

As a control of the UN conference on Human environment held on June 1972, steps were taken to prevent all natural amenities and with this in view, this act has been enacted in 1981. It consists of 7 chapters and 54 sections.

Chapter-I : This chapter defines the following terms such as air pollutant, air pollution, approved fuel ,automobile, chimney emission, control equipment etc.,

Chapter-II : It deals with the information regarding CPCB and SPCB, their constitutions, terms and conditions of service of members, delegation of powers to various officials.

Chapter-III: This chapter emphasizes the function of central board and state board such as to collect ,

compile and publish the data regarding air pollution and to guide the concerned industry for the effective prevention and control of air pollution.

Chapter-IV: This deals with prevention and control of air pollution. The boards are authorized to declare the air pollution control areas, instruct regarding the emission standards from automobiles and restrict the activities of certain industries. According to this chapter the industrial people are not permitted to allow excess pollutants with respect to standards and in such cases the board has the power to enter, inspect and collect sample, find out the reports in the state laboratories. On the basis of the report appeal can be made and the persons may be punished.

Chapter-V: This chapter deals with the fund, accounts and auditing of the central and state boards.

Chapter-VI: If the industry or person fails to follow the standards, they will be punished.

Punishment: Imprisonment for not less than one year and 6 months, it may extend to 6 years and with fine.

Chapter-VII: It deals with the power to amend the schedules, the necessity of state board to maintain a register containing relevant particulars and about the power of central and state government to make rules regarding the air pollution control.

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

The Water Act was enacted by Parliament Act, 1974 purpose to provide for the prevention of control of water pollution and the maintaining or restoring of wholesomeness of water. As on day, it is applicable in all the states of India. This act consists of 8 chapters and 64 sections

Chapter-I : This chapter explains the terms such as board, central ,state board, member, outlet sewer sewage effluent, trade effluent, stream and pollution.

Chapter-II : It elaborates about the constitution of central board , state board, committees, terms and conditions of service of members, meeting of the board. It also explains about delegation of powers to chairman, member secretary, officers and other employees of the board.

Chapter-III : It deals with the constitution, composition and the special provision of joint board. For eg. A Joint board for the river Cauvery includes officials from Karnataka, Tamilnadu and Pondicherry along with the Central board officials.

Chapter-IV : This chapter deals with the functions of central board, state board and their powers to give directions to concerned authorities.

Chapter-V : It explains the power of state government to collect samples of effluent, analyze in government laboratory and publish the results. On the basis of the result they may restrict the outlets and discharges into stream or well.

Chapter-VI : It deals with the maintenance of funds of central and state board, budgets, annual report submission, account and auditing.

Chapter-VII : This elaborates about the penalty in case of offences committed by companies. **Punishment:** Imprisonment for not less than one year and six months but which may extend to 6 years with fine. Incase of failure, an additional fine of Rs.5000/ will be imposed for every day. In such case the names of the offenders may be even published.

Chapter-VIII : It explains about the central and state water laboratories, analysts, reports of the analysts, protection, action in good faith and about the power of central and state government to formulate the rules. Important sections under this act are

Under Section 19 : The entire National Capital Territory of Delhi has been declared as water pollution prevention control area.

Under Section 21 : Officials of DPCC can take samples of the water effluent from any industry stream or well or sewage sample for the purpose of analysis.

Under Section 23 : Officials of the state boards can enter any premises for the purpose of examining any plant, record, register etc. or any of the functions of the Board entrusted to him.

Under Section 24 : No person shall discharge any poisonous, noxious or any polluting matter into any stream, or well or sewer or on land.

Under Section 25 : No person shall without the previous consent to establish shall

a. Establish or take any step to establish any industry, operation or process or any treatment and disposal system for any extension or addition thereto, which is likely to discharge sewage or trade effluent into a stream or well or sewer or on land or

b. Bring into use any new or altered outlet for the discharge of sewage or

c. Begin to make any new discharge of sewage.

Under this section the state board may grant consent to the industry after satisfying itself on pollution control measures taken by the unit or refuse such consent for reasons to be recorded in writing.

Under Section 27 : A state board may from time to time review any condition imposed by it on the person under section 25 and 26 and may vary or revoke that condition.

Under Section 28 : Any person aggrieved by the order made by the State Board under Section 25, 26 or section 27 may within thirty days from the date on which the order is communicated to higher authority, prefer an appeal to such authority (referred to as the appellate authority) as the State Govt. may think fit to constitute .

Under Section 33 : The State Board can direct any person who is likely to cause or has cause the pollution of water in street or well to desist from taking such action as is likely to cause its pollution or to remove such matters as specified by the Board through court.

Under Section 33A : DPCC can issue any directions to any person, officer or authority, and such person, officer or authority shall be bound to comply with such directions. The directions include the power to direct:-The closure, prohibition of any industry, Stoppage or regulations of supply of electricity, water or any other services

Under Section 43 : Whoever contravenes the provisions of Section 24 shall be punishable with imprisonment for a term which shall not be less than one year and six months but which may extend to six years with fine.

Under Section 45 : If any who has been convicted of any offence under section 24, or Section 25 or Section 26 is again found guilty of an offence involving a contravention of the same provision shall be on the second and on every subsequent conviction be punishable with imprisonment for a term which

shall not less than two years but which may extend to seven years with fine.

Under Section 45A : Whoever contravenes any of the provisions of this act or fails to comply with any order or direction given under this act for which no penalty has been elsewhere provided in this Act, shall be punishable with imprisonment which may extend to three months or with fine which may extend to ten thousand rupees or with both.

The Wildlife (protection) Act, 1972

This act is framed for the protection of wild animals, birds and plants. This act comprises 7 chapters and 66 sections. This act extends whole of India except Jammu and Kashmir.

Chapter-I: It deals with the definitions of terms such as habitat, hunting, national park, reserved forest, sanctuary etc.

Chapter-II : It clearly explains the authorities to be appointed, formation of wildlife advisory board and its duties.

Chapter-III : It emphasizes the maintenance of record of wild animals killed or captured. Details regarding hunting of wild animals and regarding the license holder are elaborated.

Chapter-IV : It gives a notes on sanctuaries, national parks, game reserves ,permission to enter a sanctuary , prohibited areas, district collector's power in maintaining these areas and also includes the power of central government to declare such areas as national parks and sanctuaries.

Chapter-V : It tells about the trade of wild animals, animal products etc., This chapter clearly explains that any animal killed , captured or trapped is a government property and also elaborates regarding the regulation of transfer of animal.

Chapter-VI : This chapter explains about the penalties when found guilty under this act, 2 years imprisonment, Rs.2000/- fine ,either or both. And in a sanctuary or animal park, when an offence is committed, imprisonment for maximum 6 years, minimum 6 months and fine not less than Rs.500/- will be levied.

Chapter-VII : It deals with protection given to officers for action taken in good faith and explains the power provided to central and state government make to rules regarding the protection of wild life.

The Wildlife Protection Act , 1972

The Wildlife Protection Act of 1972 refers to a sweeping package of legislation enacted in 1972 by the Government of India. Before 1972, India only had five designated national parks. Among other reforms, the Act established schedules of protected plant and animal species; hunting or harvesting these species was largely outlawed.

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 ofIndia, except the State of Jammu and Kashmir which has its own wildlife act. It has six schedules which give varying degrees of protection. Schedule I and part II ofSchedule II provide absolute protection - offences under these are prescribed the highest penalties. Species listed in Schedule III and Schedule IV are also protected, but the penalties are much lower. Schedule V includes the animals which may be hunted. The plants in Schedule VI are prohibited from cultivation and planting. The hunting to the Enforcement authorities have the power to compound offences under this Schedule (i.e. they impose fines on the

offenders). Up to April 2010 there have been 16 convictions under this act relating to the death of tigers. Government of India enacted a comprehensive legislation Wildlife Protection Act of 1972 with the objective of effectively controlling poaching and illegal trade in wildlife and its derivatives. This has been amended (and signed) in January, 2003 and punishment and penalty for offences under the Act have been made more stringent.

Offences pertaining to hunting of endangered species and altering of boundaries of protected areas

For offences relating to wild animals (or their parts and products) included in schedule-I or part II of Schedule- II and those relating to hunting or altering the boundaries of a sanctuary or national park the punishment and penalty have been enhanced, the minimum imprisonment prescribed is three years which may extend to seven years, with a minimum fine of Rs. 10,000/-. For a subsequent offence of this nature, the term of imprisonment shall not be less than three years but may extend to seven years with a minimum fine of Rs. 25,000. Also a new section (51 - A) has been inserted in the Act, making certain conditions applicable while granting bail: 'When any person accused of the commission of any offence relating to Schedule I or Part II of Schedule II or offences relating to hunting inside the boundaries of National Park or Wildlife Sanctuary or altering the boundaries of such parks and sanctuaries, is arrested under the provisions of the Act, then not withstanding anything contained in the Code of Criminal Procedure, 1973, no such person who had been previously convicted of an offence under this Act shall be released on bail unless -

(a) The Public Prosecutor has been given an opportunity of opposing the release on bail; and

(b) Where the Public Prosecutor opposes the application, the Court is satisfied that there are reasonable grounds for believing that he is not guilty of such offences and that he is not likely to commit any offence while on bail".

In order to improve the intelligence gathering in wildlife crime, the existing provision for rewarding the informers has been increased from 20% of the fine and composition money respectively to 50% in each case. In addition to this, a reward up to Rs. 10,000/- is also proposed to be given to the informants and others who provide assistance in detection of crime and apprehension of the offender.

At present, persons having ownership certificate in respect of Schedule I and Part II animals, can sell or gift such articles. This has been amended with a view to curb illegal trade, and thus no person can now acquire Schedule I or Part II of Schedule II animals, articles or trophies except by way of inheritance (except live elephants).

Stringent measures have also been proposed to forfeit the properties of hardcore criminals who have already been convicted in the past for heinous wildlife crimes. These provisions are similar to the provisions of 'Narcotic Drugs and Psychotropic Substances Act, 1985'. Provisions have also been made empowering officials to evict encroachments from Protected Areas.

Forest (Conservation) Act,1980

Earlier the Indian Forest Act, 1927 was adopted to include reserved forests, village forests, protected forests and non-Govt. forests. This act regulated the duty levied on timber and other forest producers. But this act does not in to consideration about conservation protection of forests. In addition this act does not consider or include the tribal who were the most conservators and protectors of forest. Hence

the forests (conservation) Act, 1980 was adopted. This act has different sections to deal with various concepts related to conservation of forests.

1. This Act has the main aim to protect all types of forests.
2. Thus indirectly help to maintain the ecosystem and biological diversity.
3. This Act, stresses that the state government would be empowered to declare a reserve forests as unreserved and any forest land cannot be used for non-forest purpose i.e., any purpose other than afforestation.
4. This act further checks the operations that must be carried out in forests such as mining which will cause ecological imbalance leading to environmental deterioration.
5. According to this act the central government has the authority to maintain an ecological balance in the forest extending from the tropical to temperate regions.
6. This act was enacted and strictly followed on the basis of the fact that forest is a valuable treasure. Forest is defined as an ecosystem in which trees are dominant form of vegetation, the plants, animals and the soil play an important role.
7. This act comprises of five important sections

- The first section deals with the usage of the forestland for non-forest purpose as described earlier.
- The next section explains the constitution of forest advisory committee.
- The next section explains the penalties when the act is violated. It includes simple imprisonment up to a period of 15 days. In such case the authority responsible for that area will also be punished.
- The next section explains the power of central government to make rules regarding the forest conservation.

Background

- Indiscriminate and massive diversion of forest land for non forestry purposes since independence.
- Approximately 4.3 million ha. of forest land diverted during 1950 to 1980 for non forestry purposes.
- In 1980, the Forest (Conservation) Act was enacted for providing a higher level of protection to the forests and to regulate diversion of forest lands for non forestry purposes.
- FC ACT, 1980 – Prior approval of the Central Government is essential for de-reservation of forest lands and / or diversion of forest lands for non-forestry purposes.
- It is a Regulatory Act, not prohibitory.
- The Act is an interface between conservation and development.
- Permits judicious and regulated use of forest land for non-forestry purposes.

By its order of 1996, the Apex Court has extended the provisions of the Act to all forests irrespective of ownership.

Procedure for Forest Clearance -

- Proposals recommended by the State / UT Govts. Forwarded to the Central Govt. for approval under Section 2 of the Act.
- Proposals examined by Forest Advisory Committee (FAC) constituted under Section 3 of the Act.
- Decisions taken on the basis of the recommendations of the FAC.
- FC Rules, 2003 prescribe specific time limits for processing the cases.

Impact of this Act

- During 1950-80, the rate of diversion of forest land for non-forestry purposes was – 1,50,000 hectares per annum
- After enactment of the FC Act, 1980, the rate of diversion of forest land for non-forestry purposes came down to about 35,000 ha per annum

Policy Initiatives of Moef

- Simplified Format of Application
- Specific time limit for States and Central Govt. for expeditious processing of proposals (90/60 days for State Governments for fresh/renewal cases and 60 days for Central Government)
- Regional Offices to process cases up to 40 ha (increased from 20 ha)
- Site inspection by Regional Offices mandatory for proposals involving more than 100 ha of forest land (increased from 40 ha)
- General approval for underground laying of electrical cables and electric wires, drinking water supply/water pipelines, telephone lines, etc.
- General approval, up to 1 ha, for public utility projects, to be executed by Government Departments, like schools, dispensary/hospital, electric and telecommunication lines, drinking water, rainwater harvesting structure, minor irrigation canal, non-conventional sources of energy, skill up-gradation/vocational training centre, power sub stations, communication posts and police establishments like police stations/outposts/watch towers.

Forest Advisory Committee (FAC)

- FAC is a seven member Committee under the chairmanship of DGF & SS, MoEF.
- Three non official members – eminent experts in forestry and allied disciplines – appointed for a period of two years.

- ADGF, MoEF; Additional Commissioner (Soil Conservation), Ministry of Agriculture.
- IGF (FC) -- Member Secretary
- Meeting not less than once a month, generally at New Delhi
- Quorum is Three.

Certain conditions are stipulated at the time of granting approval under FC Act:

- Compensatory Afforestation,
- Catchment Area Treatment,
- Phased Reclamation of mining area
- Safety zone Area
- Rehabilitation of Project affected families, if any.
- Muck disposal plan
- Wildlife management plan etc.

Lecture 16

National and state level organizations - Environmental Laws and Acts – Environmental Education – CDM

Environmental Organizations

There are a number of international and national organizations, agencies and programmes involved in different areas of environment, forestry, wildlife and other relevant aspects. Some of the important bodies of this type area as follows.

International Bodies

1. Earth scan: An agency, founded by UNEP in 1976, that commissions original articles on environmental matter and sells them as features to newspapers and magazines, especially in developing countries.

2. Convention on International Trade in Endangered Species (CITES). An international forum, whose membership for agreement is open to all countries. For India, the Ministry of Environment and Forests functions as nodal agency for participation in international agreements.

3. Environmental Protection Agency (EPA). This is an independent Federal Agency of the U.S. Government established in 1970. It deals with protection of air, water, solid wastes and management of radiation, pesticides , noise etc.

4. European Economic Community (EEC). It is community of 12 European nations with sound political, economic and legal base. The community has joint agricultural and scientific programmes. It has programmes of framing and implementation of coordinated policy for environmental improvement and conservation of natural resources. CPCB, India has taken up projects on air quality monitoring with assistance of EEC.

5. Human Exposure Assessment Location (HEAL). The project is a part of the Health Related Monitoring Programme by WHO in co-operation with UNEP. This project has three components, viz., (i) air monitoring (ii) water quality monitoring and (iii) food contamination monitoring on a global basis.

6. International Council of Scientific Unions (ICSU). A non-government organization based in Paris, that encourages the exchange of scientific information, initiates programmes requiring international scientific cooperation and studies and reports on matters related to social and political responsibilities in treatment of scientific community.

7. International Union for Conservation of Nature and Natural Resources (IUCN). An autonomous body, founded in 1948 with its Headquarters at Morges, Switzerland, that initiates and promotes scientifically based conservation measures. It also cooperates with United Nations and other intergovernmental agencies and sister bodies of World Wide Fund for Nature (WWF).

8. International Marine Consultative organization (IMCO). It regulates the operation of ship in high seas, from marine water pollution viewpoint.

9. South Asia co-operative Environment Programme (SACEP). This has been recently set up

for exchange of professional knowledge and expertise on environmental issues among member countries – Afghanistan, Bangladesh, Bhutan, India, Iran, Pakistan and Sri Lanka.

10. United Nations Educational, Scientific and Cultural Organization (UNESCO). An United Nations agency, found in 1945 to support and implement the efforts of member states to promote education, scientific research and information, and the arts to develop the cultural aspects of world relations. It also holds conferences and seminars, promotes research and exchange of information and provides technical support. Its Headquarters are in Paris. Independently as well as in collaboration with other agencies like UNEP, it supports activities related to environmental quality, human settlements, training to environmental engineers and other socio-cultural programmes related to environment.

11. United Nations Environment programme (UNEP). A UN agency, responsible for co-operation of inter-governmental measures for environmental monitoring and protection. It was set up in 1972. There is a voluntary United Nations Environment Fund to finance environmental projects. There is an Environmental Coordination Board, to coordinate the UNEP programmes. Its Headquarters are in Nairobi, Kenya. UNEP was founded to study and formulate international guidelines for management of the environment. UNEP is assisting many such programmes in India.

12. World Commission on environment and Development (WCED). This is a 23 member commission, set up in 1984 in pursuance to a UN General Assembly resolution in 1983 to re-examine the critical environmental and development issues and to formulate proposals for them. This is a call for political action to manage better environmental resources to ensure human progress and survival. The commission makes an assessment of the level of understanding and commitment of individuals, voluntary organizations and governmental bodies on environmental issues.

13. Earthwatch Programme. A world wide programme, established in 1972 under the terms of the Declaration on the Human Environment. It monitors trends in the environment, based on a series of monitoring stations. Its activities are coordinated by UNEP.

14. Project Earth. Developed in collaboration with UNEP to inspire and educate young people worldwide on the crucial issues facing the Earth's Environment.

15. Man and Biosphere Programme (MAB).The programme is the outcome of International Biological Programme (IBP) that has already concluded its activities. MAB was formerly launched by UNESCO in 1971.

Man and the Biosphere Programme (MAB)

MAB is the outcome of the experience of those involved in the International Biological Programme (IBP). It was realized that several problems require collaboration of natural and social scientists, planners and managers and the local people. MAB was conceived at the International Biosphere Conference of UNESCO in 1968 and was officially given shape by General Conference at its 16th Session in 1970. The programme was formally launched by UNESCO in November 1971, when the MAB International Coordinating Council held its first session and identified 13 project areas of cooperative research. One more project area was added in 1974.

National Organizations

There are a number of governmental as well as non-governmental organizations, agencies and programmes engaged in environmental studies. A number of non-governmental, voluntary organizations have been doing good job in this area.

Most of the governmental bodies involved in environmental studies are either put under the administrative control of, or assisted by the Department of Environment, Forests and Wildlife in the Ministry of Environment Forests, Government of India.

Department of Environment, Forests and Wildlife of India

Department of Environment was set up in 1980 to serve as the local point in the administrative structure of the Government for planning, promotion and coordination of environmental programmes. The present integrated Department of Environment, Forests and Wildlife in the Ministry of Environment and Forests was created in September 1985. The Ministry serves as the local point in the administrative structure of the Central Government of the planning, promotion and coordination of environmental and forestry programmes. The Ministry's main activities are, the survey and conservation of flora, forests and wildlife, prevention and control of pollution, afforestation and regeneration of the degraded areas of the environment.

Other National Organization

There are other governmental and non-governmental organizations / agencies involved in environmental issues. Some of the important ones are as follows:

(1) Advisory Board on Energy (ABE)
(2) Bombay Natural History Society (BNHS)
(3) Central Forestry Commission (CFC)
(4) Department of Non-Conventional Energy Sources (DNES)
(5) Industrial Toxicology Research Centre (ITRC)
(6) National Environmental Engineering Research Institute (NEERI)
(7) National Natural Development Board
(8) National Natural Research Management System
(9) National Wetland Management Committee
(10) State Pollution Control Board (SPCB)
(11) Tata Energy Research Institute (TERI)
(12) Several Research Institutes under I.C.A.R. including

I.G.F.R.I., Jhansi, Central Soil Salinity Research Institute, Karnal.

Environmental Impact Assessment

Environmental impact assessment is a written analysis or process that describes and details the probable and possible effects of planned industrial or civil project activities on the ecosystem, resources, and environment. The National Environmental Policy Act (NEPA) first promulgated guidelines for environmental impact assessments with the intention that the environment receives proper emphasis among social, economic, and political priorities in governmental decision-making. This act explains the importance of environmental impact assessments for major federal actions affecting the environment. Many states now have similar requirements for state and private activities.

Such written assessments are called Environmental Impact Statements or EISs.

Environmental Impact Statement (EIS) is a formal process used to predict how a development project or proposed legislation will affect such natural resources as water, air, land, and wildlife. The environmental impact statement was first introduced in 1969 in the United States as a requirement of the National Environmental Policy Act. Since then, an increasing number of countries have adopted the process, introducing legislation and establishing agencies with responsibility for its implementation. EISs range from brief statements to extremely detailed multi-volume reports that require many years of data collection and analysis. In general, the environmental impact assessment process requires consideration and evaluation of the proposed project, its impacts, alternatives to the project, and mitigating strategies designed to reduce the severity of adverse effects. The assessments are completed by multidisciplinary teams in government agencies and consulting firms.

The content of the assessments generally follows guidelines in the National Environmental Policy Act. Assessments usually include the following sections:

1) Background information describing the affected population and the environmental setting, including archaeological and historical features, public utilities, cultural and social values, topography, hydrology, geology and soil, climatology, natural resources, and terrestrial and aquatic communities ;

2) Description of the proposed action detailing its purpose, location, time frame, and relationship to other projects;

3) The environmental impacts of proposed action on natural resources, ecological systems, population density, distribution and growth rate, land use, and human health. These impacts should be described in detail and include primary and secondary impacts, beneficial and adverse impacts, short and long term effects, the rate of recovery, and importantly, measures to reduce or eliminate adverse effects;

4) Adverse impacts that cannot be avoided are described in detail, including a description of their magnitude and implications;

5) Alternatives to the project are described and evaluated. These must include the "no action" alternative. A comparative analysis of alternative permits the assessment of environmental benefits, risks, financial benefits and costs, and overall effectiveness;

6) The reason for selecting the proposed action is justified as a balance between risks, impacts, costs, and other factors relevant to the project;

7) The relationship between short and long term uses and maintenance is described, with the intent of detailing short and long term gains and losses;

8) Reversible and irreversible impacts;

9) Public participation in the process is described;

10) Finally, the EIS includes a discussion of problems and issues raised by interested parties, such as specific federal, state, or local agencies, citizens, and activists.

The environmental impact assessment process provides a wealth of detailed technical information. It has been effective in stopping, altering, or improving some projects. However, serious questions have been raised about the adequacy and fairness of the process. For example, assessments may be too

narrow or may not have sufficient depth. The alternatives considered may reflect the judgment of decision makers who specify objectives, the study design, and the alternatives considered. Difficult and important questions exist regarding the balance of environmental, economic, and other interests. Finally these issues often take place in a politicized and highly charged atmosphere that may not be amenable to negotiation. Despite these and other limitations, environmental impact assessments help to provide a systematic approach to sharing information that can improve public decision-making.

Environmental Laws And Regulation

Man has drawn so much from nature for the satisfaction of his needs, desires and ambitions resulting in the immediate need for proper environmental management. The proper environmental management requires that society and man's demands should be so regulated that natural environment is able to sustain the need for development. The question of environmental protection would essentially be a question of re-allocation of priorities among various needs and choosing among diverse means for meeting them. The environmental protection is the concern of everyone. The fundamental question before the world today is whether we can allow the destruction of the environment leading to the destruction of all life on the earth. Hence protection of environment is of paramount importance.

Environmental laws

Major legislations directly dealing with the protection of environment in India are

1. The wild life protection Act, 1972.
2. The forest conservation Act, 1980.
3. The water (Prevention and control of pollution) Act, 1974.
4. The air (Prevention and control of pollution) Act, 1981.
5. The Environment (Protection) Act, 1986.
6. The Public Liability Insurance Act, 1991.
7. The National Environment Tribunal Act, 1995.

The wild life protection Act, 1972 provides for rational and modern wildlife management, while the forest protection Act, 1980 has been enacted to check indiscriminate deforestation and diversion of forest land for non-forest purposes. The water and air Acts are the major instruments for the control of water and air pollution and these have provided for the establishment of the Central and State Pollution Control Boards.

Environmental protection under Indian constitution

The 42nd Amendment to the constitution brought about in the year 1974 inserted two new Articles namely.

(I) Art. 48-A under Directive principles of State Policy, making it the responsibility of the State Government to protect and improve the environment and to safeguard the forests and wildlife of the country.

(II) Art. 51-A (g) under Fundamental duties of citizens; making it the fundamental duty of every citizen to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.

The Environment (Protection) act, (EPA) 1986 is a landmark legislation which provides for a single focus in the country for the protection of environment and aims at plugging the loopholes in the existing legislation. It is a comprehensive legislation to deal with water, air and land pollution and hazardous wastes and handling, storage and transportation of hazardous chemicals and wastes.

Important sections of EPA, 1986

Section and its contents

Section 2 – define the terms, environment, environmental pollutant, environmental pollution and hazardous substance.

Section 3 : Power of Central Government to take measures to protect and improve environment.

Section 4 : Appointment of officers and their powers and functions for the purpose of this Act.

Section 5 : Power to give directions to the closure, prohibition or regulation of industry, operation or process; or stoppage or regulation of the supply of electricity or water or any other service.

Section 6 : Rules to regulate environmental pollution. Rules in respect of

(a) Standards of quality of air, water or soil for various areas and purposes;

(b) Maximum allowable limits of concentrations of environmental pollutants (including noise) for different areas;

(c) Procedures and safeguards for handling hazardous substances.

(d) Prohibition and restriction on the handling of hazardous substances in different areas.

(e) Prohibition and restriction on the location of industries and carrying on of processes and operations in different areas;

(f) Procedures and safeguards for the prevention of accidents which may cause environmental pollution and for providing remedial measures for such accidents.

The Public liability Insurance Act, 1991, provides mandatory insurance for the purpose of providing immediate relief to the persons affected by accidents occurring while handling any hazardous substance.

The National Environmental Tribunal Act, 1995, seeks to constitute a tribunal with Benches to award compensation for damage to persons, property and the environment arising out of any activity involving hazardous substances. All these Acts are amended from time to time to rationalize and expand their scope, coverage and penal provisions.

Environmental Education

Environmental education ("EE") refers to organized efforts to teach about how natural environments function and, particularly, how human beings can manage their behavior and ecosystems in order to live sustainably. The term is often used to imply education within the school system, from primary to post-secondary. However, it is sometimes used more broadly to include all efforts to educate the public and other audiences, including print materials, websites, media campaigns, etc. Related disciplines include outdoor education and experiential education. The United Nations Education Scientific and Cultural Organization (UNESCO) and United Nations Environment Program (UNEP) created three major declarations that have guided the course of environmental education.

Stockholm Declaration

June 5-16, 1972 - The Declaration of the United Nations Conference on Human Environment. The document was made up of 7 proclamations and 26 principles "to inspire and guide the peoples of the world in the preservation and enhancement of the human environment.

The Belgrade Charter

October 13-22, 1975 - The Belgrade Charter was the outcome of the International Workshop on Environmental Education held in Belgrade, Yugoslavia. The Belgrade Charter was built upon the Stockholm Declaration and adds goals, objectives, and guiding principles of environmental education programs. It defines an audience for environmental education, which includes the general public.

The Tbilisi Declaration

October 14-26, 1977 - The Tbilisi Declaration noted the unanimous accord in the important role of environmental education in the preservation and improvement of the world's environment, as well as in the sound and balanced development of the world's communities. The Tbilisi Declaration updated and clarified The Stockholm Declaration and The Belgrade Charter by including new goals, objectives, characteristics, and guiding principles of environmental education.

Antecedents

In the United States some of the antecedents of Environmental Education were Nature Studies, Conservation Education and School Camping. Nature studies integrated academic approach with outdoor exploration. Conservation Education brought awareness to the misuse of natural resources. The governmental agencies like the Forestry Service and the EPA were also pushing a conservation agenda. Conservation ideals still guide environmental education today. School Camping was exposure to the environment and use of resources outside of the classroom for educational purposes. The legacies of these antecedents are still present in the evolving arena of environmental education. Environmental education has been considered an additional or elective subject in much of traditional K-12 curriculum. At the elementary school level, environmental education can take the form of science enrichment curriculum, natural history field trips, community service projects, and participation in outdoor science schools. Insecondary school, environmental curriculum can be a focused subject within the sciences or is a part of student interest groups or clubs. At the undergraduate and graduate level, it can be considered its own field within education, environmental studies, environmental science and policy, ecology, or human/cultural ecology programs.
The North American Association for Environmental Education has established the following "Guidelines for Excellence" for environmental education:
1. Fairness and accuracy: EE materials should be fair and accurate in describing environmental problems, issues, and conditions, and in reflecting the diversity of perspectives on them.

- Factual accuracy.
- Balanced presentation of differing viewpoints and theories.

- Openness to inquiry.
- Reflection of diversity.

2. Depth: EE materials should foster an awareness of the natural and built environment, an understanding of environmental concepts, conditions, and issues, and an awareness of the feelings, values, attitudes, and perceptions at the heart of environmental issues, as appropriate for different developmental levels.

- Awareness
- Focus on concepts
- Concepts in context
- Attention to different scales.

3. Emphasis on skills building: EE materials should build lifelong skills that enable learners to address environmental issues.

- Critical and creative thinking
- Applying skills to issues
- Action skills.

4. Action orientation: EE materials should promote civic responsibility, encouraging learners to use their knowledge, personal skills, and assessments of environmental issues as a basis for environmental problem solving and action.

- Sense of personal stake and responsibility
- Self-efficacy.

5. Instructional soundness: EE materials should rely on instructional techniques that create an effective learning environment.

- Learner-centered instruction
- Different ways of learning
- Connection to learners' everyday lives
- Expanded learning environment
- Interdisciplinary
- Goals and objectives
- Appropriateness for specific learning settings
- Assessment.

6. Usability: EE materials should be well designed and easy to use.

- Clarity and logic.
- Easy to use.
- Long lived.
- Adaptable.
- Accompanied by instruction and support.
- Make substantiated claims.
- Fit with national, state, or local requirements.

Related disciplines

Environmental education has crossover with the disciplines of outdoor education and experiential education. Both disciplines complement environmental education yet have unique philosophies.

- Outdoor education means learning "in" and "for" the outdoors. It is a means of curriculum extension and enrichment through outdoor experiences. Environmental education is often taught or enhanced through outdoor experiences. The out of doors experience while not strictly environmental in nature often contain elements of teaching about the environment.
- Experiential education is a process through which a learner constructs knowledge, skill, and value from direct experiences. Experiential education can be viewed as both a process and method to deliver the ideas and skills associated with environmental education.

While each of these disciplines have their own objectives, there are points where both disciplines overlap with the intentions and philosophy of environmental education.

Trends

One of the current trends within environmental education seeks to move from an approach of ideology and activism to one that allows students to make informed decisions and take action based on experience as well as data. Within this process, environmental curricula have progressively been integrated into governmental education standards. Some environmental educators find this movement distressing and a move away from the original political and activist approach to environmental education while others find this approach more valid and accessible.

Movement

There is a movement that has progressed since the relatively recent founding (1960s) of the idea of environmental education in industrial societies, which has transported the participant from nature appreciation and awareness to education for an ecologically sustainable future. This trend may be viewed as a microcosm of how many environmental education programs seek to first engage with participants through developing a sense of nature appreciation which is then translated into actions that affect conservation and sustainability.

Clean Development Mechanism

The **Clean Development Mechanism** (**CDM**) is an arrangement under the Kyoto Protocol allowing industrialized countries with a greenhouse gas reduction commitment (called Annex 1 countries) to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. A crucial feature of an approved CDM carbon project is that it has established that the planned reductions would not occur without the additional incentive provided by emission reductions credits, a concept known as "additionality".

The CDM allows net global greenhouse gas emissions to be reduced at a much lower global cost by financing emissions reduction projects in developing countries where costs are lower than in industrialized countries. However, in recent years, criticism against the mechanism has increased. Critics claim many approved projects are not actually additional.

The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the United Nations Framework Convention on Climate Change (UNFCCC).

CDM projects to date

As of 21 July 2008, 1128 projects have been registered by the CDM Executive Board as CDM projects. These projects reduce green house gas emissions by an estimated 220 million ton CO2 equivalent per year. There are about 4,000 projects yet to be certified. These projects would reduce CO2 emissions by over 2.5 billion tons until the end of 2012. However, the previous adoption rate suggests that only a fraction of these projects will be certified.

Lecture 17
Woman and child welfare, HIV/AIDS and Role of information technology on environment and human health

Women are part and parcel of environment. Women have direct relationship with their immediate environment. Regularly they collect water, fuel wood, foods like nuts, fruits, leaves, roots etc. So women have closer vicinity with the flora and fauna of that region by living with them. Women as a social category, perform multiple role. Certain roles have been recognized universally. The physical differentiation between men and women necessitates certain social arrangements for procreation and rearing of children. Man created practices and customs which tied woman to motherhood in a familial social responsibility. A set of norms were created to curb her freedom, creative potential and suppress her in society.

Women experienced depending syndrome particularly dependency on father during childhood, dependency on the husband in adulthood and dependency on the son in old age. This made her position subordinate to man and easy exploitation women bear and rear children but no proper care for her role of motherhood. Neglect of mother and motherhood lead to maternity deaths, in human custom of female in infanticide etc. Because of poor stimulation of living and economic backwardness, women suffer from nutritional deficiency, during pregnancy and lactation. So it is necessary that there women should be educated to bring them out and should be provided with proper training to create suitable awareness and insight into the new demands in the physical and social environment.

Woman welfare and development

Even through, the first five '' Five year plans'' were focusing on women's welfare, only from the sixth 'Five year plan' (1980-1985) on wards, women were recognized as separate target group involving developmental planning activities. The 1991 census revealed that women constitute 48.1 percent of the country's population. Hence it is understood that for the development of the nation backwardness of women has to be taken care.

Women rights and privileges

The constitution of India not only guarantees equality for women, but also empowers state to adopt measures of positive discrimination in favours of women in order to overcome their disadvantages in socio economic, educational and political fields. There are many articles in the constitution specifically encourages the development of woman in the society.

- **Article 14 -** States that equal rights and opportunities for men and women in the political, economic and social spheres.
- **Article 15 -** Prohibits discrimination against any citizen on the grounds of religion, caste and sex.

- **Article 15(3) -** Makes a special provision enabling the state to make positive discrimination in favour of women.
- **Article 15(A) (e) -** Condemn the practices derogatory to the dignity of women.
- **Article 16** - Provides for equal opportunities in matter of public appointments.
- **Article 39(a) -** States that state shall direct its policy towards securing all citizens, men and women equally the right to means of livelihood.
- **Article 39(c) -** Confirms that equal pay for equal work.
- **Article 42 -** Directs the state to provide the citizens the just and human conditions at work and maternity relief.

Policies concerning women's development

Various policies advocating women's welfare and development have been evolved by the government. Some of them are given below.

- The national plan of action for women (NPA) 1976.
- The national perspective plan for women (NPP) 1988-2000.
- Sharam shakti 1988.
- The national nutritional policy (NNP) 1993.
- The national plan and action for the girl child (NPA) 1991-2000.
- National commission for women's act (new) 1990.

Child welfare and development

The future of a nation depends on the way in which the children are growing nutritionally, educationally and socially. Many children suffer from malnutrition and die for want of immunization. The national policy for children was formulation in the year 1974.

- Children are '' a supremely important asset'' of the nation.
- It is duty of the state '' to provide adequate services to the children both before and after birth and through the period of growth''.

Provision of early childhood services especially to the weaker and more vulnerable section of the community could help , prevent or minimize infant mortality, morbidity, malnutrition and stagnation in schools.

India has the world's largest integrated child development services (ICDS) program started in the year 1975, which involves supplementary nutrition, immunization, health care, growth monitoring, pre-school education and health and education. ICDS provides health checkup service like antenatal care for pregnant women, post-natal care for nursing mothers and healthcare for children less then 6 years of age. Children less than 6 years in the village are periodically examined, weighed, immunized at prescribed times and treated for ailments. Provision for nutrition and health education has been made

for women 40-45 years of age with priority given to pregnant and lactation mothers. ICDS provide the facilities like

- Foundation for personality.
- Reduction of deprivation.
- Effective Co ordination for policy implementation.
- Maternity and motherhood care through education and health care.

According to the Indian constitution that free and compulsory education for all children would be provided until they complete the age of fourteen years. There has been special emphasis in monitoring the drop outs in primary education.

National policy for children

The children population of India is nearly 300 million and the majority of the children live under socially and economically under privileged conditions that can lead to deterioration of the child's physical and mental development. The national policy for children (NPC) 1974 was founded on the conviction that child development programmes can ensure equality of opportunity to the poor children.

Various organizations towards child welfare

- **UN conventions on rights of child or international law**

It formulated a set of international standard and measures to promote and protect the well being of children in our society.

Rights of the child

The international law defines right of the child to survival, participation, development and protection.

- **The right to survival:** It emphasis on good standards of living, good nutrition and health.
- **The right to participation:** It means freedom of thought and appropriate information to child.
- **The right to development:** It ensures access to education, child hood care and support, social security and recreation.
- **The right to protection:** It means freedom from exploitation in human treatment and neglect.
- **World summit on child:** It had focused agenda for the well being of the children targeted to be achieved in the beginning of the new millennium.
- **Ministry of Human Resource Development (MHRD):** It concentrates on child's health, education, nutrition, clean and safe drinking water, sanitation and environment.

17.3. Acquired Immune Deficiency Syndrome (AIDS)

AIDS is caused by virus called HIV (Human Immune deficiency Virus). HIV breaks down the body's

immune system leaving the patient to a number of life threatening infections. The AIDs patient will be getting different kinds of severe infections including cancer, neurological disorders, skin diseases finally leading to death. As HIV infected person receives a diagnosis of AIDS after developing one of the AIDS indicator illnesses. A positive HIV test result does not mean that a person has AIDS. A diagnosis of AIDS is made by a physician using certain clinical criteria, AIDS illness indicator.
AIDS was discovered in 1983, though sufficient knowledge has been gained about the disease, yet a definite source of this virus could not be identified, but some of the sources are

- Through African monkey

Most of the evidences have suggested that the AIDS has spread from Africa. It has been believed that the HIV has transferred to humans from African monkey or chimpanzees.

- Through Vaccine programmes
- HIV has spread in Africa through HIV contaminated polio vaccine prepared from monkey's kidney
- It had spread through Hepatitis – B viral vaccine in Los Angels and New York.
- It had also spread through small pox vaccine programme of Africa

World Scenario

HIV/AIDS is the fourth leading cause of death in the world. Globally the AIDS epidemic has crossed over 20 million deaths and orphaned more than 14 million children. Nearly 90 % of the people who are infected with AIDS live in developing countries. 13 % of world's population lives in Africa, almost all states of African countries were affected by HIV. About 3 million people so far died due to HIV/AIDS in 2003. AIDS is rapidly spreading in Eastern Europe and Asia. India ranks second in the world with 5.1 million HIV/AIDS affected people. The percentage is lower than Thailand, Myanmar and South Africa.

Scenario in India

The largest numbers of infected cases have been found in Maharastra and TamilNadu, followed by Delhi, UP, Karnataka and Goa. In Tamil Nadu alone, till September 2008 a total of 24,667 cases of AIDS have been found out. The first HIV +ve case was identified in Chennai in 1986.

Mode of transmission of AIDS

Some of the key factors responsible for the spread of the deadly disease AIDS are

- Prostitution
- Homosexual activity
- Use of contaminated syringe or needle in blood transfusion.
- Maternal-fetal transmission i.e. a mother infected with AIDS can give birth to baby with AIDS.

- Other factors such as saliva, breast milk etc are also the mediums of transmittance of this disease. These body fluids have been proven to spread HIV

Blood
Semen
Vaginal fluid
Breast milk
Other body fluids containing blood.

- These are additional body fluids that may transmit the virus that healthcare workers may come into contact with
    - Fluid surrounding the brain and spinal cord.
    - Fluid surrounding the bone joints.
    - Fluid surrounding an unborn baby.

HIV tests

The most commonly used test is ELISA. Most of the hospitals are insisting of HIV test nowadays. If the sample shows positive results even after duplication, the results are confirmed using a second test called" Western blot''. In addition the following other test also used nowadays.

- Radioimmunoprecipitation assay (RIPA).
- Dot Blot Immunobinding Assay.
- Immunoflourescence assay.
- Nucleic acid testing.
- Polymerase Chain Reaction.

Functions of HIV in human body

AIDS itself does not kill humans. The death occurs due to the attack by diseases because of the weakening of immune system, white blood cell (WBC) responsible in the formation of antibodies are called T-helper cells. T-helper cells are the key infection fighters in the immune system. The HIV enter into the human body and destroys the T-cells, as a result of which various types of infection disease occur. Even cancer can easily develop in the HIV infected persons.

Various stages of HIV infection

The HIV infection stages can be divided into four stages clinically.

- The first stage is the initial infection in the blood the destruction of T-4 cells or lymphocytes or white blood corpuscles.
- The second stage is the symptomatic carrier stage.
- The third stage is the AIDS Related complex (ARC).

- The final stage is the fully infected AIDS patient receiving different kinds of infections.

Symptoms for HIV/AIDS
Minor symptoms

- Persistent cough for more than one month
- General skin disease
- Viral infection
- Fungus infection in mouth and throat
- Frequent fever, head ache, fatigue

Major symptoms

- fever for more than one month
- diarrhea for more than one month
- cough and TB for more than 6 months
- fall of hair from the head
- 10% of body weight get reduced within a short period

Screening test

The antibodies to HIV virus can be easily detected through blood tests. Hence the presence of HIV antibodies in the blood sample can confirm the HIV infection of HIV positive. One of the HIV test "ELISA, western blot " is a highly reliable test for HIV. HIV can be isolated from cultured lymphocytes, but it is an expensive and time consuming test.

Control of AIDS

- **Safe sexual activity and sex**

Since AIDS is a sexually transmitted disease due to mainly prostitution and homosexual activity. Proper moral education as well as sex education using good condoms etc., should be given to the illiterate as well as the public at large.

- **AIDS education and educating the AIDS patients**

The Public should be educated regarding the severity of the disease. For AIDS there is no vaccine or no remedial medicines have been so far successfully discovered. The AIDS patients have to undergo a gradual deterioration process to death. Since the HIV affects the immune system by destroying the lymphocytes (White Blood Corpuscles) count, the AIDS patient is highly vulnerable to any kind of infection from cough, cold etc., to cancer, typhoid etc, and cannot be treated through any kind of antibiotics or any other kind of drugs due to his shattered immunity system. Finally the AIDS

patient will become a prey to any one of the severe kind of infections.
The public should also be educated to treat AIDS patients with sympathy and concern. Since AIDS patients with sympathy and contact, people should be educated not to isolate them. Clinical and social workers should be specially trained for the welfare activities of AIDS patients. In the high school level itself, proper education regarding the prevention of AIDS and the clinical and social aspects of AIDS should be taught in the class rooms.

- **Educating illiterates as well as the educated public about AIDS prevention measures using different medias**

Various Medias such as radio, television, wall posters, pamphlets, booklets, etc should be efficiently made use for educating the public to be cautions about AIDS. The public should be educated regarding the various ways of transmission of the disease.

Role of Information Technology In Environment and Human Health

Today is an information age and tremendous flow of information is emerging in all fields throughout the world. Information in this competitive era is more precious than life and without information one cannot live at all. India is endowed with rich natural resources while facing the problems of poverty, illiteracy, population growth , environmental degradation etc. It is creating new possibilities to tackle these problems.
Information technology has tremendous potential in the field of environmental education and health as in any other field like business, economics, politics, or culture. Development of internet facilities, World Wide Web, geological information system (GLS) and information through satellites, has generated a wealth of up-to-date information on various aspects of environment and health. A number of software have been developed for environment and health studies which are user friendly and can help an early learner in knowing and understanding the subject. Nowadays the volume of data being generated from the environment is increasing manifold. The whole process of data collection, storage, processing and retrieved has become an easy task due to computerization. Lot of time saved and reduces his work through automation of many tasks.

Applications of IT in global environment

One of the important fields of IT for environmental studies is Geometrics. Geometrics is a science and technology for collecting, analyzing, interpreting, distributing and using geographic information. Geometrics involves the following,

- Surveying and mapping
- Remote sensing
- Geographic information system(GIS)
- Global positioning system(GPS)

One of the important applications of IT in the study of global environment is the satellite remote sensing technology. Satellite remote sensing technology helps in the evolution of its data and interpretations offer potentially valuable information for assisting human dimensions of global environmental changes are grouped into five major categories,

- Fossil fuel consumption
- Biomass consumption
- Land use change
- Agricultural activities
- Halocarbon production and release.

These five categories of interactions has created concern about the possible effects on the global physical , chemical and biological systems. The extra ordinary large scale in land use is frequently accompanied by changes in land cover i.e. forest and vegetation that can cause ecological imbalance. Satellite remote sensing technologies that provide satellite image data intervals which can be interpreted to study the land surfaces at repetitive intervals allow mapping and monitoring of changes is land cover of various types, amount, arrangement and the rate of change.
Satellite image products can assist the planning and co-ordination of global change research and the implementation of methodologies that contribute to a global understanding of human dimension activities which relates with the impacts of human activity in land use and land cover.
The remote sensing technology using satellite also play a major role in the environmental studies of water bodies such as lakes, rivers, estuaries, etc. as well as ocean and coastal areas. The major techniques for deriving information from satellite images are

- Image interpretation
- Digital image classification
- Data transformation
- Change detection

Remote satellite sensors

- US land state Multispectral scanner(MSS)
- French SPOT
- Indian Remote Sensing Satellite
- The Environment Information System - The ENVIS was started by MOEF in 1982 as a decentralized information network for collection, storage, retrieval and dissemination environmental information. ENVIS network presently consist of 25 subject oriented centres known as ENVIS centres.

Role of information technology in human health

Information technology plays a key role in human health. It has changed the human life style completely. Many health organizations are turning to package solution of IT to streamlining service oriented work in an effective manner.

The health service technology mainly involves three systems. They are

- Finance and accounting
- Pathology
- Patient administration-clinical systems

Application of IT in heal services

- With the help of IT packages, the data regarding birth and death rates, immunization and sanitation programme are maintained more accurately.
- It helps the doctor to monitor the health of the people effectively- tools like CT scans ,ultrasound Sonography uses IT for diagnosis
- The information regarding the outbreak of epidemic diseases can be conveyed easily.
- On-line-help of export doctors can be consulted to provide better treatment and services to the patient-through Video conferencing
- With central control system the hospital can run effectively- Most of the ICUs are now using computers to monitor the progress and condition of the patient undergoing treatments.
- Drugs and its replacement can be administered effectively.